A Comparative Study of Innovation Activities within Regulated Electricity Distribution Utilities in the UK and Ontario, Canada

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Authors:

David Barrows
Associate Director MPA Program Schulich School of Business York University

Bill Hawkins
Research Associate Schulich School of Business York University

Atipol Supapol
Associate Professor Schulich School of Business York University

J. S. Michel
Assistant Professor University of Montreal

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Introduction

In many jurisdictions across the world, policy makers are grappling with twin objectives of stimulating economic growth while improving the environmental performance of their electricity sectors.

To achieve the latter, new clean electricity generation technologies and dynamic pricing schemes are being encouraged. But for the deployment of these smaller-scale, and (often) intermittent forms of generation technologies and associated dynamic pricing programs to be successful, a fundamental transformation of existing electricity delivery grids – especially the lower-voltage distribution networks, to which the majority of these units will be connected – is required. Utility infrastructure systems that were designed and built generations ago to accommodate the one-way flow of electricity from large-scale power plants must now be overhauled to facilitate the two-way flow of both electricity and the information necessary to actively manage highly-dynamic supply and demand. Advanced technologies – for connections, conveyance, metering, data and grid management, information presentment etc… – must be developed, applied and introduced to the electricity distribution sector, along with the skills to utilize these new technologies effectively.

To achieve the former, the investment to improve electricity sector environmental performance must be efficient; the all-in total cost of power cannot be allowed to rise to uncompetitive levels. But with the cost of electricity produced from many clean generation technologies still at multiples of historical power prices, the pressure on regulators to facilitate the required modernization of distribution networks in the most cost-effective manner is intense. At the same time, policy makers in many jurisdictions are intent upon realizing the potentially significant opportunities to attract investment and realize the economic benefits of developing and supplying the advanced grid technologies to satisfy the rising global demand.

Compounding the challenge of achieving these twin objectives are the legacy effects of the efficiency-focused power industry reforms launched in many jurisdictions over the past 20 years. Research now indicates that these restructuring initiatives, which produced impressive efficiency results in certain jurisdictions (and fundamental instability in others), have contributed to a significant decrease in the degree of R&D expenditures and innovation activities across all segments of the electricity industry including distribution. This effect, described as providing evidence of a 'market failure' (Jamasb and Pollitt, 2005), is generating serious concern regarding its possible impact on electricity industries' ability to produce the innovations required to meet the ambitious environmental performance improvements now being sought by policymakers around the world. This concern is heightened when it is considered that the electricity industries exhibited relatively low levels of innovation intensity even before the restructuring wave took hold two decades ago, and 95% of the R&D undertaken within electricity sectors occurs within the world's advanced economies (Dooley and Runci, 2000. p. 225), many of which embraced the liberalization reforms most enthusiastically.

Within this context, the authors have elected to study and compare the innovation dynamics present within the distribution segments of the electricity industries in the United Kingdom (UK) and Canada's largest province, Ontario. Policymakers in both jurisdictions undertook fundamental restructurings of their power sectors: the UK's in the 1980s and Ontario's beginning in the late 1990's. And the governments in both jurisdictions have recently launched broad electricity-sector policies designed to simultaneously improve environmental performance and stimulate economic growth via development of a new, clean energy technology industry.

The intensively-regulated monopoly distribution segment was chosen in particular due to its' critically important regionally-focused role as connector of most consumers (all but the largest industrial customers, who often connect directly to high-voltage transmission networks), and, increasingly, the emerging small-scale distributed generation resources. As well, in many jurisdictions including Ontario, distributors are, in addition to owners and operators of the distribution grid, also commercial providers of advanced metering technologies and demand management services directly to end-users. Given these roles, and the local orientation of these network firms (there are over 80 Local Distribution Companies – predominantly government-owned in Ontario, and 8 Distribution Network Operators – private-sector firms – in the UK), the distribution segment of the electricity industry has the significant potential to play a vital facilitative role in the transition from yesterday's centralized, large-scale and passive grid architecture to tomorrow's decentralized, small-scale and highly-interactive networks, as well as the development of domestic 'innovation systems' and 'clusters'.

The primary objectives of this paper are to provide insight – for academic audiences, as well as policymakers and utility managers – into the degree, scope and nature of innovation activities occurring within the regulated distribution sector within the two study jurisdictions, and the available institutional means of increasing the sector's innovation-related contributions to economic growth and broader public policy ends. In addition, this comparative study seeks to outline and analyze the sectoral innovation systems present in the UK's and Ontario's regulated electricity utility industries.

In pursuing these objectives the paper compares the innovation activity of distribution utilities, within the UK and Ontario over the two most recent regulatory frameworks that operated in each market, and looks ahead to anticipated utility activities under the new frameworks which have been installed very recently in each jurisdiction.

UK Distribution Network Operator (DNO) activity through Distribution Price Control (DPCR) 3, in force from 2000-2005, and DPRC4 (2005-2010) is studied. The authors also describe and contemplate DNO behavior under DPCR5, which commenced in April 2010.

Local Distribution Company (LDC) activity in Ontario is studied from the end of the 1st Generation Incentive Regulation Mechanism (1GIRM) in 2006, through 2nd and 3rd Generation IRM (from 2007 to present). The authors also describe and contemplate LDC activity under the Green Energy and Green Economy Act (GEGEA) passed in 2009 which generates new obligations and opportunities for LDCs in the areas of connecting small-scale generation, developing 'smart grids' and introducing smart-meter and time-of-use-pricing-enabled Conservation & Demand Management (CDM) services for end-users.

Based on this research into the innovation activities of distributors within the recent and current policy/institutional frameworks present in both jurisdictions, the characteristics and conditions of the innovation systems present in distribution utility sectors are deduced, discussed and analyzed.

The paper is comprised of the following 6 sections. The research methodology employed in this study is described in Part 1, followed in Part 2 by a review of the innovation theory literature. Part 3 contains the description of the evolution of the policy and institutional environments within the two survey jurisdictions (UK and Ontario) over the respective study periods. Part 4 summarizes and analyzes the research and interview data. Part 5 describes and compares the jurisdictions as sectoral innovation systems. Part 6 summarizes the conclusions drawn from the study and the authors' policy recommendations regarding the available institutional means of increasing the electricity distribution sector's innovation-sourced contributions to economic growth and broader public policy ends.

Part 1: Research Methodology

As noted in the Introduction section of this paper, the authors have elected to study and compare the innovation dynamics present within the distribution segments of the electricity industries in the United Kingdom (UK) and Canada's largest province, Ontario. The primary objectives of this paper are to provide insight – for academic audiences, as well as policymakers and utility managers – into the degree, scope and nature of innovation activities within the regulated distribution sector within the two study jurisdictions, and the available institutional means of increasing the sector's innovation-related contributions to economic growth and broader public policy ends. A secondary objective is to contribute to the academic literature on the role of innovation in economic growth by providing a description and comparative analysis of the sectoral innovation systems present in the UK's and Ontario's regulated electricity utility industries.

To fulfill these objectives, the authors undertook four separate research initiatives. First, the available academic literature describing innovation activities within electricity distribution sectors, and electricity industries more broadly, were surveyed. Relevant details regarding innovation activity trends evident over the past 20 years (both before, during and after liberalization efforts), and factors underlying those trends, were recorded.

Second, the policy / institutional changes that occurred within the UK and Ontario electricity distribution utility sectors were researched and documented. In the UK, changes were researched back to the commencement of DPCR3 in April 2000. In Ontario, changes were researched back to final year of the 1st Generation IRM/end of the distribution rate-freeze period in 2006. Relevant details regarding key policy objectives, the policy/regulatory mechanisms to achieve those objectives, and material policy/regulatory changes through the study period were recorded for both jurisdictions (see Section 1 of this paper).

Third, a set of interviews with representative samples of distribution utility executives from both the UK and Ontario were conducted. In the UK – where there exist 8 DNOs serving 14 service territories – the authors interviewed executives from 4 DNOs which serve 8 service territories. In Ontario – where there exist over 80 LDCs serving an equal number of territories – the authors interviewed executives from 8 LDCs (including the largest 2 in the province) which collectively serve over 51% of the end-use customers in the jurisdiction. Interviews with these distribution utility executives were conducted in-person (with the exception of 1 in the UK, which was conducted by telephone). A common set of open-ended questions were used by the interviewers. The questions focused on understanding changes in utility innovation activity over the recent regulatory regimes (DPRC3, 4 & 5 in the UK, and 1st, 2nd and 3rd Generation IRM in Ontario), and the factors underlying those changes. Audio recordings and written notes were taken of each of the interviews. The same question set was used in additional interviews conducted with the industry regulators in the UK (OFGEM) and Ontario (OEB), as well as supplier firms active in the utility sector in both survey jurisdictions (GE and Cap Gemini). All interview subjects, interview dates, and the question set are documented in Appendix A.

Fourth, surveys were issued to senior-level managers in each of the distribution utilities in the UK and Ontario. These surveys sought specific firm-level information on innovation activities undertaken by each utility over the same regulatory periods as referenced above, and their utility's motivations for actions taken. The same questions were posed to the utilities in the UK and Ontario; the only material differences in the surveys used in each jurisdiction were the different regulatory time-periods covered. The survey execution and results tabulation was professionally completed by the Institute for Social Research at York University. Copies of the surveys are located in Appendix B.

For the interviews and the survey instruments, the interview subjects/respondents were supplied with common definitions of key terms (e.g. "Innovation", innovation type, "R&D". "Demonstration", "Adoption", etc…). Using the conceptual framework provided by the modern 'chain-linked' model of innovation as a foundation, questions were designed to take stock of each utility's innovation activities over the defined timeperiods. Both quantitative and qualitative measures of key dimensions of the innovation sub-processes, and the outputs, were used.

With respect to measuring the innovation activities of the distributors in the UK and Ontario, as described in detail in the literature review section of this paper, the modern view of the process of innovation is that it is composed of three overlapping sub-processes: the 'production of knowledge, the 'transformation of knowledge into artefacts' (e.g. new and improved products and processes), and the 'continuous matching of these artefacts to market needs and demands'. By focusing at the level of individual firm, the authors undertook to measure the degree to which distributors in each survey jurisdiction participated over the defined study periods in activities involved in the three sub-processes, along with the nature of their participation and outputs of their participation. The table below outlines a few basic examples of activity inputs and outputs, within each of the sub-processes (note that these are not intended to be exhaustive).

Sub-Process	**Input**	**Output**
Knowledge Production	Expenditure on R&D (often measured as 'intensity' i.e. R&D spend relative to sales)	# of inventions successfully produced (sometimes narrowly measured as # of patents)
Artefact Creation	# of Demonstration projects participated in	# of innovations successfully created
Matching Artefacts to Market Needs	# of innovations adopted	• Degree of adaption of innovations adopted • Benefits / results achieved from innovations adopted

The results of input and output indicators like those above, along with the results of the interviews, were used to track changes in performance of individual firms, as well as (where possible) the populations of distributors in each survey jurisdiction, over the study periods. Insights into potential driver factors of relative performance of individual distributors, and the overall distribution utility sector in each jurisdiction were gained through cross-tabulation of the input and output data relative to other characteristics of the firms and policy/institutional frameworks, for example:

- Proportion of employees with specialized educational backgrounds and/or advanced degrees (e.g. science & engineering, finance, etc…)
- # of Research-Focused Linkages (e.g. R&D partnerships with post-secondary institutions, etc…)
- # of Commercial Partnerships (e.g. Joint Ventures, Licensing Agreements, etc…)
- Motivations for engaging in R&D, Demonstration project, or Adoption of innovations
- Sources of innovation adopted (e.g. from development projects the firm participated in, or R&D it funded?)
- Elapsed time of adoption decisions relative to the first awareness of the innovation
- Material changes to the policy/institutional/systemic environment

Additionally, the policy / institutional environments of each jurisdiction were analyzed and combined with the interview data to develop outlines of the innovation systems present in each distribution sector. These system outlines were then analyzed and assessed using the key theoretical frameworks identified through the literature review as a 'lens'.

Part 2: Literature Review

Innovation activity – "thinking about new and better ways of doing things, and trying them out in practice" (Fagerberg, 2005. p1) – is a key behavioural trait exhibited by humankind. Evidence that this behaviour is a driver of our social and economic development surrounds us; innovations such as airplanes, automobiles, computers, telecommunications, and pharmaceuticals are essential to our modern lives. And underlying each are the fundamental innovations of the past e.g. the printing press, alphabet, mathematics, the periodic table, double entry bookkeeping, agriculture, etc....

This section provides an overview of the key concepts from the academic literature on innovation. It starts with a review of the basic theory of how innovation activity drives economic development, including how innovation-driven growth tends to occur in 'clusters', and the key role the 'diffusion' of innovations plays in generating economic development. Next, the evolution in the conceptualization of the innovation process is described, from the early 'linear' model through to the modern view of the production of innovations via a 'chain-linked' process, occurring within a 'system'. The conduct of innovation within the specialized context of regulated monopoly industries is discussed. Lastly, the innovation activity trends evident in electricity industries are outlined, along with the challenges they present.

The Basic Theory: Innovation Drives Economic Development

The argument that technological innovation is a key driver of economic development was advanced by Adam Smith and Karl Marx, but pioneered in the western academic context by Joseph Schumpeter who joined the Harvard faculty in 1932 and published an English-language version of his "Theory of Economic Development" paper in 1934 (Fagerberg, 2005). Eclipsed for many decades by macroeconomic theories focused on concepts of aggregate demand (Keynesian Theory), the allocation of supplies of capital and labour and the selection by purely rational actors of the most logical course of action from a fixed set of known alternatives (neoclassical economics), the concept of development driven by competition through innovation rose to prominence in the 1970s and 80s as the search for a more valid explanatory theory occurred following the 'stagflation' crises, and the rapid emergence of 'newly industrialized economies' and highly complex, dynamic and constantly variable competitive environments

(Mytelka/OECD 2001; Lundvall, 1995. p6). The academic literature has grown exponentially in the period since, and in parallel, policy-makers around the world have increasingly turned to innovation theory as a foundation for industrial and regional economic development policies (OECD-Eurostat 2005).

The essential elements of the theory of competition through innovation as a driver of economic development are as follows. When an 'innovation' i.e. a 'new or improved product or process' (Fagerberg, 2005 p.7) is introduced within an industry, the 'innovating firm' will be rewarded with higher profits. When the innovation and its positive effect are noticed by other firms in the industry, they seek to realize the same benefit by imitating it. The 'swarming' behaviour of these 'imitator firms' triggers investment and growth in the industry (Fagerberg, 2005), and causes the innovation to 'diffuse' via adoption (Metcalfe, 2005). As diffusion occurs, the higher profitability of the innovating firm (i.e. the first mover advantage) erodes (Fagerberg, 2005), but broader social and economic benefits are generated from the mass adoption of the innovation (Metcalfe, 2005).

One of Schumpeter's most important observations was that the act of imitation tends to be an active, creative process through which imitating firms seek to improve upon the original innovation and leverage it in new ways both within the initial and related industries. It is this dynamic process ('induced innovation', which involves adaptation of products and processes, through and by firms and organizations operating within 'networks') that causes innovations and economic growth "to concentrate in certain sectors or their surroundings" or "clusters" (Fagerberg, 2005. p 15; Schumpeter 1939 p 100-101). Examples of this phenomena exist throughout history, and can be observed at differing levels, for example at the national level the world's centre of innovation through the mid-19th century was clearly the UK (with productivity and income levels 50% higher than other nations), while through the early 20th century Germany led the world's technological development, with the US being dominant from the mid-20th century (Fagerberg, 2005. p 14). At the regional/community level California's Silicon Valley has for several decades been the recognized centre of information technology development, while New York and London have led in financial services innovation. Examples of the same clustering effect can be observed in Ontario, including in the Kitchener-Waterloo region in mobile communications and software development, and Toronto in financial services. Much attention has been invested in developing an understanding of the conditions that give rise to this clustering effect, and policy makers around the world are constantly striving to ensure their policies (fiscal, industrial, trade, educational, social, urban, etc…) and the broader institutional framework (e.g. public-private sector linkages, financial and legal institutions, etc…) are designed and coordinated to achieve it. A key example of this is the Ontario government's recent focus on generating cluster-driven economic development through the design of its 'green energy' policies (which themselves are being challenged via the WTO process as unfair by jurisdictions competing to become green energy technology and investment leaders, like Japan).

The Diffusion of Innovations: The Key Means of Producing Social & Economic Benefits

> "Once an innovation is introduced for the first time, the battle is only party won, since it must still gain widespread acceptance and use. The rate of diffusion is of great importance. The full social benefits of an innovation will not be realized if its use spreads too slowly." (E. Mansfield, quoted in Metcalfe, 2005. p. 172)

Edwin Mansfield's research through the 1960s and 70s was critical to building an understanding of how exactly firm-level innovation stimulated economy-wide development. In explaining the process, Mansfield emphasized the difference for broader social and economic development between the adoption decision by individual firms and "diffusion" i.e. the "economic importance of an innovation as measured by, for example, the proportion of the output of an industry that is produced with a given innovation" (Metcalfe 2005 p. 172). It is the mass diffusion of innovations that drives the beneficial impact of innovations on employment, productivity, and economic growth overall.

Mansfield's research illustrated that there exists a "general logistic law describing the relative diffusion of competing innovations in a population of technologies that serve some common economic purpose. It is the logistic law that predisposes population dynamics to generate logistic curves when the diffusion data are plotted over time." (Metcalfe 2005, p 171) This observation is key to appreciating at an industry-wide or economy-wide level the acceleration, then retardation of innovation diffusion that tends to be observed. It also provides evidence that the decision to adopt by individual actors (which in the aggregate drives the diffusion process) is made at different times.

When the phenomenon of innovation-driven economic development is viewed from this perspective, understanding the process and drivers of adoption becomes paramount. As Schumpeter made clear, a primary motivation for firms to engage in innovation is to profit from the commercial advantages innovation generates. While more recent research broadly substantiates that assertion, it also provides evidence that all firms do not exhibit homogenous motivations to innovate.

Consistent with Schumpeter's theory, Mansfield's study of innovations across industries (Mansfield, 1968) illustrated that adoption (and more broadly, diffusion) is a largely a product of firms' economic investment decisions, with 'profitability' and 'capital cost' accounting for 90% of the changes in adoption rates over time (Metcalfe, 2005). Recognizing the importance of private economic gain in motivating innovation, but the importance of diffusion (with its effect of eroding the advantage of the innovating firm) in producing broader economic and social benefit, consideration of how and for what period the benefits of innovations are 'appropriated' by innovating firms becomes key. How firms can protect/enhance their ability to appropriate benefits of their innovations, to profit from its successful pursuit and to maintain for a sufficient period sustained competitive advantage is a critically-important question. Policy makers have an obvious and natural interest in ensuring not simply that innovations occur but also that those same innovations subsequently and rapidly diffuse across industries and related sectors via adoption by other firms. But policies that seek to promote diffusion and rapidly deliver to consumers the benefits (often manifested in price-reduction) of innovation-driven efficiency gains (like, for example, policies that reduce patent protection periods, or regulation to impose price reductions on innovating firms) contain the risk of curtailing innovating firms' ability to appropriate sufficient benefit from their innovations to such a degree that the motivation to innovate becomes too diluted to stimulate the behaviour in the first place.

At the same time, other researchers have found that the possibility of economic benefit is not always the sole, or most powerful, factor that drives adoption. This point is illustrated by the research of Everett Rogers' (1995) which suggests that adoption decisions reflect not narrow economic considerations, but a cognitive process of learning. Rogers discovered that the mere provision of information regarding an innovation to a group of potential users was sufficient to create a linear progression from 'ignorance to interest', with the development of 'interest' being key to the decision to adopt. In testing this theory, subsequent research (Kaplan, 1999) discovered that Rogers' assertion (that knowledge leads to interest, and interest to the adoption decision) appears to hold true only for 'early adopters' (firms inherently inclined to adopt innovations). For 'later adopters', whose behaviour is particularly key to generating the mass adoption of innovations (i.e. diffusion), Kaplan's research (on, interestingly in the context of this particular paper, the adoption of solar photo-voltaic technology by rural and municipal utility managers) illustrates that 'affect' (emotion) matters significantly. 'Familiarity' – what Kaplan argues is the product of experience combined with knowledge – appears to be an important key to sparking the interest of later adopters, and triggering in them a subsequent decision to adopt.

