Renewable Natural Gas Production from Municipal Solid Organic Waste: Policy Evaluation for Newfoundland and Labrador

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Abstract

This master's thesis investigates the potential of producing Renewable Natural Gas (RNG) from municipal solid organic waste (MSOW) in Newfoundland and Labrador (NL) as a strategy to reduce greenhouse gas (GHG) emissions. The current per-person emissions in NL exceed the national average, necessitating mitigation measures such as the development of RNG, which can reduce emissions from landfills and displace fossil fuels.

The study examines the legal and regulatory frameworks governing the RNG industry with special focus on the production, distribution, and utilization of RNG. The study qualitatively analyzes data collected from document review and interviews to assess the impact of these frameworks on RNG development. To contextualize such impacts, the thesis compares NL's policies with other provinces and international jurisdictions, emphasizing economic, ecological, and demographic factors unique to NL. The research concludes with policy recommendations that address several key areas: the implementation of bans on organic waste disposal, the development of business cases, consideration of environmental impacts, and the role of government regulations. The study also proposes the strategic implementation of RNG projects in critical regions, emphasizing the need for local involvement and a comprehensive feasibility study. The conclusion highlights the challenges and opportunities in NL's waste management system, emphasizing the potential of RNG production to push the province towards net-zero emissions.

Overall, the study contributes valuable insights for scientists, industry leaders, and government officials seeking sustainable solutions for organic waste management in NL. Ultimately, the research positions NL as a potential leader in the RNG industry, presenting a roadmap for a sustainable and environmentally friendly organic waste system in the future.

Keywords: Renewable Natural Gas, Municipal Solid Organic Wastes, Greenhouse Gas Emissions, RNG Industry, Waste Management

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List of Abbreviations

- AD: Anaerobic Digestion
- GC: Government of Canada
- GHG: Greenhouse Gas
- ISWM: Integrated Solid Waste Management
- ISWMS: Integrated Solid Waste Management Systems
- MSOW: Municipal Solid Organic Waste
- MSW: Municipal Solid Waste
- NL: Newfoundland and Labrador

Chapter 1: Introduction

1.1 Introduction

The current per-person emissions in Newfoundland and Labrador (NL) stand at 18.2 tonnes of carbon dioxide equivalent per year, 3% higher than Canada's national average of 17.7 (Government of Canada, 2022). The methane escaping from landfills is a potent GHG, with GHG potential multiple times (about 25 to 30 times) higher than carbon dioxide (Schneider et al., 2013). Therefore, implementing different measures in the management of municipal solid waste (MSW), such as measures for energy recovery from landfill waste and gas, may significantly reduce GHG emissions (Schneider et al., 2013).

Creating renewable natural gas (RNG)[1] as a carbon-neutral fuel from municipal solid organic wastes (MSOW) could significantly reduce greenhouse gas (GHG) emissions from landfills across the province. All three levels of government in Canada—Federal, Provincial, and Municipal—could consider the utilization of RNG. This approach could serve as a valuable tool to divert organic waste from landfills, ultimately reducing Canada's overall GHG emissions. Moreover, the adoption of RNG will create green jobs at the local level, enhance revenue for cities by saving energy costs (because RNG can be used in place of expensive alternatives), and potentially lower waste management costs (because less material goes to landfills).

Several methods exist to transform organic waste, such as food scraps and agricultural remnants, into valuable resources. One way is composting, which turns organic waste into organic fertilizer that can help plants grow better (Chen et al., 2020). Another way is Anaerobic

[1] RNG is known by several other names, including biomethane, upgraded biogas, green gas, sustainable natural gas, bio-SNG (Synthetic Natural Gas), biogenic methane, bio-CNG (Compressed Natural Gas), bio-LNG (Liquefied Natural Gas), cellulosic methane, and anaerobic methane.

Digestion (AD). The AD method is somewhat like composting, but it happens without oxygen. During this process, organic waste breaks down and releases gases like carbon dioxide and methane (Chen et al., 2020). This mixture of gases is biogas. The biogas produced by AD is not always clean enough to use straight away. Refining or processing biogas to ensure that it meets certain cleanliness standards turns it into what we call RNG. So, in simpler terms, RNG is basically super-clean biogas that has been treated to be safe and pure enough for use as an energy source. Fundamentally, RNG is a biogas (the gas produced from the breakdown of organic materials) that has undergone refinement to meet purity criteria. (U.S. Department of Energy, n.d.).

As an example, demonstrating the potential of such products, Herron et al. (2021) evaluated the viability of waste-to-energy systems—that is, creating biogas from the digestion of biodegradable materials from municipal solid waste. They concluded that the City of Greater Geelong in Australia, with a population of 265,000, could generate 6-11 million Australian dollars from the sale of biogas/methane each year. In addition to this revenue stream, the city would have an annual projected net emissions reduction of 3797 metric tonnes. Although this evaluation considered biogas as a final product, recent studies and projects primarily discuss upgrading biogas to RNG as the final product for different economic and environmental reasons (Audrey, 2019; Herron et al., 2021; Norouzi et al., 2022)

Capturing the gas generally produced in landfills and converting it to RNG is an effective climate change mitigation measure. According to the U.S. Department of Energy (n.d.), RNG is a pipeline-quality gas that is fully interchangeable with conventional natural gas. The most significant benefit of using natural gas for energy production is that it produces substantially less pollution and carbon dioxide (compared to other alternatives, such as coal) during combustion.

Additionally, systems that use gas to generate power are well-known, adaptable, and come in a wide variety of capacities, ranging from several watts to hundreds of megawatts (Skorek-Osikowska et al., 2020). With combined cycle power plants having a net electric efficiency of about 60%, gas-based technologies are frequently distinguished by high electricity production efficiency and the ability to serve as a peak source in the electrical grid due to their quick start-up periods, often no longer than several minutes (Kotowicz & Bartela, 2011, as cited in Skorek-Osikowska et al., 2020).

Overall, in provinces like NL, where GHG emissions exceed Canada's average, producing carbon neutral RNG from MSOW may help to decarbonize the economy. This involves displacing fossil fuels with renewable green energy in urban or rural areas, which will eventually accelerate Canada's net-zero transition, create jobs, and generate revenue for city governments.

1.2 Waste Management in Newfoundland and Labrador

Managing waste can be very challenging due to population growth, increased consumption, and various developments worldwide, all contributing to the production of more waste than ever before. In Canada, from 2002 to 2018, the total solid waste generation increased by 4.8 million tonnes (or 16%) to reach 35.6 million tonnes in 2018 (Government of Canada, 2022). After diversion (e.g., recycling and composting), the amount of waste disposed in landfills or incinerated still amounted to 25.7 million tonnes, an increase of 1.7 million tonnes (or 7%) over 2002. Specifically, in 2018, 28% of the solid waste generated in Canada was diverted, while the remaining 72% was sent for disposal. In NL, the provincial government's 2019 "Review of the N.L. Provincial Solid Waste Management Strategy" confirms that estimated organics

diversion currently represents less than 1% of the total municipal solid waste stream and less than 2.5% of the organics waste stream. Consequently, 97.5% of organic waste generated in NL ends up in landfills. NL needs to divert 25.5% more waste to reach Canada's provincial average. This amount of waste in NL creates harmful leachate, pollutes local topography and water bodies, and produces methane.

1.3 Renewable Natural Gas as an Opportunity

Considering the huge amount of waste produced each year, there are many solutions that should be considered for either waste reduction or waste diversion. One of the strategies to divert organic waste from landfills is to establish waste diversion program that can produce bioenergy as final product. Figure 1 demonstrates various waste-to-energy options, including landfilling, composting, dry AD for the creation of RNG, and dry AD for electricity generation.

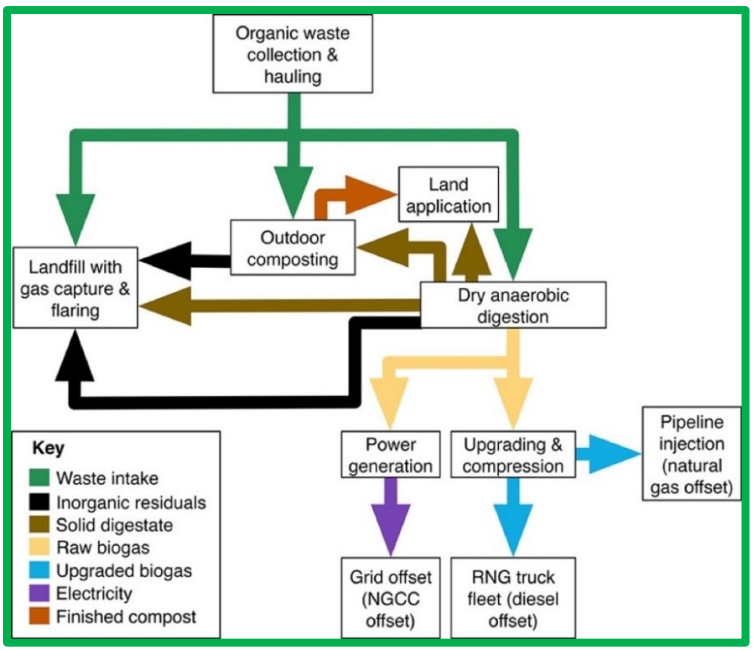

Figure 1. Waste-to-energy Systems
(Source: Nordahl et al., 2020, p. 1)

In most waste management systems, after waste is collected, landfilling is often considered the most common and straightforward disposal method for the organic wastes, which, as discussed above, is responsible for a huge portion of Canada's GHG emissions. A more environmentally friendly alternative to landfilling is composting raw organic waste. This method is simple and cost-effective. A more advanced method employs AD to generate raw biogas, which can then be upgraded and compressed to produce RNG, generally considered the most valuable final product. Recently, BiogasWorld unveiled the first visual map featuring current RNG projects in Canada and USA (see Figure 2).[2]

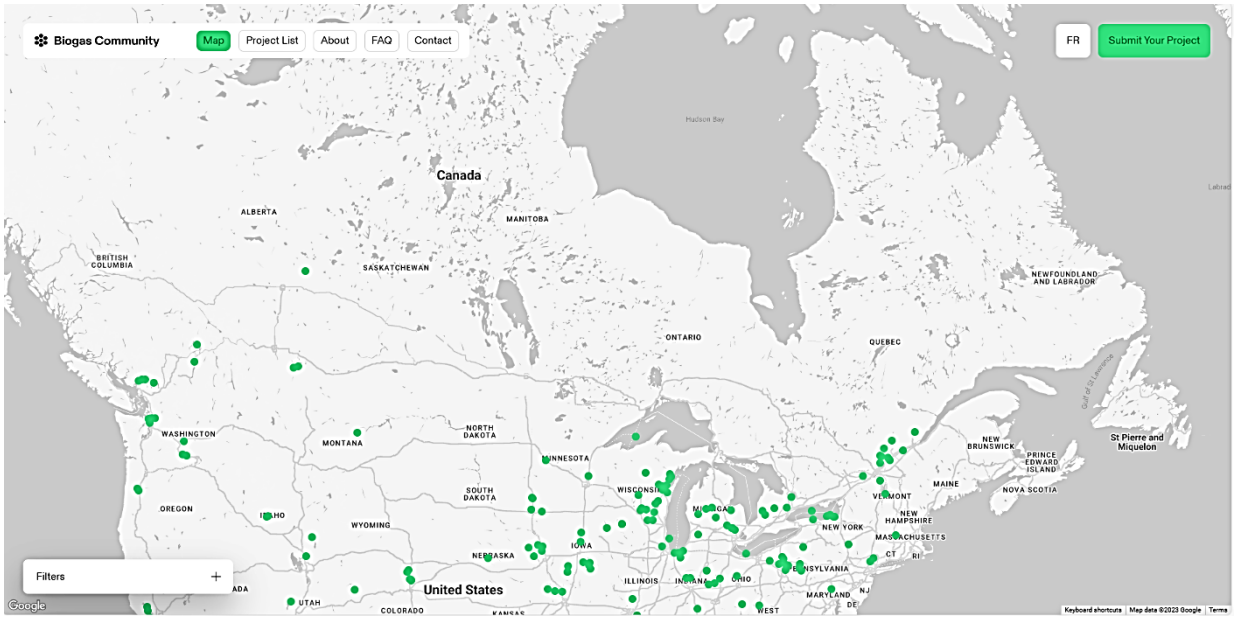

Figure 2. Current RNG/RNG Projects in Canada and the United States
(Source: BiogasWorld, 2023)

This essential map provides a comprehensive overview of current RNG projects in Canada and the USA. It offers valuable insights into the scope and distribution of RNG

[2] The map can be accessed through the following URL: https://map.biogascommunity.com/map

initiatives, helping researchers, policymakers, and industry stakeholders understand the landscape of renewable energy development. Additionally, it could serve as a reference point for future policy discussions and investment decisions in the RNG sector. RNG can be produced from various feedstocks, including landfill biogas capture, agricultural manure, food waste processing, distillers' waste, wastewater processing, and wood waste processing. Each source contributes differently to the overall production of RNG and has unique advantages and challenges. The figures on the map include these diverse feedstocks (e.g. agriculture waste, wood waste) to provide a comprehensive view of RNG production across different sectors, although this thesis focus primarily on RNG from landfills.

1.4 RNG in Newfoundland and Labrador

According to the latest action plan for developing the renewable energy industry in NL, the government plans to review the province's biogas potential at the regional level in the medium term (within two years) for future applicability (Government of N.L., n.d.). Looking at the history of RNG in the province, NL's Biogas Electricity Generation Pilot Program was established in 2014 to encourage the development of biogas power generation in NL and generate electricity for the grid (Government of NL, n.d.). In this pilot project, methane gas was planned to be burned in biogas generators to produce heat, which would then be utilized to power a turbine to generate electricity. The government aimed to benefit the environment by significantly reducing the emission of methane through its use as fuel in a generator. Under the Program, NL Hydro (a provincial corporation that generates and delivers electricity for NL) assured to purchase electricity from the biogas projects of private developers (Government of N.L., n.d.). However, the program considered electricity to be the final product, potentially

causing a conflict of interest between different government and private stakeholders, especially with the Muskrat Falls hydroelectric dam (potentially entering the commercial service phase in the near future).

The document “Newfoundland and Labrador Energy Innovation Roadmap: Phase 1 Priority Identification” (2010) clarifies waste-to-energy opportunities for the province. It divides municipal solid waste into three categories—domestic, commercial, and industrial waste, and construction and demolition waste—which have the potential to be used to produce power, heat, and transport fuels directly or via intermediates such as biogas and synthetic natural gas. The Roadmap assesses that NL generates around “400,000 tons of waste annually”, with an average of “120,000 tons containing organic materials”, demonstrating the maximum amount of raw material that could be generated from municipal solid waste resources. However, this document does not specify a clear direction or targets for waste-to-energy projects.

The 2019 "Review of the N.L. Provincial Solid Waste Management Strategy" discusses the potential impact of a provincial landfill ban on organics. According to the Multi-Materials Stewardship Board (MMSB), effectively enforcing such a ban could divert up to 100,000 metric tonnes of organic waste. This diversion could contribute to an estimated 19% of the overall waste reduction. Additionally, it would decrease the per-person waste disposal rate by 0.52 kilograms per day, or approximately 190 kilograms annually. This means an increase in waste diversion may considerably reduce waste management costs for NL’s municipal and provincial governments.

1.5 Research Objectives and Questions

This study seeks to comprehensively explore and enhance NL's RNG potential within the context of its legal and regulatory framework. The overarching goal is to understand the current landscape and advance strategies for sustainable RNG development in NL. The main data collection methods include a targeted document review, and semi-structured interviews. The research employs qualitative analysis to evaluate the effects of these policy frameworks on RNG development across the NL. Ultimately, this thesis provides insights into the legal and institutional frameworks relevant to the RNG industry. Additionally, it aims to identify new policy and legislation options that can be proposed or implemented to support RNG development.

By extension, the study aims to support governments in reducing GHG emissions associated with municipal solid waste (MSW), which accounts for almost 25% of total GHG emissions in Canada and 6.71% in NL. Additionally, it targets sectors that can be decarbonized by replacing RNG obtained from waste, such as large industries, including the oil and gas industry in NL, which is contributing to emissions of over 35% (The Way Forward on Climate Change, 2016, Government of NL). Understanding the legal and regulatory frameworks surrounding these actors is crucial for proposing effective measures to address and reduce human-related MSW-based GHG emissions. Thus, the following research questions have been formulated to deepen our understanding and guide the development of more robust strategies in the RNG sector.

- What is the legal and regulatory framework for the RNG industry in NL? [descriptive]
- What are the effects of this framework on RNG development in NL? [explanatory]

- How does this framework compare to legal and regulatory frameworks for RNG in other jurisdictions? [comparative]
- How can policies and legislation be enhanced to promote growth of RNG industry in NL towards reducing GHG emissions? [prescriptive]

1.6 Organization of the Thesis

This research aims to thoroughly investigate and improve RNG possibilities in NL, considering its legal and regulatory environment. The primary objective is to understand the current situation and advance knowledge to promote sustainable strategies for RNG development based on that understanding.

To set the stage for this study, Chapter 2 delves into an analysis of existing literature specifically relevant to RNG. Chapter 3 delineates the methodology employed in this research—elaborating document review and interview methods. In Chapter 4, the results section, the study examines relevant legislation, policies, scientific resources, and presents interview results pertaining to organic waste and RNG in NL, organized around the four research questions. The research emphasizes analysis and comparison, taking into account the economic, ecological, and demographic factors specific to NL. Chapter 5 contextualizes the data within the organic waste management and RNG adoption landscape in NL, addressing complexities, challenges, and potential solutions. It provides a deeper understanding of RNG policies, discussing specific topics beyond initial observations. Analytically, it compares NL's strategies with those of other Atlantic provinces and explores RNG project feasibility and funding dynamics, emphasizing a comprehensive policy perspective. Ultimately, it presents carefully developed policy recommendations informed by thorough research synthesis.

The thesis conclusion (Chapter 6) summarizes research questions, data collection methods, and findings, including the result of comparison with other jurisdictions. It also acknowledges study limitations and proposes practical actions for future decision-makers, suggesting the feasibility study as a crucial step. Moreover, it underscores the importance of collaboration among government departments, regulatory agencies, and industry stakeholders. It emphasizes making gradual advancements that fit NL's unique circumstances in promoting a more sustainable waste management system.

Chapter 2: Literature Review

2.1. Introduction

This chapter delves into the diverse aspects of managing organic waste; it explores theoretical frameworks, practical applications, and policy implications, focusing on NL. There is emphasis on the importance of Integrated Solid Waste Management Systems (ISWMS) and the urgent shift toward sustainable waste management practices. Additionally, the chapter outlines the policy landscape in NL, focusing on the existing waste management strategy and its objectives. Later, practical strategies for organic waste management, concentrating on composting and waste-to-energy technologies, are covered. Shifting from theory to policy, the chapter also highlights the pivotal role of RNG in organic waste management; it analyzes provincial initiatives and explores recent developments and emerging trends in RNG adoption.

2.2. Municipal Organic Waste Management Systems

As defined by the United Nations in 1997, waste management encompasses the collection, transport, treatment, and disposal of waste. It also involves the control, monitoring, and regulation of these processes as well as production, plus efforts to reduce waste production through in-process modifications, reuse, and recycling. The United Nations Environment Programme asserts that poor waste management, from nonexistent collection systems to ineffective disposal, contributes to air pollution and contamination of water and soil.

