What is Known About the Impacts of Alternative Energy Development?

A Gap Analysis of Impact and Assessment Research for Alternative Energy Development

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Key Messages

This synthesis project developed a portrait of the state of impact assessment research focused on alternative energy development in Canada (wind, solar, small scale hydro and small modular reactors) for the production of electricity, not based on the use of fossil fuels. The method involved a scan of the academic literature (peer reviewed publications, conference proceedings and book chapters) and reports and studies produced by government and other organizations. We classified relevant works by impact characteristic(s), and then outlined the state of work within a framework adapted from transition theory. The research identified the following key messages:

1. The literature addressing wind power is quite expansive. But there is a scarcity of research regarding the impacts of solar, small-scale hydro and small modular reactors (SMRs) or small-scale nuclear. In each of these three foci, there is a lack of available work addressing the social, political and cultural impacts of these energy sources accompanied by more specialized gaps in the biophysical research. In addition to the clear need for additional research, there is a short-term need for expert rendition of existing international research that may be of value to the Canadian context.
2. Drawing on a transition theory typology, the majority of the literature can be characterized as reflexive, with less than 20% of research exploring primarily operational, tactical or strategic themes. There are many sources where the research contains overlapping categories. The research for SMR impacts is distinct from the other three alternative energy sources. The SMR literature is largely strategic.
3. Overall, there is very little research that addresses impacts of SMRs. Most of this focuses on the strategic motivations for the uptake of small-scale nuclear, safety, and economics. Public and stakeholder perception was notably absent from the research on SMRs. We can assume that one of the major needs in advancing this technology is to understand and be able to address public concerns about safety and cost. More studies addressing the socio-political, environmental and energy transition issues are required for this energy type.
4. Research addressing both the positive and negative impacts of alternative energy sources on Aboriginal communities is almost entirely lacking. Given that Aboriginal peoples in Canada have unique set of rights set out in Section 35(1) of the *Constitution Act, 1982*, Canada's status as a signatory of the United Nations Declaration of the Rights of Indigenous Peoples, and the Federal Minister of Indigenous Affairs commitment to implement the declaration (Indigenous and Northern Affairs Canada 2016), this represents an essential area of exploration if alternative energy sources are going to be developed for Canada's energy future. There is a need for programmes that specifically support research in this area to ensure that the perspectives, experiences and knowledge of Aboriginal people are considered in the development of energy resources.
5. Papers addressing the economic and financial feasibility of alternative energy sources were noted in the initial scan, but were then scoped out of the synthesis given our focus on impact/environmental assessment themes. However, we suggest that this is an area that should be examined further. Presently Canadian assessment processes do not require a substantive financial or economic rationale for project justification (if at all). This may be a key area of need when considering environmental assessment reform in Canada. The financial stability and long term environmental risks of financing potential stranded assets could become a substantial problem facing the fossil fuel industry. It is an area where work is required on integrating

financial and economic viability, and better needs assessments into review and approval processes. This can help ensure that public and private resources are being invested in the most viable, sustainable and resilient energy sources and infrastructure.

6. There is a need and an opportunity for targeted programmes that support research that connects social science to the development of energy resources and their infrastructure, and for supporting work that focuses specifically on addressing important gaps in understanding the social, economic and environmental implications of expanding alternative energy systems.

Executive Summary

Alternative energy resources are an essential part of meeting Canada's commitments to climate change mitigation. Although fossil fuels may continue to play a substantial role in Canada's energy future, oil and natural gas price instability, competition, environmental policy pressures, and the impacts of climate change will require changes to the nation's energy mix (Bataille et al. 2015). If Canada is to move toward a more a stable, innovative and competitive economy, then it will have to shift away from the dominance of the fossil fuel sector. A key part of this transition will be the planning, construction and operation of alternative energy production and distribution systems.

In Canada, renewable sources such as hydro have long played a vital role in meeting regional electricity needs. Solar is also emerging, though some jurisdictions it is fraught with policy and programme controversy. Wind is also well developed in some regions and is poised for expansion. Nuclear (characterized by some as 'greener' than fossil fuels) is a significant electricity source in Ontario and may see wider development at a small-scale. These sources meet electricity needs, and with innovation (and time) they may play a larger role in meeting requirements presently met mostly by fossil fuels (e.g. personal and commercial transportation and heating). However, transition to alternative energy sources may result in environmental, social and economic impacts that are very different than the recognized impacts of existing energy systems, and thus require new information and knowledge.

We cannot assume that all aspects of new sources and systems can simply be 'plugged into current infrastructure' and regulators and alternative energy advocates may not fully understand many of the challenges inherent in implementing change (Smith et al. 2005). Further, the current regulatory and policy environment for energy development in Canada has centred on mega-project development, such as large-scale hydro, nuclear, bitumen and natural gas. Existing impact assessment (IA) processes may require different information, experience and frames of reference for assessing alternative energy projects.

There is an established literature on the impacts of fossil fuel development (e.g. Parkins and Angell 2011; Asselin and Parkins 2009); but research on the impacts of alternatives is either very sparse or thematically and geographically dispersed (e.g. Walker et al. 2015; Sprague and Parkins 2012). Our objectives in this synthesis were to: (1) Develop a portrait of the state of the academic and professional literature; (2) Identify research gaps and suggest priority research areas; and (3) To outline the state of knowledge about impacts as framed with respect to a transition theory framework. This framework provides a way of characterizing the concentration of knowledge, what form and applications the research tends to have, and areas of specific need and strength. It consists of four categories adapted from Loorbach (2010:168-171). We modified these for the impact assessment context:

Strategic: Broader societal, economic and environmental objectives, long-term goal formulation, and impact estimation and projection. *For example, the impacts of alternative energy systems on energy security, regional economic strategies, innovation and trade, or CO2 reduction*.

Tactical: Interest-driven directing activities that relate to the dominant structures of a system including rules and regulations, institutions, organizations and networks, infrastructure, and routines. *For example, the impacts of a change in energy source on such structures, or their capacity to facilitate transition.*

Operational: The activities, tests and actions (innovations too) that have a short-term horizon and support implementation. When thinking about innovation we consider all societal, technological, institutional, and behavioural practices that implement and operationalize new systems. *For example, the impacts of new technologies or systems for energy storage and delivery, or construction or operational techniques.*

Reflexive: Activities relate to monitoring, assessments and evaluation of ongoing strategies, operations and change (social, economic, cultural and biophysical). In part, they are located within existing institutions established to monitor and evaluate, but they are also socially embedded. *Reflexive activities prevent inertia and support exploration of new concepts, designs and paths. For example the impact of new energy systems on local economies and traditional land use.*

Based on current Canadian policy initiatives and controversies surrounding energy development, our recent research, and consultation with government and industry on information needs and potential priority policy areas, we focused on four alternative energy sources: (1) small-scale hydro, (2) wind, (3) solar, and (4) small modular reactors (SMRs) or small-scale nuclear. We sought to identify impact assessment research that covers the environmental, economic, political, social and Aboriginal impacts relevant to Canada in the pursuit of and production, distribution and use of alternative energy sources.

