CLIMATE RISK PERCEPTIONS IN THE ONTARIO (CANADA) ELECTRICITY SECTOR

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ABSTRACT

This thesis examines management cognition of climate risks in the electricity sector in Ontario (Canada).

Risk perception literature is combined with corporate adaptation and risk management literature to offer a broad conceptual framework of climate risk readiness among power producers and utilities. This research aims to move management cognition of climate change past prior contributions which considered climate risk as being solely physical in nature. In this work, eight exogenous and endogenous factors relating to climate risk are examined for their influence on how management may view a wider spectrum of climate change impacts. Using an inductive research approach, 20 in depth case studies explore how electricity executives/senior managers perceive those risks using construct elicitation (repertory grid technique). Findings are triangulated with a narrative analysis of their corporate reportage of climate risks, to gain deeper insight into the complex phenomena of climate risks for the sector.

Findings show some similarities and some appreciable differences in both groups' view of climate risks despite their legitimately contending positions in industry. Overall both power producers and utilities are predominantly concerned with risk analysis and assessment of climate related risks, and less with risk response, suggesting at present the sector remains in an analytical state. The potential benefits of this research approach will provide useful insights to multiple groups including managers and policy makers.

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—Anna Dowbiggin, February 21, 2018

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

APPrO	Association of Power Producers of Ontario
BCA	Benefit cost analysis
CEA	Canadian Electricity Association
CIP	Critical infrastructure protection
CUE	Centre for Urban Energy
GCM	General circulation models
GHG	Greenhouse gas
IA	Integrated assessment
IESO	Independent Electricity Systems Operator
IPCC	Intergovernmental Panel on Climate Change
NASA	National Aeronautics and Space Administration
PCA	Principal component analysis
PCIC	Pacific Climate Impacts Consortium
PCT	Personal construct theory
PM	Particulate matter
RAP	Rational actor paradigm
RGT	Repertory grid technique
RISP	Risk Information Seeking and Processing
SAR	Social amplification of risk
SO	Sulphur oxide
TCCCR	Tyndall Centre for Climate Change Research
TMI	Three Mile Island
UNFCCC	United Nations Framework Convention on Climate Change

GLOSSARY

Adaptive capacity is the ability of the organization to adjust to climate change impacts and to cope with the consequences.

Agentic self is a term used in social cognition theory that views people as self-organizing, proactive, self-reflective and self-regulating as times change.

Canadian Electricity Association (CEA) is the business association representing power producers, Utilities and transmitters in Canada.

Cap and trade is the term used to describe regulated emissions control scheme designed to limit, or 'cap' carbon dioxide emissions by industrial emitters. Emitters which produce greenhouse gases (GHG) in excess of a regulated threshold can trade allowances with others which need them, at a carbon price regulated by the participating jurisdictions.

Centre for Urban Energy (CUE) is a research centre affiliated with Ryerson University.

Climate adaptation means anticipating the adverse effects of climate change and taking appropriate action to adapt to the resulting damage they can cause.

Climate mitigation is a broad definition concerned with intervention before adverse effects of climate change increase or take hold.

Corporate adaptation to climate change means organizational response to climate change.

Committee of Sponsoring Organizations of the Treadway Commission (COSO) is a joint initiative of five financial sector associations concerned with the development of frameworks and guidance on enterprise risk management, internal control and fraud deterrence.

Critical infrastructure refers to processes, systems, facilities, technologies, networks, assets and services essential to the health, safety, security or economic well-being of modern society.

ECO Fiscal Commission of Canada is a university research initiative which studies the quantification of losses produced by climate change in Canada.

Emissions refer to the pollutants, notably GHG produced by the emitter.

Energy sources refer to source fuel types, including nuclear, hydro, natural gas, coal and renewable energy sources such as wind and solar. Energy sources are alternatively referred to as the power producers' mix

Energy systems refer to the electric power system for supply, transmission and consumption of electric power.

Expected utility theory refers to the mean of the subjective values of all relevant outcomes weighted by the subjective probability of occurrence of each.

Fat-tailed probability is a statistical phenomenon representing a greater likelihood of extreme events occurring.

Gas-fired power producer plants refers to the segment of electricity supply organizations which use fossil fuel in their fuel mix.

Greenhouse gases (GHG) are the gaseous mixtures emitted from the burning of fossil fuels. GHG are understood to be a main trigger for global warming and climate change

Grey literature means material not published in refereed journals, and usually refers to corporate literature.

Intact Centre for Climate Change is a research arm of the University of Waterloo.

Intergovernmental Panel on Climate Change (IPCC), a division of the United Nations, is a consortium of 650 climate scientists and expert specialists which track and assess global climate change patterns.

Intertie connections are found in a transmission facility that links one or more electric systems outside Ontario (in this study) to one of more points on the interconnected electric system.

Narrative analysis is an analytic approach to analysing textual or narrative statements.

National Aeronautics and Space Administration (NASA) is an independent agency of the executive branch of the United States federal government responsible for aeronautics and aerospace research including satellite based collection of climate data for North America.

Natural gas is a source fuel (see energy sources) with high carbon content. Natural gas is a fossil fuel, and is primarily Methane (CH4), which has a higher energy content relative to other fuels. Fuel combustion of Natural Gas produces nitrogen oxides (NOx), carbon monoxide (CO), and carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), volatile organic compounds (VOCs), trace amounts of sulphur dioxide (SO2), and particulate matter (PM), otherwise known as greenhouse gases (GHG).

Ontario Energy Board (OEB) is the provincial regulator for the electricity sector in Ontario**.**

Ontario Energy Board scorecard is the annual compliance ‘report card’ that utilities in Ontario produce, Ontario utilities are currently prescribed by the OEB to disclose operational efficiency and energy conservation levels., according to a set of metrics set out by the regulator.

Ouranos is a public/privately funded regional climate science consortium which tracks and assesses climate change on a regional (Canada- wide) basis.

Power producers are electricity generation companies, producing electrical power for public and private grids in Ontario.

Personal construct theory (PCT) is a psycho sociological theory of human behaviour explaining how individuals make sense of their experiences in the world in uniquely personal ways, pioneered by George Kelly in the 1950's.

Personal construct psychology is a postmodern constructivist approach in psychology which looks at the unique and personal ways in which individuals construe, (understand, interpret) their world. PCT assessment tools include the repertory grid technique.

Sensemaking describes the process by which people ascribe meaning to their experience and their actions, as first conceptualized by Karl Weick.

Utilities are municipally –owned Ontario distribution and transmission companies which transmit electrical power to end users.

Repertory grid technique (RGT) The repertory grid technique is an interviewing technique designed for eliciting personal constructs.

CHAPTER 1 INTRODUCTION

1.1 RESEARCH AIMS

The aim of the present study is to examine how electricity power producers and utilities in Ontario view climate risks and how they expect to manage those risks in the future. Climate risks are risks associated with climate change and are defined in this work as macro, exogenous risks and firm – level, endogenous risks producing downside impacts on the organization. Of particular interest are electrical utilities and the gas fired electricity production segment considered to be significant GHG emitters.

Climate change is one of the modern world's grandest challenges. Near future climate states are forecast by scientific groups to produce increased incidence of extreme weather events that will have destructive effects on electrical power supply around the world including Canada *(*IPCC, NASA, Intact, and the Centre for Urban Energy (CUE; see Glossary). Climate change has already affected Ontario electricity suppliers through heat waves, severe flooding and ice storms. Risk effects of the physical manifestations of climate change have left businesses and households without power heating or air conditioning on many occasions and are well documented. (Acharya-Tom Yew, 2014; Canadian Electricity Association, 2016). Yet little work has been done on examining the additional risk effects associated with secondary and indirect impacts of climate change on industry (Gasbarro et al., 2016).

The question of how the electricity sector expects to cope with the risk effects of climate change suggests there is a need to understand how constituents perceive climate risks in the first place, and furthermore how they expect to manage climate risk impacts in the near future. The researcher agrees with several contributions which argue that the extent to which power producers and utilities manage climate risks in the future depends upon their current management beliefs and interpretations (Berkhout et al., 2006; Bleda & Shackley, 2008; Hoffmann et al., 2009). Using an inductive research approach, 20 in depth case studies are examined to show how electricity executives/senior managers perceive those risks. Construct elicitation techniques are conducted in semi structured face-to-face interviews with study participants. Findings are then triangulated with narrative data from corporate climate risk reports to gain insight into overall management cognition of climate risks for the sector.

In this work, comparative case study methodology is adopted with a mixed methods approach: personal construct theory (PCT) and its related repertory grid technique (RGT) are employed for the exploration of individual perceptions and risk beliefs. Narrative analysis of corporate reporting of climate risk is utilized for the examination of differences in perceptions between formal public statements of climate risk and the less formal, tacit understandings of climate risk elicited in interviews.

The intention is fourfold. First and foremost, it is to identify the way in which the participants construe and make sense of exogenous and endogenous influences of risk effects of climate change. Exogenous risk effects are identified in this work as climate change itself, climate predictive data, aging infrastructure, government policy and GHG emissions regulations. Endogenous risk effects are defined in this work as technical knowledge, organizational resources and organizational capacity.

The second intention is to develop a category scheme that describes and enumerates the constructs and beliefs management have about the influences (of the risk effects) involved, as well as the examination of the differences that may exist in the construing of the two groups of sector participants.

The third intention is to assess the relative importance the participants attribute to the exogenous and endogenous risk effects using supplied construct ratings.

The fourth intention is to assess the similarities and differences between the fieldwork findings produced by the repertory grid interviews, with the findings produced from the narrative analysis of corporate reports.

The research study relies on a constructivist approach which accommodates the suggestion that climate risk impact is actually a business construct with multiple potential meanings and perceptions held by the sector participants. Prior management cognition literature has suggested that how companies chose to manage climate risks is driven by management's current risk beliefs and construal. Furthermore, several authors suggest that combining exogenous factors with older institutional views of firm - level dynamics of organizational life (Selznick, 1996) may help advance explanations about management thinking. When combined, the role of these drivers and influences may better support the debate related to how management intends to manage climate risks in the future (Ingram & Silverman, 2000).

Motivation for this work comes from the doctoral candidate's (herewith referred to as 'the researcher') professional career experience in resource planning for a large energy developer in Canada. Also providing motivation is the researcher's view that the way in which producers and utilities currently construe of climate risk may make a difference to the success of their future risk management strategies.

1.2 BACKGROUND

1.2.1 Electricity Sector at Risk in Ontario

Climate risk management is particularly salient for the electricity sector in Ontario. District utilities and their upstream generation partners are noted time and again for being vulnerable to potential extreme and sudden weather impacts (CEA, National Resources Canada, Conference Board of

Canada, and CUE). Low use of climate data in decision making and dependency on large scale and aging system infrastructure heighten exposure to climate risks (Gasbarro et al., 2016). Regulatory uncertainty and constraints on capital investments to re-build or retrofit plants, and regulator-approved cost recovery on potential damages to facilities and plants from flooding and the heat and cold effects of extreme weather impacts—further increase sector exposure to climate risks (Electricity Distributors Association, 2011; Murphy et al., 2014). Climate policies constraining fossil fuel- based generation are noted as creating 'unintended consequences' for the electricity sector at large (DeMarco, 2015). At the firm level, internal dynamics related to greater needs for climate expertise, technical knowledge, resources and overall organizational capacity to manage organizational change are seen as impacts created by climate risks (Busch, 2011).

Empirical work of how this sector group expects to cope with climate risks is found in technical and grey literature (CUE, EDA, CEA). Limited academic work has focussed on the Canadian electricity sector (Baker et al., 2011; Boyle et al., 2003; Canadian Electricity Association, 2016; Charron, 2014; Laszlo & Marchionda, 2015). Outside the country, climate risk literature not only covers a broader scope of issues and in several cases examines electricity and infrastructure in particular: Management strategies regarding climate change in Swiss and Austrian utilities (Weinhofer & Busch, 2013); risk perceptions of utility groups in the European Union (Gasbarro et al., 2016); and in Australia, behavioural studies on climate risk reporting in the Australian electricity sector (Haigh & Griffiths, 2012) are some examples of related prior research.

Prior literature covers many perspectives on the motivations for organizational response to climate change (to be discussed in Chapter 2). More recent studies however, frame climate change as a business risk (Linnenlueke et al., 2012; Weinhofer & Busch, 2013). This shift to the risk management paradigm suggests that a better understanding of how management views climate change can be gained through a risk management perspective.

Minimizing risk is an established business practice essential to organizational performance (Roberts et al., 2015). The identification, assessment and management of risks is obviously vital to business operations to avoid negative impacts on business performance (Linnenlueke et al., 2012).

How organizations intend to manage risks is a key feature of risk management planning. The research challenge here is to understand how the sector intends to manage the range of climate risks especially in light of the deep uncertainty and the systemic nature of climate risk impacts that climate change is producing (see Sections 2.1, 2.2.5). Understanding how the sector and its decision makers view such risks is to understand their risk perceptions, and is congruent with Weinhofer and Busch's (2013) claim that "the extent to which companies actually start managing climate risks depends on management's risk beliefs and interpretations" (Weinhofer & Busch, 2013, p. 122).

In other words, how companies construe of risk determines the direction of the response to the risk. Concomitantly, their mental model of such risks, including their perceptions, is key for corporate strategy and decision-making.

1.2.2 Risk Perceptions in the Electricity Sector

Two main approaches dominate literature on risk perceptions. One is the positivist, realist approach reflective of the technical and scientific field which suggests all risks are all quantifiable, objective and knowable and therefore all risks can and ought to be construed in the same way. The present study adopts the contending constructivist approach which best supports the ontological claim that risk itself is subjective and socially constructed (Berger & Luckmann, 1991; Dake, 1992; Jasanoff, 1998; Renn, 2008) and helps to explain the anticipated variation in risk beliefs and construal of sector participants.

Congruent with the chosen constructivist approach, literature is reviewed from five areas: the discourse on the systemic nature of climate risks—which include not just the sudden, direct climate events but the systemic and secondary risks created by climate change in the first instance. Second, a discussion about the electricity sector and the various pressures it faces in Ontario is provided. Third, a review of corporate adaptation to climate change literature is offered; fourth a review of literature on risk management and its application to corporate adaptation to climate change is presented. Fifth, a review of the literature pertaining to subjective views of management thinking is offered, focussing on management cognition literature, risk perceptions and social theories of risk perceptions. Included in that discussion are the contributions related to personal construct and sensemaking theory from Kelly (1991, 2003) and Weick (1995) respectively, as support for the analytical framework in this work. A brief overview of the Ontario electricity sector is offered next.

1.3 POWER PRODUCERS AND UTILITIES IN ONTARIO

Sector participants in this work are senior decision makers from two groups within the sector: the first being natural gas fired power producers which generate electricity from a fossil fuel base, and the second, municipally owned utilities which transmit electrical power to end users. (Other power production types such as nuclear, hydro and renewable energy fall outside the research scope of this work).

Natural gas power producers in Ontario (N=11) supply electricity to either the public grid or a private grid such as a manufacturing plant or hospital. All natural-gas fired power producers in this study are authorized market participants, monitored by the provincial grid systems operator (Independent Electricity Systems Operator (IESO) and regulated by the provincial Ontario Energy Board (OEB). Power producers have plant economics heavily influenced by government regulation, provincial climate legislation, and commodity prices of natural gas as well as long run capital investment horizons. Power producers in the present work are subject to annual disclosure of financial and operational performance.

Utilities in Ontario (N=73) are owned by the local municipality (the city, town or township) and are similarly regulated by the OEB and monitored by the IESO. Utilities transmit electricity from the power generation plants to retail customers. Utilities' performance in Ontario are influenced by government climate policies related to energy conservation, utilities efficiency/ performance and customer demand. Both power producers and utilities share complex energy system co-dependency which can under sub optimal operating conditions, combine and cascade into significant problems.

Given the importance of energy security and reliable electricity supply in Ontario, (and for that matter, everywhere else) examination of what, if anything, is driving management thinking about climate risks in the sector becomes more intriguing (Adger et al., 2010). How do these power producers and utilities—accustomed to high reliability standards to be 'prepared for the unpredictable' (Coutu, 2003)—perceive climate risk? How do they individually, concerned with failure prevention and resiliency, think about managing climate change impacts on their plants and facilities? (Hoffman et al., 1995). And more centrally, what do they view as the greatest challenge of anticipated climate risk management? It is likely that, given their different roles and accountabilities in the sector, the pressures on the two groups may be different, resulting in expected differences in climate risk perception.

1.4 RATIONALE

The rationale for the present study is to acquire deeper insight into a lightly explored area of research which may offer answers to how decision makers in critical industries view the prospects of climate risk impacts and its management. Prior contributions considered climate change as being solely physical in nature, and sidestepped a broader spectrum of downside risks that climate change creates. Much prior research on climate impact and adaptation addressed perspectives on human health, biodiversity loss while corporate adaptation research has tended to be theoretical and not be context specific (Winn et al., 2011). Even the more recent contributions on corporate climate change response in the regulated utility and power field, mainly view climate change impact as being only a physical phenomenon (Gasbarro & Pinkse, 2015).

A further rationale for the present work is to probe for cognition of climate risk among technical and more highly informed corporate executives—another lightly explored area of research. Abundant and important research exists already for lay population respondents, where risk perceptions of climate change have been examined by researchers seeking to explain why 'climate change doesn't worry us' (Leiserowitz, 2005) or why climate change is or isn't viewed as dangerous, threatening, or even 'real' (Renn et al., 2000). Some work has been directed towards professional environmental managers but explores personal values (Hill & Thompson, 2006). Few studies have attempted to explore management cognition of climate risks as they directly relate to their organizations, and fewer still have attempted to compare sub groups within one sector for differences, if any, in risk perception. Furthermore, comparing individual constructs with public and more formal expressions of climate risks in a mixed methods approach does not appear to have been conducted anywhere in the corporate adaptation research field.

It is noted here that the rationale for this work does not just include theory construction per se, but that the work examines existing models and theories for concepts that could be usefully integrated in the climate risk perception debate. At present there appears to be a lack of theoretical consensus about professional perceptions of risk as a social and a psychological phenomenon. This work seeks to contribute to theory by looking at the phenomena of climate risk impacts for the electricity sector and considers how it may be generalized to other similar groups facing the same set of pressures.

1.5 SOURCES OF CLIMATE RISK IMPACTS

Like all businesses, utilities and power producers need reliable conditions, resources and stable business environments to conduct business. Reliable business environments allow companies to plan and prepare for the future; resources enable organizational action and risk planning. Stable business environments better enable companies to deal with uncertainty and vulnerability reduction. Perceptions of uncertainty and vulnerability produced by risk impacts of climate change inform and complicate risk planning; being under-resourced in areas management views as important, produces pressure for organizations and their decision makers.

1.5.1 External Exogenous Factors

Key to understanding the sector participants' constructs of climate risk, and how they expect to manage those risks in the near future, is to consider the influence and pressure from their external institutional environment. The influence of external constituents is limited in this work to policy makers, regulators, and system grid partners (other utilities/generators). External policy makers, regulators and grid partners are accountable and predominantly concerned with producing government climate policy, GHG abatement regulations and managing aging electricity infrastructure.

Two further external factors proposed as influencers are added to the list. The first is climate change itself, in the sense of it being a physical phenomenon, described as and limited to sudden, direct climate events. The second is climate (predictive) data, seen as a climate risk pressure which may be regarded as lessening the sensitivity of the organization to climate impacts. Given the long-term capital investment horizon of the electricity sector, the issue of how management construes of climate data in managing future (1-5 years) climate risk is also considered.

In keeping with the intention to move management cognition beyond the physical impacts of climate change, and to consider perceptions as driven by a broader range of climate risk impacts, external influences are further combined with firm-level, or endogenous influences. Three additional sources of climate risk impacts are introduced.

1.5.2 Endogenous Pressures

Combined with the five aforementioned external pressures, the spectrum of climate risk impacts is extended to firm-level pressures, where technical knowledge, organizational resources and capacity are considered. Combining pressures from both the macro environment with internal dynamics is not only reflective of current organizational theory (Delmas & Toffel, 2008) but seeks to address what is identified as climate induced organizational change. Where Gasbarro and Pinkse (2015) examined how corporations view their resources and capacities in order to respond to climate change, Okereke et al. (2011) put it this way: 'Relying on old and pre-existing sets of skills and capacity to handle the new risks and challenges posed by climate change is bound to lead to suboptimal and ineffective response strategies' (Okereke et al., 2011, p.25)

1.5.3 Climate Change as Exogenous Pressure

Climate change's potentiality for catastrophic impact on human welfare and institutions is well documented as a physical phenomenon (Winn et al., 2011). Defining climate change according to its chief attributes is an important first step in appreciating the challenge it presents for the sector participants. In advance of the more detailed discussion in Chapter 2, four key characteristics of climate change are discussed here.

1.5.3.1 Non-Linear, Dynamic and Chaotic Characteristics

Firstly, natural sciences literature has defined climate change as 'non-linear, dynamic and chaotic in nature' (Daron, 2011; Lorenz, 2011; Solomon et al., 2007). The 2014 IPCC related those three features to its assertion that climate change has and will continue to produce three outcomes: an increase in mean temperatures; greater variability in weather patterns, and consequentially, an intensification of extreme weather patterns (IPCC 2014). Similarly, management literature has called climate change "climate disruption- to (dispute) this global warming as part of a natural cycle and emphasize our contribution to the coming changes and the speed at which they are approaching" (Rand, 2014, p. 9).

1.5.3.2 Deeply Uncertain Characteristic

Secondly, climate change is complicated by the presence of deep uncertainty (Weitzman, 2011). Because climate data cannot reliably forecast future states based on historical evidence, Weitzman (2011) suggested that it makes decision-making difficult as it is "immune to standard benefit cost analysis (BCA) to the possibility of extreme outcomes" (Weitzman 2011, p 276).

1.5.3.3 Dangerous Characteristic

Thirdly, references to climate change as 'dangerous' were noted by the United Nations Framework Convention on Climate Change (UNFCCC) as early as 1992 when it called for GHG stabilization such that 'dangerous anthropogenic interference' with the climate system is prevented (Dietz 2007 p 313). In Dessai et al.'s (2004) essay *'Defining and Experiencing Dangerous Climate Change'* the authors concluded that external (objective, scientific) and internal (personal) definitions of *dangerous* climate change need accounting for in climate policy making (Dessai et al., 2004).

1.5.3.4 Systemic Characteristic

Fourthly, climate change is characterized as being systemic. Slovic (1981) construed of risks as being systemic where multiple groups are affected either at the same time or in ripple patterns and cascading ways. In the context of climate change impacts, 'systemic risk' is an apt term where climate risk exists at the intersection between natural events, economic consequences and policy driven actions (Renn, 2005).

1.5.4 Government Policy and Regulation as Exogenous Pressure

Governmental climate policies in this work are attributed to the current and intended long term market de-carbonization 'Long Term Energy Plan' policy of the Ontario government and related GHG reduction regulations (Energy, 2017). Both bring external pressure to bear on electricity producers and utilities in the form of political and regulatory risk impacts with wide-ranging compliance costs, measures and reporting.

From the cognitive perspective, external constituents' views of risk may lead and influence internal, management perceptions of risk. In regulated industries, where organizations are compelled to behave according to compliance rules set by external constituents, risk perceptions of regulators and policy makers become powerful instruments for shaping risk perceptions inside the organization. Furthermore, where organizations seek to influence external constituents, Wachinger & Renn's (2008) concept of social and political arenas is apt – "where which powerful groups struggle for resources to pursue their interests and objectives... act as powerful shaping instruments for eliciting new beliefs about the risk or the source of risk" (Wachinger & Renn, 2010, p. 13).

Prior research also suggests that the trust response to external constituents who control and influence business environments drives risk perceptions within business (Dietz et al., 2007; Lorenzoni & Pidgeon, 2006). In the context of this work, critics note the prevalence of policy and regulatory uncertainty in the electricity sector since 1980, calling provincial energy policy 'unstable' and 'ad hoc', creating ultimate uncertainty for long term planning. (Winfield & MacWhirter, 2013). Energy policy and regulation in Ontario are recent consequences of climate change. The seemingly contradictory policy models have created external pressure on producers and utilities having to respond to a variety of climate-driven policy responses. As Winfield & MacWhirter (2013) recount it, "Energy policies since the 1980s have sequenced from supply planning, soft energy path policies, integrated resource planning, a 'market' model; a 'hybrid' model combining market and planning elements, a renewable energy paradigm fostered by the Ontario Green Energy Act (2009) and more recently, an ad hoc approach driven by political management considerations" (Winfield & MacWhirter, 2013, p. 1).

1.5.5 Climate Data as Exogenous Pressure

Scientific research groups located outside of the sector participants' domain produce specialized and predictive climate data. Due to the complex nature of climate change, decision makers are dependent on scientists and professional experts to define what evidence is seen to be relevant. Reliance on climate data for corporate response direction to climate risks is deemed in this work as an exogenous pressure. How climate data is dispensed at the international and the more local, provincial level is explored in this work.

1.5.6 Aging Infrastructure as Exogenous Pressure

Power producers and utilities are networked energy grid operators which manage system assets (transformers, conductors, wires, poles, cables) according to standards set at the time of installation. Today, assets for producers and utilities are variously aging and most are at the end of lifecycle (Murphy et al., 2014).

Aging infrastructure is described as a risk impact of climate change and is frequently mentioned in electricity producers' corporate reports. Increased vulnerability to climate change is described as being caused by aging infrastructure and is viewed is this work as an 'instance of climate risk'.

1.5.7 Organizational Capacity and Organizational Resources as Endogenous Pressure

At the firm level, phenomena which influence the participants' risk perceptions, are thought of as the internal resources of the organization and its capacity to deal with climate change impacts. Here, resources are defined as the fundamental assets owned or controlled by the corporation, including technical knowledge; organizational capacity is defined as the capability of the organization to exploit and deploy its resources. While Renn and Rohrmann's (2000) integrative model of risk perception draws attention to the importance of social and political macroeconomic contexts that drive personal constructs, how the participants' risk perceptions are influenced by these factors within their own organizations has yet to be addressed in the literature. Understanding the firm level context of business pressures facing the sector participants is discussed in the next section.

1.5.8 Technical Knowledge as Endogenous Pressure

The pressure for more specialized and technical knowledge within organizations responding to climate change is evident in literature. Busch (2011) referred to “climate knowledge absorption” as an organizational capability for organizational adaptation (Busch, 2011, p. 389) while Berkhout et al. (2006) suggested that “organizational learning” was instrumental to coping with climate adaptation (Berkhout et al., 2006, p. 135).

Unsurprisingly, how organizations expect to learn from the direct experience of climate events, interpret climate data, assess new standards for climate- hardened systems and equipment, procedures and processes calls for improved and specialized technical knowledge and expertise.

1.6 THE ELECTRICITY SECTOR IN ONTARIO (CANADA)

Canadians consume more electricity on a per capita basis than any other OECD country surpassed only by Norway and Iceland (World Bank, 2014), and are seventh highest consumers of electricity in the world on a per capita basis (CIA, 2016). Ontario (the data location in this work) has the highest per capita usage of electricity in the country, and the largest infrastructure network of electrical utilities (Electricity Distributors Association, 2011). Population intensification in the southwest quadrant of the province continues to increase electricity demand (Hydro Ontario, 2016) though some energy planning groups suggest a ‘highly uncertain’ longer term demand outlook due to the prospects of economic downturn and end user energy conservation (IESO, 2016). Concurrent with the above, demand forecasts based on assumptions related to the province’s vehicle electrification programs suggest yet another demand outlook for electricity. Nevertheless, extreme weather forecasting done in 2001 suggested Ontario was at high risk for flooding and freezing temperatures (McCarthy, 2001). Fifteen years later, the Canadian Electricity Association reiterated the same claim, asserting the sector is increasingly more vulnerable to climate risk due to aging transmission equipment, lack of capital investment for infrastructure renewal and lack of planning for climate change impacts (Canadian Electricity Association, 2016). CEA documents state that recent Canadian government infrastructure planning did not include considerations for ‘climate hardening’ or the technical and structural modifications to protect electrical power plants and equipment from specific physical impacts of flooding and extreme hot and cold temperatures (Coad et al., 2012).

1.7 MANAGEMENT COGNITION, RISK PERCEPTONS, AND PERSONAL CONSTRUCTS

Prior contributions on management cognition and strategy have suggested organizational strategies are influenced by management expectations about the future state of their enterprise, and about the degree of uncertainty in assessing future conditions (Mililken, 1987). How management interprets pressures and risks informs strategic choices and action (Leiserowitz, 2005; O'Connor et al., 1999). Furthermore, how organizational decision makers make sense of and interpret the likelihood of exposure to climate risks may determine how they build specific capabilities and strategies (Berkhout et al., 2006). Claims like these found in literature depend on a view of management cognition as being instrumental for organizational response to climate change.

It can be noted that in the risk perception literature, particularly when climate change is discussed, two main but contending approaches are suggested for the climate risk debate. One of them, the positivist approach, is consistent with the concept of bringing perception as close as possible to the objective risk of an activity or an event. It assumes there is an outside objective world with risks we can recognize and acknowledge (Rosa, 1998; Rosa, 2008). The researcher maintains that the positivist approach would not question the climate risk per se, but would more likely argue that the problem of risk perceptions can be solved with more information and a greater understanding of the risk. Positivist approaches are invariably regarded as the quantitative, fact-driven approaches adopted by expert constituents.

With climate change however, the 'non-linear, dynamic and chaotic, dangerous, deeply uncertain and systemic nature' of it suggests we know very little still about the probability, magnitude, time scales, and complexity of the phenomenon (see Sections 2.2.3, 2.2.4, and 2.2.5). Climate change therefore is a non-re-occurring complex phenomenon where quantitative approaches may not yield all the answers to how industry will cope with it. The qualitative factors driving individual constructions of climate risks may explain more. According to Wachinger and Renn (2010), cultural factors, social political influences, cognitive and affective factors along with personal heuristics of information processing may help explain it better. Renn and Rohrmann's (2010) integrative model of risk perception partitions those factors to show how various levels of influences may affect perception. While the model relies on lay persons' perceptions and emphasizes personal values—neither of which are examined in this work—it nonetheless has been selected as a useful organizing framework for the discussion regarding qualitative factors and context levels affecting the sector participants.

In addition, the above climate-based challenges facing power producers and utilities can be viewed *not* as a single reality but as a series of multiple realities, each of which should be understood and taken into account. Taking the position that risk, and climate risk in particular, is a social construction (Berger & Luckmann, 1991; Dake, 1992) and that decision-makers operate in a socially constructed world, the importance of examining individual constructs of the sector participants becomes more compelling.

Furthermore, these constructs/factors which influence management perceptions may support the expected differences in perceptions between the two sector groups (producers versus utilities) examined. These groups may have different risk beliefs and perceptions, stemming from their legitimately contending industry positions and objectives. These assumptions lead to the research questions and objectives, discussed next.

1.8 RESEARCH AIM, OBJECTIVES, AND RESEARCH QUESTIONS

The aim of the present study is to examine how electricity power producers and utilities in Ontario view climate risks and how they expect to manage those risks in the future. The primary objective that emerges from the above discussion is to identify the way in which the participants construe and make sense of these ‘influencing’ factors related to the following: climate change itself, climate data, governmental interventions of greenhouse gas regulation and climate policy, aging infrastructure and the firm-level factors of organizational resources, capacity and technical knowledge.

The primary objective is broken down into three subordinate objectives to be addressed in the empirical work: a) the development of a category scheme that describes and enumerates the constructs they have about the drivers/influences/factors involved; b) the examination of the similarities and differences that may exist in the constructs of the two groups of participants; and c) the examination of the similarities and differences that may exist in the constructs expressed in the more formal, published corporate reportage of climate risks, compared with the individual constructs elicited from the participants.

Following on from the primary research objective, the central research question then becomes:

How do the sector participants construe and make sense of the factors outlined in this work, in assessing the impact they have for managing those risks in the future?

1.9 METHODOLOGY OVERVIEW

This work adopts a constructivist approach to the research topic. Insights are taken from cognitive science, economics, psychology, organizational studies, and sociology, dealing with qualitative studies of organizational response, risk management, management cognition and risk perception.

Personal construct theory (PCT) is viewed as applicable to the study of individual risk perceptions and is used in this work to guide data collection via the repertory grid technique (RGT) and its related analytical framework. The description and explanation of management’s personal understandings of climate risk are accomplished by using the RGT to elicit and identify participant constructs; narrative content analysis is used to examine published constructs of climate risk, enabling methodological and data triangulation to increase credibility of findings.

By ‘unpacking’ perceptions and further comparing them between the two sector groups, a richer understanding is expected of what is driving management thinking in the electricity sector. While Karl Weick’s (1995) esteemed sensemaking approach using questionnaires, interviews, observational and documentary techniques are valuable as a methodology for this subject matter, the researcher proposed that examining participants’ views with a constructivist approach based on Kelly’s (1991) personal construct theory and its associated technique (RGT) would produce deeper and more precise findings.

1.10 SIGNIFICANCE

Climate risk is a phenomenon already examined and understood within the financial and insurance sector. It is still less examined in management literature which until recently, has tended to rely on paradigms of organizational change and business transformation to discuss organizational responses to climate change (Berkhout et al., 2004; Gasbarro & Pinkse, 2015; Linnenluecke et al., 2008; Winn et al., 2011).

Using a broader range of exogenous and endogenous instances of climate risk impacts moves the debate past prior contributions which considered climate change impacts as being solely physical in nature. Identifying management perceptions and risk beliefs about climate change gives voice and empirical evidence to a sector facing complex and evolving challenges today and in the near future. Due to the paucity of climate risk research in Canada, the CEA initiated a climate risk assessment report in 2015. While the report's findings are suggestive and would have implications for infrastructure financing and public policy, it is useful to note that the scope of risks assessed related to *weather impacts* only. Again, this mirrors most corporate response research and does not take into account secondary and indirect impacts of climate risks. In understanding the more individual views of how climate risk perceptions are influenced, as well as what priorities electricity executives might believe are necessary for future climate risk management, would produce greater insight and benefits to constituents.

While theory construction has already been stated as *not* a primary objective of this work, empirical data collected may open up the climate risk 'black box' by showing how management cognition of risks is influenced by influential factors appearing on multiple fronts in the sector. Constructs and themes found in management scholarship which can be integrated in this examination may produce useful findings for policy actors and for risk management practices in the sector.

1.11 OUTLINE OF THESIS

The organization of the present work begins with an introduction of the research topic, already completed in Chapter 1.

Chapter 2 presents a critical literature review.

Chapter 3 provides details on the methodology.

Chapter 4 presents the results obtained of the pilot study and the main research plan including an analysis of the data.

Chapter 5 deals with a discussion and interpretation of the main study findings related to the literature review.

Chapter 6 describes the present work's contribution to the knowledge base and practice, as well as limitations and suggestions for further research topics.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This thesis examines management cognition of climate risks in the electricity sector in Ontario (Canada). The aim of the work is to examine how electricity power producers and utilities view climate risks and how they expect to manage them in the future.

The research objective of the present study contributes to the knowledge base by empirically examining the constructions/perceptions of electricity executives on how they view the prospects of managing future climate risks. First, the researcher begins with controlling for some corporate characteristics such as location (Ontario), fuel type (natural gas), operating status (authorized market operator) and respondent type (senior executives). Next, an in-depth exploration of **risk identification, assessment and response** issues is conducted to assess how management views climate risks now and in the future. Findings and conclusions are drawn on an inductive basis to answer the research question: How does the electricity sector view climate risks now and for the future?

In this chapter, the literature review and literature synthesis combine five important literature threads which pertain to the research topic and which help formulate and argue for the empirical work conducted in this study. The literature threads pertain to the current knowledge base of research relating to: 1) relevant literature on climate change and climate science; 2) the electricity sector in Ontario; 3) the literature on corporate adaptation to climate change; 4) the literature on risk management pertaining to climate mitigation issues; and 5) the literature on the management cognition, including the risk perception literature. The five threads help establish the context and justification for the research study. This chapter discusses relevant findings and insights from prior contributions in these five literature threads to offer a broad conceptual framework of climate risk readiness among power producers and utilities.

2.1.1 Overview and rationale for the selected literature threads

A brief overview of the rationale and focus within each of the five threads is introduced below.

Firstly, literature on climate change and climate science is provided to shed light on current and multiple perspectives of the phenomenon. Attention is given to climate literature which addresses the chosen constructivist view, including how message framing and the language of climate change affects risk perceptions. By doing so, the researcher suggests the ‘effect of climate change’ debate supports the constructivist argument in this work. The researcher argues that climate risk itself is a subjective and individual construct. The effect of message framing of climate change is already understood in past contributions (Gifford & Comeau, 2011) and that the effect of meaning or the interpretation ascribed to different definitions of climate change elicit different risk perceptions

(Sidortsov, 2014). The existence of both objective and subjective treatments of risk perceptions is acknowledged. Discussion is extended to illustrate how the contributions of scientific institutions justifiably vested in the realist paradigm, influence and inform risk perceptions. Their important contributions to climate science and modelling and the effect of them on risk perceptions for the participants is considered.

Secondly, a review of current knowledge on the electricity sector's contribution to critical infrastructure, and the particular business environment of electricity producers and utilities in Ontario is offered. This thread illustrates show how this 'climate-sensitive' group of organizations are subject to a unique set of pressures derived from climate change, and how those pressures affect their business environment (Davis & Clemmer, 2014; Gasbarro et al., 2016; Haigh & Griffiths, 2012). Literature on the Ontario electricity sector is provided for context and insight into the two sector groups examined in this work.

Thirdly, a review of the extant literature on business response and corporate adaptation to climate change is provided. This thread illustrates the current state of knowledge and multiple research perspectives in corporate adaptation literature. Specific attention is given to corporate adaptation by utilities and other critical sector groups' response to climate change.

Fourthly, a review of risk management literature, pertaining to climate issues is provided as support for the framework used in the analysis phase of this work. This chosen thread departs from prior research which has tended to rely on alternate frameworks of business transformation and knowledge management to explain corporate adaptation to climate change. The conceptual treatment of climate risk as a subjectively perceived emergent state is a recurring theme throughout this work. Thusly, the inclusion of a risk management literature thread helps support the approach taken in this study.

Fifthly, the literature on management cognition studies and theories including sensemaking theory and a survey of risk perceptions theories. Special attention is given to personal construct theory (PCT). The subjective constructivist debate around climate risk perceptions is supported by this important review of literature. As Sidortsov (2014) stated: "What is understood and described as a risk often reflects and influences what decision makers actually do about risks" (Sidortsov, 2014, p. 173). Beck (2006) added "Risk does not mean catastrophe, Risk means the anticipation of catastrophe" (Beck, 2006, p. 332). The determinants of risk perception in the subjective constructivist mode is key to the aims and objectives of this work.

As described above, special attention is given to PCT as it serves as the theoretical framework to support the phenomenological orientation of this research. Prior research on management cognition and sensemaking processes derived from Karl Weick's (1995) work are discussed. Though Weick's approach support the constructivist comparative case study approach of this work, emphasis will be placed on PCT as it is expected to elicit deeper insights from the individual sector participants.

The five literature threads are combined to provide context and opportunity for examining how the study participants construe and make sense of climate risk. Combined, the literature threads respond to the primary research question of how the sector participants construe and make sense of the factors outlined in this work, in assessing the impact they have for managing those risks in the future.

In turning to the first thread on climate change and climate science, the review of literature is guided by three questions developed by the researcher:

What is it about climate change that creates risk?

How does the climate science community view climate risk?

How are perceptions of climate risk different for all others?

Guided by these questions, it is anticipated that the complexity of the perceptions debate is appropriately discussed and produces a clearer picture of the determinants of risk perceptions for the study participants

2.2 CLIMATE CHANGE AND CLIMATE SCIENCE

Understanding what constitutes the concept of climate change is critical for corporate action (Busch, 2011; Schneider, 2001). Literature shows variations in conceptual understanding about climate change; exploring what they are and why they exist is a useful pre- condition for the discussion around climate risk perception. Furthermore, literature shows that the framing of climate language produces multiple interpretations for expert actors, professional managers and the lay public (Gifford & Comeau, 2011; Sidortsov, 2014). More significantly, stakeholder groups may not necessarily and completely understand the hazard (climate change) itself and chose instead to reference climate change/risk as the effect (Sidortsov, 2014) Consequently, clear challenges exist for different actors in understanding climate change's inherent complexity, deep uncertainty and its 'non-linear, dynamic, chaotic' features (Daron, 2011, p. 12).

Given that climate literature is terminology-heavy and filled with semantically non-equivalent expressions and terms, a review of the phraseology and definitions related to climate change is presented next.

2.2.1 Terminology, Definitions, Semantics

Literature examining the effect of language use of climate change terminology began in the first decade of the 21st century, the warmest decade recorded globally since 1880 (Schmunk, 2010). Global warming over the past 50 years has been widely attributed to the increase of greenhouse gases in the atmosphere, primarily caused by anthropogenic emissions of carbon dioxide, methane and other trace GHGs (Parry, 2007). The term 'global warming' was the dominant popular usage in climate discourse from when it was first coined by Wallace Broecker of Columbia University, who commented: 'It is possible that we are on the brink of a several decade long period of rapid warming' (Broecker, 1975, p. 462).

The term 'climate change' entered the lexicon of climate science in the 1990s when the IPCC formally recognized that the side effects of global warming such as melting glaciers, heavier rainstorms, or more frequent drought, were also part of an emerging future climate state (Solomon et al., 2007). Research has shown however, that 'global warming' and 'climate change' are not semantically equivalent terms and have different connotations eliciting different reactions in people (Whitmarsh, 2008). Today, the use of the term 'climate change' however continues to dominate usage by the Intergovernmental Panel on Climate Change (IPCC), the National Aeronautics and Space Administration (NASA), and Canadian governmental groups.

2.2.2 Differing Views of Climate Change Terminology

Differing views of climate change are represented by objective and subjective treatments of climate change language. These different views are variously reflective of the disciplines and institutions which have them. Two striking examples are the narratives produced by the IPCC consortium and by the Tyndall Centre for Climate Change Research (TCCCR). Both institutions have used the same terms to characterize climate change but with different meanings. The IPCC's technological orientation representative of its global scientific consortia, produces what one researcher referred to as an 'objective' description of climate change (Dessai et al., 2004). Functionally, the IPCC aggregates and distributes global state of the art, spatial and temporal descriptions of climate variability and intensity changes. IPCC climate assessment reports are derived from regional climate research contributions including the TCCCR in the UK and the Ouranos research group in Canada. IPCCC assessment reports ultimately inform international communities with policy directives based on their climate risk assessments.

Another example is Dessai et al's (2004)'s work when they described the IPCC paradigm of "top down, scientific, quantitative indicators, used as inputs in hierarchical models, and concerned with physical measures and threats to continued functioning of some part of the non-human world", as the objective perspective (Dessai et al., 2004, p. 11). In contrast, they noted that the competing, internalized perspective of climate change "recognizes that to be real, the danger (of climate change) has to be either experienced or perceived" (Dessai et al., 2004, p. 11). Sidortsov (2014) called Dessai et al's reference to the internalized perspective as a subjective perceived risk, and proposed that the key difference between objective and subjective perceived risk stems from who actually anticipates the risk (Sidortsov, 2014). In contrast, social science institutions pre-occupied with sustainability objectives relating to human and or biological adaptation to climate risk, offer different if not contradictory definitions of climate effects.

The TCCCR, as the other example, explained the difference as follows: “Social scientists and climate scientists often mean different things when they use the term (climate) ‘vulnerability’; whereas social scientists end to view vulnerability as representing the set of social-economic factors that determine people’s ability to cope with stress or change climate scientists often view vulnerability in terms of the likelihood of occurrence and impacts of weather and climate related events” (Allen, 2003; Brooks, 2003).

It is noted here that while rationalist explanations provide useful insights, rational utility theory, subsumed in many of the principles of the rational actor paradigm (RAP) (Jaeger et al., 2001), they do not adequately address the human decision making challenges of climate risk problems. Because climate change and catastrophic risks, being defined as low-probability events are still not well understood, expected utility theories may not work well because of a general underestimation of low probability events (Chichilnisky, 2000). Consistent with this, Chichilnisky (2000) claimed that “using such criteria (of utility theories) undervalues catastrophic risks and hence conflicts with the observed evidence of how humans evaluate such risks” (Chichilnisky, 2000, p. 224). This contributes to the researcher’s preference for the constructivist approach of the present study.

2.2.3 Hazard versus Risk Descriptions of Climate Change

The terms ‘hazard’ and ‘risk’ are frequently applied to descriptions of climate change in the literature. The researcher notes in prior work, the conflation of the word risk with the word hazard, or in other cases, ‘risk as hazard’. In further contradiction, the International Risk Governance Council (IRGC) deemed that hazards actually characterize risks, while other work notes that risks are the potential effects that hazards are likely to cause (Renn, 2005; Rosa, 2008).

Sidortsov’s (2014) work provides a useful example of ‘risk as effect’. Using the case of ocean acidification as an environmental risk event he explained “Stakeholders may be familiar with the effect of an activity and not necessarily the activity itself” (Sidortsov, 2014, p. 172). In that example, he defines climate change as the hazard, GHG emitting oil exploration as the hazard source, and ocean acidification as the effect (Sidortsov, 2014, p. 172) The researcher agrees with Sidortsov’s view that risk operates as the effect (of a hazard) and determines in this work that ‘climate risk is defined as the effect of climate change’.

2.2.4 ‘Dangerous’ Descriptions of Climate Change

Prior research also notes climate impacts as being essentially ‘dangerous’ (Weber, 2006; Weber, 2010; Weinhofer & Busch, 2013). Leiserowitz (2005) maintained that the term ‘dangerous’ is an ambiguous expression contested by multiple definitions of danger, while other climate literature indicates the use of the words ‘danger and dangerous’ are defined as a function of both hazard and risk.

For example, the IPCC 2014 Fourth Assessment reported references to climate change as having 'dangerous' consequences—as well as admitting that 'interpretations of danger are complex and can only be partially supported with science' (Intergovernmental Panel on Climate Change, 2014, p. 122). Integrative statements like this which acknowledge 'multiple interpretations and normative judgements of acceptable levels of danger (climate risk) reflect new IPCC requirements to "synthesize' different perspectives on acceptable levels of climate impacts" (Intergovernmental Panel on Climate Change, 2014, p. 122).

Other contributions appear to view climate change in light of dangerous consequences to human and natural environments specifically. Sarewitz (2003) defined risk as 'social or inherent vulnerability' (Sarewitz et al., 2003, p. 803) while Schneider (2001) maintained that danger is determined by personal experience, values, information and trust.

2.2.5 'Uncertain' Descriptions of Climate Change

The reference to uncertainty and the effect of it (uncertainty) on risk perceptions is widely debated in the climate literature (Heal & Kriström, 2002; Jaeger et al., 2001; Polasky et al., 2011; Prato, 2008; Renn et al., 2000; Weitzman, 2011; Willows et al., 2003).

At the 2011 Harvard symposium on the Economics of Climate Change for example, Weitzman (2011) asserted that "the deep structural uncertainty about the unknown unknowns of climate change is coupled with essentially unlimited downside liability on possible planetary damages", and referenced statistical 'fat tail' (see Glossary), uncertainty as another constituent feature of climate change (Weitzman, 2011, p. 275).

The distinction between risk and uncertainty in the context of 'non-linear, dynamic and chaotic' climate change is a nuanced but useful one to the discussion around climate data and information. Prato (2008), in another instance, claimed that decision makers who assign probabilities to future climate change states base their decisions on 'climate risk', and when the probabilities of future climate states cannot be determined, decision makers base their decisions on 'climate uncertainty' (Prato, 2008). Despite documented evidence and accumulating scientific consensus on the causes of climate change (Anderegg et al., 2010; Cook et al., 2016) incertitude about future climate states is referred in economic literature to as the 'unknown unknowns' of climate change (Purchase, 2013; Stern, 2008). Given that climate simulation models are limited and cannot capture all the variables necessary to create a concrete picture of the future, as discussed in Section 2.2.5, the challenge for constituents however is one of decision making with imperfect information. More specifically, incorporating climate change into risk assessments is challenging because of the significant difficulty of assigning measures of probability to any future climate state.