Municipal solid waste significantly contributes to GHG emissions through decomposition and life-cycle activities. Most of these emissions result from landfill disposal, which is the leading waste disposal method globally (Lou & Nair, 2009). The latest waste management

strategy in NL, still enforced by the provincial government, is the policy from 2002. This Newfoundland and Labrador Waste Management Strategy document (2002), with its implementation plan and funding commitment announced in 2007, emphasizes the need to change the current approach to waste management, which relies mainly on disposing of unsorted waste at a landfill site. The primary targets that the provincial government is following based on this strategy are: a 50% diversion of solid waste, an 80% reduction in the number of waste disposal sites, the elimination of open burning and incineration, and the phase-out of unlined landfills, all to be implemented province-wide by 2025. The government of NL is committed to developing a modern waste management system designed to meet the province's needs.

Seadon (2010), argues that transitioning to a more sustainable society necessitates advanced waste management. According to him, traditional reductionist strategies are unsustainable due to their inflexibility and short-term solutions. Sustainable waste management should involve diverting waste from disposal; minimizing the generation of waste and harmful substances; maximizing the reuse, recycling, or recovery of materials; and minimizing disposal of waste to preserve resources for the future (International Solid Waste Association, 2013, as cited in Cucchiella, 2017).

Globally, the United Nations Environment Programme (UNEP) supports implementing ISWMS as an effective solution (UNEP, n.d.). The United States Environmental Protection Agency (2002) defines ISWM as a comprehensive waste prevention, recycling, composting, and disposal program. The agency stresses the importance of an efficient ISWMS that considers strategies for preventing, recycling, and managing solid waste in a manner that prioritizes the protection of human health and the environment. The ISWMS evaluates local needs and

conditions and then selects and combines the most appropriate waste management activities for those conditions (US Environmental Protection Agency, 2002).

In this thesis, the concepts of sustainable waste management and ISWM are both critical but distinct. Sustainable waste management, as explained by Seadon (2010) and the International Solid Waste Association (2013), focuses on reducing waste generation, maximizing recycling and reuse, and ensuring safe disposal for long-term environmental, economic, and social benefits. In contrast, ISWM, as defined by UNEP (n.d.) and the US Environmental Protection Agency (2002), is a comprehensive approach that includes waste collection, transportation, treatment, and disposal in an integrated system, prioritizing efficiency, and adaptability. ISWM offers an organized framework for effectively applying sustainable waste management principles to achieve broader environmental goals. The ISWMS serves as a pathway to advance waste management practices, ultimately leading to a more sustainable society, as argued by Seadon (2010). Essentially, ISWM is a broader concept than sustainable waste management; the former can incorporate the latter.

Figure 3 below illustrates the hierarchy of ISWMS. The primary strategy involves reducing waste generation and reusing products where possible, such as repurposing discarded clothes. However, for items that cannot be directly reused, the next step involves recycling. This entails processing materials to extract useful components or transforming them into alternative formats suitable for reintroduction into consumption. For instance, materials may undergo repackaging, refurbishing, or remanufacturing to extend their lifecycle and minimize waste. When it comes to biodegradables, composting and waste-to-energy methods are the next two steps to achieve success in waste diversion. If these four steps are fully considered, only a small amount of waste will be left, which is neither chemically nor biologically reactive and will not

decompose or will do so very slowly. These remnants may still end up in landfills unless new methods emerge for their recovery as well.

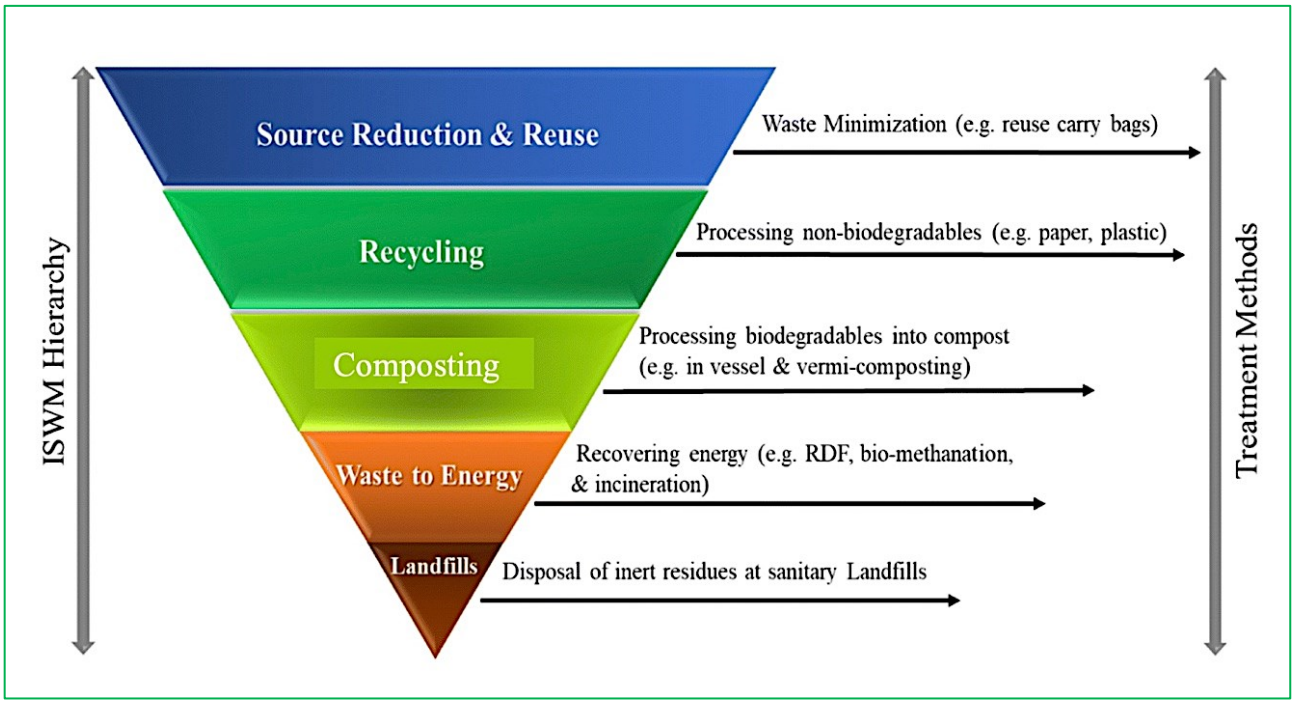

Figure 3. Integrated Solid Waste Management System Hierarchy
(Source: Mushtaq et al., 2020, p. 8)

According to the ISWMS, landfill disposal is considered the ultimate remedy only after reduction, reuse, recycling, composting, and waste-to-energy options are exhausted. However, as stated in the provincial government's 2019 "Review of the N.L. Provincial Solid Waste Management Strategy" introduced in Chapter 1, an ISWMS has not yet been implemented in the NL waste management system, and 97.5% of the province's organic waste still ends up landfills.

On the other hand, the 2022 report on "Organic Waste Management in NL: Exploring Opportunities in Management and Utilization" focuses on improved organic waste management methods, particularly initiatives that convert waste into valuable products—this emphasis aligns with various aspects of the waste management hierarchy which not only promotes the diversion of organic waste but also emphasizes its reuse (Memorial University of Newfoundland, 2022).

Some legislation and policies, such as the *Environmental Protection Act* (2002), define waste management as encompassing the collection, transportation, handling, storage, treatment, utilization, diversion, recycling, reuse, recovery, reduction, and disposal of waste material, while a waste management program refers to a program containing provisions or requirements for waste management. The document *Landfill Bans, Special Wastes, and Diversion Programs* provides a quick reference summary table of landfill bans, diversion programs, and special considerations in effect, as directed by the NL Department of Environment, Climate Change, and Municipalities (Government of Newfoundland and Labrador, n.d.).

Moving forward, the *Review of the Provincial Solid Waste Management Strategy* shows that significant progress has been made in NL, with closures of waste disposal sites, cessation of open burning and incineration, and increased access to modern waste management services, including a new landfill in Labrador West (Government of Newfoundland and Labrador, 2019). In addition, the "Newfoundland and Labrador Waste Management Strategy" (2002) remains the most recent comprehensive waste management strategy in NL, still enforced by the provincial government. It includes targets such as half diversion of solid waste, a significant reduction in waste disposal sites, the cessation of open burning and incineration, and the phasing out of unlined landfills, all to be achieved by 2025. These documents indicate that that NL must formulate and implement new strategies for establishing an ISWMS in the province. When effectively implemented, such a system employs advanced source separation and reduction, composting, and waste-to-energy steps. This approach can potentially divert up to 97.5% of organic waste from landfills, significantly reducing the environmental impact of waste disposal in NL.

2.3 Waste to Compost and Energy

In the ISWMS (Figure 3), composting and waste-to-energy steps are crucial after processing non-biodegradables. These steps are vital as they represent the last attempt to prevent waste from being dumped into landfills for disposal. Consequently, governments are implementing alternative waste management systems, such as energy recovery from landfill gas capture, aerobic landfilling, pre-composting of waste before landfilling, landfill capping, and composting the organic fraction of municipal solid waste (Lou & Nair, 2009).

Energy recovery from landfill gas involves collecting the gases produced by decomposing organic waste in landfills. Landfill gas facilities typically capture and burn this methane to produce electricity, heat, or both (Speight, 2019). Additionally, some governments employ methods such as aerobic landfilling, which promotes the decomposition of waste in the presence of oxygen (Read et al., 2001).

Composting is the most common among these approaches all around the world. Lou and Nair (2009) demonstrate that composting results significantly fewer GHG emissions compared to landfills. Encouraged by government incentives, waste corporations throughout Europe have shifted their investments into AD systems, which involve the breakdown of organic materials by microorganisms in an environment devoid of oxygen (Ayilara et al., 2020). Through these government incentives, composting might undergo a new evolution involving bioenergy technologies, such as AD. Composting could be utilized to enhance the value, agronomic advantages, and environmental benefits of the by-products of bioenergy operations (Ayilara et al., 2020).

Action 1 of the NL Waste Management Strategy (2002) underscores the significance of waste recovery as a pivotal approach to strengthening waste diversion efforts. Waste recovery

encompasses various methods, including recycling, composting, and energy recovery. These methods aim to extract value from discarded materials, diverting them away from landfills. By embracing such strategies, the objective is to minimize landfill disposal, mitigate environmental impacts, and conserve resources effectively. This policy explains that most organic material can be decomposed to create compost. Based on recent research conducted by the NL provincial government and presented in the *Review of the NL Provincial Solid Waste Management Strategy*, most respondents (NL residents) agree that keeping organic waste out of landfills is crucial (Government of Newfoundland and Labrador, 2019).

The report reveals seventy-four percent of survey participants consider this objective to be highly important. Additionally, about half of the respondents support introducing organic waste diversion and composting programs. Therefore, as emphasized in the NL Waste Management Strategy document (2002), the current approach to waste management in the NL needs to be replaced by a modern system. The ISWMS, with a specific focus on composting and waste-to-energy options, might be considered as an alternative for the future of NL provincial waste-related policies.

2.4. The Road to Net Zero with RNG

Canada has set various national, provincial, and territorial GHG emission reduction targets for 2030, 2040, and 2050, with the strictest national target being to achieve net-zero GHG emissions by the year 2050. This national target is legally supported by the Canadian Net-Zero Emissions Accountability Act, especially Article 6. The Article emphasizes that, for greater certainty, nothing in this Act precludes attaining net-zero emissions before 2050. In 2015, 27% of Canada's total GHG emissions were from landfill emissions (Mohsen & Abbassi, 2020).

Additionally, according to Environment and Climate Change Canada (2022), the total volume of solid waste produced in Canada from 2002 to 2018 increased by 4.8 million tonnes (or 16%), reaching 35.6 million tonnes (i.e. the amount produced in 2018 alone). Furthermore, the quantity of waste burned or dumped in landfills grew by 1.7 million tonnes (or 7%), increasing to 25.7 million tonnes. More than 70% of the solid waste produced yearly in Canada has been disposed of in landfills (Environment and Climate Change Canada, 2022). Therefore, as Thompson & Tanapat (2005) stated, new approaches and strategies are required to minimize methane emissions due to Canada's high per capita emissions from solid waste disposal on land.

Canada's 2021 nationally determined contribution (NDC) under the Paris Agreement states that Canada's updated NDC is to reduce emissions by 40-45% below 2005 levels by 2030. In line with this target, the federal government is investing $1.5 billion in a Clean Fuels Fund to help grow Canada's clean fuel markets, introducing an accelerated capital cost allowance for clean energy equipment, including equipment to produce solid and liquid fuels (e.g., wood pellets and renewable diesel) from specified waste material (Government of Canada, 2021).

Canada's 2021 NDC also highlights some of the leading provincial policies. According to this document, the government of British Columbia is exploring new opportunities for reductions through negative emissions technology, the bioeconomy, and the circular economy. Negative emissions technology involves methods to remove GHG emissions from the atmosphere. The bioeconomy encompasses sustainable utilization of biological resources. The circular economy focuses on minimizing waste and maximizing resource efficiency. The government of British Columbia is exploring opportunities in these areas for emissions reduction.

The Manitoba Government is updating the provincial Waste Diversion and Recycling Framework, including delivering and expanding organics diversion and composting programs

(Government of Canada, 2021). The government of Quebec supports the development of strategic sectors to decarbonize the economy, such as the diversification of renewable energy sources, including bioenergy (Government of Canada, 2021).

At the provincial level, NL has one of Canada's highest waste disposal rates per household (Keske et al., 2018). As well, NL's GHG emissions in 2020 were 9.5 megatons of carbon dioxide equivalent (Government of Canada, 2022). The latest data indicates that NL's emissions per capita are 18.2 tonnes of carbon dioxide equivalent per year, which is 3% above the Canadian average of 17.7 tonnes per capita (Government of Canada, 2022). The primary sectors responsible for the highest levels of emissions in NL are transportation, accounting for 41% of total emissions, followed by the oil and gas sector at 22%, and industry and manufacturing at 10% (Government of Canada, 2022). Regarding the waste sector in NL, the provincial climate action document *The Way Forward on Climate Change* indicated that the waste sector was directly responsible for at least 6 percent of the emissions in NL (Government of Newfoundland and Labrador, 2016). In response to climate change impacts, the current Climate Change Action Plan for NL (2019) introduced two programs for GHG emission reduction projects: the Climate Change Challenge Fund and the Transportation Energy Efficiency Program, which includes $3.9 million for municipalities and waste management organizations. The current Climate Change Action Plan (2019) emphasizes the importance of waste reduction from landfills in achieving the net-zero goal; however, it might be challenging to achieve this goal without considering new sustainable organic waste management strategies in the province. Furthermore, the Pan-Canadian Framework on Clean Growth and Climate Change explicitly identifies bioenergy, such as Renewable Natural Gas (RNG), as one of its strategies for reducing GHG emissions across all economic sectors in Canada (Giuntoli et al., 2021).

To comprehend biogas (or its upgraded form: RNG), it is important to understand the AD process, a biochemical process in which bacteria break down organic matter, with one of the final products being compost. Kirk and Gould (2020) define AD as a complicated, naturally occurring biochemical process carried out in several steps by a community of microorganisms that flourish in low-oxygen environments. Biogas, produced through AD, is considered a kind of renewable energy technology that can be used to produce RNG, electricity, or heat, all of which have positive societal effects (Kirk & Gould, 2020). To produce biogas, a digester is fed a range of organic wastes, often referred to as feedstocks or biomass (Kirk & Gould, 2020). Methane and carbon dioxide are the primary components of the biogas produced during digestion (Kirk & Gould, 2020). RNG is a term used to describe anaerobically generated biogas that has been upgraded for use in place of fossil natural gas (U.S. EPA, 2020). The main difference between biogas and RNG is that raw biogas typically has a methane (CH4) content between 45 and 65 percent, while purified RNG has a CH4 content of 90 percent or greater (U.S. EPA, 2020).

A study by Parker et al. (2017) in California demonstrated that RNG provides an economically viable option for methane emission reduction for a quarter of the dairy manure in the state. The study suggested that RNG has potential to help California achieve its low-carbon fuel goals; however, they also explained that to fully realize this potential, there must be an increase in the demand for natural gas in the transportation sector. As per the U.S. EPA (2020), developing RNG resources is one way to expand fuel sources, enhance fuel security, benefit communities and end users economically, improve local air quality, and reduce GHG emissions.

The economic effects of converting heavy-duty diesel-fueled trucks in California to RNG fuel, including the advantages of developing RNG processing and fueling station infrastructure and the impact of purchasing CNG vehicles, were examined in a study carried out by the

California Natural Gas Vehicle Coalition (2017). The study found that RNG produced in California and used in heavy-duty trucks can drive economic growth and create jobs while helping achieve environmental goals. Dedicated investments in deploying trucks powered by RNG could create up to 134,000 jobs and provide up to $14 billion of added economic value by 2030. The study also notes other RNG-related sectors that may experience high job creation include construction, manufacturing, repair and maintenance of equipment, engineering services, environmental consulting services, and service industries.

Gasper and Searchinger (2018) explained that producing RNG (upgraded biogas) is an evolving approach to turning organic waste into a low-carbon fuel for vehicle use. They found that RNG has the potential to be a successful GHG reduction solution when it satisfies two requirements: if it is made from waste, and if its use reduces methane emissions to the atmosphere. Gasper and Searchinger (2018) concluded that the most viable RNG initiatives involve diverting food and yard waste from landfills and implementing methane capture projects on farms where methane is not already being captured. According to this research, utilizing RNG from these projects in heavy-duty vehicles can lead to net life cycle GHG reductions. However, they advise municipalities, states, and businesses considering RNG as a climate strategy to assess aspects such as: net GHG reductions, project expenditures, benefits of new projects, and necessary policies in advance.

Another recent study conducted by Norouzi et al. (2022) examined membrane systems designed for the recovery of methane from biogas. These systems are utilized to purify biogas to comply with the established specifications of natural gas pipelines as outlined by gas utility companies, or to meet the fuel standards required for natural gas vehicles as stipulated by engine manufacturers. They found that the key drivers of today's rapidly expanding Canadian RNG

sector are the cheaper project cost of RNG and the already-existing natural gas pipeline infrastructure. Norouzi et al. (2022) evaluated biogas-upgrading technologies, including water scrubbing, organic solvents, amine absorption, deep eutectic solvents, pressure swing adsorption, adsorption on a solid surface, and cryogenic separation. They believe the most significant challenge is finding the most advanced technology with the lowest investment and operating expenses. Their research demonstrated that "membrane separation technology" is Canada's most common upgrading technology due to the century-old knowledge regarding gas permeation membranes typically utilized in the natural gas sector.

2.5. Recent RNG Developments in Canada and the United States

The RNG industry has been rapidly developing in Canada recently (with about 80% of the projects developed after 2010). As listed in Table 1 below, 11 biogas-to-RNG projects are currently established in Canada (Norouzi et al., 2022).