Our research involved searching multiple databases to identify relevant and available academic and professional literature on the impacts of the four alternative energy sources, categorizing this literature to identify the predominant type of impacts addressed and emergent themes within those impacts and the category of transition theory. Using these categories as an entry point, we then reviewed the literature to identify potential knowledge gaps. To focus on knowledge appropriate to the Canadian context, we only analyzed research set in North America, Europe, Australia, New Zealand; and technology and innovation-based publications not tied to a specific geographic location.

We identified **840 publications and reports** (including some overlap amongst the energy sources) that focus on the impacts of alternative energy sources and the measurement and management of impacts. The works we identified include academic literature (peer reviewed publications, conference proceedings and book chapters) and reports and studies produced by government and other entities.

The scope and depth of the literature varies considerably amongst the four alternative energies that we included in the synthesis. We identified only 47 papers that meet our criteria and directly address the impacts of small-scale hydro, 17 papers that address the impacts of SMRs, and 89 papers that address the impact of solar power. In contrast, our scan identified 656 works that address the impacts of wind. We also identified 31 papers that addressed more than one alternative energy source. See Tables 1 to 4 for a list of themes, subthemes and example publications.

Wind energy is the only sector with an established body of research that discuss methods of assessment of impacts, comprehensive literature reviews, and provide a relatively large number of case studies. The wind-focused literature also includes substantial research specific to onshore wind development in the Canadian context. Although the deficiencies vary, the research is generally lacking for solar, small-scale hydro and SMRs. Our initial scans revealed that at least half of the topical research is set in geographic locations beyond the scope of this synthesis. This likely explains some of the gaps in the literature and also suggests an immediate path forward: the interpretation of the international literature for the Canadian context.

We found that in three of the four energy types (wind, solar, and small-scale hydro) there is a strong bias in the literature toward work that addresses effects on the biophysical environment (56% of all work for these three), with far fewer works addressing health, social impacts and cultural impacts (23%).

This is also a recognized pattern in the broader impact assessment research literature and practice (Burdge 2002; du Pisani and Sandham 2006; Hildebrandt and Sandham 2014; McGuigan 2015). In contrast, the very limited SMR research focuses on economics, safety and the attention to social effects centres on energy security.

Not unexpectedly, the major disciplines and research approaches also vary amongst the four foci. For example, life cycle assessment is widely used in the solar energy research (23% of papers), only occasionally used in the wind research (4% of papers), and absent from the small-scale hydro and SMR research. Notably, there is limited research addressing the biological, ecological and landscape level impacts of large-scale solar installations. In contrast these themes are well addressed in the wind literature.

Public and stakeholder perception emerged as an important theme within the literature. It is particularly well examined for wind power, addressed to some extent for solar and small-scale hydro, but particularly absent from the literature on SMRs. For SMRs it is discussed subtly as part of the social issues affecting development, but not explored in great depth. We can assume that one of the major needs in applying this technology to broader energy production is to understand and be able to address public concerns about the safety and cost of nuclear energy. More studies addressing the socio-political, environmental and energy transitions issues are required for this energy type.

There is an emerging body of research addressing the effects of industrial development on Indigenous peoples and their role in environmental assessments (e.g., Fitzpatrick and Sinclair 2003, Sandlos and Keeling 2015; Gadner et al. 2015; Craik 2016). This synthesis, however, demonstrated that research addressing both the positive and negative impacts of alternative energy sources on Indigenous communities is largely lacking. Aboriginal peoples in Canada have distinct set of rights as set out in Section 35(1) of the *Constitution Act, 1982*, reflected also in Canada's status as a signatory of the United Nations Declaration of the Rights of Indigenous Peoples, and by the Federal Minister of Indigenous Affairs recent commitment to implement the declaration (Indigenous and Northern Affairs Canada 2016). Given that many sites for alternative energy systems and their supporting infrastructure are likely to be constructed in places with Aboriginal title or potential interests and claims, this represents a much needed avenue of exploration if alternative energy sources are going to play a significant role in Canada's energy future.

Papers addressing means of improving the economic and financial feasibility of alternative energy sources were identified in the initial scan, but were scoped out since our synthesis was focused on impacts as they are typically defined in environmental assessment/impact assessment. We observed that this was a theme particularly prevalent in the solar energy literature. This is also an area that could have substantial importance for impact assessment practice. It warrants further research. Presently Canadian assessment processes do not require a substantive financial or economic rationale for project justification (if at all). This is an area of need when considering environmental assessment reform in Canada. The financial stability and long term environmental risks of financing potential stranded assets could become a substantial challenge for the fossil fuel industry. It is certainly an area where there is potential for research to develop methods for integrating financial and economic viability and need into assessment processes.

Lastly, we applied a four-category transition theory framework to the literature (described above). The application of the framework, typically associated with how systems or their qualities can be changed or transformed, to the classification of a knowledge base is a novel contribution of the research. With the exception of SMR impact research, the vast majority of the literature contains primary research where impacts are analyzed and characterized mostly on a reflexive level, with less than 20% of research exploring primarily operational, tactical or strategic themes. However, many works contain overlapping categories, which are not unexpected in impact assessment and reflects the integrative and multi-disciplinary qualities of the assessment field, and of complex energy systems and technologies.

Transition theory can provide a helpful way of understanding the foci of research and the 'places' where knowledge strengths lay, and areas of knowledge need. But the categories are multi-faceted and may not provide an easy or quickly applied label for many works, especially for those that may contain only one of the character tics of a specific transition category. The notable distinction is the SMR literature, which is largely strategic in nature. This may reflect the emergent nature of the technology (at this scale) and the need to build the policy case for advancing it. Aspects of the broader literature on impacts that has developed around large-scale nuclear development may also be applicable to the SMR experience.

This synthesis shows that there are considerable research opportunities and needs within the realm of alternative energy sources. Short-term priorities should include applying the international literature to the Canadian context, considering the impacts and opportunities of alternative energy sources for Aboriginal communities, developing programmes that support better connection between the social sciences and alternative energy research, and better integration of biophysical and applied science-and-social science approaches to understanding impact assessment issues.

