

Barriers and Drivers of Near-term Climate Change Mitigation: A Canadian Case Study
by

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A thesis submitted in conformity with the requirements
for the degree of Master of Applied Science
Department of Civil and Mineral Engineering
University of Toronto

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2024

Abstract

This work investigates, through semi-structured interviews, the prospect for rapid transitions towards sustainable civil infrastructure. Rapid greenhouse gas (GHG) mitigation is critical to facilitate near-term (i.e., within five years) reductions needed to limit global temperature rise to 2°C. Moreover, ongoing delays in climate action in many countries and sectors mean that rapid interventions will be needed in the coming decades as the need to mitigate becomes more urgent. This work examines, among twenty decisionmakers involved in developing, operating, or using Canadian infrastructure: (1) ongoing and expected near-term GHG mitigation actions (2) barriers constraining faster change, and (3) mitigation goals and expectations of the near future. Interview participants prioritize enabling deep change in a more distant future over executing rapid change and view government policy certainty as crucial to near-term action. This work identifies deficits in action on the near-term scale and aids decisionmakers by describing planned mitigation actions and barriers.

Acknowledgments

I often feel lucky to have had the opportunity to spend two years reading, writing, thinking, and talking with people. But crediting luck for all of this would be to ignore the many people who have supported me throughout. I'd like to thank my partner, Elizabeth, for unfailingly offering a positive perspective when I unfailingly over-analyzed things. Also, thank you to my family and friends who trusted me even when I couldn't explain what I was doing or why I was doing it.

Thank you to my supervisors, Professor Daniel Posen and Professor Shoshanna Saxe, who taught me so much about research (including the ability to consider two often vastly different viewpoints at the same time), and whose constant enthusiasm and trust gave me the confidence to stay 'lost in the forest' until a new idea presented itself. Thank you to my colleagues at UofT, for not only inspiring me in reading groups, classes, and chats in GB418, but for sharing bike rides, coffees, dinners, and beers. Thanks to Sidney, for being a keen second set of eyes and an excellent analyst. Thank you as well to my mentors and former colleagues, without whose support I would not have had the confidence to jump into such a new world.

Finally, I extend my thanks to the many people who agreed to participate in an interview for this work. Without your contributions this research would be much shallower and far less valuable. So many of you stressed the value of relationships in getting things done, and when I consider the long list of people who supported me these last two years, I understand.

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Chapter 1

1 Thesis Introduction

This thesis uses Canada as a case study to investigate the near-term actions being taken by organizations involved in the use or provision of infrastructure, and the factors driving and constraining their ability to accelerate reductions. Canada must substantially reduce its greenhouse gas (GHG) emissions in the near-term (next five years) to align with the country's commitment under the Paris Agreement to reduce emissions by 40% relative to 2005 levels by 2030. Despite this commitment, 2021 emissions were only 8.4% below 2005 levels (Environment and Climate Change Canada, 2022). Stated another way, Canada's emissions declined at a rate of 0.5% per year between 2005 and 2021 but must decline at a compounded rate of 3.5% per year between 2021 and 2030. Two major factors make achieving targets of this kind challenging: (1) the lack of obvious market motivation for reducing emissions and (2) the unprecedented speed with which broad change is required. Recognizing these challenges, the primary objective of this research is to develop knowledge about the state of near-term emissions goals and what is necessary to rapidly reduce infrastructure emissions.

1.1 Thesis organization

This thesis is organized as follows. Chapter 1 describes the motivation and objectives for the research, background on the research approach chosen, and the research questions. Chapter 2 consists of a paper including a literature review which highlights the research gaps, and the results of a qualitative research study designed to answer the research questions. Chapter 3 concludes the thesis by returning to the research questions and proposing areas for future work.

1.2 Background

1.2.1 Near-term Climate Change Mitigation

The 2015 Paris Agreement signalled the importance of achieving rapid reductions of GHG emissions before 2030 in order to limit global average temperature rise to 2°C (Winning et al., 2019). As 2030 approaches, achieving this goal must rely on solutions that can be deployed

within months or years, rather than decades. This calls for an understanding of the features of effective near-term action.

While much has been written about ‘near-term’ climate change mitigation, the topic has been inconsistently approached. For example, the IPCC has variously defined near-term as the period between 2007-2030 (IPCC, 2007), 2022-2030 (IPCC, 2023a), and 2022-2040 (Calvin et al., 2023). In this thesis, I refer to the near-term as both the period before 2030 and a rolling period of five years ahead of the present. This is because, even if the 2030 target is not met, knowledge about rapid climate change mitigation will likely become increasingly valuable as the effects of climate change become more obvious and governments look to act faster.

1.2.2 Assessing Technology Deployment Speed

Given the relevance of technical systems to GHG emissions, the field of ‘innovation studies’ acted as an initial entry point for this research. Innovation studies are concerned with improvements in technology production and quality, and their effects on deployment (Godin, 2012). Factors that affect innovation speed (Bresnahan & Trajtenberg, 1992; McNerney et al., 2011; Nemet, 2006) and deployment speed (Carrillo-Hermosilla et al., 2009; Venkatesh et al., 2003; Wilson et al., 2020) are often seen as related, and innovations literature has identified many factors that affect a technology’s speed of deployment. A more thorough discussion of these factors is provided in Chapter 2.

Innovations studies’ descriptions of factors associated with rapid technology deployment suggest the possibility that a framework could be developed to assess different climate change interventions’ suitability for rapid deployment. A major challenge with this approach is the fact that sustainability interventions represent a broad category of actions including deployment of manufactured products (e.g., solar panels), systems improvements (e.g., building retrofits, industrial efficiency improvements), organizational changes (e.g., changes to procurement practices) and demand side behavioral changes (e.g., encouraging active transport for employee commuting). In contrast, many factors described by innovations studies, such as design standardization (Malhotra & Schmidt, 2020) or market competition (Nemet, 2006), are relevant only to a narrow category of technologies (e.g., manufactured goods like electric vehicles) and less relevant to other interventions such as procurement standards or industry lobbying. To illustrate, Figure 1.1 shows a calculation of the change in standardization of electric vehicle

charging infrastructure in Ontario, Canada which according to (Malhotra & Schmidt, 2020) is useful for predicting a technology’s speed of deployment. Such a calculation requires data on the ubiquity and specifications of different forms of charging infrastructure. A similar calculation would not be appropriate to assess, for example, the potential speed of a program to encourage active transport in employee commuting. This variation makes it challenging to develop a scoring system that is both open to a broad range of interventions and useful for decisionmakers.

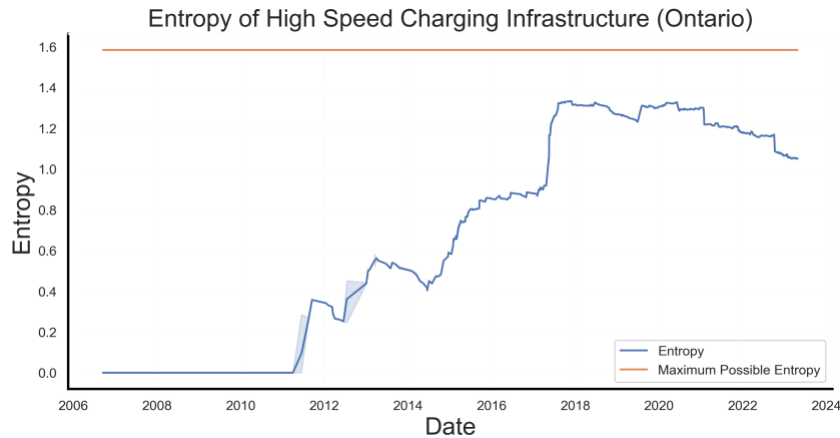


Figure 1.1 Entropy of electric vehicle charging infrastructure in Ontario, Canada. Higher values indicate a greater diversity of charging technologies in use. The chart shows that charging infrastructure initially grew less standardized before beginning to standardize in 2020, suggesting greater potential for rapid deployment. Such a calculation is illustrative for some climate change interventions but inappropriate for many other interventions not based on deployment of manufactured goods. Data from Wards Intelligence (2022).

1.2.3 Understanding the Near-term Future

The challenge of creating a usefully broad framework for identifying interventions with potential for rapid deployment suggests the value of exploring the future through other means, namely by understanding the decisions being made by today’s decisionmakers. (Alvial-Palavicino, 2015) describes the future as a product of the ‘the promises, visions, concerns’ of decisionmakers. In this way, understanding the attitudes and choices of today’s decisionmakers offers a view of how climate change mitigation will likely unfold in the near-term. Rather than develop a systematic framework for assessing all potential interventions, this approach contributes a base of knowledge about the range of sustainability interventions being pursued by organizations and the challenges they are facing in deploying interventions with near-term GHG reduction impacts. Such knowledge is both valuable to policymakers now and possibly useful for the future development of such a framework.

Moreover, many of the innovation studies conducted in the past focus on historical case studies (Becker et al., 2022; Figenbaum, 2017; Roberts & Geels, 2019). In contrast, the sustainable transition implied by the Paris Agreement is unprecedented in history due to its lack of market motivation, speed, and breadth (Andersen et al., 2023; Geels, 2010). This lack of precedent suggests that historical case studies, while helpful, cannot provide a fulsome picture of what is necessary to achieve the transition, or predict how attempts to achieve it are likely to unfold.

This research therefore chooses a perspective that focuses on the views of present-day decisionmakers and looks to understand which climate change mitigation interventions organizations in Canada are choosing, why they chose them, and what constrains faster action.

1.3 Objective and Research Questions

The objective of this thesis is to develop knowledge about the state of near-term emissions goals and what is necessary to rapidly reduce infrastructure emissions. As discussed above, the expectations and goals of present-day decisionmakers are likely to have a strong influence on the near-future emissions of Canadian infrastructure. With that view, this thesis looks to answer the following research questions:

1. What are the near-term GHG emissions expectations and goals of Canadian organizations involved in the development, operation, or use of infrastructure?
2. What are the factors that motivate or deter present-day decisionmakers within these organizations from reducing their emissions?
3. What do decisionmakers at these organizations believe to be the common characteristics of effective rapid mitigation actions?

1.4 Background on Research Approach

Section 2.3 provides a detailed description of the method employed in this research. However, the following section provides broader background (on semi-structured interviews and bias management) not included in Section 2.3 for the sake of brevity.

1.4.1 Semi-structured Interviews

The semi-structured interview is a useful tool for investigating complex phenomena lacking obvious boundaries. Semi-structured interviews take elements from structured interviews (in that interviewers prepare a set of questions in advance) and unstructured interviews (in that interviewers have freedom to deviate from the prepared questions and follow new lines of inquiry) (Galletta, 2013). Because of this flexibility, semi-structured interviews are suited to a range of research goals, and the amount of structure can be dialed to the subject at hand.

Sustainability researchers have used interviews to understand the dynamics of the interconnected market, social, and technical systems. Common approaches include the development of in-depth case studies (Helveston et al., 2019), using semi-structured interviews as an initial step to define the boundaries of later surveys (Deviney et al., 2023), or using interviews to gather stakeholder opinions in a given field (Lienert et al., 2013; Rietbergen et al., 2015).

One challenge in conducting interview-based research is in determining the point at which additional interviews are no longer needed to make a conclusion – the ‘saturation point’ (Saunders et al., 2018). Ideally, saturation can be observed when additional interviews no longer yield new useful data. In practice, this point can be challenging to identify, and saturation may be guided by the researcher’s opinion based on their ongoing analysis of data. In section 2.3.5.1, we describe the factors involved in our assessment of saturation.

1.4.2 Perspective Management

The reliance on researcher judgment introduces bias to qualitative research. For example, a researcher’s positionality (i.e., their personal views, assumptions, and experiences) might affect the types of follow-up questions asked or the way in which results are interpreted. In qualitative research, attempts are made to manage bias, rather than eliminate it entirely (Levitt, 2020). Several perspective management approaches are commonly employed – usually in the analysis and reporting stage – such as identifying one’s positionality (Darwin Holmes, 2020), using multiple analysts, and acknowledging the possibility for multiple interpretations of the data.

1.4.2.1 Positionality Statement

In reporting the results of this study, I acknowledge my own positionality as a male Canadian of European descent whose cultural biases and privilege likely informed my interactions with interviewees and interpretation of the resulting data. I also acknowledge that my position as an MAsc student in the University of Toronto's Sustainable Systems research group – a group focussed on using quantitative methods to advance the sustainability of engineering systems – likely influenced my approach to inquiry and interpretation of results.

1.4.2.2 Use of Multiple Analysts

To support the aim of managing my own bias, a summer student was asked to review each interview transcript and take notes relevant to each interview question. Through a series of meetings, we discussed their findings and compared them with my own. In some cases, the student highlighted excerpts I missed in my review, or interpreted responses differently. For example, we had different perspectives on whether small or large organizations are better equipped to execute rapid actions. Through discussion, we came to a more refined understanding of the concept of 'rapid change' that allowed for the fact that smaller organizations can likely *execute* actions more rapidly, but that larger organizations might have more capacity to execute more *significant* sustainability actions quickly. This refined understanding informed the discussion of the results in Chapter 2.

Chapter 2

2 Barriers and Drivers of Near-term Climate Change Mitigation: A Canadian Case Study

Chapter 2 explores the factors driving and constraining Canadian organizations' near-term mitigation of greenhouse gas (GHG) emissions. It begins by providing background motivation for the research and outlines the existing research on technology transitions. Results indicate that participants struggle to engage with the concepts of planning and executing action in the very near-term, evidenced by their tendency to prioritize laying groundwork for deep change over executing rapid change now (or soon). Participants also see government policy certainty as a main driver of rapid action and describe situations in which policy uncertainty slows the pace of change.

The content of this chapter is derived from a paper in final preparation for publication:

Sauer, J., Posen, I.D., Saxe, S. Barriers and Drivers of Near-term Climate Change Mitigation: A Canadian Case Study (2024).

Contributions to the paper (according to CRediT standards (McNutt et al., 2018)) are as follows:

I. D. Posen, S. Saxe, and I contributed to conceptualization of the research questions and approach, interpretation of data, and draft editing. I conducted the research interviews, data processing, coding passes, and draft writing.

2.1 Introduction

This work investigates the goals, ongoing actions, and barriers to near-term greenhouse gas (GHG) mitigation by developers, operators, and major users of civil infrastructure. The Intergovernmental Panel on Climate Change (IPCC) has divided the future into three timeframes: near-term (to 2030), mid-term (2030 to 2050), and long-term (2050 onwards) (IPCC, 2023a). Notably, the 'near-term' has gradually grown shorter, with the IPCC originally describing the period of 2007-2030 as 'near-term' (IPCC, 2007). Understanding the characteristics of climate

change mitigation measures that can be deployed in the near-term (next five years), as well as their barriers, is important for three reasons.

First, near-term choices have significant implications on the suite of actions required in the long-term. As the idea of a CO₂ ‘budget’ illustrates: the more CO₂ emitted before 2030, the less that can be emitted afterwards in order to remain within 2°C of warming (IPCC, 2023b). Near-term reductions are expected to provide greater long-term benefits than delayed reductions (IPCC, 2023b; Winning et al., 2019). In this way, higher emissions before 2030 leads to a greater reliance on negative emissions measures (e.g., carbon capture and storage) in the medium- and long-term (Eom et al., 2015).

Second, a near-term view aligns with the length of elected political timelines and common employment timelines for decisionmakers. Elected officials often act on short timelines, making significant decisions at the beginning or end of their term – termed ‘crack of dawn’ and ‘midnight’ rulemaking (O’Connell, 2008).

Thirdly, delays in many countries and sectors in taking action suggest that rapid interventions will be needed in the 2030s and 2040s as climate change becomes more severe and actors no longer have the luxury of planning for decades-long rollouts or ‘ostriching’. For these future decisionmakers, an understanding of the common drivers and barriers to rapid action will be critical.

Despite these motivations, Canada’s progress to date is not aligned with its commitment under the Paris Agreement to reduce emissions by 40% compared to 2005 levels (2021 emissions were only 8.4% below 2005 levels (Environment and Climate Change Canada, 2022)). Stated another way, Canada’s emissions declined at a rate of 0.5% per year between 2005 and 2021 but must decline at a compounded rate of 3.5% per year between 2021 and 2030. The disparity calls for knowledge to support a greatly accelerated transition.