If we look at more recent data, developments in RNG production in Canada show a significant increase in projects over the past two decades. The number of RNG projects has grown substantially, with a marked increase expected between 2021 and 2025 (Canada Energy Regulator, 2023). As of 2022, according to the Canada Energy Regulator, there were 22 operational RNG projects in Canada, and this number is projected to more than double to 39 by 2025 (Canada Energy Regulator, 2023).[3]

[3] Please visit the Canada Energy Regulator's website for an updated list of RNG projects in Canada: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2023/market-snapshot-two-decades-growth-renewable-natural-gas-canada.html

Table 1. Current Biogas-to-RNG Upgrading Projects in Canada (Data Before 2021)
(Source: Adapted from Norouzi et al., 2022, p. 10)

Location	Company	Type	Technology	Year
Berthierville (QC)	UOP	Landfill	Membrane	2003
Abbotsford (BC)	Greenlane	Biogas Plant	Water Scrubbing	2010
Hamilton (ON)	Greenlane	Wastewater Treatment Plant	Water Scrubbing	2011
L'Ascension (QC)	Sysgaz	Landfill	Amine	2012
Salmon Arm (BC)	Xebec	Landfill	Pressure Swing Adsorption	2013
Kelowna (BC)	ARC Technologies	Landfill	Pressure Swing Adsorption	2014
Delta (BC)	Greenlane	Biogas Plant	Water Scrubbing	2014
Chilliwack (BC)	Unknown	Biogas Plant	Unknown	2015
Richmond (BC)	Unknown	Wastewater Treatment Plant	Unknown	2016
Montreal (QC)	Terix Envirogaz	Landfill	Methanol	Unknown
Montreal (QC)	Shreis Scalene Greenergy	Landfill	Water Scrubbing	Unknown

In the central part of Canada, the Ontario government proposed providing RNG project support on May 26, 2016, and subsequently changed sections 1.3, 4.1, 4.2, and 6.1 of the provincial Climate Change Action Plan a month later (Canadian Biogas Association, 2017). Therefore, in recent years, Ontario has seen RNG expansion and market development due to

current incentives and policies (Canadian Biogas Association, 2017). In 2016, Ontario invested $100 million of carbon cap-and-trade proceeds over four years to assist in introducing renewable natural gas, and the province is taking the lead in the battle against climate change (Government of Ontario, 2016).

Article 6 of the Ontario Climate Change Action Plan (2016) describes establishing low-carbon content for natural gas. Ontario intends to introduce a renewable content requirement for natural gas and provide support to encourage using cleaner, RNG in the industrial, transportation, and construction sectors. Afterwards, the Plan suggests the feasibility of replacing conventional natural gas with methane derived from diverse sources, such as landfills, municipal green bin collection, agricultural residues, livestock manure, waste generated by food and beverage manufacturing, sewage treatment plants, and forestry by products. (Government of Ontario, 2016). Renewable natural gas is a low-carbon fuel that does not add new carbon to the atmosphere and is fully interchangeable with conventional natural gas, using the same infrastructure (Government of Ontario, 2016). Currently, Enbridge, a pipeline company with operations in Ontario (among many other jurisdictions), provides two services to RNG producers: i) connecting the producers to the gas pipeline and ii) upgrading biogas to a level that meets specifications (Audrey, 2019). As another Ontario example, in 2011, the City of Hamilton in Ontario came to an agreement with Union Gas that allowed RNG produced at a wastewater treatment plant (WWTP) to be distributed over the utility's network.

Figure 4 illustrates the factors contributing to a vehicle's carbon negativity (Enbridge Gas, 2022). According to a study conducted by Enbridge (2022)[4], where they compared the

[4] It should be noted that Enbridge, the entity conducting the study referenced in this section, has a vested interest in RNG as part of its business operations. As such, readers are encouraged to consider potential biases when interpreting the findings presented herein.

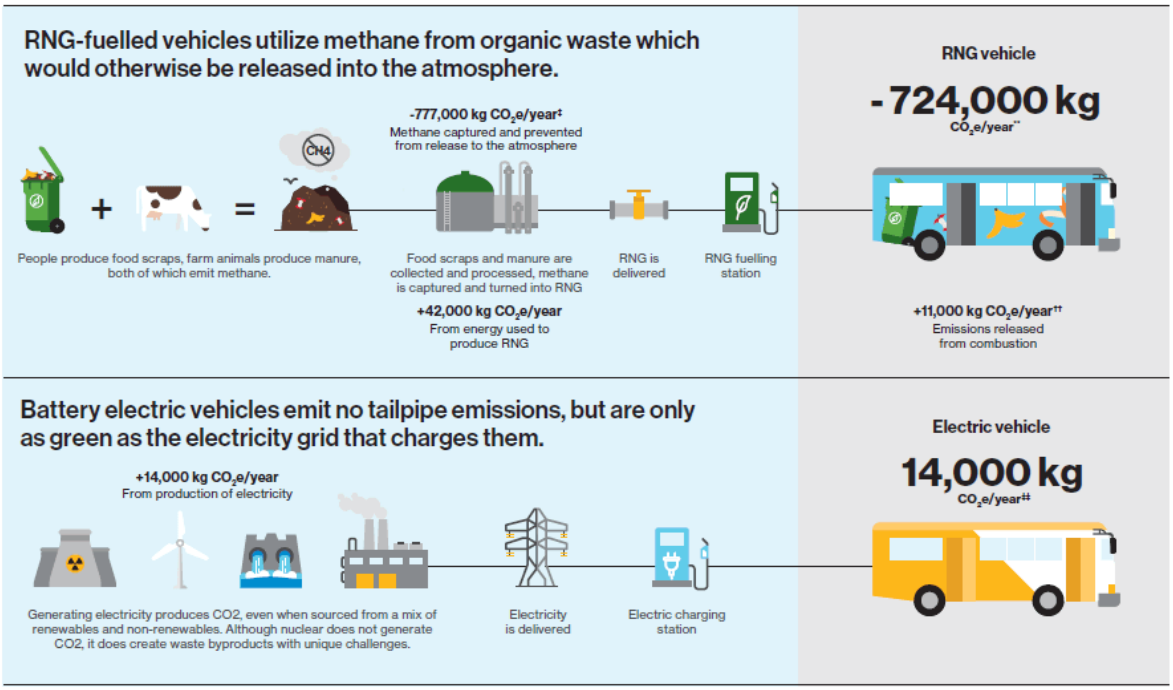

Figure 4. What Makes a Vehicle Carbon Negative?
(Source: Enbridge Gas, 2022)

GHG emissions of RNG-fueled vehicles and electric vehicles, RNG has the potential to achieve carbon negativity, which electric vehicles do not. The study highlights two key effects: firstly, when RNG replaces diesel, it burns up harmful methane that would otherwise be released into the atmosphere during the biogas/RNG generation process, thereby reducing emissions. Secondly, the combustion of RNG in a vehicle produces fewer or less potent emissions compared to burning diesel. Despite the production of tailpipe emissions, RNG-fueled vehicles contribute to carbon negativity and aid in achieving provincial climate targets. In contrast, electric vehicles do not capture emissions, and are associated with any GHG emissions from the electricity grid that powers them.

Figure 5. Dufferin Organics Processing Facility in Ontario
(Source: Biogas Community, 2023)

As an example, from the US, methane reduction goals are set for California by the Short-Lived Climate Pollutant Reduction Act, often known as Senate Bill (SB) 1383 (County of Santa Clara, 2022). The California bill SB 1383 establishes objectives to reduce the disposal of organic waste, including edible food, in landfills (County of Santa Clara, 2022). The Rialto Bioenergy Facility in the US state of California was constructed to help the state of California comply with SB 1383, a historic bill designed to cut landfill methane emissions by diverting food waste and turning it into renewable fuel (Anaergia, 2022). This vast facility can process up to 1,000 tons per day of a combination of food waste extracted from municipal waste streams, liquid waste, and municipal biosolids—and can then convert those into up to 1,000,000 MMBtu per year of carbon-negative RNG (Anaergia, 2022). GHG reduction of this project is up to 220,200 tons per year, equivalent to the emissions of 47,500 cars (Anaergia, 2022).

RNG or biogas projects are also possible in less-populated urban areas. For instance, the most recent RNG sources in the US are stand-alone digesters (US EPA, 2020). These stand-alone organic waste management operations use AD to break down organic waste, including food waste, at the source to produce biogas that can be turned into RNG (US EPA, 2020). The single-tank complete mixed anaerobic digester at Michigan State University (a currently operating system) utilizes approximately 17,000 tons of organic waste per year as feedstock to produce biogas (US EPA, 2016). The feedstock includes dairy manure from the MSU Dairy Teaching and Research Center; fruit and vegetable waste from a local food processor; fats, oil, and grease from local restaurants; and food waste from campus dining halls and sports/entertainment venues (US EPA, 2016). The Michigan State University project shows the viability of RNG projects serving small communities or institutions. The findings indicate that successful implementation and operation of RNG facilities do not necessarily require a large surrounding population, making these projects feasible in rural or less populated areas. After reviewing the literature, the comprehensive perspective on RNG developments in the US and Canada shows that the RNG industry is growing rapidly. However, some provinces or states are ahead of others in implementing new waste policies.

2.6 Conclusion

In conclusion, the United Nations' definition of waste management, as discussed above, emphasizes the importance of an effective waste management system to prevent pollution and GHG emissions. In the Newfoundland and Labrador Waste Management Strategy, goals such as a 50% diversion of solid waste and an 80% reduction in waste disposal sites all require a modern waste management system in the province, considering the four main steps of reuse, recycle,

compost, and waste to energy. These steps all warrant further study and understanding of legislation and policies, as well as ways to improve them.

In NL, the pressing need for an enhanced waste management system is evident, particularly considering the current high disposal rate of MOSW into landfills, which significantly contributes to Canada's total GHG emissions. Composting has been recognized as a practical solution to mitigate GHG emissions compared to landfills, and its implementation remains more widespread in NL, offering an efficient method to divert organic waste from landfills.

However, transitioning to a modern organic waste management system necessitates further exploration of waste-to-energy options beyond composting. Unlike composting, NL has fewer initiatives in place for waste-to-energy, such as AD or thermal treatment technologies. These waste-to-energy methods offer additional pathways for organic waste management, potentially reducing reliance on landfills and further reducing GHG emissions. While NL has made progress in composting practices to divert organic waste from landfills, there is a notable gap in the adoption of waste-to-energy solutions. Expanding the focus to include waste-to-energy options alongside composting is crucial for advancing NL's waste management system and achieving sustainability goals.

The literature indicates that RNG is a promising solution for managing organic waste and reducing GHG emissions. RNG offers significant advantages compared to traditional waste management methods such as landfilling and composting. Landfilling organic waste typically results in high GHG emissions due to releasing methane. Composting, while beneficial in diverting organic waste from landfills, still produces methane and carbon dioxide during decomposition, though at lower levels than landfilling (Lou & Nair, 2009). In contrast, RNG

production through anaerobic digestion captures methane emissions from organic waste. It processes it into a usable fuel, which can replace fossil fuels and thus reduce overall GHG emissions. This dual benefit of methane capture and renewable energy production makes RNG a potentially more effective and comprehensive solution in terms of GHG emissions reduction (Parker et al., 2017).

RNG could even be considered a carbon-negative option, unlike electrification, which still produces some GHG emissions during electricity production. Studies show recent developments across Canada and in the world, emphasizing the different roles of RNG, such as job creation and GHG emissions reduction. With this review, this study establishes the opportunities that RNG may bring to NL. The lack of an effective waste management system in NL highlights the importance of this study, which provides knowledge to support decision-makers aiming to tackle organic waste issues.

Chapter 3: Methodology

3.1. Introduction

The first question, regarding the legal and regulatory framework for the RNG industry in NL, is a descriptive question. It will be tackled through a comprehensive document review of primary and secondary legal and policy resources pertinent to Newfoundland and Labrador's RNG industry. The second question focuses on understanding the effects of this framework on RNG development in NL; it is an explanatory question. Answering it will involve analyzing trends and patterns derived from the document review to elucidate the impact of the regulatory framework. The third question is comparative, comparing NL's regulatory framework with those in other jurisdictions. Reviewing documents from NL and other jurisdictions, supplemented by interviews with key stakeholders, will provide a comprehensive understanding of this question. Lastly, the fourth question take a prescriptive approach, exploring policy and legislative changes to support RNG industry growth and reduce GHG emissions from waste in NL, to align with Canada's 2050 net-zero emissions goal. Addressing this question requires policy evaluation to identify necessary modifications in policies and legislation. Note that, while the interviews are mainly intended to answer the third research question, they will have some relevance to all four research questions.

In accordance with the four research questions, the independent variables in this study are current RNG-related legislation and policy modifications in NL and Canada. Furthermore, the dependent variables in this study could include the adoption of a more advanced organic waste management system, the progress of RNG projects, or the transition towards achieving net-zero

GHG emissions by 2050. The overarching objective is to determine how RNG-related policy (cause) has affected RNG-related projects and development (effect).

The research design is inductive. It is commonly acknowledged that inductive thinking and reasoning are employed in qualitative research as it evolves from detailed observations of specific events to develop generalizations and theories (Soiferman, 2010). In research employing the inductive approach, researchers proceed to identify themes and patterns within the gathered data (Soiferman, 2010). In comparison, a deductive design would set a hypothesis at the beginning and seek to test it. The inductive approach makes more sense for this study because the purpose is more exploratory, and no informed hypothesis could be justified at the outset.

In this study, the inductive approach starts with the review and scrutiny of RNG-related policies, regulations, and recent projects as well as interviewing stakeholders in government, NGOs, and the private sector. Then the collected data is analyzed qualitatively to identify patterns, themes, or hypotheses. For instance, in addressing research question 4, an examination of the category "Recommendations for policy improvement" revealed the recurring theme of "Support for Ban on Organic Waste Disposal" presented in the interview responses.

Rather than concentrating on a global or country-level perspective, this thesis aims to generate recommendations for potential legislation or policy modifications specific to the province of NL. Therefore, a small-N design was chosen as the research approach; the study selected only one province from the ten provinces and three territories in Canada (with brief comparisons made to a few other provinces). Typically, the small-N study design focusing on a single or a small number of cases (usually fewer than five) (Gouvea, 2017). Small-N studies share the common objective of comprehensively and contextually investigating selected cases, rather than deriving conclusions from large sample numbers (Gouvea, 2017). Because the

research design is inductive and exploratory, it makes more sense to collect greater contextual detail from a small number of cases than to collect little detail from a large number of cases.

Ultimately, this study pays more attention to a specific province to build richer contextual information intended be practical in the context of provincial or local governments. The study examines the most easterly province of Canada, NL, as a case study. On the other hand, for the comparative analysis, other jurisdictions namely Ontario or Quebec is used as the second case for comparison.

3.2. Data Collection

The study employs targeted document review and interview methods to collect data. For the targeted document review, it collects sources related to RNG in NL, mainly targeting peer-reviewed journal articles or policy documents published after 1990 with search terms in the in the title/abstract/keywords such as: "Policy," "Legislation," "Regulation," "Act," "Statute," "Bill," "Plan," "Newfoundland," "Labrador," "Biogas," "Renewable Natural Gas," "RNG," "Bioenergy," "Organic Waste," "Compost," "Way Forward," or equivalent terms. The study aimed to limit itself to a maximum of twenty documents. Therefore, the review gathers relevant legislation, policies, and regulations from various provincial governmental departments across different jurisdictions (and, if necessary, from the federal level) to achieve a comparative view for the research.

The next step involves stakeholder interviews. These interviews are semi-structured, al After completing the literature review, the interview phase primarily shares the initial study results with stakeholders. Having conducted the literature review beforehand, the study was equipped with the knowledge to ask practical semi-structured questions, enhancing the depth of

insights gathered during the interviews. Some interviewees were from NL and other interviewees were experts in organic waste from other Canadian jurisdictions (see Table 2).

Table 2. List of Interview Participants

NL Participants	Other Jurisdictions
Two representatives from a crown agency of the GNL	Municipal government representative in Ontario
Representative from a department of the GNL	Representative from a company operating RNG facilities
Representative of a not-for-profit association of businesses	Representative from a business generation network and online marketplace
Representative from an NGO	Representative from a non-profit trade association
	Representative from a RNG industry organization

In order to gather volunteers for the interview, an email request was sent to the participants (see details in Appendix A).

After 45 days of sending requests, comprising almost 75 emails and diligent follow-ups with individuals identified as working in the realms of organic waste or the RNG industry in NL or Ontario, ranging from local governments to private companies, a total of 10 interviews were successfully completed, as mentioned previously. During the interviews, conducted from December 2022 to April 2023, valuable and constructive information was collected from the diverse group of participants.

Part of the reason for the low response rate is that, for various reasons, many individuals are unfamiliar with the developments in the industry; a significant number of those I reached out to chose not to comment on the topic. Securing even 10 participants proved to be quite challenging due to the novelty and complexity of the subject, especially in Newfoundland, where

the industry is primarily centered around backyard composting for a small portion of organic waste, while the majority of organic waste is disposed of in landfills.

3.3. Interview Guide

The study adopts a semi-structured interview style, typically involving open-ended questions to begin the conversation on each sub-topic. If participants agree to be interviewed, the interviews are conducted virtually using the applications they find most convenient. The crucial step in conducting the interview is to distribute an informed consent form, which provides participants with adequate information about the study to decide whether to participate. The consent form is prepared based on guidance from the Grenfell Campus Research Ethics Board. I share a consent form with all participants, including more information about what their participation in the interview will entail, such as the broad topics that will be covered, and ask them to review it (and ask questions, if they have any). I request their signature electronically before the beginning of the interview. I also inform them that they have the option to provide additional materials (e.g., documents on organic waste management) before or after the interview.

The questions asked during the interviews are indicated in Table 3:

Table 3. Interview Guide

Please provide a brief description of your current position in organic waste/RNG industry…
(if necessary, confirm/note: field, length/type of employment, rank, etc.)

1. Your involvement and interest in organic waste/RNG related activities
   - What organic waste/RNG activities are you currently involved with? (Consider type of activity, target audience, individual vs. group, etc.)
   - Were you involved with any other organic waste/RNG activities in the past? What other waste-to-energy opportunities are you aware of?
   - Are you interested in engaging with any different activities in the future?

2. Your knowledge and drivers of your involvement in organic waste/RNG activities
   - What are your personal motivations for interest in waste-to-energy activities?
   - What is your understanding of the current situation with organic waste /RNG industry in [province]?

3. Governmental policy and rules impact on RNG development
   - How does current provincial government policy affect RNG development?
   - Are there specific policy impacts you are aware of it?

4. Comparative look at the RNG industry
   - How does the situation and policy framework differ from other jurisdictions?
   - Do you have any experience in working with other jurisdictions?

5. Organic waste/RNG in general
   - Any comments on organic waste/RNG in general, outside your own experiences?
   - Any additional comments on the future of waste to energy projects (or the way you see your own role within it)?

6. The role of government incentives or strategic planning on RNG
   - What might be done to encourage/improve RNG development in [province]?
   - What types of economic incentives you think governments might use?
   - Do you have any additional comments to make on any of the above topics?

3.4. Data Analysis

In this study, qualitative analysis used to make sense of the collected data and address the research questions. This method is chosen because the majority of the data in this study is qualitative, as justified in the selection of data collection methods above. Sandelowski (1995) explains that, in conducting qualitative analysis, researchers must first examine their data to decide what to look for in their data. She emphasizes that, in practice, qualitative analysis starts with gaining a sense of the whole, extracting facts, identifying key topics or major storylines, dimensionalizing their informational content, and using frameworks to reduce data.

