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Social dimensions of smart grid: Regional analysis in Canada and the United States. Introduction to special issue of *Renewable and Sustainable Energy Reviews*

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A R T I C L E I N F O

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A B S T R A C T

This special issue of Sustainable and Renewable Energy Reviews is focused on the social and policy dimensions of smart grids, an emerging set of technologies and practices which have the potential to transform dramatically electricity systems around the world. The six related articles explore social and political dynamics associated with smart grid deployment in the United States of America (USA) and Canada. Aspects examined in this special issue include the evolution of smart grid policy in Ontario, media coverage of smart grid experiences in Canada and smart grid approaches being taken in Québec. Other aspects covered include an analysis of smart grid systems planning post-Superstorm Sandy (that hit the Northeastern coast of the USA in 2012), the environmental framing of socio-political acceptance of the smart grid in British Columbia, and news coverage of the smart grid in the USA and Canada. These articles were supported by collaborative research from the National Science Foundation in the USA and the Social Sciences and Humanities Research Council in Canada which involved three expert workshops held in Canada in 2013, 2014 and 2015. The six articles were accepted after a vigorous review process overseen by the guest editors of this special issue. The contents are in keeping with the aims and scope of the journal which is to bring together under one roof the current advances in the ever broadening field of renewable and sustainable energy.

1. Introduction

At the June 2016 'Three Amigos Summit' in Ottawa the leaders of the United States of America (USA), Canada and Mexico committed to generating 50% of their combined electricity from clean (non-carbon emitting) energy sources by 2025. Presently the joint non-fossil fuel electricity total stands at 37%, but with marked national differences, with approximately 20% in Mexico; 33% in the USA and 80% in Canada. It is possible to question the real level of ambition implied by this recent collective commitment [1], but there is no denying that issues of electricity system reform, cross-national energy dialogue, and climate change have been assuming ever greater importance in the North American context.

Two deep-rooted drivers point to the impending transformation of today's electricity systems. First, the continuing impact of the Information and Communications Technology (ICT) revolution is opening up possibilities for technological (but also economic, social, and cultural) innovation in key sectors including personal transportation (electric vehicles, driverless vehicles, Uber), electricity supply (solar power, renewables deployment, distributed generation, demand response, smart grids), and end use of all kinds including industry, commercial, and households. Second, the growing appreciation of climate risks is encouraging movement away from the GHG emitting generation technologies which have formed the backbone of electricity supply in most countries. Research on potential long-term low carbon development pathways suggest that meeting international climate

Abbreviations: CCS, Carbon capture and storage; GHG, Greenhouse gas emissions; ICT, Information Communication Technology; IEA, International Energy Agency; NSF, National Science Foundation; RSER, Renewable and Sustainable Energy Reviews; SI, special issue; SSHRC, Social Science and Humanities Research Council;; USA, United States of America

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targets will require developed countries to complete decarbonization of electricity generation before mid-century, massively increase end-use efficiency, and double (or triple) electricity supply, as clean power is called upon to assume energy loads in transport, buildings, and industrial applications currently met by fossil fuels [2,3].

Thus we stand at the threshold of a potentially dramatic transition in electricity systems, that will change not just how power is produced and what it is used for, but also who produces and consumes it, and where. New technologies and societal expectations are already disrupting existing business models and regulatory arrangements [4,5]. 'Smart grids' are a critical element of the coming changes, representing both technological and social change that could facilitate renewables deployment, broaden household, community and industry engagement in energy decision-making, boost efficiency, expand demand management, enhance reliability and open up new energy services. But smart grids also serve to articulate very different views of electricity systems futures, involving more or less decentralized and distributed patterns of production, consumption, ownership and control [6,7].

Smart grids [8,9] have the potential to change how variable renewable energy and other energy vectors are integrated into the overall energy system [10,11], transforming pathways related to heating [12], transport [13–15] and cities (so-called smart cities) [16]. They may contribute to a more sustainable society, in keeping with the aims and objectives of the Paris Agreement on climate change [17]. And they may herald a more intelligent 'big data' driven society, where energy costs, carbon emissions, the economy and energy security are all interlinked as an energy quadrilemma [18,19] with complex social, economic and policy implications.