We take a specific focus on infrastructure, given its key role in both sustainable development and pollution (Fischer & Amekudzi, 2011; Thacker et al., 2019). In Canada, three infrastructure sectors: transportation, heating, and electricity, accounted for 37% of all GHG emissions in 2021, a share similar to global values (Environment and Climate Change Canada, 2022; World

Resources Institute, Climate Watch, 2021). In addition, infrastructure systems, due to their interconnectedness with many aspects of society, have historically changed more slowly than other technical systems (Markard et al., 2020). Any attempts to explore the possibility of climate change mitigation must engage with the interdependent system of infrastructure developers, operators, and users.

This study develops knowledge about near-term climate action by investigating the near-term GHG mitigation plans and actions of Canadian organizations involved in the use, operation, or provision of infrastructure. Through analysis of semi-structured interviews, we describe the drivers of near-term action and the barriers constraining more rapid mitigation. By taking a qualitative approach centered on semi-structured interviews, our work provides an immediate and deep understanding of decisionmakers thought processes around near-term climate action.

2.2 Background

This section begins with a literature review (1) outlining the field of transitions studies and (2) discussing the potential of accelerating sustainability transitions, (3) reviewing the drivers of rapid transitions and (4) discussing past attempts to apply these conclusions to accelerate sustainable transitions. Finally, (5) we argue for an approach focussed on present day decisionmakers' expectations, and a broad survey of near-term actions being undertaken by large infrastructure users and providers.

2.2.1 Transitions Research

A common perspective on climate action suggests that existing technologies – if deployed extensively – could meet emissions targets, demonstrated 20 years ago by (Pacala & Socolow, 2004). This frame – which views the challenge of climate change mitigation in terms of deployment, rather than primarily innovation – is relevant to studies of near-term action. However, this does not imply that the role of new technologies should be ignored. Substantial climate action will likely involve a mix of existing technologies and new ones. We also acknowledge the role for non-technical interventions such as demand side measures. In the interest of opening our discussion to a broad range of options, we use the term ‘intervention’ to describe all of these.

A wide body of literature studies technology transitions, described as the interactions between existing technologies and competing innovations. Some attempts have been made to develop generalized theories about the durations and dynamics of technology transitions. The study of technology transitions spans many fields including economics (Grubler, 1999; Smil, 2016), social science (Geels, 2004; Iyer et al., 2015; Rosenbloom & Meadowcroft, 2014), and political science (Lauber & Jacobsson, 2016). Three main perspectives have developed: techno-economic, sociotechnical, and integrated.

Techno-economic studies track the energy flows involved in markets' production and consumption of energy, often employing integrated assessment models (Smil, 2016). This perspective has been criticized for insufficiently accounting for mechanisms like technological inertia, path dependence, and policy creation (Cherp et al., 2018; Matos et al., 2022). For example, (Christophers, 2024) argues that policy decisions, not the relative cost of energy sources, are responsible for the slow rollout of renewable electricity in much of the world.

Another category of studies describes the '**sociotechnical**' system of actors and technologies employed to deliver a particular service (e.g., the sociotechnical system for electricity includes the physical infrastructure, human operators, developers of standards, etc.). These studies give more credit to the role of non-technical elements (e.g., actors and institutions) and attempt to describe the underlying social dynamics of transition (Bergek et al., 2008; Geels, 2010; Kemp et al., 1998). These theories attempt to explain the dynamics of historical technology transitions, but their focus on historical case-studies has led critics to question their generalizability or potential to extrapolate to future transitions (Grubler et al., 2016).

Several authors have suggested that transitions can only be understood by **integrating** (Cherp et al., 2018; Kennedy, 2021, 2023; Palm, 2022; Pearson & Foxon, 2012) or switching between (Sovacool & Geels, 2016) multiple perspectives. For example, (Cherp et al., 2018) describes German and Japanese nuclear energy transitions as a co-evolution of techno-economic, sociotechnical, and political systems. Similarly, (Kennedy, 2023) applies a 'biophysical economic' framework that provides technical, economic, and social descriptions of the industrial revolution and Great Depression. These 'integrated' frameworks offer convincing explanations

of past transitions, but the lack of a generalized theory makes it difficult to extract concrete recommendations for future transitions.

2.2.2 The Possibility of an Accelerated Sustainability Transition

All three categories of studies engage with the question of whether sustainability transitions can be accelerated. Studies with a greater focus on economics tend to point to the enormous economic costs of replacing dominant technical systems, arguing that a widespread low carbon transition would be necessarily slow (Smil, 2016), or at least require ‘remarkably active’ changes to infrastructure and institutions (Pearson & Foxon, 2012).

Actor-focused studies more readily suggest that large scale climate change mitigation can be accelerated. As examples, they point to exceptional cases of rapid transformation such as American industrial mobilization in World War II (Bromley, 2016), Ontario’s phaseout of coal-fired electricity (Sovacool, 2016), Norway’s uptake of electric vehicles (Figenbaum, 2017), deployment of pop-up cycling infrastructure in Berlin (Becker et al., 2022), or mRNA vaccines (Marinakis et al., 2024).

Despite this optimism, actor-focussed studies also identify barriers to rapid action. For example, (Rickards et al., 2014) describes the ‘narrow perspective’ of senior decisionmakers as the cause of a ‘deep propensity for inaction’. Similarly, (Scott, 1998) details a historical tendency of decisionmakers to fail in their attempts to make rapid changes to social systems. In Scott’s examples, most attempts to meaningfully change social systems are fought off by an unpredictable array of complicating factors (e.g., cultural norms or technical setbacks).

While sociotechnical and technoeconomic studies disagree on the possibility of deliberate acceleration, they agree on the fact that sustainability transitions differ from many past transitions in their lack of obvious market motivation (Geels, 2010) and their unprecedented “speed of implementation, breadth of action across all sectors of the economy, and depth of emission reduction” (Andersen et al., 2023; Markard et al., 2020).

Both sociotechnical and technoeconomic studies argue that sustainability transitions are driven primarily by a belief in the common good and, in the absence of policy, few incentives exist for private actors (Geels, 2010; Pearson & Foxon, 2012). For example, Pearson & Foxon (2012)

observe that because the environmental benefits of low-carbon technologies are (in the absence of carbon pricing) not easily valued by markets, consumers may base decisions on more easily priced factors like efficiency or performance.

Authors also argue that a sustainable transition would involve disruption of broad economic networks based on fossil fuels (Geels, 2010; Grubler et al., 2016; Smil, 2016). In this view, sustainability transitions are similar to the many-decades-long, ‘system of systems’ transportation and energy transitions described by Grubler et al. (2016). (Kennedy, 2023) provides an illustration of a potentially analogous disruption: the transition of the U.S. economy from one centered around rail and locomotives to one centered around roads and the automobile. In Kennedy’s formulation the Great Depression is a period of adjustment to this transition. This view suggests a tension between speed, breadth, and depth – all of which are necessary features of a sustainable transition (Andersen et al., 2023).

2.2.3 Drivers of Transitions

A related set of studies looks to understand the drivers of transitions. These studies typically take one of three perspectives: (1) that of the intrinsic characteristics of a technology or intervention, (2) the interaction (e.g., physical compatibilities or lack thereof) between an intervention and existing technical systems, or (3) the broader economic and policy factors that affect the speed of deployment.

On the deployment side, many authors have studied the relationship between elements of a technology’s design and its deployment speed. Some examples of these features are standardization (Frenken et al., 1999), design complexity (McNerney et al., 2011), improved performance over incumbents (Pearson & Foxon, 2012; Venkatesh et al., 2003), and ease of use (Venkatesh et al., 2003). (Wilson et al., 2020) integrates several of these factors into the concept of ‘granularity’, showing that technologies of lower unit cost or size are associated with faster deployment and improvement. Wilson et al. explains these relationships by showing that the granularity of a technology is associated with lower investor risk and less restricted access to capital.

A second group of studies identifies physical elements external to the technology, such as the presence of supporting infrastructure (Carrillo-Hermosilla et al., 2009; Palm, 2022), or compatibility with complementary technologies (Nylund et al. 2022; Colombo and Mosconi, 1995). This line of inquiry introduces considerations that may not be obvious when assessing only a technology’s design, though its focus on the physical aspects of systems can underappreciate the social and political forces acting on these systems.

A third group of studies consider the role of ‘intangible’ market, policy, social, and exogenous factors (e.g., climate, geopolitical events, etc.) (Sovacool & Geels, 2016). These studies are most closely related to the sociotechnical perspective on transitions, focussing on the role of networks of actors and institutions. For example, in their study of electric vehicle penetration in Norway, (Figenbaum, 2017) credits the rapid uptake of EVs to a complex network of factors, including the decisions of foreign automobile manufacturers, efforts by environmental advocates, hobbyists, indifference from the traditional automobile industry, innovations in battery technology, and government policy. These authors acknowledge that material elements like technology design and economics are important components of transitions but argue that they are decidedly not the full story. Table 2.1 provides a summary of factors that affect the speed of deployment of technologies identified in the technology transitions literature. Appendix A-2 provides additional detail on each factor.

While no single perspective allows for perfect insight into a given transition, each of them provides valuable insights into the factors that drive or constrain technology transitions. With the goal of developing a sufficiently ‘broad’ (Andersen et al., 2023) understanding of low carbon transitions, this study does not explicitly adopt a perspective, instead allowing participants to describe the features of rapid actions and, as part of the analysis, comparing the results to the characteristics described in literature (Table 2.1).

Table 2.1: Factors driving transitions. Factors fall in one of three categories, resulting from (1) the intervention’s technical design, (2) the intervention’s relationship with existing physical systems, (3) the influence of factors (market, policy, social, or exogenous) external to the technology.

Origin	Factor	Sources
Design	Pervasiveness (wide variety of applications)	(Bresnahan & Trajtenberg, 1992; Fouquet, 2016)
	Standardization	(Malhotra & Schmidt, 2020; Nylund et al., 2022)
	Improved performance (in reality and in user perception)	(Pearson & Foxon, 2012; Venkatesh et al., 2003)
	Technology Dynamism (capacity for continued innovation)	(Bresnahan & Trajtenberg, 1992)
	Innovational Complementarities (ability of regular users to innovate and modify the technology)	(Bresnahan & Trajtenberg, 1992)
	Low design complexity	(McNerney et al., 2011)

Origin	Factor	Sources
	Granularity	(Carrillo-Hermosilla et al., 2009; Wilson et al., 2020)
Technology System	Compatibility with existing technical systems	(Carrillo-Hermosilla et al., 2009; Colombo & Mosconi, 1995; Markard et al., 2020; Nylund et al., 2022)
	Requisite infrastructure buildout (augmentation, add-on, establishment)	(Environmental Protection Agency, 2023; Malhotra & Schmidt, 2020; Palm, 2022)
	Absence of locked-in, centralized incumbent	(Carrillo-Hermosilla et al., 2009; Geels, 2014; Hess, 2013)
	Powerful centralized decisionmaker	(Scott, 1998)
	Technology assessment criteria (degree of bias to incumbent)	(Carrillo-Hermosilla et al., 2009)
	Low complexity value chain	(Hoggett, 2014)
	Complex dominant design [drives deployment of related technologies which locks in the primary tech]	(Nylund et al., 2022)
	Development of value chain (economies of scale, spillover, and local learning)	(Palm, 2022)
Market	Availability of information for users & developers	(Carrillo-Hermosilla et al., 2009; Environmental Protection Agency, 2023; Viardot, 2013; Wang et al., 2018)
	Dynamic increasing returns	(Andersen et al., 2023; Environmental Protection Agency, 2023; Iyer et al., 2015; Katz & Shapiro, 1986; Nemet, 2006)
	Competition (i.e., low industry concentration, high consumer choice)	(Environmental Protection Agency, 2023; Nemet, 2006)
	Absence of market barriers (supply chain issues, skilled labour shortages, high technology costs, availability of financing)	(Environmental Protection Agency, 2023)
	Consumer expectations of technology growth	(Katz & Shapiro, 1986)
	Experience (degree of deployment)	(Andersen et al., 2023; Nemet, 2006)
	Alignment of project planning and execution timelines	(Markard et al., 2020)
	Widespread use (shift from early adopters to mainstream)	(Palm, 2022)
	Aligned incentives (as opposed to split)	(Environmental Protection Agency, 2023)
	Low up-front cost	(Environmental Protection Agency, 2023)
	Limited competition among uses	(Markard et al., 2020)
Policy	Integrated (market, communications, infrastructure investments, etc.) & consistent policy	(Andersen et al., 2023; Iyer et al., 2015; Markard et al., 2020; Palm, 2022; Roberts & Geels, 2019)
	Maintenance of protected niches	(Kemp et al., 1998)
Social	Alignment with incumbent or strongly emerging cultural, institutional, and business norms	(Andersen et al., 2023; Environmental Protection Agency, 2023; Markard et al., 2020; Venkatesh et al., 2003)
	Absence of incumbent opposition (i.e., industry, unions)	(Markard et al., 2020; Roberts & Geels, 2019)
Exogenou s	Favourable landscape pressures (climate, macroeconomic cycles, new resource discoveries)	(Roberts & Geels, 2019)

2.2.4 Research Gap

The sustainability transition required to address climate change is largely unprecedented in its lack of obvious market motivation and required speed and breadth (Andersen et al., 2023; Markard et al., 2020). For example, the International Energy Agency calls for a tripling of renewable energy capacity and a 75% reduction in methane emissions between 2023 and 2030 (IEA, 2023). These factors suggest the value of a perspective oriented to the near future that does not rely on extrapolation from historical precedent.

In contrast, many sustainability transition studies either review historical case studies (Becker et al., 2022; Figenbaum, 2017; Sovacool, 2016) or focus on longer term pathways to net-zero (Rosenbloom & Meadowcroft, 2022). Rosenbloom & Meadowcroft's (2022) approach does, however, provide insight into how a focus on the near future might be achieved. Their study describes working closely with decisionmakers in an attempt to accelerate the development of a

‘hydrogen economy’ in western Canada. Their approach shows an explicit concern for the role of decisionmakers’ choices in constructing the future. (Alvial-Palavicino, 2015) argues that the future is the aggregate result of many actors’ expectations – ‘the promises, visions, concerns’ – about the future. In the same way, today’s decisionmakers’ expectations about the future offer a picture of the near future as it is likely to unfold due to their influence and perspective.

This research therefore responds to the need for a near future perspective on sustainability transitions by investigating the plans and expectations of present-day decisionmakers. By interviewing decisionmakers at organizations involved in the use or provision of infrastructure, we develop an understanding of (1) their near-term GHG emissions expectations and goals, (2) common characteristics of effective rapid mitigation actions, and (3) the factors that motivate or deter present-day decisionmakers from accelerating mitigation. By engaging with these topics, this work seeks to identify the current state of action (or inaction) and what is necessary to enable accelerated climate change mitigation.

2.2.5 Research Approach

We deploy a qualitative approach that investigates Canadian infrastructure decisionmakers’ perspectives on near-term GHG mitigation. Qualitative research conducted through semi-structured interviews allows us to address the above challenges simultaneously. The flexibility of semi-structured interviews allows for a deep understanding of plans and motivations, while the development of a consistent set of base questions allows us to investigate a broad selection of organizations.

By engaging these challenges, this research builds knowledge that is both immediately relevant as a case study and that informs future efforts towards rapid decarbonization by organizations and policymakers. The research gap directly informs three categories of interview questions: (1) near-term GHG mitigation goals and expectations, (2) the characteristics of effective rapid mitigation actions, and (3) the barriers constraining more aggressive/faster change.

2.3 Method

We conducted a set of semi-structured interviews, followed by a mix of inductive and deductive coding of the interview transcripts. Semi-structured interviews are a useful tool for investigating

complex human systems (Galletta, 2013). Inductive codes were sorted into emergent categories appropriate to each research objective. Deductive coding was conducted on two questions, described in Section 2.3.8.3.

An initial coding pass organized the transcripts according to topics under discussion. Because participants might touch on several topics in a single excerpt, this coding pass allowed for overlap, rather than strictly dividing the conversation into sections.

2.3.1 Perspective Management

The lead researcher is a Canadian settler of European descent whose cultural biases and privilege could have influenced interactions with interviewees and interpretation of the resulting data. Additionally, the research team's background in quantitative analysis of engineering systems likely influenced the approach to inquiry and interpretation of results.

To open the analysis to additional perspectives, an analyst (female high school student with an interest in sustainability) reviewed and reported on thirteen transcripts (only a portion of the total number were reviewed due to time constraints). The lead researcher and analyst compared interview notes and discussed high level observations. The lead researcher and analyst agreed on high level results (i.e., participants' focus on electrification, the importance of government policy, and uncertainty as a barrier to action).

