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 circumstances.
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 hydroelectric) 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,
exposing the vulnerability of the power system and the dependence of industry on imported coal. This encouraged a technological switch away from coal and the ramp up of hydroelectric development (Nelles, 2005). Another consequence of the coal shortage was to open up a battle between the Dawn of Power regime and interests calling for a reconfiguration of the electricity system. Coupled with growing dissatisfaction in regards to electric power provision, the coal famine destabilized the regime and opened a window of opportunity for the emergence of niche actors consisting of industry and municipal representatives opposing the abuses of market power, dependence on foreign fuel supplies, and inconsistent electricity service (Daniels and Trebilcock, 1996). In 1903, niche actors were successful in pressuring the Ross Liberal Government (1899–1905) to explore options for a publicly owned electricity system (White, 1985). Despite its support for the incumbent regime, the political administration established a commission to study a municipal cooperative system. In 1905, the Liberal government was defeated by J.P. Whitney’s Conservatives, who were more aligned with niche interests. The coalition of niche actors, now led by Adam Beck (a mayor, industrialist and provincial parliamentarian), prompted the Conservatives to appoint a new commission to examine the electricity issue. With Beck acting as chairman, this commission was tasked with investigating all forms of public involvement, including provincial ownership (Biggar, 1920). While municipal ownership may have been in keeping with the development trajectories of some other North American jurisdictions, the move towards provincial ownership was unprecedented within the landscape (Nelles, 2005).

b) Period of flux 1
In 1906, the vision for a public electricity system gained momentum with the release of a Beck commission report recommending the establishment of a provincial hydroelectric commission with regulatory power over private utilities (White, 1985). Simultaneously, Beck launched a campaign promoting public power. The report received limited support from the Conservative government who did not want to provoke the powerful and politically influential incumbents. However, Beck’s campaign garnered increasing backing from the general public, municipalities and industrialists (Nelles, 2005). Under pressure, the Conservatives created the Hydro-Electric Power Commission of Ontario (later known as Ontario Hydro), the first provincially owned utility in Canada. This organization was created at arm’s length from the government and reported directly to the legislature through its chairman. The newly formed commission was mandated to regulate private electricity companies and build grid infrastructure, starting with a transmission line to Niagara. Moreover, the commission was given controversial expropriation powers. With this, a viable alternative to the existing system configuration had been introduced and some degree of public ownership or oversight appeared to be inevitable. This marked an inflection point, after which the Dawn of Power regime ceased to be the dominant orientation (Fig. 3). Actors within the former Dawn of Power regime were split in terms of their response. Some agreed to work with the public power commission, while others were more antagonistic. On several occasions, private power companies attempted to orient the system towards a regulated private monopoly model (see Table 2). In 1908, for instance, a number of private power firms merged into a single private utility and endeavored to win political support for this model (Ross and Smith, 2011). From a landscape perspective, this proposed arrangement was in keeping with contemporary thinking around the electricity sector in North America (Nelles, 2005). However, even though a regulated private monopoly appeared to be a possible outcome at several junctures, this bid was ultimately unsuccessful. Private power advocates also launched a series of damaging media campaigns in an attempt to protect their interests and thwart further expansion of the public electricity network. These campaigns charged the provincial government with ‘socialism’ and the confiscation of private assets, eroding investor confidence in the province (Nelles, 2005). Furthermore, newspapers sympathetic to the former Dawn of Power regime published articles encouraging farmers along key Ontario Hydro transmission corridors to demand higher prices for surrendering their land (Biggar, 1920).

Campaigns by the private power companies had the unintended effect of galvanizing support for a publicly owned...
system within the Conservative party (Ross and Smith, 2011). As a result, the construction of a provincially owned and operated grid was permitted to advance. From the ‘switch on’ ceremony in 1910, Ontario Hydro became an operating entity capable of transmitting electricity from the lowest bidder. With the incumbents’ hold over the market diminished, Ontario Hydro began transmitting lowest cost electricity from private generators at Niagara to municipalities, while expanding operations throughout the province. The pace of early growth was rapid as the grid expanded from roughly 2 MW and 10 municipalities in 1910 to nearly 60 MW and 95 municipalities in 1914 (Nelles, 2005). This capacity would double by 1916 and again in 1917. To satisfy growing load requirements, Ontario Hydro also began generating its own power in 1914, initially through acquisitions but quickly followed by project development. Throughout, the role of municipal public utility commissions also expanded.