I initiated the data analysis by categorizing or "coding" the information gathered from interviews. This step was particularly crucial in handling the substantial amount of data collected through interviews. Systematically categorizing and labeling different segments of the raw data, which initially spanned over 100 pages, allowed for the identification of patterns and the emergence of various themes and subthemes that now constitute the structure of the results section. The main categories (codes), based on the research questions, were as follows:

- Description of the current legal/regulatory/policy framework
- Effects of the current legal/regulatory/policy framework
- Comparison of policies between jurisdictions
- Recommendations for policy improvement

Thematic analysis followed as the next step, with the goal of identifying patterns within the categories. Throughout this process, I remained mindful of the research questions. Specifically, I explored the legal and regulatory framework for the bioenergy industry, particularly in relation to RNG, in NL. This involved delving into the effects of this framework on RNG development in NL, adopting a comparative approach to comprehend how the legal and institutional frameworks relevant to the RNG industry in NL differ from other jurisdictions. Additionally, I focused on identifying necessary modifications in policies and legislation that can

support RNG industry development and reduce human-related MSW-based GHG emissions in NL, aligning with the Government of Canada's commitment to achieving net-zero emissions by 2050.

Throughout the analysis, I applied continuous comparison with existing literature and prior data to ensure consistency. I discuss the findings in the subsequent chapter, primarily focusing on the results of the qualitative analysis.

Chapter 4: Results

4.1. Introduction

Given its complexity and relative novelty in the region, the legal, regulatory, and policy framework concerning RNG and organic waste in NL must be approached with caution. This chapter serves as the foundation for a comprehensive exploration of the province's organic waste policies, the obstacles encountered by waste-to-energy projects, and the evolving regulations influencing the adoption of the RNG in NL and other Canadian provinces.

This chapter examines the existing legal and regulatory framework governing RNG in NL, shedding light on its complexities and implications (i.e., research question 1). Secondly, it explores the effects of this framework on the development of RNG within the region (i.e. research question 2). Furthermore, the study undertakes a comparative analysis, examining NL's RNG regulations against those of other jurisdictions, aiming to identify areas for improvement (i.e. research question 3). Finally, the research proposes policy and legislative changes conducive to facilitating the RNG sector's growth in NL while concurrently addressing the imperative of reducing GHG emissions from waste (research question 4).

The sections and subsections are structured around the primary themes extracted from the interviews as part of qualitative analysis. Direct quotes from participants are included, with some paraphrasing before or after the quotes, to comprehensively cover all key themes with more details.

4.2. Description of Current Legal, Regulatory, and Policy Framework

Current NL Approach on Organic Waste

Producing RNG requires novel technologies in the production process, additional funding to initiate projects, and, more importantly, complex policies and planning. These complexities arise from the need to integrate technology to capture and convert methane, secure financial investments to support infrastructure development, and navigate the regulatory landscape to ensure compliance with environmental standards. These factors necessitate the involvement of government, private corporations, and local communities for successful implementation. While interviewing the participants from NL, which comprised a group of 5 participants, almost all of them mentioned composting as the principal option for diverting organic waste from landfills in NL.

The backyard composting method is widely recognized; it is popular and widely supported by the provincial government. Most people in NL are quite familiar with this method and many households have already started to use it to divert organic waste from landfills. According to the Multi-Materials Stewardship Board (MMSB), every year the organization provides homeowners in NL with compost bins at a reduced cost. They have also collaborated with municipalities to distribute over 36,000 compost bins to households across NL since 2005 (Multi-Materials Stewardship Board, 2023). Participant 2, from a crown agency of the GNL, supported this waste policy and believed it to be a successful initiative:

> We always know that backyard composting is the cheapest and lowest-carbon-footprint way to manage organic waste. There are no trucks involved. Obviously, it's manageable for households to do the backyard composting. (Participant 2)

However, not all interviewees shared the same perspective when discussing their observations regarding this NL government initiative. Some interviewees believe that a major hindrance to the government's progress in the organic waste industry is its “disorganization”, leading to the initiation of only simple small-scale composting projects. Participant 3, as an NGO representative, stressed that this option might not be the most profitable use for these resources:

> You know, there have been pilot projects. But then, none of those, I don't think, resulted in anything other than compost. Collecting and putting together a compost pile to make compost for the community gardens might not be the most profitable use. Is that generating any income or anything? So, yeah, it's kind of disorganized, I would say. So, I think the focus has been on small-scale composting, you know, backyard composting, and promoting that. (Participant 3)

As the demand for organic waste increases in NL, the newly amended 2021 guidelines, titled “Environmental Standards for Compost Facilities” outlines the environmental criteria for site selection, design, construction, operation, and decommissioning of large compost facilities. Composting is currently a top priority in NL for diverting waste away from landfills (Government of Newfoundland and Labrador, 2021). Participant 4 from another NGO cited food security as one of the top reasons why composting is given such high priority in NL: “While the demand for compost infrastructure increases, people want it. People are concerned about food security in NL. So, we want food waste for compost and for food production” (Participant 4).

Overall, among the options for diverting organic waste from landfills, it seems that the current approach in NL mainly focuses on using backyard composting to divert compostable materials from landfills, thereby reducing GHG emissions and contributing to food security in the province through the production of high-quality compost. However, some participants believe that this method may not be the most profitable strategy for the province, and there is a need to explore other alternative and novel options. Additionally, the lack of significant long-

term initiatives resulting from the pilot projects further underscores the province's limited progress and initiative regarding organic waste management.

Challenges Hindering Waste-to-Energy Initiatives in NL

The concept of waste-to-energy is relatively new in NL, and every individual I interviewed had their own unique perspective on it. Major considerations that arose during the interviews were: Are waste-to-energy projects necessary? Do these projects effectively divert waste and reduce GHG emissions? Are these projects eco-friendly and profitable? Is there a demand for bioenergy in NL or other provinces? In this section, I am going to explore the primary barriers currently affecting waste-to-energy projects in NL based on my interview results. Since there is currently no provincial mechanism to support waste-to-energy projects, it is crucial to understand the opinions shaping the current developments.

During the interviews, it became evident that the participants from NL, both from governmental and non-governmental backgrounds, primarily focus on diverting waste from landfills. This aligns with the NL Waste Management Strategy's primary goals of diverting solid waste by 50% and reducing the number of waste disposal sites by 80% by 2025 (Government of Newfoundland and Labrador, n.d.). Consequently, there is less emphasis on engaging in more complex projects, such as RNG initiatives, which require long-term planning, investment, and, most importantly, collaboration with the private sector. When asked about his personal motivation for working in the organic waste field, one interviewee with a government background explicitly stated his commitment to waste diversion. He mentioned: “I don't personally have any motivation for waste-to-energy. My primary mandate is focused on diverting waste from landfills” (Participant 2).

Another challenge is that there are currently no natural gas pipelines in NL (Canada Energy Regulator, 2024), which means the infrastructure for transporting RNG is limited. However, in 2021, significant natural gas production operations were underway at offshore NL crude oil facilities. A total of 433 million cubic feet per day (MMcf/d) of natural gas was extracted and primarily used to generate power at these offshore facilities (Canada Energy Regulator, 2024).

As I mentioned in the literature review, RNG or RNG derived from organic waste could potentially replace natural gas consumption or be used to decarbonize other sectors, such as transportation sector, or be exported to other provinces where the demand is higher. In this regard, a government participant highlighted the absence of legal mechanisms for "selling" or "exporting" the bioenergy product, even if it can be successfully produced. They provided a few examples to illustrate this point.

> Therefore, at present, industrial generators in NL, such as New World Dairy Inc. in the Codroy Valley, are among the few entities creating energy from waste and using it for their own purposes on their own sites, as they are unable to sell it to the grid. This is a notable barrier that we've encountered. (Participant 2)

Many interviewees highlighted the absence of supportive legislation to prohibit the disposal of organic waste in landfills in NL, similar to what Nova Scotia implemented in 1997. Nova Scotia imposed a ban on landfill disposal of all compostable organic materials, including food waste, yard waste, and non-recyclable paper. Participant 2 also raised concerns and questions about this issue:

> Should we wait for a program, a business, or infrastructure to be established before considering the prohibition of organic wastes from disposal? This would empower the Minister of Environment to effectively ban any such material. Currently, organic waste is not banned due to the limited disposal options available. (Participant 2)

Another participant from the provincial government believes that the government needs more information on this matter, emphasizing the necessity for further research and studies. Due to the current lack of knowledge and policies, there are limited ongoing efforts within the provincial government:

> Something is needed, like a new policy or regulation. There is very little policy here regarding RNG from organics. I don't know if it's something that's ever been explored. I mean, I can't say for sure if it's something that's ever been explored! (Participant 6)

On the other hand, a shortage of financial resources to support organic waste projects is among the barriers preventing the development of such initiatives, as reported by some of the interviewees. Although MMSB launched the Solid Waste Management Innovation Fund in 2008, organizations can only apply for a maximum non-repayable contribution of $15,000 to develop their new or improved technologies, products, services, or processes that support solid waste management in NL (MMSB, 2024). Participant 4, representing an NGO, explained how both the province and municipalities struggle to meet federal goals due to a lack of necessary funds for infrastructure investments:

> Due to a peculiar formula, we don't receive as much funding as other provinces with similar populations. This disparity may be attributed to the income generated from oil revenues, which creates the impression that we are financially well-off and less reliant on federal assistance. However, this funding doesn't benefit everyone or municipalities; instead, it often goes to oil companies. (Participant 4)

While discussing this topic with a representative of one of the Crown agencies of the GNL, I realized that the cap-on-funding approach for organic waste projects may be related to the ideology actively supported by the provincial government, which aims to divert waste by promoting the use of the backyard composting method or other simple small-scale projects. They said:

> The Solid Waste Management Innovation Fund supports projects aimed at diverting solid landfill waste, which is one of the critical waste streams. We also receive proposals and projects related to organic waste diversion, including the backyard compost bin distribution program, which we support. (Participant 10)

In considering the various obstacles uncovered in this section, it becomes evident that several key challenges exist to the advancement of RNG initiatives in the province. Firstly, there appears to be limited government interest in undertaking more complex organic waste projects, which has implications for the sector as a whole. Secondly, the absence of legal mechanisms for selling or exporting bioenergy products further complicates progress, restricting potential pathways for commercializing RNG. Additionally, the province lacks supportive legislation to proactively address the disposal of organic waste into landfills, a measure successfully implemented by Nova Scotia in 1997. Furthermore, a lack of comprehensive policies and knowledge contributes to the current state of standstill. Lastly, limited financial resources present challenges in supporting advanced organic waste initiatives. Collectively, these challenges raise uncertainties about the future of RNG developments in the province, posing significant hurdles to its growth and long-term viability.

A Shift in Policies and Directives

Cities across Canada use innovative strategies to implement organic waste projects. These strategies include policies that support the economic benefits of these projects, making them attractive to investors. Furthermore, they support these initiatives through strict climate policies and GHG emission reduction targets, ensuring that the focus goes beyond mere profitability when dealing with organic waste and bioenergy projects. Participant 1 explained the mechanism that a municipal government in Ontario has in place for RNG projects, which renders them profitable for investors despite the high operational costs:

> Once we commence day-one operations, we will initiate payments to [company] through what we are referring to as a "utility service fee". These payments will be made monthly over a 15-year term. This is how they will recover their capital and operating expenses, and they will retain ownership of all the infrastructure throughout this 15-year period. Additionally, we have the option to buy out the bio-mechanization equipment at the end of the term. (Participant 1)

On the other hand, a participant from a municipal government in Ontario emphasized the importance of collaboration with energy sector in achieving the targets: "We're collaborating to manage the entire project. Decisions are made through a steering committee, and none are made alone" (Participant 1). That participant also emphasized that policies are evolving in response to climate change. It is not profit that prioritizes RNG projects anymore; it is mainly "environmental considerations" driving these initiatives: "We declared a climate emergency in October 2019 and adopted a new Net Zero Strategy, and the City's policies and directives have evolved in response to the changing climate" (Participant 1).

Therefore, considering the given sample from Ontario, the main policies impacting the future of RNG production are no longer targeting the profitability of projects. With the influence of various climate legislation and policies, such as the Canadian Net-Zero Emissions Accountability Act, provinces are now more focused on environmental considerations than ever before. They have set targets for diverting organic waste from disposal in traditional landfills, and in some cases, they are even banning the disposal of organic waste in landfills. It is worth noting that NL, in comparison, is not currently implementing most of these measures.

Policy Drivers for RNG Adoption

While each province in Canada has its own policies, strategies, and targets for dealing with organic waste diversion from landfills, most of the interviewees consider RNG as a primary option and solution. Many mentioned that Quebec is among the provinces currently leading the

way in this sector. Participant 7 summarized the key policy drivers that facilitate RNG adoption in Quebec:

> Quebec's natural gas utilities have ambitious goals for 2030. Instead of relying on just 10% of their natural gas from RNG, they aim for a substantial increase. This significant shift is driving the industry forward. Additionally, Quebec provides robust support systems for projects, sometimes covering over 50% of the capital costs. (Participant 7)

Many participants believed that current RNG developments are mainly driven by provincial policies, particularly in Quebec and British Columbia. For instance, Participant 8 highlighted the new policy that the BC government is using to encourage its customers to use "renewable and low-carbon gas" and therefore reduce their GHG emissions through a program called the voluntary RNG program: "FortisBC has a mechanism that allows customers to voluntarily procure RNG up to a specific price over long-term contracts" (Participant 8). According to FortisBC, the company uses the term 'renewable and low-carbon gas' to encompass all low-carbon gases or fuels that the utility can obtain in compliance with the BC Greenhouse Gas Reduction (Clean Energy) Regulation (B.C. Reg. 102/2012) (FortisBC, 2024). This regulation includes Renewable Natural Gas (RNG or RNG), hydrogen, synthesis gas (from wood waste) and lignin. However, at present, FortisBC's portfolio consists only of Renewable Natural Gas as a source of renewable and low-carbon energy.

At the federal level, since transportation is responsible for almost a quarter of all emissions in Canada, the recent 2022 Clean Fuel Regulations (SOR/2022-140), prepared under the Canadian Environmental Protection Act, 1999, are an essential part of Canada's climate strategy to reduce emissions and support clean technology and fuels. These regulations aim to drive innovation and expand employment in sectors like clean technology and low-carbon energy, including hydrogen and biofuels. Regular petrol and diesel fuels are intended to

eventually become cleaner as a result of this legislation, and customers will hypothetically have access to more affordable eco-friendly choices. These legislation gives different pathways for RNG to play a role.

Participant 8 highlighted that RNG can have a significant role in many industries. They pointed out that: “RNG can play a role in compressed natural gas vehicles or through refineries. Another option is direct RNG injection into the gas grid” (Participant 8). Furthermore, they mentioned that another policy driver is: “RNG purchases are exempt from carbon pollution pricing systems, which is another effective tool.” In confirmation of this, Participant 9 also agreed and mentioned that they have recently witnessed the construction of numerous facilities aimed at supplying RNG to British Columbia and Quebec.

Participant 9, from an association promoting the development of biogas in Canada, highlighted one of their recent studies regarding the new 2022 Clean Fuel Regulations, which shows that the industry is growing less than what was expected as a result of the 2022 Clean Fuel Regulations:

> In Quebec, the policy involves a regulation that allows for the purchase of up to a certain percentage of RNG. In BC, it's more of a driving force from the utility sector. Nevertheless, these factors have a substantial impact. Additionally, carbon markets and fuel standards also play significant roles. Notably, the clean fuel standard, as well as the BC low carbon fuel standard, are key drivers. In terms of the end market, these policies contribute to the growth we observe. However, we conducted modeling with the clean fuel standard, and despite initial expectations, it only resulted in a minor increase. Therefore, we don't anticipate substantial growth from it (Participant 9)

Based on discussions in the section, it was apparent that Quebec established itself as the leader in the RNG industry, with solid adoption targets, effective project support mechanisms, and significant investment. Additionally, British Columbia promotes RNG usage via a voluntary program and new policies. Cities in Ontario have various strategies, such as the Toronto new Net

Zero Strategy discussed earlier. Additionally, the 2022 Clean Fuel Regulations at the federal level seek to cut emissions, advance clean technologies, and create environmentally friendly fuel options. Therefore, RNG is considered to have a vital role in several industries, including energy generation and transportation. Nevertheless, some stakeholders, citing cases from Quebec and British Columbia, expressed worry that the present regulations may not be enough to encourage significant RNG sector expansion despite these policies and actions.

4.3. Effects of Current Legal, Regulatory, and Policy Framework

Section 4.2 delved into the complexities of NL's legal, regulatory, and policy framework surrounding the RNG industry and its interaction with organic waste management. In this section, we examine the various positive and negative impacts and challenges posed by existing provincial and national policies, as well as the optimistic developments and favorable policies shaping the future of the RNG industry in the Canadian provinces.

Constraints of Backyard Composting in NL

Backyard composting is currently considered a primary policy instrument of the NL provincial government regarding organic waste. Although backyard composting is a natural process that converts organic materials, such as food and yard waste, into nutrient-rich compost, there are challenges associated with it. This section underscores the limitations of NL's policy framework in generating high-quality compost. The primary challenge is that this method does not cover all types of organic materials. Most backyard composting does not include dairy products, fish and shellfish products, bones, etc. Therefore, these organic materials still need to be transferred for disposal in landfills. On the other hand, backyard composting may also lead to

problems such as generating odors or attracting rodents, such as rats. Participant 2 from the NL governmental institution said that they believe the method is not entirely problem-free:

> Backyard composting only removes a portion of the organic waste stream because we do not recommend putting fish, meats, and similar dairy products in a backyard bin. This recommendation is not due to them being unsuitable but rather for practical management reasons, as it can create some challenges for homeowners. (Participant 2)

On the other hand, while backyard composting and other small-scale projects do produce compost as a final product, Participant 4, representing an NGO actively involved in this process, believes that most of the compost produced in NL is not considered high-quality. Therefore, the production of "poor-quality compost" is considered another main challenge in NL. They see this quality issue as a result of a lack of education among people on how to separate organics, what the proper ratios should be, or even what should go into the bin during the composting process:

> Authorities don't establish large-scale facilities and don't generate good-quality compost, so it's not used for food but rather for covering lands and other materials. So, that's a waste. Additionally, there are problems with contaminants. That's one of the reasons why compost is of low quality. When you have a lot of people discarding organics and leftovers, it's hard to educate them. People don't see the connection between their food scraps, food waste, and the potential of compost; they just view it as one more item next to the garbage. Recycling and educating are very challenging. We've seen this with recycling and waste management in St. John's. (Participant 4)

Therefore, this policy lacks certain essential steps in the production of high-quality compost. In more developed composting processes, such as large-scale composting or RNG projects, there is a "pre-processing step" aimed at removing contaminants from the organic materials. In some advanced processing facilities in Canada, the material undergoes pre-processing in a Hydrapulper, where it is mixed with water to facilitate the removal of non-organic materials (City of Toronto, 2024). In other facilities, organic material separation from non-organic material is achieved using a press. These methods all lead to the production of

higher-quality compost suitable for use in food production, as a top dressing for lawns, on shrubs, and in vegetable and flower gardens.

Challenges Facing RNG Industry

Establishing a new renewable energy project depends on factors like location and complexity, and it often requires obtaining permission from various authorities, including provincial governments, conservation authorities, municipalities, and federal agencies. Interviewee 7, representing a business generation network and online marketplace in RNG industry, expressed concerns about the “timely approval of RNG projects” by municipal governments across Canada. They believe that obtaining timely project support and approval from municipal governments might be the foremost challenge for energy projects in Canada, stating, 'The difficulties in navigating the permitting process for such projects, especially at the municipal level, arise from the lengthy and intricate decision-making processes in municipal projects. This challenge is not unique to Canada but exists worldwide' (Participant 7).