In sum, framing and selection of climate change language by institutional groups can be viewed as influencing risk perceptions. Science-based institutions generally take an objective, measurable approach to defining climate risks, while social science-based institutions generally assign more subjective and humanistic language to the same terms. Consistent with the constructivist approach of this work, the researcher defines climate risk as a social construct of an emergent and uncertain state. Perception of future states are supported by notions of risk and risk perceptions influenced by a number of determinants. Determinants suggested in Renn and Rohrmann's (2000) integrative model of risk perception provide a partial explanatory framework. It is expected that constructs elicited from the sector participants reflect differing factors influencing them (the constructs) in this work.

As shown above, different types of risks and associated meanings are related to user orientation. While the dominant approach in this work is subjective, it is nevertheless noteworthy to understand the orientation of the science community. Despite Dessai et al's (2004) characterization of the 'top down, mathematical orientation' of IPCC consortia partners, the climate science community is to credited with forming the empirical foundation for climate knowledge globally. Without their contribution, there would be little understanding of the phenomenon in the first place.

A brief discussion of the reportage of the IPCC, and other expert groups which independently measure the progression of climate change and likely future climate states, is provided in the next section.

2.2.6 The Climate Science Community

Due to the complexity of climate change, organizational decision makers are dependent on scientists and professional experts to define what evidence is seen to be relevant. The climate science community is credited with providing the knowledge and scientific basis on which public policy and government climate action are based. Globally the climate science community, including the network of 650 IPCC scientists, the 450 Canadian climate scientists affiliated with Pacific Climate Impacts Consortium (PCIC) and the Quebec-based Ouranos Consortia, produce aggregated evidence to formulate global climate risk assessments which in turn, inform public policy (Hulme & Mahoney, 2010; Ouranos Consortia, 2016; PCIC).

From 1990 to 2013, the IPCC published five comprehensive assessment reports on climate risk impacts used to illustrate potential future climate trajectories. The results provide the scientific basis for global GHG reduction targets and the policy debate of the UNFCCC, the affiliated organization which establishes consensus agreements among countries. They do this at annual Conference of the Parties meetings which aim to set among other goals, aspirational GHG emissions targets for member countries.

In Canada, climate science consortia partially derive their critical assessments from the IPCC so that higher resolution and more detailed climate assessments relevant to specific regions of Canada are produced. Unlike the U.S. at the time of writing, Canada does not have a national research laboratory nor an expert government department similar to the National Centre for Atmospheric Research or the U.S. Energy Information Administration (USEIA). In fact, Canadian academic critics note that climate data collected by Statistics Canada, the National Energy Board, Natural Resources Canada's Climate Adaptation Platform and Environment Canada are often incomplete and disconnected (Layzell, 2016).

Canadian and regional initiatives providing more localized and relevant climate analysis are done by volunteer and paid academic and privately sponsored university research institutions such as University of Alberta's Canadian Energy Systems Analysis and Research and the University of Waterloo's Intact Centre on Climate Adaptation (Intact, 2016; Layzell, 2016). The PCIC established by the University of British Columbia (Pacific Climate Institute of Canada, 2016) and the fee-for service Ouranos Consortia in Quebec (Ouranos Consortia, 2016) provide downscaled, higher resolution regional assessments for local governments and industry groups. The CEA's 2015 climate adaptation report *Adapting to Future Climate Change* relied on Ouranos' climate assessments (McCarthy, 2015). Climate risk findings and conclusions of that report are discussed ahead in Section 2.3.

Scientific output in the form of climate models produced or reported by the above groups produce climate information and knowledge for local constituents. Regional and local constituents ultimately derive their assessment from global work, and further disaggregate it to a level which can be used for local climate risk assessments.

2.2.7 Climate Models and Climate Data

The main instrument for simulating future climate states is a climate model. The IPCC publishes global climate studies based on data from general circulation models (GCMs) for climate impact analysis. As previously mentioned, these models are developed and prepared for the IPCC by various international research consortia, including for example, the TCCCR in the UK, and Ouranos in Canada. The GCMs are numeric and integrated multi-system models that simulate physical processes in the atmosphere, ocean, cryosphere and land surface to the effect of increasing GHG concentrations. These variables taken together, create a "mathematical representation of the climate system, based on equations that drive the physical processes governing the climate, including the role of the atmosphere, hydrosphere, biosphere, etc" (Charron, 2014, p. 78).While GCMs are considered to be the only credible climate tool currently available, their usefulness for local impact analysis is limited due to their coarse spatial resolution (typically of the order 50,000 km^2) and consequent limitations to resolve sub-grid scale features such as clouds and topography (Samadi et al., 2010; Wilby et al., 2002). Attempts to down scale for local impact analysis are nevertheless done by Canadian climate risk groups to inform regional municipalities (Tam, 2016).

2.3 ELECTRICITY SECTOR PARTICIPANTS

The aim of the present study is to examine how electricity power producers and utilities view climate risks and how they expect to manage those risks in the near future. In this study, the sector participants are fossil fuel (natural gas only) generators and electrical utilities. By virtue of their co-dependency and interconnected role in supplying reliable electricity to the province, the sector can be regarded as critical constituents in Ontario's infrastructure network. Understanding the importance of electricity's contribution to critical infrastructure, the participants' roles in the Ontario electricity sector as well as the external and firm-level pressures on their business environment, is the purpose of the next section.

2.3.1 The Electricity Sector's Contribution to Critical Infrastructure

The reliable supply of electricity is a key if not dominant component of critical infrastructure networks in the western world. Historical definitions of critical infrastructure have varied widely depending on context, but have always defined the term with reference to physical structures and networks required to support essential social and economic functions. Critical infrastructure in Canada is defined as 'the essential underlying systems and facilities upon which the health, safety, security and economic well-being of Canadians, and the effective functioning of government, rely' (Public Safety, National Strategy and Action Plan 2014). Critical infrastructure is furthermore inherently interconnected and co dependant on multiple alternate infrastructure types as shown in Figure 2.1. The Figure 2.1 depiction reflects Yusta et al.'s (2011) view of energy systems' prioritized relationship with other infrastructure systems. The success in protecting a country's critical energy infrastructure requires the involvement of every element of the energy infrastructure, with electricity ranked as the highest sector within it (Yusta et al., 2011). Yet how sovereign government agencies view the importance of the relationship between and among infrastructure types, can vary from country to country. In Canada, the federal agency Public Safety Canada under which critical infrastructure protection (CIP) is remitted, regards energy infrastructure (noted as 'energy and utilities' in most documents) as being of contentious equal footing with other critical sectors (Quigley et al., 2016). In contrast, the United States National Infrastructure Protection Program (NIPP, 2009) and the European Union's Directive 114/08 (CEU, 2008) both highlight the need for concentrated protection of the energy sector.

While the prevailing Canadian preference conflicts with many energy experts and academics (Hull et al., 2006; Loschel et al., 2010; Yusta et al., 2011), it is nevertheless useful to remind oneself that electricity system assets are so vital for any country that their destruction or degradation would have a debilitating effect on the essential functions of government, national security, national economy and public health (Hull et al., 2006). Destruction or degradation of electricity assets affect not only the reliability of electricity supply, but pose threats to energy security over longer periods of time. Examination of potential hazards or 'risk events' which threaten energy supply and security, are the remit of CIP activities of government groups. The threats examined are thought of as hazards, intentional harmful acts i.e. terrorism, cybercrime, or natural hazards such as flooding, ice storms or prolonged extreme low or high temperatures.

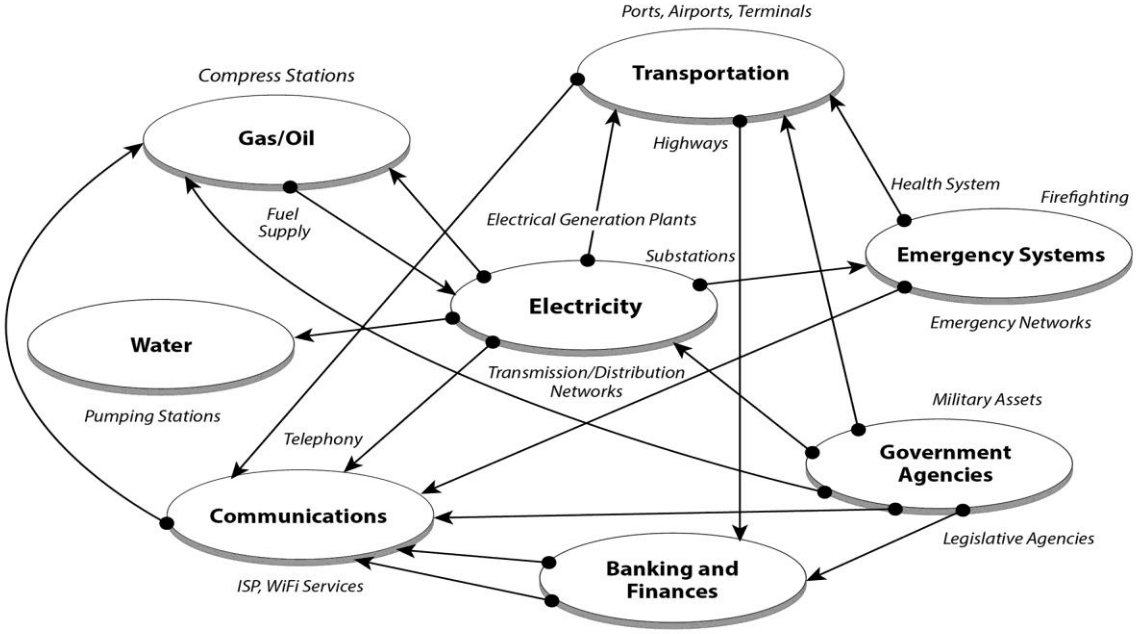


Figure 2. 1. **ELECTRICTY'S CONTRINBUTION TO INFRASTRUCTURE**. Excerpted from Yusta, Correa, & Lacal-Arantegui (2011).

Indeed, natural disasters such as extreme and sudden weather events attributed to climate change are explicitly noted as a dominant threat to Canadian infrastructure. According the Public Safety Canada documents, natural disasters account for 70% of all disasters in Canada, and are stated as a priority for public safety in Canada (Graham, 2011; Public Safety Canada, 2015). Climate change weather impacts on infrastructure were noted: "The rate and severity of extreme weather events is expected to increase in the future. The trend of urbanization, and the growth of large cities, means that a natural disaster confined to a small area can have devastating consequences on large numbers of people and cascading effects across critical infrastructure sectors" (Public Safety Canada, 2015, p. 1).

From a risk management perspective, cascading and systemic effects of infrastructure failure have important implications for decision-makers in those infrastructure groups. Individual decisions to ignore or underspend on risk management poses a risk to the entire infrastructure group, and all those that depend on it. Furthermore, where infrastructure groups are co-dependant on external, cross border groups, issues of cross border reliability and inter jurisdictional energy security are raised. The fact of Ontario's bulk electricity system's reliance on the larger connection of continental transmission systems across North America, is a case in point. Inter-tie connections (see glossary) assist in the reliability of electricity delivery in Ontario enabling electricity exports to neighbouring jurisdictions during surplus supply conditions, and imports of electrical power during regional (Ontario) supply shortages. The 2003 electrical grid blackout across north eastern Canada and the U.S. brought attention to the failure of the bulk electricity system and was deemed a critical infrastructure crisis, posing operational and strategic challenges to both government and private actors (Spears, 2013).

The above descriptions not only highlight the highly interconnected and complex nature of electricity systems in supporting critical infrastructure, but remind us how vulnerable we become the more dependent we are on electricity systems (Boin & McConnell, 2007).

Next, the sector roles of power producers and utilities are discussed.

2.3.2 The Electricity Sector in Ontario (Canada)

Historically, the electricity sector in Ontario has evolved in a somewhat uneven fashion over the last 15 years. From the 1980's the electricity market moved from a monopoly based electricity system to a competitive wholesale electricity market in 2002 effectively dismantling the province–wide Ontario Hydro's (and local municipalities') monopoly on energy provision to the province (Ontario Energy Board, 2015). Additionally, price setting previously established by the provincial government was also abandoned in favour of an open wholesale electricity price system. A mix of private, not for profit and publicly owned entities now exist in Ontario's hybrid electricity market. Ontario's wholesale electricity market was and continues to be restructured with new market constituents, pricing methodologies, policies and regulatory regimes. A progression of provincial statutes fostered the above changes including The Ontario Electricity Act (1998), The Electricity Restructuring Act (2004), The Ontario Green Energy Act (2009) and The Climate Change and Low-Carbon Economy Act (2016). Additionally, the Ontario Regulation 144/16, understood as 'The Cap and Trade Program' provides the regulatory framework for the 2016 Climate Change Act. Both the Climate Change Act and the Cap and Trade Regulation establish the details of Ontario's Cap and Trade program for the purpose of reducing GHG emissions in Ontario. For Ontario's electricity sector, the implications of GHG emissions reduction or 'abatement' has broad-reaching effects, particularly for the fossil fuel electricity power producers and their upstream natural gas fuel suppliers (see Section 2.3.4).

Sector constituents and their accountabilities and relationships are compiled by the researcher in the following chart, shown next in Table 2.1.

Table 2. 1

RELEVANT ELECTRICITY SECTOR ORGANIZATIONS IN ONTARIO, CANADA

Utilities	Utilities in Ontario are natural monopolies by virtue of their distribution service agreements and are regulated by the OEB. In Ontario, utility companies are managed by the local municipality. They are often referred to as local distribution partners (LDCs) or as municipal utilities.
Power producers	Power producers are electricity generating companies which produce and sell electrical energy to utilities. There are 11 natural gas electricity power producers in Ontario, with a total 2016 installed capacity totalling 4,116.5 Megawatts (IESO, 2016).
Natural gas–fired power producers	Natural gas fired electricity power producer are called 'fleets' in industry lexicon. Natural gas fleets emit fewer GHG than coal power producers and hence are seen as a transition fuel in some circumstances. To generate electricity, natural gas is burned, creating combustible and high amounts of GHG emissions. GHG emissions produced by gas electricity plants are monitored and have been reported since 2004 under the Greenhouse Gas Emissions Reporting Program of Environment Canada (Environment Canada, 2016) and starting in 2016, under the Ontario Quantification, Reporting and Verification of Greenhouse Gas Emissions Regulation.
The IESO	The IESO in Ontario is the market operator and is vested with procurement of new power producers, contract management with all market participants, and overall electricity system reliability. On a day to day basis it is responsible for monitoring Ontario's smart grid and optimizing the supply and demand for electricity.
Transmission companies	Transmission companies own and operate system infrastructure and transmission assets such as poles, lines, cables and transformers. They operate equipment in compliance with the IESO and the OEB. Transmission companies move bulk electricity at high voltages from generating stations to local utility companies.
OEB	The Ontario Energy Board is the provincial regulatory body which provides governance and oversight for the market operation of electricity system participants. It is a statutory corporation under the Ontario Energy Board Act, and accountable to the Ontario Ministry of Energy. Recently its regulatory style has become more prescriptive for electricity market constituents, reflecting an expanding regulatory scope over utilities and power producers.

2.3.3. Exogenous and Endogenous Pressures on studied sector group

Management literature suggest two categories of impacts/pressures affect the institutional and business environment of the studied sector groups. The first relates to the external or 'exogenous' physical impacts of climate change, the influence of climate predictive data, the risks associated with aging electricity system infrastructure, and the impact of government climate policies and regulations relevant to the study group.

The second set of impacts/ pressures found in literature relate to the firm-level, 'endogenous' pressures relating to technical knowledge requirements, and the organizational capacity and resources relevant to the study group.

Both categories of pressures are seen as existing outside and inside the organization, representing determinants of climate risk in the current study. Next, a review of the literature review pertaining to the exogenous pressures follows, with a discussion of the first set of exogenous pressures addressing governmental pressures of policy and regulation.

2.3.4 Exogenous Pressures #1—Governmental Pressures of Policy and Regulation

The first set of exogenous pressures in this study refer to the external impacts of government climate policy and GHG regulation affecting the studied participants. Government policy is understood as the policy framework promoting climate change mitigation in Ontario, as exemplified by the Ontario Long Term Energy Plan and the related statute, the Climate Change and Low Carbon Economy Act (2016). GHG abatement is embodied in the Ontario 144/16 regulation which actively prescribes emissions reduction for large GHG emitters and participation in the emissions trading scheme known as The Ontario Cap and Trade program. Both climate policy and regulation are governmental mechanisms to de-carbonize the province's energy systems, affecting electricity power producers in different ways. While the impact of government policy and regulation on other types of electricity production i.e. nuclear, hydro-electric are also significant, focus here is on the gas fired electricity power producers exclusively, and the other group, electrical utilities.

Congruent with the research aim of this work, management cognition of these two particular forces of pressure are viewed by the researcher as potential influences on climate risk perceptions. Examination of how electricity managers view these pressures are examined.

The economics of fossil fuel-based electricity power production and electricity distribution by utilities are influenced by a number of factors, including natural gas commodity prices, governmental energy policies, GHG regulations mandating emissions control expenses, grid reliability, and market factors relating to consumption and power producers mix (see Glossary) in the province. The researcher reminds that management cognition of climate risks may be influenced by either or both exogenous pressures either directly or indirectly.

Most of Ontario's electrical power producers mix (see Glossary) is generated by hydro and nuclear power producers sources; however, production by natural gas fired plants, the focus of one of two groups in the present study, is forecast to increase four fold by 2025—to 29 per cent of Ontario's overall power producers mix (Navigant Consulting, 2015). Reasons attributed to these projections include fuel-switching due to Ontario's recent coal-fired plant retirements, planned nuclear power plant refurbishments, electrification of vehicles, and increased need for natural gas produced electricity to support the province's planned integration of additional renewable power resources into the grid (Navigant Consulting, 2015).

Exogenous pressures affecting power producers' companies include upstream, supply side factors, namely commodity pricing and other characteristics of natural gas extraction. Abundantly increasing supplies of natural gas from recently discovered North American shale gas reserves, produce increases not only in production, but in reserves (in the ground, capacity) estimates. Newer fracking and horizontal drilling technologies have further increased production efficiencies of natural gas extraction, accelerated time to market and improved reliability and overall supply chain performance of natural gas–fired power producer plants (Navigant Consulting, 2015).

The increase in demand for natural gas fired electricity is further enhanced by operational versatility: the flexibility of natural gas fleets to ramp up quickly and be operated as base load, intermediate and peak load facilities (the relative degree of electricity demand, according to volume) allow for fuel switching, load switching from nuclear, and load support for intermittent power generated by time and weather-dependant renewable energy resources such as solar and wind power (National Energy Board, 2016).

More significantly. fuel substitution away from coal to natural gas operationalized by the province's 2003 Long Term Energy Plan, encouraged new construction of natural gas plants in the province, resulting in 90 per cent of all natural gas fleet being less than 10 years old (DeMarco, 2015). Reportedly, these plants were not built with emissions control technologies to meet current regulatory GHG emissions control requirements (DeMarco, 2015, p. 3).

Industry representatives from the Association of Power Producers of Ontario (APPrO) explained it this way: "Emissions improvements in this segment may be achieved only through decreased production or asset retirement, or decreased contract life of an asset. Ontario's existing natural gas fleet has no physical ability to mitigate its emissions as the power producers' technology is set at the time of construction and the supply mix directives have stipulated how much capacity is to be allocated to what power producers technologies" (DeMarco, 2015, p. 3). Supply agreements for power producers facilities under clean energy supply contracts, and the extension of older non-utilities (NUG) contracts, APPrO stated, 'do not adequately address GHG related costs in a manner that is equitable, and keeps power producers whole' (DeMarco, 2015, p. 5).

In further irony, the same energy policies which fostered increased investment in gas-fired electricity production, paradoxically now constrain their current upstream natural gas suppliers with increased costs for compliance and emissions control (Butters, 2018). At the time of this research, gas-based electricity producers were temporarily exempted until 2020 from having to purchase emissions allowances under the Cap and Trade program. However, starting in 2018, they will bear an incremental and increasing direct cost of emissions allowances at a rate of 4.57% per year (GoEnergy, 2017; MOE, 2017).

Implications of these government policy and regulatory interventions create a financial burden for industry participants in at least two ways: a reduction in total revenue requirements of power producers and an increase in the marginal cost of energy produced by natural gas fleets (Parmesano & Kury, 2015).

Firstly, anticipated total revenue reductions brought about by new climate–related regulatory pressures occur where gas fired electricity power producers are fully regulated into the government scheme in 2020 and their compliance costs will include the costs of emissions allowances or permits to 'clear' or cover their emissions levels. At the same time, natural gas electricity producers will need to find cost effective methods to reduce emissions. Emissions control technologies such as advanced turbine equipment are just being developed globally but are costly and represent significant capital expenditures for market participants (Packham, 2015).

Secondly, higher input costs of managing emissions will likely affect the marginal cost of energy produced by this segment. In a wholesale market where the marginal cost of energy is the market price of energy, and in a scenario where the marginal cost increases to include the costs of associated emissions control, market prices for electricity will increase and market demand and consumption may fall, and/or switch to alternative sources of electricity production (Parmesano & Kury, 2015).

The implications of governmental and regulatory pressures on the natural gas segment of electricity producers in the present study have been discussed. Next, the other dominant set of exogenous pressures affecting both power producers' groups and utilities, those being the impacts of climate change and climate data, are discussed.

2.3.5 Exogenous Pressures #2—Climate Impacts, Climate Data and Aging Infrastructure

The second set of exogenous pressures in this work refer to the external impacts of direct, sudden climate events, the impact of climate data and of aging infrastructure. Climate data is understood as predictive data of weather patterns in the medium term, beyond the range of local meteorological forecasting services. Aging infrastructure is understood as electricity system infrastructure relating to overhead infrastructure assets (substations, distribution lines, wires, and poles) and underground assets (below-ground substations and distribution circuits and cables; Singh et al., 2015).

Lifecycle analyses of Ontario's electricity infrastructure is variously end of lifecycle in many regions and as such, is regarded as insufficiently 'climate-hardened' for future increases in extreme weather events.

Climate impacts can be gradual over time, or sudden, surprising and catastrophic. While there is more certainty about the occurrence of long term climate changes, less is known about the effect of future sudden and potentially catastrophic weather on organizations' ability to cope with such events. Empirical evidence exists that severe weather is becoming more common. Climate risk analysts with Lloyd's of London insurance group reported that the phenomenon in which events that were expected to occur only once in 100 years are now occurring with much greater frequency. The report commented "we have tended to think of climate change as a gradual phenomenon, with the impact expected to be felt evenly over time, and any increase in loss taking place incrementally" (Lloyd's of

London, 2006, p. 3). In Ontario, storms that used to occur once every forty years now occur once every six (Reduction, 2012). Identification and assessment of these climate impacts highlight the CEA's 2015 report on Climate Adaptation. Nine specific climate impacts on electricity power producers and utilities are noted in the report: 1) increases in air and water temperatures; 2) changes in water availability; 3) ice storms; 4) sea level rises, storm surges; 5) impacts on biodiversity and invasive species; 6) changes in precipitation, runoff and ground conditions; 7) permafrost melt and ice reductions; 8) higher winds; and 9) wildfires. These climate drivers as shown in Tables 2.2 and 2.3 ahead.

Furthermore, assessments of climate impacts on electricity company performance were noted as including loss of efficiency in electricity output, damage to facilities, cables and wires, flooding of substations; and wildfires creating dangerous' flashovers' from electricity infrastructure (Canadian Electricity Association, 2015).

The CEA report also noted that "The potential climate impacts for the electricity sector will vary by region, and vary in their material importance i.e. financial sensitivities and insurance exposure, for individual companies" (Canadian Electricity Association, 2016, p. 20). Furthermore, due to the complexity and system-wide co-dependencies of the electrical power supply system, impacts which occur outside of the categories of the study groups, e.g. on a non-natural gas electricity power station, such as a nuclear power generating station, can still have significant cascading effects on natural gas plants as they are called to dispatch supporting power to offset power losses.

One measure of the magnitude of the impact of direct sudden weather events is represented by the quantification of insurable losses reported by government and insurance groups. For instance, the 2015 Quadrennial Energy Review, directed by US President Obama's via executive order, identified almost $22 billion (USD) in total losses from a range of weather events in the year 2013, excluding self-insured losses, and points out that "extreme weather events resulting in more than $1 billion (USD) in damages" are increasing (as excerpted in Canadian Electricity Association, 2016, p. 8).

Many examples of financial loss due to climate change in Canada have been documented. Utilities are increasingly reporting that climate change is the cause of power outages and service interruption in customer communications (Horizon Utilties, 2016; Hydro Quebec, 2016; Toronto Hydro Commission, 2016). Meanwhile, catastrophic loss due to climate change is becoming a more common reference where insurable loss per weather event exceed $25 million per event in a given year. The Insurance Bureau of Canada's analysis of the period 2009 to 2016, has determined that two climate variables specific to Canada are of some concern. According to the Insurance Bureau of Canada, changes in intensity and duration of rain fall events, and impacts on aging infrastructure in urban and rural settings are the leading climate drivers for catastrophic business loss (Insurance Bureau of Canada, 2015).

The second exogenous pressure in this set is the risk impact of climate data. Sudden direct climate events are inherently difficult to forecast. Climate data and modelling of high impact, low probability patterns of climate behaviour would be useful to infrastructure planners for planning purposes, and to power producers and utilities for operational and longer-term planning. Operationally, producers and utilities would be able to appraise the sufficiency of overhead and underground system assets to withstand extreme events in the future. Climate data and climate modelling simulating future climatic impacts are still limited. Due to the limitations of GCMs reported by the IPCC, the mean grid spacing for data is approximately 500 kilometres. Thus, weather developments acting on smaller scales cannot be fully determined. This results in high levels of uncertainty associated with climate data and modelling.

The third exogenous pressure identified in this section is the risk impact of aging electrical infrastructure. Many elements of the electrical grid now approach or have already exceeded their initial design span. The U.S. Association of Civil Engineers reported that North American (including Canadian inter-tie grids) electrical transmission and distribution lines were built between 1950 and 1969 with expected operating lifespans of 50 years (Engineers, 2017). In most areas of Canada, expansion and climate-hardening of the electrical transmission system lags behind the growth of electricity demand and expansion of generation capacity (Baker et al., 2011). Operating in Ontario's largest urban centre, Toronto Hydro estimated that approximately one–third of its electrical distribution assets are currently past their expected useful life (Toronto Hydro, 2013). It also attributed 40 % of outages to aging equipment (Kane, 2013, January 28; Toronto Star, 2016). Across Ontario, similarly, the largest reported threat to Ontario's bulk electricity system for the period 1992-2012, were interruptions due to severe weather and related events (Singh et al., 2015). For the present time, aging infrastructure has been and remains a key source of concern for power producers and utilities (Canadian Electricity Association, 2016).

The above serves as a brief introduction to the second set of exogenous pressures identified in this study. Understanding the context and scope of power producers' and utilities' concern for these factors is key to this work. The pressures discussed are now adapted to the nomenclature of the CEA (2015) report as 'climate drivers'. Climate drivers, as construed by the CEA for power producers and utilities, are excerpted in Tables 2.2 and 2.3.

Table 2. 2 **CLIMATE DRIVERS FOR ELECTRICITY POWER PRODUCERS**

Climate driver	Potential risks, issues, and opportunities for electricity power producers
Increases in air and water temperature	An increase in ambient temperature can reduce the efficiency of various forms of thermal power producers by decreasing the difference between ambient and combustion temperature. The loss of efficiency may be trivial in some cases by significant in others. An increase in ambient air temperature can also impact nuclear power producers by reducing thermal efficiency. As summer peaks increase in certain jurisdictions, the balance of long-term energy contracts could be impacted (e.g., the mix of 'diversity agreements' between winter- peaking and summer-peaking jurisdictions). Thermal and nuclear stations withdraw, use, and discharge significant amounts of water for cooling purposes. As air and water temperatures increase, plants may need more water for cooling, but they may also be more constrained by regulations in how they can use and discharge water, potentially even leading to plant deratings or shutdowns.
Changes in water availability	Changes to water levels could have implications for the environmental licensing process, since the allowable impacts (lake levels, flow limits) from hydroelectric plants are based on historical information. If there is an overabundance of water projected, Power producers may be required to reengineer their spillways. Almost 65% of Canada's electricity production is hydroelectric. Changes to water availability could have significant impacts throughout the electricity system. Hydro power producers rely on a resource with competing uses: lakes and rivers are also used for fishing, recreation, transportation, water consumption, etc. A change in water availability (e.g. an extended drought in the summer) may impact several or all of these uses at once, creating the potential for tensions and con ice. Changes to water availability in the United States would also have an impact on Canadian Power producers. Even moderate changes are likely to impact the electricity trade balance.
Ice storms	Ice storms may damage wind blades. Ice storms may lead to increased use of road salt, causing additional cleaning requirements and premature rusting of some equipment. Biomass power producers may benefit from ice storms by using damaged wood as a feedstock
Sea level rises and storm surges	In Canada, a rise in sea level could impact power producers' facilities in coastal areas, particularly in Charlottetown, PEI, and parts of Nova Scotia. One report found that the United States has 'more than 280 electric power plants, oil and gas refineries, and other energy facilities located on low-lying lands vulnerable to sea level rise and flooding' (Morgan, 2013; Strauss & Ziemlinski). Among other damaging effects, storm surges can hinder the ability of emergency teams to respond quickly and effectively, thus prolonging outages.

Note: Excerpted from CEA report, 'Adapting to Climate Change: State of Play and Recommendations for the Electricity Sector in Canada, 2015, Table 4, page 22.

Table 2. 3 CLIMATE DRIVERS FOR ELECTRICITY UTILITIES

Climate driver	Potential risks, issues and opportunities for electricity utilities
Increases in temperature	Higher ambient temperatures may reduce transmission and utilities efficiency. In particular, higher temperatures may result in de-rating or failure for air cooled transformers, and in sag and annealing for overhead conductors. More frequent heat waves will place more stress on the utilities system. Utilities and system planners/operators may need to respond by managing energy demand in real time, building in more system redundancy and revising maintenance and component replacement strategies.
Ice storms	Ice storms can snap power lines, break or bring down utilities poles, and significantly increase tree contacts leading to widespread infrastructure damage and power loss.
Changes in precipitation runoff, and ground conditions	Changes in precipitation and runoff may cause or exacerbate storm surges and flooding. Substations may be particularly vulnerable to flooding. Flooding may also impact the supporting infrastructure—for example, copper and fibre-optic cables used in ICT systems. Fluctuations in winter precipitation and temperatures may lead to an increased number of 'freeze/thaw' cycles. These cycles can damage concrete through the expansion and contraction of moisture, and can also 'cause cracking and deterioration of underground vaults and cable chambers over time.' Freeze/thaw cycles may also cause sinkholes, exacerbating travel challenges faced when making repairs in remote transmission locations.
Permafrost melt and ice reductions	Higher temperatures in winter months in northern parts of Canada may result in the loss of permafrost in some areas. Reductions in permafrost may impact transmission and utilities infrastructure in northern areas where infrastructure was designed and installed for permafrost conditions. Ice cover reductions could also present a challenge to trucks that use ice roads to transport diesel to remote locations for power producers.
Higher winds	High winds can damage wires and utilities systems, especially through tree contact damage.
Climate impacts on biodiversity/ invasive species	Changes to temperature and water availability and levels may have second order impacts on local biota. These changes in biota may also impact on transmission, utilities and infrastructure. For instances, changes in the seasonal migration and nesting behaviour of species of birds protected under legislation could present new environmental challenges for constructing or maintaining transmission lines. Changes in vegetation growth and/or the introduction of new invasive species may require changes in vegetation management practices.

Note: Excerpted from CEA report, 'Adapting to Climate Change: State of Play and Recommendations for the Electricity Sector in Canada, 2015 Table 5, pages 24-25.

Tables 2.2 and 2.3 illustrate the scope of the physical effects of climate change for both electricity power producers and electricity utilities in Canada. Noted chiefly are the impacts of forecasted increases in air and water temperatures on power producers, and of temperature increases and ice storms on utilities.

Next, an examination of the literature pertaining to endogenous or firm- level pressures is offered. Of particular focus is the impact on organizational capacity, organizational resources and the impact on technical knowledge.

2.3.6 Endogenous Pressures—Organizational Capacity, Resources, Technical Knowledge

Endogenous pressures, as mentioned, are those factors related to firm-level and internal pressures on the organization created by climate change. A review of the literature in this thread suggests that business responses to climate change are enabled or constrained by the capacity and resources of the firm, as well as the level of technical knowledge of the firm in managing climate-related phenomena.

Gasbarro et al. (2016) noted that firm level interpretations of physical climate impacts determined corporate adaptation behaviour. Weinhofer and Busch (2013) asserted that most negative impacts on business operations created by climate change deal with future conditions and are therefore subject to uncertainty. It was established earlier that climate change is characterized by a high degree of uncertainty. Because of this, there is greater institutional pressure to develop organizational capacities and resources to deal with uncertain future operating conditions. Prior literature of corporate climate based action dealt with corporate response to gradual changes in climate events, and included technology and management strategies accommodating slow-moving environmental changes (Linnenluecke et al., 2008). More recently, literature has broadened to include work on corporate response to sudden, high impact events, providing practical approaches of corporate strategy and decision making at the strategic and operational level of the organization. Organization capacity at the strategic and operational level of the organization, and the corporate resource of knowledge, either with experience or without prior experience, is designated here as the endogenous factors driving corporate recognition of climate risk.

Most discussions on organizational capacity were framed in the earlier resource-based view of the organization addressing the central question why some firms outperform in a competitive environment and some don't. Weinhofer and Busch (2013)'s more recent work defined organizational capacity of firms as driven by the "internal conditions (which allow) organizations to develop strategies and mechanisms for reducing exposure to extreme climate events" (Weinhofer & Busch, 2013, p. 193). Their work echoes prior contributions that proposed that decision making biases and aspects of organizational implementation can influence organizational capacity (Amit and Schoemaker,1993).

In the context of climate risk management, the strategic capabilities of the firm, as discussed by Wilbanks & Sathaye (2007) include corporate recognition and assessment of the broader view of organizational vulnerability to projected and ongoing changes in weather patterns. Awareness and understanding of how climate events interact with organizational activities and identification of weather hotspots are part of strategic capabilities (Wilbanks & Sathaye, 2007). Discussions in their work are noted operational capacity as including crisis management programs but note them however as temporary and short term.

In other contributions, theories about what causes changes in organizational capacity related to ideas about munificence, complexity and dynamism (Dess & Beard, 1984). More recent discussions about the effect on organizational capacity by the 'surprise' element of extreme climate events appear, not too surprisingly in climate literature (Haigh & Griffiths, 2012). Moreover, knowledge regarding how to respond to these dynamic environmental changes are driven by social constructions of climate change and are 'routed into the social political context of the organization' (Rothenberg & Zyglidopoulos, 2007, p. 40).

Other contributions suggest the implications of strategic and operational capacities are derived from the organization's knowledge and sensemaking capacity informed by prior experience with direct and extreme weather events (Holling et al., 2002). According to several contributors, firm-level sensemaking of experience instils corporate memory, learning moments, teachable moments and knowledge useful for appraisal and decision-making (Berkes & Folke, 2002; Linnenluecke et al., 2008; Schneider, 2001; Smith, 1997). References to corporate knowledge without experience (first-hand experience) are rare however, since most companies tend to accelerate ways to learn from the experience of others through observations, case studies, and best practices. Busch (2011) said corporate knowledge on climate issues is significantly different from 'business as usual' corporate knowledge and suggested that knowledge absorption, operational flexibility and strategic integration of climate knowledge were prescriptive for corporate improvements in this area.

2.4 CORPORATE ADAPTATION TO CLIMATE CHANGE

How business succeeds or fails is a driving theme in research and theory construction (Yin, 2014). How business succeeds or fails to respond or adapt to climate change impacts is a relatively new field of investigation in academic literature. Corporate adaptation can be understood as the result of measures that a company chooses to implement to adapt to climate change (Adger et al., 2010). This section draws together the relatively recent contributions addressing corporate adaptation from a number of different perspectives.

Several research streams stand out for their conceptual and empirical contributions to the corporate adaptation debate. A sizable body of earlier academic literature explains corporate adaptation by open–systems organizational theory (Pfeffer, 1997), where organizations rarely adapt "autonomously" (Berkhout et al., 2006, p. 135) but instead are strongly influenced by other organizations and influences outside the firm. Strategic fit, and, alignment are constructs found in that earlier work—where organizational environments pre-dated the recognition of climate change as a fact of organizational life (Winn et al., 2011).

However, while the open systems concept of organizational response complements the research design of this work (where multiple macro, external and firm level, internal influences are construed as climate drivers), only three sub themes appear to dominate corporate adaptation literature at this point in time. Beyond descriptive discussions of types of adaptation i.e. planned versus unplanned adaptation (Metzger & Rounsevell, 2011), anticipatory adaptation (Linnenlueke et al., 2012), pre-emptive versus reactive adaptation (Gasbarro & Pinkse, 2015) prior research has tended to answer three general questions: What climate change impacts is the organization adapting to? What are the factors influencing the process of adaptation? What does the adaptation process look like? A review of literature addressing those sub themes is offered next.

2.4.1 Adaptation to Impacts

In answering the first question of what climate change impacts is the organization adapting to, the answer appears to lie in only two well discussed areas: the impact of regulation and the impact of climate change as a physical phenomenon. Climate impacts research has looked at the effect of regulatory carbon management regimes in various contributions (Hoffmann et al., 2009; Kolk et al., 2008; Kolk & Pinkse, 2004; Weinhofer & Hoffmann, 2008). A great deal more has focussed on the physical dimensions of climate change, e.g. (Linnenluecke & Griffiths, 2010; Linnenluecke et al., 2008; Linnenlueke et al., 2012; Winn et al., 2011; Winn & Kirchgeorg, 2005). Provocative and novel terms for climate change impacts were offered in those contributions, such as “massive discontinuous change” (Winn et al., 2011, p. 157) and “disruptions in the natural environment” (Busch, 2011, p. 389). Definitions of climate impacts in that literature seem variously reflective of the ‘organization and the natural environment’ paradigm.

2.4.2 Factors Influencing Adaptation

In answering the second question of what factors seem to play a role in driving corporate adaptation, the research is mixed. Factors identified in prior work were awareness and concern (Arnell & Delaney, 2005) vulnerability (Berkhout et al., 2004) regulatory uncertainty (Hoffmann et al., 2009), organizational capabilities (Busch, 2011),and location (Galbreath, 2014). More recently, subjective reasoning and management interpretation of factors influencing corporate adaptation has appeared in the literature. Gasbarro and Pinkse (2015) asserted that the way in which firms *interpret* climate impacts will play a role in organizational response. Similarly, Linnenlueke et al. (2012)‘s work proposed that the process of management interpretation of climate impacts was done through organizational sensemaking to model corporate adaptation.

2.4.3 Adaptation Process

The researcher agrees with contributions that suggest how an organization responds to climate impacts is actually a form of organizational adaptation. Whether the organization prepares in advance for future conditions through mitigative action, or responds to impacts as they unfold, both responses are adaptive in nature. A review of literature pertaining to how industries are planning to cope with climate impacts can be found in prior empirical work in the agriculture, residential construction and winter tourism industries (Schneider et al., 2000; Warner et al., 2010) Hertin et al., 2003) (Konig & Abegg, 2010). In those contributions, corporate adaptation is described as a corporate innovation mode (Pinkse & Kolk, 2010) and in others, as organizational learning (Berkhout et al., 2006; Okereke et al., 2011). Still others suggest that the corporate adaptation processes bear close similarity with standard risk management approaches and that corporate adaptive behaviour resembles risk management strategy (Weinhofer & Busch, 2013). This work accommodates this last approach. Bridging the discussion about the process of corporate adaptation with the process of risk management is the goal of the next section.

2.5 RISK MANAGEMENT OF CLIMATE IMPACTS

A review of literature pertaining to the management of climate risks indicated that contributions exist albeit in a narrow empirical context dominated by the financial and insurance fields (Disclosures, 2017; Power, 2003).

A growing body of empirical literature now suggests that the impact of climate change is of material interest to businesses, and as such, ought to be managed within a risk management framework (Weinhofer and Busch 2013). Indeed, the proposition of this study suggests that climate risks are appearing on a number of fronts within the studied electricity sector: the definition of climate risk is broader than just the impact of physical events attributed to climate change. Climate risks now represent for the study participants a wide range of exogenous and endogenous impacts on organizations in the studied field. Congruently, the proactive and systematic process of understanding and managing risks across the organization can be better served by risk management disciplines. Not only is risk management a component of good management and decision making, its relevance for climate risk management cannot be understated. It offers important insights for identifying, assessing and responding to risks (Grinyer et al., 1980). Most risk management programs are standardized and process-based and seek to immunize subjective interpretations of corporate risks (Roberts et al., 2015). However, effective risk management nevertheless requires an understanding of the perceptions and beliefs of involved parties, and how these beliefs give rise to actions that influence those risk management decisions (Wood et al., 2012).

Most if not all risk management focuses on potential events, rather than past performance and therefore has no uniquely identifiable measurement mechanism. Instead one finds in risk management practice a variety of risk identification and assessment tools and processes to explicate future eventualities (Mikes & Kaplan, 2014). The Committee of Sponsoring Organizations of the Treadway Commission (COSO, see glossary) defined risk management as ‘ a process, affected by an entity’s board of directors and management designed to identify potential events that may affect the entity, and manage those risks to be within its risk appetite, and to provide reasonable assurance regarding the achievement of entity objectives (Steinberg et al, 2004, p. 2).

2.5.1 Risk Management as Type of Corporate Adaptation to Climate Impacts

Standardized risk management taught in business schools today reference an integral three phase process for identifying risks, analysing them and then deciding upon a response (Roberts et al. 2005). More specifically, Weinhofer and Busch (2013) defined corporate management of climate risks as those three measures 'taken by the organization to address the potential negative impacts imposed on their business activities arising from climate change' (Weinhofer & Busch, 2013, p. 127).

Corporate response to climate change that mirror the three-stage corporate risk management framework are evident in other contributions. For instance, Arnell and Delaney (2005) suggested organizations must be aware of climate risks in order to address the impacts, be concerned about the consequences and be able to develop a corporate response to the impacts. Berkhout et al. (2006)'s adaptation strategy of "risk assessment and options appraisal" suggested the organization begin a risk management process by focusing on risk identification and risk assessment (Berkhout et al., 2006, p. 151). The third stage of risk management—that being risk response- is reflected in Berkhout et al.'s (2006) strategy for "bearing and managing risks" and "sharing and shifting risks"- which focuses on transferring risk through insurance and collaboration (Berkhout et al., 2006, p. 151).

How decision makers interpret or appraise the implications of risk may be categorized by risk management techniques. For example, companies may rely on climate data to identify the source and classification of extreme and sudden weather events (Changnon et al., 1995; Ouranos Consortia, 2016). Decision makers may use technical risk estimates of the probability of harm or damage to evaluate or assess risks. Decisions on how to respond to risks may be preventative in nature, or rely on risk transfer options such as insurance to protect organizational assets.

2.5.2 Climate Risk Readiness

The construct of *climate risk readiness* identified in Weinhofer and Busch's (2013) empirical work of European electricity utilities is a useful one in the present study. Weinhofer and Busch (2013) relied on a risk management framework in their methodology to identify the state of climate risk readiness of European utilities. Their conclusion was respondents were in various stages of climate risk readiness "predominantly ascribed to different levels of knowledge about climate changes and the already experienced, expected and not yet fully anticipated negative impacts caused by these changes" (Weinhofer & Busch, 2013, p.138).

The same framework will be used in this work to establish the broad categories of participant constructs elicited in the Pilot Study (see Chapter 4) and in the Main Study (see Chapter 5).

Next the researcher turns to the review of the literature on management cognition and the survey of risk perception theories, including sensemaking theories. Special focus is given to PCT in the following section.

2.6 MANAGEMENT COGNITION, RISK, AND RISK PERCEPTIONS THEORIES

2.6.1 Management Cognition

Central to this research is the question of how management construes and makes sense of climate risks. Unsurprisingly, the examination of how management thinks about issues, strategies and business risks is found in management cognition literature. A number of post-war theories of organizational life viewed management thinking as rationally-bounded and objectivist in nature (Simon, 1955). Until Chandler (1962) wrote *Strategy and Structure*, views of corporate decision making mainly rested on notions of think-alike, utility seeking managers, producing similar or same responses to management issues. Schendel and Hofer (1979)'s strategic management paradigm extended Chandler's (1962) proposition, implying a cognitive basis for management thinking. Stubbart (1989)'s work drew greater attention to management cognition theory, admonishing "rationality as an ideal rather than as an empirical fact" (Smircich & Stubbart, 1985, p. 238). Stubbart asserted that individuals are not cognitively homogeneous, as had been previously thought. Smircich & Stubbart (1985) proposed that business environments are 'enacted' or formed through social construction and interactive processes of constituent groups (Smircich & Stubbart, 1985). They and later, others, i.e. Weick (1988) and Kahneman and Tversky (1984) suggested that normative models of decision making would better explain why managers are capable of envisioning, perceiving and construing of the future. Stubbart's (1989) landmark contribution *Managerial Cognition: A Missing Link in Strategic Management Research* is no less explicit in remarking that the contributions of cognitive science and psychology might better explain management cognition.

Around the same time Stubbart was theorizing about management cognition, behavioural psychologists (i.e. Wood and Bandura, 1989) and later, interpretive sociologists (i.e. Weick, 1995) were proposing that social cognitive and psychological theories might better explain corporate performance. Wood and Bandura (1989) 's social cognitive theory of organizational management, for instance, proposed that organizational performance was a function of managerial ability driven by managers' cognitive, social and behavioural competencies.

A decade later, Weick's (1995) fieldwork on decision making within high reliability organizations (nuclear plants, in one instance) suggested that corporate actors interpret and act upon serious business impacts (such as nuclear accidents) through a process of sensemaking. Using this process, managers try to make sense of external stimuli through a process combining beliefs, preferences and ideology to guide organizational response to external threats. Weick (1995) argued that organizational ideology acts as a key driver for the sensemaking process as 'it combines belief about cause and effect relations, preferences for certain outcomes, and expectations to which sensemaking of appropriate behaviour' (Weick, 1995, p. 111). It is noteworthy that more recent examinations of corporate response to climate change suggest that sensemaking processes aren't necessarily useful. According to

Linnenlueke et al. (2012), organizational ideologies which drive the sensemaking process, pose cognitive limits for individuals, constrain management choices and actions within the organization (Linnenlueke et al., 2012, p. 26).

Next, the researcher turns to the discussions in the literature about risk itself, and its inherent characteristics and implications for risk perceptions.

2.6.2 The Nature of Risk

In understanding risk, one can begin with the contemplation that the concept of risk itself is epistemologically questionable if not flawed altogether. Why? Its primary condition is that of an emergent state associated with situations in which it is possible but not certain that some undesirable event will take place. Where there is a risk, there must be something unknown about the situation, or the situation has an unknown outcome. In other words, knowledge about risk is knowledge about the lack of knowledge. In this way, the study of risk and its various types, i.e., objective and subjective, introduced in Section 2.2.2 and discussed further here, raises questions about their epistemological status.