Ontario Hydro continued to weaken the incumbents by imposing limits on their use of water at Niagara and undermining their export contracts with the United States (Nelles, 2005). Beck capitalized on landscape developments (the electricity shortage during World War I) to further curtail the exports of private generators. Starved for revenue and increasingly captive to the whims of officials at Ontario Hydro, private power companies were gradually bought up. Despite continued criticisms from private power advocates (Fleming, 1992), the largest remaining privately owned electric power company was acquired by Ontario Hydro in 1922 (Ontario Power Generation, 2005). By this time, Ontario Hydro was producing more than four times as much electricity as private entities (White, 1985) Fig. 3.

c) The Endless Expansion regime

The new regime configuration – referred to here as the Endless Expansion regime – was founded upon low cost public power, rapid expansion and industrial development. The primary regime actors under this new configuration – many of whom had been central instigators of the earlier transformation – consisted of Ontario Hydro, electric component and appliance manufacturers, municipal distribution companies, various government agencies, and industrial energy users (McKay, 1983). Regime actors benefited tremendously from the rapid rollout of grid infrastructure and generating capacity, while political supporters and the province enjoyed unparalleled economic growth (Table 3).

The reign of the Endless Expansion regime spanned three quarters of a century (1922–1997). Understandably, regime dynamics, technological choices and impinging contextual factors varied considerably over this period. As a result, it can best be understood as comprised of three phases: (1) **Building an empire** (1922–1973), where expansion continued relatively unhindered; (2) **Cracks appear** (1973–1991), where expansion begins to erode, and (3) **Regime in crisis** (1991–1997), where external and internal forces build up, resulting ultimately in a collapse.

i) Building an empire (1922–1973)

For the first decades of its existence, the Endless Expansion regime gained momentum with relatively little resistance. Early expansion plans consisted of building grid infrastructure and large hydroelectric units (Ontario Power Generation, 2005). The development aspirations of the regime satisfied public, municipal and industrial interests by providing affordable and reliable power as well as tremendous economic growth. The electrification of industrial processes was encouraged through a variety of campaigns and incentives which helped to fuel additional demand and corresponding grid expansion.

Like other Canadian jurisdictions in the early 20th century, Ontario Hydro’s activities were deeply intertwined with the industrial development of the province (Hampton, 2003). Electricity was seen as a central means of achieving economic prosperity and successive political administrations (mainly Conservative) from 1922 to the 1970s provided Ontario Hydro with funding to implement ambitious expansion plans (McKay, 1983).

Landscape and internal dynamics facilitated expansion activities throughout the early decades of the regime. Landscape factors included: favorable political circumstances, substantial government spending and unprecedented economic growth in the province (Nelles, 2005). Internal enabling factors included the availability and low variable cost of hydroelectricity, which lent itself to the regime’s expansion strategy. The result was growing revenues for Ontario Hydro and municipal distribution companies along with rising profits for regime actors and aligned interests as the purchase of electrical appliances increased (McKay, 1983).

Still, the regime’s expansion plans faced some early pressures (supply surpluses during the Great Depression), political battles (primarily between Ontario Hydro and the government) and financial issues (Nelles, 2005). Yet these hurdles did not have lasting adverse impacts on the pace of development. As a result, over the course of the grid rollout, the regime and its expansion aspirations became increasingly socially embedded and intertwined with economic growth in the province.

In the 1950s, the electricity regime began vigorously promoting residential electricity consumption through the ‘Live Better Electrically’ campaign (Hampton, 2003). This campaign was a partnership between Ontario Hydro, electric appliance manufacturers and electrical system component producers. In addition to stimulating electricity demand, another aim was to use natural gas as the dominant space heating fuel by promoting the ‘all electric home’ despite the fact that natural gas was more affordable (McKay, 1983).

By the mid-1960s rising electricity demand created internal tensions for the electricity regime. The regime was predicting that 90,000 MW of installed capacity would be required to meet peak demand by the year 2000 (McKay, 1983). As a result of this anticipated growth, hydroelectric development was marginalized in favor of coal-fired and nuclear megaprojects. Concerns over the cost implications of massive nuclear and coal expansion plans went relatively unheeded at the time (Hampton, 2003).