2.3.2 Participant Selection

Participants represented organizations involved in the delivery, operation, or use of infrastructure (including water, electricity, heating, and transport) in Canada. Only companies based in Canada or with major Canadian operators were considered. 'Users' include organizations whose core functions rely significantly on infrastructure system, beyond what is required to comfortably house employees in a commercial setting. For example, a grocery store chain that relies on electricity for refrigeration would be considered a user. An accounting firm with no significant emissions directly related to its operations would not be included.

Participants directly involved in the decision-making process of the associated organization were prioritized. However, we were often referred to alternate interview subjects (e.g., the organization's sustainability officer) and generally deferred to the organization regarding who

would be best placed to respond to the interview questions. While most participants were connected to the researchers via professional networks, individuals with whom the researchers had had a previous supervisory relationship were excluded. Interviews were conducted remotely using Zoom between November 2023 and April 2024.

2.3.3 Study Participants

A brainstorming session among the researchers generated an initial list of 81 relevant organizations, potential interviewees, and contacts who might act as a source of connections within a given sector. Of these, 62 individuals whose contact information was publicly available, or whose contact information the research team already had, were contacted. Of this selection, 13 agreed to schedule an interview and eight additional interviewees were added via referrals from the original selection. The total number of interviews conducted was 21.

Some participants requested to include one or two additional members of their organization in the interview. These requests were granted if the additional members could justifiably provide detail that the main participant could not. For example, interview C-3 included an organization's head of sustainability as well as the individual who directly developed the organization's sustainability plan. We acknowledge that interviewees with such 'back-up' may have been better able to engage with difficult concepts. Informed consent was granted individually by all interviewees.

2.3.4 Researcher-Participant Relationship

The prior relationships between participants and researchers varied from non-existent (in the case of referrals) to long-term (e.g., former university colleagues). None of these relationships were of a supervisory nature. It is reasonable to assume that some interviewees felt participation in the research could strengthen their professional relationship with the researchers.

2.3.5 Participant Recruitment Process

Participants were recruited via a boilerplate email (see Appendix 1) that outlined the research background, structure of the interview, and a request for other potential interviewees should the contact be unable to participate. Participants were not compensated for their participation in the study. Participants were informed of the motivations and broad themes of the research but were

not provided with a list of questions in advance. The decision to withhold the question list was made with the intention of encouraging candid responses. In retrospect, this decision may have led to less detailed responses to some questions; providing a list of questions in advance would have allowed participants time to develop more nuanced responses. However, this would have limited our ability to observe participants' real-time attempts to engage with the questions.

Twenty-one individuals were interviewed, with one participant withdrawing following their interview due to concerns about their ability to speak publicly on the topic. Participants represented a selection of sectors relevant to Canadian infrastructure (Table 2.2). Given the uneven distribution across sectors, we have restricted our sector level observations, instead focussing on the broader characteristics of the participants as decisionmakers.

Table 2.2: Sectors, types of organizations, and generic descriptions of interviewees' roles. Where more than one role is listed for an organization, that interview involved a single conversation with more than one representative of the organization.

Sector	Identifier	Organization Type	Role
Construction (4)	C-1	Building developer	Sustainability director Vice president
	C-2	General contractor	Sustainability director Innovation director
	C-3	General contractor	Sustainability director Sustainability vice president
	C-4	Municipal buildings department	Program manager
Electricity (3)	E-1	Electrical utility	Sustainability director
	E-2	Electrical utility	Senior engineer
	E-3	Electrical utility	Government relations manager
Finance (2)	F-1	Financial institution	Planning and policy director
	F-2	Financial institution	Sustainability director
Industrial (3)	Ind-1	Cement manufacturer	Sustainability manager
	Ind-2	Primary metal producer	Innovation director
	Ind-3	Forestry products	Researcher/Consultant
Institution (2)	Ins-1	University department	Facilities director
	Ins-2	University	Sustainability manager
Transportation (6)	T-1	Courier	Innovation specialist
	T-2	Municipal fleet department	Program manager
	T-3	Municipal cycling department	Project manager
	T-4	Port authority	Sustainability manager
	T-5	Courier	Fleet manager Sustainability specialist
	T-6	Municipal transit agency	Sustainability manager Sustainability director

2.3.5.1 Saturation

Determining the point of saturation for this study was challenging, given the mix of deductive and inductive coding applied, as well as the mix of open- and closed-ended questions. Acknowledging the risk that the concept of saturation is ‘stretched too widely’ (Saunders et al., 2018), we do not claim that the selection of participants is a saturated sample of all decisionmakers in Canada. Instead, we note that the categories of responses identified during the initial fifteen interviews remained stable and accommodating of new data. While new insights were generated in the final five interviews, these largely confirmed or refined results found in earlier interviews. For example, the final interviewee, T-6, elaborated significantly on the problem of misalignment between goals and budgetary horizons. This concept had been mentioned in an earlier interview (Ins-1).

While additional interviews could have reasonably produced additional insights, time constraints related to the availability of funding would have likely required a shallower approach to interviews and analysis. In this way, the selection of twenty interviewees supported the research objective of conducting a broad and deep analysis of actors’ actions and attitudes.

2.3.6 Consent and Ethics

The research protocol – including the core set of interview questions – was approved under University of Toronto Human Protocol Number 45512. Interviewees accepted a limited social risk in participating in the study. Because each participant belongs to a small category of expert (e.g., there are only so many ‘Sustainability Directors’ in Canada’s electricity sector), it is plausible that a reader of this paper could deduce opinions of individual interviewees. If this is the case, there is a potential risk to the participant if published responses do not represent the values of their organization. To minimize this risk, interview transcripts were provided for review and responses were modified accordingly if requested. As a result of this process, one participant requested redactions, and one participant withdrew from the study.

Text transcripts, audio recordings, and video recordings were taken with the participants’ consent. Upon scheduling an interview, participants were provided with an informed consent letter for review (see Appendix 2). The letter provided additional background and motivation for the research, described potential risks to the participants, procedures for withdrawal from the

study, and description of data security measures taken. At the start of each interview, the lead researcher reviewed the letter and recorded the participants’ verbal consent.

2.3.7 Data Collection

The purpose of the interviews was to elicit participants’ expert opinions on implementation of GHG mitigation measures in the next five years. Thirteen questions were prepared for the interview, some of which included multiple parts (Table 2.3). The questions fell under five categories, beginning with close-ended questions and transitioning to open-ended hypothetical questions: (1) Organizational planning and near-term GHG mitigation goals, (2) Characteristics of rapid action (3) Near-term mitigation actions, (4) Barriers to rapid action, and (5) Expectations of the future. This approach aimed to ease participants into deeper thinking as the interview progressed. Section 2.4 summarizes the responses to these questions.

Table 2.3: List of interview questions. Questions marked with an asterisk were considered core questions that directly engaged with the objective. These questions were asked of all participants (with occasional exceptions due to time constraints). Other questions (those without an asterisk) were included to solicit additional information when time allowed.

#	Question
(1) Organizational planning and near-term GHG mitigation goals	
1*	In general, how long is your organization’s operational planning horizon (as opposed to aspirational/strategic planning)?
2	What are your organization’s sustainability goals? How did your organization choose these goals?
3*	What are your organization’s GHG mitigation goals? How did you choose these goals?
(2) Characteristics of rapid action	
4*	Briefly describe an initiative your organization is working through (not necessarily sustainability related) that you are confident can be completed over the course of five years.
4.1*	What characteristics of the project make implementation within five years feasible?
(3) Near-term actions	
5*	What actions is your organization taking within one/five/beyond five year(s) to achieve its mitigation goals?
6	What other actions to reduce GHG emissions did your organization consider?
6.1	What other actions could an organization like yours theoretically take even if you did not consider them when developing your GHG mitigation targets?
6.2	Which actions are you aware your peer organizations are taking to reduce emissions?
7	What other actions is your organization taking related to sustainability but not necessarily GHG reductions? These could be related to, for example: biodiversity, freshwater usage, land-use change, or ozone depletion.
(4) Barriers to rapid action	
8*	What factors are influencing (positively or negatively) your organization’s ability to achieve GHG mitigation goals in the next five years?

#	Question
8.1	Which of these factors are within your organization’s control?
8.2	Which are outside of your organization’s control?
9	What factors are influencing (positively or negatively) your sector’s ability to reduce GHG emissions in the next five years?
(5) Expectations of the future	
10*	Imagine that, in five years, your organization has outperformed its GHG mitigation targets by 50%. What combination of factors might have led to this situation?
11*	Imagine that, in five years, your organization has underperformed its GHG mitigation targets by 50%. What combination of factors might have led to this situation?
12*	Assuming all constraints on money or resources were removed, what actions would you recommend your organization take to achieve the greatest GHG reductions within five years?
13	Still assuming zero resource constraints, which actions would remain just outside a five year window?
13.1	What would it take to bring some of those actions within a five year window?

Eight “core” questions were asked of each interviewee (asterisked in Table 2.3), while the remaining five were addressed as time permitted. This strategy was intended to ensure the core research questions were answered but provide the interviewer with additional prompts that could add nuance to the responses as time permitted. By default, questions were asked in the order shown in Table 2.3, however if a participant’s response touched on points relevant to a later question, the later question could be asked as a follow up, rather than continuing sequentially. For example, a participant describing a near-term action (Q5) might naturally begin to describe the barriers to achieving that action. In this case the interviewer had discretion to ask for more detail on those barriers, effectively jumping to Q8. The intention of this approach was to support a more natural flow to the conversation.

Given the broad range of organizations, questions were occasionally adjusted to logically fit a given participant. For example, two organizations did not have explicit near-term goals upon which to speculate (i.e., Ind-3 and T-4). These participants were instead asked to imagine a world in which their organization exceeds or falls short of their current *expectation* of 2030 emissions reductions.

2.3.8 Analysis Approach

This section describes the timing and form of analysis conducted on the interview transcripts.

The primary method of data analysis was qualitative coding of transcript responses. An initial coding pass identified the topics under discussion in each excerpt (i.e., mitigation goals, perspectives on characteristics of rapid action, near-term actions, barriers to actions, or expectations of the future). This step was necessary because participants occasionally touched on one topic while responding to a question about another (e.g., describing barriers to action after being asked about their mitigation goals). Next, excerpts were coded according to their content. For example, 34 codes were created to reflect the unique near-term actions described by participants in response to question 5. Finally, codes were categorized to draw out common themes. These methods are described in more detail below.

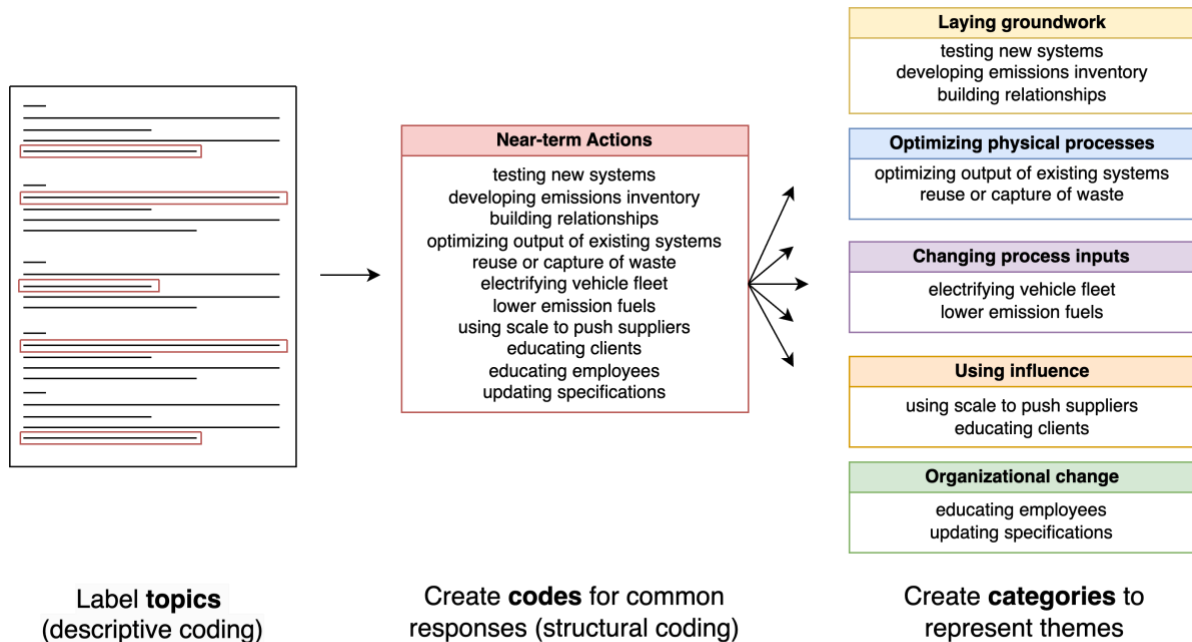


Figure 2.1: Example of the inductive coding process, illustrated by the development of categories of near-term actions. (a) Pass 1: interview transcripts were coded according to which of the five topics (listed in Table 2.3) were under discussion. (b) Pass 2: a set of conceptual codes were produced for each topic. The example above shows some conceptual codes developed for the topic ‘Near-term actions.’ (c) Finally, conceptual codes were consolidated and sorted into an emerging set of useful categories for analysis.

2.3.8.1 Timing

Data analysis progressed in step with collection allowing both processes to inform one another. For example, analysis following the first five interviews showed that participants answering questions 5 sometimes described longer term actions. While this result is notable, the researchers

made the decision to more heavily stress the ‘near-term’ aspect of the question in future interviews.

2.3.8.2 Inductive Coding

Fieldnotes, taken during each interview, acted as both a record of discussion and a tool of analysis. These notes were transcribed immediately after the interview into a freeform one page memo that identified notable responses, the interviewer’s reflection on those responses and practical notes about the interview process. In addition to organizing the interviewer’s immediate impressions these memos were referred to later in the analysis process.

Interview text transcripts were then uploaded to the software NVivo 14, where an initial pass coded sections of each transcript based on the question being answered. Due to the overlapping nature of the questions, some excerpts answered multiple questions. These excerpts were coded according to all questions answered. Following this step, a more detailed structural coding pass was conducted with the broad goal of identifying common themes and highlighting salient phrases. A typical pass might result in the following annotations:

E-1: For some of the shorter-term projects that we've been looking at, **one of the things that we're working through right now is integrating consideration for sustainability, climate change, mitigation into our business processes.** And so the key thing that we're looking at - that I'm expecting to make it successful - is the fact that we're understanding our business and the way that it works. **We're trying to incorporate climate change considerations in the way that is least impactful to the day-to-day way that people do work. So it's not a wholesale change, it's not a large flirting something new, but it's not a large learning something new, but it's sort of augmenting what already exists** with the theory that that is going to lead to more successful outcomes than trying to create something that is whole scale new around climate change and sustainability.

Integrating sustainability as a decision criterion

Minimizing disruption

'augmenting what already exists'

Figure 2.2: Example of an interview excerpt containing overlapping codes. Codes are displayed on the right margin next to the relevant excerpt.

Here, ‘integrating sustainability as a decision criterion’ is highlighted as a near-term action taken by E-1, while ‘minimizing disruption’ and ‘augmentation of existing’ are features of that action.

Codes were either direct *in vivo* quotations (e.g., ‘augmenting what already exists’) or generic descriptions of the excerpt (e.g., ‘minimizing disruption’). Because of the iterative nature of coding, initial coding passes generated many *in vivo* codes, with these gradually merging into more generic codes in later iterations.

Once half of the transcripts had been reviewed, codes were sorted into useful categories for analysis. This is a subjective process on the side of the coder and involves considering which features of each code are most relevant to analysis. For example, barriers to rapid action could be sorted according to their source, mechanism, or some other essential characteristics. To complicate matters, some codes fit in multiple categories - for example, the barrier ‘too fast is unsafe’ might be considered a technical barrier but could also be viewed as a regulatory barrier (worker safety is a legal consideration), or social barrier (society values safely run organizations).

While codes could reasonably be categorized in many ways, categories were chosen to limit ambiguity (i.e., so that most codes fit well in a single category). In cases where ambiguity exists, the action was sorted according to the researchers’ judgment of the most appropriate category. For example, ‘electrifying vehicle fleet’ is both a ‘change of process input’ (from gasoline/diesel to electricity) and ‘physical process optimization’ (electric drivetrains are generally more efficient than internal combustion engine drivetrains). In our judgement, the more salient attribute of this action is the ‘change of process input’. This approach aligns with the research objective of synthesizing findings between many sectors, since it allowed seemingly disparate comments from different participants to fit into the same essential categories.

Once categories were chosen, some quantitative analysis of the data was possible. Given the small selection of participants, this was restricted to high level features (e.g., identifying the most frequently cited types of near-term actions), rather than deployed to make specific claims about a given sector or participant.