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Context

Renewable and alternative energy resources will be an essential part of meeting Canada's commitments to climate change mitigation. Fossil fuels will likely play a substantial role in Canada's energy future, and will continue to be dominated by unconventional sources (oil sands and tight formations) (EIA 2014). However, oil and natural gas price instability, competition, environmental policy pressures, and the impacts of climate change will require changes to Canada's energy mix (Bataille et al. 2015). A key part of this transition will be the planning, construction and operation of alternative energy (alternative to fossil fuels) production and distribution systems.

Innovation will play the main role in determining the demand for energy in the future, the desired forms, and places and method of production/generation. Liquid fuels will undoubtedly continue to be in demand in those sectors for which there is no feasible alternative; such as aviation. But for other sectors, especially transportation, the potential for a significant shift to electric engines seems increasingly plausible—even in the near future. Innovations in engine design and battery storage life, and declining technology and product costs have been observed in recent years. Such shifts will affect not only personal transportation, but inevitably will be extended to commercial transportation (mass and goods transport) and other industrial vehicles (e.g. mining, forestry, and agriculture). This provides new demands for electricity and new opportunities for Canada, which is well positioned to develop non-substantial fossil fuel based electricity options. Such demands will also increase in the US, providing new regional markets for Canadian green electricity. The potential contribution from wind, solar, hydro and nuclear systems based in Canada could be substantial and sustainable and can contribute to the development of new research and development capacities, and innovative manufacturing opportunities.

As Canada seeks to move forward with the development of new clean energy sources we cannot assume that all aspects of new sources and systems can simply be 'plugged into current infrastructure' and regulators and alternative energy advocates may not fully understand many of the challenges inherent in implementing change (Smith et al. 2005). For example, the expanded use of eclectic cars could entail significant grid infrastructure challenges for urban areas. The transition to a system based overwhelmingly on alternative energy sources will entail environmental, social and economic impacts that can be very different than the recognized impacts of existing energy systems, and will require new information and knowledge. There is a well-established literature on the social and cultural impacts of fossil fuel development (e.g. Angel and Parkins 2011; Asselin and Parkins 2009); but research on the impacts of alternatives can seem lacking, or thematically and geographically dispersed (e.g. Walker and Baxter 2015; Richards et al. 2012; Sprague and Parkins 2012).

In Canada, renewable sources such as hydro has long played a vital role in meeting select regional electricity needs, wind power is advancing. Solar development is advancing, but has been fraught with policy and programme controversy. Nuclear (debatably characterized by some as 'greener' than fossil fuels) is a significant electric supplier in some regions, and may be poised for wider development at a small-scale. These sources meet electricity needs and with innovation (and time) they may play a larger role in meeting needs presently met mostly by fossil fuels (e.g. transportation and heating). However, the development of different upstream facilities and potentially new patterns of midstream and downstream development can entail uncertain social, environmental and economic implications in the quest for and extraction, production, movement and use of alternative energy resources. Further, the current regulatory and policy environment for energy development in Canada has centred on mega-project development, such as large-scale hydro, nuclear, and bitumen and natural gas. But these are fraught with environmental, social and economic risks.This does not mean that such opportunities should not be developed, but they should not be seen as the sole or even primary foundation for a stable, secure or sustainable energy future. A key challenge for policy makers and researchers is to understand and acknowledge what we know about the impacts of alternative energy systems, what knowledge gaps exist, and which of those gaps require attention.

Implications

This knowledge synthesis focuses on identifying impact assessment (IA) research, which covers impacts as broadly understood and defined in IA research. The results identify a range of IA research gaps and potential priority research areas, and develop a portrait of the state of impact assessment research relative to alternative energy development.

The synthesis provides a section that summarizes the state of research relevant to key alternative energy sectors, and select small-scale sector development issues.

The results can be used to help define research directions for the applicants and colleagues, to help frame new research funding programmes within the Social Sciences and Humanities Research Council and at other funding organizations, to help inform the research priorities of federal and provincial agencies, and identify important knowledge gaps that policy makers and developers will need to fill in order to facilitate a transition to a sustainable and secure energy mix. For the impact assessment practitioner community, the synthesis provides an indication of where areas of knowledge concentration exist, and what areas may provide little research-based information when framing project plans, developing approval and licence applications, and developing environmental assessments.

Approach

We focused on IA research that covers the environmental, economic, political, social and Aboriginal impacts of the pursuit of and extraction, production and use of alternative energy relevant to Canada.

The synthesis concentrated on four alternative energy sources: small-scale hydro, wind, solar, and small-scale nuclear. The foci were selected based on current Canadian policy initiatives and controversies surrounding energy development, our current research interests (e.g. Hanna, small-scale hydro; Noble, small-scale nuclear; and Parkins, wind), and consultation with government and industry colleagues on IA information needs and their perception of the priority policy areas.

Our initial search efforts revealed that no single database could provide the scope of peer reviewed and grey literature we sought to capture. It was necessary to search Scopus, Web of Science, and Google Scholar. Although the search approaches varied slightly based on the search functions that are available in each of the databases, we employed the following criteria for the Scopus and the Web of Science searches:

1. We searched for papers that contained the terms *impact*, *assessment*, or *effect* in the title, abstract or keywords. Each search term was followed by a wildcard to permit variations such as *impacts* and *effects*. This inclusive approach ensured that we captured all manner of relevant publications such as those addressing *environmental impact assessment, impacts of* specific activities*, cumulative impacts*, *social impacts, economic impacts, health impact assessment*, *and strategic impact assessment*.

2. For each of the four foci, we identified lists of relevant search terms and further restricted the searches to identify papers containing these terms in the title.

Using all of the search terms in combination, we also conducted searches in Google Scholar to identify additional peer reviewed sources and relevant *grey literature* (e.g. government and industry reports). The final step in our search involved reviewing the references in and citations of highly relevant papers to capture additional papers and to ensure that our search terms were comprehensive.

The resulting papers for each of the four foci were reviewed individually and the relevant papers were compiled. To focus on research germane to the Canadian context and related definitions of 'impacts', we focused on research in North America, Europe, Australia, and New Zealand since these arguably have the most relevance to the Canadian political and economic setting. But exceptions were made for technology-focused impacts that would occur regardless of the context (e.g. a given turbine would be expected to perform that same/similar regardless of the location of the hydro facility; all things being equal). We excluded documents that were not readily available online. Although this approach will not have captured all of the relevant literature, it resulted in a substantial selection from which to synthesize key work regarding the impacts of alternative energy sources.