Debates over whether quantitative interpretations of risk earn more epistemological status over qualitative interpretations are beyond the scope of this work. The key point to remember is that climate change discourse, as discussed in Section 2.2., recognizes climate risk as a phenomenon that gets treated in different ways by different groups. The quantitative definition of risk as ‘probability multiplied by severity of an adverse impact’ satisfies the pre-occupation with cost benefit analysis and technological assessment in natural science, insurance and jurisprudence (Sidortsov, 2014). In contrast, qualitative definitions of risk as the effect of a hazard, and which is subject to multiple interpretations of what the effect is, is aligned with the constructivist preference in this work.

The discussion of whether risk is to be treated with objective or subjective reasoning was addressed by Adams (1995). He asserted that objective views of risk were the prerogatives of experts, while subjective views were for lay people with their own ‘individual and socially constructed perceptions of risk’ (Adams, 1995, p. 20). It is useful to note here that in prior work the objective- subjective dichotomy was consistently and perhaps conveniently ascribed to either expert or non-expert groups. None if any literature seems to have considered whether expert groups could themselves have multiple risk constructions. Findings in the present study may throw light on this point, as study participants themselves have expertise in climate risk management beyond what would be expected of lay persons.

Extreme positions on the nature of risk are also noted. At one end of the spectrum, Brehmer and Brehmer (1987) rejected subjective risks altogether arguing that no one can actually *sense* risk. At the other end, proponents of subjective risk deny outright the existence of objective risk because “all risks are at some point appraised by humans” (Beck, 2006, p. 334).

Sjöberg (1996) positioned in the middle ground, argued for co-existence of objective and subjective risks, seemingly reflective of Sandman (1987)’s work that had defined risk as “combination of hazard with outrage” (Sandman, 1987, pp. 21-22). Since Sjoberg (1996), other contributions have continued to support the “fragile compromise” debate (between quantitative and subjective views). Renn et al.’s (2000) work, for instance, suggested risk was ‘both a potential for harm as well as a social construction for worry’ (p. 1).

Other important contributions on the nature of risk are found in Slovic’s (1981, 2000) work. His construct of systemic risk, where multiple groups are affected either at the same time or in rippling and cascading ways, is an appropriate reference to climate risk in this work. To appreciate this, one could reflect on the 2003 OECD report entitled ‘Emerging Risks in the 21st Century’ where the threat of climate change was stated as being concentrated and directed towards “human and natural environments” (Hood, 2005, p. 30). However, in the context of energy systems, infrastructure and electricity supply, more is at stake than human and natural environments. ‘Systemic risk’ is a more apt term for climate change impacts. It not only reflects current risk governance literature which note risk as embedded in the larger context of societal, financial and economic consequences, but it is at the intersection between natural events, economic, social and technological developments and policy-driven actions (Renn, 2005; Slovic, 2000; Slovic et al., 1981).

Other contributions made by Slovic (2000) and Beck (2006) broadened descriptions of systemic risk in different and important ways. Slovic’s (2000) work on the Three Mile Island (TMI) nuclear accident reckoned other consequences of risk besides injury, death and property damage, as costs of stricter regulation (capital and operating costs), reduced operation of reactors worldwide, greater public opposition to nuclear power, investor flight, community opposition and litigation. He put TMI like accidents in the category of ‘unknown’ and ‘dread hazards’ capable of creating ‘large ripples’ or cascading, systemic effects of risks. Wiser et al. (2004) called systemic risk a risk that affects all members of a group simultaneously. Beck’s (2006) contribution to systemic risk in his essay *Living in the World Risk Society*, noted that modern societies are being shaped by new kinds of risks characterized by de-localization (risks are omnipresent) incalculableness (risks cannot be calculated) and non-compensability (risks cannot be compensated for) (Beck, 2006, p. 334). Beck’s non-compensability concept is reflected in the ‘precautionary principle’, discussed ahead in Section 2.6.3.5. As Beck stated: ‘Not only is prevention taking precedence over compensation, we are also trying to anticipate and prevent risks whose existence has not been proven’ (Beck, 2006, p. 330).

Two preliminary agreements for the debate on risk perceptions have been arrived at so far. The first was acknowledgement of the existence of subjective risk; in other words, if the notion of subjective risk was rejected there would be no need to discuss risk perceptions. The second agreement that risk exists for many as the ‘effect’ of a hazard. The ‘risk as hazard’ proposition aligns with the research topic in this work where climate risk is defined as the effect of climate change (the hazard). Having addressed both, the researcher turns next to the review of literature which variously attempts to explain how perceptions of risk are formed.

2.6.3 Theories of Risk Perception

Theories of risk perception are found in literature from the sociology, political science, psychology and anthropology fields. Uniformly, theorists sought to explain how risks interact with social, institutional and cultural processes (Thompson et al., 1990). Congruently with that, the emphasis in this literature review concentrates on theories which support the constructivist preference of the present study. The literature reviewed here clearly departs from theories perhaps first articulated by Lord Kelvin who said: ‘Anything that exists, exists in some quantity and can therefore be measured’ (Beer, 1967). Kelvin’s views suggested quantitative reasoning could account for all phenomena. It is useful to note that Kelvin school fostered the basis for the RAP, which views risk as an objective condition with a rational and individual bias (Jaeger et al., 2001, pp. 19-22). In risk management, certain tools lend themselves to a RAP approach to risk. Probabilistic risk assessments offer a method for analysing the failure of complex system. Risk estimates of a systems failure are typically based on fault tree and event tree methods (Jaeger et al., 2001, p. 90). Yet rare events such as direct sudden climate events discussed in Section 2.2 have little or no event data. Furthermore, the implications of rare events as a social experience cannot be necessarily accommodated by RAP thinking.

Renn et al. (2000) and other critics of RAP have asserted that the social experience of risk has to be reconciled with scientific assessments in what Renn et al. (2000) called a “fragile compromise” (Renn et al., 2000, p. 1). Congruently with the above, the researcher looks away from RAP to focus on constructivist contributions, offering either theoretical explanations or empirical evidence of subjective approaches to risk. What follows is a survey of social theories of risk, a brief discussion of the Social Amplification of Risk (SAR) framework followed by an introduction to Renn and Rohrmann’s (2000) integrative model of risk perceptions, which serves ultimately as the organizing framework for the present study (Renn & Rohrmann, 2000).

Wildavsky and Dake’s (1990) review of risk theories provides a useful sequence and outline for the initial discussion (Thompson et al., 1990). Generally viewed as adherents of cultural theory, Wildavsky and Dake themselves proposed that social theories of risk relate to five predictive forces: knowledge, personality, economic, political, and cultural dimensions. Wildavsky and Dake’s (1990) taxonomy, including their own cultural force proposition, preceded the more recent contribution of psychometric theory and related psychological theories - which are added to this discussion.

2.6.3.1 Knowledge Theory of Risk Perception

At the time, Wildavsky and Dake (1990) claimed knowledge theory as the most widely held theory of risk perception, suggesting actors perceive risks to be dangerous because they know them to be dangerous. The theoretical assumption overlays the notion that perceptions and knowledge are interconnected; in other words, people can't perceive what they don't know, or in reverse logic, what people know, and the extent to which they do, informs their perceptions of risk. Knowledge theory is embedded in notions of qualitative, scientific explanations of hazards and risks, and explains perceptions as being produced by cognitive processing of objective information. Knowledge theory underpins mental modelling approaches in research, which examine inferences respondents make based on the knowledge they have benchmarked against knowledge of experts (Bostrom & Lashof, 2004; Bostrom et al., 1994; Craik, 1943; Gentner & Whitley, 1997).

Mental model studies are prevalent in research of public views of climate change benchmarked against expert and professional views (Bostrom et al., 1994). In other climate studies, benchmarks are dispensed with altogether as in the case of Hill and Thompson (2006)'s climate risk perception study. Their work raised questions about the power of knowledge, salience, intrinsic value of nature, and perceived resilience of nature from professional managers and their views on global environmental risk—without using classical convergence measurement tools used in traditional mental model work. Still again, mental model research related to climate change has been modified in other cases to accommodate subjective information. Views on climate change induced heat wave risks, collected by Chowdhrury (2012)for example, mapped knowledge structures of opinions in a modified mental model approach where associated belief systems of participants were added to provide ' continuum of knowledge capturing human belief systems from both scientific as well as wider social contexts (Chowdhrury, 2012, p. 166).

Climate scholars note climate risk forecasts and assessments, a critical source of knowledge have important roles in risk perception (Leiserowitz, 2005; O'Connor et al., 1999). Critics of knowledge theory contend however that successful transmission of climate knowledge is subject to message framing and is dependent on levels of personal concern and trust in the institutions producing the knowledge (Flynn & Goldsmith, 1999; Gifford & Comeau, 2011; Metlay, 1999; Spence & Pidgeon, 2010; Weber, 2010).

Distancing or temporal and spatial perspectives along with fear- invoking messaging produce gain-loss risk perceptions (Spence & Pidgeon, 2010). Motivating or sacrificing message framing was shown to have effect on climate change behavioural intentions in Gifford and Comeau (2011)'s work.

In other contributions, knowledge theory is embedded in the Risk Information Seeking and Processing Model (RISP) literature. Yang et al. (2014) explored the effect of message elaboration, information sufficiency and risk information- seeking on climate perceptions. The RISP framework relies on the premise that risk information processing is motivated by information insufficiency. The RISP model proposes that an individual's cognitive assessment of a potential hazard, or risk perception, stimulates their emotional responses to the risk which subsequently elevate their information seeking behaviour (Slovic et al., 2004; Yang et al., 2014).

Bridging knowledge theory with principles of behavioural economics, Suarez and Patt (2004) explored the effect of information overload (of climate forecasts) on food security NGOs in Zimbabwe as an explanation for climate forecasting caution. Cautionary approaches were explained as reflective of behaviour economic theory which implies decision-makers have limited ability to process information as problem solvers and don't always act rationally in the face of information producing anomalies (Suarez & Patt, 2004).

Another example of integrated theory- making between knowledge theory and system dynamic modelling is found in Bleda and Shackley (2008) examination of 'process formation of belief' in climate change at the organizational level. Kollmuss and Agyeman (2002) noted knowledge of issues, and knowledge as action strategies as contributing factors for corporate response.

2.6.3.2 Personality Theory of Risk Perception

The second, social risk theory of 'personality' suggests that risk adverse or risk taking propensities of individuals are explanatory factors for their own risk perceptions and inform their preferences for risk management (Sitkin & Weingart, 1995; Thompson et al., 1990).

Prior work in this area suggests risk-based personality traits reflect individual attitudes towards danger; however where individuals are embedded in organizations as decision-makers, organizational risk culture may influence the risk propensity of the individual (Ortiz & Harwood, 2007) Disagreements about personality theory's contribution to risk perceptions is based on discussions whether risk propensity is a behaviour or a personality trait (Ortiz & Harwood, 2007). Measurements of risk propensity, behaviour trends relating to risks, and organizational risk propensity have been critiqued for methodological validity Harwood's critique of risk propensity measures, contended a lack of 'analytical process transparency, as most of these studies are conducted in 'laboratory' settings and adopt a deductive approach' (Ortiz & Harwood, 2007).

2.6.3.3 Economic Theory of Risk Perception

The third, theoretical explanation of risk perceptions is found in economic theory. Classical economic theory is pre-occupied with notions of expected utility, described here as the degree of satisfaction or dissatisfaction associated with an action or decision, and with 'probabilities' classically defined as relative frequencies. Fischhoff et al. (1978) broadened the definition and deemed probabilities as 'strengths of belief' building on Tversky and Kahneman's (1974) critical work that maintained people show different preferences when combining subjective probabilities and utility (Fischhoff et al.,

1978) Their contributions suggested that individuals don’t base their risk judgements on expected values but are motivated by internal biases affecting their ability to draw inferences from probabilistic information. Their important contribution adds to the discussion about the fifth ‘psychological theory of risk’ section. The economic risk concept, as Renn (1998) suggested, ‘is good for situations where utility decisions are made and the consequences of them are confined to the decision-maker’ (p. 58). In the context of climate change however, most risk decisions are collective decisions affecting aggregate utility of different groups, leading one to consider a behavioural economic approach or an alternative framework altogether. Sidortsov’s (2014) behavioural economic ideas suggested economically affluent individuals are buffered against risks and therefore more inclined to view risks as manageable. He suggested that while marginalized and vulnerable populations may do whatever it takes (including taking more risks) to become wealthier (Sidortsov, 2014, page 174) affluent groups may be less concerned with pursuing material rewards because they already have what they feel are sufficient resources.

He further suggested that affluent individuals are more concerned with global climate change because they can afford to be concerned with long run probabilities. The researcher suggests Sidortsov’s (2014) distinctions are congruent with cultural theory concepts of worldview and social economic status, to be discussed in the cultural theory of risk, Section 2.6.3.5.

2.6.3.4 Political Theory of Risk Perception

Next, fourthly, the political theory of risk, which concerns itself with allocation of interests and power in society, explains risk perception by predictive power of social and political characteristics. Renn (1998) noted that the struggle of group power and ideology is germane to risk appraisals. Adherents to political theory of risk suggest North American party affiliations and global warming beliefs are related. Cotgrove (1982) said liberal and conservative ratings and or adherence to certain political parties reflect dichotomous views of climate change as catastrophic or cornucopian respectively (Cotgrove, 1982). Furthermore, partisan support for climate change has widened in recent years between left- right sides of the political spectrum (Dispensa & Brulle, 2003). Closely aligned with political theory is cultural theory, discussed next.

2.6.3.5 Cultural Theory of Risk Perception

Fifthly, cultural theory, pioneered by the British anthropologist Mary Douglas suggested risk is a socio- cultural construction and not an objective entity to be measured independently of the context in which hazards occur (Douglas & Wildavsky, 1982). Cultural theorists i.e. Beck (2009),Cvetkovich and Earle (1991),Dake (1992), (Johnson & Covello, 1987),Thompson et al. (1990) saw risk as a danger or threat to a value system subsumed in institutional arrangements. Furthermore, adherents of cultural theory maintained that cultural differences, when applied to matters of risk, produces two general types of risk responses. Douglas and Wildavsky (1982) exemplified this when began their work with both a question and an answer: ‘Can we know the risks we face now and in the future? No we cannot; but yes, we must act as if we do’ (Cvetkovich & Earle, 1991, p. 1). They were trying to illustrate how social groups vary in response to risks: some rationalist groups would say ‘no we don’t know the risks and therefore we won’t respond (because we don’t know the risks)’ and other groups, open to subjectivist reasoning, will say ‘no we don’t know the risks, but we should act on it anyway’.

It is useful here to note that the subjective reasoning argument aligns with the pre-cautionary principle, which has and continues to guide much of the environmental movement. Just as Douglas and Wildavsky (1982) proposed, the precautionary principle suggests that the approach to managing risk should be based on prevention and elimination of risk exposure, if not wholesale adoption of cost-effective action. The pre-cautionary principle arose because of the perception that the pace of efforts to combat climate change is too slow and that climate risks continue to emerge more rapidly than society’s ability to identify and manage them (Quigley et al., 2016). Furthermore, the precautionary principle prescribes approaches to risk management based on preventative action in the face of uncertainty and complexity. Kriebel et al. (2001) asserted that the principle also means shifting the burden of proof to the proponents of the (risk-producing) activity, exploring a wide range of alternatives to possibly harmful actions and increasing public participation in the decision-making of what constitutes precautionary measures (Kriebel et al., 2001).

Douglas and Wildavsky (1982) proposed that cultural theory explained much of risk perception, maintaining that groups and individuals are active organizers of their own perceptions and that they choose what to fear and how much to fear it in order to support their way of life. According to them, risk preferences related to cultural biases or worldviews and ideologies entailing deeply held beliefs and values that support social relations of differing personal views and ways of life.

Worldviews of these groups, their cultural proposition goes, could be distinguished by classification of hierarchical, egalitarian, individualistic and fatalist types. This worldview classification becomes more useful and appropriate in the current climate debate when it is applied to general assumptions about nature. Contributions offered by Holling et al. (2002) and Schwarz and Thompson (1990) note the Myth of Nature Framework developed by Dake (1992).The literature shows all three argued that the origins of the beliefs of nature guide risk taking decisions in a number of different ways depending on which worldview was at stake. For example**,** adherents of ‘hierarchical’ bias and values are socially optimistic and obedient to authority and rely on experts to assess and endorse risks as being manageable. In contrast, proponents of the ‘egalitarian’ bias hold views that ‘nature is fragile’ to justify sharing environmental assets. Distinctions of the individualistic bias are belief in competition and that nature is abundant, cornucopian; and a general trust in institutions to control or compensate for the downside of extreme (climate) events (Thompson et al., 1990).

Cultural theory proponents further argued individuals can be expected to form risk perceptions that reinforce their idealized way of life. Congruent with that, persons whose values are hierarchical or individualistic would be sceptical of environmental risk while egalitarian value groups more likely to be ambivalent towards commerce and industry and readily accept that business should be regulated (Adams, 1995; Dake, 1992; Thompson et al., 1990).While constructs in cultural theory were illuminating, critics maintained it (cultural theory) could not claim universal validity because empirical support for it was weak and inherently problematic. The inability and difficulty to account for universal conditions outside empirical settings, which may or may not be consistent with research observations, produced what Renn (2008) called 'a lack of ontological realism'.

2.6.3.6 Psychological Theory of Risk Perception

The sixth theory in this discussion is broadly defined as psychological theory along with the companion psychometric paradigm, credited to Chauncey Starr (Starr, 1969). Adherents of psychological theory rejected social and cultural claims for predicting evaluations of risk and proposed that personal qualities better predict risk perceptions (Fischhoff et al., 1978; Slovic et al., 1981). The psychometric paradigm- the theory and technique of mental measurement- helped to conceptualize risk as personal expressions of individual fears or expectations. Cognitive psychologists suggested that individuals respond to their own perceptions, regardless of how those perceptions reflect 'reality'. Fischhoff's landmark 1978 paper '*How Safe is safe enough?*' attempted to measure how individuals respond to their own perceptions by asking them to appraise technology risks against benefits to society.

Other 'psychology of risk' literature addresses risk perceptions where outcomes are unknown and not well understood. Kahneman and Tversky's (1974) enduring work on heuristics and biases is relevant in current debates about climate risks. Heuristics and biases better explain how individuals draw inferences from risk information, according to availability, anchoring, representative and avoidance biases. Heuristics in this context are thought of as problem- specific thinking mechanisms for deciding upon something (how to prepare for climate risks) where there is incomplete information; biases are thought of as the preferences for the approach. An explanation of the heuristics found in PCT is discussed in Section 2.7.2.

Contributions to each of the theoretical propositions presented thus far address a particular dimension or context for the risk perception debate. Wildavsky and Dake went so far as to call them 'rival' theories suggesting each as being reductive and universally applicable in explaining the social experience of risk, one theory or the other. However, as the researcher has shown, each of the six theoretical frameworks has potential to combine with other explanations in an integrated way. Nor are they necessarily mutually exclusive. Theories which explain social and political environments as predictive do not account for, for example, the personal heuristics of a manager who has never experienced a catastrophic climate event, or who might be disinclined to access the anchoring effect bias because of low personal salience for climate change.

Theoretical reach may not extend into other levels of context, as is the case with psychological theories which tend to neglect exogenous political forces such as policy communities, sector associations, institutional affiliations and geographic focus that might influence risk perceptions. The relevance of credibility and trust in institutions attempting to manage climate change problems, in fact, is a construct to be explored with the study participants. Specialized focus on institutional trust was raised in O'Riordan and Jordan (1999)'s work and further assessed by Stedman (2004) who observed that institutional position and opinion relative to climate change varied among Canadian policy actors, when a combination of cognitive structure factors, sociodemographic variables and political identity factors were observed.

2.6.3.7 Social Amplification of Risk

Kasperson et al. (1988), motivated by this assemblage of social risk theories in previous years, formulated a social amplification of risk framework (SAR) as an attempt to integrate risk concepts and explain how risks interact with psychological, social, institutional, and cultural processes in ways that may amplify or attenuate public responses to the risk or risk event.

Kasperson's (1988) thesis argued that social amplification occurs at two stages: in the transfer of information about the risk, and in the response mechanisms of society. Signals about risk are processed by individual and social amplification stations, including the scientist who communicates the risk assessment, the news media, cultural groups, interpersonal networks, and others. Critics of SAR on the other hand, suggest the model concretizes risk, is ill equipped to describe social complexity and sides with the risk assessor against 'non-expert' stakeholders (Duckett & Busby, 2013).

2.6.3.8 Integrative Model of Risk Perception

So, what is left? Renn & Rohrmann (2000), who sought to understand the relevance of cultural theory, concluded the issue of risk perceptions was complex and not explainable on the basis of a single theory (Renn & Rohrmann, 2000, p. 213). In the face of theoretical limitations and open and unanswered questions, their proposition of a structured framework of factors which account for perceptions according to differing and integrated levels of context provides the best available model for the present discussion. The researcher argues risk perception is a multi-dimensional concept whose examination is better served by integrative thinking according to personal and collective approaches, levels of context and interdependencies of factors. Determinants of risk perceptions in Renn & Rohrmann's (2000) integrative model of risk perception at least allows for mutual contingencies among heuristic factors, cognitive-affective factors, social and political institutional factors and the overarching influence of cultural background. The model is depicted below.

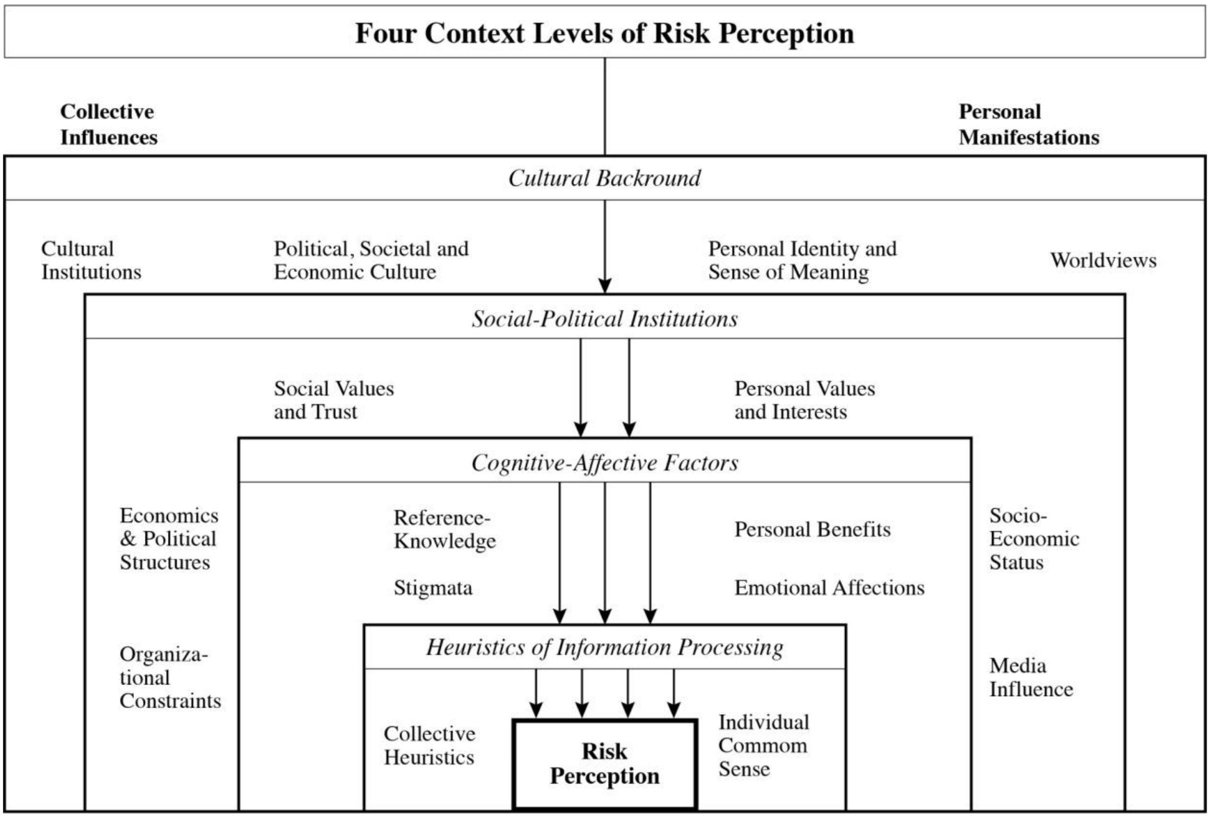


Figure 2. 2. INTEGRATIVE MODEL OF RISK PERCEPTION. Source: Excerpted from Renn & Rohrmann, 2000, p. 221)

The first level includes the collective and individual heuristics that individuals and groups use when forming judgements about risks. The recognition of heuristics and biases, as discussed earlier in Tversky and Kahneman’s work, is supported in empirical work capturing common characteristics of dread, catastrophic potential, perceived controllability and familiarity with the risk source (Slovic, 2000).

The second level of the model builds on knowledge theory and is concerned with cognitive and affective factors that influence the risk perception process directly. For example, Rosa’s work comparing Japanese and American views of catastrophic risk, showed that different cognitive routes can be taken to arrive at the same perceptions of risk, with Japanese relying on personal familiarity and primary knowledge of risk in contrast to American cognitive preferences for associating collective scientific knowledge with catastrophic potential (Renn & Rohrmann, 2000).

The third level offers explanation through social and political frameworks, based on influences of institutional trust, personal and social value commitments, organizational constraints, social and political structures and the social-economic status of each individual. Building on previous research of political and social structures as discussed in Sections 2.6.3.4 and 2.6.3.5, Renn & Rohrmann (2000) noted the contributions of Short and Clarke (1992) and Freudenburg (1992, 1993) who contributed to theory on organizational constraints. In the present study, the researcher has referred to the more up to date institutional constraints as 'pressures' existing exogenously and endogenously for the participants, as previously discussed in Sections 1.5 and 2.3.3. Endogenous pressures of organizational capacity and resources, coupled with exogenous pressures of governmental policy and regulations are congruent with Renn & Rohrmann's Level 3 social-political tenet in their Integrative Model of Risk Perception.

The fourth and last context level refers to cultural factors which govern the lower levels of influence suggesting cultural based preferences and biases drive risk perceptions. While validity over cultural theory has been contested on grounds of empirical weakness (Sjoberg, Rosa, Slovic), Renn & Rohrmann (2000) nevertheless claim that while 'universal yardsticks to evaluate risks exist' (p. 222), they are contingent on lower levels of cognitive and affective patters (level three) and social and political environments (Level 2). Renn & Rohrmann's model is provided in Figure 2.2.

The Integrative Model of Risk Perception has however some limitations. Renn & Rohrmann's model illuminates and organizes the relationship among and between four levels of social theories of risk perceptions; however, its limitations are twofold. First, it appears to be a linear top-down construction that does not account for potential feedback loops between theoretical 'levels' that may otherwise exist in integrative models. Second, it does not appear to address other variables within each level other than the 'individual' or the 'collective or group' variable. This is significant in this work for three reasons. First, Renn & Rohrmann's four-factor model applies to a lay population and not to expert or professional individuals or groups, as is the case in this research. Second, the model implies that values—trust and 'social value commitments' for example in Level 3 of the model—inform risk perceptions. Perceptions of climate risk are conditioned by values which may vary according to assumptions, conventions and practices. Personal values however, are not addressed in this work, as specified in Section 1.8. Third, the effect of media and other social institutions in Level 3 that mediate experiences of risk (for the individual or collective group which has not experienced it first hand) also do not apply in this work. Sector participants in this research have personal experience of the risk, and are able to verify their own organizational claims of risk. Research participants in this work are well informed executives and have a high degree of personal efficacy for risk decision-making in their organizations.

While there is little evidence for any theory of risk perceptions of individual professionals per se, several attempts have been made. Hill & Thompson (2006) explored global environmental views between environmental managers and non-environmental managers, concluding that professionals viewed environmental issues as more important because of heightened knowledge, perceived resilience of nature and emotional connection to the environment (Hill & Thompson, 2006, p. 779).

Public versus expert perceptions of climate risk events (heat waves in Canada) were studied by Chowdhrury (2012), concluding that experts had more knowledge about the risk effects associated with heat waves and that knowledge gaps existed for public respondents studied. Reynolds et al. (2010) compared 'educated' laypeople's understanding of climate change effects in 1992 and 2009 to assess knowledge among the respondent group, concluding not much had changed in risk perceptions in 17 years. Olatumile (2013) assessed environmental professional's perception of awareness and knowledge of climate change concluding that more knowledge about climate change and risk effects 'will be helpful in meeting their information needs' (Olatumile, 2013).

Theoretical support for the study of risk perceptions among individual professionals seems to be incoherent and unresolved. While Renn & Rohrmann's (2000) model does not apply to professional groups, nor abstract the risk concept to one rigid formula, it does assume that multiple forces conspire to affect perceptions of risks—an assumption which sounds intuitively reasonable. The model is conceptually appealing for three more reasons: (a) it does recognize that what people believe to be true about risks determines how they think about risk characteristics and how serious the risk is (Level 2); (b) it recognizes that organizations outside of the personal or corporate setting can impact risk perceptions (Level 3); and (c) it proposes that macro-sociological developments and a prevailing scepticism about contests in social arenas where 'powerful groups struggle for resources to pursue their interests and objectives' shape risk perceptions (Level 4). In conclusion, it is foremost an organizing framework which elucidates multiple social theories against which sensemaking theory and PCT can be applied, as discussed in the next section.

2.7 SENSE MAKING AND PERSONAL CONSTRUCT THEORY

In exploring the factors influencing decision-maker's views of climate risks, two further and important contributions are drawn into the debate: sensemaking and personal construct theories, from Weick and Kelly respectively. While both theories attempt to explain how individuals form their judgements about risks, they have striking differences in theoretical stance and empirical support, as will be discussed next.

2.7.1 Sensemaking Theory

Sensemaking, or the 'making of sense' by Weick builds on ideas of the agentic self (see Glossary) 'constructing sensible, sensable events' (Huber & Daft, 1987, p. 154) and where individuals 'structure the unknown' into something more tangible (Waterman, 1990, p. 41). Weick asserted sensemaking was an explanatory process of 'invention' where the individual 'constructs, filters, frames and creates facticity ' (Weick, 1995, p. 114). In high hazard and high reliability industries where high risk failure events may occur, sensemaking theory provides relevant explanatory power for how individuals form judgements under stressful and ambiguous operating conditions. In predictable environments, where the relationship between organizational action and outcome are known, organizations can predictably deploy resources to deal with routine situations, and institute familiar sounding 'Standard Operating Procedures'. In operating environments where the action-outcome relationship is ambiguous or completely unknown, as is likely to be the case with extreme and sudden climate risk events, decision makers must make sense their own accumulating practical experience with the risks at hand to arrive at a judgement or decision (Carroll, 1995).

It is useful to note here again the enduring work of Tversky & Kahneman (1971, 1973, 1974, and 1984). Their contributions to the field of decision making under uncertainty proposed that individuals often rely on reflexive interpretations employing judgemental heuristics or biases, to arrive at a judgement or a decision. Reliance on the accumulating practical experience that Carroll (1995) above reported, would have been viewed in the Tversky & Kahneman lens as an activation of personal heuristics or biases. They proposed that in making predictions and judgements under uncertainty, people do not appear to follow statistical theories of prediction. Instead they rely on a limited number of heuristics, namely the heuristics of availability (judgements made according to how easily a scenario is called to mind), representativeness (judgements made by comparing with a prior mental model) and or anchoring and adjustment heuristic (judgements made on an initial value or anchor, modified by additional information). The researcher asserts that Tversky & Kahneman's contributions do not necessarily clash with sensemaking theory, only to remark their work illuminates the psychological dimension of the sensemaking process by identifying biases which may be operating in the sensemaking individual. Where there is information missing, judgements about climate future imply a prediction, as in 'This looks like an ice storm coming through; we may have to launch back up systems'. Predictions intrinsically imply some kind of judgement that involves uncertainty. In assessing future climate risks, where exact climate impacts are not completely known, judgements about the future cannot necessarily be appraised on the basis of Carroll's (1995) 'accumulating practical experience with the risks at hand'.

From surveying other contributions, sensemaking appears to be explained as a kind of psychological process purposefully contributing to a collective aim. For example, proponents define sensemaking variously as 'an iterative social process that allows people to exchange interpretations and the construal of schemas likely to generate coherent adaptive strategies' (Landau & Drori, 2008, p. 703). Further definitions suggest it as a 'contribution to organizational identity' (Pratt, 2000) and as a 'mechanism that minimizes ambiguity and uncertainty by providing organizational members with an interpretative reference point during or after periods of change (Landau & Drori, 2008, p. 702).

One concludes from a survey of the sensemaking literature that sensemaking theory, valuable as it is, is vested in the 'collective self' where the higher priority of organizational goals eclipses the personal and individual sense making of events. In the Weickian view, organizational values are superior to personal values, and sensemaking theory is instrumental in supporting group and social values.

Additionally, the researcher's review of relevant case studies suggests a general pre-occupation with sensemaking of past events (Coutu, 2003; Landau & Drori, 2008; Weick, 1988; Weick, 1995; Weick & Roberts, 1993). Few if any published empirical studies appear to deal with sensemaking of anticipated events –a scenario that is central to the research topic of this thesis.

Still again, applying sensemaking theory to Renn & Rohrmann's (2000) integrative model of risk perception, discussed in Section 2.6.3.7, illustrates its lack of relevance in the present study. Using Renn's model as an organizing framework, Sense making theory contributes to the model's interface between higher levels of influence of social political institutions, including organizational constraints (pressure, ambiguity and incomplete information) and with the next lower levels of cognitive affective factors of knowledge and reference. Its alignment is weakest with Renn & Rohrmann's 'heuristics of information processing' explanatory level where individual heuristics and common sense drive risk perceptions at the personal level. In the present study it is, in fact, individual heuristics and individual common sense at the personal level which drive risk perceptions and support the approach and research design of this work.

Given this, reliance on sensemaking theory in the present study, where individual perceptions of anticipated events with unknown effects are central to this thesis, does not seem productive. Furthermore, empirical support for sensemaking relies on methodologies involving questionnaires and surveys, which may or may not elicit the range and depth of personal constructs to the extent that PCT promises.

2.7.2 Personal Construct Theory

Kelly's work on PCT offers a more individually based examination of factors to explain how the individual makes sense of her/his (further referenced as 'his') world. Kelly preferred to call his theory an 'interim' psychological one, reflecting his distinctive philosophical position of 'constructive alternativism' where 'all perceptions are open to question and reconsideration' which includes PCT itself (Kelly, 2003 p4). In other words, Kelly is both saying all perceptions are open to questioning and reconsideration- as are his own views and theories as well.

Kelly's central theoretical assumption is that we ascribe meanings to events, past and anticipated, or put another way, 'the way a person anticipates events is a function of his own personal constructs' (Kelly, 2003, p. 7). PCT suggests people develop constructs—or internal models of reality—to understand and explain the world around them, and in so doing, they can actively predict what will happen next (Jankowicz, 2001).

Of key interest to the present study are several of Kelly's assertions or corollaries of PCT. Beyond PCT's fundamental assumption that all individuals operate and process their world according to internal models of their own experiences the PCT corollaries of construction, organization, experience, individual and commonality are useful in the current debate in the following five ways, noted in the chart below:

1. The Construction corollary, which describes how people develop internal representations by recognizing recurring patterns in their experience supports the anticipated perceptions of participants who define climate risks in terms of their past experiences with it;

2. The Organization corollary, which suggests that individuals organize their personal constructs in a hierarchical way, with some constructs in a superordinate position and others subordinate to them. This corollary suggests, in the current work, that perceptions of climate risks may or may not be influenced by his/her personal values;

3. The Experience corollary, where constructs are 'working hypotheses' about what will happen next, supports the notion that if constructs fail in predictive power, they are open to amendment in light of new events. This would be the case of participants who acknowledge that existing preferences for managing operational risks, may no longer be effective in the future;

4. The Individuality corollary, where different people develop their own meanings for the same events, supports the observation of multiple participants arriving at entirely different constructs for the same event;

5. The Commonality corollary, which contends that 'people are similar to the extent they construe similarly; not because they encounter similar events, nor because they behave in the same way' (Jankowicz, 2001). In the current work, this corollary applies to the anticipated consensus among varying participants that 'managing climate risks is an industry priority'; and

6. The Sociality Corollary proposes that it is possible to discern and make sense of other people's constructs, regardless if one uses those constructs oneself. In this way, the corollary is about being able to discern and utilize other's constructs whether they are similar to, or indeed very different from one's own.

In the present study, it can be noted that multiple actors in intra and inter organizational relationships, i.e. electricity producers and their utility partners- may view a need to interact to manage anticipated climate risks, but may share or have differing construal of the same climate events, past and future. As well, the Sociality Corollary suggests that the better individuals are at observing what's driving other people's behaviour, the more effectively they can interact with them.

One can conclude that Sense Making Theory and PCT, while both contributing to the study of risk perceptions, do so in different ways: sensemaking theory relies on the instructive power of social and collective values while Personal Construct Theory focusses on an individualistic orientation. The present study is concerned with the exploration of individual constructs of future unknown events presented by climate change. Examining the expected variability of risk-based views of participants, who work in an engineering culture where qualitative assessments provide (competing) corporate legitimacy, is expected to prove fruitful with a constructivist approach. Demarcating personal views away from corporate objectives and organizational values highlighted in sensemaking may well expose personal and internalized risk perceptions of critical importance to industry and public policy, let alone differences which may exist between the two sub groups studied in this work. Climate risk construal may be different between power producers and their supply chain utilities partners due to differing pressures and resources and ultimately suggest different industry priorities for managing climate risks.

Both sector groups examined in the present study represent different component parts of the electricity production supply chain. At the upstream position in the electricity production supply chain, natural gas electricity power producer companies operate under a unique set of business conditions, government regulation and pressures while their downstream (closer to the end user) supply chain partners in transmission and utilities likewise operate under different sets of business conditions, government regulations and operating pressures, as discussed in Sections 1.5, 1.5.2, and 2.3.4. Elicitation of constructs from decision makers from both groups are likely to show how their differing accountabilities, business pressures, resources and organizational capacities may reflect different priorities for managing climate risks, as stated in Sections 1.3 and 2.3.2.

2.8 LITERATURE REVIEW SUMMARY

The previously reviewed literature threads on climate change and climate science, the electricity sector, corporate adaptation, risk management, management cognition, risk perceptions theories and PCT in particular, are summarized below, and crystallized in point form. Gaps and further critical analysis in the extant literature are also included. As stated earlier, the research objective is to examine the way in which the sector participants construe of the influencing factors of climate risk.

The discussion was first developed with a broader discussion on climate change and climate science and the climate risks presented for industry. Reasons for why climate risks are salient for the electricity sector were discussed. Theories and empirical work on corporate adaptation were presented next, followed by contextualizing corporate adaptation in the risk management paradigm. A discussion around management cognition and decision making and the subjectivity of organizational life was then presented, followed by a review of risk and risk perceptions theories.

A narrower discussion about psychological theories of risk perception introduced sense making and finally PCT. Renn & Rohrmann’s (2000) integrative model of risk perception was finally suggested as a partial organizing framework against which to assign the examination of perceptions of climate risk among the sector participants in this work.

Point #1. *The exploration of management risk perceptions is key to understanding how companies expect to prepare for extreme and sudden climate events. Perceptions matter, in the sense that perceptions drive corporate climate strategy.*

In building a foundation for the discussion around the ultimate source of climate risk—that being the physical phenomenon of climate change itself, multiple relevant literature sources were noted. Contributions made by IPCC consortia authors including Pachauri et al. (2015) and Solomon et al. (2007) asserted that future, extreme and sudden changing climate states will prevail, that scientific consensus for future conditions is documented (Cook et al., 2016) and that future climate states will likely have severe consequences for businesses and potential catastrophic effects on organizations relying on critical infrastructure including electricity (Linnenlueke et al., 2012). Daron (2011) drew on multiple literature sources in his PhD thesis to characterize climate change as a 'non-linear, dynamic and chaotic' phenomenon, while Stern (2008) and later Weitzman (2011) referenced future climate change as high-impact, low probability events which have created 'unknown unknowns' and 'fat tails' of probability utility respectively.

Point #2. *Many interpretations of risk and hazards exist in the general climate change lexicon. When climate risks are discussed, there is still no unifying definition of climate risks.*

The contributions of Heal & Kriström (2002); Jaeger et al. (2001); Prato (2008); Renn et al. (2000) and Willows et al. (2003) discussed the effect of the complexity and uncertainty of climate change on risk perceptions. Literature suggested that climate language and terminology have an effect on risk perceptions. This proposition was supported by three propositions on framing, experience and knowledge source by Gifford & Comeau's (2011) work on message framing; Dessai et al's (2004) theory on how internalized perspectives of climate change information lead to personal and subjective understandings of climate risks; and Sidortsov's (2014) work that proposed that climate language emanates from two camps, the positivist camp of technical and scientific experts and from the subjective, constructivist camp differs according to who is anticipating the risk. As Sidortsov (2014) said, perceptions of climate risks vary according to who is actually anticipating the risk.

His work suggested, that climate change terminology evokes two distinct perspectives in the debate: one dominated by the positivist, objective perspectives of technical climate experts to describe climate risks in terms of mathematically modelled explanations of climate change impacts; and the other, subjective, constructivist school which is either equally and/or more concerned with overall sustainability and systemic risks attributed to climate change. These distinctions were raised by Brooks (2003), Allen (2003), and Chichilnisky (2000). Tversky & Kahneman (1974) concluded that various biases influence judgements under uncertainty and showed that judgement can be distorted by memory.

Renn (2000) also noted the failure of rationalist utilities approaches to account for human perceptions of risk, concluding that appraisals of climate risks ought to at least include or be prescribed by constructivist thinking to allow for variability and individual perceptions.

Point #3. *Risk perceptions, ultimately informing one's appraisal of anticipated risks, are particularly vexatious when dealing with climate risks. Climate risks are not well understood because they are complex and difficult to predict.*

Sidortsov's (2014) research and literature from climate science consortia groups were included in the literature review to suggest that climate knowledge and climate modelling reports are generally the main source of knowledge for industry of future climate states. Climate assessments conducted by the Canadian Ouranos consortia were foundational to the findings of the CEA's 2015 forward-looking climate Adaptation report for the Canadian electricity sector. The report findings articulated specific and detailed climate risks for the electricity sector, and excerpts of their findings were included in prior sections. The direct and more prevalent climate risks to Ontario electrical power operators were noted as being floods and heavy precipitation, ice storms and polar vortex climate events.

Providing context about the study groups' business environment, a general description of the industry was assembled from energy regulatory documents, legislative summaries, public policy analyses and energy consultants' reports. The resulting profile of the sector groups indicated that it is governed by macro, external institutional forces of government regulation and interventions, and significantly in the current context, subjected to GHG emissions abatement policies and Cap and Trade (emissions certificate trading) schemes. It is also subject to firm-level internal pressures relating to organizational resources, capacity and technical knowledge.

Point #4. *Climate risks have high saliency for electricity companies. They are climate- sensitive organizations and are considered vulnerable to sudden extreme climate events because of aging infrastructure, regulatory and governmental policy risks and accountabilities for continuous provision of electrical supply. They are also considered to be sensitive to climate risks in terms of the risk impacts associated with organizational resources, capacity and technical knowledge.*

The review of corporate adaptation literature showed that debates and discussions about responses to climate change are relatively recent. Literature indicated that corporate adaptation to climate change is understood as an outcome of measures the company chooses to implement to adapt to risks presented by climate change.

Point #5. *Corporate adaptation to climate change is an organizational response to external and internal factors in the business environment. Climate change itself is seen as an external impact; however, it is not the only climate risk impact discussed in climate adaptation literature.*

Corporate adaptation literature acknowledges the open system organizational perspective where responses are done to factors outside and inside the organization.

Point #6. *Factors influencing the process of corporate adaptation are mixed and varied; however, literature has raised the issue of management interpretation of risk impacts as an influencing factor.*

Three themes were identified in corporate adaptation literature relating to the types of impacts the organization is adapting to, the factors influencing the process of adaptation and to the characteristics of the adaptation process.

Examples of corporate adaptive responses in the literature show how prior contributions contextualize the debate in different frames and paradigms (organizational transformation, organizational change, knowledge management and learning environments). More recent work suggests corporate climate adaptation most resembles risk management strategy.

Point #7. *Corporate adaptation research is increasingly contextualizing climate risks within the risk management paradigm.*

Risk management literature noted that climate change impacts are a newly regarded material business risk. Even corporate adaptation scholars suggested that climate change impacts should be treated within a risk management framework (Gasbarro et al., 2016). While risk management practice cannot measure risk impacts that haven't occurred yet, it nonetheless offers useful tools and approaches for the identification, assessment and response decisions relating to climate impacts.

Point #8. *Climate change impacts are seen as a material business risk for organizations.*

Literature suggested the three stages of traditional risk management processes resemble corporate adaptation phases. For example, Arnell and Delaney (2005) proposed that organizations must be firstly aware of climate risks to address the impacts—a similar process to the traditional risk identification phase.

Point #9. *Risk management practice offer useful tools and approaches for responding to climate impacts.*

(Berkhout et al., 2006)stated that corporate strategy of 'risk assessment and options appraisal' mirrors the process of the risk assessment phase. The risk response phase, normally the third and final stage of traditional risk management programs, resembled Berkhout et al.'s (2006) strategy for 'managing and sharing risks'. Before response decisions are made, risk management practice suggests that the prior two phases need to be addressed.

Point #10. *Risk management phases resemble phases in adaptation strategy, and examples exist in the literature. Risk readiness is implied by which risk management stage the organization is in.*

Prior sections also canvassed 30 years of risk perception literature to establish why risk perceptions vary among cultures, institutions, groups and individuals.

While it is a reasonable view that risk perceptions cannot be exclusively explained by one factor, Renn & Rohrmann's (2000) integrative model of risk perception, while useful as an organizing structure, suggests how complex and nascent the literature of risk perceptions still is. Many facets of the model are shown to have unidirectional influence, from top to bottom, contradicting what might otherwise be expected of an integrated model. It includes, notably, the presence of cultural force on risk perceptions albeit within a range, in contradiction to Renn & Rohrmann's initial rejection of cultural theory.

Point #11. *Risk perception theories attempt to explain which factors drive perceptions. Not all risk perception theories have been shown to have empirical support. Perceptions of risk cannot be explained by one theory alone.*

Further literature presented contributions of sensemaking theory and PCT by Weick and Kelly respectively. Both theories support the exploration of internal individual construction of events or phenomena to help explain 'what happened' or 'what will happen', as is the case in Kelly's (1991, 2003) PCT proposition. PCT in the present work is helpful in understanding how decision makers make sense of and construe the influences and pressures affecting their views of managing climate risks in the future.

Point #12. *While sensemaking theory is useful in understanding how individuals and processes within organizations understand 'what happened', Kelly's proposition that individuals' construing of future events based on their experience of the past, is more apt to the theme of the current research.*

2.9 LITERATURE SYNTHESIS

In synthesizing the literature review, a number of unifying statements can be made, as offered below.

1. Given the sheer complexity of formulating approaches to managing the impacts of climate change, it may be fruitful to focus on the perceptions and construal of managers involved in planning the corporate response. This arises from Points 1, 2, 3, and 4.
2. Researchers have found it convenient to analyse climate risks within a risk management framework. The identification, assessment and risk response decisions depend on how climate risk impacts are interpreted, and on the emphasis given to each of the three stages, by the managers involved. This arises from Points 5, 6, 7, 8, 9, and 10.
3. While various theories of risk perceptions exist, with varying degrees of empirical support, there is still no consensus on a single approach. Since, however, this work focuses on the managers responsible for the corporate response to risk impacts, it is clear that it is their

personal theorizing, their sensemaking and their construing, which should form the focus of this empirical work. This arises from Points 11 and 12.