Ontario’s nuclear era began with the completion of the nuclear demonstration project near Chalk River in 1962 (Swift and Stewart, 2004). The project was a joint venture...
between Ontario Hydro, Canadian General Electric and Atomic Energy Canada Limited. The facility used a single CANDU heavy water reactor with an output of 22 MW (Ontario Power Generation, 2005). The project foreshadowed the nuclear experience of the province as the station was behind schedule and over budget (Mckay, 1983). This plant was followed by the first commercial-scale nuclear demonstration project at Douglas Point (the site that would later be home to the Bruce nuclear station), which also encountered delays and cost overruns (Hampton, 2003). Before either of these stations had entered into service, Ontario Hydro had approved the construction of the considerably larger Pickering nuclear station. And, by the 1970s, plans for Darlington nuclear station, with a capacity of 3600 MW, would be in place. These plants would be plagued by mismanagement, cost overruns and delays, which would later haunt the regime (Winfield et al., 2006).


The first serious challenges encountered by the regime came with the 1973 oil crisis, which catalyzed two important changes within the electricity system (changes which were also experienced to varying degrees in other jurisdictions). First, it ushered in an era of energy conservation, dampening efforts to stimulate electricity demand (Mckay, 1983). Second, rising fossil fuel prices cemented Ontario Hydro’s preference for nuclear power (Ontario Energy Board, 2012), embedding this technology and its proponents more deeply within the regime and the province’s industrial development strategy. As of 1975, Ontario hydro planned for nuclear to meet 60–70% of the province’s future electricity demand (Mckay, 1983).

With a continued emphasis on nuclear expansion, the regime encountered mounting difficulties in the face of internal and landscape pressures. First, nuclear generation was becoming increasingly politically divisive (particularly in light of Three Mile Island in 1979 and Chernobyl in 1986) (cadham, 2009). Second, as electricity rates began to rise with the completion of nuclear units in the mid-1980s, a wedge was driven between the regime and industrial energy consumers (Dewees, 2001). Third, the province experienced periods of slow economic and electricity consumption growth in the 1980s. This drew the attention of successive political administrations to Ontario Hydro’s costly expansion plans and resulted in several downward revisions (Daniels and Trebilcock, 1996). A notable intervention into the regime’s affairs came with the Porter Commission (1975–1979), which attempted to reorient Ontario Hydro towards conservation and efficiency.

While the regime resisted these reorientation attempts, the release of Ontario Hydro’s 1989 plan ‘Providing the Balance of Power’ suggested that repeated interventions were bearing fruit (Swift and Stewart, 2004). The document reflected a growing appreciation that energy use and economic growth were becoming decoupled and represented a turn away from megaprojects in favor of smaller-scale generation and efficiency gains. This understanding ran counter to the guiding principles, practices and technological preferences the regime had pursued for several decades. However, the beliefs of the previous decades were difficult to dislodge as the 1989 report continued to forecast inflated electricity demand statistics, overestimating demand in 2012 by as much as 44.5% (Ontario Hydro, 1989).


During the 1990s, internal and landscape pressures began to compound and significantly destabilized the regime. The recession of the early 1990s and a long-term shift towards a service-based economy (also occurring in other North American jurisdictions) saw electricity demand stagnate or fall (Daniels and Trebilcock, 1996). As a result, Ontario Hydro had a smaller revenue base through which to recoup nuclear investments ($14.4 billion in the case of Darlington). This drove Ontario Hydro to raise electricity rates by 31 percent between 1991 and 1993, further reducing demand and fragmenting regime interests and supporters (Doern et al., 2001; Winfield et al., 2006). Essentially, Ontario Hydro was approaching insolvency.

International ideological winds were also shifting in favor of market deregulation, allowing pro-market niche actors to gain momentum. The Rae New Democrats (1990–1995) and Harris Conservatives (1995–2002) instituted a number of key changes, including: the strategic appointment of liberalization proponents to top positions within the bureaucracy; the creation of a simulated internal power exchange based on competition; several legislative amendments (for instance, expanding grid access to non-utility generators); the dismissal of nearly 30 percent of Ontario Hydro’s employees, most of whom were from the nuclear power division; and, the appointment of the Advisory Committee on Competition in Ontario’s Electricity System (1996) (Hampton, 2003; Swift and Stewart, 2004). The committee report (1996) proposed the privatization of much of Ontario Hydro’s assets as well as the creation of a competitive electricity market, arguing that the benefits to Ontario would include lower electricity rates, increased tax revenues and the elimination of Ontario Hydro’s stranded debt. Nevertheless, the Conservative government did not have sufficient political capital to proceed with privatization.