2.3.8.3 Deductive Coding

Deductive coding (in which transcripts are coded according to pre-determined categories) was conducted on two questions related to the characteristics and barriers to rapid action:

Question 4.1 (characteristics of rapid actions): The goal of this coding pass was to understand which characteristics of rapid actions described in literature were salient to participants and identify possible disagreements between participants and literature. To complete this pass, a code book was developed based on the drivers of rapid action found in literature and shown in Table 2.1. Participants' responses to question 4.1 were then compared to the codebook. The results of this pass are presented in section 2.4.2.2.

Question 8 (barriers to rapid action): The goal of this coding pass was to understand which barriers were most relevant to the speed of an intervention. Two codes were used for this pass, defining barriers to action as either slowing action ('temporal' barriers) or completely blocking it ('general' barriers). A barrier was coded as temporal if participants used time-related words to describe their effect (e.g., delay, wait, slow), or general if the participant referred primarily to challenges with implementing actions without mentioning time. In ambiguous cases, this approach relied on the researchers' judgement based on context. An example of this can be seen in C-1's discussion of material scarcity "Demand can work against economies of scale. For example, the whole market [might be] asking for a certain material, but the supply chain can't catch up to that demand" (C-1). Categorizing this as a temporal barrier requires the assumption that the supply chain challenges C-1 refers to will eventually be overcome. The results of this pass are shown in section 2.4.4.2.

2.4 Results

This section describes the responses to each category of interview questions outlined in Table 2.3 (i.e., (1) participants' approach to near-term planning, (2) their opinions about the features and drivers of rapid action, (3) the near-term actions planned by participants, (4) their perceived barriers to action, and (5) participants' responses to hypothetical versions of the near future).

Subsections detail the main findings of the research, but an abridged version of those findings is as follows: (1) The maturity of near-term plans varied significantly, with most participants having goals but lacking granular road maps and two (Ind-2 and T-4) having no explicit goals. (2) Participants' opinions on the features of rapid action generally aligned with those described in literature (Table 2.1) with a strong preference for actions that mitigate perceived risks of acting too fast. (3) Near-term actions tended towards activities that enabled future mitigation,

rather than near-term reductions in emissions. (4) Uncertainty about the future, or else a tension between climate action and other priorities, were commonly described as slowing the pace of change. (5) Finally, participants struggled to describe tangible paths towards overperforming on their emissions goals, with underperformance being comparatively easy to imagine.

2.4.1 Organizational Planning and GHG Mitigation Goals

While nearly all participants had some form of mitigation goal, the maturity of these plans varied. Some participants' planning horizons are out of sync with budget timelines and few participants described granular 'roadmaps' for the near-term or set interim targets before 2030. Finally, some mitigation goals were stated through proxy targets (e.g., achieving Leadership in Energy and Environmental Design certification on a subset of projects), which suggests mitigation's position as one priority among many, or that proxy goals are a more easily measurable or approachable goal.

2.4.1.1 Some Goals were Misaligned with Budgetary Horizons

The timing of some participants' mitigation goals was misaligned with organizational budgetary horizons. For example, T-6 (a municipal transit agency) described struggling to complete a three and a half year fleet electrification project due to lack of funding certainty:

We're only funded until Q1 of 2026. My direct responsibility is to provide the charging infrastructure...but that's three and a half years' worth of work. If we're in 2024 and I don't have money past Q1 2026, I'm already behind on the work that needs to be implemented for 2026 and almost ready to slip on the 2027 portion of the plan.

Here, near-term action is hindered by even nearer term financial concerns. T-6 pointed out that the electrification project is integrated in the organization's fifteen year capital plan. Despite this, the timing of funding for the organization slows progress. T-6 says of the budgetary uncertainty, "It's in danger of stopping us...it's pretty dark."

Similarly, Ins-1's decarbonization goals are stalled due to a lack of budgetary certainty:

I've got a couple things that I want to do within the next five years. And so, I'm sort of trying to steer the ship in that direction, but whether I'll be able to do them or whether we're going to have the money for them, I don't know.

Two reasonable inferences from the above examples are: 1) organizations can accelerate climate action by committing consistent funding at least for the near-term horizon (five years), and 2) actions that align with an organization's budgetary horizons (even when they are very short) are less likely to be slowed by financial uncertainty.

2.4.1.2 Granular 'Roadmaps' of Near-term Action were Rare

One goal of the analysis was to understand precisely when each action was expected to result in GHG mitigation. For example, a project to construct a hydroelectric dam to displace coal energy might be a net source of emissions in the next five years, before beginning to mitigate emissions once completed. Understanding the projected dates of completion of different actions would have highlighted which actions were practically 'near-term' and which were not. However, this level of detail was difficult to elicit during interviews. Most participants described 2030 mitigation goals but failed to specify interim targets. When near-term actions were described, it was unclear to what extent those actions would contribute to the broader targets. For example, C-3's roadmap was among the most mature, describing milestones for 2025, 2030, and 2035. However, their goal to deploy hybrid diesel-battery generators on construction sites 'by 2025' does not specify how many sites will receive these hybrid generators. This echoes (Markard et al., 2020)'s observation about grid expansion projects for electric vehicles: planning and execution timelines are often out of sync.

2.4.1.3 Some GHG Mitigation Goals were Stated Through Proxy Targets

Some participants described GHG mitigation goals in terms of a proxy target. For example, C-2 described a goal to achieve LEED certification in a percentage (the exact value is withheld to avoid identifying the organization) of their buildings by 2030. This goal is specific, measurable, achievable, and timebound, but it acts as a proxy for several environmental actions, and its GHG mitigation potential is uncertain. By framing mitigation in terms of achieving a building certification, C-2 gains an actionable set of targets, but loses a direct focus on mitigating emissions. This may reflect the fact that decisionmakers (even those with 'Sustainability' in their

titles) are navigating many priorities, of which climate change mitigation is only one. It also likely reflects the relative ease of planning for proxy goals like LEED certification compared to the challenge of implementing a direct mitigation program. In this sense, ease of implementation comes at the cost of any potential benefits of directly targeting emissions.

As another example, F-2 and Ind-1 used the proxy target of emissions intensity (in tCO₂ per dollar invested or per quantity of material produced, respectively). F-2 explained that this strategy avoids a conflict between a financial organization's need to grow its asset base with its GHG mitigation goals: "The objective is to manage a larger and larger share of money...emissions intensity [as a measure] allows you to look through those issues of managing larger piles of money and get to the question of whether the companies [we are investing in] are decarbonizing" (F-2). Of course, success in reducing emissions intensity does not guarantee a reduction in the organization's emissions, especially if the overall emissions of the organization's investments grows faster than their emissions intensity declines. While the measure of emissions intensity is certainly associated with absolute emissions, too much focus on a proxy risks optimizing away any useful link between the measure and underlying goal (John et al., 2024)

The above examples highlight the challenge of setting tangible and achievable GHG mitigation goals. While proxy goals dilute the impact of absolute mitigation goals, they provide participants with clear actions and help to balance competing priorities.

2.4.2 Characteristics of Rapid Action

Because Question 2 focused on the characteristics of actions being taken by participants, their descriptions were contextualized by the parts of infrastructure systems upon which they can act. As a result, the pool of participants produced a wide range of characteristics, with lessons on rapid near-term action relevant to technology design, system structure, organizations, governments, and society. Ultimately, participants' beliefs about the common features of rapid action revealed a preference for low risk actions involving proven solutions.

2.4.2.1 Inductive Coding: Categories of Characteristics

The initial inductive coding pass produced 19 codes, which we merged into seven categories: ‘proven solution’, ‘little things can add up’, ‘least regret’, ‘central control’, ‘willingness to take on risks’, ‘clear policy direction’, and ‘public appetite’ (Table 2.4). These categories can be understood as loose rules that guide participants’ choice of actions. The most cited characteristics were those in the ‘clear policy direction’ (related to the policy level) and ‘proven solution’ (related to the technology design level) categories. Table 2.4 shows these categories and implications for different levels of sociotechnical systems, as well as lists example literature sources that align with each category. An important caveat is that the results in Table 2.4 reflect participants’ *beliefs* about rapid action; the reader is encouraged to reflect on the validity of these beliefs and how they will affect each decisionmaker’s approach to mitigation.

Table 2.4: Characteristics of rapid actions as proposed by participants. Bolded characteristics are high level categories. Numbers in brackets for each characteristic represent the number of unique participants mentioning the characteristic. For high level categories, the numbers in brackets (X; Y) represent X = the number of unique mentions of characteristics within the overall category; Y = the number of unique participants mentioning at least one characteristic in that overall category. Factors from literature that correspond to each category are listed alongside interview excerpts and implications for different levels of sociotechnical systems.

Characteristics	Samples of related literature	Example	Implication
<p>'Clear policy direction' (15;11) Policy incentives (7) Policy consistency (5) Performance-driven regulations (1) Administrative support (2)</p>	<p>Carbon pricing certainty (Iyer et al., 2015) Integrated rather than compartmentalized policy (Markard et al., 2020) Institutional alignment (enabling, clarifying, constraining, incentivizing) (Palm, 2022) Government planning, consensus between policymakers and business actors, subsidies (Roberts & Geels, 2019) Strong policy support (grants, subsidies, public procurement, etc.) (Andersen et al., 2023)</p>	<p><i>If you are doing a market study...to try to justify a project, and you know with certainty that the carbon tax is going to be \$170 by 2030, you can very simply do your calculation to say 'okay if I invest in this heat recovery unit...it's going to pay itself in 2 years'. If we don't have a carbon tax, then it's never going to pay itself. (Ind-3)</i></p> <p><i>If a subsequent federal government says 'we're not doing carbon pricing anymore'...industry is going to say 'hey look we've already made significant investment under the assumption there will be a carbon price'...If somebody kills carbon pricing today that hurts me, it doesn't help me one iota. (Ind-1)</i></p>	<p>Governments can accelerate enduring mitigation action with consistent, meaningful supports and policy.</p>
<p>Proven solution (12;10) Compatible with existing infrastructure (1) Drop-in capability (3) Standardized (3) Successful in similar context (5)</p>	<p>Widespread use (Palm, 2022) Standardization (Malhotra & Schmidt, 2020; Nylund et al., 2022) Cost reductions from accumulated experience (Nemet, 2006) Absence of incumbent opposition (Markard et al., 2020; Roberts & Geels, 2019) Availability of information for users & developers (Carrillo-Hermosilla et al., 2009; Wang et al., 2018) Developed value chain (economies of scale, spillover, local learning) (Palm, 2022)</p>	<p><i>You want to be strategic about maybe being a close second [adopter] and seeing how that plays out for a couple of years to make sure that that idea someone else is testing out is really viable before... spending the limited resources that we have. We want to pick as many winners as we possibly can. (E-1)</i></p>	<p>Organizations more rapidly adopt technologies with standard, proven designs or established local niches.</p>
<p>'Little things can add up' (8;8) Progress not perfection (1) Incremental improvements (4) Low up-front cost (3)</p>	<p>Granularity (Wilson et al., 2020) Low up-front cost (Environmental Protection Agency, 2023)</p>	<p><i>We don't need to build necessarily huge things. We need to build a lot of small things over and over and over again. (F-1)</i></p> <p><i>Every new megawatt [of low emission electricity we produce] is one last megawatt that can come out of an emitting source of electricity or allows me to power a few more electric vehicles...I don't think we should be dismissive of the little things. (E-1)</i></p> <p><i>There is no silver bullet to [decarbonization]...it's more like silver buckshot. (Ind-2)</i></p>	<p>Small scale individual interventions can add up to significant outcomes.</p>
<p>Long-term vision (7;7) Long-term risk horizon (5)</p>	<p>Reorientation of business actors towards belief in low carbon tech (Andersen et al., 2023)</p>	<p><i>Our owners have shifted their thinking around carbon impacts and values aligned investment. That's probably</i></p>	

Characteristics	Samples of related literature	Example	Implication
Higher risk tolerance of larger organizations (2)	Availability of financing (Environmental Protection Agency, 2023) Low risk aversion among investors (Environmental Protection Agency, 2023) Consumer expectations of technology growth (Katz & Shapiro, n.d.)	<i>the single biggest piece that lets us go a little bit farther faster. [Our owners understand that] if we can figure this out now, it'll save us money later, but we need a bit more resources today to figure that out. (C-1)</i>	Near-term mitigation requires organizations to think long-term and find ways to manage additional risks.
Central control (5;4) Centralized systems (2) Direct control (3)	Powerful, centralized decisionmaker (Scott, 1998)	<i>The fact that I've got a district energy system that is connected to all these buildings is a good thing because if I [electrify the main boilers], I pass on that efficiency to the buildings. (Ins-2)</i> <i>I think the key is that [development scale projects are] large. You can do one large project and get rid of thousands of tons [of GHGs]... it's less of a distributed challenge... Those are the kinds of 'elephants that we need to go after. (C-4)</i>	Systems with high impact, central components can change faster than distributed systems.
'Public appetite' (4;3) Depoliticization of climate policy (2) Minimizing disruption (2)	Favourable landscape pressures (climate, economic, political, new resource discoveries) (Roberts & Geels, 2019) Minimal tension with incumbent cultural, institutional, and business norms (Markard et al., 2020) Social influence (Venkatesh et al., 2003)	<i>I think ideally in order to reach that target in 2030, no matter who is in power, climate change [must] always be a priority. (T-6)</i> <i>If there was a larger public appetite or engagement on advancing some of the climate change work because effectively that provides more regulatory certainty, more political will, and more appetite to change the way that you're bearing the costs. (E-1)</i>	Society ultimately dictates the speed of transition by directing public policy.
'Least regret' (3;3) Multiple benefits (2) Low risk (1)	Improved performance (Palm, 2022; Venkatesh et al., 2003) Aligned incentives (Environmental Protection Agency, 2023)	<i>[Efficiency improvements are] an easy sell...[You can find] cost savings if you find efficiency savings... it's an easy business case to push through and get management or project sites on board...because it directly benefits them. (C-3)</i> <i>We can go back to our regulators and say, hey, if we do it this way, we can still be safe, we can meet all your requirements, but we can also lower emissions. Those are the conversations that we need to have with the regulators. (E-1)</i>	Interventions that deliver system benefits in addition to emissions mitigation are more readily adopted by organizations.

2.4.2.2 Deductive Coding: Comparison to Literature

This section describes the results of a deductive coding pass, in which participants' views on the characteristics of rapid actions were compared to a codebook based on the literature review summarized in Table 2.1.

Salient characteristics: Table 2.5 shows the points of most frequent alignment between participants' opinions and those found in literature. Half of participants cited factors related to 'integrated and consistent policy' as a characteristic of successful rapid actions. The next most salient factors, 'absence of market barriers' and 'widespread use' reflect participants' preference for deploying easily procured, widely used interventions. This result aligns with the prominence of the 'clear policy direction' and 'proven solution' categories developed in the inductive coding pass and summarized in Table 2.4.

Table 2.5: Rapid action characteristics from literature with most salience to participants. '# Participants' refers to the number of participants who mentioned a characteristic approximately equivalent to the characteristic mentioned in literature. The full list of characteristics from literature can be found in Table 2.1.

Characteristic	Source	# Participants
integrated and consistent policy	(Andersen et al., 2023; Iyer et al., 2015; Markard et al., 2020; Palm, 2022; Roberts & Geels, 2019)	10
absence of market barriers	(Environmental Protection Agency, 2023)	7
widespread use	(Palm, 2022)	5

Characteristics not found in codebook: Two characteristics described by participants were not found in our literature review: 'presence of contingency plans', and 'ability to choose less regulated options'. For example, T-3 described developing contingency plans to reduce the lag time between one intervention failing and C-4 described a preference for options less constrained by government regulation.

Tensions with literature: Four participants described the way that 'central control' can generate rapid action. C-4 describes the allure of actions that require little coordination across systems:

I think the key is that [development scale projects are] large. You can do one large project and get rid of thousands of tons [of GHGs]... it's less of a distributed challenge... Those are the kinds of 'elephants' that we need to go after (C-4).

C-4's preference for 'elephants' is reminiscent of the motivation behind the sweeping social projects criticized by (Scott, 1998). While acknowledging the power of central control, Scott cautions that such sweeping changes usually fail when imposed without widespread buy-in from stakeholders. However, a relevant example – Ontario's phaseout of coal-fired power – suggests that 'elephants' can be pursued successfully. There, a centrally directed action succeeded in achieving the largest GHG mitigation in North America, despite strong opposition from some stakeholders (Rosenbloom, 2018).

