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Article

Sustainable Development and Underexplored Topics in Canada's Energy Transition

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Abstract Canada's energy system is undergoing a fundamental shift, which will change how Canadians produce and consume energy. The success of Canada's energy transition will be influenced by the ability of energy practitioners to manage the tensions and trade-offs in a variety of topics. The purpose of this research was to identify topics that are relevant to Canada's energy transition and to identify the concepts that energy practitioners are using to manage the tensions and trade-offs in these topics. According to in-depth interviews with Canadian energy practitioners in 2021, the two most important topics in Canada's energy transition are climate change and reconciliation with Indigenous Peoples. In addition, according to a 2021 focus group with Canadian energy practitioners, three relevant and underexplored topics in Canada's energy transition are environmental rights, a systemic reduction in energy consumption, and learning from the energy transition in other countries, notably, Germany. These three underexplored topics were studied by completing additional in-depth interviews in 2022 and 2023, and a causal loop analysis in 2023. This research suggests that the concepts of sustainable development and multi-level perspective are complementary, can increase understanding of important and underexplored energy transition topics, and can generate solutions to complex sustainability challenges.

Keywords energy transition; Canada; sustainable development; multi-level perspective; climate change; reconciliation

1. Introduction

Sustainability transitions promote fundamental shifts in unsustainable patterns of consumption and production [1]. These fundamental shifts happen over long periods of time and involve significant uncertainty [2,3]. There is currently a fundamental shift happening in Canada's energy system, and the resulting energy transition will cause a significant change in how Canadians produce and consume energy [4,5].

It is important to understand the current realities of Canada's energy system to understand how it is shifting. The energy system is an essential component of Canada's modern society, and it includes "energy sources, their conversions, and specific uses of energy flows" [6]. Canada is one of the largest energy producers in the world with 23,315 PJ of primary energy produced and 14,528 PJ of energy and energy products exported in 2022 [7]. This domestic energy production included 52% from crude oil, 31% from natural gas, 6% from hydro, 5% from coal, 4% from nuclear, 2% from biofuels and waste, and 1% from wind and solar photovoltaics (PV) [8]. Canada is also one of the world's highest energy consumers on a per capita basis with 8585 PJ of energy consumed in 2022 [7]. This energy consumption included 30% by the transport sector, 24% by the industry sector, 17% by the residential sector, 14% by commercial and public services, 12% by non-energy use, and 3% by agriculture and forestry [8].

The challenges faced by Canadians to fundamentally shift the energy system are consistent with the global challenges for energy systems to help create a "safe and just space for humanity" [9]. The current realities of Canada's energy system include some positive trends. From the perspective of a safe space for humanity, Canada's total greenhouse gas (GHG) emissions decreased by 8.4% from 2005 to 2021, Canada's per capita emissions have declined from 22.7 t CO_2 eq/capita in 2005 to 17.5 t CO_2 eq/capita in 2021, and the GHG emissions intensity for the entire Canadian economy (GHG per GDP) declined by 29% from 2005 to 2021 [10]. This included notable reductions in coal consumption for electricity production (e.g., the provinces of Alberta and Ontario), and increases in non-emitting sources for electricity production (e.g., solar and wind). From the perspective of a just space for humanity, there are trends towards advancing

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reconciliation with Indigenous Peoples [11,12], improving energy efficiency, and promoting behavioral changes about the use of energy [13].

The current realities of Canada's energy system also include some negative trends. From the perspective of a safe space for humanity, there is uncertainty about whether the government of Canada is likely to meet its science-based 2030 commitment to reduce GHG emissions to 40% below 2005 levels [14]. From the perspective of a just space for humanity, there are unequal distributions of costs and benefits in Canada's existing energy system, including:

- *Cultural genocide is the destruction of those structures and practices that allow the group to continue as a group. […]. In its dealing with Indigenous Peoples, Canada did all these things* [11],
- *Many rural people continue to pay a relatively high price, in their economies, environments, and health, and receive relatively few benefits of lucrative oil, gas, uranium, and hydroelectric sales* [15], *and*
- *6% to 19% of households in Canada are considered energy-poor, which means that people spend more than 10% of their after-tax income on electricity and fuel for their household* [16–18].

If Canada's energy transition is going to succeed, then current positive trends must increase and current negative trends must decrease. It is not possible for any single individual to control a complex system, such as an energy system. However, it is possible to understand the system by consulting with those who work inside the system [19]. The purpose of this research was to identify topics that are relevant to Canada's energy transition and the concepts that energy practitioners use to manage the tensions and trade-offs within these topics. This was achieved by working with energy practitioners to better understand the elements and interconnections of and within Canada's energy system, and to generate useable knowledge that helps shift Canada's energy system towards sustainable development (SD) [20]. The following questions were developed to guide this research:

- Research Question 1: What are important topics in Canada's energy transition?
- Research Question 2: What are underexplored topics in Canada's energy transition?
- Research Question 3: What concepts are energy practitioners using to make progress (i.e., navigate tensions and trade-offs) on important and underexplored topics?

The rest of the paper is organized as follows. Section 2 of this article describes key concepts, including SD and the multi-level perspective. Section 3 describes the material and methods for conducting this research. Section 4 describes the results and discussion of this research, including important and underexplored topics in Canada's energy transition, and the focus group results. Section 5 offers concluding remarks about the research results that indicate combining the concepts of SD and the multi-level perspective is useful for energy practitioners in navigating the tensions and trade-offs in Canada's energy transition, and in generating solutions to complex sustainability challenges.

2. Key Concepts

There are different concepts available to help navigate the uncertainty involved in sustainability transitions, including SD and the multi-level perspective. Both concepts are analytical frameworks that can be applied in specific contexts.

2.1. Sustainable Development

The most popular definition of SD is from the Brundtland Report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [21]. This definition has been inspiring people for 37 years to fulfill its call to action to "promote harmony among human beings and between humanity and nature" [21]. This inspiration has produced countless initiatives in countries around the world, including the establishment of the United Nations Sustainable Development Goals [22] that cover a wide range of topics from ending poverty in all its forms everywhere (Goal 1), ensuring access to affordable, reliable, sustainable, and modern energy for all (Goal 7), reducing inequality within and among countries (Goal 10), and taking urgent action to combat climate change and its impacts (Goal 13).

SD is a broad concept that addresses social, environmental, and economic considerations, and offers three strategies to make progress (i.e., social choice—relying on the values of citizens, political choice—relying on government intervention, and economic choice—relying on market

mechanisms) [23]. SD includes different elements, such as SD approaches, SD goals, and sustainability principles. The three main SD approaches are commonly known as weak sustainability, strong sustainability, and the human development approach [24]. There are SD goals established for different organizations and regions, and the most well-known are the 17 Sustainable Development Goals established by the United Nations [22]. Sustainability principles provide useful guidance for evaluating whether we are moving towards a sustainable society. The most well-known are the following sustainability principles established by the Natural Step [25–27]:

- *nature is not subject to systematically increasing concentrations of substances from the Earth's crust (such as fossil CO_2 and heavy metals),*
- *nature is not subject to systematically increasing concentrations of substances produced by society (such as antibiotics and endocrine disruptors),*
- *nature is not subject to systematically increasing degradation by physical means (such as deforestation and draining of groundwater tables), and*
- *in that society, there are no structural obstacles to people's health, influence, competence, impartiality, and meaning.*

Figure 1 presents an integrated model of SD that links these elements together. Linking these elements builds on their strengths: SD goals describe specific future outcomes that can be measured; SD approaches provide strategies on how to move towards these future outcomes; and sustainability principles are broader than goals and describe the rules of the game (e.g., basic conditions for nature and human needs). SD is a concept that is useful for navigating the energy transition in Canada because it promotes collaboration and dialogue, adopts a systems perspective, and covers social, environmental, and economic considerations [28].