What the above-cited works make clear is that modern research has illustrated firms exhibit heterogenous motivations and inclinations for innovating and adopting. The importance of tacit knowledge, learning effects, self-reinforcing routines, and emotion/perceptions in the diffusion process, alongside economic/investment considerations and invention/knowledge creation factors have all been observed. In other words, the multi-dimensionality, circumstance-specificity and high complexity of innovation-related decisions (and thus the innovation diffusion process) has been recognized and must be taken into account if a full understanding is to be gained of how innovation drives economic development.

Just as recent research brought to light the complexity of the means through which innovation drives economic development, so too has it produced a dramatic evolution in the conception of the process through which innovation itself occurs.

The Early View: Innovation via a Linear, Science-based Process, Generating Radical Change

Perhaps not surprisingly, much of the early academic work in the field of innovation theory focused on and emphasized the importance of technological inventions (usually tangible capital goods based on patented concepts) and their creation via basic research and R&D

(Mytelka/OECD, 2001). The 1945 report authored by Vannevar Bush, the Director of the US Office of Scientific Research and Development, to US President Roosevelt provides a classic example of this thinking in positing that basic research was the source of "progress" on all key fronts: disease, national security, public welfare, economic development and growth (Bush, 1945). Consistent with this early line of thinking, a conception of the process innovation as a 'linear model' emerged. In this model, innovation was viewed as applied science, with well-defined stages that are progressed through sequentially: Basic Research, then Development, then Deployment/Mass Production (Fagerberg, 2005). A clear implication of this early work was that a chain of causation exists between the stages of the process, with the outputs of basic research as the fundamental driver of the process (Fagerberg, 2005). In terms of outputs, the invention of 'radical' innovations (i.e. revolutionary technological inventions) were emphasized as being of primary importance, as opposed to 'incremental' innovations which were considered of secondary interest (Fagerberg, 2005). Whether radical or incremental, the early research observed that innovations could be generally categorized as types of either 'products' or 'processes' (Fagerberg, 2005; Schmookler, 1966).

While the general categorization of innovation types remains broadly accepted today (albeit with the clear recognition that these are highly generalized terms, i.e. that 'products' encompass both tangible and intangible goods and services, and 'process' innovations encompass a wide range of typologies e.g. production processes, organizational structures/ designs, marketing techniques, etc…), more recent scholarly work has illustrated the weakness of many of the assumptions which were reflected in the early thinking. In a very influential paper published in 1986, Kline and Rosenberg observed that instead of relying on basic research, firms most commonly generate commercial innovations by "reviewing and combining existing knowledge" (Fagerberg, 2005 p.9; Kline and Rosenberg, 1986). The importance of 'tacit knowledge' in the process of innovation became recognized, and scholars (Von Hippel 1988; Lundvall 1988) observed it is actually the "experience of users" (learning by using/doing) that appears to be the most important source of innovation, not basic science. As well, Kline and Rosenberg also observed that the majority of innovations are not produced by firms via a linear sequence through clear stages, but rather via iterative processes involving many feedback loops and varied inputs (often from other organizations/actors). Further, it has become a widely held view that "the cumulative impact of incremental innovations is just as great (if not greater) (than radical innovations), and that to ignore these lends to a biased view of long run economic and social change" (Fagerberg, 2005, p. 8; Lundvall, 1988).

Contemporary research has also illustrated that there is a distinct difference between the act of 'invention' i.e. "the first occurrence of an idea for a new product or process", and the act of 'innovation' i.e. the first attempt to carry out a new product or process in commercial practice (Fagerberg, 2005. p 4), and that these different acts are routinely carried out by different actors, in different places and at different times. Lags of several decades or more between invention and innovation are not uncommon (Fagerberg, 2005; Rogers, 1995). This fact reflects that to convert inventions into innovations firms operate within fundamentally different environments, and need a far different set of resources, skills, knowledge and relationships than the individuals or organizations that generated the invention.

It has also been recognized that innovating firms routinely face material uncertainties, and that precise outcomes of their initiatives (innovation included) cannot be predicted ex ante with any significant degree of accuracy. In the face of this uncertainty, firms display a tendency to develop internal 'routines' which when followed permit them to exist within the environmental circumstances they are accustomed to facing. The strategic decisions made by the managers of firms reflect these routines, which may or may not be suitable to permit the firm to successfully exist in the unknown environmental circumstances of the future. In this context, decisions to fully commit to particular innovations carry the risk of 'locking-in' firms to specific technologies and/or approaches (Fagerberg, 2005; Mytelka/OECD, 2001; Arthur, 1994). Adoption decisions, which often involve significant investment in adapting the particular innovation being deployed, can – especially when they reflect and reinforce existing routines – generate 'inertia' and 'path-dependency', where the future course of the firm is dependent upon the outcome of the innovations deployed by it. Just as this is a real risk at the level of individual firms, it can also exist across entire industries and sectors.

The Modern View: Innovation via Feedback-based Sub-Processes, Operating within Systems

As a result of the deeper understanding produced by the intensified research undertaken in the field of innovation studies over the last 40 years, a new conception of the innovation process has emerged. Based significantly on the foundational research of Kline & Rosenberg (1986), the contemporary view of innovation is of a 'chain-linked' (as opposed to 'linear') process. In contrast to the causal-staged linear model of science-generated invention production, the 'chain-linked' concept describes innovations as being produced via an iterative process based on varied inputs and feedbacks, and featuring overlapping 'sub-processes': the 'production of knowledge, the 'transformation of knowledge into artefacts' (e.g. new and improved products and processes), and the 'continuous matching of these artefacts to market needs and demands' (Pavitt, 2005. p. 86).

Inventions generated through basic scientific research and R&D are still recognized as an important input to the production of new knowledge (i.e. a key part of one of the subprocesses), however the model recognizes the key research finding that R&D tends to be undertaken as a problem solving step within the broader innovation process, rather than being the initiating factor to the process (Smith, 2005; Kline and Rosenberg, 1986). Instead, it is the experience of the actors within the innovation process (firms, their customers and suppliers) recombining features and aspects of existing products and processes (i.e. via learning by doing and using, with results translated back via feedback loops) that is now recognized as the key driver of the process.

As well, the significant contribution of incremental innovations to economic and social development is now also fully recognized, as is the highly imitative and adaptive nature of most innovation initiatives (as opposed to involving the deployment of radical new inventions). Overall, the innovation process is characterized by highly externally-dependent actors operating under conditions of fundamental uncertainty, with inherently-biased and 'bounded' (i.e. constrained) knowledge, capabilities, routines and resource sets.

A central feature of the contemporary view of innovation is that firms depend materially on external sources for key inputs and feedback (Fagerberg, 2005. p. 12). The recognition of this factor (which itself is a key driver of the 'clustering' phenomenon evident in innovation-based economic growth) has led scholars to commonly rely upon ‘systems’ perspectives to analyze the innovation activities of firms and how those activities occur and are undertaken within wider frameworks. Several different framework perspectives (Mytelka/OECD, 2001; Nelson & Rosenberg, 1993; Carlsson et al, 2002) have been developed and applied, including ‘sectoral-systems’ (focused on the diffusion of innovations within particular industries and sectors), and technology-based systems (focused on the diffusion of particular technologies across industries). Spatially-oriented frameworks based on political-jurisdictional boundaries are also very common (e.g. ‘regional’ and ‘national’ systems of innovation). All these approaches tend to include as part of each analytical framework not just the constituent firms and innovations, but also public policy and ‘institutional’ characteristics of each system (e.g. legal/regulatory and firm/industry governance frameworks, industrial, trade, labor and educational policies, etc….) (Fagerberg, 2005). Significant attention is paid to the conditions within, and the nature of the relationship linkages between, and behaviors of all actors (inventors, innovators, users, institutions, etc…) within each system network (Fagerberg, 2005).

The application of these types of analytical frames has permitted researchers and system managers (e.g. policy makers, industry associations, etc…) to focus on the internal workings of the systems under analysis. Given the highly variable and uncertain characteristics within most modern systems, and the significant external dependencies exhibited by all agents active in them, much attention has been paid to identifying the most economically-advantageous agent/firm-level behaviours and policy-responsive environmental conditions within them (to, for example, better encourage the development of industry clusters and mass adoption). At both the firm- and system-level, the literature reflects a significant focus on the concepts of relative ‘openness’ and the existence and quality of ‘linkages’. However, just as firms can display the blinkering effects of ‘inertia’, ‘lock-in’ and ‘path-dependency’, so too has it been recognized that systems themselves can become closed to new ideas. “The more open a system is to impulses from the outside, the less the change of being ‘locked out’ from promising new paths of development that emerge from outside the system.” (Fagerberg, 2005. p 13). The related concept of “absorptive capacity” (Cohen and Levinthal, 1990) of both systems and agents within them is equally critical given the imitative and externally-dependent nature of innovation. Without the stream of novelty produced by innovation, economies and industries risk settling into a “stationary state” with little or no growth (Fagerberg, 2005 p.20; Metcalfe 1998). Broad and varied linkages between firms and systems are key to maintaining openness and the capacity to recognized and absorb new ideas. Recognizing this fact, organizational structures have received much attention in terms of their effect on firms' and systems' ability to absorb and learn from new ideas, technologies and other types of changes in their environment (e.g. institutional or competitive dynamics) and successfully adapt and position themselves advantageously relative to them (Lam, 2005).

Innovation within Regulated Monopoly Industries

The focus of this paper is on innovation activity in the electricity distribution utility industry, particularly within the UK and Ontario. The electricity distribution business – defined generally as the conveyance of electricity at low-voltages – is considered to be a natural economic monopoly. Absent the ability for consumers' interests to be served by market forces acting on competing firms within the industry, regulation of prices and service levels by government is required. In other words, in the electricity distribution industry government must, through regulatory control, mimic the effects of competitive market forces which control prices and deliver acceptable service quality levels in naturally competitive industries. The regulated nature of the electricity distribution firms presents is of critical importance to the study of innovation dynamics within the industry.

Literature on the effect of regulation on the innovation activities of electricity distributors specifically is sparse. However a few key studies have considered the impact of regulation on the investment and innovation behavior of monopoly firms, and their findings are outlined below.

The original, groundbreaking paper in this field was published in 1962 by Harvey Averch and Leland Johnson. Their research advanced a theory, tested via study of the US telecommunications industry, of the 'behavior of firms under regulatory constraint'. The particular constraint that Averch and Johnson focused on was regulators' control of prices using a 'fair return' standard. They described this regulatory standard as follows: "After the firm subtracts its operating expenses from gross revenues, the remaining net revenue should be just sufficient to compensate the firm for its investment in plant and equipment. If the rate of return, computed as the ratio of net revenue to the value of plant and equipment (the rate base), is judged to be excessive, pressure is brought to bear on the firm to reduce prices. If the rate is considered to be too low, the firm is permitted to increase prices" (Averch and Johnson, 1962. p 1052). Averch and Johnson posited that firms whose rates are regulated under this standard (which represents the general framework for the economic regulation of electricity distributors in most jurisdictions, including UK and Ontario) will exhibit a "regulatory bias" as a result of the regulatory model 'pressuring' firms to "inflate their ratebases by substituting capital for labor" (Averch and Johnson, 1962. p 1068). The prospect of the dynamic where the investment behaviour of regulated monopolies is oriented toward capital investment has since become known as the Averch-Johnson effect.

Where Averch and Johnson focused on the possibility of rate-regulation 'pressuring' profit-maximizing monopoly firms to gold-plate their ratebases, subsequent researchers focused on the impact on such firms of regulators' actions to eliminate innovation-produced profits.

Elizabeth Bailey's 1974 paper, 'Innovation and Regulation', reflecting the same basic ideas advanced by Schumpeter and Mansfield, observed that "the timing of the economic forces which act to eliminate an innovating firm's profits is of great interest to society. If such forces act quickly, a firm is discouraged from making investments in innovation, and society is thus deprived of any benefits such innovation would have generated. If their timing is slow, then while innovative activity may be plentiful, the firm may reap most of the associated benefits rather than passing price reductions on to the consumer" (p. 285). On this matter of firms' appropriation of the benefits of innovation, Bailey noted that in industries with natural monopoly firms, a regulatory commission "determines the length of the interval before prices are adjusted, and hence it is this commission rather than a competing firm which determines the extent to which cost-reducing innovations are profitable for the firm to undertake. Such commissions can, at least in theory, use the interval between price adjustments (the 'regulatory lag') in a flexible manner which is not possible under the patent laws or in the competitive mechanism" (p. 285). Bailey posited that "regulatory lag can be used as an instrument to influence the size and distribution of benefits from innovation" (p. 285). The conclusion of her study of the innovation behaviour of a profit-maximizing monopoly firm under regulatory price control is that "if regulatory lag is short, the firm will adopt a lower level of innovative activity. If the lag is longer, then the firm innovates more but society does not obtain as quickly the benefit in the form of lower price." (p. 295). Bailey asserted that the challenge in all cases is for policy-makers to find "an optimal innovation-regulatory lag pair…which maximizes the benefits to society from innovation." (p. 295).

The challenge of finding an 'optimal innovation-regulatory lag pair' was highlighted by the research of George Sweeney, who in 1981 illustrated that in many circumstances "a regulated monopolist can maximize the present value of profits only by delaying adoption of an innovation. That is, rather than completely adopting a cost-saving innovation when it becomes available, a profit-maximizing regulated firm will choose to adopt the innovation only gradually over time." (p. 437). In other words, Sweeney's research made clear that the assumption that a profit-maximizing monopoly firm will quickly and automatically embrace innovations that produce profit is faulty. Instead, he argued that such firms will adopt innovations only at the speed that will allow them realize their goal of profit maximization (and that pace may or may not be the optimal pace from a societal perspective).

Complicating the matter was further research which illustrated – in parallel, interestingly, with that of Rogers (1995) and Kaplan (1999) – that simple profit maximization could not always be assumed to be the key motivation driving the behavior of monopoly utilities. In 1995, Thomas Lyon of Indiana University responded to Sweeney's 'oversimplified' argument and the "discussion in the trade press (that) indicates that utility executives also believe regulated firms are slow to adopt new technology" with a study of productivity enhancements in US utilities. Lyon's paper found that "throughout most of the 20th century – especially during the 2 decades following World War II – productivity enhancements in the industry outpaced those in most other sectors of the economy. Only since the mid-to-late 1970s has the pace of innovation slowed" (p. 233-234). Lyon noted that the slowdown coincided with the adoption by utility regulators of so-called 'hindsight reviews' (i.e. examinations of whether already-made expenditures had been 'prudently incurred' and whether assets were 'used and useful'), and thus his study examined "the effects of regulatory 'hindsight reviews' on utilities' incentives to innovate". Lyon found that the 'ceiling' on utility earnings (produced by the application by regulators of the fair return standard) "indeed discourages firms from adopting risky new technologies, but an earnings floor produces the opposite effect. The net effect depends on which constraint is the more tightly binding” (p. 251). He found that the application of retrospective prudence reviews, which were commonly adopted by regulators following the significant number of “disastrous outcomes” through the 1970s where monopoly utilities “overinvested in risky technologies”, “may discourage utilities from making potentially desirable investments in promising new technologies. Capital cost disallowances based on avoided costs, by penalizing high cost or low performance outcomes, may discourage the adoption of new technologies whose performance is uncertain. In some cases, the threat of retrospective review may cause a utility to switch from an innovative technology to a more costly conventional one. In other cases, the utility may underinvest or even cease making any generation investments at all” (p. 251). In other words, Lyon’s work illustrated that electric utilities in the US tended to behave in a way that maximized certainty of a positive regulatory treatment (even when that was not in the best interest of consumers) as opposed to maximization of profits. Lyon suggested that more optimal utility behavior (i.e. the pursuit of innovation in order to produce benefits for consumers and society) could be produced by reforming the approach to rate regulation to address the “potentially harmful effects of retrospective review”, introducing the sharing between consumers and utilities of the profits generated by innovations, and basing rate regulation and the return standard on total costs as opposed to merely capital.

As noted above, Lyon’s study in 1995 was followed quickly by Kaplan’s paper which provided further evidence of factors other than profit-maximization driving electric utilities’ innovation behavior. Instead of economic considerations (like profit maximization and capital/ratebase bias), or institutional considerations (like regulatory treatment and lag-times), Kaplan’s research illustrated that an ‘affect’ of utility managers – the concept of their ‘familiarity’ with new technologies – was a key factor underlying their (general lack of) innovation behaviour and relative positioning as ‘later adopters’ of innovations. The observance of multiple factors influencing innovation, some emanating from within firms and others from without, is of course consistent with the previously-introduced concept of innovation occurring within a industry sectoral system, featuring multiple feedback loops between biased/routinized and ‘boundedly’-constrained actors and organizations operating inside an institutional/policy context.

Innovation Activity Trends in Electricity Industries

There is at present relatively little research available on the innovation activity trends within electricity industries when viewed through the lens provided by the contemporary view of innovation as a 'chain-linked' process. However, a number of studies have – reflecting the past dominance of the 'linear' conception of innovation – measured and tracked the level of R&D activities within electricity industries over time. Even recognizing that innovation involves more inputs than just R&D, the findings of these studies are instructive. They illustrate that R&D spending in the electricity industries of the world's advanced economies through the 1980s dropped to levels "substantially lower" than those evident in the 1970s and early 1980s (Jamasb and Pollitt, 2005. p 1) and that the reductions deepened from the mid-1980s through the end of the 1990s. The data indicates that the reductions through this period occurred across both the private and public sectors, with Dooley and Runci (2000, p.225) illustrating that from 1985-1998 public-sector R&D expenditures in the energy sectors of key leading industrialized jurisdictions (US, EU, Germany, and UK, the leading subset of the 9 OECD nations whose activities have historically made up over 95% of the world's long-term energy R&D) dropped in real terms by 36% (US), 37% (EU), 78% (Germany) and 88% (UK). As discussed in more detail below, within these energy sector averages, electricity industries demonstrated even deeper reductions in R&D spending.

The authors of these studies note that the reductions in electricity industry R&D activities coincided with the emergence of electricity sector reforms in many countries around the world, including within most of the leading industrialized jurisdictions. Following the 'disastrous outcomes' noted by Lyon which were common through the 1970s and 80s (Ontario's version was the de facto bankrupting of the government-owned vertically-integrated utility, Ontario Hydro, as a result of massive cost overruns on nuclear plants) "the main objective (of these reforms) has been to improve operational and investment efficiency through restructuring, competition, regulatory reform, and privatization" (Jamasb and Pollitt, 2005 p. 1). These studies provide "mounting evidence that the ongoing deregulation of the energy industries in many countries is exerting downward pressure on energy R&D activities, particularly in the private sector (Dooley, 1998). For example, whereas U.S. industries invested about an average of 3.1% of annual sales revenues on R&D, U.S. utilities devoted, on average, 0.3% of sales to R&D in 1994; estimates indicate that this percentage has continued to decline since then (General Accounting Office, 1996). This utility R&D-to-sales investment ratio falls below that of even the least R&D-intensive industrial sector of 'food, kindred, and tobacco products' (Standard Industrial Classification sections 20 and 21)'. By virtue of the reductions in utility R&D investments, U.S. private sector investments in energy R&D have fallen by an estimated 53% in real terms, or the equivalent of U.S. $2.2 billion, from their 1985 levels (Dooley, 1997). Similar trends are evident elsewhere in the OECD. Utilities in the United Kingdom have reduced their R&D investments steadily over the past decade to a level that currently stands between 0.1% and 0.3% of sales (International Energy Agency, 1996)." (Dooley and Runci, 2000. p. 227). Further, "it appears that (R&D) spending in counties with the most extensive reforms (e.g. the UK and Spain) show more of a downward trend than in countries with the least extensive reforms (e.g. Japan and France) (Jamasb and Pollitt, 2005. p. 1). The findings within the context of the electricity sector reforms embraced by many of the world's industrialized jurisdictions through the 1990s – and which were based on an "implicit assumption that energy research is a commodity to be sponsored by private users" (Jamasb et al, 2008 p. 4611-2) – "may provide evidence of a significant market failure with respect to R&D expenditure" (Jamasb and Pollitt, 2005. p. 3). In other words, an unintended by-product of the efficiency-oriented electricity industry reforms (which include the hindsight reviews discussed by Lyon) pursued through the 1980s and 1990s has been a dramatic reduction in critical innovation-related activities, and it appears that restructured industries do not contain the incentives necessary to ensure innovations are pursued and generated. Indeed, the research "would seem to confirm the hypothesis that much of this research is a public good" (Jamasb et al, 2008. p. 4612), and that "like other public goods generally, presents inherent challenges that are difficult to surmount. For example, public goods are non-excludable, which means that, once furnished, they are available even to those who have not paid for them. Likewise, public goods are non-rivalrous in consumption; thus, those who pay for the provision of public goods not only are unable to prevent free riders from gaining access to the good but are incapable of preventing their enjoying the full measure of benefits that flow from a public good's existence. These inherent properties of public goods obviously create strong disincentives for those who might be capable of paying for their provision.” (Dooley and Runci, 2000. p.220)

Very recent research suggests that there has been an escalating effort on the part of policymakers to attract investment into the power generation technologies, and to a much lesser extent, the grid connection technologies, necessary to improve the environmental performance of electricity industries. The absolute spending levels and relative allocation of resources under these policies toward ‘market pull’ (predominantly via ‘standard-offer’/’feed-in tariffs’ for renewable energy supply) as opposed to ‘technology push’ mechanisms (e.g. R&D initiatives) “imply that technical progress due to market pull should be significantly stronger than that of technology push” (Jamasb et al, 2008. p. 4613). However, no empirical evidence or analysis exists to justify this policy bias, and to the contrary research has illustrated that “R&D can be at least as important for technology learning as is capacity deployment” (Jamasb et al, 2008. p. 4613).