For both wind and solar, papers were further categorized based on the type of technology (solar) and the size of development. Papers were categorized based on location of research, type of impacts addressed (socio-cultural, economic, health, biophysical, other). For each of the four alternative energy sources, we identified a number of emergent research themes. The themes were selected based on the focus of this research (environmental impacts) and vary amongst the energy sources as a result of the unique characteristics of each energy source and the focus and volume of the research. Although many papers addressed multiple themes, we strove to identify mutually exclusive themes, forcing the papers into categories. Papers were further coded to identify subthemes that were not mutually exclusive.

We also outlined the state of knowledge about impacts as framed with respect to a transition theory framework. This framework provides a way of characterizing the concentration of knowledge, what form and applications research tends to have, and areas of specific need and strength. It consists of four categories adapted from Loorbach (2010). More specifically, based on the complexity of contemporary energy governance systems, this framework "is an analytical lens to assess how societal actors deal with complex societal issues at different levels but consequently also to develop and implement strategies to influence" governance processes (Loorbach, 2010:168). In other words, these categories offer a way to disentangle the points of focus and areas of emphasis that are found within the broad literature on various types of energy production. To situate our review and synthesis, we modified these categories for an impact assessment context:

Strategic: Broader societal, economic and environmental objectives, long-term goal formulation, and impact estimation and projection. *For example the impacts of alternative energy systems on energy security, regional economic strategies, innovation and trade, or CO2 reduction*.

Tactical: Interest-driven directing activities that relate to the dominant structures of a system including rules and regulations, institutions, organizations and networks, infrastructure, and routines. *For example, the impacts of a change in energy source on such structures, or their capacity to facilitate transition.*

Operational: The activities, tests and actions (innovations too) that have a short-term horizon and support implementation. When thinking about innovation we consider all societal, technological, institutional, and behavioural practices that implement and operationalize new systems. *For example, the impacts of new technologies or systems for energy storage and delivery, or construction or operational techniques.*

Reflexive: Activities relate to monitoring, assessments and evaluation of ongoing strategies, operations and change (social, economic, cultural and biophysical). In part, they are located within existing institutions established to monitor and evaluate, but they are also socially embedded. *Reflexive activities prevent inertia and support exploration of new concepts, designs and paths. For example the impact of new energy systems on local economies and traditional land use.*

Based on the themes and subthemes for each of the papers (evident in the key words and abstract), we identified which of the four categories best characterizes the research represented in the paper.

The State of the Research: An Overview

We identified **840 publications** and reports that focus on the impacts of alternative energy sources and the measurement and management of impacts. These works include academic literature (peer reviewed publications, conference proceedings and book chapters including primary research and literature reviews) and reports and studies produced by government and other entities.

The scope and depth of the literature varied considerably amongst the four alternative energies that we included in the synthesis. We identified only 47 papers that meet our criteria and directly address the impacts of small-scale hydro, 17 papers that address the impacts of SMRs, and 89 papers that address the impact of solar power. In contrast, our scan identified **656 works that address the impacts of wind**. And we identified 31 papers that addressed more than one alternative energy source.

Focusing on the papers that directly address the assessment of environmental impacts, we found that there is a strong bias toward effects on the biophysical environment (68%) and far fewer efforts addressing health, economic, social and cultural impacts (32%) in any notable manner. This emphasis is driven by three of the four energy types (wind, solar and small-scale hydro) and is a recognized pattern in the broader impact assessment research literature and practice (Burdge 2002; du Pisani and Sandham 2006; Hildebrandt and Sandham 2014; McGuigan 2015). In contrast, the very limited SMR literature mostly addresses economics and safety.

Across the four energy types, we identified a number of emergent themes and subthemes. These included the effects of an alternative energy source on greenhouse gas (GHG) reduction and climate change mitigation.

Small Modular Reactors

In addition to being very limited in numbers of papers (17 papers) and impacts addressed, the SMR research differed considerably from the other four energy types. It focuses primarily on risk and safety and security (~3/4 of the published research), which is not necessarily unexpected. Cost is the next most common subject area— these often focused on profitability. Greenhouse gas reduction was also addressed by about 5% of papers. But little work seems to have been done on impacts, social acceptance, and community capacity issues (e.g. qualified personal available, location challenges for operating complex technologies, potential automation).

In terms of transition theory characterization, the SMR literature is largely strategic. This reflects the emergent nature of the technology. The SMR research reflects the need to build the policy case for developing what is a costly technology with potentially significant public concerns. The attention to the GHG reduction contributions of the technology, which was the focus of some of the research, also reflects a strategic quality. Given the need to build regulator and public confidence and awareness we expected impact related research for this type of energy development would have a stronger operational and tactical representation. See Box 1.

The nuclear industry, with the exception of facilities for research, naval uses, and the production of radioisotopes tends to be presently structured around large-scale operations with substantial MW production. SMRs pose a new and novel form and scale of nuclear development, on a scale with very different cost, location, and management requirements, but possibly with the same public and stakeholder perceptions of risk and operational security associated with larger plants. The experiences of research done on such issues for larger plants could be adapted to the knowledge needs of SMR development. See Table 1.

Small-Scale Hydro

Small-scale hydro may be one of the most promising forms of energy development in many parts of Canada. While the work (47 papers) addressing small-scale hydro include a number of analyses and case studies of environmental assessments, over half of the works focus on the effects of small-scale hydro on the aquatic environment—including water quality and flow, sediment and fish species. There is a need for a broader examination of the potential for and the impacts of the technology; especially for remote and rural areas. For example, among the works addressing social and community impacts, George and Van Schaik (1988) looked at the potential for small-scale hydro in remote Aboriginal communities in Canada. But this work is now 28 years old. There are ~175 such Aboriginal and northern communities in Canada, and the technology may have significant social/economic and environmental benefits for those where location makes hydro possible. Small-scale hydro may also be a desirable alternative to large scale hydro developments, which can impose substantial impacts on communities and landscapes, contribute to GHG emissions during operation, and come with high embodied GHG outputs in construction and materials. See Table 2.

In terms of the transition characteristics, small-scale hydro research fits mostly into the reflexive realm. However, the research relates mostly to monitoring, assessments and evaluation of ongoing strategies, as well as operations and change specific to biophysical impacts. There is less attention given to social/cultural or economic issues. See Box 1.

Solar

The solar literature (89 papers) addresses the effects of large scale (utility) and small-scale installations (residential and commercial building) and the effects of solar technology production in general, with a significant emphasis on photovoltaic solar, relative to concentrated solar power (CSP). This is an energy source that presents significant opportunity for many parts of Canada; especially at the building scale and for urban areas. Understanding and anticipating the impacts, and how to manage them, is an important part of developing a regulatory and planning setting to support the implementation of solar energy systems.