On the other hand, many interviewees expressed concerns about the value of the final product. In comparison, a study conducted by Cucchiella et al. (2018) in Italy revealed that economic feasibility in RNG projects can be achieved, and RNG can contribute to the development of the circular economy. However, some participants noted that RNG may have lower economic viability when compared to profit-driven fossil fuel industries, such as natural gas or oil. Therefore, whether RNG could be a viable product or merely an environmentally driven product depends on the factors mentioned.

Furthermore, most interviewees did not emphasize the social and environmental benefits of RNG, such as GHG emission reduction or organic waste diversion. During an interview with a representative from the RNG industry organization, the participant initiated the discussion with the statement, “Regarding biogas, which currently lacks value in Canada” (Participant 9). This initial statement indicates that there are varying attitudes and opinions toward the industry; the diversity of perspectives could potentially make discussions more complex and challenging, as participants may have differing viewpoints.

While profitability was frequently discussed, Participant 3, after mentioning viability several times, admitted that the lack of viability studies and knowledge might influence her understanding of the industry. Therefore, her opinion was perhaps marked by doubt rather than certainty: "It is a growing industry but not yet profitable in Canada. That's my impression, but there is still a lack of knowledge and information here. There are not many articles about how to profit from organic waste, and there are not many studies in Canada yet." (Participant 3). However, when I looked at the federal government resources about RNG, the main question that came to mind was whether the lack of knowledge is due to a shortage of resources and studies conducted in Canada, or if it is a normal process given that the industry is relatively new, and most provinces are in the stage of learning and examining RNG projects.

In addition to the lack of adequate scientific data or access to reliable scientific sources mentioned earlier, some interviews in NL also discussed the 'absence of organizational processes or structure' within the organic waste management system. The complex nature of organic waste projects raises the question of whether the government or the industry should take the first step in establishing RNG projects. During an interview with a representative from the RNG industry organization, they explained how complicated the initial steps can be. This process involves a lot

of back-and-forth because the organic waste management system is believed to lack clear regulations and procedures, making it less structured and organized than it should be.

> Sometimes, it can get confusing and complicated because it's a bit of a chicken and egg situation. Lenders want to see the power purchase agreement before they lend money, but the parties with the power purchase agreement want to see proof of financing before the project can proceed. It's a kind of back-and-forth situation. That's an issue, but the growth created because of these policies in Quebec and BC shows that such policies make a difference. (Participant 9)

Another topic was the impact of Muskrat Falls on energy investments in NL. Interviewee 9 from the from the RNG industry organization also explained that the expectation of having lower energy prices soon in NL negatively impacts the growth of other energy projects. This government approach, which emphasizes lower energy prices, makes it hard to plan a project in NL, especially considering the higher cost of RNG production. However, discussing this topic in this report might be challenging, as it is still unclear what the direct impact of Muskrat Falls will be on energy expenses. The 2019 report by the NL government, titled "Cost Impacts of Muskrat Falls," (Government of Newfoundland and Labrador, 2019) explains at the beginning of the report how it presents a solution to prevent electricity rates from doubling, highlighting the potential costliness of this project. Additionally, Participant 9 provided insights into another aspect of the issue, highlighting the impact of Muskrat Falls on energy investments in NL and the associated challenges. They stated:

> Part of the issue is willingness to pay lower price for the power in NL. With the new Muskrat Falls coming online, it further drove down the cost of energy. While this was beneficial in general, it also meant that the price of biogas became lower. It's not like there would be a significant gap if they were to pay more. Additionally, there was a lack of support. This is what I mentioned during my presentation. (Participant 9)

Overall, interviewees highlighted the main challenges facing the RNG industry. The complicated process of acquiring permissions from various governmental levels, particularly

municipal governments, is one of the top difficulties and presents a significant barrier for RNG projects. Furthermore, questions about the perceived value of the final product further complicate issues as there is doubt about the viability and profitability of the final product. On the other hand, it was apparent that some stakeholders and authorities are perhaps not updated or informed on the most recent RNG advancements due to the industry's knowledge gap.

Additionally, the organic waste management system's lack of established organizational procedures in NL raises concerns regarding its effectiveness. Additional difficulties and different viewpoints are brought about by the government's role in developing RNG projects and its potential impact on energy investments in NL, as demonstrated by the example of the Muskrat Falls project. These complex issues summarize the significant concerns the RNG industry is now dealing with and what might negatively impact the industry's future in NL.

Increased Interest and Traction on RNG

Despite the current challenges the industry is facing, there are also positive developments in the industry. When we look at the ongoing developments, such as new RNG plants being established or in the planning stage in Canada, it becomes evident that the sector is gaining value. This momentum is especially clear as the impacts of climate change become more apparent, and organic waste in many literatures and policies is identified as a major contributor to climate change. The positive effects of these developments suggest that more decision makers are now persuaded by the promise of RNG than ever before.

A 2020 report prepared by the International Energy Agency emphasized that, regardless of the direction the energy system takes in the coming decades, RNG is on a growth trajectory (International Energy Agency, 2020). The report also highlights that electricity alone cannot be

the sole driver of the energy sector's transformation. Energy transitions present biogas and RNG with the opportunity to establish a more substantial presence in global energy consumption. Interviewee 1 from a municipal government in Ontario, after mentioning that they had been working within this field for many years, summarized their observations by explaining the increase in knowledge and industry traction gained among municipalities:

> You know, the commissioning of RNG facilities or the initiation of RNG facilities has gained more traction. I believe municipalities are becoming increasingly interested and eager to learn more about it. Knowledge has increased since I started, and not many people were initially involved or interested. We've reached a point where I'm frequently asked for consultations by municipalities that want to begin this kind of work. You can see that the market is growing, and this is also reflected in the price of RNG. So that's a motivating factor as well. (Participant 1)

Furthermore, they provided their prediction on how this traction is favorably impacting the future of green initiatives within a municipal government in Ontario: “So my experience has been great, and I believe RNG industry will only continue to improve. With the increasing availability of gas, I think we'll be in a perfect position to establish a new revenue stream and direct those funds into future green initiatives” (Participant 1). Therefore, the City expects to generate new revenue streams based on RNG sales and allocate those funds to establish and finance new RNG projects, which would also generate more revenue in the long term and ensure the developments.

On the other hand, Interviewee 1 also elucidated how City's internal policies have shifted the focus from the economic aspect to “environmental aspects” in recent years concerning RNG projects. The City has replaced RNG with other sources of energy that were traditionally used, such as regular natural gas or as a fuel in waste collection trucks—emphasizing not only revenue but also concentrating on reducing costs associated with the purchase of fossil fuels, which all contributes to viability. This approach also addresses

various environmental factors, including decreasing emissions from fossil fuels through the replacement with RNG:

> Various factors have come into play, shifting our focus away from the economic aspect towards the environmental side. Now, we're using the RNG we produce within our city's infrastructure and assets. This means we're using it to heat our buildings and fuel our collection trucks, including the initial collection trucks that gather the materials. This allows us to close the carbon loop, which is our primary goal with the gas. We typically distribute the cost across the natural gas divisions, but we're effectively reducing our annual natural gas and fossilized natural gas purchases by the amount of RNG we can replace. This is our current approach with it. (Participant 1)

In sum, new RNG facilities are being built in Canada, highlighting the industry's growing importance, particularly in reducing GHG emissions. As previously said, some organizations generate revenue from RNG sales to finance green activities. They have also changed their attention from project profitability to environmental concerns, employing RNG for heating and fuelling to reduce emissions and cost. All these developments are increasing the industry's interest and traction.

Favorable Policies and Positive Developments

Policies and regulations play an essential role in developing industries. This development can occur through incentives, subsidies, research support, providing market access, ensuring consumer protection, and more. In the case of the RNG or green gas industry, most provinces in Canada, along with the federal government, is actively pushing the industry forward using various regulatory and policy instruments. Quebec stands out as one of the leading provinces and enforces stricter policies compared to other provinces, significantly boosting the industry. Interviewee 7 from a business generation network and online marketplace in RNG industry highlights one of the policy instruments driving the RNG industry in Quebec:

> We are currently witnessing very positive developments, driven primarily by ongoing initiatives in Quebec. As you may have heard, by 2030, natural gas facilities in Quebec will rely on more than just 10% of their natural gas from renewable sources. (Participant 7)

According to the Québec Green Hydrogen and Bioenergy Strategy (2022), the Gouvernement du Québec also confirms its objective of increasing bioenergy production by 50% by 2030. To promote the consumption of bioenergy produced in Québec, the Government is adopting ambitious regulatory targets, including the injection of 10% renewable source gas into the natural gas network by 2030 (Gouvernement du Québec, 2022). Interviewee 8 from a non-profit trade association highlighted recent policy developments in Quebec and British Columbia that are expediting the establishment of new bioenergy projects. These policies involve providing grants for capital costs and offering long-term contracts to producers, thereby enhancing project stability. Interviewee 8 stated:

> Recently, the Quebec Public Utilities Commission, referred to as Residual Energy Quebec, approved a set price and contract terms to expedite the pre-approval process for new projects that can be procured by the primary energy provider in Quebec. This provides a clearer understanding of how projects in Quebec can secure financing with long-term contracts and capital grants from the Quebec Ministry of Energy. In British Columbia, a similar mechanism allows two utilities to procure RNG at a specific price through long-term contracts. FortisBC in British Columbia is, I believe, the first utility in North America to have a voluntary RNG program, enabling its customers to participate voluntarily. (Participant 8)

Therefore, the main drivers of the RNG industry are funding in the forms of grants, subsidies, contracts, tax incentives—and compliance through rules, regulations, laws, and standards. With increasing concerns regarding climate change and the contribution of organic waste to it, I cautiously expect more favorable policies to emerge from all levels of government. These policies may include stricter waste reduction targets, increased resource recovery of food and organic waste, and a potential ban on traditional landfill disposal of organic waste in highly populated cities. Therefore, the pivotal role of government policies and regulations in driving the

growth of the RNG industry in Canada can expedite the adoption of renewable energy sources and encourage industry innovation. These policies highlight the significance of government intervention in shaping the future of the RNG sector in Canada.

4.4. Comparison of Policy between Jurisdictions

In the previous section, we discussed the effects of the current legal, regulatory, and policy framework, particularly highlighting the significance of government policies and regulations in shaping industries like the RNG sector in Canada. In this section, I will delve deeper into comparison and the discovery of differences among various jurisdictions. Comparing different jurisdictions can enhance our understanding of significant problems and progress across various waste management systems. It can provide clearer insights into the differences in waste systems and the strategies employed to divert organic waste from landfills, as well as whether RNG projects have been developed. This chapter will compare developments in three categories: Atlantic Canada, Canada, and the international scale.

Successes in Nova Scotia and PEI, Challenges Faced by New Brunswick

Organic waste has been a persistent challenge in the Atlantic region. If we examine the historical context, the Solid Waste-Resource Management Strategy laid the foundation for Nova Scotians to divert 50% of their waste from disposal by 2000 (Government of Nova Scotia, n.d.). The province banned compostable organic materials from disposal, including food waste (such as meat, fish, bones, and dairy products), leaf and yard waste, and non-recyclable paper products. The Nova Scotia government employs “source separation”, which involves collecting organic materials in containers separate from the general waste stream.

While the province has had some success in implementing a waste source separation program, its primary focus lies on “composting” as a solution for organic waste. Numerous ongoing projects, ranging from simple backyard composting to high-tech composters, are indicative of their commitment to this approach. Interviewee 2 from NL a Crown agency of the GNL emphasized the effectiveness of policies in Nova Scotia, but noted that they are not sufficient and many difficulties remain, as the organic waste can still end up in landfills:

> Nova Scotia has implemented disposal bans, which effectively prevent materials from going to landfills. This system is working well for them. However, organics remain their biggest challenge during landfill site audits. Organics are still the primary material found in landfills because it is challenging for the public to separate, and it can be unpleasant due to various factors. The public faces more difficulties in managing organic waste compared to containers or pieces of paper. Nova Scotia hasn't perfected their approach yet, but they are doing well. They have the necessary infrastructure, underlying policies, disposal bans, and other supporting elements. Nova Scotia is on the right track. (Participant 2)

Another interviewee from the same organization also believed that most of the developments in Nova Scotia are a result of the province's ban on the disposal of compostable organic materials in 1997. This ban has increased industry support, infrastructure development, and, more importantly, curbside collection programs:

> Nova Scotia, for instance—they have landfill bans on organics. As a result, they've established a well-developed organic waste diversion program because organic waste is prohibited from going to landfills. They also have industry support for it and all that. I know that many other provinces have similar initiatives with the necessary infrastructure in place. (Participant 10)

PEI is also on track to have one of the most developed waste policies in Atlantic Canada. This policy includes a sorting system that classifies materials as compost, waste, or recyclable. More importantly, the island is implementing waste-to-energy projects, including a waste-to-energy plant, which converts municipal solid waste and biomass, as well as scrap wood from forest harvesting operations, into energy. According to a CBC 2022 report, the existing plant

heats more than 145 buildings in the city by turning about 26,000 tonnes of solid waste into thermal energy annually (CBC, 2022). Additionally, the plant processes biomass and scrap wood from forest operations, further enhancing its energy output. Later, the interviewee from a GNL crown agency also clarified that some materials still go for composting, while others are sent to the thermal plant.

> PEI is also succeeding with a substantial organic waste facility, specifically a composting facility. In Atlantic Canada, there is limited use of thermal treatment methods, such as PEI's energy waste-to-energy facility, primarily for materials that cannot be recycled or composted. Currently, materials like Styrofoam, EMS, and flexible packaging films are sent to their waste-to-energy facility. (Participant 2)

While PEI and Nova Scotia are leading the developments in organic waste, it seems that New Brunswick is in a situation more closely resembling that of NL. According to Vanderkloet (2023), PEI and NS have much higher diversion rates than NB and NL in Atlantic Canada (Vanderkloet, 2023). However, the recently published Waste Reduction and Diversion policy by the New Brunswick government, titled 'New Strategic Action Plan 2023-2030: Transforming our Waste into Materials for Tomorrow,' has established a long-term goal for this province (Government of New Brunswick, n.d.).

As per this Strategic Action Plan, by 2030 the province aims to reduce the amount of solid waste landfilled in its regions by 40,000 tonnes annually, while simultaneously laying the foundation for future waste reduction efforts. However, it is not clear how and where the organic waste can be used. Will they move forward with composting or waste-to-energy projects? Interviewee number 2, after mentioning that NB and NL have limited options for organic waste, also pointed out that the new NB policy is boosting the province's efforts in reducing organic waste from going to landfills:

> As for New Brunswick, it is currently on par with NL in terms of organic waste management. Organic waste management options in New Brunswick are limited.

> However, the province is just beginning to develop a new waste management strategy, and I am interested to see if organics will be included in that strategy. It will be intriguing to observe New Brunswick's approach, given that they are essentially starting from scratch with organics. (Participant 2)

Taking all developments happening in Atlantic Canada into consideration, Prince Edward Island and Nova Scotia boast more progressive policies. While organic waste diversion in Nova Scotia has improved significantly, there are still issues to address. PEI is notable for its waste-to-energy initiatives and sorting system. Although New Brunswick's challenges are comparable to those of NL, a recent initiative aims to dramatically reduce landfill waste. Specific plans for managing organic waste in New Brunswick are not yet known; however, overall, the region is moving forward toward a more sustainable organic waste management system.

Municipal Factors in RNG Development (Ontario and Quebec)

Even though many mega-cities like Toronto now have a full system of organic waste collection and processing, leading to the production of RNG, several cities in Ontario are at different stages of development. One of the basic requirements for developing a RNG project is the effective implementation of organic waste collection systems. Having these systems in place is crucial during the feasibility study of the project, as it can enhance the understanding of volumes and other metrics, ultimately bolstering the feasibility and making a stronger business case.

Interviewee number 1 from a municipal government in Ontario exemplified how many cities in Ontario are still grappling with the challenge of transitioning from a one-way waste stream system to a system where organic waste is completely separated:

> Even within Ontario, there are differences among neighboring municipalities; they all have distinct waste streams and collection practices. These variations can significantly impact the quality and feasibility of a project. Without an organic waste collection system in place, it becomes challenging to predict the quality of gas or the inputs and outputs of such a project. The predictability is hampered because we have our organic waste stream, which provides a consistent collection curve, supporting our business case for this project. I'm uncertain how someone would approach it if there's only a one-way stream, and what it would entail. The collection aspect, I believe, is quite challenging. (Participant 1)

They also explained how City Councils play a crucial role in expanding organic waste or RNG projects, because the topic may not be a priority for some councils. As I mentioned in the previous chapters, evaluating these projects solely based on economic viability might not be sufficient. For RNG projects, it is essential to consider their environmental perspective and their impact on climate change mitigation and adaptation.

Conversely, RNG projects may not be a priority for some municipalities or councils if they rely solely on tax-based funding. The participant from a municipal government in Ontario also emphasized how their favorable position is due to the fact that they operate on a “rate-based system”, which reduces the burden on tax revenues. Rate-based systems assist utilities in creating steady, predictable income streams for the maintenance and growth of their networks for energy distribution. This system is in contrast with focusing only on a tax-based funding system, which may fluctuate and not always be dedicated. In a rate-based system, utilities collect income directly from customers based on the amount of electricity they consume. This creates a steady and predictable income stream for utilities, enabling them to efficiently maintain and expand their energy distribution networks. This contrasts with a tax-based funding system, where revenue fluctuates and may not always be dedicated to specific projects or infrastructure needs.

> Furthermore, the motivation for such projects depends on the priorities within different municipalities and how the Council views them. This is a significant priority for the City Council, but it may not hold the same importance in more rural municipalities. These differences exist across the board, even within Ontario. I can

> only imagine that if you were to expand your scope and look at a national level across Canada, various factors would come into play. The availability of funding, whether it's tax-based or rate-based, is a significant motivator. In our case, we are rate-based, which places us in a favorable position for large capital construction projects. (Participant 1)

In other parts of Canada, such as Quebec, two main funding opportunities were frequently mentioned in discussions. The first was the Renewable Natural Gas Production Support Program and the second was financial support for initial investments. In light of the recent announcements regarding modifications to Quebec's Renewable Natural Gas Production Support Program, several noteworthy developments have taken place. One significant addition is a dedicated component for financing feasibility studies, which provides a subsidy of up to 75% of the actual expenses, with a maximum limit of $300,000 per project (Biogas World, 2021).

Furthermore, the maximum provincial funding available for projects involving RNG generation has increased from $8 million to $12 million in Quebec. The program has also expanded to include new qualifying RNG generation technologies. Interviewee 7, representing a business generation network and online marketplace in RNG industry, believed that these two motivators are the primary driving forces in Quebec, leading to significant progress in the development of new projects.

> In Quebec, there are currently two funding opportunities available. The first is a Renewable Natural Gas Production Support Program, which includes subsidies for feasibility studies. Feasibility studies can be quite expensive, and this program helps cover a portion of those costs. Additionally, they offer support for initial investments, which can go up to 50%. Given that biogas and RNG projects can cost millions, this funding opportunity is significant and can greatly benefit those in the industry. (Participant 7)

In summary, as discussed, an effective organic waste collection system plays a crucial role in RNG project development in Ontario. The interviewee from a municipal government in Ontario highlighted the importance of transitioning to a system where all waste is separated and

the support these projects receive from City Councils. It is imperative to consider environmental perspectives alongside project viability. Municipalities with waste systems based on rates rather than taxes are performing well in these projects, as they do not directly strain tax revenues. Furthermore, in Quebec, the financial support and grants provided by the government, from feasibility studies to infrastructure development, are viewed by Interviewee 7 as incentives driving substantial progress in Quebec's project development.