North American electricity systems are shaped by state and provincial level laws, regulations, and policies, and by utility-specific approaches and technology adoption decisions which are influencing perceptions of the value of renewable resources and shaping smart grid development [20]. Variation in state and provincial policies has influenced renewable energy development and integration in different ways which, coupled with divergent utility policies, is creating a complex and heterogeneous North American energy landscape [21]. But inter-system linkages are changing how energy grids across North America are planned, built and operated, and how citizens engage with energy issues. The bilateral links between the states and provinces in the USA and Canada are particularly important because of close interdependence.

This special issue (SI) of six articles in *Renewable and Sustainable Energy Reviews* (RSER) explores some of the social dynamics and complexity currently shaping perceptions of smart grid and renewable energy in the USA and Canada. The articles stem from collaborative research funded by the National Science Foundation (NSF) in the USA and the Social Sciences and Humanities Research Council (SSHRC) in Canada. They explore different provincial contexts (Ontario, Quebec and British Columbia), country contexts (the USA and Canada), and regional perceptions following electricity system disruption (Hurricane Sandy).

2. Social science research and energy system change

As the pace of energy system change accelerates, the need for energy-related social science is increasingly acknowledged [22–24]. While energy research has traditionally tended to focus on technological innovation and economic analysis, recognition of the importance of cultural, social, political and institutional dimensions has been growing rapidly [26,27]. Social and political factors profoundly influence energy outcomes. Consider why some countries have turned their back on nuclear power (Germany), while their neighbors continue to rely heavily on this technology (France). Or reflect upon the recent upsurge in movements to block pipeline construction in Canada and the USA. It is not engineering or economics that primarily lie behind these developments, but political and social factors. Note also how political skepticism and public opposition in many countries have torpedoed the International Energy Agency's (IEA) ambitious plans to roll out a hundred large-scale carbon capture and storage (CCS) demonstration projects, despite initial support from many governments which considered CCS deployment as an important tool to secure cost-effective climate mitigation [28]. And witness how vocal public opposition to Ontario's wind energy roll-out was spurred by poor policy design which favored large scale multinational-led deployments (that left little place for community projects) and rode rough shod over local planning institutions [29].

Social science research can contribute to the way societies address energy problems by helping identify critical questions and enhancing societal reflexivity, interrogating the interests, institutions and ideas that are at play, and identifying pathways towards more sustainable energy systems. By analyzing factors shaping policy implementation and technology deployment in practice, social scientists are able to engage in critical operational arguments that can lead to increased understandings of the complexities of energy technology innovation. Social science research employs many kinds of methodologies, examining phenomena at individual, group and broader systems level, and employing a variety of quantitative and qualitative techniques. Some of the more important contemporary energy politics- and policy-related literatures include those on innovation systems [30], societal transitions [31–33], political economy [34], and social practice [35].

3. Smart grid as a critical site of contestation

The idea of smart grid is generally associated with the application of ICT systems to transmission system design and operation, but it has come to be used more widely to refer to the overall configuration of the electricity system of the future [6,36]. Smart grids are typically presented as embodying a progressive, technologically optimistic, future that offers a portfolio of societal benefits, including increased system efficiencies, economic gains (high tech industry, jobs), and energy security or resilience, as well as empowering societies to address urgent environmental problems such as climate change [36]. But there is no *one* smart grid vision. Instead the idea covers a range of technological configurations (some already deployed or deployable, others still on the drawing boards) and many different social models for building the electricity systems of the future [36]. At one extreme, smart grids could be largely about 'micro grids' and a devolved and decentralized system of supply. On the other, they could involve a 'super grid' moving large amounts of power across continents [6]. Ownership, control and information flows could be organized in different ways, involving existing utilities, new entrants, local communities and cooperatives, or individual 'prosumers' [37].

In fact, societal debates, utility planning and investment decisions being taken today *already* privilege some patterns of smart grid transitions over others [38]. Choices relating to the ends pursed as priorities (e.g. efficiency gains, cost containment, resiliency enhancement, renewable deployment, demand management, and so on) favor particular technological configurations, and the sequencing or timing of innovation. Moreover, there is a vast gulf between the idealistic visions of an enhanced grid – that would allow electricity to do so much more for societies – and the practical experiences with smart meter deployment (the first public face of the smart grid) experienced by consumers in some areas. So 'smart grids' have emerged as a site of negotiation and contestation, where different groups of social actors (e.g. utilities, regulators, large and small consumers, technology companies, energy service providers, etc.) argue over the future of the electricity system [6,36,39,40]. And by examining these struggles it is possible to gain a critical understanding about the social and political factors influencing the evolution of electricity provision.