2.9.1 Gaps and Additional Critical Analysis of the Literature

The present study builds on prior empirical studies and theoretical contributions on risk perceptions. It provides a Canadian and a single industry context to the exploration of climate perceptions among utilities managers in Ontario (Canada). Given climate risk is a relatively new academic topic, it was not surprising that many contributions noted the need for future work into a) how businesses perceive climate change; and b) how their perceptions are reflected in their own organizational response to climate change (Cox Jr, 2012; Gasbarro & Pinkse, 2015; Gasbarro et al., 2016; Lempert & Collins, 2007; Linnenluecke et al., 2008; Lujala et al., 2015; Stedman, 2004; Weinhofer & Busch, 2013; Winn et al., 2011)

In critically assessing prior literature however, a number of empirical contributions were noted for having low external validity and of low internal validity, as discussed next.

External validity, or *the extent to which the internally valid results of a study can be held to be true for other cases, other people or other times* produces generalizability for future investigations. In the prior qualitative literature which relied heavily on single and multiple case study approaches in specific geographic locations (Galbreath, 2014; Gasbarro et al., 2016; Haigh & Griffiths, 2012; Stedman, 2004), generalizability to the industry at large and across multiple geographic locations could not be achieved. Galbreath et al. (2014) noted in their cross sectional study of businesses that 'the ability of these findings should not be assumed' (Galbreath, 2014, p. 102).They further noted that other organizations in the same industry but at different locations were not experiencing the same climate effects. In other words, extant corporate climate research seeks answers for industry specific contexts but also for the effect of location-based climate impacts on the studied organizations.

With respect to internal validity, two types of research limitations in the prior work are noted as potentially reducing internal validity. There appears to be a lack thus far of longitudinal data in the climate literature to account for how perceptions or organizational responses change over time. This lack of empirical support may be noted for limiting the research claim that risk perceptions are dynamic and may evolve in the constructivist 'man as scientist, continually reassessing and re-construing the world' proposition. Haigh & Griffiths (2012)'s empirical work which considered 'climate surprise' as a driver for management cognition suggests cognitive change took place despite the absence of 'before and after' empirical support.

Furthermore, prior climate literature which relied heavily on questionnaires and surveys for insights into management cognition on climate risks (Stedman, 2004; Weinhofer & Busch, 2013) may have been subject to social desirability bias from respondents. Responses that answer questions in a manner that will be viewed favourably by others, is a social science research risk where researchers conventionally note it as a limitation in the final discussions in research papers. De Jong et al. (2010) reflected that socially desirable responding has been recognized as an issue that can adversely affect the validity of social science research.

Given the chosen inductive research strategy of the present study, it can be noted that the data collection technique (RGT) supporting the chosen framework of personal construct theory, helps reduce response bias in a number of ways, to be discussed further in the next section on Methodology.

2.10 RESEARCH QUESTIONS AND FRAMEWORK OF ANALYSIS

The aim of the present work is to examine how electricity managers view climate risks and how they expect to manage those risks in the near future.

The previous Sections 2.3.3, 2.3.4, 2.3.5, and 2.3.6 showed how a number of external and internal pressures- climate change itself, government policy and GHG regulation, and operational resources and capacities are likely to affect electricity managers' risk perceptions, informing future risk management. A simple model conceptualized by the researcher depicting these relationships is provided in Figure 2.3.

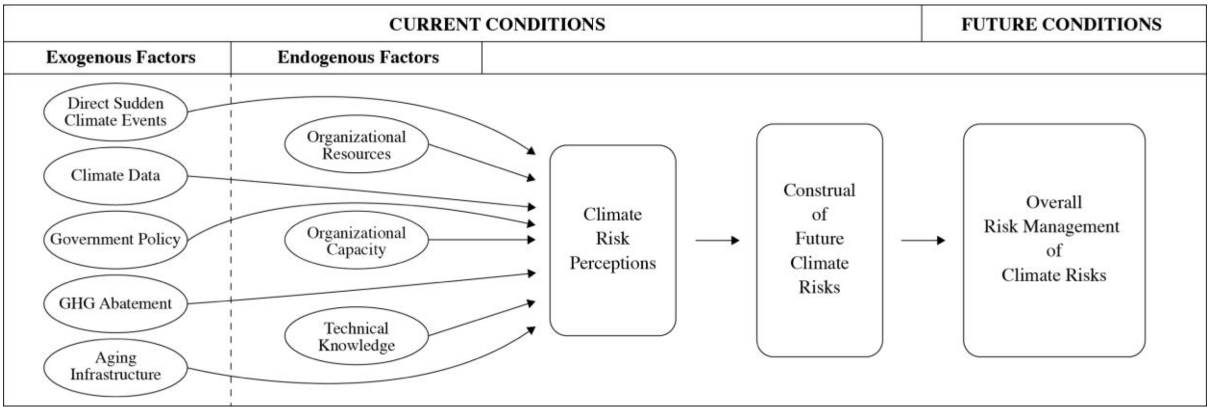


Figure 2. 3. SIMPLE MODEL OF RISK PERCEPTIONS IN THE ELECTRICITY SECTOR.

The above depiction shows the relationship of exogenous and endogenous factors with climate risk perceptions. Both sets of pressures are shown to influence management perceptions of climate risks—which in turn influence the construal made about managing climate risks in the future.

The literature review also suggested that the approach taken from Kelly's PCT, provides a reliable and more detailed examination of how these pressures are perceived as influencing their risk perceptions.

The objective is therefore to identify the way in which the participants construe and make sense of these 'influencing' factors of climate change itself, governmental interventions of regulation and climate policy and internal organizational resources and capacity.

This leads to three research questions in particular:

1. How do the study participants construe and make sense of the influential pressures outlined in this work, in assessing the impact of future climate risks on their operations?

Since there are two sector groups within the study group, as explained earlier in Sections 1.3 and 2.3, the comparison of respondents' construal may illuminate differing priorities, the first research question is demarcated into a second and third research question:

2. What differences in risk perceptions, if any, exist between the two sector groups (power producers and utilities)?

3. How do the sector participants construe of the relative influence of climate drivers on their view of future climate risk management?

In summary, the primary research question is designed to gain an understanding of how electricity managers view climate risks and how they expect to manage those risks in the near future.

The second and third research questions are designed to compare any differences or similarities in individual constructs between the two sub-groups, and differences or similarities in the assessment of the relative importance of the different climate drivers (the element analysis).

2.11 CHAPTER SUMMARY

As a review of the literature, this chapter brought focus to the research topic of climate risk perceptions in the electricity sector in Ontario. The work is presented in the broader field of risk perception theories, and in the prior work of industry-specific studies of challenges facing infrastructure and electricity companies in the western world. The chapter considered some of the primary literature sources related to climate change itself, the electricity sector in Ontario, corporate adaptation, risk management practice, risk perception theories, and PCT. The resulting view suggested the prospects of managing future climate change impacts are driven by perceptions of risk; and that risk perceptions themselves are potentially influenced by a range of drivers/pressures relevant to the present study.

Congruent with that, the former chapter described two constructivist approaches to understanding how individuals construe and make sense of their world—that of sensemaking theory and of PCT. The chosen research design, described in the next chapter, will rely on PCT and the RGT to elicit respondent constructs of climate risk in relation to the previously discussed factors, deemed the 'elements' in the grid, as will be shown in the next chapter.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

This chapter provides an explanation of the many and varied issues relating to the research design and methodology used in the main study and the pilot analysis.

For ease of reference, the aims, objectives and research question are recapped below.

3.1 RESEARCH AIM

The research aim of the present study is to understand how decision makers in the electricity sector in Ontario (Canada) view climate risks and how they expect to manage those risks in the near future.

3.2 RESEARCH OBJECTIVES

The primary objective that emerges from the above discussion is to identify the way in which the participants construe and make sense of the influencing factors related to the exogenous and endogenous pressures on electricity producers and utilities. Exogenous pressures in this study are direct climate impacts of extreme weather events, the indirect climate impacts of climate data, aging infrastructure, government policy, and GHG regulation. Endogenous pressures in this study are the risk impacts of technical knowledge, organizational resources and organizational capacity.

From the above, further empirical work is proposed to address three subordinate objectives, namely, a) the development of a category scheme that describes and enumerates the constructs participants have about the drivers/influences involved, b) the examination of the differences that may exist in the constructs of the two groups of participants and c) the examination of the differences in the constructs expressed in the more formal published corporate reportage of climate risks, compared with the individual constructs elicited from the participants.

3.3 RESEARCH QUESTION

Based on the above, the central research question is recapped here for consistency: How do the sector participants construe and make sense of the factors outlined in this work in assessing the impact they have for managing those risks in the future?

3.4 METHODOLOGY FOR THE EMPIRICAL WORK

The present study is concerned with exploring management thinking about climate risks in the electricity sector. It has been noted in Sections 1.4, 1.8, and 2.6 that how electricity executives perceive climate risks for their own operations—in light of external and internal factors, including most visibly a sector wide ‘call for action’ on climate risks (CEA 2015) is likely to inform their decisions and actions.

Other climate risks related to aging infrastructure, while a concern for both groups, may inform participants’ perceptions of climate risk impacts in different ways. Additionally, government_policy and GHG abatement regulations targeting the participants place unique and pervasive pressures on (natural gas) power producers' groups—but not likely to the same extent on their counterpart utility groups.

Furthermore, organizational pressures for increased capacity and resources to manage future risks, whether direct impacts of extreme weather or whether indirect impacts of public policy and regulation and organizational burdens, may produce variations in perceptions reflecting different constructs in the utilities manager.

While risk perceptions of climate change may have associations with highly variable meanings, the constructivist approach adopted in this work suggests that decision-makers' constructs reflect their assumptions about the risks that climate change produces in the first place.

Based on the above, and the importance of the perceptions held by the utilities managers under study, a phenomenological approach organised as an exploratory study is appropriate.

Given the research objective to understand the differences between and among multiple case studies, a comparative case study approach is selected. A further mixed methods approach using narrative analysis of participant corporate reports is introduced in the second phase of the empirical work.

3.5 RESEARCH PARADIGM

The researcher's philosophical assumptions about the empirical nature of the present study, and about the way in which data about climate risk perceptions should be gathered and analysed, are provided by the following and brief discussion about the philosophical and paradigmatic features of the work.

Briefly the phenomenological approach is discussed followed by the recognition of the ontology and epistemology of the research topic, with specific reference to constructivism. All three facets shape the approach to theory and methods in qualitative inquiry (Gibbert et al., 2008).

Firstly, the present inquiry is committed to a phenomenological approach so that the analysis can seek to "grasp and elucidate the meaning structure and essence of the lived phenomenon for a person or a group of people" (Patton, 2002, p. 482). In the words of Snape & Spencer (2003), "phenomenological research seeks to understand the constructs people use in everyday life to make sense of their world" (Snape & Spencer, 2003, p. 12). Congruent with that, the central focus of the present work is primarily on eliciting these constructs from the participants to understand their perceptions of climate risk on their organizations.

Secondly, the ontology and epistemology—which are two ways of describing the philosophical position taken, are considered. Ontology can be defined as a belief system that reflects the interpretation of an individual about what she/he sees as 'reality'. In simpler terms, ontology is associated with a central question of whether phenomena need be identified as objective or realist, or subjective. In the present work and shown throughout Sections 1.8, 2.2, 2.6.1, and 2.6.2, the ontological orientation of the climate risk perceptions debate has been argued and supported through the extensive use of literature depicting climate risk as a social construction. Given that, the ontology for the present work is phenomenological in nature.

Epistemology, another philosophical dimension, deals with the nature of knowledge and what counts as proof. A prior reference in this work about the discussion of climate risk suggested that the concept of risk itself is epistemologically questionable however, given that knowledge about it (risk) is knowledge about the lack of knowledge (See Section 2.6.2 for further discussion).Overall however, the epistemological position is one of constructivism, allowing for the collection of individual risk perceptions according to a constructivist approach using methodology and data collection techniques to explore human perception and appraisals of future climate risks.

Understanding constructivism in terms of what it is and what it is not, produces an opportunity to compare it with its paradigmatic opposite—the positivist school of inquiry. In the context of the present work, a constructivist approach will provide a way of understanding and interpreting the world of electricity utilities managers, and will look for multiple meanings and complexity of the participants' viewpoints on climate risk. In other words, constructivism aims to understand how the participants create meanings about their world and experiences when asked, in this work, about the prospects of managing future climate risks. In the constructivist tradition, different meanings of the same phenomena are seen as due to different individual constructs derived from a variety of experiences. This is consistent with a phenomenological approach, a variant of the constructivist school, where the researcher gains knowledge about the 'lived experiences' of participants through exploratory techniques and analysis of narrative data.

In contrast, positivism is concerned almost exclusively with empirical observation of variables, hypothesis and testing, often resulting in statistically supported conclusions about correlations or causal relationships between/among variables.

Unlike the constructivist approach where all phenomena (variables) and their interacting relationships are observed, the positivist school is oriented towards holding variables constant to test for relationships which support established theoretical assumptions. In further distinction the corresponding research paradigm for constructivist inquiry is one of a 'bottom up' inductive reasoning (Jankowicz et al., 2016). The inductive approach used in this work corresponds with assumptions of using empirical observations first to generate broader generalizations and theory development.

Constructivism is concerned with the 'making of meaning' where according to Crotty (1998) 'meaning is not discovered but constructed', and with 'inviting a radical spirit of openness' to accommodate a variety of individual experiences and personal meanings' (Crotty, 1998, p. 9).

In literature the constructivist variants ‘radical constructivism’, ‘social constructivism’ and ‘constructivist alternativism’ are useful to note (Von Glasersfeld, 1989) prior to discussing PCT as theoretical support for the present research method and technique.

Radical constructivism claims “all knowledge is actively received and built up by the cognizing subject, where the function of cognition is adaptive and helps to organize the experiential world for the individual” (Von Glasersfeld, 1989, p. 162).

In contrast social constructivist-based theory emphasizes the role of culture and context in developing shared interpretations of reality where meaning is an agreement shaped by social patterns and the assumptions encapsulated in language. *(*Von Glasersfeld, 1989*).* In other words, social constructivism refers to the process of individuals making ‘meaning’ within a social context (Berger & Luckmann, 1991).

Contributions from Lorsbach and Tobin (1992) suggest that the process of construing incorporates both social and individual aspects where individuals will form relationships and construe of each other’s constructs, often resulting in an improved understanding of others/groups constructs. This sociality proposition is noted in Kelly’s sociality corollary ‘as the pattern of behaviour that an individual will follow and modify based on her/his understanding and prediction of her social environment (Kelly, 2003, p. 96).

Before the social constructivist movement took hold, Kelly expanded the concept of constructivist thinking to one called ‘constructivist alternativism’ to support his ‘man as scientist’ argument, where individuals may be initially committed to a belief, held tentatively—but continually reappraise new and alternative information to form alternate constructions.

Kelly’s formal explanation of Personal Construct Theory used logic based, axiomatic language and described the basic principles of PCT as fundamental postulates and corollaries. As noted in Section 2.7.2, chief among them are the five PCT principles relevant for the present study: (a) the construction corollary (individuals develop internal representations of reality by recognizing patterns in their experiences); (b) the experience corollary (where constructs are tentative about what will happen next); (c) the individuality corollary (individuals have different constructs); (d) the commonality corollary (individuals may share constructs with others, promoting role relations); and (e) the sociality corollary, as described above.

While once rejecting the traditional label of ‘cognitive’ processing where it would apply to mental reasoning, logic and deduction to explain for constructs, Kelly nevertheless referred to the predictive power of cognitive complexity (Kelly, 2003) in an individual. He explained that the level of differentiation, or ‘the greater the degree of differentiation among constructs, the greater will be the predictive power of the individual’ (Kelly, 2003, p. 53). Furthermore, the more cognitively complex individuals are in terms of constructs they use to interpret their own experience, the more constructs their social and business partners will need, to effectively construe their construction processes (Kelly, 2003, p. 54). It can be noted that Kelly's notion of cognitive complexity is significant and implied in the RGT where there is a procedural aim to elicit from four to six constructs as a minimum, from each individual. Further discussion of RGT and data collection is found the next section.

Kelly (2003) explained his view of individuals as incipient scientists that create their own ways of seeing the world and events, this way: 'As a scientist, a man seeks to predict and control the course of events. The constructs which he formulates are intended to aid him in his predictive efforts' (Kelly 1963, p 12). While recent critics of Kelly's man as scientist proposition have argued that individuals in fact do not always make good scientists in view of modern day idolatry and celebrity messaging of information, (Bannister & Fransella, 1986), the researcher believes that Kelly's guiding principle of 'man as scientist' sufficiently applies to constructs elicited in this work, given the technical orientation and industrial training of the participants.

3.6 RESEARCH METHOD

Congruent with the epistemological constructivism and the qualitative nature of this inquiry the selected method is one of case study design. While the six main research methods—interpretivist, survey, experiment, case study, action research and grounded theory (Jankowicz et al., 2016) have been considered, the preferred research method for the present work is a comparative case study, enabling the researcher to not only explore constructs elicited in case study design, but to compare them between two distinct groups in the study. The terms case work, case study research and case study method are used interchangeably in this discussion.

The case study rationale for this work is based on the assumption that this work investigates 'a contemporary phenomenon within its real life context' (Yin, 2014, p. 16). He suggested 'where the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used' (Yin, 2014, p. 17) case study design is appropriate. In other words, a case study is a unique way of observing any natural phenomenon which exists in a set of data—unlike positivist work "which may observe patterns in data at the macro level on the basis of frequency being observed, case studies observe the data at the micro level" (Zainal, 2007, p. 2). It can be noted here that the units of analysis in the present work are the individual constructs of the participants.

Conditions supporting the rationale for the case study method are noted in literature (Dooley, 2002; Eisenhardt, 1989; Eisenhardt, 1991; Yin, 2014). Specific discussions about multiple case studies are supported in contributions (Herriott & Firestone, 1983; Yin, 2014). Eisenhardt (1991) asserted the rationale for multiple case studies allows for a wider base of knowledge, and allows "the researcher to view patterns on a larger scale" (Eisenhardt, 1991, p. 620). Similarly, Herriott and Firestone (1983) maintained that the overall study is regarded as being more robust (than a single case study).

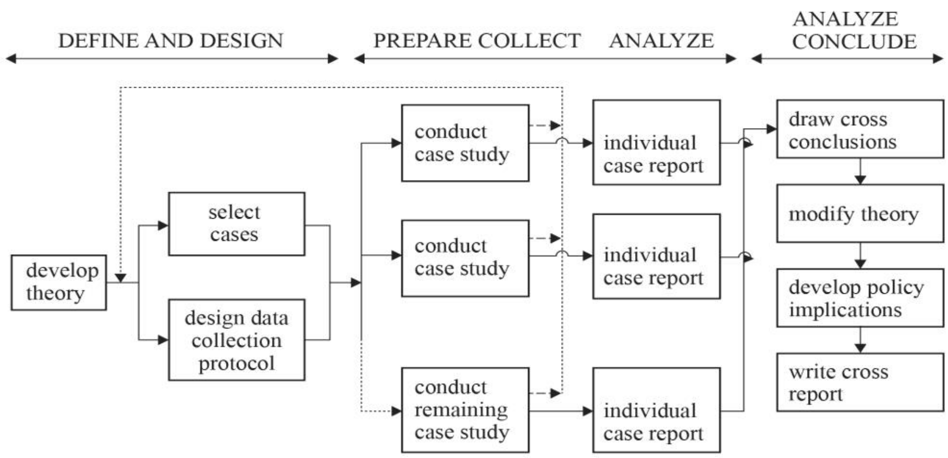
To increase methodological rigour, the issues of reliability and replicability are considered (Gibbert et al., 2008). Yin (2014) noted the use of multiple case studies is congruent with the use of ‘replication logic’ and ‘analytical generalization’—two important dimensions of research design, included in the following section.

3.7 RESEARCH DESIGN

The research objective of the present work is to surface views of climate risk from two key groups in the electricity sector as noted in section 1.9. Designing the main study to achieve the research objective is noted here.

The research design can be viewed as the blueprint of the research method, and deals with design process, data collection techniques and case study selection. The related issue of building in reliability criteria into the research plan, including construct validity, replication logic and external validity with specific reference to analytical generalization are however discussed interchangeably with the design process. The process for research design in the present work draws on Yin’s (2014) work, following his three-phase model for multiple case studies as follows: ‘define and design’, ‘prepare collect and analyse’ and ‘analyses and conclude’. A flow chart depicting this phased approach is provided in Table 3.1.

Table 3. 1
REPLICATION LOGIC TABLE (Multiple Case Study Research Design)



Source: Yin 2003, p.50

Significantly, this phased research design intentionally supports two quality criteria for research design: a) construct (internal) validity (Gibbert et al., 2008) during the data collection phase; and b) the production of analytical conclusions allowing for greater external generalization of findings (Yin, 2014). As Denzin & Lincoln (1994) stated, construct validity is defined as the extent to which a (research) procedure leads to accurate observations, or in other words, ‘the extent to which a study investigates what it claims to investigate (Gibbert et al., 2008, p. 3). Formulating the research design as a protocol as Yin has shown, establishes ‘a clear chain of evidence to re-construct how the researcher went from the original research questions to the final conclusions’ (Yin, 2014, p. 237).

Secondly, external validity or generalizability assumes that operationalized theories must be shown to account for phenomena not only in the settings in which they are studied, but also in other settings (Calder et al., 1981; McGrath & Brinberg, 1983).

The rationale and application of generalization techniques in differing research contexts are well discussed in literature (Maxwell, 1992, 2005; Polit & Beck, 2010; Yin, 2014). Case study method uses analytical generalization by applying specific findings derived from one case to other cases in which similar theoretical propositions are felt to apply—rather than by using statistical generalization. Statistical generalization, in contrast, relies on some defined population that has been sampled.

Replication logic—or asking the same questions repeatedly of two or more contrasted groups to see whether the results are as expected from the theory with which the analytical generalization is working (Jankowicz,2016) promotes external validity through replicability of results.

Yin’s (2014) replication logic for multiple case studies followed in this work is as follows:

The Define and Design phase, beyond theory building, encompasses case study selection and establishment of data collection protocol;

The Prepare, Collect and Analyse phase encompasses data collection from each case study and report writing;

The Analyse and Conclude phase involves in case and cross case analyses, any theory modification and the cross-case report writing.

3.8. THEORY DEVELOPMENT

The focus of this research is to understand and gain insight from two sector groups, their perceptions of climate risk that may influence views of future management of them (climate risks). The theory used as an organizing framework to understand the risk source and level of influence on risk perceptions is Renn & Rohrmann’s (2000) integrative model of risk perception (as introduced in Section 2.6.3.7).

According to Renn et al.’s model, and where it applies to ‘personal manifestations’ (see Figure 2.2), perceptions of risk result from four factors: (a) heuristics of information processing at the most individual level; (b) cognitive and affective factors; (c) social and political institutions; and (d) cultural background. These four levels of factors in Renn & Rohrmann’s proposition influence risk perceptions in a hierarchical structure where the most immediate influence on individual perceptions is heuristics and common sense.

In exploring the individual perceptions of the two key study groups it is expected that the source of influence over individual perceptions in the empirical data may match or relate to those in Renn's model. Theory contribution is anticipated where if any differences in perceptions pertaining to the two groups are noted in the empirical work; hence the empirical data collected will provide data for the test of Renn & Rohrmann's (2000) integrative model of risk perception.

Additionally, there has not been, to the best of the researcher's knowledge, any prior empirical testing of the integrative model of risk perception; nor have standard measures been developed to test the validity of the model. Emergent results from this study will be novel and contribute to theory building.

3.9 CASE STUDY SELECTION

Multiple case studies were purposively selected from two groups in the electricity sector: one group of 10 case studies was selected from the natural gas electricity power producer industry and the other group of 10 case studies was selected from the electricity production and utilities industry. Twenty case study organizations in total are identified and selected using a purposive selection strategy (Transportation Research Board, 2009).

According to Yin (2014), six to 10 case studies would provide compelling support while Patton (2002) suggested there are no specific rules for the number of cases in multiple case study research of this nature (Quirk, 2013). Furthermore, Eisenhardt (1989)stated while there is no ideal number of cases in phenomenological and constructivist research, four to 10 cases is normally ideal (Quirk 2013). In consideration of the RGT procedural requirements for eliciting 300-350 constructs however, a total of 20 case study organizations were selected on the assumption that each participant would produce between 12-15 constructs in the grid process. Following Diaz de Leon & Guild (2003) 's work which obtained an average of 11 constructs per interview, it is anticipated that between 12-15 constructs per interview would be acceptable.

The selection of the participating organisations took place as follows. After information from multiple sources of secondary data were retrieved, an industry-wide survey of power producers, transmission and utilities companies operating in Ontario was obtained in October 2016. Relevant statistics and corporate characteristics of all market operating companies were compiled in excel spreadsheets for ease of handling. Annual report links were embedded in the documents, as were any relevant internet-sourced industry and specialist's commentary on risk issues pertaining to the organizations.

After assembling a formal statement of the total population of gas fired electricity producers and municipal utilities in Ontario, the researcher's task was six-fold:

1. Determine operating status of the company within the province of Ontario;
2. Determine whether the power producers and utilities were contracted by the Independent Market Operator (IESO) so as to verify connectivity with the Ontario public grid (see Sections 1.6 and 2.3);
3. Determine whether the organizations were certified under the CEA's sustainable utilities program, as participating organizations were thought to have more value to contribute to this research;
4. Determine names and roles of informants within the organization for securing access and research participation;
5. Contact industry sources (the CEA, the Association of Power Producers, Electricity Distribution Association) and government agencies (Ministry of Energy in Ontario, the IESO) to determine which organizations had the most potential to contribute to this research. This process assisted in also assessing which companies were interested in participating in the field study, and
6. Execute a geo-locational selection criterion to limit the case selection to organizations located in the south west quadrant of Ontario (within a 200 km radius of Toronto, Ontario). Limiting the geographic reach of the study was a pragmatic consideration of the in-person requirement for interviewing and also of Ontario's inclement winter weather during the scheduled data collection phase. Most of Ontario's electricity infrastructure, as mentioned in Sections 1.7 and 2.3, are located in the southwest quadrant, accounting for over 75 per cent of electrical power producers and utilities in the province.

The unit of analysis in this work is the construct (elicited) fulfilling what Yin (2014) deemed as the definition of the case, and is related to the way the research question is defined. In other words, each construct represents a single unit of meaning (Jankowicz, 2004).

3.9.1 Respondent Selection

After identifying 20 companies (10 producers, 10 utilities) the researcher emailed and posted a written request for the grid interview (see Pilot Appendix B). Attached with the correspondence were letters of acknowledgement from CEA, APPrO as well as a certified letter of introduction from Heriot Watt University (see Pilot Appendices A, D and E).

The purposive targeting of senior executives was done to obtain participation from the most knowledgeable individual within the organization. Selection criteria were based on two assumptions: a) that the chief executive officer was most familiar with the strategic climate risks the company faced; and b) that they would speak with candour about their individual views of climate risk management.

The assumption was made that line managers might be less knowledgeable on all matters and be reluctant to speak freely about all issues. It can be noted that the researcher was cognizant of the possibility of systemic bias among all executive respondents who might promote a shared industry agenda.

3.10. REPERTORY GRID TECHNIQUE

This section deals with the description, the rationale and for the chosen primary data collection method, the repertory grid technique.

Developed by Kelly (1991) as an investigative tool in his constructivist research, RGT is a tool that reduces the influence of the researcher's frame of reference on what is observed, leaving the participant to reveal their own personal mental models or cognitive maps on a topic (Diaz de Leon & Guild, 2003). The investigator's world view is set aside in construct elicitation under the procedures suggested by (Jankowicz, 2004; Jankowicz et al., 2016) so that the resulting narrative data are relatively free of researcher's bias (Reger & Huff, 1993).

Fransella (2003) described the RGT as an instrument which provides a concise description of the way an individual understands the world. Kelly (2003) proposed that individuals over time develop subjective theoretical frameworks of their world enabling them to make meaningful judgements or evaluations of specific situation as well as anticipate or manage events. Thus, risk perceptions influenced primarily by these subjective frameworks, can be drawn out through RGT. This framework produces for the researcher cognitive maps of how decision makers construe climate risk drivers and organizational pressures on their organizations. Moreover, the framework is essential to answering the research questions and is aligned with the constructivist approach of understanding how utilities managers make sense of the influences drivers and pressures on their views for managing climate risk in the future. Participants develop and express their own constructs to reveal the thinking the participants possess but are possibly unable to articulate (Diaz de Leon & Guild, 2003). Congruent with that, RGT is an appropriate technique for reducing social desirability bias which may otherwise distort results (Jankowicz, 2004).

Construct elicitation by the interviewer it is noted may require surfacing of tacit constructs enabling the participant to express what the participant intends to say and on occasion suggesting the words that might express the intended meaning (assuming the participant agrees). Assisting the participant to articulate the words that might best express the meaning intended is one such process subtlety.

The RGT has been variously used in applied business cases though its genesis is found in Kelly's earlier clinical psychology investigations. Variations on elicitation methods are noted in literature where RGT was used for eliciting management views relating to: strategic planning assumptions (Calori et al., 1994); consumer marketing (Rogers & Ryals, 2007); usability studies of technology (Oppenheim et al., 2003); stakeholder diversity (Girard, 2013); and intangibles in venture capital groups (Diaz de Leon & Guild, 2003).

As well as identifying an individual's basic constructs, one variation of the basic RGT procedure is to identify the kinds of constructs that indicate the personal values a person holds about the topic of the grid. Three reasons militate against this variation: time constraints (eliciting values would tend to double the interview time to an unacceptable level), technical orientation (where the respondents do not generally make their decisions based on personal values, but follow technical criteria) and the presence of a regulatory system that emphasises operational rather than technical demands.

While elicitation techniques varied in this group of contributions, RGT protocol for the present study will be discussed next.

3.11 REPERTORY GRID PROCEDURE

The RGT was the primary data collection tool used in the work for unearthing individual meanings/beliefs (constructs) from the participants. The rationale for the technique has been addressed above and data were collected from the participants through face-to-face interviews.

The interview process was conducted in two phases, an introduction and overview as the first phase and the constructs elicitation as the second phase. The interview process began with the researcher briefly describing the research topic, objectives, and procedure for the interview. A researcher's statement of research was provided as well as the letter of introduction from Edinburgh Business School. The researcher reiterated that collected data is anonymized and also disclosed to the participant after each interview. The participant was asked to initial the grid documents.

In the second phase, primary data were collected with the RGT, according to the multistep process noted in literature (Fransella, 2003; Jankowicz, 2004; Rogers & Ryals, 2007) in the following manner:

The topic for the grid was stated. In this study it is how climate risks influence participant's views of future climate risk management.

Elements were provided and explained. The elements 2343 the factors identified in the literature (see Chapter 2) and provided for in Table 3.2.

Constructs were elicited from triadic style elicitation of elements, where elements are selected in a unique sequence (to prevent repeating combinations) and the recurring question posed to the participant: 'In what way are two of these the same and different from the third—in terms of the way they influence your management of climate risks?'

The participant was asked to rate on a scale the bi polar positions of constructs he/she identified.

Steps 3 and 4 were repeated until no new constructs are offered by the participant.

To improve the specificity of constructs, the laddering down technique was employed, using the 'in what way, how' line of inquiry. To ensure that the elicited constructs provide a suitable level of detail, the 'laddering down' technique was used as necessary. This asked the interviewee to state 'in what way'/ 'how' the construct might be stated in more detailed operationally specific terms.

Results from the grid interview were recorded in a repertory grid matrix template, prepared in advance of the interview (See Pilot Appendix C).

3.11.1 Elements

As noted above, the RGT uses elements, or 'the things or events which are abstracted by a construct ' (Kelly, 1991, p. 137). Elements are an example of the topic and are developed to reflect a 'range of convenience', or the context of the constructs used (Fransella, 2003). Elements can be developed by the researcher or by the participant (Jankowicz, 2004).

While Fransella (2004) noted "it is common practice for the elements to be developed by the grid designer" (Fransella, 2003, p. 21), variations in approach are noted in literature (Calori et al., 1994; Diaz de Leon & Guild, 2003; Girard, 2013; Oppenheim et al., 2003).

In this study, eight elements were supplied by the researcher: three were selected from the CEA's climate risk adaptation report, and five more were gathered from the literature and conference proceedings of electricity utilities conferences in Canada. The selected elements reflect a homogeneous range of climate risk impacts and are categorized in three categories of concern for the industry (a) direct weather effects; (b) exogenous factors (climate data, government policy, emissions regulation, aging infrastructure); and (c) endogenous factors (technical knowledge, organizational capacity and resources).

Table 3. 2: PROPOSED LIST OF ELEMENTS PRIOR TO PILOT STUDY

Code	Element
E1	**Sudden, direct climate events.** This encompasses the weather-based risk assessment set out in the CEA report, noting general unpreparedness in the electricity sector. As noted in Sections 1.2, 1.3, and 2.3.5, heavy rains, flooding and freezing temperatures are noted as most probable weather events negatively impacting electrical power producers and transmission groups.
E2	**Climate data**. As discussed in Sections 1.5.3, 2.2.6, and 2.2.7, this encompasses issues relating to access to reliable and relevant climate modelling data so utilities groups have forecasting and modelling information to better prepare for weather impacts.
E3	**Government policy**. Sections 1.5.2 and 2.3.4 noted climate related policies impacting the electricity sector.
E4	**GHG abatement.** Noted in Sections 1.5.2 and 2.3.4, the impact of government regulations pertaining to GHG emissions directly affects natural gas (fossil fuel) generator participants.
E5	**Technical knowledge**. This relates to new and evolving requirements for technical expertise related to climate data and plant re-designs to harden facilities against weather impacts, as noted in Section 1.6.1.
E6	**Aging infrastructure.** The CEA report explicitly noted aging infrastructure as a risk to the electricity sector in Ontario, noted in Section 1.5.4.
E7	**Organizational capacity**. Discussed in Section 1.6, organizational ability to respond to climate impacts in the short and long term is of on-going concern to the sector.
E8	**Organizational resources**. This includes staffing issues, technical expertise and knowledge and access to data, noted in Section 1.6.

3.11.2 Constructs

The key purpose of the RGT in this work is to collect data from the participants in the form of constructs illustrating to the researcher perceptions of risk associated with climate change. The work is concerned with individual constructs and not collective ones; nor is it concerned with motivation nor any theory of action or communication. Constructs elicited are based on the assumption that the elements supplied—and supported in pilot work- are indicative of climate risk events representing potential operational business loss to the participants.

In the preceding literature synthesis, the key issue given is one of anticipated climate risk management, and therefore, the following construct elicitation phrase is established: ‘In what way are two of these (constructs) the same and one different, in terms of the way they influence your management of climate risks?'

The elicitation process is expected to surface differences in constructs from study participants on an individual basis. Comparisons are expected to be made between individual constructs in one group with the other, looking for differences in the construing of both groups studied. Moreover, the proposed construct elicitation provides the foundation for Honey's content analysis technique (Honey, 1979) for identifying the most salient personal construct identified in the content analysis stage. Furthermore, construct elicitation, as described above, is likely to be useful in the proposed testing Renn & Rohrmann's (2000) integrative model of risk perception.

Construct elicitation, as indicated in the previous section, was done with triadic options presented to the participant. The process was intended to produce two contrasting poles for the construct representing opposites in meaning. From the research method point of view, constructs offered by participants should present an accurate picture of personal meaning for the participant in a 'constellatory' manner where additional associations can be elicited (Easterby-Smith et al.,1996, p. 8).

There are however four non-performing construct types which may challenge the researcher to abandon or employ laddering down techniques: (a) situational constructs ('power producers plant new, operating only for three months now'); (b) excessively permeable ('our industry is government regulated'); (c) vague or superficial constructs ('sounds like a good idea'); and (d) constructs generated by the role title ('aging infrastructure is old'; Easterby-Smith, 1980). Easterby-Smith et al. (1996), Jankowicz (2004), and other RGT exponents suggest laddering down techniques to obtain specificity in construct power producers, as in 'in what way does government regulation have an effect on your thoughts about future climate risk management?'

3.11.3 Grid Analysis—Cluster, Principal Component and Content Analyses

Once grid data was collected, a quantitative analysis of the relationships inter and intra elements and constructs was done to assess and describe the relative strength of relationships in the participant's construct system. Similarly to Bell (1990), three central questions were asked of grid data to answer such inquiries:

How do the constructs relate to one another? That is, are some constructs seen as similar to one another and if so, do they exist in clusters or bundles? Which constructs are seen as dissimilar?

How do the elements relate to one another? Which elements are seen as similar and which are dissimilar?

How do the elements relate to the constructs? Which constructs are important when the subject construes a particular element?

While content analysis was the main technique proposed in the present work, an overview of all three grid analysis techniques was provided for clarity. In general, three main statistical techniques are used in grid analysis: cluster, principal component and content analysis—after an 'eyeball' analysis and general construct characterization is done by the researcher (Jankowicz, 2004, p. 72) to establish the integrity of the grid results.

Statistical similarity using measures of correlation between different constructs or elements was done in cluster analysis to determine whether highly correlated constructs in a cluster have a relationship to another construct or a distinct cluster of constructs. In other words, can constructs be explained by one unique name or label, or several? Cluster analysis is done with both individual case reports and across case or aggregated reports of all case studies.

Calculations on construct relationships, expressed with nominal or ordinal data, are displayed in tree, dendrogram and correlation table representations. The interpretation of results from cluster analysis for the Pilot Study is found in Section 4.5.1 where results and conclusions are discussed.

Principal component analysis (PCA) goes farther than cluster analysis to express the relationship if any between constructs and elements in the same individual grid. Fransella (2003) Bell (1990) and Bannister (1986) proposed a singular-value decomposition technique that approximates a grid by examining two component loaded matrices –one for elements and one for constructs. The decomposition technique identifies variability of the components in descending order. The process 'decomposes' by eliminating the greatest variability then examines the next. The interpretation of results from a PCA for the pilot study are found in Section 4.5.2 where results and conclusions are discussed.

While cluster and principal component techniques are applied for analysis of individual grids, the third analysis technique—content analysis where constructs across all case groups are aggregated and categorized—is the main tool for analysing multiple grid data produced by the study informants. Content analysis in the present study is seen as a 'technique in which the constructs of all interviewees are pooled and categorized according to the meanings they express,' (Jankowicz 2004, p.148). Content analysis enables the researcher to examine the different ways in which utilities managers make sense of climate risks and how they might be managed.

Procedures applied at the content analysis stage are Honey's Technique (Honey, 1979) and Bootstrapping (Jankowicz, 2004). While both procedures are done to aggregate meaning from multiple RGT interviews, the rationale, process and outcome for each technique is different, discussed next. Honey's Technique was chosen over other techniques, such as Wright (2004)'s aggregated super- grid approach, to better fit with Kelly's view of constructive alternativism. Essentially the (Honey) technique is a compilation of the separate grids provided by a sample of interviewees presenting the set of constructs and ratings as a single grid. Quirk (2013) stated, 'Wright's (2004) approach creates an 'average' person that does not really exists resulting in the loss of the individuality of the different interviewee's grids' (Quirk, 2013, p. 68).

Honey's (1979) procedure identifies constructs which are particularly salient to the participants, and in so doing, preserves the information about each individuals' view in terms of how they personally look at the topic (Jankowicz 2004).

3.11.4 Honey's (1979) Procedure

Honey (1979) offers a useful technique for aggregating the meaning in a set of grids while keeping track of each interviewee's own understanding of the topic. S/he does so by supplying the interviewee with an 'Overall' construct. In the present work, since the researcher is interested in the ways in which the interviewees view the influences on their management of climate risk, this is worded as:' Overall, has a stronger influence on my management of climate risks/overall has a weaker influence on my management of climate risks.'

S/he then identifies the extent to which the elicited constructs share meaning with the Overall. Some of the constructs will rate the elements in much the same way as the Overall; others, differently. S/he does this by summing the differences between the ratings of the elements on each construct and the Overall. S/he then turns these sums of differences into a percentage similarity score, since this is easier to interpret. (100% indicates identical ratings).

Because constructs are bipolar, the ratings on each construct are compared once with the Overall ratings, and again with the Overall ratings reversed; the higher of the two being used in the subsequent analysis.

Honey's technique takes into account that different people have different similarity metrics: one person may use ratings which match in the range 60% to 75% with his or her Overall, while another may use ratings in the range 75% to 100%. To reflect this, Honey labels the top third of each individual's similarity scores High (H); the middle third as Intermediate (I) and the bottom third as LOW (L)—for that person.

In summary, the content analysis will indicate the different kinds of meaning present in the whole group of interviewees, while Honey's procedure, with each construct's% matching score tagged with its H-I-L label, will indicate how important that construct is to each individual's personal understanding of the topic.

The formula used for the% Matching Score of elicited construct ratings with ratings on the supplied overall construct is as follows:

$$\%MatchingScore = 100 - \frac{(100 * \sum d)}{(r-1) * e}$$

Where

$\sum d$ is the sum of differences between the rating of each elements on the supplied overall construct and each elicited construct;

r is the maximum possible rating; and

e is the number of elements over which the differences have been summed.

3.11.5 Bootstrapping Technique for Core Categorization

After Honey's (1979) technique was completed, a Bootstrapping procedure was then done at the content analysis stage. As stated earlier where the pre-existing category scheme from Weinhofer and Busch's (2011) methodology was being employed, a Bootstrapping approach nevertheless was applied to determine if there were additional categories of constructs. The bootstrapping (Jankowicz 2004) procedure was conducted as follows: subcategories were developed from the construct data to express the different kinds of meanings present in the sample of respondents as a whole. The core procedure was one in which all the constructs were assigned to a set of mutually exclusive set of categories allowing for a 'miscellaneous category containing no more than 5% of the constructs.

The reliability of the core categorization results was then assessed to ensure the category system was logical. The reliability analysis was carried out independently by two researchers and reliability indices based on percentage agreement, using Cohen's Kappa Index was computed. The researchers repeated the reliability analysis after a careful discussion of category definitions had taken place, resulting in an acceptably high (>95% agreement) level of reliability.

Levels and similarities were assessed according to reliability tables and Cohen's Kappa (Cohen 1969). Inter-rater reliability values were acknowledged at.80 or better.

3.12 ETHICAL CONSIDERATIONS

Ethical principles and values in research promote the aim of the research 'such as knowledge, truth and avoidance of error' (Resnick, 2015). The research in the present work has complied with the highest ethical principles in accordance with the post graduate research policies of Heriot Watt University. As such, those principles must be communicated to the participant prior to data collection.

In so doing, prior to the collection of any data from the pilot or the main study, the Heriot Watt University/Edinburgh Business School Letter of Introduction (see Pilot Appendix A) was presented to each participant. In light of the governmental regulatory environment for the study participants in Ontario (see Sections 1.7 and 2.3), assurances regarding confidentiality and anonymity are discussed and provided for in the researcher's written request for participation (see Pilot Appendix B).

Third, each participant was asked to initial the grid interview document (see Pilot Appendix C) at the end of the interview, acknowledging that their participation is voluntary and that they agree with thesis publication disclosures.

Lastly, a letter of support from the CEA and/or the Association of Power Producers in Ontario is supplied to the researcher's request for an interview (see Pilot Appendices D and E).

In summary, the four documents reflecting ethical standards for the present work and presented to the study participants before and after grid interviews take place are:

Heriot Watt /Edinburgh Business School Letter of Introduction

Researcher's 'request for a grid interview' letter

Acknowledgement of informed consent, via the grid document

Industry Letters of Support

CHAPTER 4 PILOT STUDY

4.1 INTRODUCTION AND OBJECTIVES

A pilot study involving one decision maker from each of the two study groups was conducted to test and refine the data collection and analysis techniques, specifically the use of the repertory grid technique (RGT). The pilot study was planned as a two-part study with grid interviews conducted before the second set of data collection and analysis was conducted.

The objectives of the RGT phase of the pilot study were:

1. To assess the relevance of the supplied elements.
2. To identify the types of constructs that utilities managers in the electricity sector use to construe climate risk impacts on their organizations. While results in the pilot stage are not expected to be conclusive, they are supposed to help in understanding the range of issues and provide a preliminary look at the types of constructs that are likely to surface in the main study.
3. To estimate a typical number of elicited constructs for the repertory grid interview. In doing so, an approximation could be made of the number of interviews needed in the final research phase. For conclusive results a total of 250-300 constructs is needed.
4. To gain proficiency with RGT. In gaining proficiency, the interviewer is sufficiently practiced with the technique, allowing her to focus on construct eliciting in a more conversational, interactive manner with the interviewee.
5. To practice cluster analysis, PCA and content analysis. By doing so, the analysis software is reviewed and tested prior to the main study. The analysis software provides a part of the eventual analysis of the main sample data.
6. To appraise the viability of additional data access from the participants. Time constraints were raised in the participant's correspondence prior to grid interviews; asking for more time for values elicitation, or a questionnaire was deferred until after the grid interviews were completed.

4.2 PILOT STUDY SAMPLE

Two pilot study interviews were conducted in total. A senior climate risk analyst from the largest electrical power producer company in Ontario and the chief executive officer from a large municipally owned electricity utility company agreed to participate in the pilot study. Selecting one from each of the two key study groups was expected to generate views and attitudes of the two groups to produce sufficiently unique empirical data to demonstrate the potential differences and potential similarities in attitudes and perceptions of climate risks.

Table 4.1 shows the details of the pilot interviewees. The individuals were selected based on their willingness to participate in the study, their corporate commitment to managing and analysing climate risks and their active involvement in climate risk working groups with industry associations (APPrO, Electrical Utilities Association [EDA]). The selection of pilot cases is consistent with Yin's (2014) remarks that 'In general, convenience, access and geographical proximity can be the main criteria for selecting pilot cases' (Yin, 2014, p. 96).

Table 4. 1
PILOT STUDY INTERVIEWEE PROFILES

Code	Title of interviewee
P1 (power producer)	Senior Risk Analyst, Provincial Electrical Corporation
P2 (utility)	CEO, Regional Electricity Utility Company

4.3 PROCEDURE

Both interviews commenced with a description of the study, and both interviewees were asked to initial the repertory grid document at the end of the interview confirming their consent for publication purposes (see Pilot Appendix C).

The first part of the interview involved reviewing each of the eight RGT elements—eight instances of climate risk impacts, to confirm the saliency of each element for the interviewee. They were both asked if any other categories of climate risk were missing and needed adding. They both agreed the list and nomenclature were appropriate and comprehensive.

The second phase of the interview involved the construct elicitation phase of the RGT (see Sections 3.11, 3.11.1, and 3.11.2.). This phase included the elicitation of the overall construct at the end of the elicitation phase.

Results from each pilot interview were recorded onto a rep grid matrix template, prepared in advance of the interviews. (See Pilot Appendix C).

4.4 DATA ANALYSIS

Three types of data analysis were done: cluster analysis, PCA, and a content analysis incorporating the Honey (1979) method. Results of all three analytic approaches are best thought of as exploratory and tentative, given the small sample size of the pilot.

The purpose of the cluster analysis is to identify patterns in meaning of the ways in which utilities managers structure their views about the effects of climate risks on their organization. Cluster analysis determines whether highly correlated constructs in a cluster have a relationship to another construct or a distinct cluster of constructs.

The purpose of the PCA in the present work is to examine data on proportion of variance accounted for by the first two components so as to gain a view of the level of cognitive complexity of the grid interviewees.

The purpose of the Honey (1979) method is to assist in understanding the saliency associated with 'greatest influence versus weakest influence on risk management'. In the present study, Honey's (1979) method facilitates in understanding the views and perceptions which are most similar to the overall supplied construct of 'greatest influence versus weakest influence' (see Section 3.11.4).