Global RNG Industry Expansion (US and Europe)

Besides Canada, the industry is also rapidly expanding in other parts of the world, including the neighboring USA. According to the American Biogas Council (2023), the U.S. currently boasts more than 2,400 sites producing biogas across all 50 states. This includes 473 anaerobic digesters on farms, 1,269 water resource recovery facilities utilizing anaerobic digesters, 102 stand-alone systems for food waste digestion, and—most importantly for the focus of this thesis—566 landfill gas projects (American Biogas Council, 2023). Many interviewees believe that the overall system is similar, but that some parts of the USA, such as California, are more advanced.

Interviewee 5, from a company that operates RNG facilities, pointed out that specific policies in US have a significant impact on the industry's development. For example, they mentioned that in the state of New York, facilities required to have waste diversion plan are specified by the government, while in California, businesses are not named. In California, there is only one organic waste hauler serving both residential and commercial areas, which means that organic waste projects can be planned more efficiently as the amount of organic waste is clearly assessed in any given residential or commercial area.

> There are diversion policies in place in New York and California. In New York, on the industrial and commercial side, they specify the facilities required for diversion. This means we don't have to guess or approach businesses wondering if they comply with the policy. They publicly name and even shame non-compliant entities in New York, which is quite helpful. On the other hand, in California, it's similar to Ontario, where they don't name specific entities, but there are fewer what I call 'open market conditions.' In Ontario, any waste hauler can pursue a customer like McDonald's or Tim Hortons. In contrast, in California, a single waste hauler works within a city, serving both residential and commercial clients. So, when you visit a community in California, you already know who the hauler is, like Waste Management, and you don't have to guess. This simplifies the process of determining who controls waste collection in a particular area. (Participant 5)

In each part of the US, there are various regulations and policies that directly or indirectly impact the RNG industry. In California, it's the “California Low Carbon Fuel Standard”, which was created to reduce reliance on petroleum and improve air quality. The Low Carbon Fuel Standard of California aims to lower the carbon intensity of California's transportation fuel and provide a growing selection of low-carbon and renewable options. Interviewee number 8 from a non-profit trade association not only mentioned these regulations but also another policy called “SB 1383 Regulations”, known as "California’s Short-Lived Climate Pollutant Reduction Strategy." This policy is designed to assist the state reach the 75 percent organic waste diversion goal by 2025. This policy also implements a mechanism requiring local governments to use products made from recovered organic material, such as renewable natural gas.

> In the US, the California Low Carbon Fuel Standard has been a significant driver of RNG growth, and that's the program Canada is now adopting with their clean fuel regulations. It forces fuel suppliers to reduce the carbon intensity of the fuel. So, all of these are effective tools, and they are also related to your research area, particularly food waste diversion policy. It's very helpful. California has a target, if I'm not mistaken, called SB 1383, which requires California municipalities to divert 75% of their food waste by 2030. To achieve this, they've implemented a mechanism where you must purchase products made from organic waste, which can include RNG. (Participant 8)

In Europe, the RNG industry is experiencing rapid growth. According to The European Union Agency for the Cooperation of Energy Regulators' 2022 report, biogas and RNG

production could account for 10% of conventional gas demand by 2030 and over 20% by 2050 in Europe (ACER and CEER, 2022). Some countries are even outpacing others. For example, as Interviewee 9 mentioned, Denmark has an ambitious goal of reaching 70% by 2030 and has already reached the point where 40% of the natural gas is replaced by RNG.

> Denmark is projected to have 70% RNG in their grid by 2030, and I think they currently have around 40%. It's a significant achievement. In Canada, we're aiming for 10%. So, what they're doing in Denmark is truly remarkable. If you're looking for a comparison and want to study prosperous regions, that would be an excellent place to start. (Participant 9)

Therefore, as discussed in this section, there are over 550 landfill gas production facilities spread throughout all 50 states in the United States, where the RNG sector is growing. The sector's growth is influenced by specific legislation in different U.S. states, such as diversion policies in place in New York and California. The "SB 1383 Regulations" and the "California Low Carbon Fuel Standard" are important laws in California that promote the expansion of RNG and the diversion of organic waste from landfills. Furthermore, the RNG sector in Europe is also expanding rapidly. Some European countries like Denmark even have more ambitious goals, such as reaching a 70% replacement of natural gas by RNG. This highlights the potential of landfill gas and other RNG sources in achieving substantial reductions in greenhouse gas emissions and supporting Europe's transition to a more sustainable energy future.

Following the assessment of organic waste management policies and initiatives across Atlantic Canada, it becomes evident that, while progress has been made, there are opportunities for enhancement. Prince Edward Island and Nova Scotia have set a commendable example with their progressive policies, particularly in waste diversion and waste-to-energy initiatives. Despite Nova Scotia's significant progress in organic waste diversion and PEI's notable waste-to-energy initiatives, challenges persist. However, recent initiatives in New Brunswick indicate a positive

shift toward reducing landfill waste. Moving forward, it is essential to prioritize effective organic waste collection systems, as demonstrated in Ontario, while considering environmental perspectives and project viability.

Moreover, the Quebec government's initiatives exemplify the role of financial support and incentives. Globally, the RNG sector is witnessing growth, driven by specific legislation and regulations, such as those in the United States and Europe, further emphasizing the importance of sustainable waste management solutions on a global scale. The next section provides recommendations based on all the lessons learned.

4.5. Recommendations for Policy Improvement

In this section, the main policy recommendations are provided, considering legislation and policies relevant to, as well as the social and economic impacts of, the RNG industry.

Ban on Organic Waste Disposal in Landfills

One of the topics discussed in almost every interview was the possible ban on organic waste disposal in landfills. This topic is currently covered very frequently in news media as well. However, implementing a new regulation to ban organics may require careful consideration, such as determining where the organic waste should go once it is prohibited from being traditionally disposed of in landfills. Is the infrastructure ready for this change? Still, most interviewees believed such a ban to be necessary and the only way to effectively enhance organic waste management, composting, and RNG production strategies.

Interviewee number 1 from a municipal government in Ontario, while supporting this potential policy or regulation, also mentioned how a ban could potentially help build a successful

business case by facilitating a better understanding of the volume of organic waste. This would make it traceable and, more importantly, predictable, as there would only be one waste stream after the ban is implemented.

> I mean, they are looking at it. I'm not sure where it's at, but they're considering a ban on organics going to the landfill. So, I think this would certainly support the RNG projects because you would be compelled to create a new diversion stream and a new waste stream. This means you'll have a dedicated waste stream that's easily traceable and, more importantly, predictable. It's predictability that allows you to use these specifications to build a business case. (Participant 1)

Another result of implementing a ban might be the encouragement or compulsion of large corporations or organizations to create a specific action plan for the organic waste they produce, aiming for zero organic waste in their operations. This, in turn, can assist the government in reaching its long-term goal of achieving net-zero GHG emissions and further boosting the RNG industry. Interviewee 3, who is an NGO representative dealing with organic waste and composting, pointed out that having a single entity to enforce the ban can compel and encourage individuals or organizations to develop an action plan for managing their organic waste.

> And the regulations could be enforced by a single entity, implementing measures such as bans on waste going to landfills or setting limits on waste percentages. For example, I know that in some provinces, they are working on waste bans or imposing specific limits. These regulations would compel individuals or organizations to take action regarding organic waste, especially considering that organic waste is a category that can be replaced. (Participant 3)

One question or concern that one of the participants discussed was whether we need to create a market for organic waste first, such as by establishing RNG projects or other viable markets that can attract attention. Then, we could expect the industry to move towards achieving net zero emissions from organic waste while generating profits for organizations or individuals. Alternatively, should we ban organics from disposal in landfills to push the industry to consider alternatives and solutions for their produced organic waste? Interviewee 2 clarified that one

option is to, instead of implementing a complete ban all at once, establish the groundwork for a ban. This could involve creating a policy to establish the market for organic waste products so that the industry can be prepared for the eventual ban.

> Organic waste is obviously not banned because there are very few destinations for the material. So, are we waiting for a destination, or are we implementing the ban first and hoping it creates a place for this waste? I believe you understand what I mean by establishing a market or a location for this material. This presents a challenge for governments. Should the location or market for the material come first, or should the policy come first, such as a disposal ban prohibiting this material from going to the landfill? This is a significant concern when it comes to biogas in the province. (Participant 2)

Additionally, Interviewee 5 explained that a ban in NL could be enforced at the transfer station, as almost 95% of waste goes to the transfer stations first. A transfer station, also called a resource recovery center, is a crucial facility in the waste management process. At these centers, waste is temporarily deposited, consolidated, and gathered before being transported to its destination for further processing or disposal. These centers are essential in optimizing waste management operations by offering a centralized hub for collecting and processing waste. According to participant 5, small businesses or individuals may not require the organic waste diversion policy. Instead, the focus can be on applying the ban to large businesses and corporations with substantial organic waste production. This strategy helps divert waste from landfills and reduces landfill-related costs. By targeting major waste producers like large businesses and corporations, organic waste bans at transfer stations aim to manage industrial waste efficiently while mitigating household impact. Regulating waste at transfer stations allows policymakers to address varying waste generation patterns and promote eco-friendly practices among large generators, leading to decreased landfill usage and enhanced organic waste recovery.

The participant added the point that any ban should provide enough time for organizations to figure out how they are going to handle their waste. However, they believe that any deadline based on the policy should consider the fact that not everyone is going to follow it by the deadlines. There should always be enough time given, such as three to five years, as it might take a few years for everyone to comply properly. The participant also expressed the belief that many people would assume the ban might be reversed if the lead time is too long, such as over five or ten years. According to this, considering that people do not want to change quickly, many organizations will wait until the last minute. This should be considered while drafting the policy.

> A total ban can help this industry grow in general. Generators of a specific size and above cannot go to the landfill in Ontario, as they would end up in the atmosphere. Therefore, a ban on organics going to the landfill means that 95% of the trash in Ontario goes through a transfer station. Consequently, it can be collected and sorted separately from the garbage, and the change can be enforced on that side. This doesn't mean that Joe's Auto Body Shop needs an organic program; that doesn't make sense. However, Costco needs an organic diversion policy for the products in their stores. The first step is to delink the processing costs for organics from the landfill, and the most effective way to do that is by eliminating the landfill as an option. If you ban organics from the landfill, whether in Ontario, Michigan, or elsewhere, that is the most effective way for anybody to drive the projects. It makes a lot of sense as a policy because it ensures that organics don't end up in landfills. By the time you get to smaller generators, you're chasing nickels or dimes in terms of the order of magnitude. This means giving time to phase in the ban. If the government works on it today and announces that in 2025 the ban will kick in, fully implemented by 2028, it gives people time to comply. People don't like change, and the best way to enforce it is through the law. By saying, "This is happening, I'm giving you time to comply," it provides a framework, but people may still miss deadlines due to procrastination or hoping it goes away. That's why there needs to be a stick. (Participant 5)

In general, most participants favored banning organic waste disposal in landfills. They debated whether this ban should come before establishing an RNG market or if the market should naturally drive waste away from landfills. Some believed the ban could benefit RNG projects by ensuring a consistent supply of organic waste. Suggestions included choosing a

single enforcing entity to push organizations into action and implementing the ban at waste transfer stations. Participants emphasized the need for a transition period to prepare organizations for the ban. However, hesitancy to change among businesses may lead to delayed action, hoping for policy changes.

It was evident that a ban on organic waste disposal in landfills could stimulate the growth of the composting and RNG industries, especially with careful planning, suitable timelines, and policy instruments to enforce it.

Developing the Business Case

Like other projects, RNG projects also require a business case to articulate the reasons for initiating them. It is not only about the business factor, however; having a business case is crucial to demonstrate where resources will be utilized and for what purpose. In the case of RNG, viability, environmental, and social factors are involved, making the planning more intricate.

In Interview 1 with a municipal government representative in Ontario, it was emphasized that to develop a business case, access to a source of organic waste with a minimum volume of 20,000 tonnes annually is necessary for large-scale capital projects. These types of RNG projects are typically extensive in scale, high in cost, and require considerable planning compared to other investments.

NL produces an average of 120,000 tonnes of organic waste annually, so the province has enough organic waste to support 5 to 6 large-scale RNG projects, if other considerations are met and geographic distribution is accommodated (Food First NL, n.d.). The same participant also brought up that in real scenarios, there are many small municipalities that collect less than 20,000 tonnes of waste. One solution for having large capital projects might be a collaboration

between small municipalities to increase the volume of available organic waste and therefore be able to create a business case. However, for the case of Newfoundland, as some municipalities are far from each other or remote, a feasibility study could determine which locations are actually viable for RNG projects.

> Making the business case is the biggest challenge; there is a threshold or a sweet spot for presenting that business case. When it comes to an organics RNG facility, you need to be collecting around 20,000 to 30,000 tonnes of source-separated organics annually to justify moving forward with a large-scale capital construction project. In some municipalities, for instance, they're collecting around 8,000 tonnes. So, as it progresses, they need to start considering collaboration opportunities and entering into partnerships with other smaller municipalities to make that case. This could also involve forming joint ventures so that the financial burden isn't placed on a single small municipality. (Participant 1)

In support of this topic, Interviewee 5 from a company that operates RNG facilities highlighted that, in Newfoundland, the best locations for the first RNG projects could be either in St. John's, with a population of over 100,000, or Corner Brook, which has around 20,000 residents. Building on the earlier discussion, the waste generated in these cities could potentially be combined with nearby smaller municipalities. For example, the Town of Conception Bay South, near St. John's, or the Town of Pasadena, near Corner Brook on the West Coast of Newfoundland, might collectively produce adequate tonnes of source-separated organics annually, which could justify moving forward with an RNG project. In NL, each person produces an average of 4.5 pounds (2.04 kg) of waste per day (Food First NL, n.d.). As much as 30% of this waste is organic (Food First NL, n.d.). Therefore, in St. John's, with a population of 112,165, approximately 68.68 tonnes of organic waste are produced daily, resulting in about 25,069 tonnes annually. In the Town of Conception Bay South, with a population of 26,199, approximately 16 tonnes of organic waste are produced daily, amounting to about 5,855 tonnes annually. However, these amounts need to be evaluated further during the feasibility study.

However, that interviewee also stressed that transportation distance translates to higher costs in the project, as most ingredients in organic waste typically contain around 70-90% water, which is heavy. The reality is that, in successful RNG projects, the main source of fuel in transportation should be generated from the RNG plant or other renewable available sources. This may decrease the cost of transportation and the amount of emissions involved in the waste collection process.

> And 10,000 of it is in St. John's. The rest is probably spread out. The transportation distance and cost increase because organics are primarily water and heavy. It becomes challenging to manage. I just found out that St. John's now has a population of 181,000, so that's the focus area. Your next biggest city is Corner Brook with 20,000. These are the key areas. (Participant 5)

Another issue in NL is related to the government's approach to organic waste. Interviewee 3 from a not-for-profit association of businesses believed that there is a need for a third-party company to provide an offer to the government about organic waste. This participant emphasized that unless the government receives an offer, the materials will probably continue to go to landfills. They proposed that someone should make the connection between all parties: provincial government, municipal governments, organic waste producers, RNG industry leaders, and investors. However, the question of who should initiate these projects in NL is not an easy one.

> We have a good pace for that, but currently, these materials are either being stockpiled, buried, or sent to the landfill. I believe there's a need for someone to make those connections and figure out how people can use them. I think we are at a point now where the industries themselves aren't going to use it. Therefore, it's up to a third-party company to come in and say, "Hey, we have a use for this; let's set up a manufacturing facility or something like that." So, it's not something that forestry or lumber mill owners are going to set up. (Participant 3)

Another common topic in discussions was the absence of a natural gas grid in NL and the question of where RNG is going to be used. This question mainly arises from a lack of

knowledge in this topic, as the industry is quite new in Canada. While natural gas grids are one of the best destinations for renewable natural gas, they are not the only option. RNG could be used in many industries to decarbonize the economy. Interviewee 8 from a non-profit trade association mentioned the advantages that RNG can have even in locations without access to the natural gas grid. They emphasized that RNG in places like NLcan be used to fuel trucks and buses. It could even be used for fueling the waste management trucks themselves.

> You can still take advantage of RNG when you don't have a good gas grid. For instance, in an area with a lot of organic waste but without access to a gas grid, you can still have local refueling stations to fuel trucks and buses. In the case of a landfill, for example, that goes back and forth bringing organic waste (whether it's bringing the waste to the landfill or collecting it), RNG can power those trucks locally. (Participant 8)

The participant carried on describing other end uses for RNG, all of which can be considered as options. Indeed, the non-natural-gas-grid options are broad enough as to be a legitimate subject for another thesis project. According to Participant 8, even though the electrification of industries is advancing rapidly, there are some sectors referred to as "hard-to-electrify sectors" that require high-temperature heat, and this is where RNG can play a key role. Another end use could be using RNG to produce hydrogen as a clean fuel or even liquid biofuels such as biodiesel. There is also a type of biofuel that can power aircraft and has properties similar to conventional jet fuel but with a smaller carbon footprint. Furthermore, RNG can be used in the marine shipping industry, for instance, as Liquified Natural Gas (LNG), which is considered a clean energy source in shipping and the marine industry nowadays.

> To decarbonize some of their electricity output, we see all those sectors staying in the mix of RNG users. Eventually, RNG will be increasingly used in heavy industry and hard-to-electrify sectors, especially for processes that require high-temperature heat. Additionally, it can be used to produce other clean fuels, such as hydrogen. Hydrogen can be derived from RNG. Moreover, when combined with carbon capture and storage, RNG can be utilized to produce other liquid biofuels like biodiesel, ethanol, and, notably, sustainable aviation fuels. RNG can serve as an input to this

> process, reducing the carbon intensity of the sustainable aviation fuels produced. There are also sectors, like marine shipping, that lack outstanding candidates or perfect options for decarbonization. LNG ships are considered good options, as mentioned in Canada, particularly for the remaining hard-to-decarbonize electricity sector power plants. (Participant 8)

While everyone has different opinions on where RNG can be consumed, it is crucial to understand that, in creating the business case, the destination of the product can be key to a successful business case. The question of where the RNG can be used to bring the highest economic, environmental, and social value to the project and the community is vital.

In Interviewee 9, the participant from the RNG industry organization supported the idea that the best final use is to replace “industries that consume diesel”, such as the transportation sector, as it offers the highest value in GHG emission reduction by replacing fossil fuels. They continued by highlighting the importance of having an end market, emphasizing that this stage of the project is as vital as the initial stage of obtaining the organic waste feedstock.

> But I also think RNG and biogas—it's so versatile, but it's essential to think about the highest and best use. So, we don't focus on this part too much, but if you're looking at emissions reductions, the best use for RNG is transportation because you're displacing diesel. So, you're getting going to get the best, the best use through transport. I guess, based on what we've learned, having an end market for it is crucial. While obtaining the feedstock is super important, ultimately, having the end market will determine the success of projects. (Participant 9)

Additionally, they commented on the most proper method for handling organic waste. According to them, "AD" is valuable because, by the end of the process, both RNG and compost are produced. This compost can be used to preserve nutrients in the soil and contribute to food security. The RNG, of course, can replace fossil fuels, thereby reducing GHG emissions in municipalities. On the other hand, they also discussed recent developments in the province of Nova Scotia. Their action plan mostly concentrates on composting as the primary option.

