

What is Known About the Impacts of Alternative Energy Development?

EXECUTIVE SUMMARY

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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). The methods involved a scan of the literature that includes academic works (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 framed the work within a framework adapted from transition theory. The research identified the following key messages:

1. The literature addressing wind power is quite expansive yet there is a dearth 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 obvious need for additional research, there is a short-term need for expert translation of existing international research to the Canadian context.
2. The vast majority of the literature contains primary research analyzed only on a mostly reflexive level, with less than 15% of research exploring primarily operational, tactical or strategic themes and there are many sources where the research contains overlapping categories. However, small modular reactor (SMR) research is distinct from the other three alternative energy sources. The SMR literature is largely strategic.
3. The body of research addressing SMRs is particularly lacking and focuses predominately on the strategic motivations for the uptake of small-scale nuclear, safety and economics. Although, public perception emerged as an important theme within the broader literature, it was notably absent from the research on SMRs. 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 transition issues are required for this energy type.
4. Research addressing both the positive and negative impacts of alternative energy sources on First Nations and Inuit 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 recent 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.
5. 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. Presently Canadian assessment processes do not require a substantive financial or economic rationale for project justification (if at all). This is a key area of need when considering environmental assessment reform. 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 needs assessments into review and approval processes.

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 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 select regional electricity needs and wind power is advancing, but solar development has been hesitant and fraught with policy and programme controversy. Other non-fossil sources such as nuclear (debatably characterized by some as 'greener' than fossil fuels) is a significant electric supplier in other 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, 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, and bitumen and natural gas.

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 research objectives were to: (1) Develop a portrait of the state of the academic and professional literature; (2) Identify research gaps and 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 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.*

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.*

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.*

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 of the pursuit of and extraction, production and use of alternative energy relevant to Canada.

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.

Given the broad range of potential impact types and the many academic arenas in which these might be addressed, we found for wind power and solar power, that it was necessary to review over 5000 database listings, and that they could not be further parsed using the database filtering capabilities.

Findings

We identified about 850 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 31 papers that meet our criteria and directly address the impacts of small-scale hydro, 17 papers that address the impacts of SMRs and 95 papers that address the impact of solar power. In contrast, our scan identified 730 works that address the impacts of wind.

Wind energy is the only sector with an established body of research that papers that discuss methods of assessment of impacts, comprehensive literature reviews and a relatively large number of case studies. The wind-focused literature also includes a growing number of diverse papers specific to onshore wind development in the Canadian context. Although the deficiencies vary, the research is generally lacking for solar, small-scale hydro and small-scale 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 what appear to be gaps in the literature and also suggests an immediate path forward: the translation of the international literature for the Canadian context.

We found that in three of the four energy types (wind, solar, SMR and small-scale hydro) there is a strong bias toward literature that's primary themes address effects on the biophysical environment (56%), with far fewer efforts 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 social effects—notably energy security.

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. 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 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 notably 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 a nascent 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; Gardner 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 almost entirely lacking. 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.

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. This was a theme that was particularly prevalent in the solar energy literature. This is also an area that could have substantial importance for impact assessment. 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. 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 needs to be work done on 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 associated with framing qualities change, 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 analyzed only on a mostly reflexive level, with less than 15% of research exploring primarily operational, tactical or strategic themes and there are many sources where the research contains overlapping categories. Distinct from the other three alternative energy sources, the SMR literature is largely strategic in nature.

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 SMRs, small-scale hydro and solar.

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