Notwithstanding the lack of empirical evidence to justify the heavy reliance upon the currently-favored market pull policy mechanisms, research has illustrated that the design of the policy approaches matters significantly to their success. Engaging and permitting monopoly electricity utilities to participate and benefit in the policy initiatives designed to stimulate innovation in the electricity sector has been shown to “lead to virtuous circles of technology diffusion and capability development” through the harnessing of incumbent utilities as ‘proactive drivers’ of change in electricity systems (Stenzel and Frenzel, 2008. p. 2656). Further, studies suggest that public authorities and utilities have acted as key partners for private-sector entities in innovation-development activities, absorbing certain risks and providing demonstration platforms through public-private-partnerships, especially in the early stages of technology development and commercialization (Dinica, 2008). The observation of this dynamic is intuitive, especially when it is recognized that the grid systems to which electricity generation technologies must connect, and which require significant technological modernization themselves, are owned and operated by regulated monopoly utilities.

It does bear mentioning that the question of whether or not regulated monopoly utilities should be permitted, let alone encouraged, by policy makers to participate in innovation activities (whether ‘pull’ or ‘push’ initiatives) remains a topic of debate. Opponents of incumbent utility involvement argue that, far from generating beneficial results, monopolies’ engagement in innovation runs the risk of ‘crowding out’ non-monopolies engagement in the activity, or at least risks generating an unproductive ‘waiting game’ between the different types of firms (Lyon and Huang, 1995). To address these risks, opponents of monopoly utility involvement advocate the use of ‘asymmetric regulation’ to protect non-monopoly firms’ ability to appropriate the benefits of innovation, through use of policy mechanisms to deny appropriation by regulated monopolies (Lyon and Huang, 1995). However, as is described in further detail below, even the heavily competition-oriented regulator in the UK (OFGEM, arguably the most-pro-market electricity industry regulator in the world) has recently embraced material policy mechanisms to encourage and incentivize monopoly utility involvement in innovation activities. It appears as if practical means of permitting and incentivizing monopoly involvement in addressing the ‘innovation gap’ evident in the electricity sector can indeed be found.

So, from the above review of the innovation literature we have seen how innovation activity drives economic growth, innovation-driven growth tends to occur in ‘clusters’, and the importance of innovation ‘diffusion’ in generating economic and social development. We have reviewed the evolution in the conceptualization of the innovation process from the early ‘linear’ model through to the modern view of the production of innovations by boundedly-rational firms via an iterative and complex process of ‘chain-linked’, overlapping activities, all occurring within a ‘system’ characterized by relationship networks and policy/institutional factors. We have examined how the unique characteristics of regulated monopoly industries are expected to have a material bearing on the innovation behaviour of firms within them. And we have outlined the trends evident in innovation activity within electricity industries over the past half-century. In parts 4 and 5 of this paper we use the abstract concepts identified above from the literature to analyze and assess the sectoral innovation systems evident in the distribution industries in the UK and Ontario. But first in part 3 we describe the key characteristics and trace the recent evolution of the policy and institutional environments within our two survey jurisdictions over the respective study periods.

Part 3: Industry Structures and Regulatory Environments in UK & Ontario

This section provides a description of the broader electricity industry value chains within the UK and Ontario, and the key structural and institutional environment characteristics of the two electricity industries and the distribution utility segments within them. Given the natural-monopoly nature of distribution utilities and the consequent economic and service-quality regulation it attracts, particular focus is devoted to the recent and current iterations of the regulatory frameworks present within the two survey jurisdictions, and the specific behavioral incentives those frameworks have and continue to produce for utilities.

UK

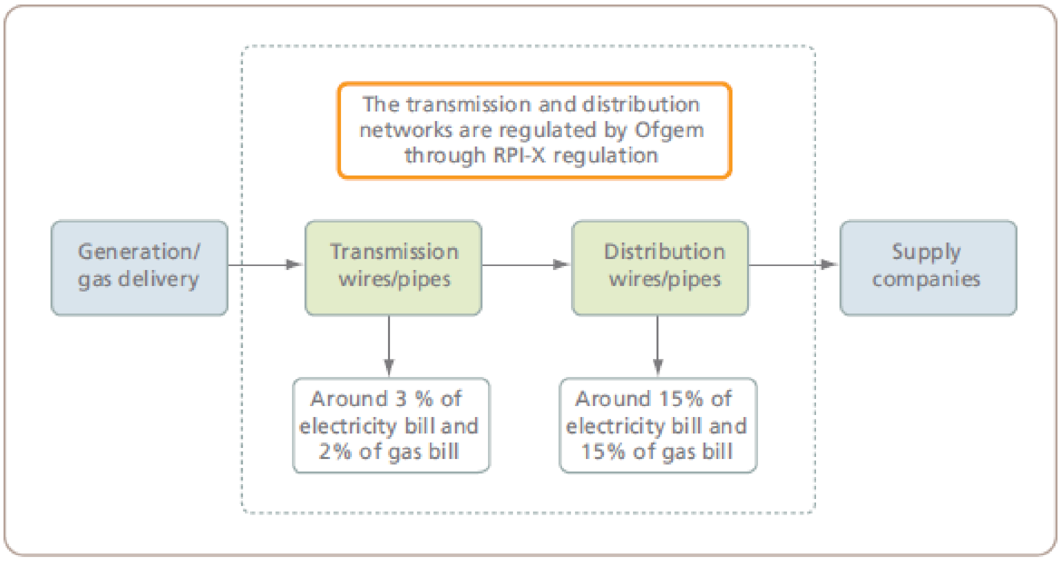
Industry Structure / Institutional Environment

The UK government undertook a fundamental restructuring of its electricity industry commencing in the late 1980's. The initiative reflected the liberal economic principles espoused by the Thatcher government, and sought to introduce competition and market forces in the generation and supply (i.e. retail) ends of the industry's value chain. From publicly-owned "boards", companies across the generation, transmission and distribution were incorporated and then privatized in 1990. The corporations in the delivery segments of the value chain (i.e. transmission and distribution), recognized natural economic monopolies, were from the same point subjected to performance-based price and service-quality regulation designed to replicate the efficiency-producing effects of competitive market forces. Transition to full retail competition was completed by 1999.

Implementation of industry reform, and the licensing and regulation of all industry participants, is undertaken in the UK through the Office of Gas and Electricity Markets (OFGEM, previously the Office of Electricity Regulation, OFFER), a non-ministerial department of the national government. OFGEM's statutory objects, established at the outset of the restructuring, include as a primary responsibility the protection of consumers by promoting "effective competition" in the gas and electricity markets, and require the regulator to "promote efficiency and economy" on the part of all licenced parties. (OFGEM, About Us, the Gas and Electricity Markets Authority http://www.ofgem.gov.uk/About%20us/Authority/Pages/TheAuthority.aspx, accessed

Feb 20 2010). A special focus of OFGEM's is on the energy delivery networks, the natural monopoly transmission and distribution companies (Figure #1).

FIGURE #1: OFGEM's Regulatory Role



(OFGEM, Reforming Networks Regulation Fact Sheet, January 2010)

The industry's basic structure has remained stable in the UK for the past 20 years. Within the 401 TWh generation market (Department of Energy and Climate Change, Digest of United Kingdom Energy Statistics 2008, http://www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx, accessed June 3 2010) ~90% of all power is currently traded through bilateral contracts established directly between generators and "suppliers" (i.e. retailers). The remainder is traded through independently operated power exchanges (UK Association of Electricity Producers, Facts and Figures, http://www.aepuk.com/about-electricity/facts-figures, accessed Feb 9 2010) and through the real-time 'balancing' market operated by a wholly-owned but independently-managed subsidiary of the transmission company (Elexon, About Us – Organization Structure, http://www.elexon.co.uk/aboutelexon/organisationstructure/default.aspx, accessed Feb 20 2010).

The high-voltage long-distance transmission system is operated in all of Great Britain by National Grid UK. The high-voltage network in Britain and Wales is currently wholly owned by

National Grid, which through privatization has evolved into a publicly-traded investor-owned transnational with electricity and gas interests in Europe and North America. The network is owned in Scotland by Scottish Power Transmission (a company currently wholly-owned by Iberdrola, a publicly-traded energy company based in Spain) and Scottish Hydro-electric Transmission (a division of a UK-based publicly-listed energy company).

Since 1999, all end-users in the UK have been served by competitive suppliers. Suppliers are responsible for commodity sales to the ~26 million metered end-users in the UK, as well as billing, collection and remittance to all ‘upstream’ parties (i.e. generation, transmission, and distribution companies). As a condition of their OFGEM-issued licence, from 2002 suppliers have also carried electricity conservation, renewable and clean energy procurement, and (since 2008) carbon-reduction obligations. Since 2007, suppliers have also carried responsibility for the competitive provision of new and replacement meters to end-users, with distribution companies obligated to transition out of the metering business as their legacy meters reach the end of their useful lives. In 2008, the UK government assigned to suppliers the additional responsibility of deploying smart meters to all end-users by no later than 2020.

The UK’s low-voltage network is divided into 14 defined monopoly service territories, within which the delivery assets are owned and operated by a Distribution Network Operator (DNO) licensed by OFGEM. These operating licenses are held by distribution companies created and privatized through the restructuring process, which are now 8 in number and owned by predominantly non-UK-based corporate parents (see Figure #2).

Regulatory Framework for UK DNOs

As natural monopolies, the DNOs’ permitted commercial activities are tightly regulated by OFGEM. Their primary activity is the conveyance of power across the low-voltage network which they own, operate (including outage response/management) and maintain. DNO’s are obligated by license to connect consumers (loads) and generators to their networks, within defined timeframes. In order to promote and facilitate competition in all non-monopoly activities, DNO’s have since 1990 been restricted from having any commercial interests in any other industry segment or business activity (e.g. generation, transmission, supply, energy management services, etc…). Further, as technology and commercial developments have occurred in business activity areas originally defined as permitted distribution activities (e.g. provision of new and replacement metering), OFGEM has tightened the definition to restrict DNO participation and foster the emergence of competitive markets.

FIGURE #2: DNO Ownership

DNO	**Current Ownership**
Electricite de France (EDF)	By namesake parent, which is 85% owned by France, 15% publicly traded
CE Electric UK	By a US-based publicly-traded parent, MidAmerican Energy
Central Networks	By Germany-based publicly-traded parent, E.ON
Northern Ireland Electricity	By an Irish parent – Viridian Group – who itself is privately owned by a Bahrain-based bank, Arcapita
Scottish Power Networks	By publicly-traded Spanish parent, Iberdrola
Scottish and Southern Power Distribution	By publicly-traded namesake Scottish utility parent, SSE
Electricity North West Ltd	jointly by JP Morgan and Commonwealth Bank of Australia
Western Power Distribution	By US utility parent, PPL

To fulfill its statutory obligation to protect consumers while promoting efficiency and economy, OFGEM has applied a series of 5-year distribution price controls (DPCr's) to the DNOs since 1990. For the timeperiods covered by this study DNO's were subject to DPCr3 (April 2000-March 2005) and DPCr4 (April 2005-March 2010). The new DPCr5 came into effect in April 2010. In establishing each DPCr regime, OFGEM, following a consultation process with the DNOs and consumer representatives, proposes revenue controls and standards of performance for each DNO. The DNOs can accept the proposed rates or appeal them to the Competition Commission.

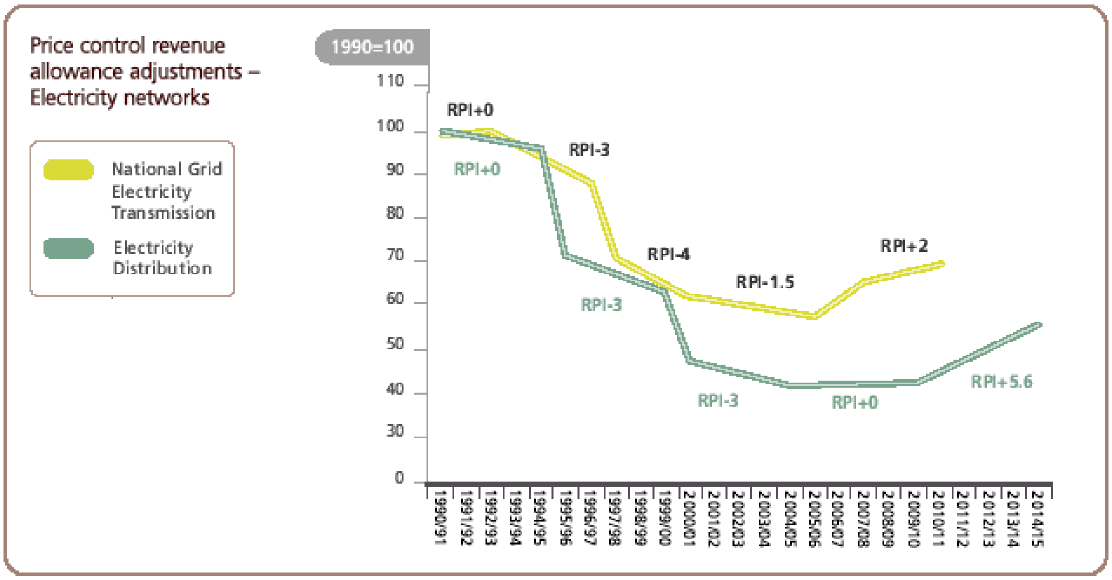
Since their introduction, the central feature of OFGEM's price controls has been a process through which each DNO's annual revenue cap is initially set for the control period based on regulator-prescribed rates of return permitted to be earned on the utility's asset base (ratebase) plus the distributor's approved operating expenses, distribution, taxes, etc…. This cap is then adjusted automatically each year by an inflation proxy (the retail price index) less a required efficiency factor, both predetermined by the regulator. Known as RPI-X, this revenue control approach was deliberately designed to provide utility managers a strong incentive to pursue cost efficiencies, while maintaining service quality. Savings from the annual efficiency factor flow to consumers, with shareholders eligible to retain additional savings achieved along with the prescribed annual returns on ratebase. As well, at the beginning of several price control periods OFGEM has required significant one-time reductions in DNO's revenue. As illustrated in Figure #3, the combination of the price-control mechanism and the one-time required reductions has reduced DNOs revenues by ~50 from the first to fourth price control.

During the DPCr2 period the potential profitability of the DNOs became very evident (via significant share price increases as the scope of potential efficiency gains within the recently-privatized DNOs became clear), which prompted the government to levy a 1.5B pound 'windfall profits tax' on the DNOs in 1997, and require them to make one-time 50pound payments to each of their customers (Jamasb & Pollitt, University of Cambridge, February 2007). Following this action of the UK government, OFGEM's DPCr3 (2000-2005) represented the apex of regulatory efforts to wring efficiencies from DNOs. In the transition from DPCr2 OFGEM required a one-time 23.4% reduction in DNOs revenues, then subjected the utilities to a 3% annual efficiency offset for each of the 5 years of DPCr3 (Jamasb & Pollitt, University of Cambridge, February 2007). Additionally a set of customer service performance standards were defined for DNOs were introduced in DPCr3 that put more than 2% of their annual revenue requirement of DNOs at risk. (See Figure #4 below, comparing the incentives over DPCr3 and 4).

While still based on the RPI-X formula, and inclusive of the intensified customer service performance standard incentives above, OFGEM's DPCr4 was tempered to reflect (with its 0% annual efficiency offset factor) the previous efficiency gains achieved in the sector, and contained key additional mechanisms to help facilitate the realization of the alternative energy supply obligation unveiled by the UK government in 2002. Beginning that year electricity suppliers became obligated to source a steadily-increasing minimum percentage of the electricity provided to their end-use customers from qualifying renewable and clean generating sources.

The schedule of minimum percentages rose from 3% in 2002-3 to over 10% by 2010-11 (Renewables Obligation Order, March 2002). This mechanism was clearly intended to 'pull' renewable generation technologies into the UK industry.

FIGURE #3: DNO Revenues under each DRCr



OFGEM, January 2010

FIGURE #4: DNO Revenue Exposure/Incentive for Quality of Service Performance

Incentive Arrangement	**Third Distribution Price Control Review 2000/01-2004/05**	**Fourth Distribution Price Control Review 2000/01-2004/05**
Interruption incentive scheme: - Duration of interruptions - Number of interruptions	+/-1.25% +/-0.5%	+/-1.8% +/-1.2%
Storm compensation arrangements	-1%	-2%
Other standards of performance	Uncapped	Uncapped
Quality of telephone response	+/- 0.125%	+0.05% to -0.25%
Quality of telephone response in storm conditions	+/- 0.125%	0 initially +/-0.25% for 3 years
Discretionary reward scheme	Not applicable	Up to + 1m pounds
Overall cap/total	*+2% to -2.875%*	*4% on downside* *No overall cap on upside*

OFGEM, 2004

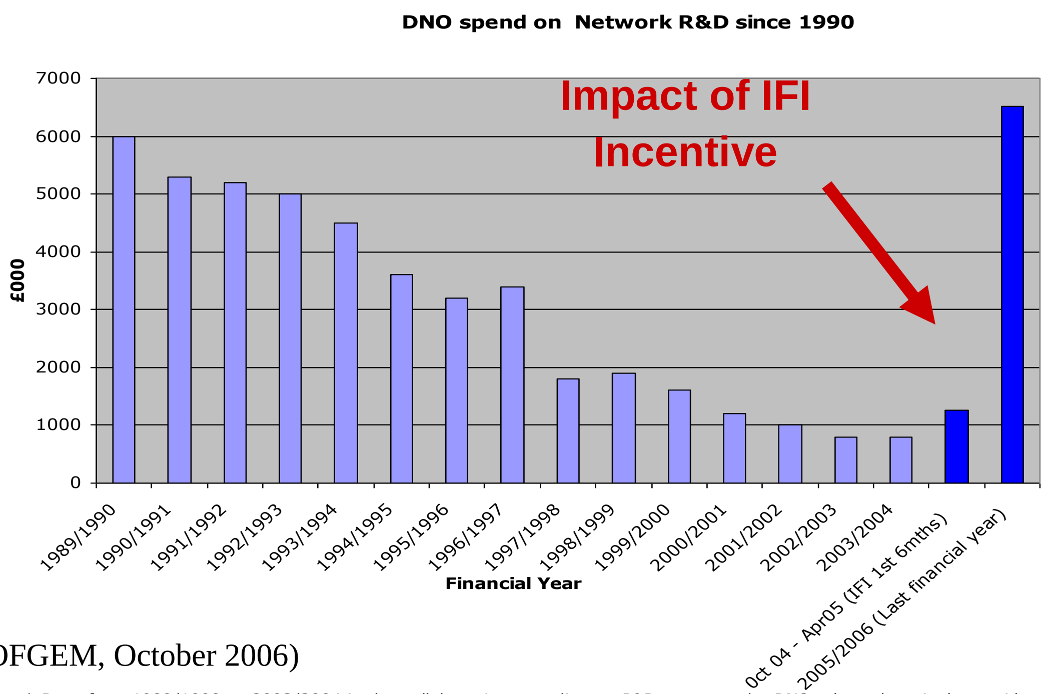
The UK government was open in stating that one of the key objectives underlying this obligation was to "assist the domestic renewables industry to become competitive in home and export markets and in doing so provide employment in a rapidly expanding sector" (http://www.berr.gov.uk/files/file22108.pdf, page 6). Thus, a comprehensive supporting program was unveiled by the government to assist suppliers through means that included technological development and demonstration projects, removal of legal and administrative barriers, and the development and facilitation of exports. The government identified specific generation technologies that were expected to be available in the near, medium, long and very long terms, and targeted development assistance (including capital contributions and promotion/marketing resources) to those anticipated to emerge within the near and medium terms.