However, they hold the view that Halifax chose this option because it is the most cost-effective and, in the long term, the optimal choice for utilizing organic waste is to establish a biogas plant.

> If you're aiming to derive the best value from organic waste, AD is the direction to pursue. It ensures the preservation of nutrients and carbon value for application back to the soil, similar to composting. Additionally, it generates renewable energy capable of displacing fossil fuels and reducing emissions. We were quite disappointed when we learned that Halifax opted for composting, as composting is no longer a widely used option, although it may be favored due to its cost-effectiveness. However, in the long term, building a biogas plant is a superior end-use option for organics compared to composting. (Participant 9)

In this section, I outlined the minimum requirements for large-scale RNG projects, with a threshold of 20,000 tons of organic waste annually as indicated by the municipal government in Ontario. However, the NL context can accommodate many small-scale RNG facilities. Key elements crucial for project success include collaboration between small municipalities and local governance, a well-prepared business case, low transportation costs, consideration of end-use for RNG, optimal location selection (initially identified as near St. John's or Corner Brook), and establishment of a viable end market.

Shift Towards Environmental Concerns

While many discuss the profitability or viability of projects, there is an extraordinary shift in mindset about organic waste worldwide. Now, the project itself is often not the primary focus; RNG is considered a solution for managing organic waste and a strategy to mitigate GHG emissions from landfills. In the municipal or corporate environment, there typically needs to be a well-written business case to justify the project's necessity. However, the topic of organic waste and RNG is becoming a part of global climate action efforts and the fight against climate change.

According to Canada's Greenhouse Gas Inventory, in 2021, emissions from Canadian landfills accounted for 19% of national methane emissions (Governmnet of Canada, 2023). So,

the topic goes beyond mere viability considerations. Interviewee 1 from a municipal government in Ontario interpreted this shift as an influence on the City's climate action plan. For instance, they highlighted using RNG to heat the City's infrastructure and assets, replacing the fossil fuels that the City traditionally purchased with RNG produced from organic waste generated within the City. Additionally, they spoke about how RNG is now integrated with the City's collection trucks, allowing them to close the carbon loop.

> There are all these different things that have come into play and shifted our mindset away from the economic side of things and more towards the environmental side. We are now consuming the RNG we produce within city infrastructure and assets. We're heating our buildings and fueling our collection trucks, like those initial collection trucks that are collecting the material. This way, we're closing that carbon loop. That's what we are doing with the gas. (Participant 1)

In provinces like Newfoundland, which heavily relies on the shipping industry to import groceries, GHG emissions result from the industry's predominant use of oil-based fossil fuels. According to the International Shipping Agency, to align with the Net Zero Scenario, the sector must increase its use of alternative fuels such as biofuels, hydrogen, ammonia, and electricity (International Energy Agency, International Shipping, 2023). European Technology & Innovation Platforms (n.d.) verifies that biofuels represent one of the alternatives to decrease carbon intensity in ship propulsion and mitigate the impact of emissions on local air quality.

Interviewee 3 from a not-for-profit association of businesses emphasized the GHG cost of every food imported to Newfoundland. Interestingly, RNG produced in NL could potentially be used to decarbonize the shipping process to the province. However, a careful review of legislation and policies at the local, provincial, federal, and international levels is needed to address the question of whether RNG/RNG can be used to decarbonize the shipping process for food to Newfoundland.

> Grow this stuff that would make the oil, right? Then you have that closer supply chain stuff, mainly things about self-sufficiency. You know, having the products you need on the island itself. No, I do not rely on shipping stuff so often. It's just the whole climate change environment type of stuff. If you're shipping here, there's a GHG cost. And if we have those targets for net zero by 2050, there will have to be changes that happen. So, there's that as well, I think. (Participant 3)

While thinking about a RNG project, many interviewees commenced their discussions with questions like, 'Is the final product valuable? Is there a market for the final product? How are we going to make a profit from this project?' However, as discussed in this section, a shift in perspective to a more environmental focus, instead of primarily viability, may be warranted. The question of how we are going to make a profit from the project might be replaced with 'Do we really need a business case?' or 'How can sustainable waste management help us reach net zero one day?' Interviewee 8 from a non-profit trade association supported the idea that the main focus of policies should be on how we are going to decarbonize waste, and there is less need to worry about the end use of RNG. They mentioned that nowadays in many parts of Canada, RNG is automatically considered an attractive solution for organic waste, and many sectors still need to decarbonize their fuel by replacing it with cleaner energy options. This is where RNG plays a role as a clean energy option in waste management: reaching the net zero target.

> We don't necessarily have to worry about the perfect end use for that RNG today because, to reach net zero, you need to decarbonize waste. And it happens that RNG is often the most attractive option to decarbonize that waste. So, there are many sectors that need clean energy and clean fuels. The demand for RNG is higher than the supply available. People often see RNG as a cleaner energy option, and then they tend to overlook or undermine its importance because of limited organic waste feedstock. (Participant 8)

In this section, I aimed to discuss the importance of environmental concerns and emphasize how policies should prioritize them in the initial stages of project planning. The mindset shift was crucial—from viewing RNG as a product to sell to recognizing it as a tool to reduce GHG emissions from landfills and decarbonize specific industries. The municipal

government in Ontario served as a notable example where Renewable Natural Gas (RNG) replaced fossil fuels in city-owned buildings and trucks, forming a vital component of the City's strategy to combat climate change. Subsequently, I highlighted how NL could have utilized RNG to decarbonize the shipping industry. Based on numerous interviews, it became evident that environmental considerations should take precedence. RNG emerged as a potential clean fuel capable of replacing fossil fuels, even in industries where electrification proved complicated and challenging.

Compliance and Growth

This section will cover the regulatory and policy changes discussed during the interviews that might have a significant impact on the industry. One idea that emerged during discussions with the interviewee from a the RNG industry organization was that, even though the natural gas grid is absent in Newfoundland, the province could potentially explore options to "sell the final product to Quebec". This idea needs a separate study as many factors can be involved. That interviewee also emphasized ongoing RNG-related efforts and proposals. For instance, they are currently proposing a federal RNG mandate and Clean Fuel Standards. Overall, their association identifies a federal RNG mandate as the single most powerful policy tool for reducing Canada's emissions with biogas and RNG.

> When it comes to Newfoundland, where a natural gas grid is absent, policy changes will be necessary. For instance, allowing a project from NL to sell to Quebec is one potential adjustment. This is a significant aspect we are monitoring, and everyone is trying to understand the limitations of selling gas to other jurisdictions. We discuss achieving Canada's climate targets with biogas and RNG, along with the policies that could make a difference. A federal RNG mandate, for example, could require a specific amount of RNG in the grid, leading to substantial growth. Although not currently in effect, it's something we believe would have a significant impact. We are proposing a Clean Fuel Standard, focusing on regulating gaseous fuel and reducing the carbon intensity of natural gas with RNG. This proposal, if adopted, would

> facilitate the growth of the sector. For instance, in places like Newfoundland, where a natural gas grid is absent, RNG could still be utilized. (Participant 9)

Regarding the Clean Fuel Regulations, some participants expressed their disappointments with the new regulations, as they predominantly focused on compressed natural gas (CNG). As a sustainable and renewable fuel for CNG production, RNG serves as an eco-friendly substitute for traditional natural gas. However, the process may entail higher capital costs and more intricate planning.

The focus on CNG in the Clean Fuel Regulations is perceived as a problem because it potentially limits the recognition and utilization of RNG as an alternative fuel source. While RNG can indeed be used to produce CNG, regulatory emphasis on CNG may overlook the environmental benefits and potential infrastructure developments associated with RNG. By prioritizing CNG, regulations may unintentionally hinder the adoption of RNG and its associated benefits, including reduced GHG emissions and advancements in infrastructure. The interviewee from a municipal government in Ontario emphasized that opting for RNG instead of CNG could potentially facilitate infrastructure development. Moreover, regulations on RNG could compel energy companies to invest more in greener pipelines in the future, moving beyond voluntary efforts.

> There is the Clean Fuels Fund, and we provided some comments, suggesting that RNG should be included to encourage the development of that type of infrastructure. They've made some adjustments, incorporating a bit of language, and I anticipate it will continue to improve. Currently, it seems more focused on compressed natural gas (CNG), but I believe it will progress further. We've also observed different companies, such as Enbridge, aiming for a greener pipeline in the future. While it's currently voluntary, we anticipate regulatory requirements in the future. These policies and regulations from the federal government would be instrumental in supporting such projects, shifting everyone's mindset toward renewable energy, and closing the carbon loop. (Participant 1)

Another interviewee also explained that they experienced similar feelings after the regulations were released in 2022, noticing that RNG was not included in these regulations. They went on to highlight two factors positively impacting the industry: funding and compliance. Funding primarily entails the allocation of financial resources and capital for RNG projects, while compliance involves conforming to established rules, regulations, laws, or standards. Continuing, they stated that if the compliance aspect of RNG, such as requiring a certain amount of RNG in the fuel, is established, the industry could witness growth as a result.

> From our current observations worldwide, it appears that the driving forces behind the industry are funding and compliance. For instance, if there is a requirement—such as the current clean fuel standard—initially, when it was being prepared, renewable fuels were strongly considered. However, when the standard was published, they were not included. In cases where there is a compliance requirement for gas suppliers to incorporate a certain percentage of renewable content in their fuels, that's what will drive the development of the market. (Participant 7)

Additionally, Interviewee 8 from a non-profit trade association provided examples of policies that impact the industry, such as clean heat standards—a gradually increasing percentage of low-emission heating services—and low carbon fuel standards designed to decrease the carbon intensity of transportation fuel. They also referenced cap-and-trade programs, which establish a market-driven framework imposing strict limits on GHG emissions. Despite noting that these policies have had less impact on RNG industry growth than expected, they suggested that two methods—namely “Capital Grants” to support capital expenditures and “Investment Tax Credits”, a tax credit for businesses investing in technology or infrastructure associated with RNG production—are extremely impactful on RNG developments.

> So, the standard for renewable gas could be, let's say, clean heat standards, and the second is low carbon fuel standards, which I group together with cap and trade and carbon pricing systems. Currently, there hasn't been much development of RNG driven by cap-and-trade programs, such as the Quebec and California cap and trade programs. Having a capital grant or an investment tax credit, like the Inflation Reduction Act in the US, which provides an investment tax credit for RNG

> equipment. That's one of the things we're advocating at the federal level—to establish a Canadian investment tax credit in this case. (Participant 8)

Overall, the discussion in this section has examined the crucial regulatory adjustments required to facilitate the growth of RNG in Canada. Exploring pathways for selling the final product to provinces with established gas grids underscores the potential for broader market access and regional collaboration. Moreover, the absence of clear regulations addressing clean fuel and the suggestion to re-evaluate these regulations to categorize the final product as RNG rather than CNG correctly highlights a critical area for policy improvement. Additionally, the significant impact of capital grants and investment tax credits in driving RNG advancements across the country underscores the importance of financial incentives in fostering innovation and investment in renewable energy infrastructure. Overall, these insights underscore the diverse approach needed to cultivate a supportive regulatory environment supportive to Canada's sustainable growth of the RNG sector.

4.6 Conclusion

In conclusion, studying organic waste management in NL highlights critical challenges and opportunities regarding adopting RNG as a sustainable solution. While NL predominantly relies on backyard composting to divert organic waste from landfills, stakeholders recognize the limitations of this approach, especially in terms of profitability and long-term sustainability. Moreover, the lack of significant long-term initiatives and regulatory frameworks further hinders progress in organic waste management, intensifying the province's environmental challenges.

Several vital challenges hinder the advancement of RNG initiatives in NL, including limited government interest, regulatory gaps, and financial constraints. The lack of legal mechanisms for selling bioenergy products and supportive legislation and comprehensive

policies compound these challenges. Compared to other provinces like Quebec and British Columbia, which have established themselves as leaders in the RNG industry, NL faces significant barriers to encouraging RNG development due to these barriers and uncertainties about its future viability.

Despite these challenges, there is growing recognition of RNG's potential role in reducing GHG emissions and advancing sustainable waste management practices. Stakeholders emphasized the importance of governmental support, financial incentives, and regulatory reforms to promote RNG growth in NL and across Canada. Additionally, the shift towards prioritizing environmental considerations over project profitability underscores the need for proactive policy interventions and collaborative efforts to drive the transition toward renewable energy sources.

The forthcoming discussion chapter will delve into actionable recommendations to address these challenges and drive the RNG sector's sustainable development in NL. By utilizing lessons from other provinces and adopting a diverse approach that prioritizes environmental stewardship and innovation, NL can position itself as a key player in Canada's renewable energy landscape.

Chapter 5: Discussion

5.1. Introduction

This discussion chapter aims to contextualize the data collected and analyzed within the broader landscape of organic waste management and the adoption of RNG in NL. Unlike the results chapter, this section delves into the complexities, challenges, and potential solutions derived from the findings. It seeks to provide a deeper understanding of RNG policies, offering discussions on specific topics related to RNG beyond the initial observations presented in the previous results section.

The tables herein, such as Table 4 and Table 5, serve as concise reference points for understanding the legal, regulatory, and policy frameworks and their impacts, providing readers with a structured overview before delving into the detailed analysis. The chapter's analytical part compares NL's organic waste management strategies with those of other provinces in Atlantic Canada, highlighting similarities and differences. Additionally, it explores the feasibility and funding dynamics of RNG projects, revealing the complex challenges and stressing the importance of a comprehensive perspective in RNG policies that encompasses economic, environmental, and social factors of the region.

In summary, the discussion chapter yields a collection of carefully developed policy recommendations tailored to NL's specific circumstances. These recommendations are informed by a thorough synthesis of the research findings.

5.2. RNG in NL Waste

Despite having a smaller population than many other provinces in Canada, NL produces more GHG emissions per capita than the national average. As well, over 97.5% of the organic waste in NL in 2019 was disposed of in landfills, which is 25.5% higher than Canada's average, according to the Review of the NL Provincial Solid Waste Management Strategy (Government of Newfoundland and Labrador, 2019). In this research, I attempted to evaluate the policies around using RNG/RNG as a possible solution for organic waste in NL.

The current approach in NL to organic waste is based on composting, specifically backyard composting, which is an attractive and simple method of managing organic waste at home. Therefore, the provincial policy mainly aims to address the organic waste issue at the source location instead of adopting a more complicated approach outside the home. Despite the challenges, many residents of NL positively embrace this method, with one of the motivators being the reduced costs of compost bins distributed by the Multi-Materials Stewardship Board (MMSB). The main issue here is the impact this method has on organic waste diversion.

Many stakeholders believe that government initiatives on organic waste are disorganized and inadequate, leading them to choose small-scale composting methods as the best option for organic waste. Some argue that this may not be a profitable strategy for organic waste management in the long term and suggest that provincial and local governments in NL prioritize seeking alternative, more technologically profitable, and comprehensive alternatives.

The idea of waste-to-energy initiatives in NL is currently facing several challenges. Local and provincial governments lack interest in becoming involved in more intricate bioenergy projects. The absence of legal mechanisms for selling or exporting bioenergy products, a lack of regulations and policies to ban organic waste from being disposed of in landfills, and insufficient

funding for waste management initiatives, especially RNG projects, are among these barriers. As there is no legal mechanism for selling or exporting RNG/RNG, this decreases interest from corporations to invest in these projects. When these barriers are mixed with other geographical conditions, such as the dearth of a natural gas grid, a smaller population compared to other provinces, low population density, and financial constraints in initiating RNG projects, they may hinder developments in the province and, more importantly, the sustainability of any future RNG projects.

However, while these barriers pose significant challenges, they underscore the need for collaborative action involving provincial and local governments, corporations, and industry. By working together, these stakeholders can overcome these obstacles and develop a more comprehensive, environmentally friendly, and profitable approach to organic waste management.

Renewable natural gas presents itself as a potential solution to the current situation, offering a sustainable alternative for managing organic waste. Earlier, I interpreted that innovative strategies are required at this point – strategies that can increase the economic benefit of RNG projects to attract investors. An example is the 15-year term contract of Enbridge with a municipal government in Ontario, based on a utility service fee. Decision-making should involve considerations of both profit and emission reduction, not just the former. GHG emission reduction and climate targets are key rationales for why Quebec covers 50% of the capital costs in RNG projects, as they use the final RNG to replace fossil fuel-based natural gas.

Some might only think about the natural gas grid replacement side of RNG; however, this overlooks other options. RNG is a source of energy and, like other energies, can be used in many places where there is no access to an energy grid. For instance, as mentioned before, RNG can be transported and utilized in areas without access to an energy grid, offering versatility beyond

natural gas grid replacement. It will find increasing application in heavy industry and sectors difficult to electrify, particularly for processes requiring high-temperature heat. Additionally, RNG can be used to produce liquid biofuels such as biodiesel, ethanol, and sustainable aviation and shipping fuels. This diverse range of applications highlights the potential of RNG beyond traditional energy grid usage. Table 4 below presents a summary of the legal, regulatory, and policy frameworks currently impacting the organic waste and RNG industry in Newfoundland.

Table 4. Description of Current Legal, Regulatory, and Policy Framework.

Aspect	Summary
Current Approach in NL	The approach mainly revolves around backyard composting, which is supported by the provincial government. The Multi-Materials Stewardship Board (MMSB) provides reduced-cost compost bins to residents.
Challenges and Criticism (NL)	Some participants believe that the provincial government's approach is disorganized, as they choose small-scale composting, which is not the best practice for organic waste. There is recognition that the government needs to explore novel options for organic waste.
Government Inertia and Focus on Waste Diversion (NL)	The main barrier for waste-to-energy projects in NL is the lack of government interest in undertaking more complex organic waste projects. They primarily aim to divert waste from landfills without engaging in long-term projects that require investment and collaboration with industries.
Legal and Financial Barriers (NL)	There are no legal mechanisms allowing the export or sale of the final RNG product. NL lacks supportive legislation to prevent the disposal of organic waste in landfills. Due to the lack of knowledge and supportive policies, there is uncertainty about waste-to-energy projects, leading to a lack of financial support.
Policy Shift towards Environmental Considerations	In Canada, some new policies prioritize environmental concerns over profitability in RNG projects. The participant from an Ontario municipal administration clarified that they prioritize environmental benefits first and then consider profitability. Climate legislation and policies such as the Canadian Net-Zero Emissions Accountability Act also impact the growth of RNG projects.
Collaborative and Profitable Models in Ontario	Policies in Ontario emphasize project profitability to attract investors. For instance, collaboration with Enbridge through a "utility service fee" over a 15-year term ensures the company can recover the capital

	cost and operating costs of RNG projects. The representative from a municipal administration in Ontario explained that decisions on RNG projects are made through a steering committee, which is an example of collaborative decision-making. This committee typically comprises various stakeholders, including representatives from municipal government departments, industry experts, community organizations, environmental advocates, and sometimes members of the public. The composition of the committee depends on the purpose and scope of its mandate.
Policies Driving RNG Adoption (Quebec and BC)	Quebec's natural gas utilities have ambitious goals for 2030. Instead of relying on just 10% of their natural gas from RNG, they aim for a substantial increase. This significant shift is driving the industry forward. Additionally, Quebec provides robust support systems for projects, sometimes covering over 50% of the capital costs. BC is actively promoting RNG adoption currently through a voluntary program.
Federal Clean Fuel Regulations	The 2022 Clean Fuel Regulations focus on reducing emissions by supporting clean fuels. Currently, it only includes compressed natural gas. Additionally, RNG is exempted from Carbon pollution pricing systems in most parts of Canada, which is an effective policy driver.