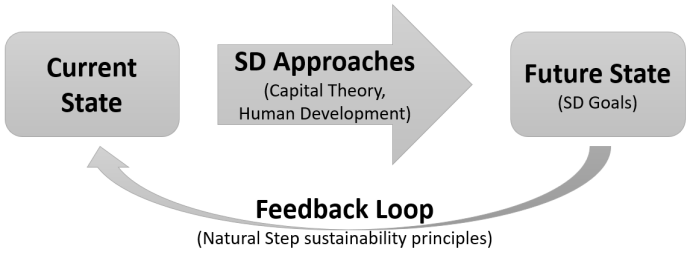


Figure 1. Integrated Model of Sustainable Development. *Source:* [28].

2.2. Multi-level Perspective on Transitions

The multi-level perspective studies how systems change over time as a result of interactions and alignments between the niche, regime, and landscape levels [29]. According to Geels [2], niches are protected spaces that support emerging innovations (e.g., research and development laboratories), the regime is the deep structure that produces stability for an existing system (e.g., practices and associated rules), and the landscape is the wider context (e.g., demographic trends, societal values, political beliefs, and macro-economic patterns). The multi-level perspective is often used to study systems that combine social and technological aspects, including energy systems.

During energy transitions, there will be interactions that influence the behavior of an energy system between elements within a level, and also between elements from different levels. Energy practitioners who are working on energy transitions can use the multi-level perspective to better understand the existing and emerging elements in a system, how these elements interact within a specific level, and how these elements interact between different levels. The ability to shift a system over time depends on changes at all three levels—the niche, the regime, and the landscape [30].

3. Materials and Methods

This section describes the materials and methods used in conducting this research, including a focus group, in-depth interviews, and causal loop analysis.

3.1. Focus Group

The first method used was a focus group comprised of Canadian energy practitioners. Focus groups are commonly understood to occur when a moderator asks questions on a particular topic to a group of participants [31]. One of the major reasons for using focus groups in social science

research is to promote collaboration, for example, by promoting "group interaction to produce data and insight that would be less accessible without the interaction found in a group" [32]. This was exactly the intent (i.e., using group interactions to collectively identify important and underexplored topics in Canada's energy transition). Promoting collaboration is also consistent with the results of previous research that found collaboration and dialogue play a prominent role in energy transitions [28]. This is consistent with the idea of transdisciplinarity, which suggests that research should be problem-oriented, relevant to society, and include collaboration with people from outside of academia [33].

The focus group included 15 Fellows of the Energy Futures Lab (i.e., a diverse group of innovators and influencers that are actively working on the energy transition in Canada). The Energy Futures Lab was selected because it is an ongoing initiative that brings together energy practitioners from across Canada who are actively working on Canada's energy transition. The primary purpose of the focus group was to co-develop a list of underexplored topics in Canada's energy transition. The general structure of the focus group included an overview of Canada's energy system, time for personal reflections, small group discussions, a large group discussion, and then a voting process to identify the top topics. The underexplored topics identified by the focus group included environmental rights in Canada's energy transition, systemic reduction in Canada's energy consumption, and interest in the energy transition in other countries, notably Germany, with whose experience most were familiar (see Section 5 for additional details). The secondary purpose of the focus group was to validate the two most important topics in Canada's energy transition (i.e., those topics that were identified in in-depth interviews with the five members of the design and delivery team of the Energy Futures Lab). The focus group with Fellows of the Energy Futures Lab occurred in 2021.

The analysis of the focus group results included a thematic analysis (i.e., identifying patterns), and an analysis of interactions within the focus group (i.e., identifying areas of strong agreement or disagreement) [34]. The thematic analysis generated a list of underexplored topics, and the analysis of interactions informed the questions for in-depth interviews. The list of underexplored topics was not anticipated [31] and took the research in a different direction.

Ethics Statement

Ethical approval was requested and received from the Royal Roads Office of Research Ethics for conducting the focus group. Consent was obtained from all participants in advance of conducting the focus group.

3.2. In-depth Interviews

The second method used was in-depth interviews. In particular, a question-and-answer exchange was designed to "extract as much information as possible from a person (the interviewee) who has expertise on the topics the interviewer is interested in" [35]. Regarding the identification of the most important topics in Canada's energy transition, five members were interviewed from the design and delivery team of the Energy Futures Lab. These five members were not part of the focus group. These five members were asked semi-structured and open-ended questions about Canada's energy system and energy transition [36]. The in-depth interviews with the design and delivery team of the Energy Futures Lab occurred in 2021. After the design and delivery team identified the two most important topics in Canada's energy transition, these results were validated by the focus group.

The focus group identified the underexplored topics, including learning from the energy transition in other countries, notably, Germany. Potential interviewees were identified by looking for practitioners and academics who were publicly writing on the topic. Snowball sampling was then used to ask initial potential interviewees to nominate other potential interviewees [37]. In the end, seven people were interviewed. Six of the seven interviewees were living in Germany and actively working on energy transitions, and one of them was a German citizen living in Europe who was working on energy transitions. The interview questions were informed by the results of the focus group. There were six interviewees from different organizations in Germany (i.e., one government representative, one industry representative, two representatives from large NGOs, and two representatives from German universities) and one interviewee from a Swedish university. The interviewees had a variety of expertise, including renewable energy, non-renewable

energy, transportation, industry, production, and consumption. The in-depth interviews with practitioners and academics on Germany's energy transition occurred in 2022.

The focus group identified underexplored topics, including environmental rights. Potential interviewees were identified by looking for practitioners and academics who were publicly writing on the topic. There was a much smaller group of people who were actively working on this topic, so it was relatively straight forward to identify practitioners and academics actively working on promoting environmental rights in Canada. Twelve people were contacted as potential interviewees; however, in the end, only two people were willing to be interviewed. Both interviewees were based in Canada with one from a small NGO and the other from a Canadian university. The interview questions were informed by the results of the focus group. These two in-depth interviews occurred in 2023. Given the low number of interviews, interviews were supplemented by analyzing existing interviews on the topic of environmental rights. In particular, the website www.thegreeninterview.com has publicly available four interviews on the topic of environmental rights in Canada with prominent Canadians, including David Boyd and David Suzuki.

For all in-depth interviews, content analysis was used to identify and categorize similar ideas together [37]. This was an iterative process that looked for ideas that were relevant across interviews and also relevant to Canada's energy transition.

Ethics Statement

Ethical approval was requested and received for in-depth interviews from the Royal Roads Office of Research Ethics. Consent was obtained from all participants in advance of conducting these interviews.

3.3. Causal Loop Analysis

The third method used was causal loop analysis, which includes the creation of a causal loop diagram (CLD). This is a method closely associated with thinking in systems. A systems-thinking perspective is complementary to a reductionist-thinking perspective and ideally promotes creativity in system redesign [19]. A CLD is a mental model [38], a simple graphical representation [39], and a cognitive map [40] of a system. The following process was used to create a CLD for Canada's energy system [41]:

- *define the problem,*
- *define the system boundaries,*
- *identify the key elements of the system,*
- *identify the relationships between the key elements of the system,*
- *test the CLD for consistency, and*
- *learn and revise the CLD.*

It was an iterative process with much of the testing, learning, and revising of the CLD being influenced and informed by the results of the focus group and in-depth interviews. The purpose of creating a CLD was to gain greater insights into the elements and interconnections of Canada's energy system. The emphasis in Canada is often limited to the supply side of the energy system so this visual tool is meant to better highlight the relationship between supply and demand.

4. Results and Discussion

4.1. Important Topics in Canada's Energy Transition: Reconciliation and Climate Change

During in-depth interviews in 2021, the members of the design team of the Energy Futures Lab identified climate change and reconciliation with Indigenous Peoples as the two most important topics in Canada's energy transition. During the 2021 focus group, the participating energy practitioners agreed that these are the two most important topics. These two topics are reflected in the portfolio of the work of the Energy Futures Lab and are broadly recognized as topics that are shaping Canada's energy transition.