d) Period of flux 2

In 1997, the Endless Expansion regime was dealt a fatal blow with the release of the Independent and Integrated Performance Assessment Report headed by US nuclear expert Carl Andognini. The assessment was initiated by the president of Ontario Hydro after a series of performance and safety failures at the Pickering nuclear station from 1983 to 1996 prompted the Atomic Energy Control Board (predecessor to the Canadian Nuclear Safety Commission) to reduce the facility’s operating license from 2 years to 6 months (Taylor and Spivak, 2001). The report was highly critical of Ontario Hydro’s management of nuclear assets and resulted in the temporary shutdown of several reactors due to safety concerns (Energy Probe, 2009). This report was the final straw which provoked a crisis of legitimacy for the regime, marking an inflection point after which the old regime was no longer the dominant orientation and a privatized/deregulated model could move forward (Table 4).

Niche actors and their political supporters advanced a privatized/deregulated model founded upon the recommendations of the Advisory Committee on Competition in Ontario’s Electricity System. The potential beneficiaries of this new vision — many of whom had been intimately involved in designing the market rules — included investment banks, electricity marketing and trading companies, along with the Association of Major Power Consumers in Ontario. While large industrial energy users had been deeply intertwined with the previous regime, a market system promised lower rates through long-term contracts with low cost generators (Swift and Stewart, 2004). In 1998, the Energy Competition Act was passed, dismantling Ontario Hydro. The primary actor within the former regime was divided into separate entities that would be ready for privatization. The transmission and distribution functions were encompassed under Hydro One, whereas generation now fell under the purview of Ontario Power Generation (OPG). The Act saw
the creation of both the Electrical Safety Authority to adminis-
ter safety regulations and the Ontario Electricity Financial
Corporation to manage the stranded debt from Ontario Hydro.
The Independent Market Operator (IMO) – later renamed the
Independent Electricity System Operator (IESO) – was formed
to balance the electricity system and manage the competitive
market. Local distribution companies were also required to
incorporate under the Act, which promoted consolidation
under Hydro One (the province went from 306 local utilities
in 1998 to 92 by 2000) (Power Stream, 2012). In addition, the
role of the Ontario Energy Board (OEB) was expanded to
include the oversight of these new entities (Ontario Energy
Board, 2012).

Despite making progress towards a privatized/deregulated
model, this arrangement would never fully take hold due to a
perfect storm of landscape developments. On May 1st, 2002, in
the shadow of the California energy crisis and the collapse of
Enron, the Ontario wholesale and retail electricity markets
opened. At first, the market price of electricity remained low.
However, a summer heat wave in conjunction with lengthy
nuclear reactor repairs created a supply shortage and prompted
prices to rise precipitously (Simon, 2002). As prices continued
to rise, a public backlash was brewing which provoked some
Conservative caucus members to call for a rate freeze (Wyman,
2008). In response, Premier Eves froze rates at pre-market
levels in the autumn of 2002, aborting the privatized/deregu-
lated model. Fig. 4
e) The current electricity regime: the Hybrid configuration

Following the election of the McGuinty Liberals in 2003, the
government attempted to stabilize the electricity system and
address several unresolved issues left by their predecessors.
This resulted in what we describe as the Hybrid regime, with
characteristics reflecting both the Endless Expansion regime
and the failed privatized/deregulated model. First, the privati-
zation agenda was tempered: OPG would retain its assets,
Hydro One would not be privatized and vocal liberalization
advocates would be dismissed (Swift and Stewart, 2004).

Second, the competitive market was kept in place, while a
regulated price plan was created to offer price stability for low
volume consumers (Wyman, 2008). Finally, the OPA was estab-
lished in 2004 to plan for the electricity system, procure private
generation and develop programs related to demand manage-
ment, conservation and the promotion of cleaner energy sources
(Ontario Power Authority, 2010b). The government assumed
powers of ministerial direction over the OPA and, as a result, the
electricity regime was now under more direct control by
political actors than ever before (Wyman, 2008).