Notably, we identified only limited research addressing the biological, ecological and landscape level impacts of large-scale solar installations. A large proportion of the solar literature addresses photovoltaic technology, mainly addressing worker health and safety (during production of units) and end-of-life waste management. See Table 3.

The solar research tends to focus on the reflexive qualities that relate to activities to prevent inertia and support exploration of new production models and materials innovation, and system and product design. There is less focus on the reflexive qualities that address broader social dimensions of the technology and it use. See Box 1.

Wind Energy

Wind energy is the only sector with a large, well established body of impact assessment research; including papers that discuss the varied effects of onshore and offshore wind power on the environment, methods of assessment of impacts, comprehensive literature reviews, strategic papers, theory-based research, and case studies. The most widely examined direct environmental effects associated with wind power are impacts of onshore wind energy development on birds and bats and the effects of offshore development (noise) on marine mammals.

Human health effects and effects on radar infrastructure are also well covered. The measurement, effects and mitigation of noise-associated impacts were a crosscutting subtheme. Sixteen percent (108 papers) of the works identified, explore public and stakeholder perception addressing issues that include visual values, conflict, and planning and community engagement.

About 5% of the wind-focused literature directly addresses the Canadian context. For Canada-specific research the relatively recent publication dates suggest that work here is emerging; but then so is the industry. Seventy-five percent of the Canada-specific publications address only onshore development. We identified only two publications that directly and exclusively address offshore wind development in Canada, one addressing noise levels and the other addressing the impacts of noise on marine mammals. We identified eight relatively recent papers that address public and stakeholder perception in Canada, addressing issues ranging from visual impact, health risk perception, conflict and policy. See Table 4.

The wind IA literature is largely reflexive (89%), with an equal number of works falling primarily into the other categories. Again, this may not be unexpected given the focus on typical assessment qualities (monitoring and evaluation), and the tendency to frame research within the needs of assessment, or to analyse projects or technologies relative to their impacts, or to assessment requirements.

Comments on Transition Theory

The application of a framework based on transition theory to the classification of a knowledge base is a novel contribution of the research. With the exception of SMR IA research, the large majority of the literature contains mainly research that is reflexive in nature. Less than 20% of research exploring primarily operational, tactical or strategic themes, and there are examples where the research plainly contains overlapping categories. See Box 1.

Box 1. Percentage of papers in each of four categories of transition theory (categories are not mutually exclusive).

Energy type	Strategic	Tactical	Operational	Reflexive
Solar	16%	8%	7%	72%
Small-scale Hydro	17%	0%	0%	89%
SMR	29%	12%	35%	24%
Wind	6%	6%	5%	89%
Across all types	**8%**	**5%**	**5%**	**81%**

However, in many instances the reflexive qualities or content of individual papers are not necessarily as broad as the definition of 'reflexive'. For example, the description holds that it covers those activities related to monitoring, assessments and evaluation of strategies, operations and change. Changes, or impacts, are seen as social, economic, cultural and biophysical. But in many instances the reflexive qualities of the research focus on one impact realm, such as biophysical impacts and the monitoring of change, and then responding to it. Attention to social and institutional capacities may be largely absent. This points to the challenge posed is classifying work that is often very specific, according to the broad nature of transition categories–even after we modified the categories for the assessment setting.

As we noted, the SMR research is distinct from the other three alternative energy sources. It is largely strategic in nature, but then this is a small number of papers and the impact realm of this technology is not widely researched, at least for now. Our expectation was indeed that the impact research literature for each energy type would have included a large body of work that was primarily reflexive in scope, especially for hydro and SMRs where the direct impacts of facility construction and operation tend to dominate public discourses. If the technology were to become more widely used, it may be that the research that evolves around it would become increasingly reflexive. In the future, it would be helpful to compare the SMR IA research to the established body of IA work relating to large-scale nuclear projects.

For small-scale hydro we did not identify any papers as being primarily tactical and operational, though some thematic overlap exists. The emphasis of research on this energy source is overwhelmingly reflexive, with some strategic work.

Lastly, the categorization of work according to transition theory characteristics relied on a brief review of a paper's keywords and abstract. But a full reading of specific papers may reveal different transition qualities, instances of overlap, or even an interpretation different from what the keywords and abstracts provide. Nonetheless, it is not unsurprising that the IA literature would be mostly reflexive in nature, given the focus on analysing the assessment, evaluation and monitoring functions, efficacy and efficiency of IA practice, and the likely prevalence of even more critical theoretical works that would also focus on these attributes.

With respect to the development of alternative energy systems, at this stage the field would benefit from more research that takes a strategic perspective, as part of understanding the interaction between estimation and projection of impacts (beneficial and not), and the related implications and objectives of new systems (e.g. broader societal, economic and environmental objectives). Operational characteristics should be explored better, especially to understand the challenges in implementation of new technologies, and the substantial infrastructure that will be needed to connect many developments to existing delivery and consumer systems. This need is not unique to the subject areas we examined; it likely reflects a concentration or 'strength' within IA research.

Research Gaps and Priorities

Connecting International Work to the Canadian Context

Beyond the need for targeted IA research for these energy types, this synthesis revealed a number of underexplored, high level research gaps and research opportunities, some of which are specific to certain energy sources and others that are cross-cutting. The literature on the environmental effects of alternative energy development in Canada is very limited. This is particularly true for solar, hydro and SMRs and to a lesser extent for wind. In addition to additional research there is the need for *expert-led interpretation* of the existing literature for the Canadian context. As well as providing a valuable resource for practitioners, regulators and stakeholders, this will enhance our understanding of additional and specific knowledge gaps.

Impacts on Aboriginal Communities

There is a growing body of research addressing the effects of industrial development on Indigenous peoples and their role in environmental assessments (e.g., Fitzpatrick and Sinclair 2003, Sandlos and Keeling 2015; Gadner et al. 2015; Craik 2016). This synthesis however, demonstrated that recent research addressing either the positive and negative impacts of alternative energy sources on Indigenous communities is almost entirely lacking. This indicates a clear need and opportunity for developing programmes that support research into the impacts of alternative energy development on Aboriginal communities in Canada, and for providing support for work to examine the role of perspectives, experiences and knowledge of Aboriginal communities in the planning, review and approval of energy projects.