In developing DPCR4 in this context, OFGEM faced three key motivations. First it bore an obligation to address DNOs ability to contribute to the government's renewable energy objectives, which required connection of smaller scale and intermittent distributed generation resources to the low-voltage networks. Second, it had received analyses that demonstrated (a) three times more distributed generation could be accommodated on distribution networks once converted from passive to active operation (OFGEM, July 2003; Strbac et al, May 2002), and (b) identified that there were significant opportunities to achieve innovation in distribution networks, such that more than 480M pounds net direct benefit to consumers was potentially available to be realized through key innovation-stimulation mechanisms (Mott MacDonald, March 2004). Lastly, OFGEM had recognized that the strong efficiency focus through DPCr3 had materially reduced DNO spending on R&D and innovation, and that its regulatory approach needed to reflect that 'innovation has a different risk/reward balance compared to a DNO's core business'. To address these motivations, OFGEM incorporated into the new control 3 specific innovation-related mechanisms: the Innovation Funding Incentive (IFI), Registered Power Zones (RPZ), and the Distributed Generation (DG) Incentive.

The IFI represented Ofgem's primary response to the consistent decline evident in research and development investment by DNOs since the introduction of the efficiency-oriented RPI-X price control approach in 1990 (see Figure #5). This reduction in R&D spending was the product of

DNOs search for cost-reductions to meet the pressures of DPCr3, and contributed to a significant change in the institutional environment. Since 1966 a single public institution, the Electricity Council Research Centre (ECRC), acted as the central R&D resource within the state-owned

FIGURE #5: DNO R&D Spend, 1989-2006



(OFGEM, October 2006)

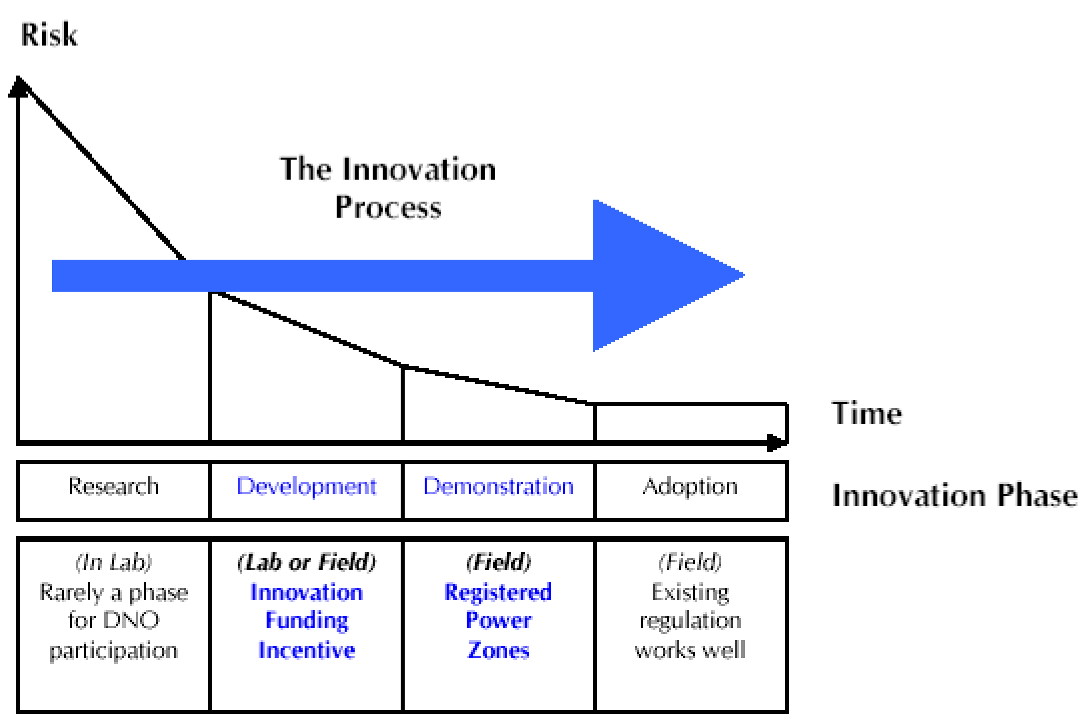
* Data from 1989/1990 to 2003/2004 is the collaborative spending on R&D amongst the DNOs through a single provider.
* Data from Oct 2004 - April 2005 and the last financial year (2005/2006) shows reported total IFI spend.

electricity industry and was collectively funded by all publicly-owned entities in the industry. As the restructuring and commercialization of the UK power industry, privatization, and application of price controls on the monopoly segments were implemented (which caused DNO expenditures on R&D to fall dramatically), the ECRC evolved to in 1997 become a fully-independent, commercial enterprise, operating under a new name: EA Technology Ltd (EATL) (EATL, http://www.eatechnology.com/aboutus/history, accessed June 1 2010).

IFI allowed a DNO to pass through to customers 80% (tapered from 90% to 70% from the start of DPCr4 in 2005 to its end in 2010) of the cost of eligible IFI projects, which are “designed to enhance the technical development of distribution networks (up to and including 132KV) and to deliver value (i.e. financial, supply quality, environmental, safety) to end consumers…. (and) will embrace all aspects of distribution system asset management from design through to construction, commissioning, operation, maintenance and decommissioning. …Projects must be justified prior to commitment on the expectation that the present value of their costs will be exceeded by the present value of the benefits which could be delivered to customers." (OFGEM, February 2005, p 11). DNO's were permitted to reach attain a maximum R&D intensity (percentage of annual turnover) through IFI of 0.5%, which equated to ~1-2M Pounds for each DNO service territory (OFGEM, October 2006).

Both the IFI and RPZ were introduced in the DPCr4 as "transitional arrangements intended to be in place until DG becomes 'business as usual'" (OFGEM July 2003, p 4). IFI in particular was designed to "bridge the gap between Research and Demonstration" (OFGEM July 2003, p 5). Figure #5 illustrates how the IFI and RPZ mechanisms are targeted to particular stages of the innovation process.

FIGURE #6: Innovation Process, IFI & RPZ



OFGEM, July 2003, p5

Recognizing that the slow rate of technological change in distribution companies in the UK "is in part due to the extended lifetimes that DNO equipment can achieve" (OFGEM July 2003, p 7), and that the cost of connecting DG to DNO systems was likely to rise as density of connections increased, OFGEM considered it to be "in customers' interest for DNO's to invest appropriate resources in technology development activities and to manage such activities to best practice standards" (OFGEM July 2003 p 7). As well, OFGEM noted that by the early 2000s many UK DNO's regulatory accounts categorized no expenditures as R&D, with average R&D intensity across the DNO sector at less than 0.1% (OFGEM July 2003 p 8). However, while aimed at increasing DNOs' R&D intensity, the IFI was not intended by OFGEM to encourage DNOs to establish in-house R&D capabilities. Rather, OFGEM envisaged "a business model in which the DNOs are informed buyers of specialist R&D services from 3rd parties and are proactive partners in collaborative projects. OFGEM recognizes that R&D funding in DNO opex budgets comes under great internal pressure as companies respond to RPI-X incentives to out-perform the price control. The IFI is therefore intended to give higher visibility to a DNO's R&D spend, make it allowable but capped at 'good practice' levels and disallow it if it is not spent on innovation or is poorly managed." (OFGEM July 2003 p 8).

The RPZ mechanism was introduced to specifically encourage DNOs to move from their traditional passive 'fit and forget' approach to connecting DG capacity to their networks. If the density of DG connections on DNO's networks was to be significantly increased, new "technical and commercial strategies" as well as the ability to actively manage the connected units were, in OFGEM's view, necessary to keep operating and network reinforcement costs "maintained at efficient levels" (OFGEM July 2003 p 9). The RPZ mechanism was designed to encourage DNOs to demonstrate new technology solutions that "could have wide application once proven" to achieve more efficient DG connection and operation, as well as improve quality of supply to customers from DG units. (OFGEM July 2003 p 9). Under the mechanism, DNO's were permitted to propose to OFGEM specific generation connection projects using as-yet unproven methods. Once each 'zone' proposed by a DNO became 'registered' by OFGEM, the project became eligible for an annual output incentive double that offered through the Distributed Generation Incentive (outlined below), in order to compensate the DNO for the heightened risk of utilizing an as-yet-unproven connection method. While DNO's were limited to a total annual revenue increase of 0.5M pounds from the RPZ incentive, DNOs were permitted to utilize, with no diminishment of the RPZ incentive, additional funding from R&D grant sources for eligible projects (OFGEM, April 2005).

Under DPCr4 OFGEM also established the 'Distribution Generation Incentive' to encourage DNOs to connect, through already-proven means, the specific generation technology types targeted by the government's renewable energy policy, and to be 'generally proactive in responding to connection requests' (OFGEM, April 2005). This initiative permitted DNOs to pass through 80% of the costs of these connections at regular WACC + 1%, and receive an 'output' incentive of 1.5pounds/kW of capacity connected plus a 1 pound/kW for O&M recovery (i.e. total 2.5 pounds/kW), for a 15 year period based on an assumed life of each connected unit. The annual revenue available to each DNO under this DG Incentive was capped at an amount equal to twice the allowed total cost of capital on eligible investments, and 'floored' at the DNO's cost of debt on those same investments (OFGEM, March 2004).

As well, DPCr4 featured an incentive for DNOs to reduce losses on their systems. The scheme featured a reward or penalty of 48pounds per MWh if system losses were lower or higher, respectively, than a pre-defined target. (OFGEM, Dec 2009).

Through DPCr4, utilities responded positively to most of these new innovation-oriented incentives. Full takeup of the available IFI funding was observed on the part of at least 2 of the DNOs, with material participation across the remaining utilities. At the same time, utilities came under increasing pressure to fully expend their allowable opex and capex amounts for the maintenance and replacement of aging assets (most of which were installed in 1950s and 1960s), as well as to accommodate new system capacity development (including for DG) (OFGEM, Dec 2009).

At the institutional level, through the DPCr4 period criticism of OFGEM's "short term price focus" and emphasis on promoting competition also began to emerge (AEA Energy and Environment, March 2007). Also through the latter part of the decade, the British government, via its participation in the EU, assumed as legal obligations the commitment to achieve by 2020 the so-called "20-20-20 Targets": satisfying 20% of consumption with renewable energy, a 20% reduction in primary energy use via efficiency initiatives, and reduction of GHG emissions to 20% less than 1990 levels (European Commission, http://ec.europa.eu/environment/climat/climate_action.htm, accessed June 3 2010). The planning and implementation of the UKs efforts to achieve these targets is being led by the Department for Energy and Climate Change (DECC). Created in 2008, DECC has assumed a long-term and broad perspective on the electricity sector and the objectives that the UK's policies should be geared towards. This perspective has been widely recognized as a contrast to that of OFGEM,

Against this backdrop, DPCr5, OFGEM's latest 5 year price control which commenced in April 2010, retained almost all of the key features of DPCr4. In the face of rising equipment prices and the intensifying need for asset replacement, an accommodating efficiency x-factor has been set (+5.6% annually) (OFGEM, Dec 2009), which will permit DNOs to collect an aggregate total of 22B pounds over the life of the price control to March 2015. The IFI, DG and IIS incentives remain available to DNOs, at essentially the same levels, while the RPZ was eliminated (take-up across the sector was extremely low, with only 3 projects approved through all of DPCr4). The losses incentive has been modified to include 16M pounds of upfront funding to DNOs for 'low loss investments', coupled with an intensified reward/penalty incentive of 60pounds/MWh for performance improvement relative to a pre-defined loss target. However, in addition to these legacy mechanisms were added two significant, fundamentally new initiatives.

The first is the equalization of investment incentive between operating and capital cost. OFGEM noted that "Current regulatory arrangements may provide DNOs with a skewed incentive to solve network problems or constraint problems through further investment in transformers and cables, rather than maintaining existing assets to prolong their life." (OFGEM, Dec 2009. p 27). The biased incentive to invest capital instead operating dollars was, according to OFGEM, not only causing higher net investment than required, but also was generating significant regulatory cost to 'police' the accounting and capitalization policies of DNOs. To address these concerns, DNOs are required under DPCr5 to capitalize 85% of all costs (other than 'business support costs, which under no circumstances are permitted to be capitalized) for a 20 year amortization period. Thus, DPCr5 seeks to equalize the incentives between capex and opex to permit DNO managers to develop investment and asset management plans free from bias.

The second is the introduction of a 500M pound "Low Carbon Networks Fund" to

> "encourage DNOs to use the DPCr5 period to try out new technology, operating and commercial arrangements. The objective of these trials and demonstration projects is to help all DNOs understand how they can provide security of supply at value for money as Great Britain moves to a low carbon economy, and what role they could play in facilitating the low carbon and energy saving initiatives that are underway to tackle climate change.
>
> The future use of the electricity distribution networks could change considerably with the increased take-up of low carbon initiatives such as DG, DSM, electric space heating, electric vehicles and electricity storage. This could require significant changes to the way the networks are designed and operated, and the commercial role the DNOs play."
> (OFGEM, April 2010, p. 1).

Under the LCNF, two tiers of funding will be available to DNOs. The first tier (~80M pounds) will be made available for DNOs, to through application, "recover a proportion of expenditure incurred on small scale projects and to recover expenditure incurred to put in place the people, resources and processes to progress innovative projects" (OFGEM, April 2010. p 2). The second tier ($320M pounds) will be allocated by OFGEM, through an annual competitive award process, "for a small number of significant 'flagship' projects" (OFGEM, April 2010. p 2). For either tier, DNOs will be expected "to collaborate with each other and external partners in the electricity supply chain (from generators to suppliers). … Similarly, DNOs may benefit from the technologies used and lessons learned in other industries, including the telecoms and information technology sectors, in which case partnerships with technology providers and other outside the energy industry will be valuable." (OFGEM, April 2010. p 4). Publication and dissemination of all learnings generated via the funded projects is a mandatory requirement. Indeed, the intellectual property (IP) from all LCNF projects are to be shared domestically (rules have yet to be defined with respect to who will be authorized to commercially leverage the IP in non-domestic markets). Further, under the LCNF Ofgem retains the right to allocate up to 100M in 'discretionary awards' to DNOs for "a set of reward criteria… (which) will include the degree of learning that the projects have delivered, the extent to which the learning can be deployed, and evidence of particularly successful collaborations, including to the extent to which the project has involved the DNO reaching out beyond the energy industry to form new partnerships and to learn from the experience of other sectors.” (OFGEM, April 2010. p 22).

Ontario:

Industry Structure / Institutional Environment

Ontario’s provincial government commenced a fundamental restructuring of its electricity industry in 1998. Ontario’s initiative reflected many of the same liberal economic principles espoused by the UK government’s project which began almost a decade earlier – with the exception of an explicit public commitment to privatization of government-owned entities – and similarly sought to introduce competition and market forces in the generation and supply (i.e. retail) ends of the industry’s value chain. The provincially-owned vertically-integrated utility was disaggregated to create a single dominant generating firm and an integrated delivery (transmission and distribution) utility. However both remained under provincial ownership. The over 300 locally-administered ‘hydro-electric commissions’ were corporatized as distributors and placed under municipal ownership. Both delivery segments of the industry were also placed under ‘performance-based’ regulation that permitted commercial returns on invested capital.

Implementation of industry reform, and the licensing and regulation of all industry participants, is undertaken in Ontario through the Ontario Energy Board, an arm’s length quasi-judicial agency of the provincial government. Like OFGEM, the OEB’s statutory objects were established at the outset of the restructuring and initially included as a primary responsibility the protection of consumers by promoting competition in the gas and electricity markets, ensuring economic efficiency on the part of all licenced parties across all segments, and the financial viability of the industries (Statutes of Ontario, Energy Competition Act, 1998). Over the decade since, the provincial government has amended the OEB’s objectives via statute, most notably through the mid-2000s when the references to competition were removed and consumer education obligations were inserted, and in 2009 when the Board was assigned responsibility for promoting and facilitating renewable generation development and connections, conservation and demand management, and smart grid (OEB, History of the OEB, http://www.oeb.gov.on.ca/OEB/Industry/About+the+OEB/Legislation/History+of+the+OEB, accessed June 13, 2010). In electricity, a significant focus of the OEB is, similar to OFGEM, on the natural monopoly transmission and distribution companies.

Unlike the reasonably stable experience in the UK, Ontario's industry structure has continued to evolve fundamentally since the restructuring project began in the late 1990s, as a result of a series of governmental interventions. The original industry model featured a single spot market within which real-time wholesale prices were set on an hourly basis and were passed directly on to retail consumers. Retailers (the equivalent of 'suppliers' in the UK) were expected to emerge to satisfy the demand that was anticipated from consumers of all sizes for price stability and related energy services. However, only 6 months after the May 2002 opening of the spot price pass-through model, provincial policy-makers responded in November of 2002 to the negative consumer reaction to becoming subject to the volatile market prices by re-introducing fixed prices for residential and small commercial customers at below-cost rates subsidized by the province (note: large commercial and industrial customers continued to be subject to spot market pricing). Wholesale prices continued to be determined via the spot market, but by 2005 the province had established a central agency (the Ontario Power Authority, OPA) through which the majority of all supply has thereafter been contracted via 20 year power purchase agreements (PPAs) at guaranteed prices. In the meantime, the retail price subsidies remained in place only until December 2003, after which a regime of fixed seasonal prices (administered by the OEB to be reflective of the 'true cost of power') was introduced. Beginning in 2009, these seasonal prices have begun to be gradually replaced in communities across the province by a uniform daily schedule of 'time-of-use' (TOU) prices administered by the OEB. The provincial government's current stated goal is for 80% of all smart meters to be billed using TOU prices by spring 2011.

Ontario's generation segment continues to be dominated by the wholly-provincially-owned Ontario Power Generation (OPG), which has occupied a ~70% market share since market opening. Given its market power, OPG's commercial bidding in the wholesale market and rate of return is constrained through public policies set by the Province. The remaining spot market participants are independent power producers (IPPs) of varying sizes, some publicly listed. However, since 2005 not only has all new supply has been contracted through OPA-issued PPAs, but the majority of all IPPs who existed prior to 2005 have also entered long-term PPAs offered by the OPA. None of the OPA-issued PPAs are reflected in the wholesale spot market price, with the result being it does not reflect the true cost of power in the Province.

The vast majority of the high-voltage transmission network in Ontario is owned and operated by the wholly-provincially-owned Hydro One. A small portion is wholly-owned and operated by a Canadian-based, publicly-traded firm with international business interests (Brookfield).

All end-use customers in Ontario have since May 2002 enjoyed the right to be served by retailers. A competitive power supply and services market for industrial and large commercial customers has emerged, but due to the fixed prices administered by the OEB for residential and small commercial users since the government's market intervention in November 2002, the development of a market for the retail provision of energy supply and services has been significantly stunted.

Ontario's low-voltage network is owned and operated by local distribution companies (LDCs). As noted above, at the commencement of the industry restructuring project in 1998 there were over 300 such companies. After an intense period of consolidation, by 2002 this number had reduced to ~100 (provincially-owned Hydro One alone purchased almost 90). By 2005 the number of LDCs had reduced to ~90, each licensed by the OEB to serve a specific monopoly service territory. Each of these consolidation phases were spurred by a provincial tax measure (the suspension, for time-limited periods, of a tax on utility assets transferred via M&A transactions) which was re-established in 2010 on what appears to be a permanent basis. Outside of Hydro One's distribution (the largest LDC in Ontario, serving ~25% of the 4.5M metered end-users in Ontario) the vast majority of LDCs have remained wholly-owned by municipal governments; fewer than 10% have any portion of private-sector ownership, and less than 5% are wholly-owned by private-sector firms.

Unlike the UK's DNOs, Ontario's LDCs have retained responsibility to deliver a broad set of services to end-users. Distributors in the province are responsible not merely for connecting loads and generators and delivering electricity to consumers (including outage response/management), but also:

- billing all end-use consumers on behalf of all industry participants (including retailers),
- offering ‘standard supply service’ (i.e. the ‘default’ commodity service at OEB-administered prices for customers who do not enter a contract with a retailer),
- metering (including the mandatory deployment of smart metering by the end of 2010), and
- providing conservation and demand management (CDM) services.