4. Articles in this special issue

The work presented in the articles in this SI builds on previous social science research published in this venue focusing on the complexities of assessing the value [41] and benefits of smart grids [42], smart grid experiences in particular countries [43], and end-user perceptions and acceptance of smart grid technology [44]. As *Renewable & Sustainable Energy Reviews* covers advances in sustainable energy and renewable energy technology, it is an ideal venue for analysis of the social and policy dimensions of smart grid. The journal has published extensively on the technical dimensions of smart grid [45,46], ranging from the creation of micro-grids to large-scale wind integration [47], and addressing country-specific contexts for smart grid development [43]. The six papers in this SI complement the existing publications in RSER by providing analysis of the social dimensions of smart grids in different regions of Canada and the United States.

In the first article, 'Electric (Dis) Connections: Comparative Review of Smart Grid News Coverage in the United States and Canada' [48], the authors examine press treatment of smart grids in the two countries, tracing the different patterns of smart grid engagement. The next three articles focus on the experience in different Canadian provinces, tracing the reception of smart grid related policy initiatives in Quebec, Ontario and British Columbia. 'Smart Grid Development in Quebec: A Review and Policy Approach' [49], draws on John Kingdon's analysis of 'policy streams' to explain why smart grid initiatives in that province have remained modest and 'security focused'. 'Institutional Diversity, Policy Niches and Smart Grids: A Review of the Evolution of Smart Grid Policy and Practice in Ontario, Canada' [50], highlights the more active policy engagement with smart grids in Canada's largest province, and notes the ever more important role assumed by non-traditional 'behind the meter' actors and activities. And 'The Role of Environmental Framing in Socio-political Acceptance of Smart Grid: The Case of British Columbia, Canada' [51] examines the different frames used by BC actors to structure ongoing argument about smart grids. The fifth article – 'Smart Grid Framing Through Smart Meter Coverage in the Canadian Media: Technologies Coupled with Experiences' [52] - is focused upon media coverage of smart-meter installation across Canada, assessing the different levels and character of public opposition in key regions. Finally, 'Smart Grid Electricity System Planning and Climate Disruptions: A Review of Climate and Energy Discourse Post-Superstorm Sandy' [53] compares the ways electricity system stakeholders in Massachusetts, New York and Vermont reacted in the aftermath of Superstorm Sandy, focusing on the links between energy policy and climate change, and the relative importance accorded to climate adaptation and mitigation.

Taken together, these articles allow for a rich and multi-faceted examination of how different contexts are shaping smart grid development. These contexts highlight different political priorities which are transforming energy markets, international electricity sales, and different configurations for smart grid technologies. Additionally, the papers use multiple social science methods including media analysis, focus groups, interviews and documentary analysis to explore social dimensions of smart grid development.

5. Conclusion

As the articles in this collection illustrate, new technologies are born into a dense complex of existing techno-social relations. Energy transitions involve complex struggles as new technological options and social configurations are defined, contested and redefined [54–56]. The ICT revolution and the imperative of addressing climate change are enabling disruptive innovation that opens the door to reconstruction of electricity systems to more adequately fulfill societal needs [6,36]. Increased international co-ordination (as witnessed in the United States, Canada, Mexico agreement cited at the outset of this introduction) and intra-state cooperation (consider the recent Quebec/Ontario power agreement that will bring cheap hydro from Quebec to slow electricity rate increases in Ontario and help the province meet its climate targets) are important features of this new context. But it is also true that arguments about electricity system modernization in North America are currently taking place in an uncertain economic environment, where recovery from the 2008 recession remains uneven, and concern about growing inequality is expanding including greater awareness about concentrated income gains at the top of the earnings pyramid. To this must be added the political uncertainty created by the 2016 U.S. presidential election. So it is perhaps not surprising that proposals for altering electricity provision get entangled with broader societal debates.

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