Reconciliation with Indigenous Peoples in Canada is a process of "establishing and maintaining respectful relationships between Indigenous and non-Indigenous Peoples" [11]. This process can only be successful if the voices of Indigenous Peoples are leading the way in exercising their own right to self-determination [42]. There are simple reasons why reconciliation is important (e.g., it is the right thing to do) and there are deeper reasons (e.g., Indigenous Peoples have inherent rights, Treaty rights, and constitutionally protected rights). For example, the rights of

Indigenous Peoples are protected by Section 35(1) of *The Constitution Act, 1982*, which states: the existing Aboriginal and treaty rights of the Aboriginal peoples of Canada are hereby recognized and affirmed. There are many activities in Canada's energy system that have the potential to impact the rights of Indigenous Peoples. Fortunately, there is a growing area of scholarship investigating the interactions between Indigenous and Treaty rights and the energy system [43–45], including work by Indigenous researchers [46]. As a result, energy practitioners need an awareness of Indigenous Peoples and their rights, the potential impacts of activities on Indigenous Peoples and their rights, and measures to avoid or reduce negative impacts and enhance positive impacts. One of the interviewees stated:

> *We need an energy transition that leaves no one behind. We have embraced the concept of reconciliation (e.g., understanding and integrating different world views) and committed to a continuous practice of learning and unlearning as part of our professional and personal truth and reconciliation journeys.*

There are numerous initiatives in the Energy Futures Lab portfolio that are related to reconciliation (e.g., Indigenous equity participation, Louis Bull First Nation renewable schools project) and climate change (e.g., sustainable aviation fuels, geothermal energy project, financing the transition to future-fit hydrocarbons, rural community resilience in a low-carbon future). These two topics are also reflected in the Energy Future Labs vision for an energy system in 2050 that [47]:

- *leverages Canada's assets and innovation capacity to accelerate an inclusive and equitable transition to a prosperous net-zero future; and*
- *becomes a leader in energy-based partnerships towards reconciliation with Indigenous Peoples in Canada.*

Reconciliation with Indigenous Peoples was identified as one of the two most important topics, but it was not the only equity consideration identified by interviewees. All the interviewees agreed that Canada's energy transition will only be successful if it is inclusive and equitable with special attention to marginalized individuals and communities. This is consistent with the idea that environmental justice, and social justice more broadly, is "a prerequisite for the transformation towards just sustainability" [48].

Climate change is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" [49]. The energy system is often the focal point of climate change discussions but there are interconnections with other systems. These interconnections become more apparent when you look at Canada's GHG emissions by economic sector in 2021: 28% oil and gas, 22% transport, 13% buildings, 11% heavy industry, 10% agriculture, 8% electricity, and 7% waste and others [10]. Progress is necessary in all of the systems for Canada to reach its goal of reducing GHG emissions to 40–45% below 2005 levels by 2030. The government of Canada has established the following key initiatives to help reach this goal: the Pan-Canadian Framework on Clean Growth and Climate Change (2016), Canada's Strengthened Climate Plan (2020), the Canadian Net-Zero Emissions Accountability Act (2021), the Clean Electricity Regulations Frame Document (2022), the Draft Clean Electricity Regulations (2023), and the Regulatory Framework for an Oil and Gas Sector Greenhouse Gas Emissions Cap (2023). In addition to these key initiatives, there is a wide range of initiatives on climate change from provincial, municipal, and Indigenous governments, as well as individual citizens.

Progress is currently being made in Canada on these two topics, and much more work will need to be done to advance reconciliation and renew the relationship with Indigenous Peoples [11,12], and to achieve net-zero emissions by 2050 [10,50]. The efforts of the Energy Futures Lab on these two topics are guided by SD and the multi-level perspective. The interviewees from the Energy Futures Lab stated that the concepts of SD and multi-level perspective are not only relevant but indispensable in their efforts to shape Canada's energy transition. For example, the multi-level perspective and SD, including the Natural Step sustainability principles, are used to identify and prioritize issues, create opportunities for collaboration, and generate and strengthen solutions. The Energy Futures Lab explores solutions at the niche, regime, and landscape levels.

4.2. Focus Group Results

As mentioned earlier, the primary purpose of the focus group was to co-develop a list of the most significant underexplored topics in Canada's energy transition. The focus group identified the following important, yet underexplored topics in Canada's energy transition (in order of priority as voted by the focus group participants):

1. systematic changes to energy consumption in Canada,
2. environmental rights in Canada,
3. lessons from Germany's energy transition,
4. system-change and technology-change to address point source and distributed emissions,
5. sustainable finance mechanisms,
6. social movements and civil disobedience,
7. provincial and federal regulatory frameworks in Canada for the energy transition,
8. expansion of the carbon market,
9. progress in the transportation system,
10. carbon, capture, utilization, and storage, and
11. environmental racism in Canada.

As a result of the input from the focus group, this research took a closer look at the top three underexplored topics: systemic reduction in Canada's energy consumption, environmental rights in Canada's energy transition, and Germany's energy transition. The inclusion of Germany's energy transition was treated as a comparative case study with the hope of identifying best practices and warnings from the German experience that are applicable to Canada's energy transition.

4.3. Underexplored Topic: Systemic Change to Energy Consumption in Canada

Reducing energy consumption is often presented as a simple solution to protect the planet and save everyone's money. During the energy crisis of the 1970s, the idea of reducing energy consumption was largely focused on energy conservation (i.e., not using energy) [51]. In more recent times, the idea of reducing energy consumption is largely focused on energy efficiency (e.g., using less energy to accomplish the same amount of useful work) and demand response (e.g., shifting peak energy demand), which can be accomplished with incentive-based, market-based, and price-based programs [52]. This recent focus on energy efficiency and demand response is similar to the broader (i.e., beyond the energy system) reliance on efficiency gains to reduce the environmental and social impacts of consumption [53].

There are concerns about this shift towards efficiency and demand response, including the rebound effect (e.g., "*energy services have positive cost elasticity, so that increases in energy efficiency lead to reduced cost of energy services, which lead in turn to higher demand for these energy services*") and the Jevons paradox (e.g., "*higher efficiency means higher productivity, the latter an economic stimulant that produces growth and thus promotes energy consumption*") [54,55]. The Jevons paradox is frequently discussed in environmental economics and is based on observations in England in the 19th century about the relationship between increased efficiency in coal use and increased consumption of coal across the economy [56].

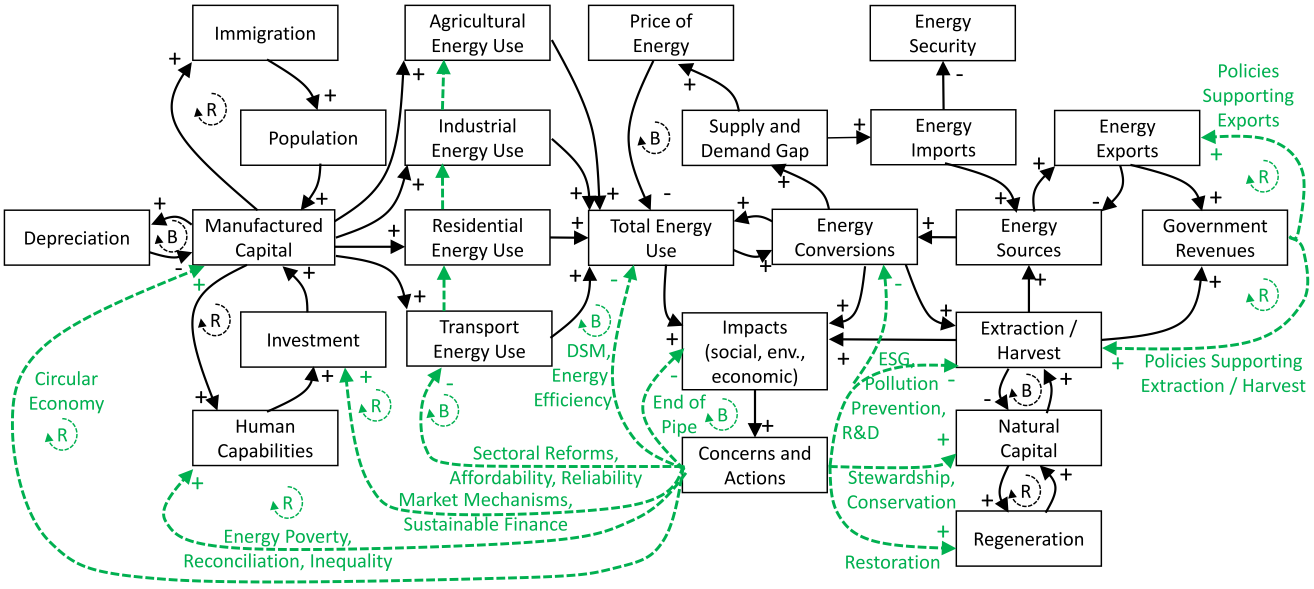
Reducing energy consumption is considered a challenge because of the close relationship between energy consumption and economic growth [51]. This trend is consistent across developing countries; however, there are examples from North America and Europe where they have been able to decouple energy consumption and economic growth on a per capita basis [57], including Canada [58].