This is an important realm in the Canadian context, and it would benefit from inter-disciplinary expertise and approaches drawn from the social sciences. Given that Aboriginal peoples in Canada have distinct set of rights set out in Section 35(1) of the *Constitution Act, 1982*, Canada's status as a signatory of the United Nations Declaration of the Rights of Indigenous Peoples, and the Federal Minister of Indigenous Affairs recent commitment to implement the declaration (Indigenous and Northern Affairs Canada 2016), this represents a much needed avenue of exploration if alternative energy sources are going to play a significant role in Canada's energy future.

Economic and Financial Feasibility

Papers addressing means of improving the economic and financial feasibility of alternative energy sources were noted in the initial scan, but were scoped out of the summary since our synthesis was focused on impacts as they are typically defined in Canadian environmental assessment. We observed that the subject was sometimes linked to assessment themes, and we suggest that it requires further research.

The financial stability and long term environmental risks of financing potential stranded assets could become a substantial challenge for the fossil fuel industry, and poses significant risks for lenders and for public bodies which may provide subsidies or other financial support, and may be left with costly stewardship responsibilities for projects that have been abandoned or rendered unnecessary before their estimated decommission dates.

This is an area where work is required on integrating financial and economic viability, and better needs assessments into review and approval processes. Such can help ensure that public and private resources are being invested in the most viable, sustainable and resilient energy sources and infrastructure. Though financial viability is an information requirement in some IA systems in Canada, it does not categorically constitute the major factor in review or approval conditions. Review panels or agencies may question the validity of the needs case for a project, but it would not necessarily be an outright reason for a rejection recommendation. Conversely, a project approval recommendation may highlight a convincing needs case made by a proponent. The long-term financial viability of projects is not demonstrably a fundamental assessment criterion/factor. This is an area that could have substantial importance for impact assessment in Canada, and may be a way of helping to frame the sustainability of projects. Research that helps define impact assessment relevant, and practical approaches and methods for assessing economic and financial feasibility of projects would make an important contribution to environmental assessment reform, and to IA practice generally.

Conclusion

This synthesis shows that there is considerable research opportunity and need within the realm of alternative energy sources. Short-term priorities should include translating the international literature for the Canadian context and considering the impacts and opportunities of alternative energy sources for Indigenous communities. In the longer term, there is a substantial need for additional research in the field, with a particular emphasis on understanding the operational and strategic qualities of project development.

Our scan revealed that a substantial quantity of the topical research is set in geographic locations beyond the scope of the synthesis. This explains some of what appear to be gaps in the literature and also suggests an immediate research or communication opportunity: the interpretation of the international literature for the Canadian context to best identify knowledge, and relevant experiences and cases.

The approach was set within a theoretical framework adapted from transition theory. This is a novel approach to developing and presenting a research scan beyond an unrefined comprehensive overview. One feature of transition theory is a focus on the ways in which different levels of analysis are interlinked. For example, Loorbach (2010) notes that transition management has a certain attractive quality because “it allows for all sorts of interactions between and within the different types of governance. In transition management practice, these interactions and their effects are unpredictable and not directly managed, but because they fit within the same overall direction and emerge within a network of actors, they can contribute largely to collective goals (Loorbach, 2010:171). In the case of energy transition in Canada, we observe in this synthesis a strong focus on monitoring and evaluation as a reflexive category within our analytical framework (Box 1). But given the lack of information in other categories (i.e., strategic, tactical, and operation) the sophistication of transition management may be compromised because there are limited opportunities for recursive interaction, and influence and change within the system as theorized by Loorbach and other scholars.

Furthermore, we encourage continued focus on specific types of monitoring and evaluation for energy transition. These include “physical changes in the system in question, slowly changing macro-developments, fast niche developments, and seeds of change, as well as movements of individual and collective actors” (Loorbach 2010:177) at the societal level that are engaged in processes of energy transition and specific niche developments of alternative energy systems.

The transition concentration for IA research is reflexive, which is not unexpected given the nature of the IA field and the focus on the assessment, evaluation and monitoring needs of practice. Our application of the categories from transition theory was based on keywords and abstracts. A review of the papers beyond keywords and abstracts might have revealed nuanced insights and different or overlapping transition themes. The application of transition theory to understanding the state of research is helpful for framing the state of knowledge, and for identifying tactical areas of research that can be helpful in advancing new and innovative technologies, with impacts that may be quite diverse from those that are well known and widely studied

Not unexpectedly, the predominant disciplines and research approaches also vary amongst the four foci. For example, life cycle assessment is widely used in the solar energy research (23% of papers), occasionally used in the wind research (4% of papers) and absent from the small-scale hydro and SMR research. Integrated environmental assessment

Public and stakeholder perception emerged as an important theme within the literature. Frequently addressed in the wind literature, addressed to some extent for solar and small-scale hydro, but notably absent from the literature on SMRs. We can assume with confidence that the wind sector will grow in Canada as we search for better ways to deliver non-fossil fuel based energy, as wind technology improves in both capacity and cost, and as we see continued improvement in storage technology. There is an opportunity to develop research that systematically reviews, analyses and transfers the knowledge and experience of other jurisdictions to the Canadian setting

For SMRs public and stakeholder perception are discussed subtly as part of the social issues affecting development, but not explored in great depth. We see this as one of the major needs in applying this technology to broader energy production. The sector will need to be able to address public concerns about the safety and cost of nuclear energy, before political, policy and social acceptance is likely. More work addressing the socio-political, environmental and energy transitions issues are required for this energy type, and again this is an area where targeted support for social science-based research can benefit the development and advancement of an alternative energy source.

The broader IA implications of an expanded solar industry, in terms of landscape impacts, infrastructure and other development needs, poses significant knowledge needs for impact assessment. Assessment of the manufacturing and materials implications of the industry are arguably well ahead of IA-specific research. As the sector expands there will be need for understanding the assessment, planning and regulatory implications of what could become a common feature of many urban and rural areas.

The development of alternative energy systems will entail new and often unanticipated impacts. Different sectors will likely advance at different rates, and consumer level technology may progress ahead of the supporting infrastructure. For example, in transportation the ability to convert fossil fuel systems to electricity-based ones will be likely well before sufficient support infrastructure is in place. Building or retrofitting such infrastructure will entail significant change and impacts. Assessing these, understanding the strategic and tactical implications, and being able to predict, monitor and evaluate impacts presents needs for regulators and decision-makers, and opportunities for the research community.