Characteristics not described by participants: The factors not mentioned by participants reflect a focus on factors that directly affect their own ability to deploy an intervention, rather than the less visible factors described in the literature. However, many of these unmentioned factors are likely still relevant. For example, the concepts of pervasiveness (a wide variety of applications) (Bresnahan & Trajtenberg, 1992), competitive markets (Environmental Protection Agency, 2023), protected niches (Kemp et al., 1998), and favourable technology assessment criteria (Carrillo-Hermosilla et al., 2009) can all be argued to have assisted in the development of a global electric vehicle chain. However, none of the participants who described the features of electric vehicles referred to these factors, instead citing government procurement standards (T-2), policy incentives (T-3, T-5), and the availability of options at market (T-1, T-2, T-6).

2.4.3 Near-term Actions

All participants described actions being taken (or planned) to reduce GHG emissions. Participants identified 78 actions being taken in the next five years, 34 of which were unique (e.g., seven organizations described transitioning their vehicle fleet to electric vehicles). Because of the time constraints of the interview, the actions described by participants do not represent the entire breadth of mitigation action undertaken by each organization. The actions described below should therefore be viewed as a selection of salient actions rather than a representative sample.

2.4.3.1 Categories of Actions

The near-term actions described by participants can be understood as belonging to five categories: 'change of energy source', 'laying groundwork', 'organizational change', 'physical process optimization', and 'using influence'. Table 2.6 shows the more specific actions contained within each category alongside illustrative interview excerpts.

The most frequently described action was ‘building infrastructure to support future technology’ (eight participants). This is, notably, an action that, rather than immediately reducing emissions, prepares an organization for future reductions. E-1 describes this type of work as ‘enabling conditions’ for future mitigation.

The prominence of fleet electrification (seven participants) is partly because six of the participants came from organizations in the transportation sector (five of whom operate fleets of vehicles and four of whom described electrifying those fleets). However, the fact that fleet electrification was also somewhat common among organizations outside of the transportation sector (three organizations) validates (Malhotra & Schmidt, 2020)’s argument that electric vehicles’ high degree of standardization (in terms of components, distribution channels, product categories, quality criteria, etc.) allows them to be deployed with rapidly in many contexts. Further, electric vehicles are a direct substitute for an existing technology, and require little change in use compared to, for example, a shift to active transport or public transit.

Table 2.6: Near-term actions described by participants. For categories (first column), the numbers in brackets (X; Y) represent X = the number of unique actions within the overall category; Y = the number of unique participants mentioning at least one action in that overall category. For actions (second column), numbers in brackets for each action represent the number of unique participants mentioning the characteristic. The third column provides a small selection of literature relevant to each category.

Category	Actions	Relevant Literature	Examples
Laying groundwork (21;12) means preparing a system for future decarbonization without necessarily reducing emissions in the near-term.	<ul style="list-style-type: none"> building infrastructure for future technology (9) preparing reports (3) testing new systems (3) developing emissions inventory (2) indigenous consultation (1) seeking approvals (1) building relationships (2) 	<ul style="list-style-type: none"> Grid readiness for electric vehicles (ICF Canada, 2021) Indigenous consultation in the energy transition (Owen et al., 2022) 	<p><i>It's enabling those conditions so that when shovels get in the ground, you're going to successful and you're going to be able to build. (E-1)</i></p> <p><i>In 2024 [we're] mainly preparing infrastructure to receive electric vehicles, installing chargers, and upgrading our facility...because most of the grid is not strong enough. (T-1)</i></p>
Changing process inputs (21;11) aims to directly reduce emissions by moving to lower emission energy source or material inputs.	<ul style="list-style-type: none"> electrifying vehicle fleet (7) lower emission fuels (6) electrifying processes (4) active transport on the job (2) change of material (1) piloting hydrogen vehicles (1) 	<ul style="list-style-type: none"> Shift consumption to lower carbon alternatives (Creutzig et al., 2018) 	<p><i>We have a plan - a target actually - to electrify [redacted for anonymity] % of our fleet by 2025. (C-2)</i></p> <p><i>We're looking into hybrid generators...[plus] renewable diesel biodiesel, methanol, or propane. (C-3)</i></p> <p><i>We [are replacing] fossil fuels with biomass fuels. (Ind-1)</i></p> <p><i>Most of the efforts right now are focused on fuel switching. (Ind-3)</i></p>
Participants exert external influence (19;10) on clients, policymakers, and suppliers.	<ul style="list-style-type: none"> using scale to push suppliers (6) educating clients (5) lobbying government (4) finding regulatory efficiencies (2) funding or conducting research (1) demonstration projects (1) 	<ul style="list-style-type: none"> Use of industry associations to motivate action (Wakabayashi & Arimura, 2016) 	<p><i>It's [about] partnering and educating our clients [about] what already exists and really advocating for strong, stringent building code requirements (C-3)</i></p> <p><i>An organization of our size and scope has enough leverage with some of the major manufacturers which we have already benefit from and utilized. (T-2)</i></p>
Organizational change (15;11) seeks to mitigate emissions by influencing employees and changing processes.	<ul style="list-style-type: none"> integrating sustainability as a decision criterion (4) encouraging low emission employee commuting (3) pushing decisions down (3) educating employees (3) bundling projects (1) importing expertise (1) 	<ul style="list-style-type: none"> Organizational change for sustainability (Mohrman & Bartunek, 2023) 	<p><i>Our objective this year is to make sure that we give more transparency and more control in the hands of the project managers, for example. (C-2)</i></p> <p><i>We actually tie our compensation to our outcomes and our targets. (F-1)</i></p>
Optimizing physical processes (15;10) involves deploying technical interventions that reduce the amount of energy or other inputs required to perform a task.	<ul style="list-style-type: none"> optimizing output of existing systems (4) reuse or capture of waste (3) using digital systems to optimize (2) retrofitting building insulation (1) software tools to support low carbon decisions (1) right-sizing (1) prefabrication (1) updating control systems (1) higher efficiency site heating (1) 	<ul style="list-style-type: none"> Avoid excess consumption and improve energy efficiency of processes (Creutzig et al., 2018) 	<p><i>We're sending a lot of heat outside that's not being recovered. So, a significant portion of our building retrofits is about recovering heat. (Ins-2)</i></p> <p><i>We've gone – and continue to go – through an operational review to right-size our fleet. We've reduced the number of vehicles or reduced the size of vehicles. (T-2)</i></p>

2.4.3.2 'Fast' vs. 'Deep'

Participants' focus on actions in the 'laying groundwork' category is notable, given that these actions are not particularly well-suited to rapid emissions reduction. This suggests that participants' near-term focus is less on making significant reductions as quickly as possible, and more on the (comparatively cautious) goal of building conditions for future reductions. This might also reveal a tension between 'fast' and 'deep' change, with participants preferring to focus on the latter.

2.4.3.3 Budgetary Certainty and Risk Tolerance

Organizations with longer budgetary horizons showed a preference for larger, riskier decarbonization actions. This is especially clear in the presence of two categories: 'least regret' and 'willingness to take on risks.' That is, some participants seek out primarily low risk actions, while others believe that a certain willingness to accept risk is necessary for rapid mitigation actions. For example, E-3, an electricity distributor whose expenditures are uncertain beyond a regulator-approved five-year window, describes meticulous planning to identify 'least regret' solutions:

“...it's like no matter which path we go - like slow, medium, fast - these are kind of foundational solid investments that you won't regret if things don't move as quickly. If there's a new federal government and every subsidy disappears tomorrow, we won't be in trouble for being over-zealous and reading the tea leaves wrong. But if everybody gets an EV in the next 10 years, we will be ready as well. [Our plan is] about really trying to find that balance and support the unknown pace.”

To E-3, being 'over-zealous' about climate mitigation can get one 'in trouble'. In their opinion, the way to justify moving quickly is to find additional benefits of an action.

C-1's organization, on the other hand, focuses on long-term (>10 year) projects, and enjoys a secure source of long-term funding. As a result, their approach to risk involves reframing risks taken today as investments leading to long-term savings:

“Our owners have shifted their thinking around carbon impacts and values aligned investment. That's probably the single biggest piece that lets us go a little bit farther faster. [Our owners understand that] if we can figure this out now, it'll save us money later, but we need a bit more resources today to figure that out” (C-1).

2.4.4 Barriers to Rapid Action

Participants most frequently cited uncertainty about the future as a barrier to near-term action. Descriptions of barriers to rapid action spanned both economic concerns and actor-focused descriptions (Geels, 2019; Smil, 2016). Sixteen participants described some form of uncertainty as a barrier to near-term action, evidencing an aversion to risk. Notably, discussions often strayed into generalities about the difficulty of enacting sustainability principles, rather than temporal barriers (i.e., barriers to near-term or rapid action).

2.4.4.1 Categories of Barriers

Coding of participants' description of barriers to rapid action revealed seven general types of barriers: 'uncertainty', 'tensions among priorities', 'coordination', 'inertia', 'scarcity', 'decision authority', and 'compatibility' (Table 2.7).

Table 2.7: Categories of barriers to rapid action listed by participants. For high level categories, the numbers in brackets (X; Y) represent X = the number of unique mentions of barriers within the overall category; Y = the number of unique participants mentioning at least one barrier in that overall category. For barriers, numbers in brackets represent the number of unique participants mentioning the barrier. The third column lists a small selection of literature relevant to the category.

Categories	Barriers	Relevant Literature	Examples
Uncertainty (23;16) about the future causing delays due to indecision.	<ul style="list-style-type: none"> policy uncertainty (6) waiting for technology (6) emerging technical issues (4) clients lacking knowledge (2) budgetary uncertainty (2) lack of data (2) unpredictable exogenous factors (1) 	<p>Uncertainty and risk aversion among investors (Environmental Protection Agency, 2023)</p> <p>Carbon pricing uncertainty (Iyer et al., 2015)</p>	<p><i>When...we're unclear what the regulations are going to be...nobody's moving because they're too afraid they're gonna price themselves out of out of the market." (C-3)</i></p> <p><i>Uncertainty can be a barrier...What does [a federal election] mean? How does that change the conversation around decarbonization goals?(E-3)</i></p>
Tension (18;10) between emissions mitigation and other priorities.	<ul style="list-style-type: none"> too fast is not financially responsible (5) too fast is unsafe (2) too fast is disruptive (2) immediate effects of climate change (2) cheap resources slow innovation (1) conflict between growth and mitigation (1) construction cost inflation (1) retrofits are disruptive (1) high upfront cost (1) low carbon version is lower quality (1) maintenance backlog (1) 	<p>High monetary costs (Wilson et al., 2020)</p> <p>Maladaptive responses to climate change (Niemeyer et al., 2005)</p>	<p><i>There's a tension between going too fast and getting pushback from the development industry and making sure we have something that's sustainable (C-4)</i></p> <p><i>While I really do want to reduce our emissions as much as possible...there is that benefit analysis of: 'is it worth looking at this one tiny process load in the grand scheme of things and moving too quickly?' (T-6)</i></p>
Coordination (15;8) between physical or human systems.	<ul style="list-style-type: none"> permitting delays (5) multiple dependencies (3) need for consultation (2) difficult to work in active systems (1) speed of action too slow to qualify for gov't programs (1) bundling projects can cause delays (1) overlapping systems (1) overall complexity of procurement process (1) 	<p>Coordination between contractors and owners (Ahmad et al., 2019)</p>	<p><i>If you make a change to the electrical, are you suddenly going over capacity? Are you triggering a panel upgrade because our panels don't necessarily meet current code? (Ins-1)</i></p> <p><i>There's always a timeline associated with [grants to build bike lanes], and often the trail projects are long, and we cannot meet [the grant's] funding timeline. They might say two years or a year to have this facility open and often with trail work we require other approvals that are outside of our control. (T-3)</i></p>
Inertia (17;11) inherent to a human or physical system that resists rapid change.	<ul style="list-style-type: none"> status quo is comfortable (4) limited infrastructure capacity (4) locked in with old assets (4) new operating practices required (3) decentralized systems struggle to change quickly (2) 	<p>Resistance by incumbent sociotechnical system (Markard et al., 2020)</p>	<p><i>Emissions are created by the production of new trucks. So, if a company like ours were to just throw out all our old diesel trucks and replace everything with electric overnight, what's the impact of that type of wastefulness? (T-5)</i></p> <p><i>Smaller institutions, I would argue, have a little bit of an easier go with [building automation]. If you're newer, too, maybe you have it a bit easier because [older institutions have] some of the [obsolete]</i></p>

Categories	Barriers	Relevant Literature	Examples
			<i>technologies for heating and controlling from many years ago. (Ins-2)</i>
Scarcity (15;12) of materials or human resources that slows or prevents action from happening.	limited options at market (5) supply chain delay (3) labour shortages (3) scarcity of materials (2) scarcity of expertise (2)	Lack of infrastructure, materials, or skills (Malhotra & Schmidt, 2020)	<i>Demand can work against economies of scale. For example, the whole market [might be] asking for certain material, but the supply chain can't catch up to that demand. (C-1)</i> <i>I mean the labor - it is so impossible to find. Everyone's really competing for resources (E-2)</i>
Decision Authority (12;9) issues, resulting a lack of control over action.	client or customer has ultimate control (7) low carbon option is illegal (2) government has control over major decisions (2) overlapping jurisdiction (1)	Split incentives (Environmental Protection Agency, 2023) Slow decision-making by project owner (Ahmad et al., 2019)	<i>It's hard for a general contractor to change the materials that are being specified by the designer or the client on the construction site, but we're doing everything we can (C-2)</i> <i>If [we only meet half our target] that kind of gives you a sense of where consumers are at around climate change. (E-3)</i> <i>We're saying, look, let us use these waste fuels instead of fossil fuels. And there are jurisdictions like Ontario that have a big problem with that. Why do they have a problem with that? Well, because the people making the decisions are uneducated and scared. (Ind-1)</i>
Compatibility (2;2) issues that make certain mitigation options impossible or inconvenient.	work from home not feasible (1) lack of standardization (1)	High degree of customization needed (Malhotra & Schmidt, 2020)	<i>You can't run an airport, for example, without staff coming in. (T-4)</i> <i>I guess I also see why retailers would be hesitant because there isn't a lot of standardization [of electric vehicle chargers]. (T-5)</i>

2.4.4.2 Barriers Associated with Time

This section summarizes the results of the deductive coding pass on question 8, which categorized barriers according to whether or not they were related to time. The coding revealed that barriers related to inertia, coordination, and scarcity were predominantly related to time. For example, T-6 describes hesitating to deploy low carbon solutions in bus depots until more options are at market: ‘In terms of market available solutions for those process loads, those are still more in their infancy compared to say, fuel switching HVAC of a commercial office building - which is partially why we're hesitant.’

Other barriers described by participants were unrelated to time. The effects of barriers related to decision authority, incompatibility, and tension among priorities were just as frequently time related as not (Table 2.8). In fact, one of the most commonly described barriers, ‘client or customer has ultimate control’, was not directly related to time. C-3 described the way that client control can stop climate action in its tracks: ‘If we don't have clients who are saying, well, we're going to build net-zero buildings, we're not going to be able to meet those targets.’

Table 2.8: Relevance of barriers cited to time. Responses to question 8 were coded according to whether participants described a barrier as completely blocking action (general) or slowing action (temporal). Note: the counts in this table refer to the number of barriers described, and therefore may not match the total in Table 2.7, which list the number of unique participants mentioning barriers in a given category.

Category	# General	# Temporal
Inertia	0	10
Coordination	3	9
Scarcity	2	6
Uncertainty	4	12
Incompatibility	1	1
Tension	6	6
Decision authority	6	5

2.4.5 Expectations of the Future

While participants often provided lucid descriptions of ways in which their organization might underperform on their targets, descriptions of the opposite scenario were usually less detailed. Moreover, while participants often cited financing or market forces as a barrier to rapid action, our question offering the participants unlimited resources often drew out additional sources of

delay such as labour shortages, supply chain disruptions, or ‘black swan’ events. Participants did, however, see money as relieving another primary source of delay – risk.

2.4.5.1 Underperformance on Goals was Easier to Imagine than Overperformance

Participants more readily listed events that might derail their 2030 emissions targets than those that might cause them to overperform. Participants often listed many possible reasons for underperformance, ‘changes in policy...black swan events...the war in Ukraine or COVID...large disruptions in our supply chain...whole scale changes in our workforce’ (E-1) and relatively few causes of overperformance ‘more regulatory certainty, more political will [for climate change mitigation]’ (E-1). This could reflect a conservative tendency to focus on risk mitigation – a ‘survival instinct’. Imagining futures in which mitigation goals are surpassed may have been difficult for participants because it represents taking actions that increase risk exposure beyond what they deem acceptable today.