There are additional challenges in reducing energy consumption for countries, such as Canada, that are net exporters of energy. Canada exported approximately 60% of the energy that it produced in 2019 (e.g., 8552 PJ of oil exports, 2705 of gas exports, 953 PJ of oil product exports, 866 PJ of coal exports, 217 PJ of electricity exports, 59 PJ of biofuels and waste exports) [59]. There are significant global GHG emissions associated with exporting this amount of energy. Canada consumes a significant amount of energy to produce the energy that it exports; however, reducing energy consumption by reducing energy exports has implications for providing affordable, reliable, sustainable, and modern energy for all. Developing countries require extensive support to develop cleaner and renewable energy [60]. Canada will need to carefully consider its obligations to other countries, particularly developing countries, in terms of providing energy exports.

Results and Discussion

Reducing energy consumption in Canada requires an appreciation of the key elements of the energy system and the interconnections between the key elements. As discussed in Section 3, a causal loop analysis was conducted, including the creation of a CLD to illustrate Canada's energy

system (see Figure 2). The creation of the CLD was based on input from the in-depth interviews with the design and delivery team of the Energy Futures Lab. The black arrows indicate a relationship between two elements in the energy system. The green arrows indicated a potential relationship between the two elements. The positive or negative signs associated with each arrow indicate the direction of causality between elements. For example, a positive sign is a positive causality (e.g., the positive sign between "energy conversions" and "impacts" means that more "energy conversions" causes more "impacts", or alternatively, less "energy conversions" causes less "impacts") and a negative sign is a negative causality (e.g., the negative between "price of energy" and "total energy use" means that more "price of energy" causes less "total energy use", or alternatively, less "price of energy" causes more "total energy use"). The CLD also illustrates reinforcing loops (i.e., where change in one direction is combined with more change in the same direction) and balancing loops (i.e., where change in one direction is combined with change in the opposite direction).



Legend

⟶	Cause-effect Relationship	+	Positive Causality (more of this = more of that)	B	Balancing Loop (negative feedback loop)
⇢	Potential Cause-effect Relationship (dependent on decisions)	-	Negative Causality (more of this = less of that)	R	Reinforcing Loop (positive feedback loop)

Figure 2. CLD of Canada's Energy System. *Source:* Created by the author.

The purpose of creating a CLD of Canada's energy system is to illustrate the challenge of reducing energy consumption. In particular, total energy use is not an independent element. Total energy use depends directly on (and has a positive relationship with) residential, industrial, transportation, and agricultural energy use. The ability to reduce total energy consumption depends on decisions within the residential, industrial, transportation, and agricultural systems on how to pursue strategies of energy conservation, energy efficiency, and demand response.

The interviewees stated that the energy transition in Canada is composed of many energy transitions. Different regions are experiencing different energy transitions, and each region needs to find its own path forward. Also, different systems (i.e., residential, industrial, transportation, and agricultural systems) are experiencing different energy transitions, and each system needs to find its own path forward. The interviewees also stated that different regions and different systems will be affected differently by climate change. Unpredictable and extreme weather patterns (e.g., flooding, drought, heat waves, polar vortex) will make it more challenging for regions and systems to find their paths forward.

The CLD makes the interconnections between different elements in the energy system visually clear. Different regions and different systems can learn from other energy transitions but ultimately each energy transition will have to develop its own solutions. If these solutions do not

create better or cheaper forms of energy, within the regional context, history has shown that people are reluctant to make the change [15].

The CLD is useful at illustrating certain aspects of the energy system, but it also fails to show other aspects, in particular, existing systemic injustices. A lack of awareness of existing systemic injustices can unintentionally reinforce existing challenges or create new challenges for marginalized communities in energy transitions [61]. Special attention should be given to each of the elements within Figure 1, including the residential, industrial, transport, and agricultural systems, to understand and address issues of equity, fairness, and justice [62]. This can only be done successfully if energy practitioners are willing to collaborate with marginalized communities.

4.4. Underexplored Topic: Environmental Rights and Canada's Energy Transition

There is a saying that "rights emerge and evolve in response to wrongs" [63]. Some of the wrongs that are influencing the global debate about environmental rights are the findings that six out of nine planetary boundaries are beyond the safe operating space for humanity [64]. One of the wrongs that is influencing the debate about environmental rights in Canada is the estimate that 15,300 premature deaths per year in Canada are caused by above-background level air pollution [65].

Environmental rights can be framed in different ways. At one end of the spectrum are human-centered environmental rights (e.g., the right for humans to have a safe and adequate environment), in the middle is a combination of rights (e.g., the right to a healthy and ecologically balanced environment), and at the other end of the spectrum are inherent rights for nature [66]. Even though recent interest in environmental rights is often attributed to the 1972 article "Should Trees Have Standing?" [67], which focused on the inherent rights of nature, discussions about environmental rights in Canada tend towards the other end of the spectrum (i.e., closer towards human-centered environmental rights). Environmental rights include procedural rights (e.g., access to information, meaningful participation in environmental decision-making, access to effective remedies) and substantive rights (e.g., protecting the environment) [68]. There are many reasons for establishing environmental rights, including [63]:

- *reducing the harm suffered by sentient animals,*
- *stopping human-caused species extinction, and*
- *protecting the planet's life support systems*.

At the international level, the Stockholm Declaration in 1972 was the first formal declaration about the right for people to live in a healthy environment and the corresponding responsibility for people to protect the environment [63]. Today, more than 150 different countries have adopted legal recognition of the right to a healthy environment [69] as one of their tools to address environmental challenges. Many of these countries demonstrate that establishing the right to a healthy environment is an integral part of economic progress. Boyd [63] stated:

> *What the Scandinavian countries have done is shown that there's a myth about this trade-off between environmental protection and economic competitiveness and that what really happens is that when you pass stronger environmental laws and policies, that stimulates innovation. It stimulates creativity, it stimulates ingenuity, and it creates a virtuous circle where those countries are then attracting more investment, attracting a higher caliber of people to their countries, and their health-care costs go down.*

In addition to the progress made by individual countries, the General Assembly of the United Nations [70] recently adopted a resolution that:

- *Recognizes the right to a clean, healthy, and sustainable environment as a human right; and*
- *Calls upon States, international organizations, business enterprises and other relevant stakeholders to adopt policies, to enhance international cooperation, strengthen capacity-building, and continue to share good practices in order to scale up efforts to ensure a clean, healthy, and sustainable environment for all.*

At the national level, environmental rights and responsibilities have long been key considerations within the cultures and legal traditions of Indigenous Peoples [71]. Today, there are different options for Canada to recognize environmental rights, including amending the *Constitution Act, 1982* (which according to many may not be a simple task, e.g., [72]), pursuing recognition in federal statutes (e.g., the draft text of Bill S-5 to amend the *Canadian Environmental Protection Act* recognizes that every individual in Canada has a right to a healthy environment [73]), and

continuing to pursue recognition in provincial statutes (which has already been accomplished in the *Quebec Environment Quality Act*, *Ontario Environmental Bill of Rights*, *Yukon Environment Act*, and *Northwest Territories Environmental Rights Act*). Regarding constitutional reform, this could be accomplished by a direct amendment to the *Constitution Act, 1982*, by court decisions (e.g., cases arguing that there is an implicit right to a health environment in Section 7 of the Canadian Charter of Rights and Freedoms), or by a judicial reference question to the Supreme Court [63]. Advancing environmental rights is one tool to protect the environment by encouraging non-regression for environmental standards [74], and challenging "anthropocentric and ethnocentric worldviews of humans' relationship to nature" [75].

