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The journey towards decarbonization: Exploring socio-technical transitions in the electricity sector in the province of Ontario (1885–2013) and potential low-carbon pathways

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HIGHLIGHTS

- Investigates transitions in the electricity sector using the multi-level perspective.
- Explores the socio-technical evolution of the electricity system in Ontario.
- Draws lessons relevant for low-carbon transitions.
- Poses key questions for the development of low-carbon pathways in Ontario.
- Provides insights on the political dimensions of low-carbon transitions.

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ABSTRACT

This article employs the multi-level perspective on socio-technical transitions to explore the historical evolution of the electricity regime in the province of Ontario from 1885-2013 and to interpret the potential for future movement towards decarbonization. With an emphasis on the political and social dimensions of transitions, this analysis traces the key features influencing change within Ontario's electricity system over the past century. This paper uses multiple criteria (the phase of electrification; role of the electricity system in economic development; structures of ownership, market and regulation; dominant technologies; and the relative stability of arrangements) to characterize distinct regime configurations and periods of instability which separate relatively stable system orientations. Lessons are drawn from the historical case with implications for future decarbonization in the province, including the importance of: (1) residual momentum; (2) embedded guiding principles; and, (3) politico-economic coalitions.

1. Introduction

In coming decades significant progress must be made in eliminating GHG emissions from electricity supply systems if societies are to reduce the risks associated with human induced climate change. Discussion of movement towards low-carbon emission energy futures typically starts from an analysis of existing energy systems – including dominant technologies and established economic and regulatory practices – before moving on to consider technological alternatives and policy instruments that can encourage movement away from current practices. This article takes a slightly different approach. It begins with the assumption that if we want to understand the potential for future change we would do well to understand previous episodes of system transformation and the development trajectory which led to present circumstances. In other words, it suggests that an historical understanding of the evolution of specific energy systems is important when contemplating future decarbonization strategies. The article applies theoretical concepts drawn from historically grounded transition scholarship to understand the long term development of Ontario's electric system and to assess perspectives for movement towards a lower carbon configuration.

The argument develops in three steps. It opens with a brief discussion of the transition perspective. The bulk of the piece then provides an analysis of the historical development of electricity provision in Ontario. The final section considers the implications of this analysis for movement towards a low-carbon emission energy system.

2. Transition scholarship

Over the past decade, transition scholarship has become an increasingly important analytical framework for understanding

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more sustainable trajectories. The transition approach has developed important insights with respect to the large-scale societal transformations needed to respond to climate change. The Multi-Level Perspective (MLP), in particular, provides a useful heuristic for understanding the dynamics of low-carbon transitions in energy systems (Turnheim and Geels, 2012; Verbong and Geels, 2010). This study adapts the MLP to trace the historical developments which have transformed the electricity system in Ontario over the past century. Developed initially by European transition theorists (Geels, 2002; Rip and Kemp, 1998) the MLP, understands transitions in terms of interactions among three dynamic and interconnected dimensions: *niches* consisting of emerging technologies, innovative practices and supporting coalitions of actors; a *landscape* involving macro level political influences, shocks and developments; and, a *regime* made up of incumbent institutions, practices and technologies. The MLP suggests radical change can unfold as landscape developments and internal pressures act to destabilize the incumbent regime, creating opportunities for niche innovations to emerge and displace entrenched technologies, institutions and interests (Geels and Schot, 2007; Turnheim and Geels, 2012). Although transition writing has typically focused on the socio-technical processes of long-term system change, adequate weight has not always been given to political dimensions (Smith et al., 2010; Meadowcroft, 2011). This article responds to this criticism with a more deliberate focus on the political factors surrounding the transformation of the electricity system in Ontario. Indeed the analysis presented here suggests that *political intervention* was decisive in consolidating major shifts in the system of electricity provision. To be sure, this is a story of changing generation technologies (in fact, a layering of new technologies on top of old: coal, then hydro, then coal again, then nuclear, gas, new renewables, and so on); and of succeeding phases of electrification (nascent, expanding, saturated, and modernizing). But it is also one of shifting societal understandings of the relationship between electricity supply and economic development, and of appropriate ownership structures, actor configurations and regulatory frameworks. Precisely in order to track these changes we deploy an approach that pays attention to multiple dimensions when defining electricity system regime change and which identifies periods of instability which separate more stable regime conditions.