4.5 PILOT STUDY RESULTS

The cluster analysis identifies patterns of meaning by computing how constructs and elements group together. Web grid software produces tree-diagrams showing the relative position of most similar constructs and separately, most similar elements. Most similar constructs are indicated as a cluster formation in the dendrogram. 'Branched' constructs and branched elements reflect a comparable percentage of similarity (see Pilot Appendix G).

4.5.1 Content Analysis (Individual)

Participant #1

Pilot Participant #1 (power producer) showed six construct clusters. The first cluster indicates an identical (100% match) in constructs between proactive management of impacts with preventative maintenance, and reactive management with 'fix and restart' constructs. The second two sub-cluster associates three constructs with a 95% similarity, and likely reflects the power producer's perceived importance of process control, documentation and knowledge. The second sub cluster surround two constructs with another 95% of similarity, likely revealing the importance of corporate initiative with business decision making and regulatory compliance issues. The last two clusters at 80% similarity associate a) specialized skills and endogenous impact, and b) risk governance with investment in resources (see Pilot Appendix G).

Participant #1 (power producer) perceptions of most similar elements (instances of climate risks) is also provided for in the cluster analysis. Participant #1 has a high (90% similarity score) association of organizational resources with organizational capacity. Participant #1 also highly associates though less so (80%), GHG abatement and emissions control with governmental policy.

Participant #2

Participant #2 (utility) clusters around four construct groups. In this case, the first subgroup (97% similarity) suggest its strong association of external expertise (outside consultants) with macro, enterprise wide pressures and corporate knowledge with targeted pressures on the organization. Another sub cluster at 85% similarity shows an association between power producers' partnerships and business needs.

Cluster analysis of the elements for Participant #2 showed a similar pattern to Participant #1 (90% similarity) for associating organizational resources with organizational capacity, albeit at a slightly weaker (80% similarity) value.

4.5.2 Principal Component Analysis (Individual)

PCA observes patterns of variability or components, with the first (largest) accounting for the largest variation, and the second and subsequent, increasingly residual degrees of variation. PCA benchmarks for cognitive complexity are indicated when the largest variance accounts for 50% or more (Fransella, 2003). (See Pilot Appendix I)

Cognitive complexity suggests that the actuarial variety of issues a person construes of to a topic, indicates the level of complexity in construing. In other words, the lower the variance accounted for by the first two principal components, the higher the level of cognitive complexity; it implies that one needs more distinct components to account for the total variety in thinking (Diaz de Leon and Guild, 2003). Pilot Appendix I shows the PCA maps generated.

Participant #1 (power producer) showed a total percentage of variance in the first two components combined at 67% while Participant #2 (utility) showed a total percentage of variance in their first two components at 58.7%, indicating that Participant #2 was likely more cognitively complex.

For Participant #1, it was shown that constructs related to knowledge capture, documentation and business decisions are closely related to the first component. For Participant #2 constructs related to technical knowledge and mitigative and adaptive responses, are highly important to the participant. This may indicate that Participant #2 used more associations of issues when reflecting on the impact of climate risk on operations.

4.5.3 Content Analysis (Aggregate Analysis)

The constructs of both grids were then analysed and categorized (see Pilot Appendix K). For the pilot, three categories were derived from the climate change and climate risk literature (Chapter 2) and from Weinhofer & Busch's (2013) analytical framework for assessing risk management preparedness among European utilities (see Section 2.5).

While the pilot sample is small and therefore preliminary, the content analysis of two participants nevertheless provides an example of the approach to be used in the main study. The bootstrapping technique would be used to capture any additional sub categories in the main study.

Two steps were taken to confirm the reliability of the pilot classification scheme following the procedure summarized in Section 3.11.5. Separately, classifications were done by the researcher and a colleague to determine which constructs would be classified according to which of the three branches of risk management: risk identification; risk assessment and risk response. Criteria for selection was mutual exclusiveness and saturation. Consensus was reached after discussions, explanations and re-classifications were done. The reliability check was conducted as a simple index of agreement Cohen's kappa (Cohen 1969).

The construct summary provided in Pilot Appendices K and L indicates that Participant #1's main constructs are concerned with risk response (69.4%) whereas Participant #2 is more concerned with risk identification (74%) and marginally less so with risk assessment (72.0%).

Conclusions cannot be based on a pilot sample of two companies, but an illustration of the kinds of conclusions that might be made if these data were to be reflected in the main study would be along the following lines: power producers company reflects on issues related to business continuity (84% similarity) to be of highest priority in their climate risk management. In contrast, the utilities/transmission company views dynamic change (84% similarity) as being of the greatest influence on their management of climate risks.

From the classification scheme perspective, the power producer participant shows the relative lowest concern with risk assessment issues (65.3%) relating to knowledge retention, process control, planning process, specialized skills, system boundaries and knowledge capture. While the participant may place business decisions, time horizon considerations, endogenous impacts, risk governance and business continuity practices in the middle range of importance at 67.6%, her relative concern for risk assessment issues is only marginally less so, at 65.3% similarity.

4.5.4 Honey (1979) Method

Consistent with Honey method, a supplied construct of 'greatest influence –weakest influence on risk management was captured in the pilot in advance of the main study. The supplied construct is to help indicate 'the interviewee's individual stance to the topic as a whole' (Jankowicz 2004, p 170).

The pilot study indicates, for illustrative purposes, that Participant #1's (power producer company) constructs pertaining to business continuity matched highest with her overall construct ratings. For Participant #2's (utility company) constructs relating to dynamic change matched highest with his overall construct ratings (see Pilot Appendix J).

4.5.5 Cross Case Analysis

From the 32 constructs elicited in the pilot study, it is noteworthy that the constructs vary widely; no construct is shared by the participants. While the power producer company participant views the assessment of climate risk from the perspective of knowledge management, skills, process and planning control, the utility company participant views climate assessment differently by considering (in part) issues external to the organization (external consultants, customer expectations and system – wide reliability).

These pilot results indicate that it is feasible that appreciable differences might be identified between the main sample power producers' companies' and the main sample utilities companies' constructs.

Looking at elements, both participants group together organizational resources with organizational capacity (90% power producer; 80% utility) suggesting however, a consistency in views about the 'two sides of the same coin' relationship between resources and capacity.

Additionally, the power producer shows a view of GHG abatement and emissions control as being 'almost equal' in construal to government policy (90%).

4.6 PILOT STUDY CONCLUSION

The pilot study was designed to test and refine the data collection techniques with special attention to the RGT. Additionally, the pilot study provided a test sample of the constructs of utilities managers with respect to the ways in which they view climate impacts and the implications they have on operational risk management.

The pilot study grid produced 32 constructs related to climate risk management supplied by two participants. The constructs were grouped into categories identified by the prior work of Weinhofer and Busch (2011) with a reliability check of 78.12% (final agreement on 25 of 32 constructs). This resulted in three main categories presented in Pilot Appendices K and L. Next, the content was analysed using Honey's (1979) method to identify similarities and differences between power producers and the utilities constructs of climate risk. The constructs were put in order according to the matching score between their ratings, and those of the supplied construct 'greatest versus weakest' construct.

4.6.1 Achievement of Objectives

The objectives of the pilot study were presented in Section 4.1. Outcomes of the pilot study were as follows:

1. *To assess the relevance of the supplied elements.* Both pilot interviewees were asked if the supplied elements reflected the range of climate impacts relevant to their

industry and whether additional instances of climate risk impacts needed adding. Both interviewees found the supplied elements to be comprehensive and representative.

2. *To identify the types of constructs that managers in the electricity sector use to construe climate risk impacts on their organizations*.
   Thirty-two unique constructs were elicited in total in the two pilot interviews.
3. *To estimate a typical number of elicited constructs for the repertory grid interviews*.
   Based on pilot results it is anticipated that 15 constructs per interviewee are attainable for the main study interviews. The number of constructs elicited in the pilot study suggested that around 20 interviews would be required in the main study to attain the 250 to 300 constructs necessary for a content analysis.
4. *To gain proficiency with RGT*.
   The pilot study provided the opportunity to practice and improve data collection procedures of the RGT to be used in the main study. This included construct elicitation and laddering down techniques. Each pilot interview was approximately 75 minutes in duration.
5. *To practice cluster, PCA, and content analysis for the pilot participants*.
   PCA and cluster analysis were done for each pilot interview using WebGrid Plus. The PCA graph and Cluster analysis charts are provided for in Pilot Appendices G and H. Content analysis, using Honey method was done manually by the researcher.

4.6.2 Pilot Study Outcomes and Implications

A number of outcomes and implications for the main study became apparent during the pilot study phase.

4.6.2.1 Evaluation and implications of time constraints (participants)

Due to the time constraints of the pilot interviewees, the researcher concluded that the direct collection of additional data from the participants was not achievable. Up to this phase of this pilot study, the researcher had deferred appraising the participants for their willingness to participate in a second round of data collection by either values elicitation, questionnaire or survey. The researcher had determined that a second source of empirical data was necessary to obtain a broader and fuller picture of the phenomenon under study but would reappraise the issue of data access after the first phase of the pilot was completed. In analysing the pilot data, informal discussions with the pilot interviewees, the researcher’s own experience as a senior practitioner all suggested that the grid data of the main study would be greatly enriched by examination of information contained in corporate climate change/environmental reports.

4.6.2.2 Selection of a second data source

The selection of a second data source was done to triangulate findings between the less formal tacit interview constructs, with the more formal and public expressions of climate risk constructs, derived from corporate reports. Electrical power companies in Ontario release annual environmental and sustainability reports either as a stand-alone document or as a designated section in their corporate annual report. Report content conveys the corporations' management of environmental issues including climate change impacts on their operations. It was determined that the environmental report and not the annual report, would offer richer narratives about how the corporation is managing climate risks. The 2015 editions of environmental reports were available at the time of the pilot study. To achieve the research objectives, corporate environmental and sustainability reports of the RGT grid respondents were therefore established as the second data source for the pilot and the main study

4.6.2.3 Implications for research design

By examining two sets of data by different means and from different sources, a stronger measure of data triangulation would be achieved. Both techniques support the overall mixed methods approach where not only the techniques are mixed but also ontological and epistemological orientations are blended as well (Creswell et al., 2007). The details of the construal of climate risks in two different data groups can have significant impact on findings that otherwise might remain limited. The rep grid data can be used as a rich source of data in choosing appropriate categories for the narrative analyses. Prior work has used a similar approach where ethnographic interviews were used to assist in choosing grid elements (Dobosz-Bourne, 2004).

4.6.2.4 Implications for research aim

Examining additional empirical data continues to preserve the research aim, expressed as 'to understand how Electricity Utilities in Ontario (Canada) view the prospects of climate risk management in light of increasing climate change impacts, macroeconomic factors and internal pressures to embed a climate risk mentality within their organizations' (Section 3.1)

4.6.2.5 Implications for research objectives

Examining additional empirical data continues to preserve the primary research objective and the subordinate objectives, described in Section 3.2, and provided here.

The primary objective is to identify the way in which the participants construe and make sense of the direct climate impacts of extreme weather events.

From the above, two subordinate objectives: namely, (a) the development of a category scheme that describes and enumerates the constructs participants have about the drivers/influences involved, and

(b) the examination of the differences that may exist in the construing of the two key groups of participants—power producers' groups and transmission and utilities groups.

Adding the reports to the empirical work produces more data to analyse while maintaining consistency with the research objectives.

Significantly, a further research objective can now be added:

The additional objective will be to contribute to an effective mixed method from two disciplines—narrative analysis (sociological approach) and the RGT (psychological approach). Expected results may create an efficient integrated approach to analysing individual perceptions about risk along with the organizational and public view of risk. More significantly, additional data provides more opportunity to expand the research questions, described in the next section.

4.6.2.6 Implications for research questions

The increase in empirical data to include corporate narratives on climate risk provide the opportunity to pose additional research questions. In addition to the primary one established in Section 3.3 as 'how do the study participants construe and make sense of the pressures outlined in this work, in assessing the impact they have for managing those risks', the additional research question can now be added: 'How do the participants' views and tacit knowledge of climate risk differ from formal, public knowledge disclosed by their corporations?'

4.6.2.7 Implications for methodology

The RGT methodology is preserved. Methodology for the second data source would be conducted according the following procedural steps:

1. Upon completion of the grid analyses, corporate environmental/sustainability reports are matched to the grid participants.
2. Narrative analysis (Barthes & Duisit, 1975; Landrum, 2008) is conducted on each report with particular attention to analysing passages (multiple sentences) which related to themes of: 1) how the company views climate risks; 2) how it is managing those risks; and where evident, 3) how the company expects to manage those risks in the future. The sampling unit is the report itself, and the recording unit (unit of analysis) is the narrative passage (Roberts et al., 2015).
3. Constructs embedded in those themes are then matched to the three grid categories and further bootstrapping for additional categories or sub categories are conducted
4. Narrative analyses of the power producers and the utilities reports are done and recorded separately in keeping with the research objectives. Narratives analyses are compared between the two groups and compared with the corresponding grid participant. It is expected that

differences in climate risk construal may differ from report to grid interview, and from power producers' group report to utilities group report.

5. A reliability check on the narrative analyses will be provided through a 'showing of the workings'. A sample original text document will appear in the Appendices, illustrating how the researcher marked up the categories in the sample and tabulated the outcome. The recording unit and the relevant themes will be underlined and highlighted. (See Appendix O.)

A worked example of the pilot power producers' company's narrative analysis is found in Pilot Appendix N.

4.7 CHAPTER CONCLUSION

This chapter detailed the pilot study objectives, procedures, analysis, results and outcomes of the grid data collection. Implications of a second data source on research aim, objectives, questions and methodology were included. Detailed results of the pilot study are found in the Pilot Appendices F, G, H, I, J, K, L, M, and N. Documents related to ethical conduct are in Pilot Appendices B and C and letters of support are in Pilot Appendices D and E.

The pilot study provided a preliminary, indicative glimpse of the potential constructs that may well be identified in the main study.

Details of the main study are found next in Chapters 5 and 6.

CHAPTER 5 FINDINGS AND ANALYSES

5.1 INTRODUCTION

This chapter presents the finding and analysis of the main study. It is divided into two main sections, Sections 5.2 and 5.3. Section 5.2 presents the findings on the repertory grid interviews and Section 5.3 presents the findings of the corporate report narratives. Discussions about the results of grid interviews and company narratives, and the significance of the constructs about future climate risk management, are presented in the next chapter.

5.2 REPERTORY GRID INTERVIEWS

The results of the 20 interviews conducted with executives and senior managers using the RGT are presented in this section. The interviews were conducted over an eight-week period with individual participants at electricity companies in Ontario. Ten interviews were conducted with decision makers at gas-fired electricity power producers' companies, and 10 were conducted with participants at electrical utilities companies. Interviewee profiles are found in Table 5.1. The interviews generated 324 constructs. Additionally, one common construct was supplied by the researcher and presented to the interviewee at the end of each interview. As a result, 344 constructs were generated: 171 constructs from the power producers group and 173 from the utilities group. The purpose of the supplied construct was to preserve the respondent's view of the research topic in overall terms. By doing so, the individual constructs can be analysed to understand which elements the respondents view as being most influential on their attitudes/beliefs about future climate risk management.

Table 5. 1
INTERVIEWEE PROFILES

Participant	CEO/ President	Vice President/ General Manager	Chief Risk Officer	Senior Risk Manager	Director/ Manager	Total
P1 (power producers)	1	7		1	1	10
P2 (utilities)	7	1	1		1	10
Total	8	8	1	1	2	20

As stated earlier, one of the research objectives was to understand the similarities and differences between constructs elicited from power producers and utilities participants. Accordingly, once the repertory grid data was generated, it was content analysed using the method described in Jankowicz (2004) together with Honey's (1979) procedure (see Section 3.11.4). Findings of the comparative analysis data are discussed in Sections 5.2.3, 5.2.4 and 5.2.5.

5.2.1 Content Analysis

Content analysis on the grid data was done so that the elicited constructs could be grouped and categorized based on the meanings they express. Content analysis as outlined by Jankowicz (2004) was used in the analysis furthermore as an aggregation technique. In this work, analysis went beyond examining the individual descriptions of how each respondent thinks, as provided in the repertory grids—to a summary of the kinds of meanings (categories) that were more frequent and less frequent in the sample as a whole. From there, content analysis made it possible to identify the differences in attitudes and beliefs of the two groups. As discussed in Chapter 3, Honey's (1979) technique provided a way of preserving the personal similarity metric, and provided a way of allowing for differences among personal metrics within this aggregation.

The constructs were analysed and grouped into the original three super categories as set out and tested in the pilot study. The three super categories reflected the category scheme used by Weinhofer and Busch (2013). Both the respondent and an independent collaborator agreed on the super categories, and the constructs assigned to those categories, to an almost perfect match. Given the data load of 344 constructs however, each of the three super categories were disaggregated into eight smaller categories by the researcher and then a reliability check done on the assignment of constructs to those categories with an independent colleague. The first comparison of how the researcher and the independent colleague assigned constructs to each of those eight categories produced an 86.77 percentage agreement. After the second attempt and discussion over category meanings, revisions resulted in a 97.23 percentage agreement, indicating a high level of agreement (see Appendix Q).

Given the small 2.77% agreement difference, in the final categorization of data used in the subsequent analysis, the 'Interviewer' categorization was used as this is the typical procedure (Jankowicz 2004, p 163) because the researcher designed the study and had more familiarity with the constructs.

Tables 5.2, 5.3, and 5.4 summarize the categorization of the grid data. Table 5.2 presents the risk management scheme categories used in Weinhofer and Busch (2013) as discussed in Section 2.5.2. It also presents the frequency count of the constructs allocated to the study category scheme, and the corresponding percentage of those constructs.

Table 5. 2
'SUPER CATEGORIES' TAKEN FROM WEINHOFER AND BUSCH (2013)

Super-Category	Definition	f Constructs	% Constructs
Risk Identification	In the first stage of a risk management program, companies determine which risks affect their business activities. In the identification stage, companies seek to understand the relevance of specific types of risks, including the source of the risk and the potential risk effect/outcome risk.	61	18.8
Risk Assessment	In the 2nd stage of a risk management program, companies evaluate their exposure to identified risks based on probability and their potential consequences for the company.	**166**	**51.2**
Risk Response	In the 3rd stage, companies select a risk response type to minimize exposure to their business activities to risk. The Risk response type and timing are part of the risk response phase. Whether the company views its response as a singular response ('we go it alone') or views their response as being shared with other actors are two additional categories added by bootstrapping technique by the researcher to this framework.	88	27.2
(Miscellaneous)		**9**	**2.8**
Total		324	100

Three points from Table 5.2 are to be noted.

First, the most frequently mentioned response in the risk management framework pertained to risk assessment at 51.2%. This would suggest participants were appreciably concerned with assessment of climate risks. Their focus was on issues pertaining to the evaluation of their company's exposure to climate risk, and the potential consequences for the company—in contrast to a lower level of focus for the other categories of risk identification and risk response.

Second, the super categories used in this study partially replicate Weinhofer and Busch's 2013 work. Weinhofer and Busch used the conventional 3-stage sequential risk management framework to determine which 'stage' of risk management their respondents were in. While their exploratory research focused on Swiss and Austrian electricity utilities, their chosen approach of using a risk management framework can be reliably used in this Canadian study to determine which of these three main or super-categories of risk management, the study participants associated with in the grid interviews. Third, the proportion of miscellaneous constructs was 2.8%—appreciably lower than the 5% upper level indicator conventionally used in practice for 'unclassifiable' constructs, which is further evidence of the reliability of the content analysis already demonstrated in Section 4.6.

Table 5. 3
CONTENT ANALYSIS—GRID DATA

Super-category	Category	Definitions	f Constructs	% Constructs
Risk Identification	Risk Source	Inside or outside the organization, original location of risk, supported by data or not	23	7.10
	Risk Effect	The *general* result or outcome of the risk occurring related to speed, timing, relationship among/between risks	38	11.73
Risk Assessment	Risk Characteristics	Predictability, control, manageability, risk urgency, measurement relating to metrics and data	59	18.21
	Risk Consequences	The *direct* implications for the electricity company	107	33.02
Risk Response	Risk Response Type	Prevention, mitigation, absorption, adaptation	19	5.86
	Risk Response Timing	Temporal considerations, time horizons	10	3.09
	Individual Corporate Response	What electricity companies understand they can manage on their own	36	11.11
	Shared Corporate Response	What electricity companies understand they can manage with other groups	23	7.10
	Miscellaneous		9	2.78
	Total		324	100%

Table 5.3 shows proportions (%) of the disaggregated categories. Here, the notable finding is the prevalence of constructions which relate to the direct implications (risk consequences) of climate change impacts on the company. Out of the super category of assessment, 33.02% of constructs related to consequences, followed by a lower proportion of constructs related to risk characteristics (predictability, manageability, control, urgency) at 18.21%.

To better illustrate the order of importance of constructs per category, the descriptive statistics were re-ordered according to the frequency count of constructs, shown in Table 5.4. Calculations were done for the mean% similarity scores for each category as well as the% of 'H' constructs.

Construct categories are listed in order of frequency of occurrence in Table 5.4. Overall, it can be seen that 62.96% (204 of the 324 constructs elicited in the grid interviews) related to assessment and effects of climate risk impacts on the organization. Participants expressed fewer constructions relating to corporate response ('what we are going to do') at an overall level of 27.2%. However, 59 constructs (18.21%) related to the more specific issues of a singular corporate response: 'we go it alone'; or a shared one: 'we need to work with other groups'. This would suggest that participants' thinking about how they will manage or their own or how they will manage with other market actors is more important to them than the general statements about mitigation and adaption strategies, and time horizons for implementation.

5.2.2 Categories/Themes

As noted in Sections 2.5 and 5.2.1, the three super categories were disaggregated into eight categories, enabling refinement in the analysis of meanings of the participants' grid interview responses. A summary of the themes and their definitions res represented in Tables 5.3 and 5.4.

It can be noted in Table 5.4 that the mean percentage similarity scores were calculated to demonstrate what proportion of those construct categories were rated by participants as being of highest personal value to the topic of climate risk management. Notable here is, while the frequency count of shared corporate response constructs is relatively low at 7.10 per cent of all constructs, as a category it (the shared corporate response) was rated almost as high as the dominant construct category.

Table 5. 4
CONTENT ANALYSIS SUMMARY

Super-category	Category	Definitions	f Constructs	% Constructs	Mean% Similarity	% of 'H' Constructs
Risk Assessment	**Risk Consequences**	Direct implications for the electricity company	107	33.02	81.84	35.51
	Risk Characteristics	Predictability, control, manageability, risk urgency, measurement relating to metrics and data	59	18.21	71.52	30.51
Risk Identification	**Risk Effect**	The general result or outcome of the risk occurring related to speed, timing, relationship among/between risks	38	11.73	70.31	31.58
Risk Response	**Individual Corporate Response**	What electricity companies understand they can manage on their own	36	11.11	71.03	30.55
	Shared Corporate Response	What electricity companies understand they can manage with other groups	23	7.10	78.89	21.74
Risk Identifi-cation	**Risk Source**	Inside or outside the organization, original location of risk, supported by data or not	23	7.10	71.70	39.13
Risk Response	**Risk Response Type**	Prevention, mitigation, absorption, adaptation	19	5.86	60.53	31.58
	Risk Response Timing	Temporal considerations, time horizons	10	3.09	68.8	30.0
	Miscellaneous		9	2.78		
	Total		324	100%		

This would suggest that overall, participants spoke little of it (shared corporate response) but assigned enormous value to it when they did. Overall, few participants mentioned it but when they did it mattered a lot to them.

5.2.2.1 Risk Identification—Risk Source and Risk Effect

As noted in Weinhofer and Busch's (2013) contribution, organizations which acknowledge climate change impact as a business risk tend to rely on a risk management approach to identify, assess and respond to those risks. Identifying the risk source and the risk effect is a common if not standard management practice related to the risk identification process (Roberts et al., 2015).

Congruent with that, the researcher disaggregated the risk identification category into categories of risk source and risk effect. Risk source can be seen as the location or point at which the risks originate while risk effect is seen as the general result or outcome of the risk occurring. Category data from Table 5.3 showed 18.8 per cent of the 324 constructs related to risk identification. Out of that, as shown in Table 5.4, 7.10% of all constructions were about the source of climate risks, while the general effect or outcome of climate risks represented were 11.73%.

5.2.2.2 Risk Assessment—Risk Characteristics and Risk Consequences

Similarly, the original super category of risk assessment was disaggregated into two: risk characteristics and risk consequences. Respondent's constructions about climate risk characteristics related to how manageable or controllable they believed climate risks were, while their construal about risk consequences were viewed as the direct implications for the participant's organization. Category data showed 51.2 per cent of the 324 constructs related to risk assessment. Out of that 33 per cent of constructs related to direct consequences for the participant's company and 18.21% related to characteristics of the risks themselves (see Table.5.4).

5.2.2.3 Risk Response—Risk Response Type, Timing, and Singular and Shared Corporate Response

The third super category of risk response was broken down into four refinements: response type, response timing, singular corporate response and shared corporate response. Themes related to Response Type included the broad descriptive terms of mitigation, preventative maintenance, adaptation and fix and re-start constructions. Risk response timing themes were expressed by the participants as being related to temporal considerations: when or what point in time did they perceive climate risks appearing and becoming an issue for the organization. Category data showed 27.2 per cent of the 324 constructs related to risk response.

The final 3rd and 4th categories relating to risk response were divided between what the participants viewed as a singular corporate response ('we go it alone'), and as a shared climate risk response requiring the involvement of other groups, e.g. other grid operators, government, associations. Risk response constructions relating to a singular corporate response ('we go it alone') represented 11.11% of all constructs, while a shared risk response represented 7.10%.

After disaggregating the super categories (now, the 'categories'), frequency and percentage data produced a moderately more detailed picture. As a group, the respondents focussed appreciably on assessment (51% of all constructs) and this assessment was dominated by the potential direct consequences for the company (33% of all constructs being in the risk consequences category), rather than characteristics such as predictability and control (18% of all constructs, albeit the second most frequent category overall). Both categories produced an appreciably high mean per cent similarity Scores (see Section 3.11.4) with risk consequences producing an 81.8 per cent similarity score and risk characteristics producing a 71.5 per cent similarity score. Overall, both categories, as well as being the two more frequent categories overall, produced the highest mean per cent similarity scores suggesting that these two categories most strongly identify with what the whole topic means for the participants. Furthermore, corporate aspects of the risk response (singular corporate at 11% and shared corporate at 7%, dominate over implementation –type risk response, risk type at 6% and risk timing at 3% (see Table 5.4).

Following the analysis of the findings shown in Tables 5.2, 5.3 and 5.4, it is useful to understand if the overall results presented are the same in a comparative analysis of both groups. Determining whether the power producers and utilities respondents differ in category frequencies and proportions, is in keeping with Yin's case study approach for analytical generalization (Yin, 2014).

5.2.3 Comparative Analysis

A comparative analysis of both participant groups was done to determine if the same patterns exist in the same way for each of the two groups. By doing so, the researcher could determine if participant groups see the different categories as more or less important. The comparative analysis of power producers and utilities constructs revealed a number of findings. Table 5.5 highlights the categorization of the constructs.

5.2.4 Comparative Themes

This subsection reports on the findings of two sets of grid data which compare construct categories/themes between both participant groups.

5.2.4.1 Power producers—Themes

For power producers, the themes with the most constructs were their perceptions about risk consequences and risk characteristics (36%, 14.91% of all constructs). Both categories are thematically related to general risk assessment about climate change impacts and therefore would otherwise suggest power producers were largely focussing on risk assessment issues. The categories with the fewest constructs for power producers were risk response type and risk response timing (4.46% and 4.35% of all constructs), suggesting they are relatively less concerned with thinking about temporal considerations of risks appearing and their understanding of how they will manage climate risks on their own.

Table 5. 5
PARTICIPANT GROUP COMPARISON OF CONSTRUCT CATEGORIES

Super-Category	Category	f- Overall-Constructs	Overall % of Constructs	f-Constructs (Producers)	% P1 (Producers)	f-Constructs (Utilities)	%- P2 (Utilities)
Risk Identifi-cation	Risk Source	23	7.10	14	8.69	9	5.52
	Risk Effect	38	11.73	15	9.32	23	14.1
Risk Assess-ment	Risk Characteristics	59	18.21	24	14.91	35	21.47
	Risk Consequences	107	33.02	58	36.02	49	30.06
Risk Responses	Risk Response Type	19	5.86	7	4.46	12	7.36
	Risk Response Timing	10	3.09	5	4.35	5	3.07
	Singular Corporate Response	36	11.11	22	13.66	14	8.59
	Shared Corporate Response	23	7.10	11	6.83	12	7.36
	Miscellaneous	9	2.78	5	3.10	4	2.45
	TOTAL			161	100%	163	100%

5.2.4.2 Utilities—Themes

For utilities, the themes with the most constructs were also their perceptions about risk consequences and risk characteristics (30.06%, 21.47% of all constructs). Both categories are thematically related to general risk assessment about climate change impacts and therefore would otherwise suggest that utilities participants are almost equally concerned with their power producer counterparts about risk assessment. The categories with the fewest constructs for utilities were risk response timing and risk source (3.07%, 5.52% of all constructs) suggesting they are relatively less concerned with temporal considerations and the origin and location of climate risks. This lessor concern for timing is surprising, given the physical impact climate change has already created for utilities.

Overall, it remains that both groups concentrate on risk consequences; that there is among them, much more concern for both categories of risk identification and risk assessment, in comparison to risk response.

5.2.5 Honey’s (1979) Technique

The researcher supplied an overall construct to help elicit interviewee constructions about the topic being researched, per Honey’s (1979) technique (see Section 3.11.4). The overall construct supplied was ‘greatest—weakest influence’ on future climate risk management.

Honey's (1979) content analysis technique was used to assign HIL (high-intermediate-low) indices to constructs based on the sum of differences between the overall construct and each of the elicited constructs. This assisted in developing the individual stance (the 'personal metric') on the topic. A construct with a low HIL indices has relatively low relation to the topic and a high HIL indices indicate a relatively high association between the topic and a given construct. All constructs with H values greater than 75% degree of similarity with the topic as a whole are provided in Appendix R.

In addition to understanding the individual stance on the topic, the Honey construct was employed so that the individual percentage similarity scores ('the personal metric') could be compared with the findings of the second data set—corporate climate change narratives, addressed ahead in Section 5.3.

Information on the comparison of power producers and utilities in terms of their construct categorization, their percentage similarity scores and the percentage of H scores for H-I-L values are presented in Table. 5.6.

While there is a difference in the proportions for each of the construct categories, several are notable in Table 5.6. Utilities proportionally expressed more constructs about the effects of climate risk (14.11%, compared to 9.32% for power producers) and of risk characteristics (21.47% versus 14.91%) and to a lesser extent, types of risk responses (7.36% versus 4.35%). Furthermore, utilities had proportionally more constructs about how their company would manage climate risks collaboratively with other market actors (7.36% versus 6.83%). On the other hand, power producers expressed proportionally more concern for the consequences of climate change impacts on their firm (36.01% versus 30.06%) and more constructions about how their company would singularly manage climate risk (13.66% versus 8.59%).

Table 5. 6
POWER PRODUCERS AND UTILITIES—PARTICIPANT GROUP CATEGORIZATION DETAILS

	POWER PRODUCERS				UTILITIES			
Category	**f constructs**	**% of constructs**	**Mean% similarity score**	**% scores w H values**	**f constructs**	**% of constructs**	**Mean% similarity score**	**% scores w H values**
Risk source	14	8.69	70.36	28.57	9	5.52	74.11	55.55
Risk effect	15	9.32	67.33	13.33	23	14.11	72.26	43.48
Risk characteristics	24	14.91	74.0	25.0	35	21.47	69.83	34.28
Risk consequences	58	36.01	66.64	36.21	49	30.06	70.39	34.69
Risk response type	7	4.35	69.28	57.19	12	7.36	55.42	16.67
Risk response timing	5	3.10	68.6	20.00	5	3.07	69.00	20.0
Singular corporate response	22	13.66	72.32	27.27	14	8.59	69.00	35.71
Shared corporate response	11	6.83	74.91	27.27	12	7.36	65.93	16.66
Miscellaneous	5	3.10	63.20	60.0	4	2.45	79.00	50.0
TOTAL	161	100%			163	100%		

While proportional differences between the two groups in the mean percentage similarity scores were not appreciably different, the difference in percentage scores with H values presents a different picture.

High (H) values were assigned to the highest one third of similarity scores and represented the constructs which were deemed personally most important to the participant. As such, the percentage scores of H value constructs produce a picture of more striking differences between the two groups. Power producers deemed personally more important constructions about various types of risk response they envisioned (57.19% versus 16.67%). This may suggest that power producers have a more developed or concretized view of the issues driving their climate risk responses. Of less proportion in terms of personal importance, power producers deemed that the consequences of climate risk for their organizations was marginally higher than how utilities viewed the matter (36.21% versus 34.69%). This may suggest a sense of relative urgency that their utilities counterparts may or may not have. Constructions they made about sharing the risk of climate change impacts with other market actors (27.27% versus 16.66%) they deemed as being personally important in the overall topic of climate risk management. This may suggest that power producers think proportionally more about shared corporate responses that include other market actors, than their utilities counterparts.

5.2.6 Element Analysis, Using Honey's Technique

The above sections dealt with the findings pertaining to how the participants made sense of the influence of climate drivers (the elements) on their and anticipated future climate risk management plans. The study is *also* concerned with how the participants view the *relative* importance of the climate drivers (the elements) in their constructions about future climate risk management plans. As stated in Sections 1.8 and 3.2, the primary research objective was to identify the ways in which the participants construe and make sense of the supplied climate drivers, i.e., the influencing factors of climate risks. These perceptions/construals relate to two important features of the research study: the construal of the influence of the climate drivers on the research topic, and the construal of the relative importance of the climate drivers.

Having presented findings relating to the first two research objectives (to identify how participants construe climate change, and to examine possible differences in construing between the two groups), it remains to draw on these findings to examine how participants characterised the relative importance of the eight elements themselves. (It will be recalled from Sections 1.5 and 2.3.3 that these relate to the direct climate impacts of extreme weather events, the indirect climate impacts of government intervention and the subsequent pressures on organizations resources and capacity).

This was done by drawing on Honey's technique to examine the ratings of the supplied construct as shown in Appendix S; Table 5.7 focuses on the ratings of '1' and '2' which represent relatively strong impact, and the ratings of '4' and '5' which represent relatively weak impact.

Table 5. 7
SECTOR GROUP TOTAL ELEMENT RATINGS

Table 5.7: Sector Group (n=20) Total Element Ratings on the Overall Supplied Construct (Influence on future climate risk management)

	Elements							
	Sudden Direct Climate Events	Climate Data	Government Policy	GHG Abatement	Technical Knowledge	Aging Infrastructure	Organizational Capacity	Organizational Resources
Rating	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**
1	5	3	11	1	0	0	2	1
2	4	3	1	8	6	6	4	2
Highest Ratings			**12**	**9**				
3	3	11	5	2	6	7	4	4
4	5	3	2	3	7	4	6	7
5	3	0	1	6	1	3	6	6
Lowest Ratings							**12**	**13**
Total	20	20	20	20	20	20	20	20

Overall, Table 5.7 shows how participants rated the elements (climate drivers) according to their relative importance.

Elements which scored relatively high in importance of influence (1 and 2 ratings) were E3—government policy (12 observations) and E4—GHG abatement (nine observations). High element ratings for government policy and GHG abatement, discussed earlier in sections 1.5.2 and 2.3.4, appear to be consistent with the literature. The sector group as a whole is shown to be most concerned with government policy and GHG abatement.

Elements which scored relatively low in importance (4 and 5 ratings) were E8—organizational resources (13 observations) and E7-organizational capacity (12 observations.) Low element ratings for organizational capacity and resources suggest that participants view these climate drivers as less important in the debate around the relative importance of all drivers.

To further understand *which* participants viewed the' most influential' climate driver on the topic as a whole (future climate risk management), overall ratings were summarized in Table 5.8 which shows the total ratings allocated to each element by each group. The actual ratings are derived from Appendix S. A frequency count was performed vertically for all ratings (applicable to each climate driver/element) to arrive at totals shown in Table 5.8. Lowest total rating scores indicated for that element, the group deemed the element/climate driver as the most important influence on the topic as a whole.

Table 5. 8
RELATIVE IMPORTANCE OF EACH ELEMENT (CLIMATE CHANGE FACTOR): Summed Ratings on the Supplied 'More Important—Less Important' Construct. (Low Sums Indicate Greater Relative Importance)

Company	Element	1	2	3	4	5	6	7	8
Producers		34	**27**	**18**	29	33	35	41	41
Utilities		**23**	27	**23**	36	32	29	29	35

The implications of those findings are that that power producers group deemed that E3—government policy and E2—climate data were the greatest relative influences on their views of managing climate risks in the future.

Findings shown in Table 5.8 show that the utilities group deemed E1- sudden direct climate events and E3- government policy were the greatest influences on their views of future climate risk management. This suggests that utilities perceive exposure to sudden direct climate events and government policy of primary importance. More significantly, government policy was seen by both groups as being of the highest influence for both groups—and well higher than the physical impacts of climate change for power producers.

5.2.7 Summary of Findings Related to Grid Data

5.2.7.1 Overall Findings

The first emergent finding from the grid data showed that both groups overall are much more concerned with the 'assessment' of climate risks than any other construct category. 166 out of 324 constructs related to either the direct consequences of climate change impacts on their organization or to the characteristics of climate risks as they viewed them, eclipsing all other categories including response constructs, or the more formative risk management phase of risk identification constructs.

The second emergent finding showed that out of the general category of assessment, participants in both groups are most concerned with the implications/consequences of climate change impacts for their organization. This would suggest an operational, 'on the ground' view of risk management, devoid of longer term strategic intention but most concerned with reaction and 'what will happen next'.

The third emergent finding showed a prevalence of constructs about singular and shared corporate responses produced in the risk response theme for both groups. This would suggest that climate risk management is construed not simply in terms of a corporate response taken by the organization alone, but within the wider context provided by other sector groups and constituents beyond the immediate organization.

The fourth emergent finding showed that overall, power producers and utilities don't differ in their perception of the relative importance of construct categories.

The fifth emergent finding is that they do differ partially in their views about the relative importance of climate drivers. Comparative findings are discussed next.

5.2.7.2 Comparative Findings

Comparatively, there were additionally a number of findings which suggest that the two groups have different views on climate risk management, in several areas:

1. Utilities expressed proportionally more constructs about the *effects* of climate risk than power producers.
2. Utilities expressed proportionally more constructs about the *manageability of risk and other characteristics* than power producers.
3. Utilities had proportionally more constructions about how their company would manage climate risks collaboratively with other market actors.
4. On the other hand, power producers expressed proportionally more concern for the direct *consequences* of climate change impacts on their firm.

5. Power producers produced more constructions about how their company would singularly manage climate risk.

Where constructs were rated as personally more important to the overall topic of climate risk management, more findings emerged from the Honey analysis (see Sections 5.2.5 and 5.2.6):

1. Power producers tended to rate corporate response as personally more important compared to Utilities, suggesting a relative difference in the way power producers view the importance of responding to climate risks.
2. Power producers also rated ‘shared corporate response’—the sharing of corporate responses with other market actors- as personally more important, suggesting that power producers have a broader view of market and stakeholder alliances as being part of an overall climate risk response in the electricity sector.
3. Power producers and utilities both deemed government policy as a climate driver, as having the greatest influence on their views of how they would expect to manage climate risks in the future.
4. Despite their shared view of government policy as having high relevance for their views on future climate risk management, producers and utilities differed in their views regarding the relative importance of the physical manifestation of climate change (E1) and of climate data (E2). There, producers deemed climate data is having the second highest influence of future climate action while utilities rated sudden direct climate events as being equally important as government policy.

The main findings and analysis using the repertory grid methods have been shown and quantified above. The analyses included content analysis, Honey’s technique and an element analysis, using Honey’s technique. All three analyses have been applied to the case study group as a whole, and to each of the two groups, for a comparative analysis of similarities and differences. Discussed next, are the findings and analyses pertaining to corporate report narrative of the same 20 participant organizations.

5.3 CORPORATE REPORT NARRATIVES

The second phase of the empirical work was an analysis of published corporate statements (narrative statements) about climate risks made by the sector group. Comparing the more explicit and public narrative statements with the less formal tacit expressions of climate risk construals was done to produce more findings and insight and to improve the overall credibility of the empirical work.

5.3.1 Introduction

As indicated in Section 4.5.2, the 2015 corporate reports of the participants’ companies were examined by narrative analysis in the ethnographic tradition to determine the triangulation effect of construct categories and elements (climate drivers) established in the grid data. This mixed methods approach facilitates the comparison of' private perception' of the grid data with the more 'public expression' of corporate reporting. By doing so, insights are expected to emerge into how the sector construes of future climate risk management. Corporate reporting standards mandate accurate and timely discussion of operational and financial performance, including the company's risk management context in which their financial results were achieved. With respect to this research study, of particular concern in corporate reporting are the risks the company believes are associated with climate change. How the sector participants construed of climate risks in the more public domain of corporate reporting, is key to the triangulation of constructs in this work. Furthermore, how the participants' reports discuss climate change impacts in terms of risk identification, risk assessment and risk response categories will help to understand the relative strength of the triangulation effect.

5.3.2 Narrative Analysis

In keeping with Yin's (2014) case study approach and the use of replication logic to help improve generalizability to the Ontario population, the following four steps were conducted to systematically evaluate the climate risk content in the corporate reports: a) development of the list of source documents (corporate reports) for the sector participants; b) development of the identification of 'narrative statements' about climate risks the company construes; and c) development of the triangulation scheme for construct categories and elements. The results are provided for in Appendix T. Each stage of how Appendix T was assembled is discussed below in more detail.

5.3.2.1 Step 1—Source Documents

In the first step, a web search was conducted to retrieve all 2015 annual public disclosure documents of the participants. Four types of public reporting documents were reviewed for the group as a whole: 2015 annual financial reports, 2015 environmental reports, 2015 municipal financial reports, and 2015 regulatory (OEB) reports.

For the 10 power producers, only annual financial and environmental reports were available. For the 10 utilities, annual municipal reports and annual regulatory reports were only available. There was one instance of a utility producing an extended sustainability report on climate change impacts.

5.3.2.2 Step 2— Narrative Statements

The researcher manually scanned each of the corporate documents named above for statements made about climate change impacts and climate risk. Particular attention was given to how the company described climate risk, if at all, in the risk disclosure section of corporate annual financial reports and municipal annual financial reports. As shown in Appendix T, each statement was recorded as a direct quotation with the corresponding participant code and the page location in the company's report. The risk management construct categories as well as elements/climate drivers were allocated to the narrative statement by the researcher. To provide more dimensionality, any related issues mentioned in the narrative statement were noted and manually coded as a related issue.

5.3.2.3 Step 3—Triangulation Scheme

A triangulation scheme was established to show how, if at all, construct categories and elements (climate drivers) established in the grid data are reflected in corporate narrative statements. For example, turning to Appendix T, the statement ‘The Corporation has identified climate change adaptation and extreme weather as a strategic risk for the company’ was made by Participant #1.1 and pertains to risk effect (construct category) where ‘sudden direct climate events’ is noted as the element (climate driver) and is expressed and seen by the company as an issue for corporate strategy (related issue). Further examples of the triangulation effect are provided in Section 5.3.3.

While all narrative statements made in the reports are contained in Appendix T, a representative selection of quotations was chosen which reflected the most diverse and most detailed statements pertaining to the construct categories and the climate drivers used in the grid data.

5.3.2.4 Step 4—Pattern Recognition and Explanation Building

Explanation building is a form of triangulation which goes beyond confirming, in this research, the exemplification of construct categories and looks at what else is being said, related to the construct categories. The point here is that an explanation is not necessarily proved to be valid when the explanation is shown to be consistent with data; but rather, that it accounts for all the data, and that there are no additional data that might contradict the explanation and suggest some alternative explanation.

It is important to note that all of the corporate statements about climate risks are in fact exemplified in the grid construct categories. This suggests that each and every corporate statement corresponded with risk identification, risk assessment or risk response constructs. Climate drivers established in the pilot study and supported by literature are also exemplified in the corporate narrative data. Both construct categories and climate drivers assigned to corporate statements are found in Appendix T. Alongside constructs and drivers are noted the related issues implied or stated in the corporate statement. The related issue may indicate additional meanings the participants attribute to the construct, or to the climate driver. P1.4’s statement is one example:

> Our business is subject to various risks and include without limitation, the effects of weather, which affect demand for electricity and fuel as well as operating conditions; risk beyond our control, including but not limited to natural disasters or other catastrophic events; the impact of significant energy, environmental and other regulations on our projects.

In this case, energy demand, is an additional construct which the sector participant is construing of as a future climate risk- related to risk assessment. The relevance of additional constructs is discussed ahead in Section 5.3.3.1

5.3.3. Triangulation of Data

A careful inspection of the narrative statements presented in Appendix T showed three distinctions:

1. The narrative statements of participants 1.1 and 1.10 (power producers) are identical since both power producers are owned by the same corporation. Thusly, narrative statements made by the parent corporation were allocated to both participants.
2. 50% of utility reports contained a standardized statement on 'weather' risks, in the 'voice' of and prepared by the Ontario regulator (OEB). The narrative statements indicated in Appendix T were supplied as the 'Note to Reader of 2015 Scorecard MD&A' in five out of the 10 utilities reports.
3. A systematic search for the following terms was done: 'climate change', 'climate risk', 'climate data', 'government policy', 'emmissions', 'aging infrastructure'.

The sum of all corporate narrative statements found in corporate reports are included in Appendix T. Based on Appendix T, the triangulation effect of the narrative data was shown in the risk management construct categories and elements (climate drivers) in the following examples. Triangulation of construct categories i**s** discussed first, followed by triangulation of element categories. Finally, narrative data are examined that pertain to one particular issue: the balance of singular and shared concerns relating to corporate risk response.

As shown below, construct categories in some instances are combined where the narrative statements bundled references to multiple constructs. Examples of quotations are provided in descending order of construct prevalence in the narrative data.

5.3.3.1 Constructs Triangulation

Construct category—risk consequences (direct)

> To date the company has not experienced impacts attributable to climate change but it is recognized that efforts are required to assess the short and long-term risks and to monitor for developments in climate science, adaptation activities and potential changes to policy and regulatory requirements. (Power producer, page 22, 2015 Environmental Report)

> The generation group's thermal Energy Division uses natural gas and oil, and produces exhaust gases which if not properly treated and monitored could cause hazardous chemicals to be released into the atmosphere. The units could be restricted from purchasing gas/oil due to either shortages or pollution levels, which could hamper output of the facility. (Power producer, page 62, 2015 Environmental Report)

> As a result of more favorable conditions brought on by climate change, the rates of vegetation and tree growth have increased. This increase, in turn, increases the potential risk to reliability and safety. In terms of the health of the trees, there are limits to the amount of foliage that can be removed without having a negative impact. (Utility, page 37, 2015 Sustainability Report)

The above quotations indicate how the companies construe of the specific and direct effects of climate impacts on their organization.