Regulatory Framework for Ontario LDCs

Distribution rates in Ontario, regulated by the OEB, recover all capital and operating costs associated with the distribution network and customer care. As noted above, LDCs in Ontario have been since 2001 subject to ‘performance based’ regulation. The price control approach to economic regulation in Ontario is relatively similar to the UK’s RPI-X model, with one material difference: where the UK’s model is a ‘revenue cap’ (ie. the inflation adjustment and productivity offsets are made to each DNO’s annual revenues) the Ontario model is a ‘price-cap’ (ie. all adjustments are made to the rates each LDC charges to their consumers). The result is that the annual revenues of LDCs in Ontario are the product of consumption volumes in any given year, unlike in the UK where DNOs annual revenues are guaranteed by the regulator. In other words, LDCs in Ontario bear volume risk where DNOs in the UK do not.

Another key feature of the Ontario price control is that any revenues earned via the regulated utility from activities not defined as ‘distribution’ (a definition the Province controls, via statute and regulation) must be returned to distribution customers via reduced rates. In other words, there is a strong financial disincentive to conduct ‘non-distribution’ activities in a corporate entity other than the regulated LDC.

‘Going in’ rates for each LDCs’ customer classes are set via a formal quasi-judicial application process involving a rigorous scrutiny by staff at the regulator and intervenor groups of each utility’s “cost of service” (i.e. each LDC’s forecast annual capital and operating costs, and the allocation of those costs across each customer class served). Thereafter each LDC's rates are adjusted annually to account for inflation less the mandated productivity offset.

The original 'performance based regulation' model introduced in 2001 featured a productivity factor of -1.5%, which was applied to LDCs' 2002/3 rates along with a second 'tranche' of ROE (the provincial government had deemed that utilities' permitted ROE of 9.88% would be phased in through 3 equal annual 'tranches' beginning in 2001/2). While this '1st generation PBR' model was intended to operate for at least 3 years, as part of the government's intervention in late 2002 LDCs' rates were frozen. The freeze remained in place until utilities were permitted by the government in 2005/6 to incorporate into their rates the remaining 3rd tranche of ROE (along with a charge to recover the market-opening expenses that had been stranded since 2002, and miscellaneous tax changes) provided they committed to spend an amount equal to one year of revenues from this tranche on conservation and demand management (CDM) activities before 2007, a choice most LDCs accepted.

This decision to allow LDCs to conduct the commodity-related (and not naturally monopolistic) activity of CDM reflected the provincial government's stated goal of developing a 'conservation culture' in Ontario. Embodied in the adoption of a target of reducing peak demand in the province by ~20% and legislation ultimately passed in 2006 (the Energy Conservation Responsibility Act), the Province's policies heavily leveraged LDCs to achieve their goal. In addition the gaining permission to conduct CDM, LDCs were at the same time mandated to deploy smart meters across their service territories by 2010, and introduce thereafter TOU pricing.

In 2006/7, utilities' distribution rates were reset to reflect a 'new' cost base (either actual 2004/5 costs or forecasted 2006/7 costs, at each LDC's discretion), a new OEB-prescribed ROE of 8.01% and a 'rate adder' to begin to recover the cost of the provincially-mandated 'smart metering' initiative. The smart metering initiative, launched by the government to fulfill a 2003 election campaign commitment, involved a very contention debate in 2005 over the appropriate role and operational responsibilities of LDCs. The Province initially gave serious consideration to removing the metering and customer care function from distributors, and placing those functions into a central, provincially-owned ‘meterco’. This proposal prompted significant concern and outcry from both the LDCs and their municipal owners, who sought to retain these functions through an aggressive lobbying campaign. By the 2006/7 rate year a compromise position had been reached, with LDCs retaining the metering and customer care relationships, but with the province establishing a single ‘meter data management & repository’ system (MDMR) to process and store all data produced by LDCs smart metering systems. The smart meter rate adders established in 2006/7 were intended to facilitate LDCs procurement and installation of smart meter technologies that met the minimum functionality specification standard developed and issued by the Ministry of Energy. This specification was and continues to be the subject of some debate and criticism, given that it does not include an in-home consumer display, and effectively disallowed ‘pre-pay/pay-as-you-go’ meters which one Ontario utility had already successfully deployed across their service territory.

Beginning in 2007/8, the OEB introduced the “2nd Generation Incentive Rate Model”. 2GIRM, which featured for all LDCs an annual productivity offset of 1% for all LDCs and based rate-setting on a similarly-uniform ‘deemed’ 60:40 debt/equity capital structure. As well, 2GIRM rates included for most LDCs recovery of anticipated smart metering expenses, while the recovery of CDM activities undertaken by LDCs (mostly administered via contracts issued by OPA) was shifted from distribution rates into to a commodity-related uplift charge passed through to all consumers, the ‘Global Adjustment’.

With all LDCs’ rates now based on 2GIRM, utilities are moving through a scheduled transition into a ‘3rd Generation’ IRM in 4 annual groups from 2008/9 to 2011/12. 3GIRM features an additional productivity ‘stretch’ factor for each LDC (i.e. supplemental to the uniform offset still applied to all LDCs), which is annually determined by their operating efficiency performance relative to that of their OEB-defined ‘comparator’ utilities. Three clusters of ‘comparator’ utilities have been defined by the OEB, with utilities that demonstrate relatively high-efficiency receiving a low stretch factor for the next year, medium-performing utilities receiving a moderate stretch factor, and relatively low-efficiency utilities receiving a high stretch factor. 3GIRM is expected to operate until 2012/3.

Ontario LDCs, unlike their DNO counterparts, have been permitted to only retain underspend on opex through each price control period (i.e. not capex underspend), but are eligible to keep 100% of all opex underspend achieved through the period (i.e. no sharing with customers until rates are reset in the subsequent price control). As well, while LDCs are required to report the regulator on a set of operational performance indicators, the OEB has not linked utility operational performance with financial rewards or penalties. And commodity losses on the networks are simply passed through to consumers.

In 2009 the provincial government passed the 'Green Energy and Green Economy Act', a sweeping package of legislative reforms designed to position Ontario as "North America's leader in renewable energy" (Ontario Ministry of Energy & Infrastructure, http://www.mei.gov.on.ca/en/energy/gea/, accessed March 21, 2010). Similar to the renewable-focused policy reforms pursued in the UK, the Ontario's GEA reflected the government's effort to achieve the dual objectives of improving the environmental performance of the electricity sector while stimulating and attracting economic activity related to green energy. To create a 'pull' mechanism for renewable energy generation technologies, the Ontario Power Authority has been authorized to dramatically increase its procurement of renewable electricity from small and medium-sized distribution-connected DG facilities, through generous 'Feed-In Tariffs'. This mechanism is one of the policy instruments created by the Province to support it's commitment to eliminate coal-fired generation in Ontario

As part of this initiative, the Province recognized that tailored policies were required to facilitate generator connections to the low-voltage networks. In addition to permitting LDCs to own and operate renewable power projects (albeit on a 'ring-fenced' economic basis, i.e. accounted for separately from the core distribution business, and supported financially through a PPA issued by the OPA, as opposed to distribution rates), the GEA minimized renewable generators' share of the grid connection costs by mandating LDCs to bear all generic 'renewable enabling improvements' and reinforcement costs of connecting renewable power projects to their local grids. (OEB, Connection Cost Responsibility Proceeding, http://www.oeb.gov.on.ca/OEB/Industry/Regulatory+Proceedings/Policy+Initiatives+and+Consultations/DSC+-+Connection+Cost+Responsibility, accessed June 3 2010)

Utilities are now obligated to develop and present to the OEB capital investment plans that will facilitate the connection of anticipated renewable generation development. (OEB, Distribution System Plan Filing Guidelines, http://www.oeb.gov.on.ca/OEB/Industry/Regulatory+Proceedings/Policy+Initiatives+and+Consultations/Filing+Requirements+-+Distribution+System+Plans, accessed June 3 2010). While distributors' investment plans will be required in future to foster development of 'smart grids', the OEB has limited LDCs current expenditures in this area to pilot projects only, with no recovery of R&D expenditures permitted. (OEB, Distribution System Planning Guidelines, http://www.oeb.gov.on.ca/OEB/_Documents/EB-2009-0087/Dx_System_Planning_Guidelines_20090616.pdf, accessed June 3 2010). With respect to these connection, system reinforcement, and grid development investments, LDCs will be able to recover 100% of the costs (at their deemed WACC) in the same manner as for conventional investments in their distribution system. At the same time, the OEB will permit LDCs to apply to utilize innovative 'alternative mechanisms' for cost recovery of GEA-related investments. These alternatives include project specific ROEs, capital structures, and accelerated capital recovery. (OEB, The Regulatory Treatment of Infrastructure Investment in connection with the Rate-Regulated Activities of Distributors and Transmitters in Ontario, Jan 15 2010).

As well, to defray anticipated increases in operating expenses due to an increase in connection applications from small-scale generators, LDCs have been authorized by the OEB to charge 'micro-generators' (ie. generators of 10kW of capacity or less) a monthly account fee (of ~$5.50 Cdn) (OEB, Micro-Generator Rate Proceeding, http://www.oeb.gov.on.ca/OEB/Industry/Regulatory+Proceedings/Policy+Initiatives+and+Consultations/Rates+-+Embedded+Micro+Generators, accessed June 3 2010)

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Via the GEA, the Province also shifted CDM from a permissible to an obligatory activity for LDCs, through the establishment of mandatory conservation and peak demand reduction targets. Achievement of these targets, to be achieved over a multi-year year period from 2011, will be a condition of the license of each LDC. The new scheme envisions LDCs implementing CDM activities through mandatory delivery of OPA-developed programs that will be offered province-wide, supplemented by optional participation in programs either collaboratively developed and delivered on a regional basis by a number of LDCs, and/or locally by a single LDC. A strict 'no duplication of province-wide programs' test is expected to be applied to LDCs contemplating regional or local initiatives. Funding for all CDM programs will continue to be through the Global Adjustment uplift charge (not distribution rates). In addition to full cost recovery, the funding regimes are expected to make available to LDCs a management fee as well as a performance incentive for every additional increment of results produced from 80% through to 100% of target.

Most recently, the OEB has commenced a consultation to examine means to "address revenue erosion resulting from unforecasted changes in the volume of energy sold" (OEB, Distribution Revenue Decoupling Proceeding (EB-2010-0060), http://www.oeb.gov.on.ca/OEB/Industry/Regulatory+Proceedings/Policy+Initiatives+and+Consultations/Distribution+Revenue+Decoupling, accessed June 3 2010). These means, "commonly referred to as 'revenue decoupling' mechanisms insofar as each involves some means of fully or partially disconnecting the link between the volume of energy consumed by customers and the recovery by energy distributors of their approved revenue requirement" (OEB, Distribution Revenue Decoupling Proceeding (EB-2010-0060), http://www.oeb.gov.on.ca/OEB/Industry/Regulatory+Proceedings/Policy+Initiatives+and+Consultations/Distribution+Revenue+Decoupling, accessed June 3 2010), would if implemented reduce the disincentive that utilities currently experience in engaging in CDM activities, which by their nature lower delivered volumes. A mechanism to recoup revenue eroded by CDM-driven volume reductions, the Lost Revenue Adjustment Mechanism, is currently available to LDCs. However it is very costly to utilize and is limited in terms of its coverage (only volume losses from LDC-delivered CDM is eligible to be recovered).

Part 4: Summary and Analysis of the Research Data

This section summarizes the findings of the research interviews conducted in the course of this study, and places the results from each jurisdiction into the context of the respective industry/policy environment evolutionary path described in Part 3 of the paper.

UK:

As outlined in Figure X below, it is evident that the changing policy objectives of the UK government have had a focusing effect on the nature of the regulatory frameworks established by the regulator for the purposes of governing DNO activity.

DPCr2:

During the DPCr2 period the potential profitability of the DNOs became very evident (via significant share price increases as the scope of potential efficiency gains within the recently-privatized DNOs became clear), which prompted the government to levy the 1.5B pound 'windfall profits tax' on the DNOs in 1997, and require them to make one-time 50pound payments to each of their customers. Consistent with this approach, OFGEM's DPCr3 which came into effect in April 2000 was extremely aggressive in seeking to drive the benefits of efficiencies out to customers, via the 23.4% one-time cut in DNO's revenues and annual -3% X factor. The system performance incentive, worth +/- 2% of each DNOs revenues acted as a protective mechanism to motivate utilities to ensure their cost cuts preserved service levels.

The privatized utilities responded to the aggressive price control by taking equally aggressive action internally to reduce cost. Utility representatives reported that the majority of the savings were derived from the beginning of DPCr3 through immediate and across-the-board cuts in staffing, operational, and capital spending ('blind swings of the axe' was the descriptive term used by more than one of the interviewees). The staffing reductions appear to have been absorbed with little negative medium or long-term impact being reported, suggesting to the respondents that the labour forces had been at unnecessarily high levels. The spending reductions on operations and capital were made possible by the longer-than anticipated durability of the distribution systems that had been for the most part installed in the 1950s and 1960s. Capital assets with anticipated 30 year lifespans proved to have actual useful lives closer to 65-70 years. Some DNO representatives indicated that this unanticipated durability was the product of underutilization of assets due to the materialization of lower-than-forecast demand, as opposed to deliberate overbuilding on the part of utility managers. Whatever the reason, the ability to derive longer-than-anticipated lifespans from the distribution equipment was commonly acknowledged.

DPCr3:

It appears that a minority of the immediate savings produced in DPCr3 were derived from innovations within the DNOs. However, innovations – largely of a process/organizational nature – were indeed reported to have been developed and utilized to redesign DNOs' key internal processes to adapt to the new, more cost-constrained operating reality generated by the aggressive price control. All DNO representatives interviewed cited the adoption of fundamentally new approaches to their firm's core asset management and outage management methodologies during the 2000-2005 period (note: the very activities that are linked to the performance standards embedded in DPCr3). The sources of these innovations, and the linkages through which they were produced, were varied:

- one DNO reported the acquisition of a very powerful asset management approach via a merger with another DNO (i.e. the innovation was sourced from within the DNO sector);
- another reported the development of a very successful business process redesign capability from within their own DNO, a function which was eventually spun out as a BPR consultancy;
- another reported working closely with a major IT consultancy to develop a unique method of responding to call volumes and field staff deployments during outages,
- and still another reported the partial integration of their DNOs administration with that of a water utility owned by the same parent.

However, notwithstanding the emergence of new processes in the areas of asset and outage management, all interviewees did report a significant net reduction in their traditional expenditures on R&D activities and relationships through the DPCr3. For most this merely meant the essentially painless act of discontinuing funding for ECRC, which had not focused much if any attention on distribution technologies anyway. But one DNO did report the cessation of internal utility activities that had previously, during DPCr1 and 2, resulted in the development of proprietary metering software which had been successfully sold to a supplier entrant to the UK market, and of – in partnership with GE – handheld field force devices which had been patented. This suggests that the net reduction in DNO spending on R&D-related activities through the DPCr3 period did include curtailment of some activities with proven commercial merit.

DPCr4:

Where DPCr3 involved all DNOs undertaking relatively similar efforts to achieve cost efficiencies in the immediate term, the policy and regulatory framework of DPCr4 resulted in more fundamental differences in approach between DNOs to the business of distribution, and the role of innovation within it, to become evident. The availability under the price control of the IFI, DGI, and RPZ mechanisms, alongside the strengthened performance standard incentive, and in the context of an average X factor of zero, is reported to have resulted in material differences in utility behaviors.

The predominant focus across the sector through the price control is reported to have remained squarely on the performance standard incentive and the related internal processes of asset and outage management (and 'an explosion of activities' – in particular with a focus on distribution automation e.g. remote switching, fault restoration – was reported by DNO representatives to have continued in these areas). And similarly it was also the commonly reported view that the RPZ incentive was too weak to compensate for the risks involved in deploying unproven technology, and the DG incentive was welcome but given its magnitude and cap not in and of itself strong enough to stimulate proactive effort to search out renewable generators to connect. However two different approaches do appear to have become apparent relative to DNOs utilization of the IFI mechanism.

One approach, embraced by at least the 2 DNOs who spent up to their full allowed IFI levels, reflected the view that innovation is key to the advancement of their conduct of the business of distribution, and in this regard the IFI was viewed as a 'fantastic springboard' through which to

FIGURE #7: UK Summary

Time Period	Policy Objective	Policy Mechanisms Employed	Broad Results Observed
Initial restructuring: late 1980s, DPCRs 1&2 – 1990-2000.	Successful privatization of DNOs, followed by focus on driving economic efficiency	Privatization to create competitive market forces (mimicked via RPI-X regulation for DNOs, mild strength X factors and accounting separation/cost allocation requirement, until aggressive DPCRs 2&3) Ever-increasing fragmentation of market segments to spur competition / curtail involvement of DNOs	Significant efficiency gains (some via true process innovations, others through asset harvesting), but spends on innovation inputs (R&D) were steadily reduced. Central research institutions dramatically shrunk, re-orientation begins.
2000-2005: DPCR3	Aggressive Economic Efficiency to the Benefit of Customers	-24% going-in revenue cut to DNOs, -3% X factor, with Performance Incentive (IIP: 2%+ of DNO revenues at risk for outage #'s and minutes)	Increased focus on system performance improvements led to some process innovations, but also blind/crudely targeted cuts. Difficulty for narrowly-scoped actors to make the business case to sponsor innovation ('not in-scope', public good effects). DNO funding to ECRC eliminated.
2002: ROO for suppliers 2005 - 2010: DPCR4 incentives: IIS, DGI, RPZ, IFI, losses	Development of Green / Renewables Energy Industry Connection of Renewables Economically-efficient renewal of aging distribution grids	2002 ROO (an RPS) for suppliers (10% by 2010) 2005: Renewable Connection Incentives: DGI, RPZ established as part of DPCR4 0% X factor coupled with intensified system performance incentive (IIS: 4%+ of DNO revenues at risk), Asset management innovation incentive (IFI: up to 0.5% of DNO revenue add), loss reduction incentive	Increased connection of renewables via DGI. RPZ drew little interest due to weak incentives relative to risks. Increased focus on system performance improvements Increased expenditures on innovation inputs (R&D on products and processes) across DNO sector, supports becoming needed for deployment of innovations
2007: GHG / Carbon reduction goals 2010 - 2015: DPRC5	20-20-20 Goals: GHG/Carbon Reduction, Intensified Renewables Target, Energy Security Lowest net cost to renew distribution grids, to avoid overbuilding	Creation of DECC, taking DOE out of Dept. of Trade & Industry (where it was bundled since 1992) DPCR5: retention of DGI, IFI (0.5% cap), IIS (4%+), and LCNF (500M pounds/5yrs = 2.3% of DNO sector revenue of 22B pounds/5yrs, but will be unequal) +5.6% X factor coupled with Equalization of Investment Incentive between capex and opex via "Totex", augmented loss reduction incentive	OFGEM's economic efficiency/competition focus is being placed in broader context (formal review of OFGEM's role has been launched by the Cameron-Clegg coalition government) DPCR5 impact is TBD, although the fact that LCNF is geared to, in part, support deployment of innovations is key In 2008 4 DNOs (ENW, CE, SSE, SP) have jointly invested with EATL and NW UK eco. dev. agencies, to create a commercial innovation business incubator with a focus on distribution networks

identify new product and process ideas through partnerships (linkages) with academia, suppliers, and contractors. The clear objective of the DNOs who subscribed to this view was to use the IFI mechanism to develop innovations that could in future be deployed across their businesses, and as a means of acquiring ideas from for use in the distribution business from non-utility organizations. Interestingly, these same utilities reported that while at the beginning of DPCr4 their business aspirations included the ownership and leveraging for commercial purposes of any IP developed through their IFI activities, by 2005 they had concluded that their only real interest was to secure rights to use within their service territory any IP created (i.e. any future commercial leveraging of the IP should be left to their partners). In short, it appears that the DNOs who reportedly undertook this approach appear to have exhibited a greater openness to incorporating change and evolution into their established business routines (i.e. 'absorptive capacity').

The other approach, reportedly held by many of the remaining DNOs, which did not spend up to their allowable caps under the incentive, was that participation in the IFI was necessary for 'public relations' and 'regulatory-relations' purposes. In other words, these DNOs participated in some IFI-funded activities because they felt it was expected of them, and thus they did so to the degree they felt it necessary to appear they'd done enough. Reputational preservation and necessity appears to have been their true objective and motivating factor, as opposed to utilizing the mechanism to seek inspirations on how to transform their businesses. As a result these DNOs were commonly reported to have engaged through the IFI in 'trials for trials' sake', and via fewer and a narrower range of partnerships with external parties.