Tables: Themes, subthemes and publication examples

Table 1. Current SMR energy research themes, subthemes and examples

Themes	Predominant Subthemes*	Recent Examples***
Risk, safety and security (74%)**	Proliferation risk assessment Probabilistic risk assessment SMR design and technology type Facility condition Aircraft impact (if facility hit) Risk informed planning Weighing risk with economic benefits Security Siting	Petrovic et al. 2012; Glaser et al. 2013; James et al. 2014
Economic effects (11%)	Profitability and economies of scale	Locatelli et al. 2011
Energy security and infrastructure (5%)	Compatibility of SMRs and modern power grids	Islam and Gabbar 2013
Climate change mitigation and greenhouse gas reduction (5%)	Reducing greenhouse gas reduction through global use of SMRs	Iyer et al. 2014
Social priorities versus technical capabilities (5%)	Potential for SMRs to achieve goals for technology	Ramana and Mian 2014; Sovacool and Ramana 2015

*subthemes are not mutually exclusive
**% of papers in this energy type
***Examples only, this is not a list of all publications identified
Bold text indicates research specific to Canada

Table 2. Current small-scale hydro energy research themes, subthemes and examples

Themes	Predominant Subthemes*	Recent Examples***
Comprehensive effects assessment (13%)**	Risk analysis Land use Biophysical environmental effects Cumulative effects Strategic environmental assessment Sustainability	Bonnel and Storey 2000; Abbasi and Abassi 2011; Baskaya et al. 2011
Effects on the aquatic environment (55%)	Aquatic species (e.g., lamprey, eels, trout) and assemblages Water flow Water quality and sediment Benthic ecosystem Macroinvertebrates	Almodóvar and Nicola 1999; Jesus et al. 2004; Gosset et al. 2005; Santos et al. 2006; Travade et al. 2010; Larinier 2008
Economic effects (6%)	Regional economic effects Effects on property	Kaldellis 2007; Aras 2012
Public and stakeholder perception (4%)	Local attitudes Landscape preferences conflict	Malesios and Arabatzis 2010; Lazdane 2012; Kaldellis et al. 2013
Noise impacts (4%)	Implications of known weir acoustics for small-scale hydro Noise modelling	Johnson et al. 2014; Tibone et al. 2009
Effects on social values (4%)	Potential for small-scale hydro in remote Aboriginal communities	George and Van Schaik 1988
Climate change mitigation and greenhouse gas reduction (8%)	Reduction	Tondi and Chiaramonti 1999; Jaliu et al. 2009; Gallagher et al. 2015
Methods and tools (4%)	General environmental assessment methods Quality of assessments	Pinho et al. 2007
Air Quality (2%)	Abatement	Yüksek and Kaygusuz 2006

*subthemes are not mutually exclusive
**% of papers in this energy type
***Examples only, this is not a list of all publications identified
Bold text indicates research specific to Canada

Table 3. Current solar power research themes, subthemes and examples

Themes	Predominant Subthemes*	Recent Examples***
Comprehensive effects assessments (large- and small-scale) (21%)**	Comprehensive life cycle assessment (PV and CSP) Exergetic life cycle assessment (PV) Widespread deployment of solar (PV and CSP) Sustainability and sustainability indices (PV) Impacts of solar versus fossil fuels (PV) Impacts of solar versus biofuel (PV) Case study of large scale facility	Ardente et al. 2015; Cucchiella et al. 2015; Lamnatou et al. 2015; Hernandez et al. 2014; Fthenakis and Kim 2011; Turney and Fthenakis 2011; Kaygusuz 2009; Raugei and Frankl 2009; Tsoutsos et al 2005
Effects of large-scale facilities (25%)	Wildlife (PV and CSP) Micro-climate (PV) Plant-soil carbon cycling (PV) Regional effects on other land uses including conservation (PV and CSP) Siting to minimize impact (PV and CSP) Land use (PV and CSP) Visual impacts (PV and CSP) Biodiversity (PV and CSP) Economic effects of grid-connected facilities on consumer (PV) Employment levels (PV and CSP) Existing power infrastructure Safety near airports (PV) Water consumption (CSP) Greenhouse gas emissions (CSP and PV*) (some papers focus directly and exclusively on GHGs)* Focused life cycle assessment (CSP)	Bernal-Agustin and Dufo-Lopez 2006; Çetin and Eĝrican 2011; Lovich and Ennen 2011; Cameron et al. 2012; Klein and Rubin 2013; Bergesen et al. 2014; Calvert and Mabee 2015; Chiabrando et al. 2015; Stylos and Koroneos 2015
Effects of small-scale facilities (10%)	Economic and supply effects of grid-connected small-scale facilities (PV) User behaviour (PV) Regional economic effects of policy supporting household solar (PV) Economic effects of grid-connected facilities to consumers, rate pay (PV) Regulatory approaches to grid-connected, net-metered facilities (PV) Integrating small scale solar with electric vehicle recharge systems (PV) Greenhouse gas emissions (CSP and PV) Regulatory and ratemaking approaches to mitigate financial impacts of net-metered PV on utilities and ratepayers Solar-powered LED tunnel illumination (PV)	Burns and Kang 2012; Orioli and Di Gangi 2013; Satchwell et al. 2015; Darghouth et al. 2016

Themes	Predominant Subthemes*	Recent Examples***
Effects of solar technology (27%) *Includes research specific to technology (often films) but not the facility type (e.g. scale)*	Life cycle assessment (CSP and PV) Managing end-of-life of contaminants and emissions (PV) Health impacts of production on workers (PV) Ecotoxicology (PV) Sustainability (CSP and PV) Greenhouse gas emissions (CSP and PV)	Moskowitz and Fthenakis 1985; Thun et al. 1985; Fthenakis 2000; Raugei and Fthenakis 2010; Cyrs 2014
Effects assessment methods and tools (4%)	Challenges of dynamic environmental assessment Life-cycle assessment	Laratte and Guillaume 2014
Climate change mitigation and greenhouse gas mitigation (2%)	Greenhouse gas emissions (PV and CSP) Lifecycle greenhouse gas emissions (PV and CSP)	Bergesen et al. 2014; Stylos and Koroneos 2015
Public and stakeholder perception (4%)	Large scale solar facilities (PV) Residential solar infrastructure (PV) Public debate regarding solar (PV) Effects of advocacy on uptake (PV)	Noll et al. 2014; Rai and Beck 2015
Hybridization and integration with other technology (3%)	Integrating concentrated solar power with natural gas (CSP) Small-scale remote integration with diesel (PV) Integration of residential solar with battery systems (PV)	Celik et al. 2008; Akyuz 2009; Corona et al. 2014

*subthemes are not mutually exclusive
**% of papers in this energy type
***Examples only, this is not a list of all publications identified
Bold text indicates research specific to Canada