Construct category—risk source, risk consequences

> Climate change is a risk relating to the external environment. In the short term, climate phenomena will have an impact on energy power producers as well as on demand for electricity. In the longer term, climate change could have a broader impact on the company's activities: changing energy needs, CO2 emissions reduction, etc. (Power producer, page 21, 2015 Integrated Annual Report)

> The effects of weather and climate change may adversely impact our business, results of operations and financial condition. Our operations are affected by weather conditions which directly influence the demand for electricity. Temperatures above normal levels in the summer tend to increased summer cooling electricity demand and revenues. Conversely, moderate temperatures in winter tend to increase winter heating electricity demand and revenues. To the extent that weather is warmer in the summer or colder in the winter than assumed, we may require greater resources to meet our contractual commitments. These conditions which cannot be accurately predicted, may have an adverse effect on our business results of operations and financial condition by causing us to seek additional capacity at a time when wholesale markets are tight or to seek to sell excess capacity at a time when markets are weak. (Power producer, page 27, 2015 Annual Information Report)

> The company's facilities and projects are exposed to the elements such as wind, water and are also susceptible to weather and other natural events such as hurricanes tornadoes lightning storms and icing events that can cause construction delays. Natural events may also make it impossible for operations and maintenance crews to access the disabled equipment. (Utility, page 42, 2015 Annual Report)

These quotations combine risk source with risk consequences, providing a more detailed explanation of how the company attributes the risk consequence to the risk source.

Construct category—risk effect (general)

> Unusual or unpredictable weather has the potential to damage electricity power producers and transmission infrastructure. (Power producer, page 22, 2015 Environmental Report)

> The corporation has identified climate change adaptation and extreme weather as a strategic risk for the company. (Power producer, page 22, 2015 Environmental Report)

> The information provided by Utilities on their future performance (or what can be construed as forward-looking information) may be subject to a number of risks, uncertainties and other factors that may cause actual events, conditions or results to differ materially from historical results or those contemplated by the distributor regarding their future importance. (Utility, page 19, 2015 Regulatory Report)

The above quotations show in effect how the company construes of the general effect of climate impacts on their organization.

Construct category—singular corporate response

> We have incident, emergency and crisis management systems to ensure an effective response to minimize further loss or injuries and to enhance our ability to resume operations. We also have a business continuity program that determines critical business processes and develops resumption plans to ensure process continuity. We have comprehensive insurance to mitigate certain of these risks, but insurance does not cover all events in all circumstances. (Power producer, page 94, 2015 Annual Report)

> The increased demand on our system due to climate change (i.e. the increase in the number and duration of peak demand days and severe storms) is mitigated by the robust infrastructure that our capital reinvestment strategy has created. (Utility, page 36, 2015 Sustainability Report)

> The corporation began a review of the emergency flood plan and embarked upon the challenge of describing the requirements of an off-site business continuity location within the city. (Utility, page 37, 2015 Sustainability Report)

The above quotations are statements reflecting how risks will be handled within the organization context.

Construct category—shared corporate response

> The corporation is an integral community partner and maintains active membership in the City's Advisory Committee on the Environment. The Sub Committee on Energy, Community Energy Action Plan. (Utility, page 37, 2015 Sustainability Report)

> The utilities and the town have implemented Business Continuity Management to ensure critical services and functions are maintained in the event of an interruption or emergency. (Utility, page 76, 2015 Municipal Annual Financial Report)

The above quotations suggest the corporation is either already working with outside groups e.g. the local municipality in determining a course of action on climate change. The triangulation effect of elements (climate drivers) is discussed next. Examples of narrative statements referencing climate drivers are provided to illustrate how the company frames climate drivers in its corporate narrative statements.

5.3.3.2 Elements Triangulation

Element/climate driver—government policy:

> To date, the company has not experienced impacts attributable to climate change but it is recognized that efforts are required to assess the short and long term risks and to monitor for developments in climate science, adaptation activities and potential changes to policy and regulatory requirements. (Power producer, page 22, 2015 Environmental Report)

> Material risk factors include the effects of changes in environmental and other laws and regulatory policy applicable to the energy and utilities sector. (Power producer, page 15, 2015 Annual Report)
>
> As power markets evolve across North America, there is the potential for regulatory bodies to implement new rules that could negatively affect us as a generator. These may be in the form of market rule changes, changes in the interpretation and application of market rules by regulators, price caps, emissions controls, emissions costs, cost allocations to Power producers and out of market actions taken by others to build excess power producers, all of which negatively affect the price of power or capacity, or both. (Power producer, page 77, 2015 Annual Report)
>
> For the last several decades, the greenhouse effect and its influence on climate change has caused environmental concern… Should any legislation related to GHG regulation impose any costs on the corporation, certain of its facilities may not be able to recover some or all of such costs under its power purchasing agreement, which would result in reduced cash flow and asset impairments upon implementation. (Power producer, page 43, 2015 Annual Report)

The above quotations provide a variety of statements about how the corporation views government policy as a source of material risk for the company.

Element/climate driver—sudden, direct climate events:

> Significant changes in temperature and other weather events have many effects on our business, ranging from the impact on demand, availability and commodity prices, to efficiency and output capability. (Power producer, page 77, 2015 Annual Report)
>
> Extreme weather can affect market demand for power and natural gas and can lead to significant price volatility. (Power producer, page 77, 2015 Annual Report)
>
> Business interruption is the highest operational risk we face. Operational risks, including labor disputes, equipment malfunctions or breakdowns, acts of terror or natural disasters and other catastrophic events. (Power producer, page 77, 2015 Annual Report)
>
> Changes in precipitation patterns, water temperatures, and ambient air temperatures can impact the availability of water resources, which could affect power production at the thermal facility. (Power producer, page 22, 2015 Environmental Report)
>
> The frequency and intensity of extreme weather, as opposed to the changing climate, is the greater concern for the electricity sector. (Power producer, page 22, 2015 Environmental Report)

The above quotations provide examples of a variety of narrative statements pertaining to the physical manifestation of climate change, noted in some cases as 'extreme weather' and in others as 'changes in precipitation patterns'.

Element/climate driver—climate data:

> To better prepare for the potential impacts of climate change, the City collaborated with the University of Western Ontario's Department of Civil and Environmental Engineering to analyze changes in rainfall intensity, duration and frequency. Results

> indicated that the frequency and intensity of rainfall in the area has increased since 1965 and is likely to increase with the onset of climate change. (Utility, page 37, 2015 Sustainability Report)

> As a result of more favorable conditions brought on by climate change, the rates of vegetation and tree growth have increased. This increase, in turn, increases the potential risk to reliability and safety. In terms of the health of the trees, there are limits to the amount of foliage that can be removed without having a negative impact. (Utility, page 37, 2015 Sustainability Report)

The above quotations reveal a concern with climate data as a source of risk for the corporation. The effect of climate data to inform how the company addresses climate risks is shown as data collection initiatives in the first instance, and as the use of data to measure vegetation and tree growth—which for utilities creates hazards for transmission lines.

Element/climate driver—aging infrastructure:

> Unusual or unpredictable weather has the potential to damage electricity power producers and transmission infrastructure. (Power producer, page 22, 2015 Environmental Report)

> Aging utilities infrastructure continues to be a challenge for many utilities today. Like most utilities in Ontario, the company must replace aging infrastructure at a steady pace in order to meet this challenge. Therefore, the company strategically plans to meet the renewal and growth of the utilities system in a cost-effective manner. (Utility, page 1, 2015 Regulatory Report)

> In 2014, the city published a comprehensive analysis of existing infrastructure and floodwater capacities which was summarized in 'The City: Vulnerability of Infrastructure to Climate Change'. As a result of this study, a long-term adaptation strategy was created. The significance of the findings regarding the potential for increased flooding directly affects the corporation. (Utility, page 37, 2015, Sustainability Report)

The above quotations provide examples of the way in which producers and utilities view the risks created by climate change on system infrastructure.

Element/climate driver—technical knowledge:

> To better prepare for the potential impacts of climate change, the City collaborated with the University of Western Ontario's Department of Civil and Environmental Engineering to analyze changes in rainfall intensity, duration and frequency. Results indicated that the frequency and intensity of rainfall in the area has increased since 1965 and is likely to increase with the onset of climate change. (Utility, page 37, 2015 Sustainability Report)

The above quotation is an example of how the corporation views the importance of having upgraded technical knowledge, especially in the area of assessing climate change impacts.

Element/climate driver—organizational capacity and resources:

> The company could also be subject to claims for damages caused by its failure to transmit or distribute electricity. (Utility, page 35, 2015 Environmental Report)
>
> The corporation is an integral community partner and maintains active membership in the City's Advisory Committee on the Environment. The Sub Committee on Energy, Community Energy Action Plan. (Utility, page 37, 2015 Sustainability Report)
>
> Although constructed, operated and maintained to industry standards, the Company's facilities may not withstand occurrences of this type in all circumstance. (Utility, page 34, 2015 Annual Report)
>
> The corporation's Safe Work Practices Manual outlines the Heat Stress and Cold Weather strategies employed to mitigate the negative effects of extreme weather on the health and safety of employees and to reduce WSIB claims costs, which are expected to increase as a result of climate change. (Utility, page 36, 2015 Annual Report)

The above quotations are examples of corporate narrative statements of how the corporation views its vulnerability to climate change in terms of organizational resources and capacity.

5.3.3.3 Corporate Risk Response: Balance of Singular + Shared Corporate Response

Another triangulation effect is found in the risk management construct category of risk response, where 14 out of 20 participant reports (nine out of 10 for producers; five out of 10 for utilities) raised the issue of what action the corporation is taking or intends to take in response to managing climate risks.

Singular corporate response was a construct category established in the grid data, and allocated to grid constructs which reflected notions of what corporate action the company *alone* intends to take. For example, referring to constructs enumerated in Appendix T, one participant said: 'We own assets and have business interests in a number of regions where there are regulations to address industrial GHG emissions. We have procedures in place to comply with these regulations' (Participant #1.4). Construct examples of a shared, collaborative response from the grid content included comments such as:

> Aging utilities infrastructure continues to be a challenge for many utilities today. Like most utilities in Ontario, the company must replace aging infrastructure at a steady pace in order to meet this challenge. Therfore the company strategically plans to meet the renewal and growth of the utilities system in a cost effective manner. (Participant #2.3)

When the more distinct response categories are considered—namely shared corporate response and singular corporate response, more distinction is shown between the two groups (see Table 5.9).

Table 5. 9

NARRATIVE STATEMENTS—CONSTRUCT CATEGORY 'CORPORATE RISK RESPONSE'

Power producers (*n* = 10)			**Utilities (*n* = 10)**	
	A 'Shared' Response	**A 'Singular' Response**	**A 'Shared' Response**	**A 'Singular' Response**
Participant	1.1	1.1	2.3	2.3
		1.2	2.4	2.4
		1.3	2.6	2.6
		1.4		2.8
		1.6	2.9	2.9
	1.7	1.7		
		1.8		
	1.10	1.10		
Total	3	8	4	5

As shown in table 5.9, eight out of the 10 producer reports expressed a singular 'we-go-it-alone' corporate response statements, suggesting their organization construes of climate risk management solutions independent of other power producers. This is in keeping with grid findings where power producers produced more constructions about response measures to climate change, and more constructions about responding ' corporately alone' to climate risks.

Among utilities, five reported how they were tackling climate change (a climate response statement). Out of those five, all reported action items (response), and four of those five included both response statements about collaboration in the response effort, as well as articulations about how the utility alone is taking response initiatives. This is illustrated in Table 5.9.

As stated in Step 4 of Section 5.3.2.4 while providing a triangulation of two sets of evidence to support a conclusion, explanation building also confirmed the conclusion by examining what else is being said about the topic to eliminate alternate explanations. Appendix T documents construct categories, climate drivers and related issues, explicitly contained or implied in the narrative data. One example from participant #1.4 was provided earlier; other examples of related issues/meanings are: corporate strategy (1.10) energy demand (1.3) supply chain/value chain (1.3), governance (1.7), vegetation control (2.3), flooding (2.4), and financial implications (2.9).

References to the above constructs indicated a broader range of cognitive associations and intepretations, in more explicit terms, beyond those expressed in the grid interviews.

5.3.4 Summary of Findings Related to the Narrative Data

The analysis of corporate report narratives indicated a number of findings pertaining to how the companies construed (in narrative statements) of climate related risks.

An initial observation was that none of the participant reports contained the term ‘climate risk’ but referred to physical climate related impacts as ‘extreme weather’ (P1.1), ‘natural disasters’ (P1.2), ‘a risk related to the external environment’ (P1.3). 35% (7) participants used the term ‘climate change’.

Overall all participant reports expressed at least one of the eight risk management construct categories in relation to climate change impacts.

Of the participant reports, 90% referenced sudden direct weather events as one source of climate risk.

Only 50% of the total group of participant reports referenced the additional seven climate drivers (elements) as risks, and none expressed all climate drivers used in the grid data as risks. Overall, most participant reports (13 out of 20) included narrative statements pertaining to the direct risk consequences of climate change on their organization. This suggests a strong triangulation effect of assessment constructs between narrative and grid data—which earlier showed a similar finding (see Section 5.2.7.1).

Most reported on climate response. 14 out of 20 participant reports (nine out of 10 for producers; five out of 10 for utilities) raised the issue of what action the corporation is taking or intends to take in response to managing climate risks. Most of the power producers reported singular, going it alone responses, while half of the utilities expressed corporate response measures they are and would take on their own and equally, what measures they would undertake with groups outside of the company.

It is useful to note a particular difference between grid findings and narrative findings (see Section 5.2.7.1) regarding the construct category of risk response. Grid findings suggested that both sector groups overall expressed more constructs about risk identification and risk assessment. Findings depicted in Table 5.5 illustrate the frequency count and percentage of constructs allocated in both the super and the main construct category levels. This suggested overall that producers and utilities provided the most constructs about risk identification and risk assessment, and in contrast, the least amount of constructs about climate responses (7.36% of overall constructs, 4.35% of overall constructs, producers and utilities, respectively).

Analysis of triangulated data showed a different pattern however, suggesting that overall both groups publically state greater instances of risk response statements (producers 45%, utilities 24.5%; see Appendix U). In some cases, sector participants discussed risk response statements ony, to the exclusion of risk identification and risk assessment categories—as was the case with Participants #1.6 and #1.7.

Similar to grid observations, producer corporate statements were significantly more focussed on discussing risk responses than utilities, as was the pattern in grid data.

With respect to the overall concern for risk assessment by the sector participants, grid findings and analysis indicated that half of the consructs expressed by both groups were about risk assessment issues (producers 50.92% of all constructs; utilities 51.53% of all constructs).

One possible conclusion one could make as to why there is an overall sector pre-occupation with climate risk assessment, based on the above issues expressed by the group, is that 'the assessment work is not complete'. The range of issues producers and utlities deem to be part of their assessment of climate risks, is not only future-bound but large and complex. Appraisals of future risks is a facet of risk management strategy. The complexity and the funding required to resolve or manage the issues, as the participants raised, suggested at the very least why the sector participants appear to remain in a risk analysis state.

To understand why this is so, a review of statements categorized as assessment statements was done to see what themes or reasons might be given or inferred (see Appendix T). Producers stated a number of related issues pertaining to their assessment statements, including corporate strategy, monitoring, sector impacts, financial implications, energy demand, operating conditions, technical impacts, market demand, energy security, capacity output and business interruption. Utilities stated or implied future performance, vegetation control (as in 'tree trimming'), reliability, safety, climate data, emergency preparedness and the built environment.

5.4 CHAPTER SUMMARY

This chapter reports on the findings and analyses of two data group settings in the empirical work. A mixed methods approach was conducted to elicit individual constructs of climate risks through the RGT, and the public constructs of climate risks through narrative analysis. Narrative analysis was conducted to determine the extent, if any, of the triangulation effect of climate risk constructs in the two settings. It can be noted that the sequence of data collection in the two settings was not dependent on one or the other; the empirical study could have commenced with either phase.

Comparing the informal tacit constructs with the more formal explicit statements made by the same organization, was done to produce more findings and insight, and to improve the overall credibility and external validity of the research study.

Chief findings from the grid data analyses showed that the participant group as a whole is very much pre-occupied with the analysis or assessment of climate risk, suggesting the group as a whole remains in an analytical state (see Tables 5.4, 5.5, 5.6).

The participant group as a whole, expressed more constructions about the direct consequences of climate risks on their operations, more so than any other construct category (see Tables 5.4, 5.5, 5.6). This 'on the ground' view of operational implications of climate related risks suggests that the companies view climate risk as an operational risk, as opposed to a strategic risk.

Another key finding in the grid data suggested both groups construe of managing climate risks not just alone but with the collaborative effort and involvement of other market actors,producers, utilities and governments (see Tables 5.4, 5.5, 5.6).

Utilities produced more constructs about the general effects of climate risks, and more constructs about how they construe *sharing* corporate action. Power producers on the other hand, produced more constructs about the direct consequences of climate change impacts, and also more constructs about how they would singularly manage the risks (see Tables 5.4, 5.5, 5.6).

Differences were found between the groups however, about the relative importance of certain climate drivers. Power producers rated government policy and climate data as their two most influential factors affecting their view of future climate risk management. Utilities viewed the phyicals effects of climate change and government policy as their two most influential factors affecting their construal of future climate risks management (see Table 5.7).

Chief findings of the narratived data suggested overall that there is a triangulation effect pertaining to risk analysis and assessment, as shown in the grid data. Findings showed triangulation with the discussions about direct implications/consequences (as part of risk assessment). While none of the participant reports mentioned all eight climate drivers (elements, from the grid data), the high majority (90%) reported that the physical effects of climate change was construed as a business risk to their organization (see Appendix T).

Another triangulation was found with how the companies reported on their responses to climate change. The majority of power producers reported 'a go it alone' response, consistent with grid findings. Utilities reported a combined collaborative and independent response on how they are and intend to respond to climate impacts. (see Appendix T).

It is notable that findings showed the emphasis is not soley on internal, organizational response to climate change. These findings challenged the researcher's initial reliance on corporate response theories of Berkhout et al. (2006); Bleda and Shackley (2008); and Hoffmann et al. (2009).

Overall, findings suggested a confluence of factors driving risk perceptions in the electricity sector, namely the influencing factors of climate change itself, governmental influence through regulation and climate policy and internal organizational resources and capacity.

Based on findings, the following is the revised model (see the orginal model as Figure 2.3 in Section 2.10) of how decision makers can be thought to view future climate risks in terms of risk readiness. Depicted in Figure 5.1 is the emphasis on risk analysis, as presented by findings, and the addition of climate risk reporting as a reflection of management perceptions. Exogenous and endogenous factors are shown to not only influence perceptions but also corporate statements about climate risks. The suggested construal of future conditions with respect to managing climate risks is shown as reaching and pausing at the risk analysis stage of future risk management. This is consistant with findings in this work, which suggested that management thinking/construal seems most pre-occupied with the analysis of climate risks.

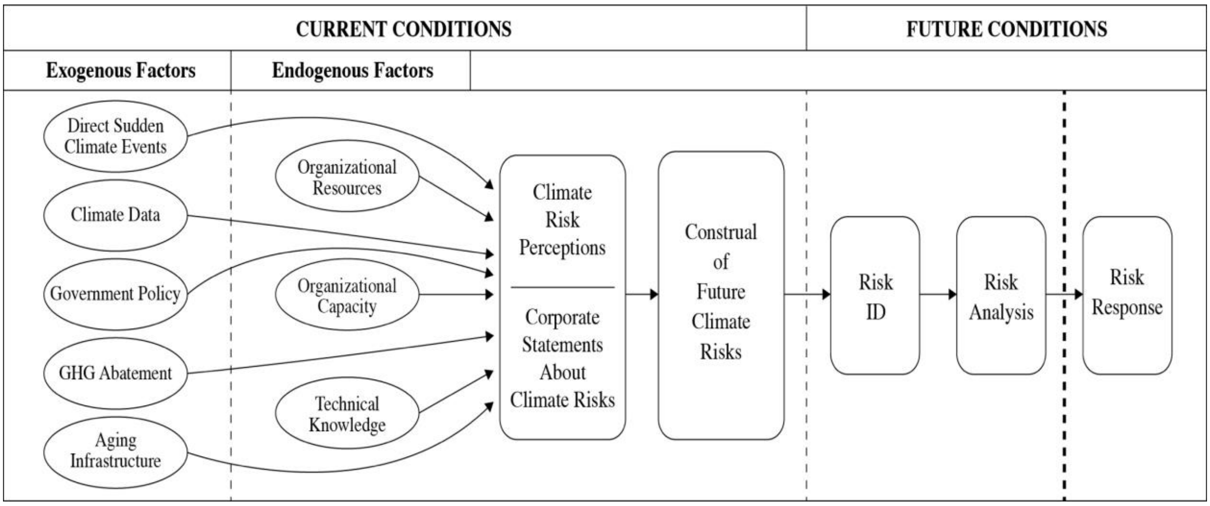


Figure 5. 1. REVISED MODEL OF RISK PERCEPTIONS IN THE ELECTRICITY SECTOR.

CHAPTER 6 DISCUSSION AND CONCLUSIONS

6.1 INTRODUCTION

This chapter discusses the findings generated in Chapter 5. Empirical outcomes of the work are reviewed and the implications for practice and theory are discussed. Finally, recommendations, limitations and suggestions for further research are presented.

6.2 EMPIRICAL OUTCOMES OF THE GRID DATA

As indicated in Chapter 5, 324 constructs were generated. Of these, 161 were from power producers and 163 were from utilities. Based on the content analysis, the following can be deduced:

1. Overall both groups expressed the greatest number of constructions about the analysis and assessment of risks, more than any other construct category. Participants overall expressed the highest number of constructs relating to the direct consequences of climate risks, in particular.
2. Power producers deemed government policy and climate data as the top two most influential factors affecting their view of how they expect to tackle climate change impacts.
3. Utilities deemed the physical manifestation of climate change and government policy equally as their top two most influential factors affecting their view of how they expect to manage climate risks.
4. Grid results indicated that the constructs could be usefully grouped into three main super categories: risk identification, risk assessment and risk response.

Next a discussion of the above, follows. It is important to examine these three categories in consecutive order. Mehr and Hedges (1963), generally viewed as the fathers of risk management, established the sequence as an industry standard - which continues to be used comtemporaniously by many proponents (Merna & Althani, 2008).

6.2.1 Risk Identification

According to risk methodologies taught in today's business schools, risk identification is the critical first stage of the process (Roberts et al., 2015). According to Roberts et al. (2015), risk identifcation has to account for risks at several levels e.g. primary risks versus secondary risks, and for the possibility of consequential and cascading risks. Abkowitz (2008) said risk management should cover a range of issues and themes and that it is important for companies to understand not only all the risks but any relationship that might exist between/among them. While approaches to risk identification may vary, most are based on risk source and effect (Roberts et al. (2015). Identifying only the physical impact of climate change as a risk is a serious oversight according to the Global Task Force on Climate Change Financial Disclosures. According to the group, many organizations "incorrectly perceive the implication of climate change as having only physical effects" and are therefore underreporting risks to the detriment of economic–decision making (Disclosures, 2017, p. 4). Furthermore, the task force has noted that many groups perceive the effects of climate change as occuring well into the future. Grid findings in this work appear to reflect that perception. Producers and utilities expressed relatively fewer constructs related to the temporal aspects of managing climate risks.

6.2.2 Risk Assessment

Risk assesssment was the most prevalent theme mentioned in the grid data. The super category of asssessment was divided into two categories: risk characteristics and risk consequences. Factors which shape corporate response to climate change are driven by the issues the corporation identifies in the assessment and analysis stage of risk management.

According to Klinke and Renn (2002) social institutions evaluate and manage risks to reduce and control them. Gasbarro and Pinkse (2015) suggested that how firms assess climate impacts is driven by management's perception of risk. Arnell and Delaney (2005) posited that awareness is a driving factor while Berkhout et al. (2006) and Weinhofer and Hoffmann (2008) suggested that how corporations assess their risk exposure and vulnerability in their risk assessments inform their responses. And again, Busch (2011) pointed to organizational capacity as key factor in assessment. Furthermore, Linnenlueke et al. (2012) suggested that corporate responses differ because of the subjective nature of risk assessment which accounts for difffering corporate responses. Weick (1995) suggested that the interpretation and evaluation of these impacts are done through sensemaking processes in the organization while Kelly (2003) proposed that assessment is done through personal construction of risks, according to a set of corollaries.

6.2.3 Risk Response

The risk response category was the second most prevalent theme mentioned after risk assessment. The super category risk response was divided further into risk response type, response timing, individual and shared corporate response. The most prevalent themes mentioned within this group were individual and shared corporate response.

Weinhofer and Busch (2013) explained the risk response phase as where companies select response actions—where appropriate—to minimize the exposure of the business to risks. Merna and Althani (2008) referred to all potential response actions can be assigned to three different response objectives: risk reduction, risk avoidance and risk transfer. Bootstrapped categories in this work enhance this risk response construct category by considering risk responses in terms of individual corporate response and shared corporate response.

6.3 EMPIRICAL OUTCOMES OF NARRATIVE DATA

As indicated in Chapter 5, a narrative analysis of corporate reports for the 20 participants was conduced to understand how the participants construed (in narrative statements) of climate related risks. Based on the narrative analysis, the following findings were deduced:

1. Low (35%) numbers of reports mentioned the term 'climate change', choosing to use alternate terms such as extreme weather, heavy precipation.
2. Almost all identified only 'sudden direct climate events' as the source of climate risk for the company.
3. Fifty per cent did not identify any of the other sources of climate risk, as were exemplified as climate drivers in the grid data.
4. Triangulation between narrative and grid data occurred on risk consequence and corporate response construct categories.

The level of climate risk disclosure in the narrative data was arguably low. Few reports mentioned climate change as a business risk, and half of them did not identify any of the other climate drivers.

Standard risk disclosure is required in corporate reports by either law or formal codes of practice in corporate governance. Firms are required to provide under the caption 'risk factors' a concise and logical discussion of the most significant factors. The paucity of *climate risk* reporting, as a new category of risk reporting was identified recently by the Global Task Force on Climate Change Financial Disclosures and by investor protection groups in Canada and the U.S.

Prior research on narrative portions of annual reports has yielded interesting findings to account for the low level of climate risk and risk reporting in general. For example H.W. and Snyder (1981) showed that a predominantly optimism bias and a 'Pollyanna effect' were evident in their analysis of corporate narratives. Crombie and Samujh (1999) pointed to deliberate obscuring of reported risks, to deflect readers from the major risks the company faced. Wright and Nyberg (2015) suggested a process of dilution occurs when corporate reporting enmeshes attention to climate change within a broader range of concerns. The low level of published expression about climate change and related impacts would suggest that a dilution process was in effect in the corporate reportage of this sector group.

In further explanation, Kohut and Segars (1992) found a predominant focus on reporting on past events and disclosures, concluding that executives felt more confident discussing the certain past rather than the uncertain future. While the empirical evidence indicated climate risk disclosure was low for the sector participants, it did raise the question of whether the phenonmenon was a reflection of management perceptions in the sector of climate risks, or was indicative of other factors. Deumes (2008) theorized that risk disclosures are an indicator for "uncertainty reduction" (Deumes, 2008, p.

151). Brashers (2001) claimed that “the effect of risk disclosure is both a cause and a sympton of underdeveloped ideas about uncertainty and methods of managing it” (Brashers, 2001, p. 478). These suggestions raises the question of what accounts for the difference between the tacit expressions of climate risk constructs in grid interviews and the low level of climate risk reporting in public documents. This area is worthy of further investigation.

6.4 IMPLICATIONS FOR THEORY

A number of implications for theory and academic contribution were found in this work, and are offered below. While this work filled a gap in climate risk research related to how senior managers perceive climate risks and how those risks could be understood for future management, the empirical work carried some implications for Renn and Rohrmann’s (2000) integrative model of risk perception, and for the use of Kelly’s PCT.

6.4.1 Renn and Rohrmann’s (2000) Integrative Model of Risk Perception

As established in Section 2.6.3.7, this research relied on the framework of Renn and Rohrmann’s (2000) integrative model of risk perception to help organize the discussion of risk perception determinants. The usefulness of the model in providing explanatory power was indicated by the empirical alignment with two out of the four factor levels found in the model. Those two are Level 3 (political influences) and Level 2 (cognitive influences) and are exemplified in the empirical findings of both grid and narrative data, and also in the characteristics of the respondents.

For example, Level 3 of the model suggests that political influences shape risk perceptions. This is in alignment with findings where government policy was perceived as the greatest influence overall on future climate risk management by both participant groups. Related to political influence is the issue of ‘trust’ as an accelator of political influence, as indicated in Figure 2.2. Constructs expressed as’ trust’ and ‘lack of trust’ did emerge in the grid interviews (see constructs P2.9.1 and P2.6.13 in Appendix P).

Level 2 of the model suggests cognitive forces influence risk perceptions. Discussed in Section 2.6.3.6, cognitive factors of knowledge, and knowledge acquired through experience, account for shaping risk perceptions. In the sense that personal familiarity and primary first-hand knowledge of risks are seen as directly influencing risk perceptions, Renn and Rohrmann’s cognitive explanation is also aligned with empirical evidence in this work. As stated earlier, sector participants have personal experience of the risks and are able to verify their own organization’s claims of risk. Participants are well-informed executives and have a high degree of personal efficacy for risk decision making in their organizations. As such, Renn and Rohrmann’s (2000) proposition that cognitive factors relating to knowledge and experience seems well explicated in the present study. Another finding supporting Level 2 alignment, is in the participants’ significant concern for climate *data*. In the field study, when asked which of all instances of climate risk did they view as the greatest influence on their views, power producers indicated climate data was their top concern.

The two remaining levels (Level 1, 4) of Renn and Rohrmann's model do not appear to offer much explanatory power in this work. For example, Level 1 factors relating to personal heuristics of information processing where bias and other constraints may be operating, are less likely to be manifest in this group of participants. Their advanced levels of technical knowledge and training make them less likely to rely on personal assumptions, schema and limitations of knowledge absorption. Likewise, Renn and Rohrmann's Level 4 explanation of cultural background, worldview and personal identify does not appear to apply in this work. While it might be useful to consider cultural force as a predictor for institutional action, or to examine its influence on legislation and policy making, it appears that the overarching influence of cultural influence bears no relevance on management perceptions of climate risk in this work.

6.4.2 Personal Construct Theory

The other framework used in this research was PCT. There again, only a partial usefulness of Kelly's PCT appears to be aligned in the empirical findings (see Section 2.7.2). The application of three of the five major PCT corollaries (construction, experience and commonality) appear to be operationalized in the research based on grid interview findings and corporate report narratives.

For example,the *construction* corollary, which describes how people develop internal representations by recognizing recurring patterns in their experience (see Section 2.7.2), appears supported. Individual participants and corporate reports indicated in many cases whether the company had prior experience of climate events, and other climate risk impacts. Sector participants widely expressed their experience and recognition of other climate risks, such as regulatory and governmental risks (e.g. P1.8, P 1.5 and P2.1 in Appendix T, and all constructs categorized as 'risk sources' in Appendix P).

The *experience* corollary, where constructs are 'working hypotheses' about what will happen next support the notion that if constructs fail in predictive power, they are open to amendment in light of new events (see Section 2.7.2). Again, the experience corollary is aligned with empirical evidence in this work. Examples of the experience corollary are produced by participants who acknowledge that existing preferences for managing risks may no longer be effective in the future. Examples of this are found in elicited constructs relating to 'uncertainty' (e.g. constructs P2.6.3, P2.4.4 in appendix P), 'lack of control' (e.g. constructs P1.5.6, P1.5.2, 1.8.5 in Appendix P), and 'unpredictability' (e.g. constructs P1.12, P2.3.3, P2.1.2, P2.3.4, and P2.4.13 in Appendix P). See also P2.2, P2.7 as further examples in Appendix T.

The *commonality* corollary, where individual share constructs with others thus promoting role relations and shared views, appears operationalized in the present study. Examples of this are found in constructs pertaining to collective industry concerns and shared corporate responses to managing climate risks (e.g., constructs 1.3.15, 2.10.14, 1.4.13, 1.5.11, 2.2.5, 2.3.7), As well, the extent of the effect of the commonality corollary is indicated by frequency counts and calculations of proportionality among each of the two study groups (See Tables 5.5, 5.6.).

6.4.3 Organizational Approaches

Berkhout et al. (2006), Bleda and Shackley (2008), and Hoffmann et al. (2009) similarily wrote that management action is informed by managers' views of climate risks, and that these views help in locating influencing factors (of climate risks) inside the organization. The present study has suggested that climate risk impacts also emenate from external forces (other than physical climate change events) suggesting that risk impacts are both exogenous and endogenous in nature. Organizational theorists that promote organizational frameworks for understanding corporate response, may want to consider both external and internal firm level impacts, in discussions about climate change. Theorectical power may be enhanced by examining multiple contexts as climate risks are appearing on multiple fronts. Furthermore, empirical evidence in this work suggests that corporate responses are seen as being shared with other market constituents. Organizational theories may need to accommodate this new phenomenon. The traditional response of corporations to manage risks on their own, may, in fact become outmoded by climate risk impacts. These issues raise questions about the current validity of some organizational theories to explain corporate response to climate change.

6.4.4 Risk Management Framework

This work relied on the lexicon of a typical risk management framework to produce the labelling scheme for categorizing constructs and narrative statements. Mehr and Hedges (1963) spoke of risk management as having essentially three sequential stages of analysis: risk identification, risk assessment and risk response—the universal three stage framework which is still recognized in management practice.

Weinhofer and Busch (2013) spoke of the same general risk management scheme as a metaphor for understanding risk readiness. For one reason or another, organizations may dwell in a particular risk management phase, unable to move onto the next phase. Utilizing a risk management framework for the present study proved to be fruitful for several reasons. Insights were gained into which phase of risk management the participants'constructs related to. Additionally, an understanding was gained into what stage of risk readiness the participants are in, as evidenced by the results of the content analysis of grid and narrative constructs. Moreoever, by identifying which stage of the risk management process participants' constructs were concentrated in, one could infer which risk management phase is still left to be developed. In all, the risk management framework proved to be robust enough in the present study for the above reasons.

6.5 IMPLICATIONS FOR PRACTICE

6.5.1 Analytic State

Findings in the grid and narrative data indicated that individual constructions of climate risks in the studied participant groups are predominantly concerned with analysis and assessment, suggesting at present the sector seems stalled in an analytical state.

The sector participants' preoccupation with assessment can be explained by some of the intrinsic difficulties in climate risk analysis. Estimating the exact timing, frequency and severity of extreme weather events is inherently problematic. Rare climate events have little to no data thus making decision making more difficult. This is consistent with the climate science literature which suggests that climate change is inherently dynamic, non linear and choatic (Daron, 2011). The provision and quality of localized climate data currently does not produce enough information to support decision making in the medium term. Moreover, re-vitalizing Ontario's aging electricity system infrastructure cannot be done without thorough feasibility assessments and careful technical co-ordination, let alone significant capital expenditures and public funding support.

Uncertainty created by fluctuating policy responses to climate change directly influence corporate behaviour and constrain business planning and climate initiatives in this regulated sector. Until such time as capital investment and system-wide infrastructure upgrading are completed, electricity groups may stall in their assessments given technical and governmental uncertainties. Low levels of understanding from external market actors, such as local municipalities and cross border intertie entitites, may delay or indirectly prevent electricity groups from proceeding with pro-active climate response.

Where risks have not been sufficiently identified and appraised in risk management, actionable response is incomplete and compromised. As Weinhofer and Busch (2013) reminded, if the risk analysis stage is incomplete, the organization cannot be viewed as 'risk ready' for moving forward into the actionable phase of risk management. The overall pre-occupation with analysis in the studied sector raises questions about the level of uncertainty and the overall need for more data and information. Analytical stasis and general unreadiness for climate response may also be a function of the formal structure of the sector. Complexity in the institutional environment and the organizational-instrumental explanations given by institutional theorists may explain more (Christensen & Peters, 1999). In Ontario, top-down, prescriptive regulation is evident for power producers and utilities in different ways. Power producers comply with a range of operating contracts to produce electricity on algorithmically based demand management agreements (Winfield & MacWhirter, 2013). Natural gas electricity power producers in particular, are constrained by grid regulation rules to produce specific output levels when called upon by the market grid operator (IESO). This requires natural gas electricity producers to be on standby, and have available generation capacity for peak or base load demands (see glossary). Electricity utilities in Ontario are likewise regulated to perform at pre-determined and increasingly high energy efficiency and conservation standards. Complexities within this regulated sector may well influence actionable climate risk responses. Inderberg (2012) 's work on the Swedish electricity sector called these regulations, rules and lines of command, the formal structure of the industry. Establishing who can do what and how, Inderberg asserted, has an effect on the adaptive capacity of the utility or producer. Christensen and Peters (1999)'s organizational-instrumental perspective suggested these formal structures influence action within the intra- or inter organizational structure and can radically affect different organizational goals (Inderberg, 2012, p. 970).

6.5.2 Government Policy

A key finding in this work suggests that both power producers and utilities uniformly view government policy as the most influential factor affecting their views of future climate risk management. In the narrative data, government policy was identified, and in some cases was conflated with regulatory risk. For example, it was put this way by two participants, one power producer (1.4) and one utility (2.4):

> The introduction of new laws, or other future regulatory developments, may have a material adverse impact on our business, operations or financial condition. Changes of provincial statutes and of regulations in Ontario could have a material effect on our projects. (1.4)

> While the nature of the risks related to climate change such as damage to the corporation's infrastructure as a result of severe storms or flooding, is primarily physical, the risks are also considered regulatory as the corporation is mandated by its regulators to maintain a reliable supply of electricity to its customers. (2.4)

Framing of government policy as a climate risk suggests it is both a stressor and a constraint to the firm's capacity to deal with climate change. This is consistant with Inderberg's (2011) work on the Norweigan electricty sector where he concluded that the nature of the institutional environment was an indicator for the amount of corporate capacity to deal with climate risks. His hypothesis was supported by organizational theory and the 'instrumental perspective' (Christensen & Peters, 1999) which focussed on "the formal structures consisting of the explicit rules and regulations that define who can do what, both between organizations and inside of them" (Inderberg, 2011, p. 2).

How both groups consistantly viewed government policy as the dominant influence/pressure may be explained by the 'organizational field' concept purported by other organizational theorists. DiMaggio and Powell (1983) for example, suggested that where institutional factors not only exist at the individual and organizational levels but span an entire sector, the phenomenon can be viewed as an 'organizational field'. Inderberg (2011) defined it (the organizational field) as a recognizable area of institutional life that includes suppliers, resources, and government and regulatory agencies. These groups are viewed as agents within such fields, sharing a common regulatory framework and a relatively unified governmental structure with congruency and sub-ordination (Scott, 2001).

6.5.3 Climate Data

Power producers pointed to climate (predictive) data in this work as the second most important influence on their views of managing climate risks in the future.While the use of climate data to inform management decision making in electricity sectors is not widely researched, some prior work sheds light on its uses and applications. Climate data in the context of this work refers to probability based forecasts for time periods from three months hence to up to four seasons ahead (Changnon et al., 1995). According to Changnon et al. (1995)'s work on the U.S. power utility market, primary applications of climate forecasts exist in power trading, local forecasting, fuel acquisition and system planning. While the present work does not generalize to the US electricity sector, Changnon et al.'s (1995) survey of 56 decision makers in six U.S. utilities nonetheless showed that only three of the 56 decision makers used forecasts (Changnon et al., 1995, p. 711). Reasons why Ontario power producers viewed climate data as of prime importance to their views of future climate risk management, are still not understood due to paucity of research.

Several reasons may exist however, for why climate data is important for power producers. One may speculate about this by asking three questions: 1.) Are the benefits of climate data are well understood? 2.) Are there current constraints to accessing and using climate data? 3.) Is the current quality of climate data insufficient for decision-making, and related, what types of decision-making are significantly reliant on climate data?

In answering the first two questions, the literature may offer some explanation. Changon et al (1995) noted that hindrances to the use of forecasts at the time of his research were "hard-to understand formats, lack of corporate acceptance and lack of expertise" (Changnon et al., 1995, p. 711). Brekke (2016) asserted that operator training in power plants would benefit from new skills and the discipline of assessing uncertainty in climate projections. Unsurprisingly, these are examples of several climate risk impacts used in this work. Training, knowledge and expertise building as indicated above are reflective of three of the eight climate drivers—organizational resources, technical knowledge and organizational capacity- used in this work.

In answering the third question of what types of decision-making are contingent on climate data, one can look to Cherry et al. (2017) whose work on arctic power plants may offer some explanation. In her work, utilitization of climate data was found to be beneficial for power producers in the area of seasonal prediction, estimation and uncertainty reductionin in both operational and strategic planning.

Cherry et al. (2017) proposed that seasonal climate data of is beneficial at the very least—where managers may not have personal past experience to anticipate necessararily critical operational decisions. She claimed that while climate data and climate models cannot perfectly forecast the climate system, even moderately flawed seasonal forecasting assists in uncertainty reduction in the shorter term. Strategic adaptive measures, according to Cherry (2017) such as licensing processes (i.e. contractual agreements for power provision) may be better negotiated between power producers and governmental and system operators. Moreover, shorter term licenses, which might include operational responses when operating or engineering thresholds are reached could be better negotiated with supporting climate impact estimates given in seasonal climate models. Likewise, Brekke (2016) suggested that licensing structures need to reflect changing and extreme climate states. The impact of climate change impacts, as evidenced by predictive climate data, may well influence formal legal structures of market activity related to contracts, licenses, and agreements between power producers and system operators and regulators. Exisiting contractual agreements between power producers and government may not take into account future climatic states which may exceed currently manageable operating and engineering threshholds.

Brekke (2016) and Cherry et al.'s (2017) reasoning seem intuitively acceptable. Given that planned and exisiting power production plants are worth millions, if not billions of dollars, climate prediction and estimation tools represent a small fraction of the cost of maintaining the facility. Climate data, those authors maintained, is useful for decision-making and can and should be used in risk management as a valuable input. The researcher raises the additional speculation that formal, legal relationships between producers and the governmental authorities which govern Ontario's electricity grids need reviewing, in light of what climate data suggests. Those may be some of the plausible reasons why power producers construed climate data as being highly important to their views of future climate risk management.

6.5.4 Corporate Planning and Strategy

Another empirical finding in this work suggests that risk response measures are construed of by the participants as occuring *within* the organizational context, but *outside* as well. Response statements in corporate reports and grid interviews indicated that many participants are working with external constituents on climate response. Examples given were collaborations on data collection with municipalities, producer and utility participation on community-at-large energy action plans, and ongoing collaboration with university researchers and the provincial regulator (see Appendix T). Findings showed climate action is to be found not just within the organizational context, but with other market actors and institutions. Integrating climate action with other groups has implications for corporate planning and strategy, especially as it might relate to the distinct approaches of the electricity sector.

6.5.5 Integration of Climate Risk Assessments

Consistent with changing organizational boundaries to accommodate collaborative climate response as described above, integration of climate risk assessments with external stakeholders seems blatantly apparent for the sector group. Kloprogge and Van Der Sluijs (2006) referred to 'Integrated Assessment (IA) as an approach to link knowledge and action in a way to accomodate uncertainties and *different perspectives* on climate risks' (Kloprogge & Van Der Sluijs, 2006, p. 359). Utilities and power producers are system partners in critical infrastructure and as such may also look to producing sector wide benefits with integrated approaches to climate risk assessment.

6.6 RECOMMENDATIONS

1. Sector-level consideration should be given to developing a coherent framework for climate risk disclosure for the sector. (At the present time, there is no obligation under existing law to disclose material information of the risk impacts of climate change for Ontario corporations.) However, voluntary disclosures in two areas may offer coherence to a risk reporting framework and yield benefits for the studied groups. The two areas of proposed climate-related disclosure should include the organization's governance of climate risks, and management's approach to managing those risks.

Disclosures related to governance should describe the board's intended oversight of risks as well as its prospective view of management's role in assessing and managing climate risks.

Risk management disclosures should describe how the organization identifies, assesses and manages climate risks. Benefits of disclosures in these two areas are threefold:

(i) Public and private groups may gain better insight into the governance and climate risk management context in which the groups' operating and financial results are achieved;

(ii) The company, internally and externally may improve awareness and understanding of climate risks, resulting in better risk management and more informed strategic planning; and

(iii) External stakeholders and financial groups may have greater confidence that the company's climate related risks are appropriately assessed and managed.

2. Firm-level and sector-level consideration should be given to strengthening information-sharing practices of climate risk management among and between sector participants. This could be done as a joint initiative by the Ontario Distributors' Association and the Association of Power Producers of Ontario, for instance. Corporate governance should provide oversight to these cross- management processes and support inter-group collaborations. Collaborations may raise external stakeholders' awareness and improve collaborative decision-making on such issues as system planning, assurance and infrastructure investments.

3. Firm-level consideration should be given to economic impact analysis of opportunities e.g. innovations, technology, funding programs, which climate risk presents. The suggestion here is that economic decision-making may be enhanced by considering the impact of risk opportunities—inside and outside the organization.

4. Firm-level consideration should be given to improving risk communication frequency and volume, and with larger audiences. Message framing can at least be initially controlled by the firm. Improved understanding of sector climate risk management by multiple constituents could be expected.

Groups which may organize and co-ordinate recommendations one and two include the Ontario Ministry of Energy, the regulatory groups in Ontario, and relevant business associations and their proponents.

Groups which may organize and implement recommendation three may include the participants themselves, in consultation with in house business or economic analysts skilled in the area of economic impact analysis.

Groups which may organize and co-ordinate recommendation four may include in-house corporate communications specialists and external communications advisors.

6.7 LIMITATIONS OF THE STUDY

6.7.1 Case Study Group

Case studies in this work consisted of 20 companies in the electricity sector in Ontario. The power producers selected were natural gas power producers, subject to fossil fuel regulations and therefore subject to more regulation than their nuclear, hydro and renewable counterparts in electricity production. (Utilities selected were homegeneous in characteristics.) Using case studies has its limitations. Limiting the case studies to companies operating in Ontario decreases the generalization to other provinces. The use of Yin’s (2014) concept of replication logic however, provides support for the findings to be generalized to other power producers and utilities in Ontario having similar characteristics. It can be noted that the benefits of using multiple case studies, where theory building with evidence from empirical observations is made, are that they result in theory that is likely to be empirically valid (Eisenhardt, 1989). Furthermore, triangulation of data produced by muliple case studies in the ‘mixed method’ approach used in this work, further helped to improve empirical validity.

6.7.2 Reliability and Generalizeability

Data collection via interviews is not without limitations. Limitations can include personal bias (of the interviewer) and lack of awareness by interviewees (Patton, 2002). Lack of awareness of the climate risk issues among the sector participants was virtually non-existent: interviewees were senior managers or executives with high levels of technical knowledge and organizational authority for decision-making. In any event, the RGT was adopted as the main data collection technique in order to overcome some of these limitations. The RGT is noted for removing interviewer bias (Diaz de Leon & Guild, 2003; Fransella, 2003; Jankowicz, 2004) and assisting in surfacing tacit knowledge of the respondent (Rogers & Ryals, 2007).

Additionally, social desireablity bias-or the interviewee's inclination to produce responses in a favourable light- is reduced with the grid interview technique, which allows the researcher to get underneath the constructs which otherwise the interviewee may view as 'the correct answer' (Easterby-Smith et al., 1996; Jankowicz, 2004). Of greater concern was the researcher's initial contemplation the the participants would express their views to be consistant with the sector regulator, or without the awareness of climate risk issues for the organization. As one measure to reduce respondent bias, the researcher solicited interviewees from senior and executive management, where it was thought the most authoritative management voice would 'unabashedly speak the (unbiased) truth'. As a counterpoint however, it can be mentioned that the researcher was also aware of potential systemic bias among executive respondents. Each interviewee, while presenting themselves as highly informed and technically astute, had the potential for what social scientists refer to as promoting systemic or institutional bias to produce a particular response. The concern was that the executive perspective would reflect a latent collective agenda among the participants.

However, if the respondents were all line managers and *not* executives, questions eliciting their constructs of climate risks would likely have been quite different. More likely, they would have been reflective of their personal but perhaps limited or specialized understanding of the issues related to climate risks. Line managers in the electricity sector function in operationally siloed and specific expertise areas and thus not likely to have the broader strategic view of the organization's challenges. They may have expert knowledge on particular operational matters, but likely little knowledge of the regulatory implications of GHG reporting, as one example.