Interestingly, even the DNOs who enthusiastically participated in the IFI readily admitted that their activities were critical to their 'brand' with customers and the regulator. But the motivation and targeted use of the IFI mechanism do appear to have been different in a more fundamental sense, depending on the internal views within different utilities of the concept of innovation and new externally-sourced ideas as a critical DNO business strategy.

A similarly fundamental difference of view appears to have become evident across DNOs through DPCr4, relating to preferred means of generating value for shareholders through the

DNO business. Certain DNOs reported a very strong view that shareholder benefit is best derived through their utility by steadily growing their ratebase to generate ever higher returns over time (i.e. 'slow money'). Other DNO representatives voiced, in equally strong terms, the view that their shareholders' best interests are served by generating 'fast money' through underspending the allowable levels of opex and capex embedded in their rates.

While this fundamental difference in approach to satisfying shareholder financial objectives does not appear to have impacted significantly on the innovation-related behaviors of DNOs over the period covered by this study, it – like the references by the interviewees to the importance of 'regulatory brand' and 'customer brand' – appears to be evidence that the expectation of key stakeholders (in this case shareholders) was foremost in the minds of DNO manager when they crafted their business strategies. Where there is alignment between the interests of stakeholders, DNO managers appear – perhaps not surprisingly – to have shown significant and meaningful interest in pursing activities designed to satisfy them. The comments of the interviewees on the types and degree of innovation-related activities undertaken by DNOs over DPCr4 suggest that the most meaningful and substantive attempts to engage in innovation were evident when there was a deep buy-in by DNO management to the need for innovation within the business of distribution. Where innovation was viewed as 'window-dressing', secondary to the essential business activities of distribution, it was reported that less meaningful and substantive initiatives, with fewer external linkages, were undertaken under DPCr4.

DPCr5:

Under DPCr5, with the continuation of the IFI and the introduction of the LCNF, the divergence between DNOs in how to create value for their shareholders and strategically position their companies operationally is anticipated to continue, and become even more deeply reflected in DNOs innovation-related activities. Dramatically different views between DNOs are apparent on what the future of the distribution business holds. At one extreme, representatives from one DNO reported that the challenges facing distributors will be to ensure they remain the entity that delivers electricity to consumers' homes in an era where wires will be only one of many sources of electricity to the home (e.g. storage, CHP, ground source, micro-renewables, etc…), and the rapid and effective adoption of information and communications technologies into the distribution business. The utility managers who hold this type of view reported an intention to use IFI and LCNF to 'tools to fundamentally reposition' their firms through DPCr5. In contrast to that type of proactive view (which itself was predicated on a belief in the validity and durability of the current policy-objectives of the UK government), another DNO reported that they see the biggest key to their utility's success being avoiding having to be 'leaders' in responding to the calls for investment into 'fad' technologies, and instead remaining positioned to react to the 'real trends' and invest in technologies to 'avoid overbuilding'.

Notwithstanding their differences of opinion on the role of innovation within the electricity distribution business, all DNO respondents expressed concern that the narrowly focused business scopes of the companies active in each of the segments of the UK electricity industry makes the business case of sponsoring and engaging in innovation activities much more challenging. The lack of commercial motivation for any existing actor in the industry to deliver conservation and demand response services was a commonly cited example. It was reported that, as an early attempt to address this shortfall and also act as good corporate citizens to encourage regional economic growth in Britain's northwest, in 2008 four DNOs have jointly provided seed funding to establish – in partnership with EATL and NW UK economic development agencies – a commercial innovation business incubator with a focus on developing and attracting investment into distribution network-oriented innovations. This organization (the Energy Innovation Centre) makes available business support services to projects and ventures, and provides a set of potential customers (the DNOs) for the successful outputs.

Another common concern expressed was that mechanisms are required by DNOs to support their deployment of new, as-yet-unproven-on-a-broad-scale technologies. Most subjects interviewed for this study noted the significantly low-risk appetite of DNOs, whose shareholders are by and large are seeking steady bond-like performance and return levels higher than are available from standard fixed-income securities. Given the caps on earnings and performance standard incentives, it was reported that DNO shareholders simply will not accept the risks associated with deployment of anything other than proven technologies. While the IFI is a helpful mechanism for promoting R&D into high-success-probability technologies and processes, it was not designed to support broad-scale deployments. Several DNO representatives expressed the hope that the rules of the LCNF will permit utilities to support larger-scale deployments of promising innovations, in order to address the need.

Summary:

In summary, five main themes emerge from the UK interviews, with respect to the degree, scope and nature of the innovation activity occurring in the DNO sector during the study period. First is that the aggressive efficiency-oriented DPCr3 resulted in across-the-board expenditure cuts that significantly reduced DNOs 'innovation' activities in the short term. At the same time however, the strong system performance incentive in DPCr3 caused DNOs to adopt innovations, from varied sources (internal and external), in related aspects of their business (asset and outage management), a dynamic that strengthened through DPCr4 as the incentive was intensified. Thirdly, the Innovation Funding Incentive appears to have been generally successful in stimulating innovative activity, also focused largely on asset management, with more significant and substantive activities occurring within DNOs whose management held the view that innovation and new ideas are key to future success within the business of electricity distribution, and who sensed that innovation was of importance to all their key stakeholders. In addition to exhibiting a more proactive stance, these firms appear to have engaged with a broader range of partners in the pursuit of innovation activities, than firms who did not share their outlook on the importance of innovation. Fourth, the strength of the system performance incentive on a relative scale – as much as 4 times the IFI – caused it to dominate the focus on the DNO management teams; on the one hand the pursuit of innovation did make it onto the priority list of DNO managers, but for most it occupied a low ranking on the list. Fifth, it appears that UK DNOs did indeed respond aggressively to financial incentives (created by the regulator, but clearly linked to policy objectives set by government), but their behavior also appears to have been motivated by non-financial factors, including most evidently reputational and 'brand' considerations, which had the effect of motivating activity even in circumstances where DNO managers saw little intrinsic commercial value in the activities.

As well, common concerns are clearly held within the UK DNO sector, regarding (a) the widely-suspected negative impact on innovation activities of the fragmented/disaggregated market structure in the UK, and (b) that supports for actual deployment of innovations on a utility-wide scale are still required, given the higher risk profile perceived.

Ontario:

As outlined in Figure Y below, it is evident that fundamental shifts in policy objectives of the Ontario government have had a dramatic effect on LDC activities, including those related to innovation, over the past decade. These changing provincial priorities resulted in three relatively distinct periods of activity over the study period. The first was the period from the province's commencement of the industry restructuring initiative in 1998 through to the imposition of a rate freeze for LDCs in late 2002. The second was the period from the commencement of the freeze to its end in the 2005/6 rate year. The third has been the period since, from the 2006/7 rate year through to present day.

Period 1: Restructuring to Rate Freeze

Through the first period the provincial policy objectives were to restructure and commercialize the LDC sector, and prepare for simultaneous opening of the wholesale and retail markets. Within this context, the most significant types of innovative activities evident on the part of utilities through this period related to organizational design/corporate structure, and the billing systems necessary to facilitate market settlements (which arose from Ontario LDCs' retention of responsibility for customer billing/care, unlike their UK DNO counterparts).

The management teams of many of the newly corporatized and commercialized monopoly LDCs established affiliates to deliver competitive services within the soon-to-be-opened markets. These affiliates included electricity retailing businesses, along with service companies which housed a range of commercial undertakings, from water heater rentals to energy management services. A number of utilities also adopted 'service company' corporate models, within which all employees and operating equipment were transferred to a serviceco, then contracted back on a fully-cost-allocated basis to the LDC, sometimes including commercial markup. These models were adopted to realize the greatest commercial value from assets – human and capital – that could be shared between the LDC and other companies, whether affiliated to the LDC or not (recognizing of course that the regulatory framework in Ontario required all revenues generated through an LDC from 'non-distribution' activities to be deducted from distribution rates, i.e. returned to LDC ratepayers). For its part the province's biggest utility, Hydro One, elected in 2001 to enter a multi-year contract with a major IT consultancy to deliver on an outsourced basis IT system support and architecture, billing and settlement, and certain accounting/finance processes. While nowhere near the breadth of the Hydro One outsourcing arrangement, many utilities did elect to outsource their settlement with wholesale customers.

In parallel to these organizational innovations, through this first period the LDC sector was focused on developing the complex billing and settlement systems required to facilitate the operation of the competitive retail market. This obligation drove investment, in the hundreds of millions of dollars, into new and enhanced billing systems. The market readiness project was characterized by a significant amount of collaboration amongst billing system utility user groups and vendor teams, and across the industry as a whole via a milestones-driven process coordinated by the OEB on behalf of the provincial government.

Also within this first period, it bears mentioning that the research and development group that historically resided within Ontario Hydro, and which was at the time was known as 'Ontario Hydro Technologies', was sold off and refocused as a supplier of commercial R&D and testing services to electricity companies across the supply chain, including generation, transmission and distribution.

Period 2: Rate Freeze

As noted above, the second distinct period evident in the evolution of the Ontario industry commenced with the November 2002 intervention of the Provincial government to freeze retail commodity prices and distribution rates. The rate freeze, imposed by the government as an attempt to alleviate customers' commodity price-related concerns that had arisen in the first 6 months since competitive market opening, eventually was lifted in 2005. The freeze itself, and the conditions the province imposed when lifting it, established a context which influenced LDC activities in directions that were fundamentally different that the pre-freeze period.

Through this period of significant financial uncertainty and mounting pressures, LDC innovation activities were evident largely in the area of efficiency-oriented asset management. Prior to the freeze, LDCs had incurred several hundreds of millions of dollars in market readiness investments, most of which had not yet been incorporated into rates. In and of itself, the rate freeze meant that LDCs had to work with their accountants and shareholders to maintain these 'stranded' investments on their books (eventually most were converted into regulatory assets, which were partially recovered in future) and prepare to absorb the cost of inflation within their operations for a then-unknown period of time. For most LDCs, shareholder demands for full permitted rates of return did not ebb, which placed more pressure upon them to generate efficiencies within the distribution business. In response, LDC management teams began to cut back on their operational and capital budgets. Much of this reduction represented a relatively unsophisticated delay of expenditures, or – in other words – the harvesting of assets that was necessary – according to some representatives of smaller utilities – "in order just to survive, and keep our heads above water". However, a material number of LDCs began through this period to adopt sophisticated new probabilistic-based asset management processes. These processes, which were often enabled by the adoption of new GIS software systems, were significantly 'pushed' into the LDC sector by utility consultancies from the US (most notably Oncor, the utility services arm of Dallas-based TXU), and software vendors. The result was that through the freeze period many Ontario LDCs became much more sophisticated in their conduct of asset management, in order to maintain acceptable reliability levels while rationalizing investment. Some of these asset management undertakings involved early attempts at coordination of procurement and supply-chain functions across LDCs.

These undertakings, and other operations-oriented collaboration, occurred and intensified during the freeze period through increasingly formalized sub-groups of LDCs. 5 groups emerged through this period: the Cornerstone Hydro-Electric Concepts group of ~16 central Ontario utilities (CHEC), the ~11 member Niagara-Erie Public Power Alliance (NEPPA), the 6 member Coalition of Large Distributors (CLD), as well as the 6 northwestern Ontario LDCs and the 10+ southwestern Ontario LDCs. While each exhibited varying degrees of formality, all began through the freeze period to work together more intensively.

FIGURE #8: Ontario Summary

Time Period	Policy Objective	Policy Mechanisms Employed	Broad Results Observed
1998 – Rate Freeze (Nov 2002)	Industry Liberalization LDC Commercialization Wholesale and Retail Market Readiness	Legislation to: - Require LDC Corporatization - Mandate Rate Regulation of LDCs by OEB - Permit commercial rates for LDCs Provincially-set Market Opening Dates, OEB-set Readiness Milestones	Organizational innovations prevalent: - Competitive affiliates - Service models - Outsourcing of wholesale customer settlement - Hydro One BPO on IT/CIS/Accounting-Finance Early GIS systems for asset mgmt adopted Significant investments in market readiness (CIS/Customer Care) Linkage focuses: - market readiness IT - Corporate Structuring/Strategy - some collaborative efforts across utilities
2002/3 - 2005/6: Rate Freeze	CDM	Rate Freeze imposed on LDCs in 2002 Freeze on LDC Rates lifted in 2005/6, provided 1 Yr's value of 3rd Tranche of ROE was spent on CDM by 2007	Adoption of Asset Mgmt Processes Intensifies (pressure to harvest significant) Most affiliates curtailed or folded (retail companies ceased, others saw limited commercial success) CDM program development by LDCs Linkages: - Asset Mgmt (Oncor) - software vendors (GIS, ERP) - utility collaboration via specific operational groups intensified (CHEC, Upper Canada, NEPPA, CLD)
2006/7 – Present: Post-Freeze	CDM Smart Meters LDC Efficiency Supply Mix Reorientation	CDM Admin. to OPA, funded thru GAM not LDC rates 2 & 3GIRM, with LDC benchmarking & smart meter rate riders Green Energy Act - FIT contracts for renewables - LDCs: mandatory CDM with targets + permission to own gen / storage	Investments to achieve multiple objectives: asset renewal, reliability, operating efficiency, CDM Linkages: - deepening of contractor relationships: emergence of 'Alliance Partnerships' - utility collaboration deepening: on CDM activities, new asset specs/ evaluation and price negotiations, regulatory compliance coordination - emergence of regional 'Strategic Energy Alliances': LDC, post-secondary institutions, economic development agencies - OEM collaboration beginning to address GEA pressures

Of course, the commodity price freeze effectively eliminated the business case for retail companies in Ontario, which drove all LDCs who had established retail and energy management affiliates to quickly shutter them. And, as the pressures for management attention grew within the LDC businesses as the freeze period continued, many of the other LDC affiliate activities withered and were shut down or materially scaled back, including all but a few of the service company models. As a result, an additional effect of the freeze was to bring to an end most of the organizational innovations that had been undertaken by LDCs. Interestingly, one of the most successful remaining LDC affiliate businesses in Ontario involves the sale to LDCs of asset management services originally developed in partnership with Oncor.

In the third year of the freeze, and the second full year of their mandate, the recently-elected Liberal government permitted LDCs to exit the freeze and obtain within their rates the final third 'tranche' of equity return (in 2002, LDCs had been in the 2^{nd} year of a 3 year phase-into rates – in equal 'tranches' – of their full rate of equity return) under the condition that they invested by 2007 the value of 1 year's worth of the remaining ROE tranche into CDM programs. To facilitate their objective of stimulating electricity conservation activities the province amended legislation, making CDM an activity permitted to be undertaken by monopoly LDCs. The exit condition, taken up by almost all LDCs, had the effect of spurring significant (almost $200M worth) of CDM activity through LDCs. A broad range of programs were developed by LDCs, some via partnerships with specialized consulting firms.

Period 3: Post-Freeze to Present

The lifting of the rate freeze in a manner designed to stimulate CDM activity in the LDC sector represented only one component of the provincial government's ambitious policy objectives relating to the electricity sector. Through 2005, the government evaluated different models for delivering on its 2003 campaign commitment to provide each consumer in Ontario with a smart meter, to enable them to better understand and control their electricity usage. One model openly considered by the government was to remove metering and customer care/billing functions out of the LDC sector (in a manner that would've reflected the UK model of the distribution business) and re-assign it to another industry actor, possibly a central, provincially-owned 'meterco'. According to many of the interviewees, this threat had a galvanizing effect upon LDCs, and led not only to an aggressive – and ultimately successful – lobbying campaign to retain the functions within the distribution business, but also to the majority of utilities in the sector actively seeking to assume and undertake the responsibility of implementing the government's advanced metering infrastructure (AMI) initiative. Driven in part by this motivation, and in part by the operational benefits that are available to be realized by utilities through the deployment of smart metering systems, in 2006 13 of the 80+ LDCs (ranging in size from small to large) volunteered to be the first wave of AMI adopters and engaged in a procurement (for metering, AMI IT and communication systems) coordinated by the province via the Ministry of Energy. In the years since, the majority of the remaining LDCs have volunteered to participate in a similar Ministry-coordinated procurement, with the remainder obligated by provincial regulation to utilize vendors that were successful under the government-coordinated processes. Through this process Ontario, along with California, have become the first jurisdictions in North America to proceed with deploying smart meters to all low-volume consumers.

In parallel with the smart meter initiative, the province in 2006/7 intensified its efforts to promote CDM activities in Ontario by assigning responsibility for the development and administration of customer programs to the OPA, and switching the primary funding source from LDC rates to the 'Global Adjustment' uplift mechanism (GAM). The OPA was directed by the Minister of Energy to ensure the achievement of aggressive conservation and peak demand reduction targets, and provided with the authority to contract to meet those targets via LDCs or directly with 3rd parties. LDCs were obligated to turn first to the OPA for GAM-sourced funding for CDM initiatives, but retained the ability to make application to the OEB for supplemental funding through distribution rates. Most utilities responded to this provincial initiative by participating in the handful of standardized programs developed by the OPA for delivery via the LDC sector. However, a handful of LDCs developed tailored investment plans and successfully applied for them through the OEB's new multi-year ratemaking model (see below for details). The applications brought by these LDCs innovatively sought to achieve, via planned capital and operating expense in the distribution system, CDM benefits (e.g. electricity loss reductions) alongside reliability improvements.

Another policy objective of the province, embraced fundamentally by the OEB, was the implementation of a new regulated rate-making model designed to stimulate continued efficiency-seeking behavior on the part of LDCs. The 3rd Generation Incentive Regulatory Mechanisms (3GIRM), adopted starting in 2007/8, incorporated not just an annual productivity (X) factor, but also an additional 'stretch' factor with 3 different intensities applied by the OEB to each LDC on the basis of their annual efficiency performance relative to their comparator peers. This new ratemaking model, which features intensive scrutiny of applications by both OEB staff and intervenor groups, has, according to the interviewees, proven to be extremely onerous and costly for LDCs. The model itself, while designed to encourage LDCs bringing forward applications for new rates only once every 4 years, provides utilities the right to attempt to apply for new rates more frequently. However the interview subjects report that most LDCs are – having gone through the process once – now significantly deterred from attempting to 'go-in' early. The fact that the government itself has publicly called upon the OEB to be vigilant in protecting consumers during the economic downturn since 2008, is causing LDCs to further doubt the prospect of positive outcomes on rate applications brought 'early'. This factor is reportedly causing an intensified effort within LDCs to search out efficiencies, largely via further improved asset management processes (especially for those utilities who are embracing these new methods for the first time). At the same time, according to the interviewees many utilities are also looking to realize efficiency gains in their internal operations via the adoption of new 'middleware' solutions linking the currently stand-alone IT systems at the heart of the distribution business: GIS, Enterprise Resource Planning (ERP) systems, Outage Management Systems (OMS), AMI, Supervisory Control and Data Acquisition (SCADA) systems, etc… Still others are reportedly entering into new multi-year relationships with their field service contractors; these 'Alliance Partnerships' are intended to save costs via coordinated project planning, lower unit pricing, contractor self-inspections, etc… And, in parallel, the collaboration between members of the sub-groups appears to be intensifying. Many of the CHEC utilities for example are adopting common regulatory compliance practices, are seeking to coordinate on asset spec'ing and price negotiation, and are participating in a co-operative billing system service. A number of Niagara-area utilities have grouped together to invest jointly in a new transformer station, alleviating constraints across multiple service territories. And the CLD has jointly hired CDM specialists to assist them in developing their conservation-oriented business strategies. In short, the onerous nature of the rate application process, coupled with the perceived lack of 'headroom' for LDCs to raise rates, appears to be forcing utilities to continue their search for new ways to achieve efficiencies.

In 2009, the Province took its latest legislative step toward defining new objectives for LDCs to pursue, through the passage of the Green Energy Act (GEA). As explained in Part 3 of this paper, the GEA established new obligations on LDCs to expeditiously connect, and bear a greater proportion of the cost of connecting small-scale renewable generation, as well as achieve (under a policy framework that has yet to be fully developed) new utility-specific CDM targets as a mandatory condition of their distribution license. Also, the GEA extended the permitted scope of LDCs business activities to include ownership and operation of small-scale renewable generation and electricity storage.