Ins-1 suggested another reason participants might balk at the possibility of overperforming: conflict between an institution’s desire to grow (which involves constructing new facilities) and its climate goals. While rarely stated, similar conflicts exist for every organization interviewed: the near future must simultaneously accommodate rapid mitigation of emissions and rapid growth. Every organization interviewed, whether governmental or commercial, looks to the future with some expectation of growth. That it is easier to imagine a future in which the fundamental driver of a business persists at the cost of its climate goals is unsurprising. This result might also reflect the sheer challenge of achieving emissions reductions in line with the Paris Agreement in such a short time.

Alternatively, participants may have had difficulty envisioning overperformance because climate targets are ‘binding constraints’ – meaning they offer little incentive for over performance. E-2, a developer and operator of electricity generation assets, described the seeming impossibility of overperforming on their goals. The only world in which they would overperform on their targets is one in which ‘the sun starts shining all day long and the wind is exactly gusting at 30 kilometers per hour.’ This is a world in which they have enabled a certain baseline mitigation (by constructing renewable generators), but in which truly meaningful change is caused by an

unpredictable, exogenous (and therefore out of their control) force. A similar chronic underestimation of progress has been observed in the United States Energy Information Administration's projections of renewable energy penetration (Gilbert & Sovacool, 2016).

Exceptions to this trend occurred when participants viewed a specific barrier as holding back rapid rollout of mitigation measures. A common example was carbon pricing uncertainty. Ind-3 suggests that in the forestry industry, lack of certainty about the future of carbon pricing is holding investment back, 'if you have clear policies, people can go and start making decisions today.'

2.4.5.2 No 'Silver Bullets'

When asked to suggest uses for a hypothetical infinite cash infusion, some participants suggested specific uses (e.g., the purchase of an abandoned bus terminal – T-5), while others described broader changes the funds would allow (e.g., E-1 discussed how a cash infusion would enable the organization to take greater financial risks). Some participants struggled to account for the time constraint of the question, initially suggesting projects that could not reasonably be completed in five years (such as the construction of a one gigawatt hydro power plant and associated transmission infrastructure – Ind-2).

Most participants, however, expressed skepticism that additional money could overcome the market, political, or social barriers holding back rapid action. C-1 was careful not to describe climate action as a set of dominoes, instead describing something closer to a list of ingredients, each of which is necessary but none of which is sufficient to kickstart action:

There is no magic bullet to making this stuff happen. It's not like if we get the regulation right it works, or if we get the financing rate it works, or if we educate the consumers to want this it works. All of those things need to happen. It's not like you flick one domino and the rest fall down...failure for any one of those things to happen will stop market transformation from occurring. We need the economics to work out. We need the support of regulation. We need the supply chain. We need the workforce. We need the utility integration. We need the trades training. It all needs to happen, and I think a lot of it is happening...in some areas more than others.

Even though many participants initially cited lack of funding as a barrier, the hypothetical availability of those funds simply alerts participants to more barriers. E-3 put it flatly, pointing out that their organization was obligated through regulation to make financially prudent decisions: ‘If we have infinite money and we build a hundred new transformer stations, and the need doesn't materialize, that's incredibly wasteful.’

2.5 Discussion

2.5.1 The Challenge of Thinking About the Near-term

A repeated observation during the interview process was a difficulty in eliciting time-specific responses within five years or before 2030. The (1) focus on enabling future reductions rather than current ones and (2) tendency to describe generic barriers rather than temporal ones reflect participants’ struggle to engage with the idea of rapid action and the near-term. Rather than attempt the greatest possible reductions as quickly as possible, participants focussed on gradual plans (e.g., replacement of vehicle fleets with electric vehicles over five to ten years) or those that set their organizations up for significant reductions beyond 2030 (e.g., integrating sustainability as a decision criterion for future projects). While many organizations have 2030 targets, an urgency to actively address them was not observed. While barely more than five years away at the time of interview, 2030 was still mostly used to mean an abstract future.

Here we return to (Alvial-Palavicino, 2015)’s argument that the expectations actors hold about a system drive their ‘anticipatory practices’ (the material actions taken, relationships formed, plans made, standards developed, etc.), which in aggregate shape the future. In this way, the view of climate change as a future for which investments can be made and targets can be set, rather than as a crisis presently unfolding, risks missing out on the greater benefits promised by near-term reductions compared to delayed reductions (IPCC, 2023b; Winning et al., 2019).

2.5.2 Policy Support as a Source of Stability

Participants’ (1) tendency to prioritize risk mitigation and (2) difficulty imagining overperforming on mitigation targets suggest an expectation of the near future as a zone of high risk. Every participant would likely empathize with Ins-1’s concern that ‘you never know what you’ll find when you open things up’. This reflects an understanding that the risks associated

with medium- and long-term plans may not become visible until the near-term. In asking participants to consider the near-term, we asked them to ‘open things up’ and confront risk.

In so doing, participants described choosing proven solutions and least regret actions (i.e., those that they might have done anyway). Here, participants show their efforts to resolve the tension caused by climate action’s lack of market motivation (Geels, 2010). While this strategy is often effective, it prioritizes an intervention’s ability to mitigate risks over its effectiveness at reducing emissions.

Policy support can mitigate risk without sacrificing a focus on emissions reductions. As seen in section 2.4.4.1 many participants believed that uncertainty around government policies was a primary barrier to near-term action (primarily carbon pricing). We can see the power of supportive policy in practice: Ins-2’s plan to electrify a central boiler – a single, centralized action that causes a network of buildings to benefit from lower emissions heat – is likely facilitated by many factors, but we highlight the policy support offered via a low interest loan extended by the federal government. The stability offered by this kind of financing eliminates much of the uncertainty and enables a transformative action.

That the most significant and ‘rapid’ action deployed by participants is facilitated by acts of policy aligns with prior authors’ arguments that meaningful and predictable government support is necessary to stimulate climate change (Christophers, 2024; Markard et al., 2020; Roberts & Geels, 2019). Our work suggests that this is no less true of rapid, near-term actions as it is of long-term change.

2.5.3 Rapid Change and Interconnected Systems

Participants’ descriptions of barriers and difficulty imagining overperforming on targets suggest the presence of ‘regime resistance’ – the set of political, economic, and physical forces that resist change in sociotechnical systems (Geels, 2014). Most authors agree that sustainability transitions will require fundamental alterations of existing systems (Grubler et al., 2016; Markard et al., 2020; Smil, 2016). In contrast, participants appeared to prefer non-disruptive, granular actions such as buying electric vehicles as old vehicles age into retirement. While powerful, such actions extend over a period of years or decades, and therefore lose some of the potential benefits of

immediate, large scale mitigation. Moreover, focussing too narrowly on a single intervention is unlikely to result in change of the kind necessary to meet targets. To take the example of vehicle electrification (the second most frequently cited action by participants), even the most ambitious deployment projections do not alone achieve sufficient reductions in the transportation sector (Milovanoff et al., 2020).

Truly transformational actions were proposed only laughingly when participants were ‘given’ unlimited resources (e.g., Ind-2’s proposal to build a gigawatt power plant next to their facility). That few participants described undertaking transformational activities in the near-term highlights the challenge of achieving change that is both rapid and fundamental. This validates the IPCC’s argument that current emissions pathways are ‘rooted in the underlying structure of societies’, and that fast, deep, and broad change ‘amounts to shifting away from existing developmental trends’ (IPCC, 2023a).

Some participants demonstrated an understanding of the ‘broad’ change required to mitigate climate change (Andersen et al., 2023). Participants understand that their organizations operate in a highly interconnected and resilient sociotechnical system that extends beyond their particular institution, fleet, or manufacturing facility. This contrasts with (Rickards et al., 2014)’s characterization of decisionmakers’ perspectives as ‘narrow’.

However, participants seem to agree with (Scott, 1998)’s argument that understanding a system is not enough to dramatically change it. Recall C-1’s skepticism about ‘dominoes’ and Ind-2’s ‘silver buckshot’ analogy for effective climate action.

On the one hand, this skepticism suggests that participants see widespread climate change mitigation as out of their control. On the other hand, the fact that participants demonstrated an understanding of the interconnected nature of transitions could guide them towards the collaborative acts necessary to mitigate climate change. A hopeful perspective comes from T-5, who acknowledges their lack of control while signaling an openness to collaborate:

Look, I don't have any trade secrets on this. This is not about ‘I know how to do it, and I won't tell you how’ – because everyone will have to go through the same bumpy road that I did... We're still moving forward. We're still making it happen.

2.5.4 Limitations and Contributions

The results of this study should be interpreted in light of its limitations. Because of time and resource constraints, participants do not represent a comprehensive sample of Canadian organizations, and sector-level generalizations should not be made. Additionally, individuals who were unable to participate due to, for example, organizational privacy restrictions are missing from the selection. Moreover, a self-selection bias may be present in the pool of participants, since individuals with stronger climate change mitigation plans may be more likely to volunteer for a conversation. Further, no individual can give a comprehensive picture of their entire organization. While interviewees were chosen according to their potential to generate insights into their organization as a whole, our understanding of each organization is limited to each representative's (subjective and therefore possibly inaccurate) perspective. Finally, the qualitative method applied in this research leaves open many possibilities for interpretation. The research team holds interests in sustainable systems and their dynamics. Other researchers may have focussed more deeply (during interviews or during their analysis) on the technical details of interventions or personal characteristics of interviewees.

Despite these limitations, this work has several strengths that contribute to the field of sustainability transitions. First, by engaging directly with decisionmakers' expectations of the future, our approach side-steps the challenge of extrapolating results to the future, which is common to research based on historical case studies. Second, the strategy of engaging deeply with a selection of participants in many sectors mirrors the much discussed all-encompassing nature of climate change (Andersen et al., 2023; Grubler et al., 2016; Markard et al., 2020; Morton, 2013; Smil, 2016). In this sense, the work provides a more accurate 'snapshot' of current attitudes towards mitigation than a shallower survey of decisionmakers' opinions.

2.5.5 Takeaways

This research detailed the challenge of deploying climate change interventions that are both available in the near-term and lead to rapid results. Interview participants, representing Canadian infrastructure organizations, struggled to imagine outperforming their set mitigation goals and we observed mismatches between goals and the development of budgetary conditions to facilitate their achievement. Regarding near-term mitigation actions, we observed a trend among

Canadian decisionmakers to focus on slower climate change interventions that enable greater emissions reductions in the long-term, if/when delivered. Finally, our exploration of the barriers and drivers of near-term action revealed a preoccupation with risk management and uncertainty, and a strong call for policy support to manage those risks. While these results may feel obvious to readers, it is important to remember that the beliefs of decisionmakers may not align with the reality of near-term mitigation. Policymakers should indeed consider the ways in which their available levers can actually address the barriers described by decisionmakers, but decisionmakers should also reckon with their own role in accelerating climate action. This is because overall, the pace of change is lagging behind what is needed to meet Canada's Paris Agreement commitment (Environment and Climate Change Canada, 2022). It is likely, then, that a higher tolerance for change and risk, and a more granular approach to planning, will be needed from both industry and government to meet near-term and longer goals. Finally, the barriers described here are likely not unique to Canada. Resolving them, therefore, has potential to accelerate near-term climate change mitigation globally.

Chapter 3

3 Conclusion

This chapter summarizes the main contributions of the thesis and recommends areas for future work. The goal of the thesis was to develop general knowledge that can enable near-term GHG reductions in a broad selection of sectors. Chapter 1 described the research direction and established three research questions regarding (1) the near-term goals and expectations of decisionmakers (2) their beliefs about the most effective rapid actions, and (3) the barriers constraining faster action. Chapter 2 reviewed literature around technology transitions and the potential for an accelerated sustainable transition, before executing a qualitative method that answered the research questions.

3.1 Contribution

In this thesis I saw that Canadian infrastructure decisionmakers have near-term climate goals but that these lack granular implementation steps. Also, when participants described the features of effective near-term mitigation actions, they often focussed on qualities that mitigate risk (low up-front costs, policy certainty, proven solutions, etc.), rather than the absolute mitigation potential of an action. This concern for uncertainty likely caused decisionmakers to struggle to imagine more ambitious climate plans, and many of them called for government policies that mitigate risks. Finally, I saw that today's decisionmakers are slowed by a desire to lay groundwork and iron out all uncertainties before acting on climate change.

This attitude reminds me of (Sennet, 2021)'s description of highly prescriptive city planning approaches, which ask the planner to 'know what [they] are doing before doing it'. Sennet argues that city plans designed through this approach lead to static, dead spaces that fail to evolve with society. Sennet's conclusions may not be wholly applicable to climate change mitigation plans, but I think a similar tendency is present in today's infrastructure decisionmakers and may be delaying near-term climate action. Infrastructure systems are enormously complex, and organizations that wait to eliminate uncertainty or risk – to 'know what they are doing' – may fail to meet the very near-term demands of climate action. This tendency may even be holding back the development of granular plans – decisionmakers may be hesitant to move beyond high

level planning if they feel challenged to ensure each small component of the plan must align with some grand design.

Canada is lagging behind what is needed to meet its Paris Agreement commitment (Environment and Climate Change Canada, 2022). While government policy can do much to alleviate the risks of engaging in rapid climate change mitigation, the urgency of the crisis suggests that organizations need more tolerance for risk and rapid change if they are to meet near-term goals. The concise way of putting this – which I acknowledge is easier said than done but not any less true for that fact – is that both government and industry need to work together to ‘just mitigate’ and face the future as it comes.

3.2 Future Work

This thesis opens several avenues for future research. One natural area for future work would be to conduct a follow up study with the participants in the original work. The follow up could be conducted in five years to align with the near-term focus of the original study. As some participants are likely to move on to other organizations, this research could be conducted at two equally promising levels: that of the organization (to identify progress on mitigation goals), or that of the original participants (to identify shifts in expectations, barriers, or opinions about the drivers of rapid action).

Future work could also investigate how decisionmakers value the concept of ‘rapid’ mitigation relative to slower, possibly deeper mitigation work. Our research revealed participants’ tendency to lay groundwork for future reductions but follow up discussions could investigate the underlying reasons for this tendency.

Another possible area of exploration is decisionmakers’ adaptations to the near-term effects of climate change. Only two participants in the study discussed ways in which their mitigation plans might be affected by climate change. Through interviews or surveys, future work could explore decisionmakers’ expectations of the near-term effects of climate change, the adaptations planned, and the relationship between climate change impacts and their mitigation goals.

Finally, future work could make targeted study of near-term mitigation action in an individual sector. The small selection of the original work minimized our ability to draw conclusions about

any single sector (the best represented sector, transportation, had only six participants). While the original study's broad perspective helped with the synthesis of common categories, a sector-focused study could potentially make more specific policy recommendations.

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Appendix

Appendix 1: Recruitment email

Hi [name],

I am a graduate student in the University of Toronto's Sustainable Systems Research Group. Along with my supervisors, Professors Shoshanna Saxe and Daniel Posen, I am trying to explore and describe decarbonization strategies that can be rolled out in the near term (i.e., within ~5 years) and what makes rapid change difficult for organizations in Canada.

I am writing to ask whether you would be willing to participate in an interview (approximately 1 hour) about the barriers and opportunities for near term emissions reduction (next five years) [organization] is facing.

Our study focusses on developers, operators, and major users of Canada's civil infrastructure (e.g., electricity, water, transportation, etc.). The work will hopefully act as a guide to policymakers by identifying common barriers and solutions that might not be visible to individual organizations.

If you are interested in participating, you can schedule a virtual interview here: [link]. Once you have scheduled, I will follow up with a letter of informed consent for your review, and a Zoom link. Neither your identity, nor the identity of your organization, will be reported. If, for some reason, publishing more identifiable information is somehow important to the analysis, I will request your consent for this.

I'm also happy to answer any additional questions you might have.

If you are not available, I would greatly appreciate if you could suggest any contacts who might be interested in participating.

Thank you for taking the time to read this email. I hope to hear from you soon!

Best regards,

Jeff Sauer

Appendix 2: Informed Consent Letter

Identifying Barriers and Opportunities to Rapid Mitigation of Greenhouse Gas Emissions of Canadian Civil Infrastructure: Project background for interview participants

October 2023

Thank you for considering participating in this research project examining near-term emissions abatement in Canada's civil infrastructure. Below you will find information related to project objectives, format for participation and any possible risks or benefits related to your participation.

If you have any questions, please contact:

Jeffrey Sauer

MASc Candidate, Department of Civil and Mineral Engineering, University of Toronto
[email and phone number redacted]

Supervising Researchers: Dr. Daniel Posen & Dr. Shoshanna Saxe

Background

Near term (i.e., before 2030) emissions mitigation is critical to limiting global temperature rise to 2°C. Understanding the barriers and opportunities to rapidly reducing emissions generated by these systems is critical to supporting Canada's commitments under the Paris Agreement. Our research focusses on the operators, developers, and major users of civil infrastructure in Canada.