Data collection via corporate reports is not without its limitations also. Five out of the 10 utilities in this work did not produce their own 2015 annual report, available in public records. As the next best alternative, the researcher looked for the organization's 2015 regulatory report. However, risk disclosures in those five reports were also non existent except for a Note to Reader MD&A, discussed in Section 5.3.3. This work is limited, in effect, by the lack of corporate 'voice' and independent risk reporting from five utilities.

6.7.3 Content Analysis

Content analysis and a form of narrative analysis were used in this study. Critics of these approaches point to researcher subjectivity as a research limitation (Dowling, 2000). To maximize reliability an independent evaluator was used to interpret construct categories in the grid interviews. The independent evaluator was a colleague with the researcher's firm with management expertise in assessing risks in infrastructure projects. A Reliability assessment was taken to reduce researcher bias. The reliability assessment followed reliability procedures reported by Janokowicz (2004) where a reliability table was created and interrater reliability coefficients were calculated. The final Cohen's Kappa was 0.965, indicating over 95% agreement on the construct allocations. Reliability measures of the narrative analysis of corporate reports followed Yin's replication logic for selection of construct categories, element categories and the systematic arrangement af narrative statements produced in corporate reports ultimately presented in Appendix T. The researcher was successful in overcoming the research biases explained above, as indicated in Section 5.2.1. and Appendix Q.

6.8 FURTHER RESEARCH

Institutional constraints

Further investigation into the effects of institutional constraints on the sector would be useful. Both groups pointed to climate policy response as having the greatest influence on how they view managing climate risks in the future. Investigating how and in what ways policy and other forms of governmental behaviour i.e. regulations and other institutional constraints, affect the sector's ability to respond to climate risks would be helpful. Further research into the relevance of climate data and modelling for power producers would also be beneficial. Future research may pose the question of what type of decision making among producers, which viewed it (climate data) as highly relevant, is contingent upon climate data and modelling.

Risk modelling and management

Examining and benchmarking management practices of risk modelling and intergrated management in this sector would provide some insights. Collaborations in this area, between sector participants and other institutions would be constructive for the sector, in light of the data which showed a concern for 'shared responses' to managing climate risks.

Capital investment and financial implications

Research which looks at how climate risks in the sector are perceived by investment and infrastructure finance groups would likely provide insights. Future research may pose the question: In what ways is the impact of climate risk modifying long term financial forecasting principles? Another area of potential research might look at economic impact modelling to quantity what it may cost society if no timely climate risk response is taken in the electricity sector. In other words, what will it cost, if the sector continues to stall in its apparent analytic state at the moment. It would be a useful reference for public policy makers to consider.

Census study

This research included empirical data collection from a portion of the naturual gas segment of electrical power producers. A census approach including every natural gas power producer as well as all other types of electricty generation participants (hydro, nuclear, renewable) would produce sector-wide findings. Apart from relying on different fuel sources, power producers in Ontario share similar corporate characteristics, and mostly use similar generation technologies but all are subject to most of the same regulations and government policies. Investigating how variously exogenous and endogenous pressures are construed by the sector at large would likely provide meaningful insights for energy planners and other constituents.

Further investigation of utilities

The study included participation from 10 utilities, five of which did not produce a public document disclosing business risks. Further research might be undertaken to triangulate grid interview findings with a management questionnaire or a more ethnographic style of research inquiry for respondents in that group.

Consequences to energy security and supply

Consideration should be given to research on the implications of unmanaged climate risks on energy supply and energy security. Unmanaged risks may threaten electricity production and distribution over longer terms than just one day or a week-long ‘severe weather event’. Research on energy supply security in Europe has looked at financial dimensions (Chalvatzis & Ioannidis, 2017), the effect of financial incentives and policies to improve energy security (Metcalf, 2014), and the growth of smart grid technology to improve the security of electricity supply (Clastres, 2011). In those cases, proactive practices were assessed for the effect they (proactive practices) had on preserving energy security.

Linking cognition with decision making

Observing longitudinal changes in management thinking about climate risks may yield useful findings in this sector, and others. Comparing management cognitions with actual climate risk decision making ex-post, may produce further intriguing findings and contribute to theory. The construct of forced response—as in, ‘we must do something’ and the extent to which the precautionary principle is utilized is another area of future research. Noting how the sector evolves, if at all, in its thinking about climate risk management would provide potentially exemplary models of how other industries or sectors might (or might not) decide to respond to climate risks.

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PILOT APPENDIX A

24 February 2017

To whom it may concern

Re: Doctoral study by Anna Dowbiggin, Student #12833-96-09

I can confirm that Anna Dowbiggin is registered on the DBA programme at Edinburgh Business School, Heriot-Watt University, Edinburgh.

Anna is currently working on her doctoral research thesis entitled ' Climate Risks in the Electricity Sector' under the supervision of Professor Devi Jankowicz. Anna's field work is being conducted in Canada and her preferred email address is amdowbiggin@gmail.com.

Anna's research is subject to University guidelines on research ethics and confidentiality. I hope you are able to offer her any assistance you can in this stage.

If any further information is required please do not hesitate to contact me on +44

(0)131 451 3090 or ac@ebs.hw.ac.uk.

Yours sincerely

Adrian Carberry

PILOT APPENDIX B

Anna Dowbiggin, Doctoral candidate

Edinburgh Business School, Heriot Watt University, Scotland UK

....
....
....
....By email (date, 2017) to:

Dear:

<u>Re: Interview request, regarding Doctoral research</u>

I am a doctoral student with the Edinburgh Business School, Scotland UK, conducting interviews for my dissertation topic, 'Climate Risk Perceptions in the Canadian Electricity Sector'. My research objective is to understand (not hypothesize or test) climate risk perceptions among gas fired power producers and transmission/utilities companies operating in Ontario. *In short, I'm interested in exploring what Ontario companies think about the effects of climate change and the full spectrum of the indirect and direct impacts of climate change on operations*. My intent is to build on the existing scholarly research on climate risk perceptions for utilities already done in the UK, European Union and Australia.

To this end, I need to conduct a series of in-person interviews, to run through a series of questions, and to ask for an opinion on an overarching question. All time taken would be 60 minutes.

Confidentiality and Anonymity

As a post graduate researcher, I comply with the Ethical Standards and Guidelines at Edinburgh Business School, and ensure steps are taken to ensure confidentiality and anonymity for the participant and his/her organization, through anonymized coding of corporate names, and confidentiality of all participants between and among them.

I will phone you directly in the next day or so to determine your availability for an interview and your suggestions for additional people at ________. If you have questions, please ask; I can be reached at 416 817 4399. *Please note that Dave Butters of APPrO and Francis Bradley of the CEA (see his attached letter of support) have given me their organization's acknowledgement and explicit support.* It is anticipated that the findings from my doctoral study will inform policy and practice and assist in the process of advancing corporate adaptation measures for future climate change in Canada.

Anna Dowbiggin, BA, MBA, DBA candidate

PILOT APPENDIX C

REPERTORY GRID INTERVIEW TEMPLATE

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2		1 The purposeof this grid is *to understand the different ways in which you view the risks associated with climate change, in terms of how you expect to respond/manage them in your organization.* 2. Our focus is on discussing *how climate impacts influence your expected response and management of climate risks* 3. Review Elements	BUSINESS CONTINUITY	RELIABLE CLIMATE PREDICITVE DATA	GOVERNMENT CLIMATE POLICY	GHG AND EMMISSIONS ABATEMENT	TECHNICAL KNOWLEDGE	AGING UTILITY INFRASTRUCTURE	ORGANIZATIONAL CAPACITY	ORGANIZATIONAL RESOURCES			4. Notes: Signature box Confidentiality and anonymity are assured; collected data is coded for eventual dissertation publication. Please initial this box to provide consent. Thank you.	
3		6. ELICIT CONSTRUCTS	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	RATE CONSTRUCT BY CONSTRUCT	IMPORT
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16		7. ON COMPLETION OF ALL CONSTRUCTS (OPTIONAL) RATE EACH CONSTRUCT ON IMPORTANCE 1 = MORE IMPORTANT, 5 = LESS IMPORTANT												
17														

PILOT APPENDIX D

Canadian Electricity Association | Association canadienne de l'électricité

Letter of Support

Anna Dowbiggin, MBA,
Doctoral Candidate, Business Administration
Edinburgh Business School
Heriot Watt University
Scotland, UK

To whom it may concern:

CEA supports a research project being planned by Anna Dowbiggin that would provide information as to how Ontario natural gas electricity generators and distributors/transmitters perceive the operational risks associated with climate change. Ms. Dowbiggin has lectured at Ryerson and Schulich Business School and is formerly a business consultant in the mining and health care field. She has had a professional history with Goldcorp, Ontario Ministry of Health and Osgoode Hall Law School.

The findings from this research project will provide valuable insight into the impact that climate risks have for our industry in terms of the way in which our members perceive them.

To that end, we encourage your participation in the grid interview process which will take approximately one hour of your or your designate's time.

Best Regards,

Francis Bradley
Chief Operating Officer
Canadian Electricity Association

275 Slater Street, Suite 1500
Ottawa, Ontario K1P 5H9

275, rue Slater, bureau 1500
Ottawa (Ontario) K1P 5H9

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www.electricity.ca

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25 Adelaide Street East, Suite 1602
Toronto, ON M5C 3A1 Canada

416.322.6549 F. 416.481.5785
www.appro.org appro@appro.org

APPrO
ASSOCIATION OF POWER PRODUCERS OF ONTARIO

March 30, 2017

Dear APPrO member,

Re: Letter of Support

The Association of Power Producers in Ontario offers its acknowledgement and support for Anna Dowbiggin of Edinburgh Business School for her PhD research on how electricity producers view climate change impacts on their operations.

APPrO views this research as being helpful in understanding how the industry at large views climate risks. We anticipate that the findings from her doctoral work will help to inform policy and practice and assist in the process of advancing corporate adaptation measures for future climate change in Canada.

We encourage you to participate in her study.

Sincerely,

David Butters
President & CEO

PILOT APPENDIX F

P1 (generation co.) REP GRID

Display G-1
"DBA pilot"

Left pole	Direct Sudden Physical Climate Impacts	Climate Predictive Data	Government Climate Policy	GHG abatement + emissions control	Technical Knowledge	Aging Infrastructure	Organizational Capacity	Organizational Resources	Right pole
Focus on Knowledge Retention	1	4	2	3	4	1	5	5	Focus on knowledge Acquisition
Business Continuity	1	5	3	3	4	1	2	2	Outcomes unknown
Well documented, rigorous process	4	1	2	3	4	1	5	5	not well documented process
Knowledge capture	3	1	3	2	4	1	5	5	Knowledge leakages (retirements, turnover)
Process control of risk management systems	4	2	3	3	4	1	4	5	Weak control
Time horizon- immediate and short term	3	3	1	1	2	1	5	4	Mid to longer term
Established planning process	5	3	3	2	5	1	5	5	more planning needed
Preventative maintenance	5	5	4	2	1	1	3	3	Fix and re-start (resilience)
proactive management of impacts	5	5	4	2	1	1	3	3	reactive
endogenous impact	5	4	5	5	1	3	2	2	exogenous impact
corporate initiative	3	3	4	5	1	2	1	1	regulatory compliance
business decision	2	2	4	5	1	3	1	1	mandated change
specialized skills	5	4	4	4	2	2	3	1	elevate knowledge across the organization
risk governance	1	2	5	4	3	4	2	2	status quo
investment in resources	1	4	5	5	2	4	3	1	carry on with status quo
more capital investments	2	4	5	3	4	1	1	2	do nothing
new system boundaries	1	3	2	3	1	5	5	4	old paradigm
GREATEST INFLUENCE ON RISK MANAGEMENT	2	1	3	5	2	5	4	4	WEAKEST INFLUENCE ON RISK RESPONSE

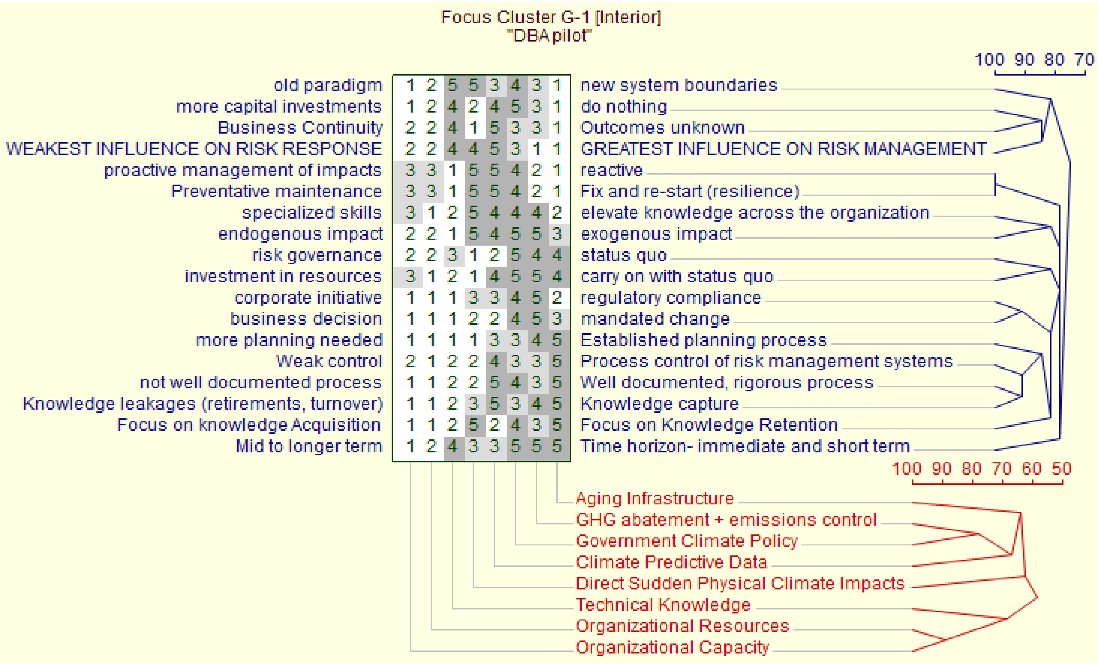
P2 (distribution co.) REP GRID

Display DT 1
"DBA THESIS"

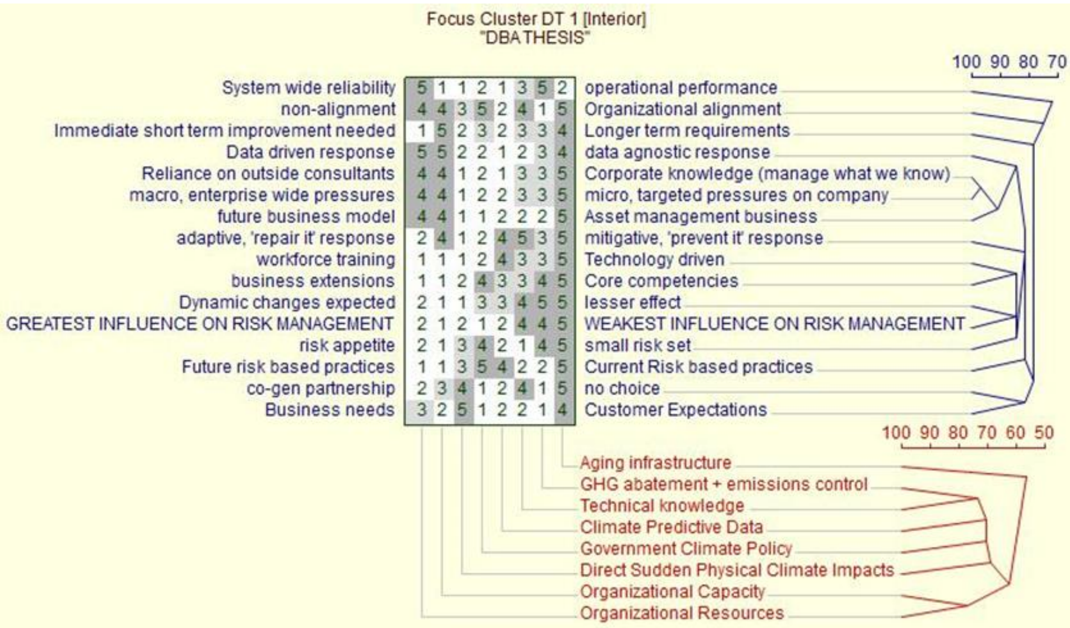
Left pole	Direct Sudden Physical Climate Impacts	Climate Predictive Data	Government Climate Policy	GHG abatement + emissions control	Technical knowledge	Aging infrastructure	Organizational Capacity	Organizational Resources	Right pole
Data driven response	2	1	2	3	2	4	5	5	data agnostic response
Dynamic changes expected	1	3	3	5	4	5	1	2	lesser effect
Reliance on outside consultants	1	1	2	3	3	5	4	4	Corporate knowledge (manage what we know)
Immediate short term improvement needed	2	2	3	3	3	4	5	1	Longer term requirements
Current Risk based practices	3	2	1	4	4	1	5	5	Future risk based practices
Core competencies	4	3	2	2	3	1	5	5	business extensions
Technology driven	5	2	4	3	3	1	5	5	workforce training
Asset management business	5	4	5	4	4	1	2	2	future business model
Customer Expectations	1	4	5	5	4	2	4	3	Business needs
System wide reliability	1	1	2	5	3	2	1	5	operational performance
macro, enterprise wide pressures	1	2	2	3	3	5	4	4	micro, targeted pressures on company
adaptive, 'repair it' response	1	4	2	3	5	5	4	2	mitigative, 'prevent it' response
Organizational alignment	3	4	1	5	2	1	2	2	non-alignment
co-gen partnership	4	2	1	1	4	5	3	2	no choice
risk appetite	3	2	4	4	1	5	1	2	small risk set
GREATEST INFLUENCE ON RISK MANAGEMENT	2	2	1	4	4	5	1	2	WEAKEST INFLUENCE ON RISK MANAGEMENT

PILOT APPENDIX G

P1 (power producer) CLUSTER



P2 (utility) CLUSTER



PILOT APPENDIX H

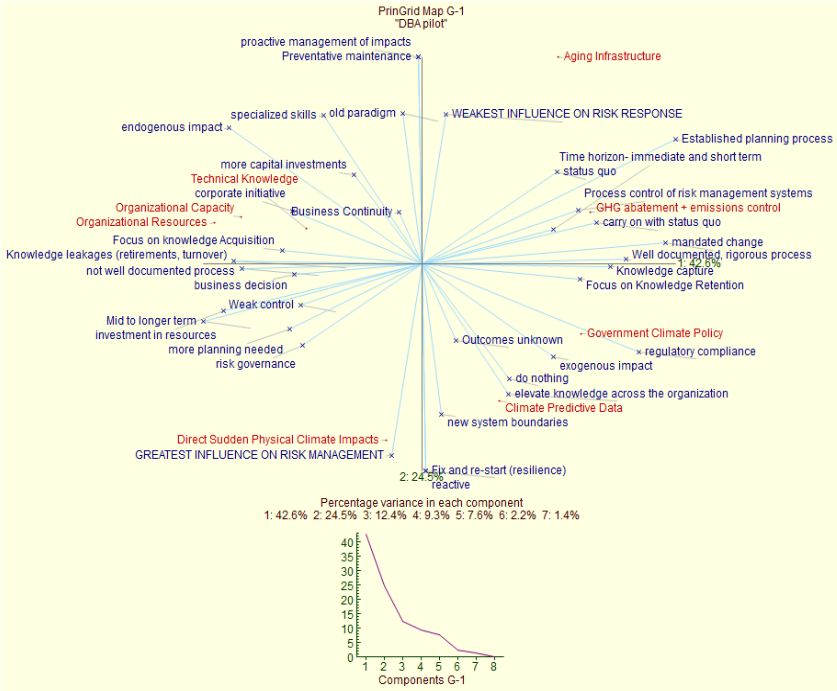
PILOT CLUSTER ANALYSIS OF CONSTRUCTS, ELEMENTS

Pilot Interview	Cluster	Cluster% Level of Similarity	Construct
P1	**A**	**95%**	**Weak control—process control over risk management systems** Not well documented process-well documented, rigorous process Knowledge leakages (retirements and turnovers)-knowledge capture
	B	**95%**	**Corporate initiative—regulatory compliance** Business decision- mandated change
	C	**85%**	**Business continuity—outcomes unknown** Weakest influence on risk management –greatest influence on Risk management
	D	**80%**	**Specialized skills—elevate knowledge across the organization** Endogenous impact- exogenous impact
	E	**80%**	**Risk governance—status quo** Investment in resources- carry on with status quo
P2	**A**	**97%**	**Reliance on outside consultants—corporate knowledge (manage with what we know)**
	B	**85%**	**Workforce training—technology driven** Business extensions –core competencies
	C	**85%**	**Greatest influence on risk management –weakest influence on risk management** Risk appetite—small risk set
	D	**85%**	**Co-power producers partnerships—no choice** Business needs—customer expectations

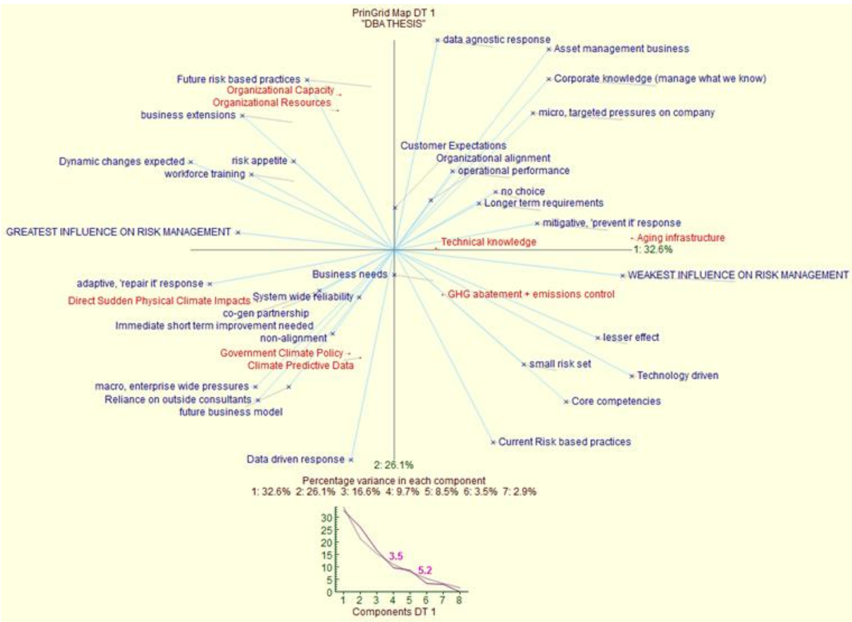
Pilot Study Interviews- Cluster Analysis Summary of Elements			
Pilot Interview	**Cluster**	**Cluster% Level of Similarity**	**Element**
1	**A**	**90%**	**Organizational resources—organizational capacity**
	B	**80%**	**GHG abatement+ emissions control—government climate policy**
2	**A**	**80%**	**Organizational capacity—organizational resources**
	B	**75%**	**GHG abatement + emissions control technical knowledge**

PILOT APPENDIX I

P1 (power producer) PRINCIPAL COMPONENT ANALYSIS



P2 (utility) PRINCIPAL COMPONENT ANALYSIS



PILOT APPENDIX J MATCHING SCORES

% Similarity with 'Overall, greatest influence versus weakest influence on risk management'

Construct	Sum of Difference	% Similarity	Sum of Difference (reversed)	% Similarity	Final % Similarity	Construct	Sum of Difference	% Similarity	Sum of Difference (reversed)	% Similarity	Final % Similarity
P1.1	15	53	17	59	59	P2.1	13	59	15	59	59
P1.2	17	47	11	84	84	P2.2	15	84	11	34	84
P1.3	13	59	17	59	59	P2.3	10	69	14	50	69
P1.4	12	63	16	63	63	P2.4	10	69	12	56	69
P1.5	12	63	14	69	69 r	P2.5	12	63	12	63	63
P1.6	14	56	18	63	63 r	P2.6	18	44	16	81	81 r
P1.7	17	47	13	66	66 r	P2.7	19	41	13	13	78 r
P1.8	18	44	12	75	75 r	P2.8	14	56	6	69	69 r
P1.9	18	44	12	75	75 r	P2.9	15	53	8	66	66 r
P1.10	15	53	9	59	59 r	P2.10	11	66	11	41	66
P1.11	14	56	12	56	56	P2.11	9	72	15	53	72
P1.12	5	66	13	47	66	P2.12	9	72	15	47	72
P1.13	15	53	11	66	66 r	P2.13	11	66	11	59	66
P1.14	11	66	11	53	66	P2.14	7	78	15	47	78
P1.15	11	66	13	47	66	P2.15	7	78	11	47	78
P1.16	8	44	6	75	75 r						
P1.17	8	75	20	38	75						

PILOT APPENDIX K

CONTENT ANALYSIS PARTICIPANT #1 (POWER PRODUCER)

Category	Constructs	No.,%	% Similarity	H.I. L.
Identification		**5,67.6%**		
	P1.12 Business decision–mandated change		**66**	**I**
	P1.6 Time horizon—short to long term		**63 r**	**I**
	P1.10 endogenous—exogenous impacts		**59 r**	**I**
	P1.14 Risk governance—paradigm change		**66**	**I**
	P1.2 Business continuity—outcome unknown		**84**	**H**
Assessment		**7,65.3%**		
	P1.1 Knowledge retention —acquisition		**59**	**I**
	P1.3 Documentation		**59**	**I**
	P1.5 Process control—weak control		**69 r**	**I**
	P1.7 Planning process—more planning		**66 r**	**I**
	P1.13 Specialized skills—elevate knowledge		**66 r**	**I**
	P1.17 System boundaries		**75**	**H**
	P1.4 Knowledge capture—leakages		**63**	**I**
Response		**5,69.4%**		
	P1.8 Preventative maintenance—fix, restart		**75 r**	**H**
	P1.9 Proactive management—reactive		**75 r**	**H**
	P1.15 Investment in resources		**66**	**I**
	P1.16 Capital investments—do nothing		**75 r**	**H**
	P1.11 Corporate initiatives		**56**	**I**

PILOT APPENDIX L

CONTENT ANALYSIS PARTICIPANT #2 (UTILITY)

Category	Constructs	No.,%	% Similarity	H.I. L.
Identification		3,74.0%		
	P2.11 Enterprise-wide impacts		72	H
	P2.2 Dynamic change		84	H
	P2.13 Organizational alignment		66	I
Assessment		5,72.0%		
	P2.15 Risk appetite		78	H
	P2. 3 Reliance on outside consultants		69	I
	P2.9 Business needs—customers' expectations		66 r	I
	P2.6 Business extensions –core competencies		81 r	H
	P2.10 System-wide reliability		66	I
Response		7,69.7%		
	P2.1 Data-driven response		59	I
	P2.4 Immediate improvements		69	I
	P2.12 Adaptive repairs		72	H
	P2.8 Business model—asset management		69 r	I
	P2.5 Current risk practices		63	I
	P2.14 Co-gen partnerships		78	H
	P2.7 Workforce training—technology		78 r	H

PILOT APPENDIX M

CONTENT ANALYSES—HONEY METHOD

Category	Power producer	% Similarity	Utility	% Similarity
Identification				
	Business decision	66	Enterprise-wide impact	72
	Time Ho rizon	63	Dynamic changes	84
	Endogenous impacts	59	Organizational alignment	66
	Risk governance	66		
	Business continuity	84		
	5	67.6%	3	74.0%
Assessment	Knowledge retention	59	Risk appetite	78
	Documentation	59	Outside consultants	69
	Process control	69	Customer expectations	66
	Planning process	66	Core competencies	81
	Specialized skills	66	System-wide reliability	66
	New system boundaries	75		
	Knowledge capture	63		
	7	65.3%	5	72.0%
Response	Preventative maintenance	75	Data-driven response	59
	Proactive stance	75	Immediate improvement	69
	Corporate initiatives	56	Adaptive repair	72
	Investment in resources	66	Asset management	69

Capital investments	**75**	**Current risk practices**	**63**
5	**69.4%**	**Co-gen partnerships**	**78**
		Technology workforce	**78**
		7	**69.7%**

PILOT APPENDIX N

Worked Example—Narrative Analysis, P1 Sustainability Report

Themes	Recording Unit	Construct	Sample Unit
Corporate strategy	"OPG has identified climate change adaptation and extreme weather as a strategic risk for the company."	Identification	#1 Page 22, 2015 Environment Report
Targeted impacts, vulnerability	"Changes in precipitation patterns water temperatures and ambient air temperatures can impact the availability of water resources, which could affect power production at thermal station".	Identification	#2 Page 22 2015 Environment Report
Impact scope	' "Unusual or unpredictable weather has the potential to damage electricity power producers and transmission infrastructure."	Identification	#3 Page 22 2015 Environment Report
Temporal considerations, Monitoring, Reliance on experts, Policy, Adaptation models	"To date OPG has not experienced impacts attributable to climate change but it is recognized that efforts are required to assess the short and long term risks and to monitor for developments in climate science, adaptation activities and potential changes to policy and regulatory requirements."	Assessment	#4 Page 22 2015 Environment Repo
Governmental relations, Cooperation, Infrastructure coordination ,Knowledge sharing	"During 2015, OPG continued its participation in climate change adaptation initiatives with municipal and regional governments, the Ontario Ministry of the Environment and Climate Change, the Ontario Ministry of Energy and Natural Resources Canada."	Response	#5 Page 22 2015 Environment Report
Themes	**Recording unit**	**Construct**	**Sample Unit**
Impact description, risk set	'The frequency and intensity of extreme weather, as opposed to the changing climate, is the greater concern for the electricity sector.'	Response	#6 Page 22 2015 Environment Report
System-wide reliability, system vulnerability	'Further, transmission and utilities infrastructure is more exposed to the elements and therefore at greater risk than power producers infrastructure in Ontario'.	Response	#7 Page 22 2015 Environment Report

Ontario Power Generati X

www.opg.com/reports/Pages/Intro.aspx

	Facilities that emit the equivalent of 50,000 tonnes or more of greenhouse gases in CO_2 equivalent units per year are required to report under Environment Canada's Greenhouse Gas Emissions Reporting Program.	
	Emissions from auxiliary boilers at thermal stations. Includes emissions from operating and retired stations.	35,048
Nuclear	Nuclear power plants do not emit CO_2 as part of the power generation process. However, OPG's nuclear sites have standby generators to provide backup electrical power to the stations if required. These generators are routinely tested to ensure their availability.	17,607
Hydro, Wind	Hydroelectric stations and wind power turbines do not emit CO_2 as part of the power generation process.	0

Climate Change Adaptation

corporate strategy ← (1) OPG has identified climate change adaptation and extreme weather as a strategic risk for the company. (2) Changes in precipitation patterns, water temperatures, and ambient air temperatures can impact the availability of water resources, which could potentially affect power production at hydroelectric stations and cooling water efficiency at nuclear and thermal stations. (3) Unusual or unpredictable weather has the potential to damage electricity generation and transmission infrastructure.

targeted impacts
vulnerability

impact scope

(4) To date, OPG has not experienced impacts attributable to climate change, but it is recognized that efforts are required to assess the short and long-term risks and to monitor for developments in climate science, adaptation activities, and potential changes to policy and regulatory requirements.

Temporal considerations
monitoring
Reliance on experts
Policy
Adaptation Models

(5) During 2015, OPG continued its participation in climate change adaptation initiatives with municipal and regional governments, the Ontario Ministry of the Environment and Climate Change, the Ontario Ministry of Energy, and Natural Resources Canada. OPG is a member of the Canadian Electricity Association (CEA) Adaptation Working Group as well as the Durham Region Roundtable on Climate Change.

governmental relations
co-operation
infrastructure co-ordination
knowledge sharing

OPG also continues to work with the CEA member companies, non-government organizations, and government to better define adaptation requirements through analysis and understanding of climate change impacts on watersheds and electricity supply and demand.

(6) The frequency and intensity of extreme weather, as opposed to the changing climate, is the greater concern for the electricity sector. (7) Further, transmission and distribution infrastructure is more exposed to the elements and therefore at greater risk than generation infrastructure in Ontario.

(6) impact description
risk set
(7) system-wide reliability
system vulnerability

Back to T

NUCLEAR EMISSIONS
2015 SUSTAINABILITY REPORT

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APPENDIX P

CONTENT ANALYSIS TABLE

Column Heading Key

Category (Count, Percent) The category is the theme or categorization of the constructs from the core-categorization procedure. The count is the number of constructs in this category, and the percent is the percentage of constructs out of the total 324 elicited constructs.

Code The code is the participant code followed by the interview number followed by construct's number (e.g. P1. 10.6 is the sixth construct from the tenth interview, from the participant group #1)

Construct The construct is the elicited construct from RGT interviews.

Per Cent Similarity Score The percent similarity score or percent matching score involves computing the sum of differences for each element rating between each elicited construct and the supplied overall construct (e.g. how closely the construct matches the supplied overall construct).

H-I-L Value The H-I-L Value is the High-Intermediate-Low value from Honey's (1979) technique using percent similarity scores to divide constructs into thirds for each interview.

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
RISK SOURCE (23, 7.10%)	P1.1.3	proof-based	⇔	not proof based	78	H
	P1.1.4	science-based	⇔	not necessarily science based	66	I
	P1.4.1	local carbon footprint	⇔	worldwide footprint	69	L
	P1.5.5	driven by natural environment	⇔	driven by organization	75	L
	P1.5.9	external risk	⇔	internal risk	85	H
	P1.6.1	acts of nature	⇔	acts of government	72	I
	P1.6.2	government intervention	⇔	no intervention	56	L
	P1.7.1	regulatory uncertainty	⇔	climate uncertainty	81	I
	P1.7.2	direct compliance risk	⇔	indirect compliance risk	50	H

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P1.7.10	behaviour of government	⇔	behaviour of climate	72	L
	P1.7.11	data-driven	⇔	not data driven	75	I
	P2.2.1	operational	⇔	financial	69	I
	P2.3.10	priority risk	⇔	non-priority risk	85	H
	P2.3.16	data driven	⇔	less data driven	69	I
	P2.4.2	data driven	⇔	less data	81	H
	P2.5.8	internal	⇔	external	69	H
	P2.7.6	data driven	⇔	event driven	72	I
	P2.6.12	weather uncertainty	⇔	regulatory uncertainty	81	H
	P1.8.1	operational risk	⇔	regulatory risk	62	I
	P1.8.3	non-contractual risk	⇔	contract risks	56	L
	P1.8.16	plant footprint	⇔	larger carbon footprint	85	H
	P2.4.1	small carbon footprint	⇔	large carbon footprint	60	L
	P2.5.10	company carbon footprint	⇔	larger footprint	81	H
	P1.7. 2	direct compliance risk	⇔	indirect compliance risk	88	H
	P1.1.1	physical phenomenon	⇔	non- physical phenomenon	69	I
	P1.2.1	short term	⇔	longer term	78	H
	P1.3.1	physical manifestation	⇔	non-physical manifestation	72	L
	P1.3.2	emerging issue	⇔	corporate manifestation	62	L
	P1.3.3	event driven	⇔	ability driven	66	L
	P1.3.4	current state	⇔	future state	81	L
RISK EFFECT	P1.4.14	beyond our control	⇔	internal control	56	L
(38, 11.73%)	P1.4.16	slow change	⇔	dynamic change	78	H
	P1.5.1	physical impact	⇔	financial impact	53	L
	P1.5.3	effects	⇔	financial effects	60	I
	P1.6.9	compounding effect	⇔	non-compounding effect	69	L
	P1.7.4	near term	⇔	longer term	66	L
	P1.8.4	paramount concern	⇔	lesser concern	69	L
	P1.8.18	forward looking	⇔	day to day	62	I

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P2.1.1	short term	⇔	long term	69	H
	P2.2.7	risk intensity changes	⇔	status quo	75	H
	P2.2.8	short term	⇔	longer term	81	H
	P2.3.2	immediate	⇔	lower relevance	78	H
	P2.5.6	new problem	⇔	historical problem	66	L
	P2.5.2	faster impact	⇔	slower impact	72	H
	P2.5.7	immediate challenge	⇔	status quo	62	L
	P1.9.3	slow-moving	⇔	acute	69	I
	P2.5.12	short term	⇔	long term	62	I
	P2.5.16	short term	⇔	long term	66	L
	P2.7.1	sudden events	⇔	gradual efforts	81	H
	P2.7.8	more immediate	⇔	future focus	78	H
	P2.8.1	end state	⇔	present state	78	I
	P2.8.7	long term	⇔	short term	72	L
	P2.9.3	future scenario	⇔	historical data	72	I
	P2.10.1	data dependent	⇔	data agnostic	60	L
	P2.6.1	tangible effect	⇔	non-tangible effect	85	H
	P2.6.8	slower response	⇔	faster response	72	I
	P2.6.9	slow change	⇔	quicker response	72	I
	P2.6.16	significant	⇔	potentially significant	66	I
	P2.6.19	unknown effect	⇔	known effect	66	I
	P2.10.2	dynamic changes expected	⇔	lessor effect	85	H
	P2.1.9	not core	⇔	core to business	75	H
	P.2.5.1	direct operational impact	⇔	indirect operational impact	69	I
RISK CHARACTERISTICS (59,19.21%)	P1.1.2	Predictable	⇔	not predictable	91	H
	P1.1.8	not a barrier to mitigation	⇔	barrier to risk mitigation	62	L
	P1.1.9	key driver to risk management	⇔	not (necessarily) key driver to risk mgmt.	75	H
	P1.1.15	strategic	⇔	not strategic	75	H
	P1.1.18	impact on resources	⇔	impact on reliability	60	L

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P1.2.3	control	⇔	no control	85	H
	P1.4.11	in control	⇔	no control	72	I
	P1.4.15	wild card effect system	⇔	manageable	72	I
	P1.5.6	beyond our control	⇔	in our control	81	I
	P1.5.7	restrictive constraints	⇔	not restrictive	85	I
	P1.5.12	within our control	⇔	partially / completely outside control	75	L
	P1.5.15	cannot control	⇔	ability to influence	50	L
	P1.6.13	large risk set	⇔	small risk set	62	I
	P1.7.3	wild cards	⇔	clear sight	78	I
	P1.8.2	influenced by public groups	⇔	not influenced by public groups	56	L
	P1.8.5	sound technical control	⇔	less-sound technical control	62	L
	P1.8.6	urgent need	⇔	not as urgent	78	I
	P1.8.9	people focus	⇔	tech focus	75	I
	P1.8.11	criticality	⇔	less urgent	75	I
	P1.8.13	risk priority	⇔	less prioritized	72	H
	P2.3.3	predictable	⇔	unpredictable	69	I
	P2.10.11	macro, enterprise wide pressures	⇔	micro, targeted pressures	72	L
	P1.8.15	'can happen'	⇔	'will happen'	66	I
	P1.9.4	sequential bundled impacts	⇔	may not be affected	78	H
	P1.10.6	timing: short term	⇔	long term	62	L
	P1.10.10	endogenous pressure	⇔	exogenous pressure	60	L
	P2.1.2	better prediction	⇔	poor prediction	75	I
	P2.1.4	predictable measure	⇔	unpredictable	75	L
	P2.1.7	operational impact	⇔	non-operational impact	69	H
	P2.1.8	risk amplification	⇔	no amplification of risk	72	H
	P2.1.10	controllable	⇔	not controllable	72	L
	P2.2.2	can control	⇔	cannot control	72	I
	P2.2.6	predictable	⇔	uncertain	62	I
	P2.3.1	day to day	⇔	broader bush	75	H
	P2.3.4	predictable	⇔	unpredictable	81	H

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P2.3.17	relevance of data	⇔	lower quality data	78	H
	P2.4.16	risk opportunity	⇔	negative risk	75	I
	P2.4.13	not predictive	⇔	predictive	62	L
	P2.4.14	uncertainty	⇔	more certain	66	I
	P2.4.15	uncertainty	⇔	more certain	69	L
	P2.4.17	quality metric	⇔	poor data	69	I
	P2.4.18	reliance on data	⇔	less reliance on data	66	L
	P2.4.20	rational	⇔	not rational	78	I
	P2.5.5	relevance	⇔	not relevant	62	I
	P2.5.11	ability to impact	⇔	can't do much	62	I
	P2.7.2	data support	⇔	lack of data	78	H
	P2.7.11	internal control	⇔	less control	56	L
	P2.8.3	risk opportunity	⇔	negative risk	81	H
	P2.8.13	political concern	⇔	customer concern	75	H
	P2.8.15	policy drivers	⇔	data influence	78	H
	P2.9.5	metrics	⇔	lack of metrics	81	H
	P2.9.7	opportunity	⇔	status quo	72	I
	P2.9.15	poor data quality	⇔	sufficient data quality	69	I
	P2.10.3	reliance on outside consultants	⇔	corporate knowledge	69	L
	P2.6.2	prediction	⇔	historical evidence	75	H
	P2.6.3	physical uncertainty	⇔	political uncertainty	88	H
	P2.6.6	control	⇔	much less control	72	L
	P2.6.10	data driven	⇔	not data driven	72	I
	P2.6.11	control	⇔	no control	66	L
	P2.4.2	data driven	⇔	less data	81	H
RISK CONSEQUENCES (107, 33.02%)	P1.1.5	relatively easy design solution	⇔	harder to design solutions	62	L
	P1.1.6	policy solution	⇔	technical solution	69	L
	P1.1.7	technical solution	⇔	independent of technical solution	72	I
	P1.1.17	system constraint	⇔	not a system constraint	56	L

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P1.2.4	weak talent	⇔	strong talent	75	I
	P1.2.12	today's operation	⇔	new business model	78	I
	P1.3.5	talent management	⇔	non-human resource issue	81	H
	P1.3.13	business decisions	⇔	stakeholder influence	88	H
	P1.3.14	ongoing operability	⇔	event based operability	66	L
	P1.4.4	old/limited technology	⇔	newer technology	75	H
	P1.4.5	cost effectiveness	⇔	not efficient	75	H
	P1.4.6	plant economics	⇔	system economics	66	L
	P1.4.8	regulatory pressure	⇔	our decision	60	L
	P1.4.12	concern for old assets	⇔	concern for new assets	72	I
	P1.5.2	don't have expertise	⇔	expertise	72	H
	P1.5.8	longer term cost impact	⇔	one-off cost	85	H
	P1.5.10	positive effect on reliability	⇔	negative effect on reliability	72	I
	P2.7.4	direct impact on risk management	⇔	less direct impact on risk management	72	I
	P1.6.3	technical assessment	⇔	treatment of a process	72	I
	P1.6.4	human capital	⇔	physical assets	62	L
	P1.6.5	financial resiliency	⇔	operational resiliency	78	H
	P1.6.6	involves people+ technology	⇔	people only	81	H
	P1.6.7	capital investments	⇔	compliance costs	75	I
	P1.6.8	strategic resources	⇔	non-aligned resources	78	H
	P1.6.10	immediate financial implications	⇔	future financial implications	78	H
	P1.8.17	choice	⇔	no choice	85	H
	P1.6.11	specific forecasting	⇔	general planning	85	H
	P1.6.12	cannot accommodate regulatory uncertainty	⇔	ability to accommodate regulatory uncertainty	66	I
	P1.7.5	business forecasting	⇔	scenario planning	78	L
	P1.7.6	asset management	⇔	unknown asset management	85	H
	P1.7.7	attempt to influence	⇔	no attempt to influence	88	H
	P1.7.8	in house resources	⇔	outside resources	60	L
	P1.7.9	financial planning	⇔	operational planning	75	L
	P1.7.14	climate indifference	⇔	business case	88	H

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P1.8.7	no lifecycle consideration	⇔	lifecycle consideration	69	L
	P1.8.8	facility management	⇔	system management	72	H
	P1.8.10	certain economic impact	⇔	uncertain eco impact	62	L
	P1.8.12	alignment with strong control measures	⇔	non-alignment low control	50	I
	P1.9.2	change	⇔	status quo	72	H
	P1.9.5	direct wholesale exposure	⇔	non-direct, specific exposure	69	L
	P1.9.6	no choice	⇔	we can choose	66	L
	P1.9.7	affects our business model	⇔	does not affect our business model	66	L
	P1.9.8	residual effect	⇔	main effect	66	I
	P1.9.9	internal expertise	⇔	outside expertise	75	I
	P1.9.10	core competency	⇔	additional skills	75	H
	P1.9.11	limited stakeholder involvement	⇔	increased stakeholder involvement	78	H
	P1.10.1	focus on knowledge retention	⇔	knowledge acquisition	60	L
	P1.10.3	well documented, rigorous process	⇔	not well documented	60	I
	P1.10.4	knowledge capture	⇔	knowledge leak	62	I
	P2.4.3	revenue impact	⇔	operational impact	69	I
	P1.10.5	Process control of r.m.	⇔	Weak control of r.m.	69	I
	P1.10.7	established planning process	⇔	more planning needed	66	L
	P1.10.11	corporate initiative	⇔	regulatory compliance	60	I
	P1.10.12	business decision	⇔	mandated change	66	L
	P1.10.15	invest in resources	⇔	carry on status quo	75	H
	P2.1.3	future planning	⇔	today’s planning	60	I
	P2.1.5	talent retention	⇔	replaceable	72	L
	P2.1.6	legacy tools	⇔	new tools	81	I
	P2.2.3	old ways	⇔	new ways	72	L
	P2.2.10	planning for future	⇔	planning today	60	L
	P2.3.5	high awareness	⇔	lower awareness	85	H
	P2.3.8	strategic alignment	⇔	reactionary	81	H
	P2.3.11	knowledge management	⇔	lack of knowledge management	69	L
	P2.4.3	revenue impact	⇔	operational impact	69	I

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P2.3.14	operational indifference	⇔	focus on climate risks	72	L
	P2.4.4	aggressive business environment	⇔	less aggressive business environment	81	H
	P2.4.7	lifecycle	⇔	no lifecycle	88	H
	P2.4.9	size matters	⇔	size doesn't matter	69	L
	P2.4.10	constraints	⇔	almost no constraints	75	I
	P2.4.11	monitoring	⇔	partial monitoring	72	I
	P2.4.12	stressed	⇔	manageable	85	H
	P2.4.19	legacy employees	⇔	new expertise	66	H
	P2.5.3	corporation only	⇔	society at large	72	H
	P2.5.4	change	⇔	as is	72	H
	P2.7.3	dictate	⇔	learn what we need	66	I
	P2.7.5	focus	⇔	not paying attention	60	L
	P2.7.7	asset management	⇔	compliance management	66	L
	P2.7.14	customer service	⇔	reduced reliability	81	H
	P2.8.9	no control	⇔	business decision	62	L
	P2.8.10	customer expectations	⇔	low expectation	75	I
	P2.8.11	business influence	⇔	low business influence	56	L
	P2.3.12	skills availability	⇔	develop skills	69	L
	P2.8.12	core competence	⇔	more training	65	L
	P2.9.8	organization myopia	⇔	new decisions	66	L
	P2.9.9	core competence	⇔	gaps in organization	69	H
	P1.5.16	aging workforce	⇔	upgrading	56	L
	P1.10.17	new system boundaries	⇔	old paradigm	75	H
	P1.3.9	high level of control	⇔	low level of control	81	I
	P1.2.9	risk mentality	⇔	no change	81	I
	P2.9.11	lack of training	⇔	day to day decisions	78	H
	P2.9.12	customer priorities	⇔	gaps in organization	71	L
	P2.9.13	private choice	⇔	statutory requirement	72	L
	P2.9.16	system exposure	⇔	system reliability	78	L
	P2.10.4	outside experts	⇔	corporate knowledge	69	I