As part of the Liberal’s politically interventionist planning
process, three critical imperatives have been imposed on the
Hybrid regime: (1) a commitment to phase out coal-fired
generation by 2014, which was prompted initially by growing
public concern in regards to air quality issues (Rowlands, 2007);
(2) an obligation to ramp up conservation programs, including
the deployment of smart meters; and, (3) the encouragement of
cleaner electricity sources through the implementation of a
series of renewable energy support mechanisms, consisting of
the Renewable Energy Source Request for Proposals, the Renew-
able Energy Standard Offer Program (RESOP), the Green Energy
and Green Economy Act (GEGEA) and the Feed-in Tariff (FiT).
In addition to reorienting guiding principles, the transformation
also reorganized the dominant actors surrounding the electric-
ity system. The Ministry of Energy and Infrastructure now plays
a larger role than under previous configurations. Other promi-
nent regime actors include the OPA, OEB, IESO, OPG, Hydro One,
local distribution companies, investor owned and/or operated
generators (Bruce Power, for instance) as well as other govern-
ment agencies (Table 5).

The Hybrid regime continues to share several characteristics
with earlier configurations. The most prominent characteristics
consistent with the Endless Expansion configuration include:
the role of public ownership and operation; central planning
aspects; the link between the electricity system and the pro-
vince’s industrial strategy (although the strategy itself has
changed); the importance of nuclear; the emphasis on address-
sing supply constraints through expansion; and, the consistency
of actors (the offspring of Ontario Hydro). The aspects that
reflect the failed privatized/deregulated model consist of: a
growing preference for private investment; the increasing role
of private generators and operators; the emphasis on smaller,
less capital intensive projects; and, the (limited) role of the
competitive market in directing investment.

The current regime also exhibits novel characteristics that
differentiate it from earlier Ontario electricity regimes. In
particular, it is more fragile and has built up less inertia due to
its relatively brief existence. Furthermore, some issues remain
unsolved and potential exists for further reforms. For example,
there are continuing discussions about a potential merger of the
IESO and OPA (Ferguson, 2013) and the sale of municipal
distribution companies (O’Toole, 2012).

The Hybrid regime continues to grapple with external pressures
originating from both the landscape and niche dimensions.
Renewable energy advocates have organized around the elec-
tricity system and have been successful in lobbying for policy
support. Starting in 2004, the Ontario Sustainable Energy
Association (OSEA) and its membership emerged as important
niche actors pressing for the development of a stable renewable
energy policy. These actors have launched several campaigns for
a FIT (OSEA, 2011). Campaigns gained traction with the Liberals,
in part due to an ideological alignment and the promise of job
creation, affording renewable energy advocates a central role in
designing the RESOP, GEGEA and FIT.

Niche actors opposed to renewable energy deployment have
also been successful in mobilizing around electricity issues.

Table 4

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<td>Ownership</td>
<td>Private</td>
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<td>Guiding principles</td>
<td>Profit maximization</td>
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<td>Planning</td>
<td>Market directed</td>
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<td>Market</td>
<td>Competitive</td>
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<tr>
<td>Pricing</td>
<td>Depends on degree of consolidation and market</td>
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<tr>
<td>System organization</td>
<td>Centralized with some smaller scale projects</td>
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<tr>
<td>Technology preference</td>
<td>Natural Gas and other cost-competitive sources</td>
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<td>State of electrification</td>
<td>Saturated</td>
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Table 5
Key features of the Hybrid regime.

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<tr>
<th>Socio-technical characteristics</th>
<th>Hybrid (2004–current)</th>
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<tr>
<td>Ownership</td>
<td>Mixed with preference for private</td>
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<td>Guiding principles</td>
<td>Coal phase-out, conservation, clean energy strategy (all politically imposed)</td>
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<tr>
<td>Planning</td>
<td>Central planning with small role for market</td>
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<td>Market</td>
<td>Regulated/competitive</td>
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<tr>
<td>Pricing</td>
<td>Higher cost</td>
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<tr>
<td>System organization</td>
<td>Predominantly centralized with tolerance for small-scale distributed</td>
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<tr>
<td>Technology preference</td>
<td>Mixed</td>
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<td>State of electrification</td>
<td>Saturated/modernizing</td>
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During the 2011 provincial election, for instance, Wind Resistance Ontario (formerly Wind Concerns Ontario) and other community groups opposed to wind turbines campaigned against the current energy policy direction. Arguably, niche actors were instrumental in rallying rural communities during the election (Howlett and Ladurantaye, 2011). More recently, the Ontario Federation of Agriculture (2012), under pressure from its membership, backed off from its support of renewable energy deployment and called for the suspension of wind development until the interests of its membership are adequately protected.