Table 4. Current wind energy research themes, subthemes and examples

Themes	Predominant Subthemes*	Recent Examples***
Comprehensive effects assessment of wind developments (3%)**	Life cycle assessment Sustainability Integrated environmental assessment	Tremeac and Meunier 2009; Weinzettel et al. 2009
Effects of onshore and offshore development on infrastructure, power supply and cost (3%)	Radar Telecommunication Power grid and cost of appropriate power grid	Prescott et al. 2009; Pinto et al. 2010; Rhodes and Lundquist 2013; Angulo et al. 2014; Angulo et al. 2015
Effects of onshore development (39%)	Ecosystems Landscape impacts and capacity Wildlife including: • reindeer (*Rangifer tarandus tarandus*), • mule deer (*Odocoileus hemionus*), • Rocky Mountain elk (*Cervus elaphus*), • Agassiz's desert tortoises (*Gopherus agassizii*), • multiple bird species, and • multiple bat species. Atmospheric and meteorological impacts Specific environmental components including: insects, microclimates, air quality (dust) Economic impacts on tourism, property values, rural benefits Physical and mental health including: • noise, • annoyance, and • electromagnetic fields. Visual impacts Quality of life Noise Seismic	Roy et al. 2004; Moller 2006; Moran and Sherrington 2007; Meyerhoff 2010; Krogh et al. 2011; Kabir et al. 2012; Christidis and Law 2012; Nissenbaum et al. 2012; Schaefer et al. 2012; Lang et al. 2014; McCallum et al. 2014; Feder et al. 2015; Skaburskis 2015; McCunney et al. 2015; Walker et al. 2015
Planning and siting onshore developments (3%)	Managing cumulative effects Role of environmental assessment in planning Land use Public policy Role of environmental assessment in planning Minimizing impacts	Rodman and Meentemeyer 2006; Nadai and Olivier 2009; Nadai and van der Horst 2010; Watson et al. 2012; Smart et al. 2014

Themes	Predominant Subthemes*	Recent Examples***
Effects of offshore development (22%)	Effects of noise on fish and marine mammals including: • harbour porpoise (*Phocoena phocoena*) • North Atlantic right whale (*Eubalaena glacialis*) • seals (*Phoca vitulina*) • Atlantic salmon (*Salmo salar*) and • cod (*Gadus morhua*) Fish and crustaceans Marine ecosystem Bird species Benthic environment Atmospheric and meteorological impacts Safety Economic impacts to other marine industries Integration with aquaculture	**Koschinski et al. 2003;** Christiansen and Hasager 2005; Desholm and Kahlert 2005; Wahlberg and Westerberg 2005; Bishop and Miller 2007; Bailey et al. 2010; Westerberg et al. 2013
Climate change mitigation and greenhouse gas mitigation (1%)		Holttinen and Tuhkanen 2004; Panwar et al. 2011; Aso 2014
Effects of both on and offshore or not stated (4 %)	Birds Wildlife Economic impacts Employment impacts Effects of noise on humans Effects of vibration on humans End-of-life waste management	Pederson and Waye 2004; Drewitt and Langston 2008; O'Neal et al. 2011; Cherrington et al. 2012
Public and stakeholder perception (18%)	Influencing factors Public preferences Planning conflict Noise Visual impacts	Devein-Wright 2005; Wolsink 2007; Devine-Wright and Howes 2010; Weissensteiner 2001; Groth and Vogt 2014
Effects assessment and monitoring methods (5%)	Assessing impacts fish and marine mammals Health Impacts Measuring and modeling noise and associated impacts Ecological risk Methods of assessing Sound and visual impacts Public and stakeholder perception	Garthe and Huppop 2004; Hurtado et al. 2004; Keith et al. 2008; Phylip-Jones and Fischer 2013; Taylor et al. 2013

Themes	Predominant Subthemes*	Recent Examples***
Integration with non-renewable energy types and technology (<1%)		van der Wijk et al. 2014; Weiss et al. 2005

*subthemes are not mutually exclusive
**% of papers in this energy type
***Examples only, this is not a list of all publications identified
Bold text indicates research specific to Canada

Knowledge Mobilization

This knowledge synthesis provides a strong sample from which to synthesize key work that has been done, to know where the research strengths lie, to identify major research themes and gaps, and to identify areas where research resources can best be focused.

A key objective of our project was to develop knowledge that is of direct benefit to impact assessment practitioners, policy audiences and researchers working in the IA field, and those working on energy policy. In part, our participation in the two Knowledge Synthesis Workshops organized by SSHRC helped to facilitate timely communication of results.

Over the next year we will continue to analyze and write results with both academic and non-academic audiences in mind. We will focus on the presentation of results, with an emphasis on formats, language and tools that provide straightforward transfer of knowledge. We are examining best approaches for posting spreadsheets with all of the scan data, and a complete list of the works identified.

A combination of internet-based information distribution (websites), the UBC-CEAR newsletter, and a conference presentation will help disseminate the results of the synthesis to broad policy audiences. We will also disseminate results to two targeted national organizations: the Canadian Council of Ministers of the Environment, and the Energy Council of Canada. The Canadian Council of Ministers of the Environment is “the primary minister-led intergovernmental forum for collective action on environmental issues” in Canada. The Energy Council of Canada is “a vehicle for strategic thinking, collaboration and action by senior executive in the private and public sectors” whose mission is to create a better understanding of energy issues to best shape the energy sectors for the benefit Canada.

To help communicate the results of Canadian research, we will present our findings and experiences at a key national conference (Ontario Association for Impact Assessment) and a key international conference (International Association for Impact Assessment). Both venues attract scholars, practitioners and policy makers in IA and energy systems.

Hanna and Noble have already met with staff from Natural Resources Canada and the Canadian Nuclear Safety Commission to provide a preliminary overview of the project’s results. Hanna and Parkins presented results to an SSHRC sponsored event featuring Knowledge Synthesis Grant recipients at the 2016 Congress of the Humanities and Social Sciences. Hanna has also provided a brief overview to Canadian Environmental Assessment Agency staff. The final report will be shared with CEAA, NRCan and CNSC colleagues.

We intend to publish results in 2 papers. One will be a report of the overall results of the gap analysis. The second will be an analysis of the state of knowledge focusing on the use of transition theory to categorize the state of research. Potential journals are Impact Assessment and Project Appraisal; EIA Review; or Env. Management; Energy Policy; or Renewable Energy Law and Policy, which target sizeable academic, policy and practice audiences.

The Knowledge Synthesis will also serve as a foundation for encouraging additional work in the field, and for identifying areas of research need which our respective universities and partners can help fill in the coming years.

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