Results and Discussion

All interviewees agreed there was a clear distinction between the right to a healthy environment and the inherent rights of nature. The right to a healthy environment emerged as a concept in the 1980s and it has relatively quickly been accepted into legal systems around the world. The momentum of this movement will likely continue to grow with the July 2022 resolution by the United Nations General Assembly. Interviewees felt that this initial resolution and the growing momentum would eventually lead to the creation of a legally binding international convention for the right to a healthy environment.

In parallel to this anticipated international development, possibilities were discussed during the interviews for Canada to establish the right to a healthy environment, including constitutional reform, provincial legislation, and common law decisions. The interviewees acknowledged the value of having environmental rights embedded in the *Constitution Acts, 1867 to 1982*, which is the supreme law of Canada. However, they were skeptical about the ability to make constitutional reforms due to the political challenges associated with making substantive changes to the *Constitution Acts, 1867 to 1982*. The interviewees were more optimistic about making changes at the provincial level, including strengthening existing provincial legislation (e.g., amendments to the existing *Ontario Environmental Bill of Rights* and *Quebec Environment Quality Act*) and creating new provincial legislation (e.g., the *Draft Environmental Bill of Rights for Alberta* [76]). Any changes at the provincial will take time because the changes should incorporate values and perspectives from Indigenous and non-Indigenous Peoples. One interviewee stated:

> *Any time you are looking to make changes in a system, it is important to understand the views of citizens and align with these views. Advancing the idea of environmental rights is a big shift in the system and a big shift requires a multi-year campaign that builds a supporting coalition that includes politicians and civil society.*

Interviewees suggested that the right to a healthy environment could potentially be a very powerful tool for protecting nature. If the right to a healthy environment is properly planned, robustly implemented, and proactively managed, then much progress is possible in this area. One of the advantages identified is that a right to a healthy environment is a more realistic option (compared to the rights of nature). It fits within existing societal structures and would be comparatively easy to implement. One of the disadvantages of the right to a healthy environment is that people must wait for something to happen before they can respond (i.e., it is a reactive tool). The natural environment must typically be damaged before anyone can assert the right to a healthy environment, attempt to prove that there has been an infringement of this right trigger, and establish protections for nature.

The idea of inherent rights of nature emerged in the 2000s and took a big leap forward in 2008 when Ecuador established the rights of nature in its constitution. This was the first country in the world to constitutionally codify the rights of nature. Chapter 7 of the Constitution of the Republic of Ecuador addresses the rights of nature, including Article 71 that states [77]:

- *Nature, or Pacha Mama, where life is reproduced and occurs, has the right to integral respect for its existence and for the maintenance and regeneration of its life cycles, structure, functions, and evolutionary processes.*
- *All persons, communities, peoples, and nations can call upon public authorities to enforce the rights of nature. To enforce and interpret these rights, the principles set forth in the Constitution shall be observed, as appropriate.*
- *The State shall give incentives to natural persons and legal entities and to communities to protect nature and to promote respect for all the elements comprising an ecosystem.*

The interviewees stated that there was much less momentum in Canada and internationally for advancing the rights of nature (vs. the right to a healthy environment) because establishing the inherent rights of nature is not well aligned with the existing liberal democratic free-trade paradigm of western nations. The Magpie River resolutions in 2021 [78,79] were the first legal recognition of the rights of nature in Canadian law. To be more precise, they were the first recognition in non-Indigenous Canadian law. Indigenous law in Canada has a long-standing tradition of recognizing the rights of nature and sentient beings. One of the advantages of the rights of nature is that people must think deeply about our relationship with nature. When you take a non-anthropocentric view of relationships between humans, other species, and our surroundings, then you challenge the foundation of our existing paradigm and invoke new paradigms. One of the disadvantages is the uncertainty of operationalizing the rights of nature (e.g., Canada would likely require new governance processes and institutions for making decisions).

All interviewees stated that there is likely some complementarity between environmental rights and progress on climate change and reconciliation with Indigenous Peoples. However, the devil is in the details. For example, caution should be taken to make sure that the creation of environmental rights does not infringe or erode the rights of Indigenous Peoples.

The interviewees stated we need all hands on deck. This includes people pushing boundaries and campaigning for the rights to a healthy environment, for the rights of nature, and for the corresponding responsibilities. Better-defined rights and responsibilities are anticipated to enhance environmental protection and other broad benefits for Canada. One interviewee stated:

> *The creation of additional rights tends to be democracy-enhancing. Placing limits on majoritarian government action allows for the protection of minorities and those without a voice, like nature, from the changing whims of the political majority. There is a role for the judiciary in holding the elected politicians accountable to fundamental rights, and there is a role for elected politicians.*

Efforts should be made to strengthen existing public participation initiatives (e.g., access to information, meaningful participation in environmental decision-making, access to effective remedies), as well as create new public participation initiatives (e.g., obtaining free, prior, and informed consent from Indigenous Peoples, requiring equity ownership for Indigenous Peoples in projects, requiring equity ownership by local communities). Enabling people to meaningfully participate in the energy transition will go a long way to ensure that there is broad public support. And given that Canada's energy transition is likely going to require much more public infrastructure to be built, this broad public support will be essential.

Overall, the interviewees left the impression that environmental rights are important because they are a tool to establish deep respect for nature and other sentient beings, and they foster an appreciation of the interconnectedness between humans and the natural environment. This is true when talking about the right to a healthy environment and the inherent rights of nature. This is consistent with the perspective of Suzuki [80] who stated "the real challenge is to look at our relationship with the Earth. […] So, if you're talking about a healthy environment, you've got to talk about the protection of the air and the water. That's absolutely critical".

4.5. Underexplored Topic: Insights from Germany's Energy Transition

Germany is considered to be a global leader in terms of modern energy transitions. Germany's modern energy transition is widely considered to have started in the 1970s with the anti-nuclear energy movement and the oil shocks of 1973 and 1979 and advanced with the 1986 accident at the Chernobyl nuclear power plant [81]. The transition was formalized at the political level in 1998 with a commitment from the Social Democrats and the Greens to pursue a future-oriented energy supply (e.g., improve energy efficiency, increase the supply of renewable energy, eliminate the supply of nuclear energy). The German Renewable Energy Sources Act (EEG) was introduced in 2000, the feed-in-tariff was raised in 2004, and a billion-dollar global market was created for solar panels [82]. The energy transition was widely embraced as a collective societal effort after the 2011 Fukushima accident [83].

The Germany energy balance in 2020 was 13,025 PJ of production and imports, including 8980 PJ of energy imports mostly comprised of oil, oil products, and gas [84]. This means that Germany remains a significant global energy importer. On the consumption side of the equation, the total final energy consumption in Germany in 2020 was 8953 PJ (i.e., 39% residential and commercial, 25% industry, 24% transport, 10% non-energy use, and 2% agriculture and

forestry) [84]. The statistics about the Germany energy balance do not fully capture the progress that has been made on the energy transition, to illustrate:

- in 2021, primary energy consumption in Germany was 15% lower than 2008 levels, with a goal to reach 20% by 2030 (compared to 2008 levels) [85];
- in 2021, 41% of German power consumption was generated by renewable resources (i.e., wind, solar, biomass, and hydro energy), with a goal to reach 80% by 2030 [85];
- in 2021, more than 40% of installed renewable power capacity was owned by private individuals and farmers [82];
- a goal of a complete coal phase-out by 2038 [85];
- a goal of carbon neutrality by 2045 [85]; and
- in 2021, greenhouse gas emissions declined by 39% since 1990 levels, with a goal to reach 65% by 2030 (compared to 1990 levels) [86].