A number of landscape developments have also influenced the Hybrid regime as wider societal debate about electricity policy has been reframed. Concerns over the environmental and health impacts of conventional generation have gradually increased since the 1970s. Moreover, the global financial crisis of 2008 has facilitated the advancement of renewable energy support mechanisms as a result of purported job creation benefits and a global consensus on stimulus spending. At present, the context of fiscal austerity is constraining the regime’s energy-related investment decisions.

4. Moving towards a low-carbon emission energy system in Ontario?

What does this analysis of the history of Ontario’s electricity regime suggest about the potential for movement towards a low-carbon emission energy system in Canada’s largest province? To address this question it is necessary to keep in mind some critical features of the ‘decarbonization’ project as well as the progress Ontario has already made in reducing electricity-related GHG emissions.

With respect to the character of the decarbonization challenge, note in the first place that this process will be politically driven. The scale of existing societal dependence on fossil fuels, their convenience and continued availability mean that sustained policy pressure will be required to encourage a decisive shift away from a GHG emitting development trajectory. Second, since energy-related emissions must be addressed across the economy – including those from transportation and other distributed sources such as residential heating – it makes little sense to approach decarbonization of the electricity sector outside this broader context. After all, electricity generation could meet a larger proportion of societal energy needs, by providing heat as well as power (through combined heat and power or ground source heat pumps), and by meeting a significant part of transport demand (through plug-in hybrid and electric vehicles or mass transit). Third, although the first impulse may be to focus on generation, changes to the ways electricity is used are crucial. Smart grids, energy storage, enhanced long distance transmission, combined heat and power and community energy systems will all be important as will closer integration of electricity system design with residential and commercial building technologies and spatial planning. Fourth, even if there is a strong societal commitment, decarbonization will only ever be one among a series of goals pursued by policymakers. Economic considerations (pricing, industrial strategy objectives), reliability of supply, social issues (regional development), and non-climate environmental impacts will remain central. Fifth, decarbonization is likely to stretch over decades and to confront a turbulent political and economic environment. There are bound to be surprises (consider how shale gas has transformed the North American energy context over the last five years) and, with time, feedback from climate change itself will affect the politico-economic context (for example, with the opening up of hydrocarbon extraction as warming accelerates in the Arctic, changes to hydroelectric potential as rainfall patterns shift, and increased demand for cooling with warmer summer temperatures).

With respect to progress so far, Ontario’s electricity system possesses a relatively low-carbon profile in comparison with many North American jurisdictions (see Fig. 5). Nuclear and hydroelectricity (with a smattering of new renewables) provide about 80% of electricity output in Ontario, with natural gas picking up the slack from declining coal generation. This is the result of legacy investments as well as the more recent decision to phase out coal, which essentially necessitated the reorganization of a quarter of electricity generation. This political decision, which was first taken in response to concerns over criterion air pollutants, was facilitated by: (1) the limited presence of coal within the generating mix; (2) the absence of coal production in Ontario (so no domestic jobs would be lost); (3) relatively quiescent demand growth (so the costs of new projects did not feed rapidly into retail power prices) and (4) the growing abundance and affordability of natural gas, which has blunted calls for a continued reliance on coal (Cunningham, 2012).

Although coal displacement has been largely successful (see Fig. 5), the decarbonization effort remains limited. The province has supported the deployment of new renewable energy technologies, with significant gains in installed capacity over the last several years. However, new renewables are playing a small role in comparison to the ramp up of natural gas (see Fig. 6). The province has rolled out smart meters and initiated time of use pricing. Yet,
the conservation benefits of these initiatives remain uncertain (Environmental Commissioner of Ontario, 2011, 2012).

Given this context, and the historical analysis presented above, we draw three lessons for the prospects for further decarbonization: first, residual momentum from previous regime configurations continues to influence the current trajectory; second, embedded guiding principles have played a central role in orienting the system; and third, politico-economic coalitions are vital for driving change (or alternatively frustrating it).

