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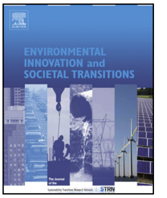

Low-carbon innovation from a hydroelectric base: The case of electric vehicles in Québec

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ABSTRACT

This article explores the transformative potential of hydroelectricity by examining interactions with electric vehicle (EV) technologies in Québec, Canada. It finds that structural features of Québec's hydroelectric regime enabled Québec's EV technological innovation system. Organizational and institutional characteristics of the socio-technical environment shaped by Québec's history of hydroelectric development played a particularly important role in promoting political legitimacy and early-stage EV innovation processes, such as knowledge development and exchange. While the technical complements between hydro and EV could lead to significant GHG reductions, technical overlaps between the two technologies were less responsible for initiating the momentum needed to build an EV innovation system. Québec's social history of hydroelectricity development provides actors with important resources for the development of EV technologies.

Abbreviations: EV, electric vehicles; MLP, multi-level perspective; TIS, technological innovation system; GW, gigawatt; HQ, Hydro-Québec; IREQ, Hydro-Québec Research Institute; GWh, gigawatt hour; SAAQ, The Québec Automobile Insurance Corporation; MDEIE, Ministry of Economic Development, Innovation, and Exportation; CNRS, French National Centre for Scientific Research; AC, alternating current; DC, direct current; USABC, United States Advanced Battery Consortium; CEVEQ, Québec Electric Vehicle Experimentation Centre; NEV, neighbourhood electric vehicle; CEO, Chief Executive Officer; R&D, Research and Development; ITAQ, Québec Advanced Transportation Institute; GHG, greenhouse gas; FTQ, Québec Federation of Labour.

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1. Introduction

Québec is a Canadian province with an abundance of hydroelectric resources. Recently, provincial leaders have outlined the ambition of becoming a “North American leader in the field of sustainable mobility through the use of hydroelectricity” (Government of Québec, 2011). This corresponds with the province’s traditional goal of using hydroelectricity as a catalyst for developing other industries such as aluminium, pulp and paper, and consulting engineering (Dales, 1957; Carpentier, 2006; Niosi and Faucher, 1987).

The goal of maximizing industrial linkages from natural resources, such as waterpower, is a recurrent issue in Canadian economic policy (Watkins, 1963, 2007). In the sustainability transition context, hydroelectricity could underpin new low-carbon technologies, such as electric vehicles (EV), and aid Canada’s escape from carbon lock-in (Haley, 2011). Nevertheless, previous experience with hydroelectric based industrial policies highlights that potentially advantageous sectoral or technological complements might fail to be realized. Historically, Canadian provinces developed hydroelectricity with the expectation that secondary manufacturing and other spin-offs would naturally evolve, however, these expectations were not fulfilled (Froschauer, 1999). To avoid repeating historic shortcomings, present-day policy agendas should consider exactly how and why EV might develop from a hydroelectric base.

This paper draws on socio-technical perspectives to investigate the performance of the emerging EV technological innovation system (TIS) in a structural environment strongly influenced by a hydroelectric “regime”. It seeks to determine how the hydroelectric regime enables, or possibly blocks, EV development by exploring the structural characteristics that influence certain innovation activities or processes, the extent to which the hydro regime versus other structural factors influence TIS development, and if there are gaps or weaknesses that policymakers should consider.

The paper is organized into the following sections: theoretical approach; research approach and methods; Québec hydroelectric and transport systems; case study of Québec EV innovations; survey of innovation processes complemented by hydroelectric structures; discussion of the findings; and conclusion.

2. Theoretical approach

Early systems of innovation approaches focused on strengths and weaknesses of structural components such as infrastructure, actors, networks, and institutions (Nelson, 1993; Lundvall, 1992). In response to drawbacks identified in this approach, researchers began to study “innovation functions” (Bergek et al., 2008; Hekkert et al., 2007). Rather than mapping the end result of innovation through technology diffusion curves or structural analyses, the functions approach permits a tracing of the activities or processes that lead to innovation. This approach provides clearer guidance to policy makers aiming to promote the evolution of new innovations. Alkemade et al. (2007) highlight that functional analyses are especially relevant to studying the performance of “technological innovation systems” (TIS), which are smaller-scale and less complex than national or regional systems.

More recently Jacobsson and Bergek (2011) identified studying the interaction of technology specific systems with higher system levels as a fruitful research avenue. They identified a need to consider not only the internal dynamics of a TIS, but also to consider how a TIS is formed by accessing “resources from their contexts”, which could be provided by related industries or the structures of national, regional, or sectoral innovation systems. Likewise, Coenen et al. (2012) highlight the importance of regional context in understanding why a TIS might successfully develop in certain places over others.

Considering higher system levels re-introduces greater complexity and makes drawing system boundaries difficult (Carlsson et al., 2002). We must ask what aspects of the structural context to consider. One option is to explore how the diffusion of a particular technology (e.g. hydroelectricity) influences structure and thus influences the selection environment encountered by other technologies (see Sandén, 2004). Sandén and Hillman (2011) created a framework for studying technological interactions by examining “structural overlaps” between two systems. These overlaps can occur across a value chain because of shared production processes or input–output relations, but they can also exist across socio-technical dimensions. For example, shared knowledge, actor coalitions, organizational