The German energy transition is now in its second phase, which requires actors to reconsider their strategies to overcome new and distinct challenges such as stabilizing, restructuring, and integrating energy systems [87,88]. This includes participatory strategies, which played an important role in the initial phase of the energy transition but may need to be formally embedded in the second phase to deliver energy democracy [89].

Results and Discussion

The in-depth interviews revealed interesting insights about Germany's energy transition. This section highlights six observations that are relevant to Canada's energy transition. These observations may seem obvious to some; however, they have not been well articulated in the literature and therefore are important to mention. These observations capture best practices and warnings from the German experience that provide potentially valuable insights for energy practitioners in Canada. The reader is reminded that these are "potentially" valuable insights because of the research limitations that arise when comparing two distinct countries with very different energy systems that are at different points in their energy transitions. One interviewee stated (and nicely articulated an overarching theme from the interviews):

> *I have visited a German coal power plant, observed the huge inputs of coal and chemicals, and observed outputs like air pollution, coal ash, and synthetic gypsum. My experience made me think that this is not something that should still be happening in Germany in the 20th century. We can solve these problems. We should be able to do better.*

Observation 1: There are different phases in energy transitions. All interviewees agreed that the German energy transition is moving into a new phase. The initial phase was focused on increasing the amount of renewable energy generated within the electricity sector, which is largely considered to be a success. However, interviewees were hopeful that this was the first step and not the last step in the transition. The second phase of the German energy transition is focused on integrating ever-increasing levels of renewable energy into the electricity sector, as well as overcoming disruptions to interconnected systems (e.g., residential, industrial, and transportation systems) associated with increased electrification and lower GHG emissions. These disruptions include expanding energy efficiency efforts, shifting heating in residential buildings from natural gas to electricity, increasing electric and hydrogen-powered personal and commercial vehicles, and creating new industrial production processes for cement, steel, and chemicals. It will be an iterative process because of the interconnections and the reality that different systems will be affected differently.

Several interviewees indicated that the solutions created by government, industry, and civil society to successfully move the energy transition through the initial phase, may not necessarily be the solutions that are required for the second phase. It is important for all actors to recognize changing conditions and to respond appropriately. For example, the interviewees acknowledged that, during the initial phase of the energy transition, the government played a leadership role (e.g., established a policy agenda to support renewables, phase-out nuclear energy, and promote energy efficiency) while the industry was a laggard-focused on protecting their own corporate interests. However, several interviewees highlighted recent examples where the government is responsible for limiting progress (e.g., the slow roll-out of smart meters, minimum distances for

wind turbines, and solar support cap) and suggested that industry may have a more constructive role to play in the second phase. One interviewee stated:

> *During the initial phase of the energy transition, energy utilities and industry were largely considered to be the bad guys. However, given appropriate long-term policy signals from the government and significant cultural shifts within businesses, industry has emerged as a pragmatic actor that is capable of developing innovative and entrepreneurial solutions for the German energy transition.*

Observation 2: Actions matter in energy transitions. All interviewees agreed it is important to take concrete actions that move the energy transition forward and suggested that perfection should not be the enemy of good. The common example provided is the decision to start the energy transition by increasing the amount of renewable energy in the electricity system. Would it have been better to start with the transportation or residential systems? Would it have been better to start with a coal phase-out or a nuclear phase-out? Several interviewees stated that many Germans have an irrational fear of nuclear energy and that coal should have been the first energy source to be phased out based on GHG emissions and human health. However, all interviewees agreed that it was more important to start making progress, rather than debating endlessly about where to start. Several of the interviewees stated that the initial steps in the German energy transition were key moments in the global energy transition because it created a market for solar panels and continued to lower the cost of producing electricity from solar panels. One of the missed opportunities was a failure to support the domestic production of solar panels in Germany, which led to China taking over the manufacturing of these solar panels. One interviewee stated:

> *On the positive side, the billions of dollars that Germany has invested into renewable energy across global energy systems has helped around the world. This type of significant investment has probably shaved a couple of years off the global energy transition.*

Interviewees stated the same mentality for taking action should hold for the second phase of the energy transition. There is a danger of complacency that comes with success so additional actions need to be explored and implemented in the second phase (e.g., residential heating system, transportation system, heavy industry). One interviewee gave a positive example of changes to section 45 of the German Road Traffic Regulations, which allows for experiments that give priority to pedestrians and cyclists on roads. One interviewee stated:

> *There are many ideas that should be explored in a transition, including nudging (e.g., clear price signals for behaviors), developing intrinsic motivations (e.g., education and empowerment), and structural transformations (e.g., policy frameworks). By properly exploring these ideas, then we can be ready to make progress when opportunities arise.*

Observation 3: Regional differences are important in energy transitions. All interviewees agreed that there is broad, long-term support for the energy transition, but challenges arise because of regional differences in the production and consumption of energy. The common example provided is the increased electricity production from wind turbines in the north, high levels of electricity consumption in the south by heavy industry, and limited long-distance electricity transmission lines between the two regions. The current electricity connections are not able to handle the electricity on windy days, which results in up to 50% of turbines being turned off, even though the owners of the turbines are being compensated by the government. Interviewees stated that these regional differences must be understood and addressed in an energy transition instead of imposing a single solution on all regions of Germany. As a result, a unifying long-term vision can be a powerful tool, but it must also be flexible enough to accommodate regional nuances in the production and consumption of energy.

One of the interviewees highlighted how regional differences affect Germany's planned coal phase-out. Many of the lignite mines are located in historic coal mining regions in former East Germany where coal played a central part in their development. These regions continue to be economically disadvantaged (e.g., higher levels of unemployment, and lower income levels) compared to former West Germany despite the significant transfer of wealth to these regions since reunification in 1990. Today, there are concerns about how the coal phase-out will affect the social and economic well-being of people in these regions. The interviewee highlighted a potential relationship between the coal phase-out and the rise of anti-immigrant, anti-climate, and anti-elite perspectives in these regions. These perspectives have the potential to undermine not

only the energy transition, but the stability of the German liberal democracy if these regional concerns are not given special care and consideration. One interviewee stated:

> *The coal phase-out should not be viewed as a simple technical change to the production of energy in Germany. You need to think about it more broadly as influencing the SD of a society, and regions within that society, that produce and consume energy.*

Observation 4: Equity considerations are important in energy transitions. All interviewees agreed that it is important to pay attention to the distribution of benefits and burdens during energy transitions. There should be a never-ending search for fairness between those positively and negatively affected by the energy transition. One interviewee provided a positive policy example from neighboring Denmark where all new wind farms must be a minimum of 20% owned by local communities to ensure opportunities for local economic participation. Another interviewee provided a negative example from Germany:

> *From an affordability perspective, the energy transition has been a catastrophe because Germany has the highest residential electricity prices in all of Europe, but this is not the case for heavy industry. This unequal distribution of costs is not fair. This gives us some insight into who the energy transition is really for, and who the energy transition actually benefits.*

Several interviewees highlighted the importance of social justice and addressing the most vulnerable people in the energy transition. The energy transition should pay attention to who is being left behind. One interviewee stated that energy poverty has not yet been adequately addressed in Germany, which has been used to undermine progress on the energy transition (e.g., narratives that challenge the legitimacy of the energy transition by highlighting the increased cost to the most vulnerable members of society). During disruptions to the energy transition caused by the COVID pandemic and the Russian invasion of Ukraine, there have been signs that the German government is paying attention to equity considerations by providing subsidies for residential energy costs and public transportation, and potentially asking for energy rationing from heavy industry. It is unclear whether this short-term focus will continue.