(1) Residual momentum
Earlier decisions continue to weigh on the existing Hybrid regime. This is most evident with respect to infrastructure, particularly the heavy investment in nuclear. One of the unanticipated consequences of the turn towards nuclear from the 1970s was to secure the relatively low-carbon emission footprint of Ontario’s current power system. However, as many of these plants approach the end of their operational lifetime, decisions must be made about their replacement. The substantial investment and financial risks associated with new-build nuclear have made regime actors and politicians wary of any rapid move in this direction. But there is residual momentum pushing towards a renewed nuclear commitment, including Ontario’s reliance on CANDU reactor designs, which represent the foundation of the Canadian nuclear industry (for if Ontario does not support CANDU with fresh orders what future can there be now that Quebec has turned its back on nuclear power?). Some refurbishment and lifetime extensions are possible, although this too has costs and critics, and the cheapest option right now would be to rollout more gas-fired generation units, moving the province further from a decarbonization pathway. While there is increasing interest in conservation (Spears, 2013), there is a residual reflex to expand generation capacity and this tension continues to constrain energy-related decision-making and potential decarbonization options.

(2) Embedded guiding principles
Perhaps the most remarkable aspect of the historical story was the resilience and longevity of what we have described as the ‘Endless Expansion Regime’. It survived for roughly seventy-five years, oversaw a massive increase in electricity usage, adapted to changing generation technologies, and for more than two decades successfully resisted political efforts to alter its course. Its relative stability rested on a broad political consensus about the economic significance of the electricity system — providing cheap power to fuel industrial activity. Although the regime was able to accommodate a succession of generation technologies (hydro, coal and nuclear), all were predicated on a centralized, large scale, supply-driven, model of power delivery where the core task was to push as much cheap power as possible down wires to commercial and retail customers. It was a techno-economic worldview which left little place for demand management, small-scale energy projects, combined heat and power, distributed energy and integrated energy solutions.

Although recent incremental progress with new renewables is promising, it is disjointed and has been driven largely by non-climate related objectives (health concerns around coal and the economic potential of a green economy, for example), raising questions about its coherence. What is missing is an explicit engagement with decarbonization founded on a long-term and integrated perspective that also addresses sectors such as transport and the built environment (Global Energy Assessment, 2012). In other words, a societal decarbonization imperative (rather than just electricity system decarbonization) needs to be embedded as a new guiding principle. And since many potential low-carbon pathways afford an important place to distributed generation, community energy solutions, semi-autonomous micro-grids, and other decentralized solutions, a consequent decarbonization perspective may well be in tension with the centralized visions which remain a legacy of nearly a century of power system development.

In the longer run, building public recognition of the centrality of the decarbonization effort and confidence in the future character of the electricity system will be crucial. Consolidation of the IESO and OPA may help with this, but many sectors of the public remain skeptical about energy infrastructure projects, whether conventional or renewable generation. In Ontario there is as yet no large scale societal recognition of the need to revolutionize the way society produces and consumes energy. And for the most part, it seems the public would like things more or less to continue as they have done. Convincing voters otherwise is a major challenge.

(3) Politico-economic coalitions
Politico-economic coalitions have played a pivotal role in instigating change and/or resisting it. The emergence of well-developed groups of actors around the electricity system has been implicated in the transformation of the system: at the turn of the 20th century, when a coalition of influential industrialists and municipal actors captured political power and laid the foundation for the most resilient electricity regime in the history of the province; and in the 1990s, when financial institutions, investors and political operators were successful in advancing an alternative vision for the system (although, this model did not fully take hold).

More recently, a coalition of renewable energy advocates (renewable energy producers and developers as well as public health advocacy groups) have been successful in influencing change. Nevertheless, this politico-economic coalition is relatively new and their influence is limited mostly to the Liberal government rather than the regime itself, and a change in government could diminish their power. In addition, this fledgling coalition continues to grapple with disjointed goals and visions (including, differing views on issues such as which technologies to pursue, how to manage siting conflicts, and the relative importance of community involvement).