The connection of small-scale, intermittent, dynamically-operated 'distributed' generation (DG) units to the distribution network is a significant challenge for LDCs in Ontario, where the grids and operating systems and processes have not been designed to accommodate DG. This pressure, coupled with the negative generator customer reaction to the early price quotes provided to them by LDCs to connect to the distribution grid have prompted a handful of utilities to commence work with original equipment manufacturers (OEMs) on cost-reducing connection equipment and developing changes in utilities' operating protocols. Respondents reported that in these working relationships, Ontario LDCs objective is to simply secure rights to use the new technologies and/or processes that are produced, not leverage that IP for additional revenues. Not only was this seen to be beyond the mandate and expertise of utility managers, but also an activity that would not make financial sense for LDCs to undertake given their obligation under Ontario's regulatory model to use any non-distribution revenues as an offset against their regulated rates.

The permission of LDCs to pursue as business activities commodity generation and storage has also been embraced by a handful of LDCs. Those that have are forging new relationships with technology suppliers and contractors, and several have taken a parallel step of spearheading the development of regional 'energy alliances'. These alliances are formalized networks involving local post-secondary institutions, local businesses, and regional economic development groups, coordinated under a mandate to spur the growth of electricity-related commercial activity. Major local employers are often at the centre of these hubs, with perhaps the best example being the Durham Strategic Energy Alliance, spearheaded by the local LDC (Veridian Connections) and which involves not just OPG as the owner/operator of the nuclear plants in the Durham Region, but also GM who operates a major auto manufacturing plant in Oshawa, and the University of Ontario Institute of Technology. Via LDCs pursuit of these initiatives, there is growing exposure of the LDC sector to new ideas, customer demands, technology change, and ways of conducting business.

Summary:

In summary, 5 main themes emerge from the Ontario interviews, with respect to the degree, scope and nature of the innovation activity occurring in the LDC sector during the study period. The first is that in Ontario the primary driver of change in the LDC sector, and thus innovation – to the extent that it's occurring – are the fundamental policy objectives defined by the provincial government. Liberalization drove corporatization and commercialization of LDCs, which in turn stimulated the organizational innovations undertaken by LDCs before the price freeze. The province's imposition of the rate freeze in 2002 unwound many of the organizational innovations, but established an efficiency imperative. The province's linkage of CDM to the 3rd tranche of ROE stimulated LDC activity in that area, and the new mandatory targets under GEA will intensify the activity.

The government's smart meter initiative positioned Ontario far ahead of most other North American jurisdictions. And the new obligations for LDCs to connect small-scale generation will spur changes in connection and system operation methodologies and equipment. The province has used a mix of policy tools that include mandatory obligations, commercial permissions, a threatened legislated removal of metering/customer care function, and Ministry coordination (of procurement) to implement its policy objectives via the LDC sector. For the most part, these tools have sufficed to implement changes within Ontario's LDC sector that could be accomplished with technologies and processes that existed and were in-use elsewhere. Adoptions of these technologies and processes have occurred to a degree in Ontario sufficient to meet the policy objectives defined to date, largely through the use of two mechanisms: inter-utility collaboration, and learning by LDCs through information imparted by 'trusted advisors' (external parties with deep experience and strong relationships with LDCs). However, interviewees reported that a fundamental difference is now facing LDCs with the most recent round of obligations: the lower cost / reliability-ensuring connection/accommodation of DG, and the aggressive new CDM targets are moving Ontario into areas where brand new technologies and processes will be required. It appears a legitimate question if the same policy and learning mechanisms used to date will suffice to produce the desired outcomes that are being defined for the LDC sector.

A second theme is that the rate-making approach employed by the regulator since 2007/8 is producing – as they clearly desire – the motivation for LDCs to focus on internal efficiencies. However the pressure being created by the 2 & 3 GIRM models, especially when coupled with the previous negative experience of LDCs in seeking to recover the market readiness investments and dealing with the financial fallout from a government intervening to undo the price effects of their own competitive market policies, is – according to the interviewees – having the effect of making LDCs more conservative with their distribution investment plans. It was a commonly reported view that asset management-intensive investment plans will not be sufficient to cause the government's broad, newly defined objectives to be realized, and – to the point above – the technologies and processes that will be required to meet the government's objectives will be newer and unproven. All interviewees reported a concern that the incentives of the regulatory model are geared to promote extreme risk aversion and conservatism on the part of LDCs, behaviors which appear to be significantly at odds with what will be required to achieve the goals articulated by the government.

Third, it appears evident from the interviews that LDCs responses to the government's objectives, as well as to the building pressure for efficiency, are significantly shaped by, and dependent on, the outlook of the CEOs and management teams of the utilities. It is clear that a segment of the management teams within the industry are feeling pressured – for a host of different reasons – to focus on 'just surviving'. Indeed, over the past 10 years, it is reported that most management teams found themselves in this position, some almost continually. Those that are in this position reportedly do not have the time or resource capacity to devote to innovation; they are focused on doing more with less, within the context of their existing operating routines and approaches. The most common reported response by management teams facing 'just survive' situations is to delay expenditures and/or hires (i.e. harvest assets). Given the aging asset base in Ontario, interviewees report this is a management approach option that is time-limited; sooner or later crises will occur as a result of assets 'running to failure'. It was a commonly reported sense that the LDC sector as a whole needs to steadily invest more resources over a sustained period to move away from a 'run-to-failure' asset management approach, and to incorporate into LDC operations the new technologies and processes that will permit the province's objectives to be realized. On the whole it would appear from the comments of the interviewees that only a minority of LDCs' management teams has the time and resource capacity to be as forward thinking and sophisticated in their approach to managing toward the future as would seem to now be required.

Fourth, a common theme that emerged from many of the interviews is that more focus and resources need to be applied by the LDC sector into building deeper and more substantive working linkages with new partners to develop the solutions needed to address the foreseeable challenges facing the distribution sector: infrastructure renewal (physical and human), connection and management of dynamic loads and intermittent supplies, intensifying customer demands (for service, power quality, etc…). Clearly relationships and networks have deepened over the survey period, but a common view was that the pace and scope of this deepening is still not what it needs to be – the LDC sector would benefit from awareness of a greater flow of new ideas for improved processes, techniques and equipment.

Fifth, it appears that Ontario LDCs as well do respond to financial incentives, but their behavior also appears to be significantly motivated by non-financial factors. Most respondents reported that the fact the Ontario LDC sector is predominantly owned by public-sector entities is reflected management teams having to position their utilities to deliver on multiple, sometimes conflicting objectives. Achieving 'optimized' rates of return, while keeping rates as low as possible were universally-reported as the expectation for LDC managers. As well, a common factor reported by the management teams of municipally-owned LDCs was the need to respect their shareholders' expectation of retaining local control over the delivery of the service, perceived as being of essential importance, of electricity delivery. Interestingly, it was reported by LDC managers who had been involved in successful mergers that, in the end, the objective of local control was ceded by local shareholders only once it evident that the financial penalty to retain local control was significant (i.e. standing alone was financially unsustainable).

Part 5: Description and Analysis of the Jurisdictions as Sectoral Innovation Systems

This section contains an outline and comparative analysis of the primary innovation drivers and dynamics observed within the regulated electricity distribution ‘sectoral systems’ present in the two study jurisdictions, UK and Ontario.

As noted in the previous section, government policy decisions are the overriding, dominant factor influencing the types of activities pursued by distributors in both study jurisdictions. While this is a common feature, the architecture of the institutional framework through which these policy decisions/directions are translated for distributors are fundamentally different between the jurisdictions. As well, the nature of the instruments and incentives that are used to elicit desired operational behaviors from utilities within these institutional frameworks are materially different. In addition, the permitted commercial scope of distributors in each jurisdiction is distinct, a fact that leads to far different relationships between distributors and end-users across the two jurisdictions. These three factors – institutional frameworks, regulatory approach and incentives, and demand types – are the most evident drivers of the different innovation dynamics noted between the UK and Ontario.

To assist in appreciating these differences, outlines of the sectoral systems in Ontario and the UK are provided in Figures 8 and 9, respectively. As a comparison of the outlines makes evident, the institutional framework in Ontario, through which government objectives are translated through regulation and other policy instruments to LDCs, is far more complex than the framework that is evident in the UK.

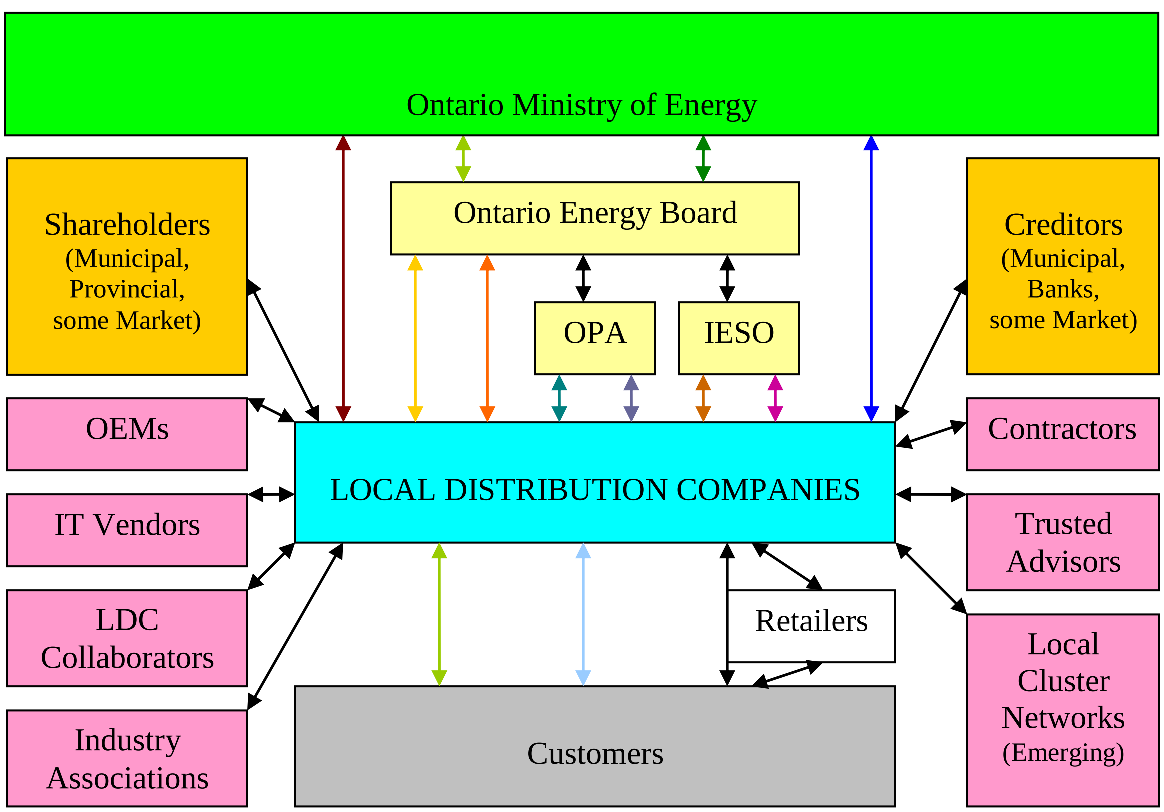
Ontario LDCs receive policy-driven inputs relating directly to their operational activities from 4 separate sources: the provincial government’s Ministry of Energy, the OEB, OPA and the IESO. Further, each of these sources issues direction to the LDCs through the use of two or more policy instruments apiece (note that within Figure 8 differently coloured arrows are used to denote this characteristic of the system). Through the study period the Ministry of Energy in Ontario used three primary instruments to directly impact the operational activities of LDCs: (a) statutory amendments to the definition of permitted activities for distributors (e.g. the permission to undertake CDM, and ownership of DG and electricity storage), (b) regulations establishing operational obligations for LDCs in implementing provincially-driven initiatives (e.g. coordinated procurement of smart meters using the Ministry-authored smart meter specification, establishment of disclosure obligations regarding the capacity of distribution systems to connect DG), and (c) instructions /obligations established through their agencies, which the Ministry significantly controls via Ministerial Directives, amendments to their statutory objects, and provincially-authored regulations. The OEB is the most authoritative of these agencies (in fact in addition to licensing and regulating utility expenditures, it does the same for OPA and IESO), regulating LDCs rates for their monopoly distribution business and associated customer service and settlement obligations, as well as authoring and policing compliance on rules for LDCs' conduct of permitted, but non-ratebaseable activities (e.g. DG, CDM). For its part the OPA develops and designs both CDM and residential DG ('microFIT') programs that LDCs are mandated to deliver, and issues renewable power purchase contracts that LDCs are now permitted to enter. And the IESO authors and administers the wholesale market rules (relating to settlement, etc…) that LDCs must comply with, and also has been tasked by the province to develop and operate the central MDMR to process data from LDCs smart meters.

Through the study period a definite trend was evident in Ontario. In addition to the province using its authority with increasing frequency to establish new operating obligations for LDCs to facilitate implementation of provincial policy objectives, the Ministry of Energy and its agencies employed with increasing frequency operationally-prescriptive approaches and the establishment of mandatory obligations. For example, where CDM activity was established in 2005 as a permitted (not mandatory) activity which LDCs could deliver through programs of their own development/design, by 2009 it had become a mandatory activity with utilities obligated to deliver broadly-scoped OPA-designed programs, and required to pass a stringent 'no-duplication of OPA programs' test in order to gain permission to deliver programs of their own design. In smart metering, as referenced above, the Ministry of Energy directly authored the specification for smart meters to be deployed in Ontario, then prescribed through regulation when and how LDCs could procure the meters. Through the same period, the province elected to have the IESO build and operate a single MDMR to process the data produced by LDCs smart meters.

When considered alongside the prudence-based, multi-year rate-making approach adopted in 2006/7 by the OEB, the institutional framework and approaches evident through the study period in Ontario significantly discouraged LDCs to engage in innovative behaviors. Instead of proactivity and innovation, the institutional framework clearly increasingly valued and encouraged amongst the vast majority of LDCs the utilization – on a necessarily reactive basis – of government and/or agency approved equipment and approaches wherever possible.

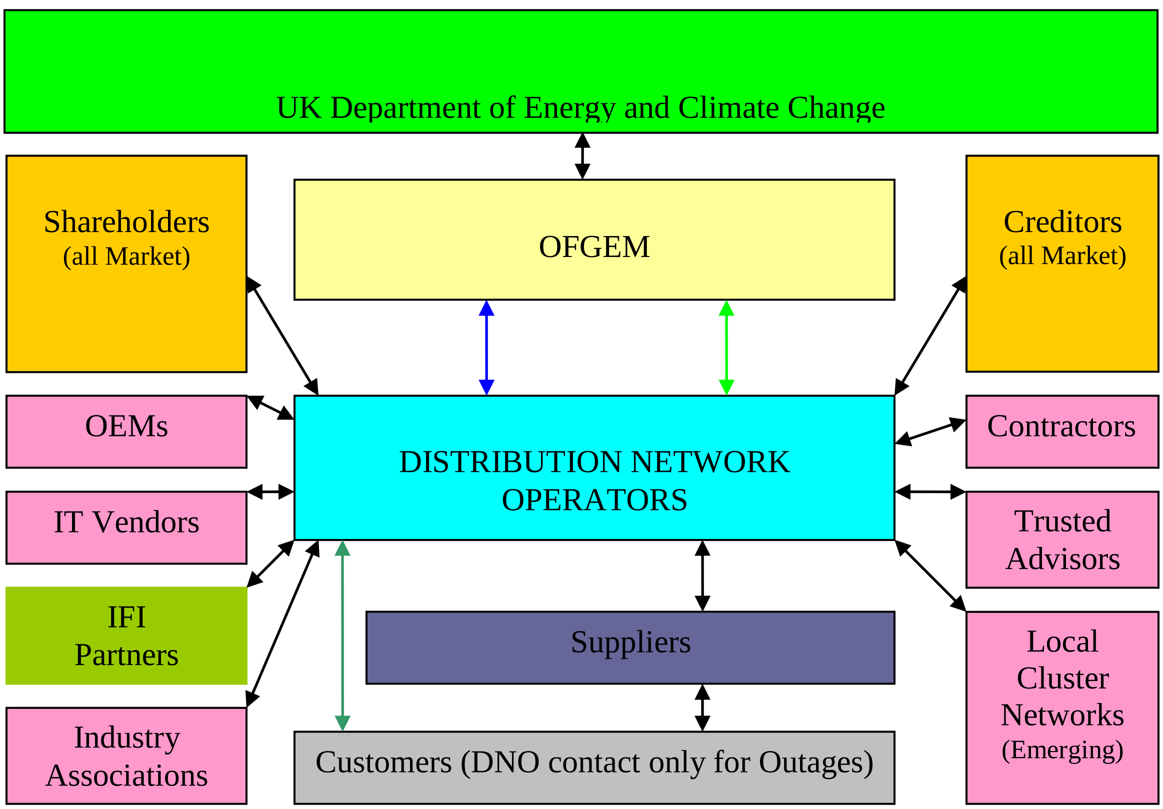
In contrast, the institutional framework evident in the UK over the study period was far less complex than Ontario's, and evolved in a way that facilitated and encouraged heterogeneous behavior amongst UK DNOs as they pursued policy objectives defined by the government. In very similar respects, the UK government pursued the same policy objectives as the Ontario government, through the study period. Increased utilization of renewables from distribution-connected generating units, was for example a common goal of both governments. As well, the UK government adopted very significant carbon reduction goals through the study period, and sought to ensure customers benefitted from the efficiency gains available across the distribution utility sector. To influence DNO operational behavior in the pursuit of these objectives, the UK government relied on a single agency, OFGEM. Its' very aggressive DPCr price controls provided strong financial incentives (both positive and negative) to drive efficiencies while at the same time maintaining high standards of operational performance (by establishing a direct and strong link between operating performance standards and financial incentives/penalties, something that has not yet occurred in Ontario). Rather than prescribing approved operational approaches in the way that occurred in Ontario, OFGEM's approach was objectives-based: desired standards for operating performance were defined, outcomes were tracked and rewarded or penalized accordingly. When it was recognized that innovation activities in the DNO sector were insufficient to address the future challenges of the sector, particularly in the area of asset management and DG connections, new commercial incentive programs (the IFI and RPZ) were established and administered through OFGEM to encourage DNOs to voluntarily engage in these activities. Highly variable approaches were employed by DNOs, and the sector dramatically increased its innovation activities. This same commercial incentive approach to motivating desired behaviors from each DNO is being used by the UK government in targeting carbon emissions in the sector, through the 500M pound LCNF. In short, compared to the Ontario model, the UK institutional framework and approach delivered far clearer, stronger signals (predominantly economic) to DNOs. Homogeneity across the utility sector in how the broad policy objectives were achieved was not pursued; to the contrary the commercial incentive mechanisms established were not prescriptive, and promoted heterogeneous approaches.

FIGURE #9: Sectoral System of Ontario's LDC Industry



The third primary driver of variances in the innovation activities evident in the electricity distribution sectors in the UK and Ontario through the study period arises from the fundamental difference that exists in the scopes of permitted distribution activities, and the resultant types of demand faced by utilities.

FIGURE #10: Sectoral System in UK's DNO Industry



In the UK, DNO's scope is very narrow: they provide low-voltage delivery service, but only interface with end-use customers during outages (or when dealing with reliability concerns) and for grid connections (the majority of end-user interface including settlement and customer care, is through suppliers). In contrast, at the outset of the study period Ontario LDCs had a broader scope of permitted activities including not just delivery, outage/reliability management, and connections, but also metering, retail settlement and customer care, and over the period of the study LDCs' permitted scope augmented to include CDM (now mandatory), implementation of Time-of-Use pricing (also mandatory), and ownership/operation of DG. The difference in the business scopes of DNOs and LDCs is striking. Revenue-capped DNOs are solely focused on reliability and connections, and have no interest in their customers' consumption behavior, or for that matter commodity pricing. In contrast LDCs – as price-capped, CDM-mandated, operators of call-centres – have significant interest in consumption behavior and commodity pricing. The nature of the end-user demand pressures faced by LDCs in Ontario is far broader than that experienced by DNOs in the UK, and as a result there is potential, as demand pressures mount in future, for the innovation-related behavior of LDCs to significantly change. Indeed, as commodity prices are beginning to increase, new activities are beginning to intensify. Forward thinking LDCs are seeking to develop tailored CDM programs for their customers, and in the few short months since gaining the authority to generate through the GEA, a handful of LDCs developed and launched renewable power businesses.

Alongside the fundamental differences between the UK and Ontario regarding the institutional framework, approach, and types of demand pressures, at least two modest parallels in the sectoral systems were observed.