Observation 5: Public participation is important in energy transitions. All interviewees agreed that public participation is important in the German energy transition (e.g., established the initial social movements in the 1970s, maintained broad societal acceptance for the energy transition, and resulted in a significant share of wind and solar generation being owned by citizens and farmers). Interviewees highlighted several reasons why public participation will continue to be important in the second phase, including the role of individual citizen behavior within different systems (e.g., the transportation system, the residential heating system) and the necessity to construct and operate additional supply-side energy infrastructure in a densely populated country. Public participation in the second phase is likely to look different than the initial phase but many principles of public participation should continue (e.g., strengthening local decision-making, supporting decentralized energy initiatives, establishing prosumers that allow citizens to both produce and consumer energy, offering opportunities for collective ownership). One interviewee stated:

> *Don't forget about the citizens! If you want to have a successful energy transition, then make sure that there is support from citizens and that they can meaningfully participate.*

Observation 6: Energy security is important in energy transitions. All interviewees agreed that it is important to pay attention to energy security during energy transitions. The 2022 invasion of Ukraine by Russia has significantly impacted the global energy landscape as well as the German energy transition. For example, interviewees stated that Germany's decision to stop all energy imports from Russia, including natural gas imports by 2024, has created major disruptions (e.g., concerns about the availability of natural gas during winter led to extending the lifespan of three nuclear plants into 2023, delaying the closure of coal plants, constructing floating liquefied natural gas (LNG) terminals, exploring rationing for industry, requesting citizens to reduce natural gas consumption, and providing subsidies to citizens to offset the high cost of natural gas). These disruptions were caused primarily by a lack of energy security and added a layer of complication to the already challenging second phase of the German energy transition (e.g., increasing renewable power to 80% of the electricity generation mix by 2030, reducing GHG emissions by 65% from 1990 levels by 2030, and decarbonizing the transportation, residential,

industrial, and agricultural systems). Some interviewees speculated that the failure to address Germany's lack of energy security was related to an irresistible desire for affordable energy, and misplaced optimism that trade with Russia could promote peace.

Some interviewees stated that these disruptions should lead to conversations about the fundamentals of the energy transition and German society. The lack of energy security could be considered an example of actors failing to critically search for solutions to narrow technical problems and broad societal problems. For example, one interviewee stated:

> *The energy transition in Germany is currently aligned with the mistaken belief in the possibility of infinite economic growth; therefore, there are some deeper questions that need to be asked. We need to better understand the relationship between energy systems and our ecological footprint, planetary boundaries, a circular economy, and our consumption-based society.*

4.6. General Discussion

SD is a normative concept that includes different approaches, strategies, principles, and goals. The multi-level perspective is also a normative concept that examines innovations and interactions at different levels; however, the underlying values of what is good or desirable are not always explicit. When these two concepts are used together, interviewees suggested that this generates greater insights into and understanding of Canada's energy transition. There is growing support in academic literature to intentionally combine complementary concepts in order to understand complex challenges [30]. However, few published articles combine a deep understanding of these two specific concepts (e.g., a deep understanding of SD might consider the three main SD approaches, the 17 SD goals, and the four Natural Step sustainability principles). The normative nature of the concepts allows sufficient flexibility for different energy transitions to happen in different countries (e.g., similarities include both Germany and Canada committing to increasing their renewable energy production, differences include Germany prioritizing the removal of nuclear energy from its electricity mix, with Canada prioritizing the removal of coal from its electricity mix). Even though different energy transitions are subject to different tensions and trade-offs, the Natural Step sustainability principles can be an effective feedback mechanism to navigate these challenges and move towards an affordable, reliable, sustainable, and modern energy system [22].

With regard to environmental rights, the right to a healthy environment could be considered a niche innovation that might compel the regime to adjust. Codifying the rights of nature could shift the existing landscape, which might create an opening for other niche innovations. Even though it is unlikely that the rights of nature will be codified in Canada in the near future, the discussion itself could play an important role in advancing the right to a healthy environment. In the future, there might be developments for the rights of nature to more forward, such as establishing rights for species that are endangered (as opposed to creating rights for all species), and appropriately integrating artificial intelligence into decision-making processes for managing natural resources.

The relationship between environmental rights and SD is perhaps not obvious at first glance, but there is one. Human-centered environmental rights (e.g., the right for humans to have a safe and adequate environment) are aligned with capital theory approaches of SD that seek to preserve either substitutable natural capital [90] or complementary natural capital [91] in order to leave future generations with a "generalized capacity to create well-being" [92]. Advocates for advancing human-centered environmental rights may learn from the experiences of scholars and practitioners focused on capital theory. Conversely, inherent rights for nature are aligned with the human development approach of SD. The main strategy within this approach is social choice, which is a process of identifying preferences by "ranking different states of affairs from a 'social point of view', in the light of the assessments of the people involved" [93]. Preferences do not need to be linked directly to a capacity to create well-being. Preferences can be related to values, such as the inherent rights for species to exist and ensuring that future generations have the same freedom to experience these species. Given the important role of public participation in shaping individual and collective preferences [94], this highlights the importance of an informed public [69] and public education about sustainability [72]. According to Sen [95]:

> *Sustaining living standards is not the same thing as sustaining people's freedom to have—or safeguard—what they value and to which they have reason to attach importance. Our reason for valuing particular opportunities need not always lie in their contribution to our living standards.*

The concept of SD can also be useful in the systemic reduction of Canada's energy consumption. Understanding the roles of energy conservation, energy efficiency, and demand response is an important part of sustainable development. It is true that we need to reduce certain types of energy consumption, for example, wasteful consumption of energy, inefficient consumption of energy, and consumption of energy that contributes to the systematic increase of: concentrations of substances from the Earth's crust (such as CO_2 and heavy metals); concentrations of substances produced by society (such as plastics); and degradation by physical means (such as deforestation). However, at the same time, it is also true that we need to increase certain types of energy consumption, for example, energy consumption that removes structural obstacles to people's health, influence, competence, impartiality, and meaning. This more nuanced understanding of energy consumption can be guided by the Natural Step sustainability principles [25–27]. This could mean that within an energy transition, energy efficiency might be more appropriate to address elements of the energy system that remove structural obstacles to health, whereas energy conservation might be more appropriate to address elements of the energy system that increase concentrations of substances from the earth's crust. When elements of the energy system do not adhere to all sustainability principles, then careful consideration should be given to the intended and unintended consequences, tensions, and trade-offs.

A better understanding of unsustainable patterns of consumption is important; however, the goal should not be to maximize sustainable consumption. If the overarching objective is to reduce energy consumption, then the nuance between positive and negative types of energy consumption will be lost. For this reason, this research suggests that it is not appropriate to use systemic reduction of consumption as an organizing objective for energy transitions. Maximizing SD [96] is a more suitable overarching objective for energy systems, and it should guide Canada's energy transition and the global energy transition.

At a more practical level, this research suggests that the energy transition in Canada is not just about Canada. There were national and global benefits from Germany investing heavily in the development of renewable energy technology. This investment helped establish a global market for solar panels that consequently quickened the global energy transition. There may be national and global benefits from Canada investing in different areas of the energy transition such as reconciliation with Indigenous Peoples, nature-based solutions, hydrogen production, small modular nuclear reactors, and carbon capture, utilization, and storage, including direct air capture.