Our project

Climate change necessitates rapid, large scale transformation of Canada's civil infrastructure (defined here as water, electricity, transportation, and heating). Our work seeks to understand 1) what actions are being taken in the next five years to accelerate this change, 2) the level of maturity of these changes, and 3) the barriers constraining more aggressive/faster change.

By identifying the barriers faced by a wide selection of organizations, we look to highlight broad trends perhaps not visible to individual stakeholders. Our results are intended to provide guidance for both policymakers and stakeholders in these sectors. Stakeholder insights will be included in a final paper that will be published in a relevant academic journal and may also be presented at an academic conference.

Participation

We are inviting you to participate in an interview in order to contribute knowledge you've acquired through your work with an organization that interacts with Canadian civil infrastructure. Interviews are voluntary, will be up to one hour in length and will be conducted via phone or Zoom.

It is our hope that you will be comfortable being included as an interviewee in the final version of our work. Individual responses will be anonymous except in certain cases where we may cite one or more of your responses directly. If this is the case, we will obtain your consent and validate your responses and their surrounding context. We are happy to respect your right to anonymity or refusal should you not wish to be cited. To protect your confidentiality, interview notes will be stored securely on a university server and will be de-identified once results have been published. De-identified data will be stored on the university server and a Canadian cloud account for five years in order to preserve key insights for future studies. We will discuss any other specific concerns you might have prior to conducting the interview.

We anticipate little to no risks to your participation. It is possible that readers may be able to deduce opinions of individual interviewees in the final research paper due to the small number of participants. If this is the case, there is a potential risk to the participant if responses do not represent the values of their company/association. To minimize this risk, interview notes will be provided to you for review/approval and responses will be modified accordingly if requested. Results will remain anonymous unless you consent to be identified and review/approve any quotes or responses prior to publication. You will be welcome to withdraw from the interview at any time without penalty or reprisal. Upon withdrawal from the study, all recorded responses will be removed.

If you have any additional questions, please do not hesitate to get in contact. Additionally, if you have any questions about your rights as a participant in the study, you can contact the University of Toronto's Office of Research Ethics at ethics.review@utoronto.ca or 416-946-3273.

Thank you again for your consideration.

Appendix 3: Factors Affecting Deployment Speed (Full List)

The table below presents the results of a literature review exploring the factors affecting deployment of technologies or interventions (e.g., process efficiency improvements). The columns are described below.

Origin column: describes the source of the factor, defined as follows. These definitions are our own, with the exception of ‘exogenous’:

- Design: elements of a technology design (e.g., its complexity or degree of standardization).
- Technology system: how a technology or intervention relates to existing technical systems.
- Market: market forces like cost, industry capacity, or investment decisions of firms.
- Policy: government policies that affect deployment of a technology or intervention.
- Social: cultural or political views of society.
- Exogenous: broader pressures not reasonably within the control of any government, market, or social actors (e.g., natural disasters, global economic trends) (Roberts & Geels, 2019).

‘What Does it Drive?’ column: indicates whether the factor directly drives deployment or one of the related concepts of innovation (improvements in a technology’s quality or production (Godin, 2012)) or lock-in (accrual of advantages that prevent similar technologies from competing (Foxon, 2013)).

Metric if Available column: provides a quantitative or qualitative metric of the factor if provided by the author. Metrics are listed due to their potential to support the development of a framework to assess deployment potential of technologies or interventions.

Factor	Origin	What Does it Drive?	Metric if Available	Source
Granularity	Design	Deployment	Unit size, cost, energy requirements, etc.	(Carrillo-Hermosilla et al., 2009; Wilson et al., 2020)
Innovational Complementarities (ability of regular users to innovate and modify the technology)	Design	Innovation	Not given	(Bresnahan & Trajtenberg, 1992)
Low design complexity	Design	Innovation	# of parts (Wilson et al., 2020; Fukuyama, 1993) OR aggregate interconnectivity (Mcnerney, 2011)	(McNerney et al., 2011)
Perception: User effort expectancy	Design	Deployment	Likert scale	(Venkatesh et al., 2003)
Perception: User performance expectancy	Design	Deployment	Likert scale	(Venkatesh et al., 2003)
Pervasiveness (wide variety of applications)	Design	Lock-in	Not given	(Bresnahan & Trajtenberg, 1992)
Presence of a dominant design	Design	Lock-in	Similar/redundant with standardization (diversity, entropy)	(Nylund et al., 2022)
Similar 'bundle' of characteristics to incumbent + some improvement	Design	Deployment	Unique to each technology, qualitative and quantitative	(Pearson & Foxon, 2012)
Standardization (low diversity system)	Design	Deployment	Diversity (Weitzman, 1992)	(Malhotra & Schmidt, 2020)
Standardization (low entropy system)	Design	Deployment	Entropy (Frenken, 1999; Theil, 1967)	(Malhotra & Schmidt, 2020)
Technology Dynamism (capacity for continued innovation)	Design	Innovation	Not given	(Bresnahan & Trajtenberg, 1992)
Favourable landscape pressures (climate, economic, political, new resource discoveries)	Exogenous	Deployment	Not given	(Roberts & Geels, 2019)
Ability of firms to capture RDD&D benefits that are often positive externalities	Market	Innovation	Not given	(Environmental Protection Agency, 2023)
Absence of market barriers (supply chain issues, skilled labour shortages, high technology costs)	Market	Deployment	Not given	(Environmental Protection Agency, 2023)
Widespread use (shift from early adopters to mainstream)	Market	Deployment	% of market segment (e.g., % of PV operated by homeowners and private sector vs. public sector)	(Palm, 2022)
Aligned incentives (as opposed to split)	Market	Deployment	Not given	(Environmental Protection Agency, 2023)
Alignment of project planning and execution timelines	Market	Deployment	Not given	(Markard et al., 2020)
Apparently almost unlimited availability of supply over long periods	Market	Deployment	Not given	(Freeman & Perez, 1988)
Appropriate distribution of costs over time (no high up-front costs)	Market	Deployment	Not given	(Environmental Protection Agency, 2023)
Clearly perceived low and rapidly falling cost	Market	Deployment	Not given	(Freeman & Perez, 1988)
Competition (i.e., low industry concentration)	Market	Innovation	Herfindahl-Hirschman Index	(Nemet, 2006)
Consumer choice	Market	Deployment	Not given	(Environmental Protection Agency, 2023)
Consumer expectations of technology growth	Market	Deployment	Not given, possibly interview	(Katz & Shapiro, 1986)
Cost reductions	Market	Deployment	Learning rate	(Arthur, 1989) by way of (Andersen et al., 2023)
Demand for services which the technology enables	Market	Deployment	Not given	(Fouquet, 2016)

Factor	Origin	What Does it Drive?	Metric if Available	Source
Dynamic increasing returns	Market	Deployment	Not given	(Iyer et al., 2015; Katz & Shapiro, 1986)
Experience (degree of deployment)	Market	Innovation	Cumulative capacity [for energy tech] (Nemet, 2005)	(Nemet, 2006); Moore's Law (performance vs. production); Wright's law (cost vs. production)
Increased adoption (positive feedback of deployment)	Market	Deployment	Not given	(Rogers, 2003) by way of (Andersen et al., 2023)
Increased Demand Elasticity	Market	Innovation	Demand Elasticity	(Nemet, 2006)
Information availability on environmental performance of products	Market	Deployment	Likert scale	(Wang et al., 2018)
Information on availability of products	Market	Deployment	Not given	(Carrillo-Hermosilla et al., 2009)
Limited competition among uses (e.g., Norwegian hydropower being stretched to accommodate many uses)	Market	Deployment	Not given	(Markard et al., 2020)
Low cost of information and low implementation costs	Market	Deployment	Not given	(Environmental Protection Agency, 2023)
Low risk aversion among investors	Market	Deployment	Not given	(Environmental Protection Agency, 2023)
Perfect information/foresight about clean energy opportunities	Market	Deployment	Not given	(Environmental Protection Agency, 2023)
Product certifications (reduces cost of information)	Market	Deployment	Not given	(Environmental Protection Agency, 2023)
Quality Reduction	Market	Innovation	Product lifetime (yrs.),	(Nemet, 2006)
Readiness to break status quo bias	Market	Deployment	Not given	(Environmental Protection Agency, 2023)
Reorientation of business actors towards belief in low carbon tech	Market	Deployment	Not given	(Stalmokaitė & Hassler, 2020) by way of (Andersen et al., 2023)
Carbon pricing certainty	Policy	Deployment	Not given	(Iyer et al., 2015)
Consensus between policymakers and business actors	Policy	Deployment	Not given	(Roberts & Geels, 2019)
Facilitating conditions (users have sufficient resources to use technology, compatible with other systems, availability of guidance, etc.)	Policy	Deployment	Likert scale	(Venkatesh et al., 2003)
Government market mechanisms (subsidies, price setting, taxation)	Policy	Deployment	Not given (but potentially \$ of subsidies)	(Roberts & Geels, 2019)
Government planning, infrastructure investments, public relations campaign, deliberate regime weakening	Policy	Deployment	Not given	(Roberts & Geels, 2019)
Institutional alignment (enabling, clarifying, constraining, incentivizing)	Policy	Deployment	Not given	(Palm, 2022)
Integrated rather than compartmentalized policy	Policy	Deployment	Not given	(Markard et al., 2020)
Maintenance of protected niches	Policy	Innovation	Not given	(Kemp et al., 1998)
Strong policy support (grants, subsidies, public procurement, etc.)	Policy	Deployment	Not given	(Andersen et al., 2023)
Absence of incumbent opposition (i.e., industry, unions)	Social	Deployment	Not given	(Markard et al., 2020)

Factor	Origin	What Does it Drive?	Metric if Available	Source
Changing social norms	Social	Deployment	Not given	Bowles (1998) (Bowles, 2024) by way of (Andersen et al., 2023)
Community based social marketing (i.e., via cooperatives)	Social	Deployment	Interviews	(Viardot, 2013)
Minimal tension with incumbent cultural, institutional, and business norms	Social	Deployment	Not given	(Markard et al., 2020)
Social influence (Subjective norms, agreements with others, internalization of group culture, image)	Social	Deployment	Likert scale	(Venkatesh et al., 2003)
Availability of supporting assets (skills, materials, finance, complementary infrastructure & technology)	Technology system	Deployment	Not given	(Malhotra & Schmidt, 2020)
Clear potential for use in many products and processes	Technology system	Deployment	Not given	(Freeman & Perez, 1988)
Compatibility with existing systems	Technology system	Deployment	Not given	(Carrillo-Hermosilla et al., 2009)
Complementarity [may be redundant with 'compatibility with existing systems']	Technology system	Deployment	Not given	(Colombo & Mosconi, 1995; Nylund et al., 2022)
Complementary technologies	Technology system	Deployment	Not given	(Markard et al., 2020)
Complex dominant design [drives deployment of related technologies which locks in the primary tech]	Technology system	Lock-in	Not given but could use # of parts (Wilson et al., 2020; Fukuyama, 1993)	(Nylund et al., 2022)
Degree of lock-in of incumbent (in terms of cost, skills, user familiarity, etc.)	Technology system	Deployment	Not given but could use a cost metric	(Carrillo-Hermosilla et al., 2009)
Development of value chain (economies of scale, spillover, and local learning)	Technology system	Deployment	Not given	(Palm, 2022)
Low complexity value chain	Technology system	Innovation	Not given, but could use index of vertex degree, the supply chain length, the flow complexity (Modrak and Marton, 2012)	(Hoggett, 2014)
Low infrastructure requirements	Technology system	Deployment	Not given	(Environmental Protection Agency, 2023)
Requisite infrastructure buildout (augmentation, add-on, establishment)	Technology system	Deployment	Not given (could measure cost of req. infra)	(Palm, 2022)
Technology assessment criteria (degree of bias to incumbent)	Technology system	Deployment	Not given, possibly expert elicitation	(Carrillo-Hermosilla et al., 2009)
Transitional expediency to meet climate goals	Technology system	Deployment	Not given	(Environmental Protection Agency, 2023)
Weak incumbent regime / breakdown of the regime	Technology system	Deployment	Not given	(Roberts & Geels, 2019)

Appendix 4: Code Book

The following tables (4.1, 4.2, and 4.3) list the codes and categories generated through review of interview transcripts. A description column is also provided.

Appendix 4.1: Characteristics of Rapid Action (Participants' Perspective)

Codes derived from participants' descriptions of the factors that drive rapid deployment of mitigation measures.

Code	Description
CENTRAL CONTROL	
centralized systems	Preference for centralized systems where a single action can have significant consequences.
direct control	The decision maker has preference for actions over which they have direct control.
CLEAR POLICY DIRECTION	
administrative support	A driver of action. Access to information about grants, market contacts, etc.
performance driven regulations	Flexible regulations that provide room for alternative solutions, so long as a performance criterion is achieved.
policy consistency	Consistent government policy supporting an intervention.
policy incentives	The presence of incentives directly supporting an intervention.
LEAST REGRET	
low risk	Options with low financial, safety, repetitional, etc. risks.
multiple benefits	Options that provide benefits in addition to their mitigation of emissions.
LITTLE THINGS CAN ADD UP	
'progress not perfection'	Presence of an attitude that prioritizes action over perfection.
incremental improvements	Incremental improvements to a process or system that gradually add up to significant change.
low upfront cost	A low upfront cost making the business case for the intervention more palatable to decision makers.
LONG-TERM VISION	
larger organizations can take bigger risks	Organizations benefiting from their large scale and the resulting ability to absorb risk.
long term risk horizon	An attitude among senior decision makers that is comfortable with managing short and long term risks.
PROVEN SOLUTION	
compatible with existing infrastructure	An intervention is compatible with infrastructure already constructed.
drop in replacements	Organization has or is planning to replace an emitting process or technology with a functionally similar non-emitting one.
standardized	The intervention can be deployed in a wide variety of contexts with little customization.
technology successful in similar context	Technology that has been successful in other contexts or jurisdictions, even if it hasn't yet been used in the organization's exact context
PUBLIC APPETITE	
depoliticization of climate policy	Supportive climate policy that remains outside the political conversation and thus remains consistent.
minimizing disruption	Disruption to organizational processes or customers. Disruption is usually cited as a reason that change cannot happen quickly, and organizations try to minimize it through measures like augmentation

Appendix 4.2: Near-term Actions

Codes derived from participants descriptions of the types of actions their organizations are pursuing in the near-term.

Code	Description
ACTIONS	
CHANGE OF PROCESS INPUT	Near term actions that involve changing an energy source or material input (e.g., from fossil fuels to electricity)
change of material	A change of process input that mitigates emissions but that is not a change of energy source. For example, the introduction of lower emission cementitious materials in a cement production process.
deploying active transportation	Replacing vehicle trips directly related to the organization's operations with walking, cycling etc. Distinct from 'encouraging low emission employee commuting', which is not directly related to organization operations
electrifying processes	Describes near term actions that seek to reduce emissions by electrifying a process of a part of a process.
electrifying vehicle fleet	Converting an existing vehicle fleet to electric vehicles
lower emission fuels	Deploying lower emission fuels such as biodiesel.
piloting hydrogen vehicles	Piloting vehicles powered by hydrogen fuel cells.
LAYING GROUNDWORK	Actions that do not reduce emissions in the near term, but prepare a system for future decarbonization (e.g., building charging infrastructure for an expected fleet of electric vehicles). Also includes administrative actions like planning or seeking approvals.
building infrastructure for future technology	Installing infrastructure to be used by future, low emitting technologies. Common action in this category is building charging infrastructure for a future electric vehicle fleet.
building relationships	Developing relationships with stakeholders, suppliers, or other decision makers to facilitate future mitigation actions
developing emissions inventory	Calculating the organization's emissions to develop a plan for mitigation.
indigenous consultation	Consulting with indigenous rights holders to facilitate future approvals for mitigation projects. Distinct from 'building relationship' due to the value of indigenous people's treaty rights compared to stakeholder interests.
preparing a report	Preparing a report on options for mitigation (usually follows 'developing emission inventory').
seeking approvals	Officially approaching government entities for approvals to engage a future intervention.
testing new systems	Work done in advance of implementing a low carbon measure to ensure that the measure can be properly integrated with existing systems (e.g., ensuring charging infrastructure can support a new electric vehicle being purchased).
ORGANIZATIONAL CHANGE	Emissions mitigation through some change to internal processes such as integrating sustainability into procurement procedures. This category also holds emissions generating activities that are not central to the organization's activities, such as employee commuting.
bundling with other projects	Aligning the timing of a mitigation project with other projects to improve its business case or speed of deployment.
educating employees	Educating employees on sustainability principles and their role in reducing emissions.
encouraging low emission employee commuting	Encouraging employees (possibly financially) to commute by carpooling, public transit, or active transportation.
importing expertise	Using the expertise of practitioners outside the organization's jurisdiction to assist in deployment of a mitigation measure.
integrating sustainability as a decision criterion	Updating procurement practices to include, alongside existing specifications, considering of a given option's environmental sustainability.
pushing decisions down	An attempt to empower individual members of the organization to make sustainable decisions every day rather than drive through top down mandates that are seen as potentially inefficient. Based on an assumption that every worker knows their job the best.
PHYSICAL PROCESS OPTIMIZATION	Near term actions that use physical interventions (as opposed to organizational interventions) to reduce the amount of energy required to perform a task
higher efficiency building heating	Near term action to reduce emissions by reducing the need for energy
optimizing output of existing systems	Modifying a process to recover and reuse heat or reduce the need for other energy inputs.
prefabrication	Reducing site production emissions by using prefabricated components.
retrofitting building insulation	Reducing the heating/cooling load of a building by improving insulation.
reuse or capture of waste	Capturing emissions or waste to be either reused or stored.
right-sizing	Assessing operational needs to allow for e.g., choosing not to replace under-utilized assets.