Interestingly, local cluster development appears to be occurring in Ontario and the UK in parallel. The DNO-led emergence of EIC in northwestern UK and the LDC-led 'regional strategic energy alliances' in Ontario (e.g. the Durham Strategic Energy Alliance, and the Golden Horseshoe Energy Alliance) occurred at approximately the same time (2008/9). The EIC does appear to be more focused on the incubation/development of technology and process innovations that could be commercially deployed on DNOs networks, whereas the Ontario cluster networks appear to be oriented more towards generalized local economic development of energy related businesses. However, it is clear that both types of endeavors have been motivated by a combination, on the part of the participating utilities, of ‘good corporate citizenship’ and community leadership, as well as seeking to realize direct commercial benefits.

As well, as is evidenced by the sectoral system outline diagrams, utilities in both jurisdictions are surrounded by, and have developed linkages to, many of the same general types of external parties. OEMs, ‘trusted advisors’ (e.g. business strategy and/or technology consultants), IT vendors, contractors, and industry associations are all within the ‘networks’ of DNOs and LDCs. At the same time though, the nature of the linkages between utilities and some of these parties appear to be significantly different between the jurisdictions. For example, DNO’s exhibited significantly deeper working and product development relationships with OEMs than appear held by LDCs. As well, DNOs appear to rely more significantly on their industry association for operational assistance and standard setting than LDCs in Ontario, who utilize their association for policy analysis and advocacy purposes (perhaps this is not surprising given the more complex institutional environment in Ontario). Further, when considering the scope of ‘linkages’ held by the distribution industry in the study jurisdictions, it is clear that the breadth of DNO relationships outpaces that of LDCs. One key driver of this is the scope of the ‘IFI partnerships’ that were developed by DNOs through DPCr4. In contrast, Ontario utilities appeared through the study period to predominantly have sought to address their operating challenges by intensifying relationships with like-minded sub-groups of LDCs, more so than reaching out and developing new relationships with parties beyond the DNO sector (although there is some evidence that by the end of the study period in Ontario this had begun to change).

Part 6: Conclusions / Recommendations

The primary objectives of this paper have been to provide insight – for academic audiences, as well as policymakers and utility managers – into the degree, scope and nature of innovation activities occurring within the regulated distribution sector in the UK and Ontario, and the available institutional means of increasing the sector's innovation-related contributions to economic growth and broader public policy ends. In addition, the authors sought to outline and analyze the sectoral innovation systems present in the regulated electricity distribution industries in the two study jurisdictions.

Parts 1 through 5 of this paper have covered the research methodology employed, a review of the innovation literature, and, for each jurisdictions, a description of the institutional environments present, the results and analysis of the research interviews conducted, and a description and analysis of the sectoral innovation systems present. In this the final section of the paper, we provide the final conclusions that have emerged for the authors from this study, along with suggestions regarding areas of focus for policymakers and utility managers consideration in managing and stimulating innovation within the complex electricity distribution industry environments.

Macro-Level Innovation Dynamics

At a macro level, the innovation-related picture of the electricity distribution industry that has emerged via this study is of one that has – in just the past 5-6 years (since 2004) – entered what promises to be a period of truly fundamental change. Given the experience and starting position and condition of the industry and the institutional frameworks used to govern it, this period of change will produce significant challenges both for utility managers and policymakers alike. This is because the coming changes are of a nature and scope that, quite simply, never have been experienced before by the industry.

The power distribution industry today is, quite naturally, significantly reflective of its past. The core electricity delivery technologies involved in the business are decades old, reflecting through much of the last generation what some might term a ‘steady state’. Many of the assets are as well, a fact which is in part reflective of the 30-40 year life of many distribution industry components. And, like many established industries, the workforce is older and rapidly approaching retirement age. Physical and HR asset renewal is a dramatically mounting pressure.

The innovation intensity of the industry, relatively low to begin with, appears by all accounts to have reduced even further as a result of the efficiency-oriented industry restructuring efforts of the last two decades. Institutional supports (i.e. publicly-supported, centralized R&D agencies) have been scaled back and/or refocused to more lucrative market segments. Utility managers, motivated by institutional pressures/mechanisms geared to produce economic efficiency, have indeed responded by adopting process innovations in key areas of the business. However the innovations adopted through utility-driven decisions have been, with few evident exceptions, incremental in nature (‘continuous improvement’) involving the application of existing technologies within the distribution industry. Lock-in, both in terms of legacy technologies and established intra-firm routines, is evident at a high-level.

Distributors, especially those in Ontario, have over the past few years been mandated to incorporate into their business fundamentally new technologies and processes (e.g. smart meters and associated communication and data management systems, early-stage CDM activities). Radical as they may have been seen to be, even these innovations reflected the application within the distribution utility sector of technologies pre-existing in other industries.

However, a powerful dynamic that is only just emerging is the new and rapidly intensifying pressure to incorporate into the distribution industry brand new, emerging technologies. Examples of this abound: electric vehicles, small-scale intermittent generating units, energy storage technologies, active consumer controls, etc… As a result, this relatively low-innovation, highly locked-in, culturally-and-institutionally-accustomed-to-a-technological-steady-state industry is facing accelerating pressures to incorporate within it new, much more radical innovations and technology-enabled processes. It is important to note that it is not merely technological change that is driving this pressure on utilities; it is also the ambitious public policy objectives being adopted by governments which are mandating distributors to embrace and fully harness the new innovations in order to produce desired economic, social and environmental outcomes.

What utilities are finding is that their existing routines, operating processes and equipment choices are insufficient to accommodate the new emerging technologies and realize the new policy objectives adopted by government. What many distributors today are beginning to realize is that they themselves require new technologies and innovations in order to accommodate and harness the emerging new technologies. A classic example of this is evident in the distribution industry's efforts to respond to the emergence of small-scale distribution-connected generation technologies. The initial response to connection requests was in many cases to simply report that the distribution networks were not designed to accommodate such generators, and deny requests. Given the attractiveness to policymakers of the outcomes that can be produced via the diffusion of these types of generators, it wasn't long until utilities were mandated to connect these generators. Now the connection cost estimates being provided by the utilities to the generator applicants are producing significant backlash (based as they are on traditional connection methodologies) and pressures for utilities to find lower-cost methods of connection. Utilities are finding that no such technologies exist, and are turning to the OEM industry to find solutions. In parallel, the search is on for new grid management equipment and software that will ensure continued grid stability and reliability once these generators with highly-dynamic operating characteristics (most are intermittent) are connected.

Also in parallel, policymakers (regulators especially) are finding that their traditional approaches to utility regulation (which heavily utilize hindsight-based 'prudence' and 'used and useful' tests) were not developed to accommodate operating realities that require the deployment of new, non-proven technologies. Regulators' initial response – just like that of the utilities – has often been to attempt to address the challenge within the conceptual frameworks of their existing regulatory models. Just like the utilities discovered, it is increasingly evident that new regulatory/oversight approaches are necessary to accommodate the very new, very real pressures being generated within the industry by these technological shifts.

A factor which makes the challenge facing utilities and policy-makers alike that much more challenging is the aging physical and human resource infrastructures in the sector. As already mentioned much of the physical plant in the industry is approaching the end of its useful life. As well utility sector workforces are heavily skewed to older demographic segments. Once-in-a-generation renewal programs are rapidly being developed for both asset types. While this clearly represents an opportunity to incorporate new technologies and innovative processes, and the human resources with the skills and knowledge required to effectively utilize these advanced tools, the replacement cost of physical assets, and the challenge of hiring sufficiently experienced staff are daunting indeed. As well, on the physical asset and technology side, significant 'technology risk' exists, which warrants material caution and focus on the part of policymakers and utility managers to ensure heterogeneity in technologies selected for deployment.

Degree, Scope and Nature of Innovation Activities

While the dynamics outlined above are evident at a macro level, a number of key differing dynamics are apparent at the jurisdictional level between the UK and Ontario.

With respect to the 'degree' of innovation activities underway, clearly the DNOs in the UK appear to be – on balance – more advanced than their Ontario counterparts. This is hardly surprising given the existence for 5+ years in the UK of the Innovation Funding Incentive mechanism. It also appears that DNOs are more advanced than their LDC counterparts in pursuing innovative approaches to asset management and reliability (including loss reduction) initiatives. Again, the presence in the UK industry for the past 10+ years of an extremely strong system performance incentive would appear to be a major reason for the different in innovation activity in these areas. That is not to say that Ontario LDCs have not undertaken innovative activities in the areas of asset management and reliability; the observation is simply that they do not appear to have engaged in it to the same degree.

Interestingly, when it comes to the "nature and scope" of innovation activities the reverse appears to be true. DNOs have, as referred to above, focused a significant amount of their innovation activities in the area of asset management and reliability. Even the IFI is geared toward those types of activities. However, Ontario's LDCs are permitted to be involved in a much broader range of activities than DNOs. As a result of this basic fact, comparatively LDCs have engaged over the study period in innovative activities of a more varied nature and broader scope than DNOs. And, looking ahead, given the exposure of Ontario LDCs to a much broader set of actual end-user demand types and pressures (not to mention policy-driven expectations for LDCs to produce successful outcomes in power delivery, generator connection, smart metering, time-of-use-pricing and CDM), it is easily anticipated that LDCs will be forced to embrace and undertake innovation activities across a wide range of business activities/responsibilities.

Recognizing this reality for Ontario's LDCs, and the real existence of 'technology risk' when new innovations are adopted on a mass scale, underscores the importance to the industry of the means by which distributors are encouraged and/or mandated within the institutional framework to undertake innovation activities. As outlined in Part 5 of this paper, a trend evident in Ontario is for policymakers to increasingly rely on operationally- and procedurally-prescriptive, homogeneity-producing institutional approaches/methods for driving mandated adoption of specific technologies (e.g. the central MDMR, single smart meter specification). What the roots are that underlie this trend is unclear, but what seems to be quite evident and intuitive is that this approach, if sustained over time, will stimulate dependence on the part of utilities in Ontario, and homogenous (and thus riskier-than-necessary) technology selections. The 'objectives/outcomes-based' approach employed by policymakers via the institutional framework governing the UK's DNO sector – within which incentive mechanisms (sticks and carrots) are established to produce desired utility behavior toward producing pre-defined desired levels of beneficial outcomes, which then DNOs are free to develop and pursue their own means of achieving – would seem to be far more appropriate for navigating the innovation-intensive years facing the distribution industry, and far less risky. The DNO industry experience through the survey period provides evidence that the objectives/outcomes-based approach can produce very effective results. Given the far greater need for Ontario LDCs to incorporate significant levels of innovation across a broader scope of activities, significant attention on the part of policymakers and utilities on the institutional approaches to produce this required behavior appears warranted.

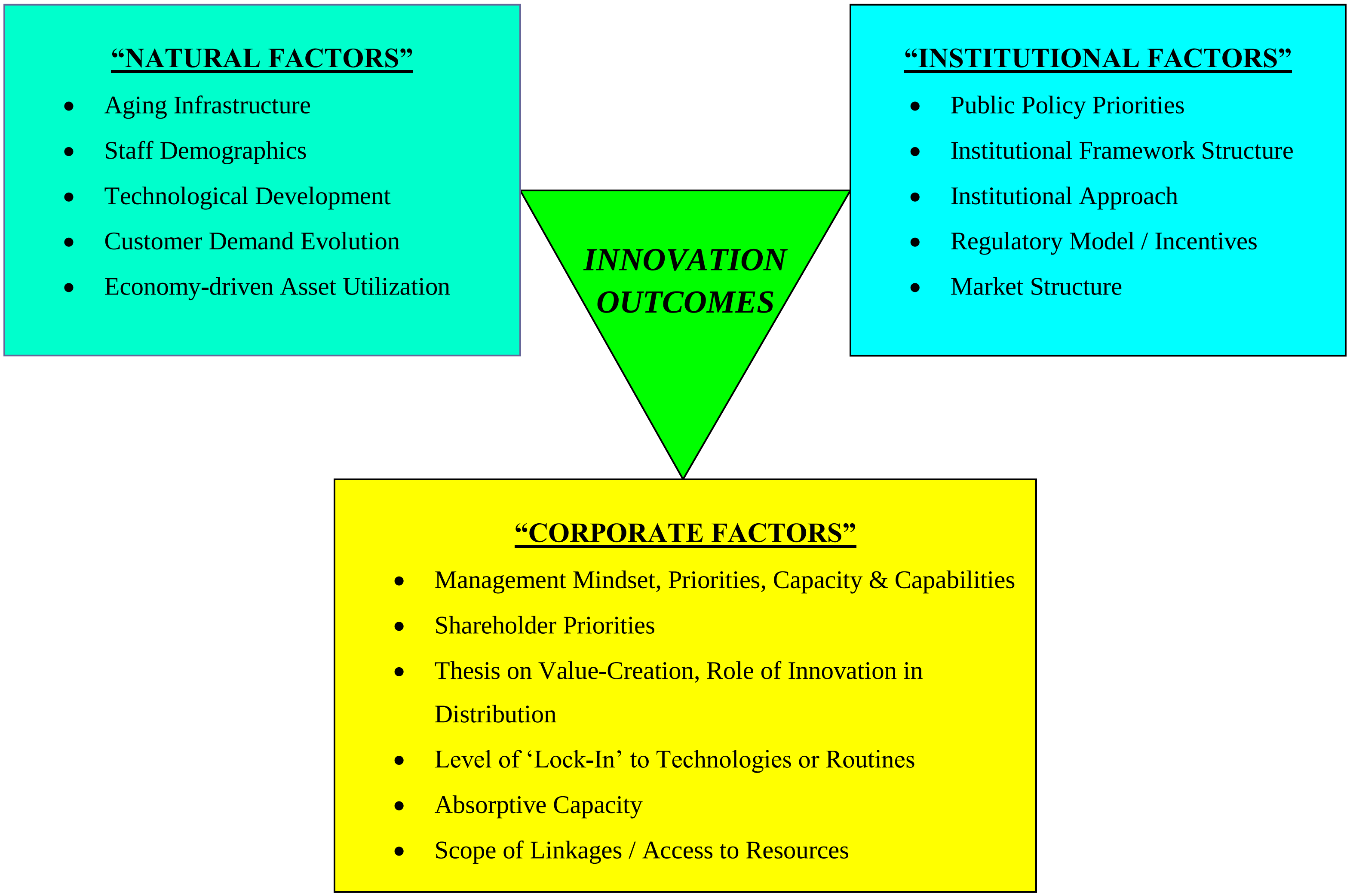
As well, the approach to stimulating appropriate levels of innovation across the distribution sectors must take into account the reality that in recent years and at present, in contrast to the UK DNO sector, it appears that a proportion of the management teams of Ontario LDCs have found themselves in a highly-stressed, 'just survive' mode. Several different types of causal drivers could be behind this type of mindset, but what seems evident is that a day-do-day survival-oriented mindset leaves no room for long-term, forward thinking innovation.

More broadly, the factor of management team mindset appears to have had very significant impact on the degree of innovation activity undertaken by utilities in both jurisdictions. Those utilities whose management teams viewed innovation as core to generating value within the distribution business, and who were motivated to be pioneers (as opposed to followers) appear to have undertaken more substantive innovation activities, in a more sustained manner, and with a broader range of partners. In Ontario, a very interesting – and perhaps counterintuitive – dynamic observed was that utilities of different sizes exhibited significant relative commitments to innovation activities. Several specific, smaller utilities were commonly cited as exhibiting high levels of innovation activities, motivated by pioneer mindsets and higher relative degrees of 'openness' to new ideas and operating approaches.

Core Determinants of Innovation

To move forward successfully through the coming period of intensive change in the distribution industry, utility managers, policymakers and industry analysts alike will require new strategic and analytical 'frames' through which to consider the sector. As evidenced by the initial experience of utilities and policymakers in grappling with the early challenges of the new innovation-intensive operating environment, the traditional, often rigid ways of thinking and conceptualizing must evolve, and new integrative and flexible approaches must be adopted. The new concepts that have emerged from this study for the authors stem from the realization that innovation outcomes within the distribution industry reflect the combination/integration of at least 3 primary determinant factors. Outlined in Figure Z, these three factor types have been termed "institutional", "natural" and "corporate".

FIGURE #11: Core Determinants of Innovation in Electricity Distribution



‘Natural’ factors are driven largely by external, macro, practically-uncontrollable forces: e.g. the passage of time, demography, technology, economics. These forces drive factors which are having powerful effects on the electricity distribution utilities of today: aging of infrastructure and workforces, emergence of new – and frequently more radical – technologies, swift evolution in customer demands and expectations, and the impact of the broader economic trends and dynamics on throughput levels and asset utilization. While these natural factors do not lend themselves to being controlled in any significant way, they can be tracked and forecasted with some degree of accuracy over the medium term.

Due to the highly regulated nature of distribution utilities, ‘institutional’ factors are a second primary driver of innovation outcomes. The definition of public policy priorities by governments has a huge focusing effect on innovation in the sector, as does the institutional framework structure and approach through which those priorities are pursued and effected. Within this framework the regulatory model in particular generates specific incentives and behavioral effects, which have significant impacts on the degree of innovation activity undertaken. And of course the market structure and segmentation – largely a policy-determined factor in electricity industries – significantly influences the nature and scope of activities undertaken by distributors. In contrast to natural factors, institutional factors are the product of policymakers decisions, and thus are – in theory at least – far more malleable and open to modification to produce particular outcomes.

Lastly, ‘corporate factors’ are the third primary driver of innovation outcomes. The mindset of management teams, their priorities, capacity for contemplation and strategic decision-making, their overall managerial capabilities and access to key resources significantly shape utilities’ behavior. The influence of shareholder priorities provides a dominant focus for management, and is an essential input into the executive team’s development of their ‘thesis’ on how to create value for the shareholder within the business. This thesis will reflect the perceived role of innovation in the company, the degree of commitment (lock-in) to existing routines, or conversely the degree of openness to new ideas (absorptive capacity). And the thesis will drive the degree and scope of linkages pursued by the firm. Our study makes clear that these corporate factors, many of which are controllable – again, at least in theory – combine to shape the personality and operating philosophy of utilities.

The innovation outcomes observed in the UK DNO and Ontario LDC sectors over the study period clearly are the products of the combination of these three types of factors. Given this, we suggest that these three 'determinants of innovation' warrant close consideration and scrutiny by utility managers, policymakers and industry analysts/academics alike. Each determinant on its own represents a useful 'lens' through which to evaluate from a particular perspective the pressures, enablers and impediments to innovation activities within the electricity distribution industry. When considered in combination, the factors provide a robust and multi-textured analytical mechanism through which to diagnose and productively commence the work of developing remedial prescriptions that will allow the electricity distribution industry to address the significant innovation-related challenges it faces now and in the years ahead.

Appendix A: Interview Subjects

United Kingdom

Organization	Title	Date
OFGEM	• Head of Profession Engineering, Distribution	4/26/2010
Western Power Distribution	• Manager – Design & Development	4/26/2010
Cap Gemini UK	• VP Utilities & Head of Smart Energy Services UK • UK Head, Utilities Transformation Centre of Excellence	4/27/2010
Energy Networks Association	• CEO • Director of Policy & Regulation • Director of Operations • Head of Engineering • Engineering Manager • Senior Engineer – Plant & Network Assets	4/27/2010
Fitch Ratings	• 2 Associate Directors of Energy, Utilities and Regulation	4/27/2010
CE Electric	• Head of Regulation & Strategy • Director of Regulation	4/28/2010
Electricity North-West	• Engineering & Planning Director • Director of Regulation	4/28/2010
Judge Business School, University of Cambridge	• Assistant Director of the ESRC Electricity Policy Research Group, & Reader in Business Economics, & Director of Studies in Management and Economics, & Fellow of Sidney Sussex College	4/29/2010
EDF	• Head of Distribution Price Control Review	5/4/2010

Ontario

Organization	Title	Date
Cap Gemini Canada	• Utilities and Energy Practice (EU&C), Industry Specialist, Smart Energy Services (SES), Global Operational Services Leader	4/20/2010
PowerStream	• EVP & COO	6/1/2010
Atikokan Hydro	• CEO	6/3/2010
Lakefront Hydro	• VP	6/4/2010
Orangeville Hydro	• VP	6/4/2010
University of Waterloo - Faculty of Engineering and the Faculty of Environment	• Professor and Ontario Research Chair in Public Policy and Sustainable Energy Management	6/7/2010
Hydro One	• VP Grid Operations	6/11/2010
Toronto Hydro	• VP Asset Management	6/16/2010
Burlington Hydro	• CEO	6/17/2010
OEB	• COO	
Utilities Kingston	• CEO	6/29/2010

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