This research suggests that the energy transition in Canada needs to address equity considerations. There were tensions in Germany resulting from the high cost of energy for residential consumers, the low cost of energy for industrial users, energy poverty, and the disproportionate effects of the coal phase-out on different regions of Germany. These tensions have been used by different actors to undermine the energy transition and challenge the stability of Germany's liberal democracy. These tensions also exist in Canada. The Canadian carbon pricing policy includes a commitment to remain revenue neutral, which is similar to the original commitment in the province of British Columbia (BC) carbon pricing policy when it was introduced in 2008; however, the BC commitment to revenue neutrality has since been dropped [97]. The Canadian Output-Based Pricing System Regulations in the *Greenhouse Gas Pollution Pricing Act* are designed to provide a price incentive for industrial emitters to lower greenhouse gas emissions while maintaining competitiveness and protecting against carbon leakage. Energy poverty in Canada remains a significant challenge that requires additional attention [18]. Concerns about Canadian federalism and provincial autonomy are raised by provinces, including Alberta, Ontario, and Saskatchewan, when actions taken by the government of Canada are not perceived to be aligned with provincial interests. These tensions cannot be addressed by simple technical solutions within energy transitions but require deeper philosophical deliberations that include equity considerations about justice, fairness, and the distribution of benefits and burdens. Addressing these tensions within energy transitions could strengthen federal unity and Canada's liberal democracy.

The integrated model of SD is useful to highlight equity considerations as an essential part of Canada's energy transition. The United Nations Sustainable Development Goals require due consideration of poverty, good health and well-being, gender equality, reduced inequalities, peace, justice, and strong institutions [22]. The Natural Step sustainability principles require due consideration of structural obstacles to people's health, influence, competence, impartiality, and meaning [26]. The SD approaches require consideration of inter and intragenerational equity, and the human development approach in particular embraces a comparative theory of justice to

reduce injustice and advance justice [93]. A comparative theory of justice looks at the practical implications of societal change based on reasoning and a broad informational foundation, which includes information from feminist, anti-racist, Indigenous, and postcolonial perspectives [61]. Highlighting equity considerations is an essential part of an inclusive and equitable energy transition. Energy practitioners must hear directly from equity-seeking individuals and communities, and meaningfully integrate these perspectives into the energy system.

This research also suggests that the energy transition in Canada needs to avoid complacency and embrace criticism. The interviewees expressed concerns about complacency in the German energy transition, which translates into a lack of urgency to make progress on the second phase of the energy transition and maintain their status as a global leader. This risk exists within regions of Canada that are currently generating a high percentage of their electricity from hydroelectric generation (e.g., British Columbia, Manitoba, and Quebec). It would be a lost opportunity if these regions that are leaders in electricity generation were unmotivated to address challenges in their other systems (i.e., residential, industrial, agriculture, and transport systems). These regions may be reticent to initiate the second phase of their own energy transition until other regions of Canada have completed the initial phase of their own energy transition. The interviewees also expressed concerns about the inclusiveness of the second phase of the energy transition in Germany. The disruptions to the energy system will have both narrow technical implications and broader societal ripples across interconnected systems (i.e., residential, industrial, transportation, and agricultural systems). The debate about Canada's energy transition is often polarizing (e.g., right vs. wrong, us vs. them) and has the potential to exclude people, intentionally or unintentionally, from the conversation. The challenges inherent in energy transitions are complex and this requires as many perspectives as possible to develop practical solutions.

> *Problems are inevitable because our knowledge will always be infinitely far from complete. Some problems are hard, but it is a mistake to confuse hard problems with problems unlikely to be solved. Problems are soluble, and each particular evil is a problem that can be solved. An optimistic civilization is open and not afraid to innovate and is based on traditions of criticism* [98].

5. Conclusions

This research embraced a transdisciplinary approach to answer questions about Canada's energy transition. This approach was problem-oriented, relevant to society, and included collaboration with people from outside of academia [33]. To achieve meaningful collaboration, the input from outside of academia fundamentally shaped the research (i.e., energy practitioners identified the top two topics in Canada's energy transition, the top three underexplored topics in Canada's energy transition, and the concepts they rely on to make progress). This approach "regards the production of novel ideas not as a property of inspirational thinking, but the outcome of systematic re-thinking of historically accumulated knowledge" [23].

This research found that bringing together SD and the multi-level perspective is useful for energy practitioners to navigate the tensions and trade-offs in Canada's energy transition. This finding is consistent with the emerging academic literature that examines how complementary concepts can be combined to better understand complex challenges [30]. There are energy practitioners in Canada who are actively working on the energy transition, have integrated these two concepts into their work, and claim these two concepts promote a deeper understanding of the energy system (e.g., the elements and interconnections of the system) and more insightful solutions to shape the energy system. Specifically, the Energy Futures Lab in Canada has incorporated SD and multi-level perspectives into its efforts to accelerate an inclusive and equitable transition to a prosperous net-zero future. Energy practitioners indicated that these two concepts are not only relevant and useful in a general sense for Canada's energy transition, but also when attempting to address the two most important topics in Canada's energy transition: climate change and reconciliation with Indigenous Peoples. This research also found that SD and the multi-level perspective may be useful for addressing underexplored topics in Canada's energy transition (i.e., environmental rights in Canada, systemic reduction in energy consumption in Canada, and learning from other countries' energy transitions, in particular that of Germany). However, additional research is needed to further explore these areas.

This research does not mean that SD and the multi-level perspective need to be used for all initiatives related to the energy transition in Canada. All concepts, with SD and multi-level perspectives being no different, have the potential to reveal and conceal different elements and

interconnections within a system. There are many different concepts that can be used to bring about positive change within a system. However, these two concepts could be useful tools in the toolbox when energy practitioners are facing difficult challenges and hard problems. Given that Canada's energy transition will happen over a long period of time and will involve significant uncertainty [2,3], energy practitioners need access to as many tools as possible. This will better equip energy practitioners to improve how Canada produces and consumes energy [7–18], to generate useable knowledge [20], and to ensure access to affordable, reliable, sustainable, and modern energy for all [22].

Limitations of the study include a small sample size and a geographic focus on Canada. There were only 15 energy practitioners who participated in the focus group that identified the underexplored topics in Canada's energy transition. This small sample size limits the diversity of perspectives. Conducting the focus group with a different group of energy practitioners or hosting the focus group with the same energy practitioners a year earlier or later, could have identified different underexplored topics. This is one of the interesting aspects of transdisciplinary research where you are collaborating with people outside of academia to guide and shape the research [33]. This research was focused on investigating important topics in Canada's energy transition, underexplored topics in Canada's energy transition, and concepts that energy practitioners are using to make progress on these topics. It is not clear how applicable or relevant the results, discussions, and conclusions from this research are for energy transitions in different countries. Context matters with respect to energy transitions.

Future research could include a deeper look into the underexplored topics of Canada's energy transition. Regarding learning from other countries, future research could include more in-depth comparisons between the energy transitions in Canada and Germany that focus on specific topics (e.g., the adoption of renewable energy, the phase-out of coal-powered electricity), or additional comparative case studies between Canada and countries like Australia and Japan. Regarding environmental rights, future research could examine the influence of rights (e.g., human rights, labor rights) on previous energy transitions (e.g., biomass to coal, coal to oil) to better understand how evolving environmental rights and Indigenous rights are shaping Canada's current energy transition. Regarding reducing energy consumption, future research could identify and distinguish elements of the energy system that remove structural obstacles to people's health, influence, competence, impartiality, and meaning (and might be addressed by energy efficiency initiatives) vs. elements of the energy system that systematically degrade nature and increase concentrations of substances from the earth's crust (and might be addressed by energy conservation initiatives) in the residential, industrial, transportation, and agricultural systems [25–27]. Future research could also study the usefulness of combining these complementary concepts (i.e., SD and the multi-level perspective) to solve other complex sustainability challenges.

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Data Availability

Data supporting this study (i.e., the focus group results) are included within Section 4.2 of the article. Additional data (i.e., the transcripts of the 14 interviews) are not publicly available because of a commitment to the Royal Roads Office of Research Ethics to hold personally identifiable information in confidence. The transcripts include a significant amount of personally identifiable information.

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Conflicts of Interest

The author declares the following financial interests/personal relationships which may be considered as potential competing interests: Michael Benson is employed by the Canada Energy Regulator.

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