The decarbonization project will require the development of a robust politico-economic coalition with shared interests around low-carbon objectives. This coalition need not be limited solely to renewable energy producers. Organizations engaging in conservation, firms involved in emerging smart grid technologies as well as electric vehicle manufacturers, for example, must also be at the table. These actors will need to propose a viable vision for the system based on low-carbon outcomes and play a role in swaying the politicians and the public. At present, these actors are disjointed and decarbonization strategies have been inadequately articulated.
A multitude of questions remain when contemplating low-carbon pathways for Ontario. First, will conservation be considered seriously? The historical case reveals that conservation, or a lack thereof, plays a fundamental role in determining the future orientation of energy provision and use. A robust commitment to conservation and efficiency would open a number of possible pathways, including the decommissioning of some nuclear capacity and/or natural gas units. Second, to what extent will the province renew its commitment to nuclear power? As a low-carbon source accounting for over 50% of electricity output, the future of nuclear will have a fundamental impact on the province’s low-carbon options. For instance, a nuclear revival – with its concomitant sustainability issues (environmental and budgetary) – may squeeze out emerging renewables and other decentralized or smaller-scale options, locking the system into a long-term nuclear trajectory. In contrast, a nuclear phase-out may create an opening for energy innovations or an even greater reliance on natural gas if emerging technologies are insufficiently developed. Third, will the province expand reliance on natural gas? Aided by shale gas development and plummeting prices, natural gas has experienced remarkable growth in the province and across North America. With the phase-out of coal, natural gas will be the only remaining source of carbon emissions in Ontario’s electricity supply mix. This raises questions about how natural gas will be used: as a temporary bridge, to facilitate new renewables or as a standalone future source with carbon capture and storage? At present, both the gas and nuclear industries are gearing up for the battle to secure their respective futures in Ontario’s electricity mix. Four, will the electricity system be used to shift emissions from transportation? The electrification of transportation presents a promising means of decarbonizing the broader energy system. However, it also presents problems in terms of accommodating additional demand. Five, will the province support emerging renewables with the deployment of synergetic technologies (electricity storage, for instance)? A renewable support pathway requires greater emphasis on energy efficient homes, smart grid technologies, dispatchable renewables and load, and electricity storage. Six, will increasing interconnections with neighboring jurisdictions be explored? If interconnections were expanded with hydroelectric systems in Quebec or Manitoba, hydro could be used to enable increased renewable energy penetration without the need for more natural gas units.

5. Conclusion

Employing the MLP as a heuristic device, our analysis explored the evolution of the electricity system in the province of Ontario and pointed to key features influencing change over the last century. The MLP, with its evolutionary, multi-dimensional and multi-actor framework, facilitated both the interpretation and articulation of the complex history of electric power development in Ontario. Although the historical story is in one sense that of technological change, the socio-political dynamics are of central importance, and continue to shape the trajectory of the electricity system. In particular, politics has played a fundamental role in propping up, directing and tearing down successive electricity regimes. Indeed, understanding regime change in this context was only possible through a close inspection of impinging political dynamics. Bringing political developments from the background to the foreground has yielded important insights with respect to the evolution of Ontario’s electricity system and future choices around decarbonization pathways.

In developing our periodization of Ontario electricity system evolution we relied on multiple criteria, including: phase of electrification; the societal understanding of the role of the electricity system in economic development; the structures of ownership, market and regulation; dominant technologies; and the relative stability of arrangements. Technologically, the electricity system has seen substantial changes in generation (and to a lesser extent transmission); but the centralized model of grid organization with a few producers pushing power to millions of consumers has remained largely stable. The layering of multiple generation technologies (hydro, coal, nuclear — each with its own socio-technical sub-systems involving fuel extraction, preparation and transport, distinctive physical plant, waste stream and environmental risks), and the centrality of electricity to economic development and public welfare, mean that the socio-technical regime changes over the past century are rather different from more straightforward socio-technical system replacement observed in other sectors (sailing ships to steam ships,outhouses to piped sewage systems, canals to railroads, and so on). From an alternative perspective, it could be argued that only through a fundamental break with the centralized model of electricity provision – for example, a shift to a dramatically decentralized system relying on widely distributed renewable generation – would a really radically different electricity ‘regime’ emerge. However, we believe that telling the story this way would be to brush over the societal significance of the changes traced here. Yet it does point to the malleability of the notion of socio-technical ‘regime change’ and its dependence on the perspective taken and the purposes of the study.

There is also the question of the extent to which elements of the Ontario story told here are generalizable to other localities. Certainly many jurisdictions in North America shared elements of the Ontario experience, including: disjointed early development, regional grid consolidation, prolonged expansion and rising electricity penetration, the landscape shocks of the 1970s oil crises, rising environmental concerns with fossil and nuclear generation, an ideological turn toward deregulation in the 1980s, and so on. Yet the particular stories have been heavily influenced by regional resource endowments and economic development trajectories, property and regulatory regimes, and contingent economic, social and political circumstances. Indeed, this suggests fruitful avenues for comparative research into power system evolution, in order to gain insight into the factors accelerating and retarding changes in systems of electricity provision, that may be pertinent for defining decarbonization pathways.

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