Code	Description
software tools to support low carbon decisions	Using software tools (e.g., Building Information Models) to find low carbon solutions.
updated control systems	Using 'smart' control systems to optimize controls for low energy use or emissions.
using digital systems to optimize	Using forecasting models or similar decision making tools to optimize for low emission pathways.
USING INFLUENCE	The organization tries to influence markets, policies, or regulations through lobbying, industry groups, etc.
demonstration projects	Deploying demonstration projects to encourage employees or the public to adopt low carbon options.
educating clients	Providing clients with knowledge required to make informed decisions that account for the emissions associated with different options.
finding regulatory efficiencies	Working with government regulators to improve processes and align them with low-carbon options
funding or conducting research	Funding or conducting research into low emissions options
lobbying government	Working alone or with industry groups to encourage government policy that supports low emission options.
using scale to push suppliers	Usually working with other organizations to encourage suppliers to provide low emission options.

Appendix 4.3: Barriers to Near-term Action

Codes derived from participants descriptions of the barriers constraining faster mitigation of emissions.

Code	Description
BARRIERS	
COORDINATION	
bundling projects can cause delays	Delays arising from a mitigation project relying on the schedule of other projects.
difficult to work in active systems	Inability to shut down working systems to deploy a mitigation measure.
multiple dependencies	Many factors need to align to move quickly. C-1: 'they all need to be in alignment and failure for any one of those things to happen will stop market transformation from occurring'
need for consultation	Community consultation, indigenous consultation
overall complexity of procurement process	Bidding and tendering
overlapping systems	The delay associated with deploying solutions within complex, overlapping systems (e.g., overlap of HVAC and electrical in a building)
permitting delays	The delay associated with gathering permits with many entities before measures can be deployed.
speed of action too slow to qualify for gov't programs	Misalignment between the timelines required by government grant applications and those practically possible.
DECISION AUTHORITY	
client or customer has ultimate control	When a participant states that some decisions are ultimately in the control of the client or customer, not them.
government has control over major decisions	Lack of control due to government oversight of a decision.
low carbon option is illegal	Regulations preventing deployment of a given measure (e.g., use of waste biomass fuels)
overlapping jurisdiction	Lack of decision control due to multiple jurisdictions declining responsibility (or claiming it)
INCOMPATIBILITY	
lack of standardization	Need for customization of solutions delaying action
work from home not feasible	The organization's operations are incompatible with a lower emission (work from home) model.
INERTIA	
decentralized systems struggle to change quickly	Slower change resulting from the need for many smaller changes
limited infrastructure capacity	Limited capacity of existing infrastructure (Electrical capacity, natural gas supply, etc.)
locked in with old assets	Lower emission replacements are available, but existing assets are far from end of life. Business case for replacement is difficult.
new operating practices required	Employees take time to learn new operating practices required to deploy a low emission measure.
status quo is comfortable	Refers to a situation in which actors hesitate to prioritize sustainability because it represents a change from the status quo.
SCARCITY	
labour shortages	Labour availability is limited and subject to competition across sectors (i.e., mining and electricity production might compete for the same pool of tradespeople).
limited options at market	Lack of low carbon options at market to enable rapid deployment.
scarcity of expertise	Can be caused by a lack of knowledge transfer between generations
scarcity of materials	Low carbon option may require inputs (e.g., biomass waste fuels) not readily available
supply chain delay	"If there's nothing there to buy it doesn't matter whether you can afford it or not" Different from lack of market choice. This refers to a situation where a product is at market but cannot be quickly procured.
TENSION	
cheap resources slow innovation	Observation of the relative slowness of organizations in jurisdictions with low cost resources (fuel, water, etc.) to adopt energy or material saving strategies.
conflict between growth and mitigation	Tension between an organization's desire to grow or accommodate growing demand and its desire to reduce emissions.
construction cost inflation	Increased construction costs causing more expensive low emission options to lose priority.
immediate effects of climate change	Climate change introduces emerging issues that compete with mitigation efforts for attention
low carbon version is lower quality	Concerns about the quality and/or marketability of a lower emission option.
maintenance backlog	Required maintenance work delaying capital improvements required to deploy low emission options.

retrofits are disruptive	Concerns about the disruption caused by building/equipment retrofits causing a project to not proceed.
too fast is disruptive	Preference to take slower actions for fear of being too disruptive to stakeholders.
too fast is not financially responsible	More relevant to regulated or publicly traded organizations. The org cannot justify large scale, rapid mitigation actions if they are not also financially prudent.
too fast is unsafe	Concerns that rapid actions are untested/unsafe.
upfront cost	High upfront cost of a measure delaying its rollout due to priority of financials.
UNCERTAINTY	
budgetary uncertainty	Lack of certainty over budgets causing a delay in execution of action.
clients lacking knowledge	Lack of understanding of low emission options causing clients to avoid them.
emerging technical issues	Or 'you never know what you're going to find once you open things up' - In vivo code from C-1 Q4. Refers to the uncertainty and potential challenges of retrofits. Connected to the code 'overlapping systems', since these are often the reason retrofits are time consuming.
lack of data	Inability to make a decision that deviates from the status quo due to a lack of supportive data.
policy uncertainty	Uncertainty about government policy (e.g., the continued presence of grants or carbon pricing) delaying an action.
unpredictable exogenous factors	Pandemic, interest rates, etc.
waiting for technology	Low-emission option is not yet available (but could be in the future), so organization delays.

Appendix 5: Speculations on Overperformance or Underperformance

Summary and interpretation of participants' responses to the question 'Imagine that, in five years, your organization has [under/over]-performed on its GHG mitigation targets by 50%. What combination of factors might have led to this situation?'

Participant	Quote	Meaning	Easier Over or Under?
C-1	<p>Overperform: 'our targets are pretty ambitious...just achieving our targets, I think, is pretty good.'</p> <p>Underperform: 'There's so many different things that have to happen in alignment. The policy is part of them...but if the economics don't work, the policy doesn't happen...if the workforce [isn't there, if] consumers don't want the product the policy doesn't matter'</p>	<p>Many things need to go right just to achieve the targets, which are ambitious. Targets are principles rather than quantitative, so it is easier to imagine a scenario in which things go wrong than in which things 'exceed' the targets.</p>	Under
C-2	<p>Underperform: "So there's like the culture...or resistance to change...profitability of projects...safety...respect of the environmental laws...technology' 'we don't know what can come...if there's a different government'</p>	<p>There are many things that could go wrong. We are doing our best to mitigate those risks. A world in which we exceed our goals is one in which we successfully mitigate all of those risks.</p>	Under
C-3	<p>Overperform: 'clarity around regulations...that are performance driven' 'a lot more collaboration...we can't hit innovative and aggressive goals if the design team is separate from the build team is separate from the operations team'</p> <p>Underperform: 'unless [renewable diesel] production picks up significantly, one of our easiest levers is kind of off the table' 'if we don't have clients who are saying, well, we're going to build net 0 buildings, we're not we're not going to be able to meet those targets' 'if the standards and codes and the processes don't allow for us to use different materials then we can't get there' 'we can't do this alone'</p>	<p>Policy is the floor that needs to be in place to make any change, but to really excel, we need a more collaborative industry within organizations but also between organizations.</p>	Either
C-4	<p>Overperform: government policy that says 'no natural gas in new buildings today...with incentives to enable that' governments prioritize finding 'the money to incentivize retrofits</p> <p>Underperform: 'Weakening of the emissions performance standards...fundamentally, the voluntary approach to retrofits is not fast enough' driven by affordability concerns, emissions of electricity grid rise, policy that favours gas connections over electrical ones, delays in building mean that 'new' buildings don't meet planned requirements because they were approved assuming a given standard that is obsolete</p>	<p>Provincial and Federal policy is the number one driver and barrier to reducing building emissions.</p>	Either
E-1	<p>Overperform: 'Nothing is ever impossible...regulatory streamlining...if we get through some of those processes in a more streamlined way, that frees up particularly the human capacity part to start looking at the next project.' 'if there was a larger public appetite or engagement on advancing some of the climate change work because effectively that that frees up the Sorry, provides more regulatory certainty, more political will and more appetite to change the way that you're bearing the costs'</p> <p>Underperform: 'changes in policy...black swan events...the war in Ukraine or COVID...large</p>	<p>Many things could disrupt the timeline. Streamlined regulatory processes and better access to financing would speed things up.</p>	Either

Participant	Quote	Meaning	Easier Over or Under?
	disruptions in our supply chain...whole scale changes in our workforce'		
E-2	<p>Overperform: 'the sun starts shining all day long and the wind is exactly gusting at 30 kilometers per hour' 'political change...I don't know how fast you could possibly respond...six years is just not a lot of time to build'</p> <p>Underperform: 'labour shortages...[dispatchable generation could] struggle to accommodate renewables on the grid...demand has gone up'</p>	Really rapid change can only be driven by unlikely external conditions. Even largescale policy changes would take more than five years to implement	Under
E-3	<p>Overperform: 'We're a demand driven business' 'market demand and availability of technology...the programs that we have developed are in fact working'</p> <p>Underperform: 'if only have the number of heat pumps are installed that kind of gives you a sense of where consumers are at'</p>	Consumers drive the change (driven by cost and preferences). Utilities just do what they can to facilitate consumer demand	Either
F-1	<p>Overperform: 'the point is not for us to hit our targets. Our targets are just...to help incentivize our teams.'</p> <p>Underperform: If the pace of our deals slows down...interest rates have put a chill on governments being able to borrow to finance as much...supply chain...labour supply...if the pace of infrastructure commitment in this country diminishes' 'some of the folks who are considering investing in Canada may have made choices to invest in the United States instead'</p>	Market conditions drive our performance. We have targets but they are meant to guide our choices. If the investment opportunity isn't there, we won't invest in uneconomic projects just to meet some target.	Under
F-2	<p>Overperform: 'advanced economies have not just continued but have increased their climate policy...whether that's taxation, subsidies, regulation' 'You need the government'</p> <p>Underperform: 'The world would have gone significantly backward on climate progress.' 'If we were off by 50% that would be considerable backsliding across multiple sectors...it would be economy wide'</p>	Underperform is only likely if the governments abandon targets, overperform is only possible with massive government support.	Over
Ind-1	<p>Overperform: 'There is no end to this. Every plant that can, will continue to make reductions'</p> <p>Underperform: if a subsequent federal government...come in and they say 'we're not doing carbon pricing anymore'...industry is gonna say 'hey look we've already made significant investment under the assumption there will be a carbon price'...if somebody kills carbon pricing today that hurts me. It doesn't help me one iota' 'The policy makers, the regulators, the building code designers, etc., haven't responded</p>	Policy changes in Canada could allow us to exceed our targets.	Over
Ind-2	<p>Overperform: 'the biggest thing would be planning...it would be how much work we're doing today' whether it's the carbon tax...a change in the market...process change... you need to start planning for that today and evaluating what those options and scenarios look like so that you're ready to take advantage of them' 'anything that would get us beyond would be things that would be within our control'</p> <p>Underperform: 'a lot of it comes down to capital or consumer demand' 'we implemented something and it did not perform as expected'</p>	Being prepared for and being able to react to unexpected events will help us maximize mitigation. [Note Ind-2 has no specific mitigation goals, so the question of '50% more' is subjective to their expectations.	Either

Participant	Quote	Meaning	Easier Over or Under?
Ind-3	Overperform: 'clarity in the policy...a lot of the things for the pulp and paper industry already exist...if you have clear policies, people can go and start making decisions today' 'a lot of the stuff that we do in the forestry industry...can help other industries to decarbonize'	Policy certainty (specifically carbon tax) can unlock very rapid reductions in the industry because technology is already there, just not economic. The biggest advancements could be made if the forestry industry expands and assists other industries with their products. This would be driven by market preferences for sustainable materials and policy.	Either
Ins-1	Underperform: 'it would be having to mitigate for climate change...you're kind of running out of rug' 'more efficient but still greater needs may or may not balance out'	Our plans could be thrown off by a greater than expected requirement to adapt to climate change	Under
Ins-2	Overperform: 'there's a lot of emerging technologies out there that might be able to help us...depending on the timing' Underperform: 'availability of materials and resources'...'the electricity grid is forecast to actually increase emissions in the next decade'	We're already doing the best we can with available technology. We could underperform if labour and materials continue to be scarce or if the grid becomes unexpectedly much dirtier.	Under
T-1	Overperform: availability of CCS + 'creating infrastructure [to sell carbon]' Underperform: 'most likely the availability of technology [that]...does not exist today'	The variance is entirely technology based. If the technology has been developed, we'll be there. If it hasn't, we won't	Either
T-2	Overperform: 'unbelievably quick maturity of [electric vehicle] supply chains...sufficient funding [to replace vehicles before end of life]' in terms of infrastructure: 'we are planning for the best case scenario' 'the first thing that gets developed in those neighborhoods is the roads they bring the power they bring all of the utilities before they even build the house. Not the other way around.' Politicians 'think very short term' Underperform: 'prolonged inability of industry to meet our needs' 'lack of foresight by decisionmakers...to invest in early and sufficiently into the supporting infrastructure'	Market availability of mitigating technologies (electric vehicles) is critical to achieving or exceeding goals. We would also need to be building infrastructure right now to support those future vehicles - this requires longer term vision from politicians	Under
T-3	Overperform: 'if [bike lanes] require [council] approvals, I don't know if we're ever gonna get there...just a more cohesive approach where if we say we're gonna do complete streets then that is the package that's delivered by our delivery team' 'if you don't need consultation' Underperform: 'implementation delays...no political buy in or community buy in...staff resourcing...funding...site conditions you were not aware of.'	A streamlined regulatory process and political/community buy in are necessary to excel. Lack of buy-in will lead to failure.	Under
T-4	Overperform: 'some kind of incentives out there for resource development, manufacturing, transport, production...successful community relationships and engagement' Underperform: 'investing in the infrastructure...also make those operational changes for efficiency or drive down...unfortunately not... in our control' 'my most straightforward answer is money...a low risk appetite'	Policy incentives and infrastructure investments would be responsible for any variance from the expected	Under
T-5	Overperform: government anchors, land use planning, transit planning, Underperform: 'the reason we're not there is resources...if some reason [T-5] just decides that they're not investing in it anymore' 'government has stopped supporting research...it's still costly that without some sort of funding they won't do it'...the government needs to have 'some really tangible actions tied to [its mitigation goals]'	Commitment to targets by my org is critical to meeting our goals, but support from government is what takes us beyond them	Under

Participant	Quote	Meaning	Easier Over or Under?
T-6	<p>Overperform: 'the grid is getting cleaner...more renewables...we collaborate with everyone...whether it's the city, private organizations...the province...' In this hypothetical world 'the cost is not really a consideration and somehow everyone's just coming to the table' 'the technology to bring down the costs' Reducing the entire transportation sector's emissions by 50% would require 'transit oriented communities...an equity lens'. How do we get there: 'advocacy work</p> <p>Underperform: 'no one's bought in' 'on the electricity grid front we keep incentivizing gas'</p>	<p>We rely on many sources outside ourselves - industry, government, individuals, advocacy groups - to achieve our goals. Either outcome is easy to imagine if those groups align or don't align.</p>	Either