3. The evolution of Ontario's electric power system

In Canada, the generation, transmission and distribution of electricity fall primarily under provincial jurisdiction. The supply mix in Ontario – Canada's largest province at over 13 million inhabitants and its traditional manufacturing center – reflects legacy investments and more recent decisions. As of 2013, the province's generating capacity of 35,858 MW consisted of nuclear (36.2%), natural gas (27.9%), hydroelectricity (22.1%), coal (9.2%), wind (4.3%) and other sources (0.3%) (Independent Electricity System Operator, 2013a). In 2012, the province's electricity demand of 141.3 TW h was met primarily with nuclear (56.4%) and hydro (22.3%), while natural gas (14.6%), coal (2.8%), wind (3%) and other sources (0.8%) played a somewhat lesser role (Independent Electricity System Operator, 2013b). According to the Ontario Power Authority (2010a) – the provincial electricity planning body – electricity demand is projected to rise to 146 TW h in 2015 and 165 TW h by 2030. The OPA has been directed by the Ontario Ministry of Energy and Infrastructure to meet rising demand through natural gas, renewable energy sources and conservation. Nuclear is expected to continue providing approximately 50% of electricity demand through refurbishments and potential new reactor construction. Ontario maintains high-voltage interconnections with Quebec, Manitoba, New York, Michigan and Minnesota, and since 2006 has been a net-exporter of electricity. Ontario's electricity system is currently a hybrid market system with a regulated price plan for low volume consumers and a wholesale competitive hourly spot market for high volume consumers.

Ontario's electricity system has a rich and textured history. Viewing its development as a whole (1885–2013) we identify three distinct regime configurations (see Fig. 1), which we refer to as the *Dawn of Power* (prior to 1906), the *Endless Expansion* (1922–1997) and the *Hybrid* (2004 onward). These are separated by what we term *Periods of Flux* (1906–1922; and 1997–2004) during which it makes little sense to talk of a dominant electricity 'regime', because the system rules and actors were in a state of turbulence (see Fig. 2). We also identify two 'failed system models', which had powerful advocates during these periods of flux, and which might have led to the emergence of alternative regime configurations, but which were unable ultimately to secure adequate support: the *Regulated Private Monopoly Model* (1906–1922) and the *Privatized/Deregulated Model* (1998–2002). We will now consider this periodization in some detail, exploring interactions among landscape factors and regime and niche actors.

a) The Dawn of Power regime

Prior to 1906, the primary actors within the electricity regime consisted of privately owned coal-fired (followed by hydro-electric) generators and distributors who held tremendous market power over industrial and municipal electricity consumers (McKay, 1983). Backed by prominent financiers and investment banks, and deeply intertwined with electric railway and lighting interests (the initial drivers of electricity consumption), the Dawn of Power regime was focused on extracting the maximum profit from its operations. Expansion plans were focused on increasing capacity feeding Toronto and New York State as these were profitable load centers. Competition was limited and electricity consumers were captive to unreliable and high priced service (Biggar, 1920) (Table 1).

In 1902, a major landscape shock caused difficulties for the Dawn of Power regime. Pennsylvania coal field workers went on strike, resulting in a severe coal shortage for electricity and steam generation in Ontario (Biggar, 1920). Electricity prices skyrocketed and manufacturers were forced to shut down,

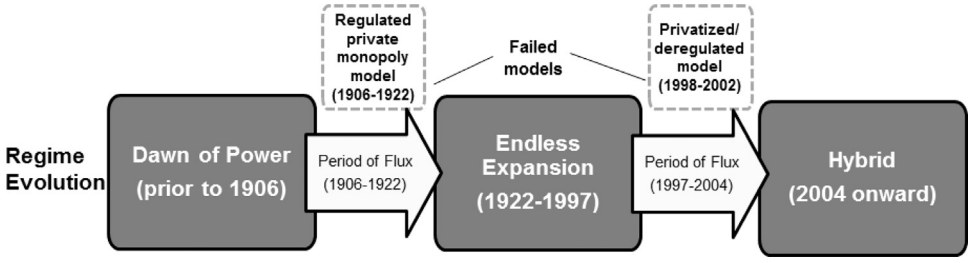

Fig. 1. The evolution of Ontario's electricity regime.