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P2.10.7	technology driven	⇔	workforce training	78	H
	P2.10.8	asset management	⇔	future business model	69	H
	P2.10.9	customer focus	⇔	business needs	66	I
	P2.10.10	system reliability	⇔	plant performance	66	L
	P2.6.5	technical appraisal	⇔	non-rational appraisal	69	L
	P2.6.7	reality	⇔	wish list	62	L
	P2.6.13	self-evidence	⇔	lack of trust	88	H
	P2.10.6	core competencies	⇔	business extensions	81	H
	P2.10.15	risk appetite	⇔	small risk set	78	H
	P2.4.6	resilience	⇔	compliance	85	H
	P2.9.1	asset management	⇔	regulatory compliance	69	I
	P2.10.5	current risk-based practices	⇔	future	62	L
RISK RESPONSE TYPE (19, 5.86%)	P1.1.10	reactive	⇔	not reactive	81	H
	P1.1.16	mitigate and manage	⇔	requires capital investment	60	L
	P1.2.2	mitigation	⇔	adaptation	60	L
	P1.2.10	proactive	⇔	reactive	53	L
	P1.5.13	action-prepared	⇔	action-restore / prevent	81	H
	P1.10.8	preventative maintenance	⇔	fix and restart, resilience	75	H
	P1.10.9	proactive management of impacts	⇔	reactive	75	H
	P2.3.15	proactive	⇔	reactive	66	L
	P2.4.6	resilience	⇔	compliance	85	H
	P2.5.13	mitigation effort	⇔	resilience effort	66	I
	P2.10.12	adaptive ‘repair it’ response	⇔	mitigative, ‘prevent it’	72	I
	P2.7.9	mitigation	⇔	contingency plans	62	L
	P2.8.2	forward looking	⇔	reactive	50	H
	P2.8.6	reactive	⇔	proactive	72	I
	P2.9.4	reactive	⇔	target	66	L
	P2.10.13	adaptation response	⇔	mitigation response	66	I
	P2.6.18	mitigative action	⇔	adaptive action	60	L

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
RISK REPONSE TIMING (10, 3.09%)	P1.1.11	planning later	⇔	now	56	L
	P1.1.12	build today's resources	⇔	build tomorrow's resources	72	I
	P1.4.2	longer response time	⇔	shorter response time	72	I
	P1.8.14	slower response	⇔	faster response	81	H
	P2.4.8	longer term response	⇔	immediate response	69	L
	P2.9.10	delaying decisions	⇔	immediate focus	60	L
	P2.9.14	proactive	⇔	waiting for it	78	H
	P2.6.14	long term planning	⇔	short term planning	78	H
	P2.2.4	longer term	⇔	near term	60	L
	P1. 10.6	time horizon: immediate	⇔	mid to long term	62	L
SINGULAR CORPORATE RESPONSE (36, 11.01%)	P1.2.5	new way of thinking	⇔	old ways	66	L
	P1.2.6	more resources needed	⇔	vulnerability	78	I
	P1.2.7	rigorous documentation	⇔	weak documentation	78	H
	P1.2.8	planning as usual	⇔	more planning needed	81	I
	P1.2.11	emergency preparedness	⇔	unknown state	62	L
	P1.3.6	specific preparedness	⇔	general preparedness	75	I
	P1.3.7	critical response drivers	⇔	maintenance activity	62	L
	P1.3.8	needed resources	⇔	already-have resources	75	I
	P1.3.10	upgrade and modify	⇔	can't upgrade / modify	81	H
	P1.4.10	business strengths	⇔	need system strength	75	H
	P1.5.14	emergency response	⇔	reliability culture	75	L
	P1.6.14	exposure to ongoing conditions	⇔	exposure to extreme conditions	53	L
	P1.6.15	asset management (how we manage)	⇔	re-appraisal of asset management	50	L
	P1.7.12	operational flexibility	⇔	status quo	81	I
	P1.7.13	new corporate mentality	⇔	old corporate mentality	94	H
	P1.7.16	slow rate of corporate change	⇔	faster rate of corporate change	72	I
	P1.7.17	business continuity	⇔	dynamic change, prepare for	88	H
	P1.8.1	climate response	⇔	corporate response alignment	62	I
	P1.10.13	specialized skills	⇔	elevate knowledge	66	I

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P1.10.14	risk governance	⇔	status quo	66	I
	P1.10.2	business continuity	⇔	outcomes unknown, manage	85	H
	P2.3.13	transition to new skills sets	⇔	status quo	69	L
	P2.5.15	specialized knowledge needed	⇔	general knowledge	66	L
	P2.7.10	more learning	⇔	status quo	75	I
	P2.7.12	more solutions	⇔	challenges	69	L
	P2.7.13	welcome new normal	⇔	same old same old	78	H
	P2.7.15	future facilities	⇔	present day facilities	66	I
	P2.8.8	decide on corporate initiative	⇔	mandates	62	L
	P2.8.14	learn from experience	⇔	low effort to learn	75	H
	P2.8.17	reliability	⇔	service interruption	75	H
	P2.9.6	reactive	⇔	more planning needed	62	L
	P2.9.17	mandate	⇔	cost of business	72	H
	P2.9.18	preparation	⇔	lack of urgency	72	H
	P2.6.4	mandates	⇔	tools	72	I
	P2.6.15	preparedness	⇔	can't prepare	53	L
	P1.10.7	established planning process	⇔	more planning needed	66	L
SHARED CORPORATE RESPONSE (23, 7.10%)	P1.3.11	financial investments for improvements	⇔	compliance costs	91	H
	P1.3.15	sector evolution	⇔	status quo	85	H
	P1.3.16	business transformation	⇔	status quo	78	I
	P1.3.17	internal control	⇔	external control	75	I
	2.10.14	CoGen partnerships	⇔	do nothing	78	I
	P1.4.3	carbon sequestration	⇔	status quo	69	L
	P1.4.7	leave it to government	⇔	we manage	69	I
	P1.4.13	reliance on external experts	⇔	in house expertise	62	L
	P1.5.11	we can manage the risk	⇔	can't manage entirely	69	I
	P1.7.15	capex needed	⇔	capex- no change	88	H
	P1.10.16	investment in resources	⇔	do nothing	66	I
	P2.2.5	business extension	⇔	business core	75	H

Category (count, percentage)	Code	Constructs			% Similarity	H-I-L Values
	P2.3.7	outside experts	⇔	learn ourselves	72	I
	P2.3.9	need to influence	⇔	no need to influence	66	I
	P2.3.18	choices / initiative	⇔	government mandates	75	I
	P2.5.14	self-reliance	⇔	outside assistance	56	L
	P2.5.17	business direction	⇔	status quo	69	L
	P2.8.4	business transformation	⇔	system transformation	75	L
	P2.8.5	future business model	⇔	status quo	72	L
	P2.8.16	asset renewal	⇔	current asset management	66	I
	P2.6.17	long term investment needed	⇔	immediate investments needed	75	H
	P1.3.12	on our alone to manage	⇔	‘one of any’ to manage	72	L
	P2.3.6	business alliances	⇔	do it ourselves	72	I
MISCELLANEOUS (10, 2.78%)	P1.1.13	operational risk identification	⇔	operational capacity to handle risk	81	H
	P1.4.9	co-dependent outcomes	⇔	independent outcomes	94	H
	P2.4.5	climate models	⇔	climate policies	81	I
	P1.5.4	available assets	⇔	not a company issue	69	L
	P2.5.9	forever changing	⇔	once in a while	78	H
	P2.9.2	risk based assessment	⇔	mandated behaviour	72	I
	P2.10.2	related climate	⇔	independent response	85	H
	P1.1.14	risk identification	⇔	risk response	72	I
	P1.5.4	available assets	⇔	not a company issue	69	L
	P1. 9.1	climate response	⇔	corporate response	78	H

APPENDIX Q

CONTENT ANALYSIS INTERRATER RELIABILITY—FIRST ATTEMPT

Content analysis Interrater Reliability Assessment—first attempt											
	Cross Tabulation of Ratings—Assignment of Constructs										
	Researcher		**Collaborator**								
Risk Identification			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**TOTALS**
			Risk Source	**Risk Effect**	**Risk** characteristics	**Risk Consequences**	**Response** Type	**Response Timing**	**Singular** Corporate Response	**Shared Corporate** Response	
	Risk Source	1	**23**								23
	Risk Effect	2		**38**		13					51
Risk Assess-ment	**Risk Characteristics**	3			**59**						59
	Risk Consequences	4		24		**107**					131
Risk Response	**Response Type**	5					**19**				19
	Response Timing	6						**10**			10
	Singular Corporate Response	7			11				**36**		47
	Shared Corporate Response	8								**23**	23
	TOTALS		23	62	70	120	19	10	36	23	363
			1st attempt—Percentage Agreement Score = 86.77%								
			Cohen's Kappa = 0.835								

(*table continues*)

APPENDIX Q (CONT'D.)

CONTENT ANALYSIS INTERRATER RELIABILITY ASSESSMENT—2ND ATTEMPT

Content analysis Interrater Reliability Assessment—2nd attempt

	Cross Tabulation of Ratings—Assignment of Constructs										
	Researcher		**Collaborator**								
Risk Identification			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**TOTALS**
			Risk Source	**Risk Effect**	**Risk** characteristics	**Risk Consequences**	**Response** Type	**Response Timing**	**Singular** Corporate Response	**Shared Corporate** Response	
	Risk Source	1	**23**								23
	Risk Effect	2		**38**							38
Risk Assess-ment	**Risk Characteristics**	3			**59**						59
	Risk Consequences	4		9		**107**					116
Risk Response	**Response Type**	5					**19**				19
	Response Timing	6						**10**			10
	Singular Corporate Response	7							**36**		36
	Shared Corporate Response	8								**23**	23
	TOTALS		23	47	59	107	19	10	36	23	324

2nd attempt—Percentage Agreement Score = 97.22%

Cohen's Kappa = 0.965

APPENDIX R

Column Heading Key

Emergent pole The emergent pole of a construct is that one which represents most of the perceived context of the construct.

Implied pole The implied pole of a construct is that one which represents the least of the perceived context of the construct.

Construct code The construct code is the elicited construct, coded, from RGT interviews.

Percent degree of similarity The percent similarity score or percent matching score involves computing the sum of differences for each element rating between each elicited construct and the supplied overall construct (e.g. how closely the construct matches the supplied overall construct).

H values The H value is the top third of the High-Intermediate-Low values, derived from Honey's (1979) technique. Constructs with H values are individually most important to participants.

Appendix R Constructs with H values (75% and higher), continued over two pages)

Power producers

Construct code	Emergent pole	–	Implied pole	% degree of similarity
1.1.2	predictable	–	unpredictable	91
1.1.3	proof-based	–	not proof-based	78
1.1.9	Key driver to risk management	–	not necessarily key driver to risk management	75
1.1.10	reactive	–	not reactive	81
1.1.13	Risk identification in operations	–	operational capacity to handle risks	81
1.1.15	strategic	–	not strategic	75
1.2.1	short term	–	long term	78
1.2.3	control	–	no control	85
1.2.7	rigorous documentation	–	weak documentation	78
1.2.9	risk mentality	–	no change	81
1.3.9	high level of control	–	low level of control	81
1.3.10	upgrade + modify	–	can't upgrade + modify	81
1.3.11	financial investments for improvements	–	compliance cost	91
1.3.13	business decisions	–	stakeholder influence	88
1.3.15	sector evolution	–	status quo	85
1.4.4	old technology	–	newer technology	75
1.4.5	cost effectiveness	–	not efficient	75
1.4.9	co-dependent	–	independent	94
1.4.10	business strengths	–	need system strength	75
1.4.16	slow change	–	dynamic change	78
1.5.8	longer term cost impact	–	one-off cost	85
1.5.9	externality	–	internal, what we can do	85
1.5.13	action-preparation	–	action-restore	81
1.5.14	emergency response	–	reliability culture	75

1.6.5	financial resiliency	–	operational resiliency	78
1.6.6	involves people + tech	–	people only	81
1.6.8	strategic resources	–	non-aligned resources	78
1.6.10	immediate financial implications	–	future financial implications	78
1.6.11	specific forecasting	–	general planning	85
1.7.6	Asset management	–	Unknown asset management	85
1.7.7	attempt to influence	–	preparedness	88
1.7.13	new corporate mentality indifference	–	old corporate mentality	94
1.7.14	Climate indifference	–	business case with climate	88
1.7.15	capital expenditures needed	–	capex—no change	88
1.7.17	business continuity	–	dynamic change, prepare for	88
1.8.14	slower response	–	faster response	81
1.8.16	plant footprint	–	larger carbon footprint	85
1.8.17	choice	–	no choice	85
1.9.1	climate response	–	corporate response	78
1.10.15	Invest in resources		Carry on, status quo	75
1.9.4	sequential bundled impacts	–	may not be affected	78
1.9.10	core competency	–	additional skills	75
1.9.11	limited stakeholder involvement	–	increased stakeholder involvement	78
1.10.2	business continuity	–	outcomes unknown, manage	85
1.10.8	preventative maintenance	–	fix & restart (resilience)	75
1.10.9	Proactive management of impacts	–	reactive	75
1.10.17	new system boundaries	–	old paradigm	75

Utilities

Construct code	Emergent pole	–	Implied pole	% degree of similarity
2.1.9	not core	–	core to business	75
2.2.5	business extension	–	business core	75
2.2.7	risk intensity changes	–	status quo	75
2.2.8	short term	–	longer term	81
2.3.1	day to day	–	broader brush	75
2.3.2	immediate	–	lower relevance	78
2.3.4	predictable	–	unpredictable	81
2.3.5	high awareness	–	low awareness	85
2.3.8	strategic alignment	–	reactionary	81
2.3.10	priority risk	–	non-priority risk	85
2.3.17	relevance of data	–	low quality data	75
2.4.2	data driven	–	less data	81
2.4.4	aggressive business environment	–	less aggressive business environment	81
2.4.5	climate models	–	climate policies	81
2.4.6	resilience	–	compliance	85
2.4.7	lifecycle factor	–	no lifecycle factor	88
2.4.12	stressed	–	manageable	85
2.6.17	Long term investment needed		Immediate investment needed	75
2.5.9	forever changing	–	once in a while	78
2.5.10	company carbon footprint	–	larger footprint	81
2.6.1	tangible effect	–	Non-tangible effect	85
2.6.2	prediction	–	historical evidence	75

2.6.3	physical uncertainty	–	political uncertainty	88
2.6.12	weather uncertainty	–	regulatory uncertainty	81
2.6.13	self-evidence	–	lack of trust	88
2.6.14	long term planning	–	short term planning	78
2.7.1	sudden events	–	gradual efforts	81
2.7.2	data support	–	lack of data	78
2.7.8	more immediate	–	future focus	78
2.7.13	new normal	–	same old same old	78
2.7.14	customer service	–	reduced reliability	81
2.8.2	forward looking	–	reactive	88
2.8.3	risk opportunity	–	negative risk	81
2.8.13	political concern	–	customer concern	75
2.8.14	learn from experience	–	low effort to learn	75
2.8.15	policy drivers	–	data influence	78
2.8.17	reliability	–	service interruption	75
2.9.5	metrics	–	lack of metrics	81
2.9.11	lack of training	–	day to day decisions	78
2.9.14	proactive	–	waiting for it	78
2.10.2	Related to climate	–	No response	85
2.10.6	core competencies	–	business extensions	81
2.10.7	technology driven	–	workforce training	78
2.10.15	risk appetite	–	small risk set	78

APPENDIX S—ELEMENT RATINGS ON THE OVERALL SUPPLIED CONSTRUCT (GREATEST- WEAKEST)								
	Elements							
	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**
Power producers	**Power producers**							
P1.1 Overall	4	3	1	2	4	3	5	5
P1.2 Overall	4	3	1	2	4	3	5	5
P1.3 Overall	3	3	1	2	4	4	4	4
P1.4 Overall	5	4	1	4	3	3	2	2
P1.5 Overall	3	3	2	1	5	4	5	5
P1.6 Overall	3	1	4	4	2	3	5	5
P1.7 Overall	4	3	1	2	4	3	5	5
P1.8 Overall	4	3	3	5	2	3	1	1
P1.9 Overall	2	3	1	2	3	4	5	5
P1.10 Overall	2	1	3	5	2	5	4	4
Utilities	**Utilities**							
P2.1 Overall	1	4	3	3	5	2	2	4
P2.2 Overall	1	1	3	3	2	2	2	4
P2.3 Overall	1	3	4	5	2	4	3	3
P2.4 Overall	4	2	1	2	4	5	3	3
P2.5 Overall	2	3	1	5	3	2	4	4
P2.6 Overall	1	4	5	5	4	2	2	3
P2.7 Overall	1	2	3	5	2	3	4	4
P2.8 Overall	5	3	1	2	3	2	4	4
P2.9 Overall	5	3	1	2	3	2	4	4
P2.10 Overall	2	2	1	4	4	5	1	2

APPENDIX T

NARRATIVE ANALYSIS—CORPORATE REPORTS (continued over 10 pages)

Power producers

Participant Code	Construct Category	Climate driver	Related issue	Statement location
1.1	Risk effect	Sudden direct climate events	Corporate strategy	Page 22, 2015 Environmental Report
'The corporation has identified climate change adaptation and extreme weather as a strategic risk for the company'.				
1.1	Risk consequences	Sudden direct climate events	Power production	Page 22, 2015 Environmental Report
'Changes in precipitation patterns, water temperatures, and ambient air temperatures can impact the availability of water resources, which could affect power production at the thermal facility'.				
1.1	Risk effect	Sudden direct climate events, aging infrastructure	System infrastructure	Page 22, 2015 Environmental Report
'Unusual or unpredictable weather has the potential to damage electricity power producers and transmission infrastructure'.				
1.1	Risk consequences	Climate data, sudden weather events, government policy, GHG abatement	Monitoring	Page 22, 2015 Environmental Report
'To date the company has not experienced impacts attributable to climate change but it is recognized that efforts are required to assess the short and long-term risks and to monitor for developments in climate science, adaptation activities and potential changes to policy and regulatory requirements'.				
1.1	Shared corporate response	Climate data, government policy	Monitoring	Page 22, 2015 Environmental Report
'During 2015, the company continued its participation in climate change adaptation initiatives with municipal and regional governments, the Ontario Ministry of the Environment and Climate Change, the Ontario Ministry of Energy and Natural Resources Canada'.				
1.1	Shared corporate response	Risk Consequences	Sudden direct climate events-sector impact	Page 22, 2015 Environmental Report

'The frequency and intensity of extreme weather, as opposed to the changing climate, is the greater concern for the electricity sector'.				
1.1	Singular corporate response	Government Policy	Monitoring	Page 22, 2015 Environmental Report
'To date, the company has not experienced impacts attributable to climate change but it is recognized that efforts are required to assess the short and long-term risks and to monitor for developments in climate science, adaptation activities and potential changes to policy and regulatory requirements'.				
Participant Code	**Construct Category**	**Climate Driver**	**Related Issue**	**Statement Location**
1.2	Shared corporate response	Government policy, GHG abatement	sector	Page 15, 2015 Annual Report
'Material risk factors include the effects of changes in environmental and other laws and regulatory policy applicable to the energy and utilities sector'.				
1.2	Risk type	Sudden direct climate events	Enterprise management of risk	Page 56, 2015 Annual Report
'The key risk categories assessed in enterprise risk management include: natural disasters, security (physical), strategic and regulatory'.				
1.2	Risk consequences	GHG abatement	Financial implications	Page 62, 2015 Annual report
'The power producer group's thermal Energy Division uses natural gas and oil, and produces exhaust gases which if not properly treated and monitored could cause hazardous chemicals to be released into the atmosphere. The units could be restricted from purchasing gas/oil due to either shortages or pollution levels, which could hamper output of the facility'.				
1.2	Singular corporate response	Sudden direct climate events	Insurance, risk transfer	Page 65, 2015 Annual Report
'The company face a number of environmental risks that are normal aspects of operating in thermal power producers and utilities business segments, which have the potential to become environmental liabilities. Many of these risks are mitigated through the maintenance of an adequate insurance program, which includes property equipment breakdown, environmental, and liability policies'.				
Participant Code	**Construct Category**	**Climate Driver**	**Related Issue**	**Statement Location**
1.3	Singular corporate response	Sudden direct climate events, GHG	Energy security, transition to low carbon economy	Page 1, 2015 Integrated Annual Report

		abatement, government policy		
'The corporation develops its businesses around a model based on responsible growth to take on the major challenges of energy's transition to a low carbon economy, access to sustainable energy, climate—change mitigation and adaptation, security of supply and the rationale use of resources'.				
1.3	Risk source, risk consequences	Sudden direct climate events	Energy demand	Page 21, 2015 Integrated Annual Report
'Climate change is a risk relating to the external environment. In the short term, climate phenomena will have an impact on energy power producers as well as on demand for electricity. In the longer term, climate change could have a broader impact on the company's activities: changing energy needs, Co2 emissions reduction, etc.'.				
1.3	shared corporate response	Sudden direct climate events	Strategy	Page 40, 015 Integrated Annual Report
'The company has placed environmental protection at the heart of its strategy. The long-term sustainability of its business model are based (in part) on the fight against climate change. As a major player in the energy transition, the company is playing an active role in international climate negotiations, and supports the need for a balanced global agreement to limit global warming to 2°C by 2050'.				
1.3	Singular corporate response	GHG abatement, sudden direct climate events	Supply chain, value chain	2015 Integrated Annual Report
'As regards its activities, the corporation is, the corporation is active throughout the value chain- from production through to end UES-seeking to limit GHG emissions and combating climate change'.				
Participant Code	**Construct Category**	**Climate Driver**	**Related Issue**	**Statement Location**
1.4	Risk consequences, risk effect	Sudden direct climate events, government policy	Operating conditions, energy demand,	Page 1+2, 2015 Annual Report
'Our business is subject to various risks, and include without limitation, the effects of weather, which affects demand for electricity and fuel as well as operating conditions; risks beyond our control, including but not limited to natural disasters or other catastrophic events; the impact of significant energy, environmental and other regulations on our projects'.				
1.4	Risk source	Sudden direct climate events	Financial implications	Page 27, 2015 Annual Information Form
'The effects of weather and climate change may adversely impact our business, results of operations and financial condition'. Our operations are affected by weather conditions which directly influence the demand for electricity. Temperatures above normal levels in the summer tend to increased summer cooling electricity demand and revenues. Conversely, moderate temperatures in winter tend to increase winter heating electricity demand and revenues. To the				

extent that weather is warmer in the summer or colder in the winter than assumed, we may require greater resources to meet our contractual commitments. These conditions which cannot be accurately predicted, may have an adverse effect on our business results of operations and financial condition by causing us to seek additional capacity at a time when wholesale markets are tight or to seek to sell excess capacity at a time when markets are weak'.				
1.4	Risk consequences	Sudden direct climate events	Financial implications	Page 28, 2015 Annual Information Form
'Our projects could also be impacted by natural disasters, more frequent and more extreme weather events, changes in temperature and precipitation patterns and other related phenomena. Severe weather or other natural disasters could be destructive or otherwise disrupt our operations or compromise the physical or cyber security of our facilities, which could result in increased costs and could adversely affect our ability to manage our business effectively'.				
1.4	Singular corporate response	Sudden direct climate events	Insurance, risk transfer	Page 28, 2015 Annual Information Form
'We maintain standard insurance against catastrophic losses, which are subject to deductibles, limits and exclusions; however our insurance coverage may not be sufficient to cover all of our losses'.				
1.4	Risk consequences	government policy, GHG abatement	Financial Implications	Page 31 2015 Annual Information Form
'The introduction of new laws, or other future regulatory developments, may have a material adverse impact on our business, operations or financial condition. Changes of provincial statutes and of regulations in Ontario could have a material effect on our projects'.				
Participant Code	**Construct Category**	**Climate Driver**	**Related Issue**	**Statement Location**
1.5	Risk source	Sudden direct climate events, government policy, GHG abatement	Financial implications	Page 67,2015 Annual Information Form
'A portion of the revenues generated by the facility are tied directly or indirectly to the wholesale market price for electricity in Ontario. Wholesale market electricity prices are impacted by a number of factors including: power producers facilities, price of fuel, the management of power producers, and the amount of excess generating capacity relative to load in a particular market; the cost of controlling emissions of pollution, the structure of the market, weather and economic conditions that impact electrical load, electricity demand growth, weather conditions that effect the amount of energy production by intermittent conservation and demand side management, and government regulations or policies'.				
1.5	Risk consequences	Government policy, GHG abatement, Sudden direct climate events	Financial implications	Page 67, 2015 Annual Information Form

'This volatility and uncertainty in the energy market and market prices for electricity could have a material adverse effect on the Corporation's financial performance'.				
Participant Code	**Construct Category**	**Climate Driver**	**Related Issue**	**Statement Location**
1.6	Singular corporate Response	GHG Abatement	Technology, innovation	Page 17, 2015 annual report
'Our (testing facility) incorporates 'Selective Catalytic Reduction' (SDR), an emissions abatement system that uses special chemical reactions to minimize the release of nitrogen oxides NO, and Sulphur oxides (SO) during generator testing'.				
Participant Code	**Construct**	**Climate Driver**	**Related Issue**	**Statement Location**
1.7	Shared corporate response	Sudden direct climate events	Information, stewardship, workplace safety, business continuity	Page 11, 2015 Integrated Annual Report
'Risk Management (comprises of) undertaking risk management on a consolidated basis, ensuring information security management, practicing rigorous environmental stewardship, enforcing comprehensive workplace guidelines for health and safety and conducting business continuity management'.				
1.7	Singular corporate response	Sudden direct climate events	Supply chain considerations	Page 63, 2015 Integrated Annual Report
'The corporation is building a global supply chain. To promote business conduct that reflects… the environment and other fields of risk across our entire supply chain, we have established the TTSC CSR Behavioural guidelines'.				
1.7	Singular corporate response	ORG resources, capacity	Process control	Page 65, 2015 Integrated Annual Report
'Furthermore in the case of an environmental accident. The corporation has a strict reporting structure in place whereby the business unit on hand takes immediate action to reduce the impact and report the accident within an hour to all relevant departments. The reporting structure then proceeds up the ladder to investigate and analyse the cause and take corrective action to prevent the accident from re-occurring'.				
1.7	Risk response	GHG abatement	Governance	Page 65, 2015 Integrated Annual Report
'The corporation has established an energy saving promotion council in striving to reduce CO2 emissions. This council is responsible for setting and implementing energy management standards for reducing CO2 emissions from the corporation's offices and conducting energy –efficiency audits to ensure that energy consumption is being managed on an ongoing basis'.				

Participant Code	Construct Category	Climate Driver	Related Issue	Statement Location
1.8	Risk source, consequences	Sudden direct climate events	Economic, financial and technical impacts	Page 77, 2015 annual report
‘Significant changes in temperature and other weather events have many effects on our business, ranging from the impact on demand, availability and commodity prices, to efficiency and output capability’.				
1.8	Risk consequences	Sudden direct climate events	Market demand, prices	Page 77, 2015 annual report
‘Extreme weather and weather can affect market demand for power and natural gas and can lead to significant price volatility’.				
1.8	Risk consequences	Sudden direct climate events	Energy security	Page 77, 2015 annual report
‘Extreme weather can also restrict the availability of natural gas and power if demand is higher than supply’.				
1.8	Risk consequences	Sudden direct climate events	Capacity output	Page 77, 2015 annual report
‘Seasonal changes in temperature can reduce the efficiency of our natural gas fired power plants, and the amount of power they produce’.				
1.8	Risk source	Government policy, GHG abatement	Price risk, capacity	Page 77, 2015 annual report
‘As power markets evolve across North America, there is the potential for regulatory bodies to implement new rules that could negatively affect us as a generator. These may be in the form of market rule changes, changes in the interpretation and application of market rules by regulators, price caps, emissions controls, emissions costs, cost allocations to Power producers and out of market actions taken by others to build excess power producers, all of which negatively affect the price of power or capacity, or both’.				
1.8	Risk effect	Sudden direct climate events	Business interruption	Page 77, 2015 annual report
‘Business interruption is the highest operational risk we face. Operational risks, including labour disputes, equipment malfunctions or breakdowns, acts of terror or natural disasters and other catastrophic events’.				
1.8	Singular corporate response	Sudden direct climate events	Risk transfer, insurance	Page 77, 2015 annual report

'Decrease in revenues, increase in operating costs or legal proceedings or other expenses of all which could reduce our earnings. Losses not covered by insurance could have an adverse effect on operations, cash flow and financial position'.				
1.8	Risk response	Sudden direct climate events	Risk transfer, insurance	Page 94, 2015 annual report
'We have incident, emergency and crisis management systems to ensure an effective response to minimize further loss or injuries and to enhance our ability to resume operations. We also have a business continuity program that determines critical business processes and develops resumption plans to ensure process continuity. We have comprehensive insurance to mitigate certain of these risks, but insurance does not cover all events in all circumstances'.				
1.8	Singular corporate response	GHG abatement	Regulatory compliance	Page 97, 2015 annual report
'We own assets and have business interests in a number of regions where there are regulations to address industrial GHG emissions. We have procedures in place to comply with these regulations'.				
Participant Code	**Construct Category**	**Climate Driver**	**Related Issue**	**Statement Location**
1.9	Risk source	Sudden direct climate events	Risk exposure	Page 42, 2015 Annual Report
'The company's facilities are projects are exposed to the elements such as wind, water and are also susceptible to weather and other natural events such as hurricanes tornadoes lightning storms and icing events that can cause construction delays. Natural events may also make it impossible for operations and maintenance crews to access the disabled equipment'.				
1.9	Risk consequences	GHG abatement, government policy	Financial implications	Page 43, 2015 Annual report
'For the last several decades, the greenhouse effect and its influence on climate change has caused environmental concern… Should any legislation related to GHG regulation impose any costs on the corporation, certain of its facilities may not be able to recover some or all of such costs under its power purchasing agreement, which would result in reduced cash flow and asset impairments upon implementation'.				
1.9	Risk source	GHG abatement, government policy	Financial implications	Page 47, 2015 Annual Report
'The company and its generating facilities are subject to policies, laws and regulations established by various levels of government and government agencies. These are subject to change by the governments or their agencies or the courts and are administered by agencies that may have discretion in their interpretation. Future legal and regulatory changes or interpretations may have a material effect on the corporation, its development prospects and /or its generating facilities'.				

Participant Code	Construct Category	Climate Driver	Related Issue	Statement Location
1.10	Risk effect	Sudden direct climate events	Corporate strategy	page 22, 2015 Environmental Report
‘The corporation has identified climate change adaptation and extreme weather as a strategic risk for the company’.				
1.10	Risk consequences	Sudden direct climate events	Power production	page 22, 2015 Environmental Report
‘Changes in precipitation patterns, water temperatures, and ambient air temperatures can impact the availability of water resources, which could affect power production at the thermal facility’.				
1.10	Risk effect	Sudden direct climate events, aging infrastructure	Infrastructure	page 22, 2015 Environmental Report
‘Unusual or unpredictable weather has the potential to damage electricity power producers and transmission infrastructure’.				
1.10	Risk consequences	Climate data, sudden weather events, government policy, GHG abatement	Monitoring	page 22, 2015 Environmental Report
To date the company has not experienced impacts attributable to climate change but it is recognized that efforts are required to assess the short and long term risks and to monitor for developments in climate science, adaptation activities and potential changes to policy and regulatory requirements’.				
1.10	Shared corporate response	Government policy, aging infrastructure, technical knowledge	Sector	Page 22, 2015 Environmental Report
‘During 2015, the company continued its participation in climate change adaptation initiatives with municipal and regional governments, the Ontario Ministry of the Environment and Climate Change, the Ontario Ministry of Energy and Natural Resources Canada.’				
1.10	Shared corporate response	Risk consequences, sudden direct climate events	Sector	Page 22, 2015 Environmental Report
‘The frequency and intensity of extreme weather, as opposed to the changing climate, is the greater concern for the electricity sector’.				

Utilities				
Participant code	**Construct category**	**Climate driver**	**Related issue**	**Statement location**
2.1	Risk effect	Not specified	Future performance	Page 19, 2015 Regulatory Report
'The information provided by Utilities on their future performance (or what can be construed as forward-looking information) may be subject to a number of risks, uncertainties and other factors that may cause actual events, conditions or results to differ materially from historical results or those contemplated by the distributor regarding their future importance'.				
2.1	Risk source	Government policy, GHG abatement, sudden direct climate events	Future performance	Page 19, 2015 Regulatory Report
'Some of the factors that could cause such differences include legislative or regulatory developments, financial market conditions, general economic conditions and the weather. For these reasons, the information on future performance is intended to be management's best judgement on the reporting date of the performance scorecard, and could be markedly different in the future'.				
Participant code	**Construct category**	**Climate driver**	**Related issue**	**Statement location**
2.2	Risk effect	not specified	Future performance	Page 7, 2015 Regulatory Report
'The information provided by Utilities on their future performance (or what can be construed as forward-looking information) may be subject to a number of risks, uncertainties and other factors that may cause actual events, conditions or results to differ materially from historical results or those contemplated by the distributor regarding their future importance'.				
2.2	Risk source	Government policy, GHG abatement, sudden direct climate events	Future performance	Page 7, 2015 Regulatory Report
'Some of the factors that could cause such differences include legislative or regulatory developments, financial market conditions, general economic conditions and the weather. For these reasons, the information on future performance is intended to be management's best judgement on the reporting date of the performance scorecard, and could be markedly different in the future'.				
Participant code	**Construct category**	**Climate driver**	**Related issue**	**Statement location**

<table>
<tr><td>2.3</td><td>Shared corporate response</td><td>Aging infrastructure</td><td>strategy</td><td>Page 1, 2015 Regulatory Report</td></tr>
<tr><td colspan="5">‘Aging utilities infrastructure continues to be a challenge for many utilities today. Like most utilities in Ontario, the company must replace aging infrastructure at a steady pace in order to meet this challenge. Therefore the company strategically plans to meet the renewal and growth of the utilities system in a cost effective manner’.</td></tr>
<tr><td>2.3</td><td>Singular corporate response</td><td>Sudden direct climate events</td><td>Vegetation control</td><td>Page 1, 2015 Regulatory Report</td></tr>
<tr><td colspan="5">‘In addition, vegetation control, including tree trimming activities, were increased in the year to reduce the vulnerability of the utilities system to external uncontrollable events, such as weather’.</td></tr>
<tr><td>2.3</td><td>Risk effect</td><td>Not specified</td><td>Future performance</td><td>Page 8, 2015 Regulatory Report</td></tr>
<tr><td colspan="5">‘The information provided by Utilities on their future performance (or what can be construed as forward-looking information) may be subject to a number of risks, uncertainties and other factors that may cause actual events, conditions or results to differ materially from historical results or those contemplated by the distributor regarding their future importance’.</td></tr>
<tr><td>2.3</td><td>Risk source</td><td>Government policy, GHG abatement, sudden direct climate events</td><td>Future performance</td><td>Page 8, 2015 Regulatory Report</td></tr>
<tr><td colspan="5">‘Some of the factors that could cause such differences include legislative or regulatory developments, financial market conditions, general economic conditions and the weather. For these reasons, the information on future performance is intended to be management’s best judgement on the reporting date of the performance scorecard, and could be markedly different in the future’.</td></tr>
<tr><td>Participant code</td><td>Construct</td><td>Climate driver</td><td>Related issue</td><td>Statement location</td></tr>
<tr><td>2.4</td><td>Risk type</td><td>Sudden direct climate events</td><td>System planning, energy security</td><td>page 36, 2015 Sustainability Report</td></tr>
<tr><td colspan="5">‘The planning department considers weather fluctuations and an increase in incident of extreme weather due to climate change… when developing the System Planning Initiatives focused on the security of supply’.</td></tr>
<tr><td>2.4</td><td>Singular risk response</td><td>Sudden direct climate events</td><td>mitigation</td><td>page 36, 2015 Sustainability Report</td></tr>
<tr><td colspan="5">‘The increased demand on our system due to climate change (i.e. the increase in the number and duration of peak demand days and severe storms) is mitigated by the robust infrastructure that our capital reinvestment strategy has created’.</td></tr>
</table>

2.4	Risk consequences	Government policy, sudden direct climate events, GHG abatement	Energy security	page 36, 2015 Sustainability Report
‘While the nature of the risks related to climate change such as damage to the corporation’s infrastructure as a result of severe storms or flooding, is primarily physical, the risks are also considered regulatory as the corporation is mandated by tis regulators to maintain a reliable supply of electricity to its customers’.				
2.4	Shared corporate response	Government policy	Financial implications	page 36, 2015 Sustainability Report
‘If the corporation were to suffer a significant loss due to a catastrophic weather event, we would attempt to recover some or all of those costs through the Ontario Energy Board rate application process.’				
2.4	Shared corporate response	ORG resources, capacity	Human health and safety	Page 36, 2015 Sustainability Report
‘The corporation’s Safe Work practices Manual outlines the heat Stress and Cold Weather strategies employed to mitigate the negative effects of extreme weather on the health and safety of employees and to reduce WSIB claims costs, which are expected to increase as a result of climate change’.				
2.4	Risk consequence	Sudden direct climate events	Vegetation control	Page 37, 2015 Sustainability Report
‘In terms of our tree maintenance program, climate change has already had a tangible effect on our operations’.				
2.4	Risk consequence	Climate data	Reliability, safety	Page 37, 2015 Sustainability Report
‘As a result of more favorable conditions brought on by climate change, the rates of vegetation and tree growth have increased. This increase, in turn, increases the potential risk to reliability and safety. In terms of the health of the trees, there are limits to the amount of foliage that can be removed without having a negative impact’.				
2.4	Shared corporate response	ORG capacity	Collaboration	Page 37, 2015 Sustainability Report
‘The corporation is an integral community partner and maintains active membership in the City’s Advisory Committee on the Environment. The Sub Committee on Energy, Community Energy Action Plan’.				
2.4	Singular corporate response	Sudden direct climate events	Energy consumption	Page 37, 2015 Sustainability Report
‘The corporation works towards reducing energy consumption during peak periods in order to mitigate our vulnerability during times of extreme temperature’.				

2.4	Shared corporate response	Sudden direct climate events, climate data	Floods, spatial consideration	Page 37, 2015 Sustainability Report
'The city is situated where two river tributaries meet. The city has a number of dikes and dams to control flood risks'.				
2.4	Shared corporate response	Technical knowledge	Technical knowledge	Page 37, 2015 Sustainability Report
'To better prepare for the potential impacts of climate change, the City collaborated with the University of Western Ontario's Department of Civil and Environmental Engineering to analyze changes in rainfall intensity, duration and frequency. Results indicated that the frequency and intensity of rainfall in the area has increased since 1965 and is likely to increase with the onset of climate change'.				
2.4	Risk consequence	Sudden direct climate events	Climate data	Page 37, 2015 Sustainability Report
'Peak flows for small storm could increase by 10- 15%, while peak flows for a larger storm could increase by up to 30% relative to historical norms'.				
2.4	Risk consequence	Sudden direct climate events	flooding	Page 37, 2015 Sustainability Report
'Climate change is expected to increase the city's vulnerability to flooding as higher and stronger flood waters may breach the existing dikes and dams'.				
2.4	Shared corporate response	Aging infrastructure	flooding	Page 37, 2015 Sustainability Report
'In 2014, the city published a comprehensive analysis of existing infrastructure and floodwater capacities which was summarized in 'The City: Vulnerability of Infrastructure to Climate Change'. As a result of this study, a long term adaptation strategy was created. The significance of the findings regarding the potential for increased flooding directly affects the corporation'.				
2.4	Singular risk response	Aging infrastructure	flooding	Page 37, 2015 Sustainability Report
'Historical impacts of flooding at our facilities are well documented. The corporation continues to take a proactive approach to reducing the negative impacts of extreme weather on its facilities and infrastructure'.				
2.4	Shared corporate response	Sudden direct climate events	Business continuity	Page 37, 2015 Sustainability Report

'The corporation began a review of the emergency flood plan and embarked upon the challenge of describing the requirements of an off-site business continuity location within the city'.				
Participant code	**Construct category**	**Climate driver**	**Related issue**	**Statement location**
2.5	Risk effect	Not specified	Future performance	Page 9, 2015 Regulatory Report
'The information provided by Utilities on their future performance (or what can be construed as forward-looking information) may be subject to a number of risks, uncertainties and other factors that may cause actual events, conditions or results to differ materially from historical results or those contemplated by the distributor regarding their future importance'.				
2.5	Risk source	Government policy, GHG abatement, sudden direct climate events	Future performance	Page 9, 2015 Regulatory Report
'Some of the factor that could cause such differences include legislative or regulatory developments, financial market conditions, general economic conditions and the weather. For these reasons, the information on future performance is intended to be management's best judgement on the reporting date of the performance scorecard, and could be markedly different in the future'.				
Participant Code	**Construct**	**Climate driver**	**Related Issue**	**Statement Location**
2.6	Risk source	ORG capacity	Financial implications	2015 Annual Report
'The corporation understands the risks inherent in its business and defines them broadly as anything that could impact its ability to achieve its strategic objectives. The corporation's exposure to a variety of risks such as credit risks, interest rate risks and liquidity risk, as well as mitigation strategies are discussed'.				
2.6	Singular corporate response	ORG capacity	System reliability	Alternate—page 1, IESO 2015 report
'In 2014, the corporation reduced the average number of power interruptions to the lowest level in five years with residents being able to rely on the power being on 99.995% of the time. In 2015, the corporation was able to maintain this exceptional level of system reliability and service'.				
2.6	Shared corporate response	Sudden direct climate events	Business continuity	Alternate- page 9, 2015 Climate Change Strategy—Technical Report,

'Critical services and functions are defined in the Business Continuity Management policy (of the local municipality) as services and functions which if disrupted, will cause a significant financial, operational, legal or regulatory impact to the town'.				
2.6	Shared corporate response	GHG abatement	Mitigation, adaptation	Alternate- page 10, 2015 Climate Change Strategy—Technical Report,
'A key initiative to mitigate the impacts of climate change is the reduction of GHG emissions. The town will work to mitigate and adapt to climate change by initiatives that include encouraging energy power producers from renewable sources as well as district energy'.				
2.6	Risk source	Sudden direct climate events	system infrastructure	Alternate-page 76, 2015 Climate Change Strategy—Technical Report,
'Intense and frequent weather events will stress our existing electrical utilities systems'.				
2.6	Risk consequences	Sudden direct climate events	Vegetation control	Alternate- page 76, 2015 Climate Change Strategy—Technical Report,
'Fallen trees on power lines, lightning strikes, aging infrastructure and electrical overload due to extreme temperatures can all result in a loss of power to portions of the town'.				
2.6	Shared corporate response	Sudden direct climate events	Business continuity	Alternate-page 76 2015 Climate Change Strategy—Technical Report,
'The town has implemented Business Continuity Management to ensure critical services and functions are maintained in the event of an interruption or emergency'.				
Participant code	**Construct category**	**Climate driver**	**Related issue**	**Statement location**
2.7	Risk effect	Not specified	Future performance	Page 13, 2015 Regulatory Report
'The information provided by Utilities on their future performance (or what can be construed as forward-looking information) may be subject to a number of risks, uncertainties and other factors that may cause actual events, conditions or results to differ materially from historical results or those contemplated by the distributor regarding their future importance'.				
2.7	Risk source	Government policy, GHG abatement, sudden direct climate events	Future performance	Page 13, 2015 Regulatory Report

‘Some of the factor that could cause such differences include legislative or regulatory developments, financial market conditions, general economic conditions and the weather. For these reasons, the information on future performance is intended to be management’s best judgement on the reporting date of the performance scorecard, and could be markedly different in the future’.				
Participant code	**Construct category**	**Climate driver**	**Related issue**	**Statement location**
2.8	Shared corporate response	Sudden direct climate events	strategy	Page 6 2015 Regional Financial Report
‘The region’s actin plan has six strategic priority areas, including’ adapting to climate change where the Region is prepared to respond to weather related events and other emergencies’.				
2.8	Risk effect	Sudden direct climate events	Memory, experience	Page 11 2015 Regional Financial Report
The significant impact of climate change has been evident around the world and within the region. The effects of the Dec 2013 ice storm and 2014 flooding are still top of mind for many residents’.				
2.8	Risk consequences	Sudden direct climate events	Emergency preparedness	Page 6 2015 Regional Financial Report
‘As a result of increased frequency and severity of weather events emergency preparedness is a key issue. In 2015 the Region increased its 311 call capacity and it is expected that four community response centers will be commissioned by the end of 2016’.				
Participant code	**Construct**	**Climate driver**	**Related issue**	**Statement location**
2.9	Risk type	Sudden direct climate events	exposure	Page 34, 2015 Annual Report
‘The company’s facilities are exposed to the effects of severe weather conditions, natural disasters, man-made events, including but not limited to cyber and physical terrorist type attacks, events which originate from third party connected systems, or any other potentially catastrophic events’.				
2.9	Risk consequences	ORG resources, aging infrastructure	Built environment	Page 34, 2015 Annual Report
‘Although constructed, operated and maintained to industry standards, the Company’s facilities may not withstand occurrences of this type in all circumstances’.				
2.9	Singular risk response	Aging infrastructure	Risk transfer, insurance	Page 35, 2015 Annual Report

'The company does not have insurance for damage to its transmission and utilities wires, poles and towers located outside its transmission and utilities stations resulting from these and other events'.				
2.9	Risk consequences	Organizational resources	Financial implications	Page 35, 2015 Annual Report
'Losses from lost revenues and repair costs could be substantial, especially for many of the company's facilities that are located in remote areas'.				
2.9	Risk identification	ORG capacity	Financial implications	Page 35, 2015 Annual Report
'The company could also be subject to claims for damages caused by its failure to transmit or distribute electricity'.				
2.9	Singular corporate response	Aging infrastructure	Partial mitigation	Page 35, 2015 Annual Report
'The company's risk is partially mitigated because its transmission system is designed and operated to withstand the loss of any major element and possesses inherent redundancy that provides alternate means to deliver large amounts of power'.				
2.9	Shared Corporate response	Sudden direct Climate events	Insurance, risk transfer	Page 35, 2015 Annual Report
'In the event of a large uninsured loss, the company would apply to the OEB (the regulator) for recovery of such loss; however, there can be no assurance that the OEB would approve any such applications in whole or in part, which could have a material adverse effect on the company'.				
Participant code	**Construct category**	**Climate driver**	**Related issue**	**Statement location**
2.10	Risk effect	Not specified	Future performance	Page 11, 2015 Regulatory Report
'The information provided by Utilities on their future performance (or what can be construed as forward-looking information) may be subject to a number of risks, uncertainties and other factors that may cause actual events, conditions or results to differ materially from historical results or those contemplated by the distributor regarding their future importance'.				
2.10	Risk source	Government policy, GHG abatement, sudden direct climate events	Future performance	Page 11,2015 Regulatory Report
'Some of the factor that could cause such differences include legislative or regulatory developments, financial market conditions, general economic conditions and the weather. For these reasons, the information on future performance is				

intended to be management's best judgement on the reporting date of the performance scorecard, and could be markedly different in the future'.

APPENDIX U

Appendix U—Risk Response Statements—Frequency, Percentage of Corporate Statements			
Participant Codes	**f—Risk Response Statements**	**f—All Statements**	**% of Risk Response Statements**
PRODUCERS			
1.1	3	7	.42
1.2	2	4	.50
1.3	3	4	.75
1.4	1	5	.20
1.5	0	2	0
1.6	1	1	1.0
1.7	4	4	1.0
1.8	3	9	.33
1.9	0	3	0
1.10	2	6	.33
		Mean	45%
UTILITIES			
2.1	0	2	0
2.2	0	2	0
2.3	2	4	.50
2.4	10	16	62.50
2.5	0	2	0
2.6	4	7	57.14
2.7	0	2	0
2.8	1	3	.33
2.9	3	7	.42
2.10	0	2	0
		Mean	24.5%