5.3. Viability and Funding in RNG Projects

Backyard composting, currently the preferred policy instrument for the GNL, is limited for several reasons. Although effective for managing organic waste, this method has limitations as it does not cover all organic materials such as dairy products, fish, or bones, and certain other organic wastes may not be suitable due to concerns about generating odors or attracting rodents.

This method leads to poor-quality compost as many people are not well-educated to separate the source properly and take care of the composting process. One common challenge in the RNG industry is that any type of bioenergy production project needs to obtain various permits from different organizations, and it generally takes longer than other projects with municipalities. Reasons contributing to this delay include, foremost, a lack of clear regulations and policies to guide the private sector. Another challenge is the value of the final

product or profitability in projects, which varies with factors like transport costs, or the type of technology used for upgrading gas. Viability is a challenging topic that may vary in each project based on fluctuating factors, so it would not be appropriate to generalize about RNG projects.

Looking at viability should be the second step in RNG projects, even if the main purpose is to divert waste from landfills and reduce the GHG emissions sources from them. Should a project proceed RNG if production only covers costs and does not generate profit? This question may receive a negative answer from a business perspective, but from an environmental perspective, it might still be considered the best option. Still, some projects are also viable in terms of profit, as seen in the Enbridge example in Ontario.

In Newfoundland, Muskrat Falls also plays a critical role as it raises the expectation of having lower energy prices, although the impact is still unclear as Muskrat Falls is not fully operational yet. Based on the CBC's recent 2024 report, it appears that more repairs are needed for the Muskrat Falls hydroelectric project's transmission lines, indicating that the project may still be undergoing maintenance and not fully operational at this time.

Despite all the challenges mentioned, interest and traction in RNG are increasing in Canada. For instance, the Government of Quebec has the objective of increasing bioenergy production by 50% by 2030, including the injection of 10% RNG into the natural gas network by 2030. Some municipalities have revenue streams from their RNG projects, and use these new revenues to create new projects, contributing to the industry's growth.

The concept of substituting fossil fuels with RNG is another strategy that the interviewee from an Ontario municipal administration highlighted, emphasizing their prioritization of environmental benefits before considering profitability. Ontario uses,

reducing costs related to the purchase of fossil fuels. From an environmental perspective, it diverts waste and replaces fossil fuels, doubling the impact on GHG emission reductions.

In places like Newfoundland, either a well-developed, organized composting project or RNG project could produce high-quality compost, contributing to food security. As previously explained, it is crucial to understand that the AD process, which is used to produce renewable natural gas, produces compost as a final product as well. Therefore, social benefits are another side of organic waste projects.

Finally, funding and compliance were two key words in my research. Various forms of grants, subsidies, contracts, and tax incentives—and rules, regulations, laws, and standards—are principal drivers if we are looking for growth in the industry. For instance, having a waste reduction target for a specific year, banning organics from disposal in landfills, or providing partial capital costs of RNG projects could all result in industry development. Table 5 presented below provides a summary of policy impacts on the industry.

Table 5. Effects of Current Legal, Regulatory, and Policy Framework

Backyard Composting	The composting process faces challenges, including incomplete coverage of all organic materials and issues with odors and rodent attraction. The current policies result in poor-quality compost due to improper source separation and lack of education.
Challenges in RNG Industry	Obtaining permits for waste to energy projects often takes longer than for others due to unclear regulations and policies. The profitability of these projects also fluctuates depending on factors such as transportation expenses and the technology used to upgrade gas. As a result, the viability of each project differs.
Viability of RNG Projects	Viability should be the secondary consideration after waste diversion and GHG emission reduction when evaluating RNG projects. It is crucial to acknowledge that business and environmental perspectives may not always be aligned in this regard. Nonetheless, there are examples of successful projects, such as Enbridge in Ontario, demonstrating the potential for RNG projects. Despite facing challenges, interest in RNG is on the rise in Canada.

Funding and Compliance	Funding and compliance are critical factors driving growth within the industry. They encompass a range of mechanisms such as grants, subsidies, contracts, tax incentives, as well as rules, regulations, laws, and standards. Initiatives aimed at waste reduction targets, landfill disposal bans, and providing partial capital costs support play significant roles in fostering the development of the industry.

5.4. Regional Contrasts in Organic Waste Management Strategies

From a comparative standpoint, when examining the Atlantic region as a whole, composting emerges as the most favored method for handling organic waste. However, each province has achieved different milestones. Nova Scotia, for example, has significantly advanced its waste management system by implementing a ban on organic waste disposal in landfills. Interviews suggest that Nova Scotians excel in source separation, facilitated by the Green Bin program.

PEI also boasts a Green Bin program and is progressing towards a modernized waste-to-energy plant. According to CBC, this project is expected to process around 46,000 tonnes of waste annually, reducing landfill volume by 75% (CBC, 2022). Unfortunately, NL lags behind in organic waste management within the Atlantic region. One initial step for matching the approach of other provinces could be the implementation of a province-wide Green Bin program, a waste management initiative aimed at diverting organic waste from landfills by collecting it separately from other types of waste. The Green Bin program is independent of RNG initiatives. This program would likely initially focuses on organic waste diversion, which can include centralized composting. However, RNG projects typically involve AD processes. As mentioned earlier, backyard composting may not be as effective as centralized composting in terms of waste reduction and methane emission mitigation. Therefore, implementing a provincial-wide Green Bin program, which likely involves centralized composting or other forms of organic waste

management, might complement but at the same time it might not directly synergize with RNG or waste-to-energy efforts as well.

In other parts of Canada, such as Ontario, particularly in cities like Toronto where RNG is actively produced from waste, the primary concerns revolve around establishing an effective waste collection and separation system to ensure high-quality gas production. Without an advanced organic waste stream, achieving a high-quality bioenergy project becomes exceptionally challenging.

Drawing from Ontario's experience with RNG project funding, a rate-based system may be more effective than tax-based funding. As mentioned in the results section, in a rate-based system, utilities generate revenue from customers based on electricity usage, ensuring a stable income for network maintenance and expansion. This differs from tax-based funding, which fluctuates and may not be allocated for specific projects or infrastructure needs. Corporations can generate a steady and predictable income, fostering network and production growth. Securing funding is crucial in bioenergy, with feasibility studies playing a pivotal role. Quebec, for instance, provides subsidies of up to 75% for these studies, assessing viability, practicality, and potential project success.

After feasibility studies, another crucial step is securing support for initial investments, with Quebec offering funding up to 50% of capital project costs.

In the USA, thousands of biogas plants, anaerobic digesters, and standalone systems exist. California's experience is noteworthy, with a single organic waste hauler serving both residential and commercial areas, making it easier to assess organic waste amounts and plan for the long term. SB 1383 regulations in California mandate municipalities to divert 75% of their

food waste by 2030 and procure a minimum amount of product made from recycled organic waste each year, fostering Renewable Natural Gas growth.

In Denmark, 40% of fossil fuel-based natural gas consumption has been replaced by RNG, with a goal of reaching 70%. The experiences of municipalities in Denmark can offer valuable insights for Canadian municipalities. Table 6 presents the results of a comparison of various organic waste policies across different jurisdictions.

Table 6. Comparison of Policy Between Jurisdictions.

Atlantic Canada Waste Management Policies	**Nova Scotia:** Implemented landfill bans on compostable organic materials, emphasizing source separation. Challenges persist with organics in landfills, but ongoing projects show commitment of the province. **Prince Edward Island:** Implements a sorting system and waste-to-energy projects, achieving success in organic waste diversion. The waste-to-energy plant serves as an example of this progress. **New Brunswick:** Faces challenges like NL, but a new policy aims to reduce landfill waste by 40,000 tonnes annually by 2030. Specific plans for organic waste management are yet to be clarified.
Municipal Factors in RNG Development	**Ontario:** Municipalities are at different stages of organic waste collection development. The representative from an Ontario municipal administration emphasized the importance of an effective organic waste collection system for RNG projects. **Quebec:** Offers financial support for feasibility studies and initial investments, driving significant progress in RNG projects. Municipalities with rate-based systems perform well.
Global RNG Industry Expansion	**U.S.:** Over 2,400 biogas production facilities across all 50 states. State-specific policies impact RNG industry growth. In California, diversion policies and regulations like the California Low Carbon Fuel Standard and SB 1383 drive RNG growth. **Europe:** The rapid expansion of the RNG industry is gaining momentum, with Denmark leading the charge towards ambitious goals, aiming for 70% RNG in the grid by 2030. While the European Union projects that biogas and RNG from all sources could meet 10% of conventional gas demand by 2030 and increase to 20% by 2050, this thesis specifically emphasizes the significant role of landfill gas in contributing to these targets.

5.5. Policy Recommendations for RNG Development

Because the topic of RNG is a new and developing subject, providing specific policy recommendations is challenging, given that many places are still experimenting with various methods of dealing with organic waste diversion and employing technologies for biogas production and conversion to RNG. In the case of Newfoundland, where there is no natural gas grid like in other provinces, and no existing organic waste stream within waste management, these limitations complicate any development more than in other locations.

However, there have been some policy recommendations that many interviews and studies agree on, and these could aid in developing the RNG industry in NL if gradually implemented. One strategy that NL could adopt is initiating a ban on sending organic waste to landfills. This potential ban could significantly boost Newfoundland's efforts to move toward net-zero GHG emissions. It might help the province build more successful business cases, as the volume of organic waste available for processing, either for compost or RNG, would become clearer, making short-term and long-term planning more straightforward. Obviously, as a result of this ban, organic waste would need to be separated, and a green bin program could potentially be implemented. Such a ban could attract investors and large corporations to invest in future bioenergy projects, particularly if enforced by a single entity and managed by a single organization, which could result in a more effective system.

The best place for implementing the ban on food waste disposal appears to be at transfer stations. Transfer stations represent the last point before waste is transported to its final disposal site, making them a strategic location for enforcement. By implementing the ban at transfer stations, authorities can effectively intercept food waste before it reaches its ultimate destination

for disposal, thereby reducing the overall volume of organic waste sent to landfills or other final disposal sites.

However, it is important to note that enforcing such a ban may require a phased approach. Initially, enforcement efforts could focus on specific industries, sectors, or organizations that produce the most food waste in Newfoundland. This targeted approach allows for a more manageable implementation process and ensures that enforcement resources are directed where they can have the greatest impact.

Additionally, when considering this banning strategy, it is crucial to provide industries with sufficient time to adapt and develop alternative waste management practices. Unexpected implementation or setting distant targets without adequate preparation may result in industries delaying action or struggling to comply with the regulations. Therefore, a well-planned transition period with clear guidance and support mechanisms is essential to facilitate a smooth and successful implementation of the ban on food waste disposal.

In developing the business case for RNG projects, environmental and social factors, in addition to economic factors, should be emphasized. In some rare cases, RNG projects might be approved and used as a strategy to reduce GHG emissions even without immediate viability. If the aim is to implement large-scale capital projects in Newfoundland, this study suggests having the RNG plant either around St. John's on the east coast or Corner Brook on the west coast, where most organic waste is produced. Any project must involve small municipalities alongside larger municipalities as well as industrial waste from different sectors. Additionally—although this study focuses on landfill gas—understanding the different feedstocks for RNG, such as landfill biogas, agricultural manure, and food waste, is essential for recognizing their distinct

impacts and benefits. Recognizing these roles is key for developing effective RNG policies and strategies.

The amount of waste generated on the west and east coasts of NL is substantial enough to justify the development of a business plan. However, it is essential to note that Newfoundland's population is sparsely distributed. Therefore, a critical consideration in RNG projects is avoiding long-distance waste transportation. Because organic waste is inherently heavy, transporting it over long distances may incur additional costs. This necessity underscores the importance of utilizing RNG or other renewable energy sources for fuel.

The unresolved question pertains to who should initiate and present the business case, given the lack of initiative and interest from the provincial government. It may fall upon corporations to step forward, but the challenges make this scenario appear infeasible. Alternatively, the federal government could facilitate an initiative to unite stakeholders, provincial and local governments, creating a cohesive approach.

In Newfoundland, several relevant NGOs and interest groups focus on environmental conservation, waste management, and renewable energy initiatives. These organizations play a crucial role in advocating for sustainable practices and facilitating collaborations between government entities, businesses, and communities. Conservation Corps Newfoundland and Labrador (CCNL), econext, East Coast Environmental Association (ECEA), NL Environmental Network (NLEN), NL Waste Management Association (NLWMA), Sierra Club Canada Foundation - Atlantic Chapter, and Greenrock - St. John's Environmental Group are among the key players in this landscape. Engaging with these organizations could provide valuable insights, resources, and support for initiatives aimed at addressing waste management challenges and promoting the adoption of renewable energy solutions like RNG in NL

Any business venture must acknowledge the absence of a natural gas grid in NL and explore alternatives such as exporting RNG to Quebec. Potential end-uses for RNG in NL include addressing hard-to-electrify sectors, industries reliant on diesel, and various applications such as transportation fuel, off-grid energy generation, heating for industrial processes, combined heat and power systems, GHG reduction credits, local community heating, agricultural applications, waste treatment plants, institutional heating, establishing microgrids, and exporting or selling to other jurisdictions. A comprehensive feasibility study at the outset is imperative.

The focus should extend beyond economic benefits to encompass environmental considerations in RNG projects. Notably, 19% of Canada's national GHG emissions stem from landfills, necessitating attention under the Canadian Net-Zero Emissions Accountability Act and provincial targets. RNG presents a dual impact by replacing fossil fuels in industries and waste collection systems, contributing to significant GHG emission reductions.

Decarbonizing marine shipping is a top priority, and AD is recommended, yielding compost as a byproduct to enhance food security in the province.

At the provincial level, there is an urgent need for regulations governing the sale of bioenergy products like RNG to other provinces, providing an alternative market if local energy demand is insufficient. Federally, Clean Fuel regulations, primarily supporting Compressed Natural Gas (CNG), should encompass RNG due to its preference in various industries.

Overall, funding in the form of capital grants, investment tax grants, and feasibility study grants, coupled with the formulation or adherence to regulations, laws, or standards, can significantly bolster the growth of the RNG industry. Table 7 presented below provides a comprehensive summary of policy recommendations derived from the observations and analyses conducted in this thesis.

Table 7. Recommendations for Policy Improvement.

Support for Ban on Organic Waste Disposal	Almost all interviewees at different levels supported a ban on organic waste disposal in landfills. This is a crucial step in reaching the net-zero emissions target and implementing strategies for waste diversion and RNG production. Many of them stated that this ban could potentially create a traceable, predictable, and sustainable waste stream.
Considerations for Implementation	- Need for careful planning and infrastructure readiness. - The decision to implement the ban should be carefully considered—whether to create the primary market or to provide incentives for the market before the ban to start reducing waste. - There should be a sufficient transition period. - A policy around enforcement at waste transfer stations, including the presence of a single entity to enforce this ban, is crucial. - There is a need for a clear policy indicating the timelines for the implementation of this ban and clear enforcement mechanisms to ensure the successful implementation of the policy. - Policies should distinguish between different RNG feedstocks, such as landfill biogas, agricultural manure, and food waste, to maximize their distinct advantages and impacts.
Business Case Development for RNG Projects	RNG projects might require a business case that not only considers viability but also takes into account environmental benefits and social aspects. Developing a business case considering all these factors could be challenging, especially for large-scale projects that require significant capital investment. The suggested collection volume is recommended to be 20,000 to 30,000 tonnes of organics to justify large-scale projects.
Success in BRNG Projects	- Collaboration between small towns and municipalities can help to reach the minimum volume of organic waste for larger projects and create a more viable business case. - In NL, the optimal location for the first RNG project could be near St. John's or Corner Brook, considering waste volumes, transportation costs, and geographic considerations. -RNG projects cannot be successful based solely on feedstock availability; choosing the right end-use for the RNG is also crucial.
Shift towards Environmental Concerns in RNG Projects	The mindset surrounding RNG projects should prioritize environmental benefits and contributions to GHG emission reductions. RNG projects can be seen as an effective solution for diverting waste from disposal in landfills and as a strategy in climate actions in municipalities. One effective policy solution could involve leveraging funding programs, such as the federal Gas Tax Fund or the Investing in Canada Infrastructure Program, to support the development of RNG infrastructure. Municipalities can also collaborate with provincial governments to establish

	Renewable Portfolio Standards or Renewable Fuel Standards that mandate a minimum percentage of RNG in the natural gas supply or transportation fuel mix. Furthermore, municipalities can enact local ordinances or bylaws requiring the use of RNG in public transit fleets or municipal vehicles, thereby creating demand for RNG and stimulating market growth.
Environmental Focus in Project Planning	The participant from an Ontario municipal administration elucidated how Ontario integrates RNG into city infrastructure, employing it for heating buildings and powering waste collection trucks to achieve carbon loop closure. In NL, the potential use of RNG could be in decarbonizing the shipping industry as part of importing food to the province
Regulatory and Policy Impact on RNG Growth	- The idea of exploring options to sell the final product to other provinces, like Quebec, where the demand for RNG is high, should be considered. - There is potential for an RNG mandate and the addition of RNG to the Clean Fuel Standards. RNG is discussed as a powerful tool for reducing GHG emissions. In regions lacking a natural gas grid, it could facilitate climate action efforts by being added to the Clean Fuel Regulations.
Importance of Funding and Compliance	- Funding and compliance are considered to be the main policy drivers. In addition to the compressed natural gas (CNG), interviewees suggest including Renewable Natural Gas (RNG) in all upcoming clean fuel regulations. - One instrument could be compliance requirements, such as mandating a certain percentage of RNG in fuels, which can result in industry growth. Providing capital grants and investment tax credits are other policy drivers for RNG development.

5.6. Conclusion

In conclusion, this chapter discussed the current challenges and potential solutions for organic waste management and RNG adoption in NL. Despite its smaller population, the province exceeds the national average in GHG emissions due to inefficient organic waste practices. Backyard composting, supported by NL policies, faces criticism for its limitations, underscoring the need for more comprehensive, long-term solutions.

This study highlights the barriers hindering RNG projects in NL, such as government inertia, legal and financial obstacles, and a lack of interest in intricate bioenergy initiatives. The

absence of a natural gas grid and geographical and financial constraints further complicates the adoption of RNG in the province. I observed the need for collaborative action involving provincial and local governments, corporations, and industries to develop a more environmentally friendly and profitable approach to organic waste management.

Furthermore, the viability and funding aspects of RNG projects are discussed, acknowledging challenges in the current policy framework and emphasizing the importance of considering environmental and social factors alongside economic elements. The research compares NL's organic waste management strategies with those of other provinces in Atlantic Canada and provides insights into successful RNG initiatives in Ontario, Quebec, the United States, and Europe.

The chapter concludes with policy recommendations tailored for NL's unique circumstances. Proposals include implementing a ban on organic waste disposal in landfills, developing a business case for RNG projects that considers environmental and social benefits, emphasizing environmental considerations in project planning, and addressing regulatory and policy aspects to support RNG growth. The significance of funding and compliance mechanisms, including grants, tax incentives, and feasibility study support, is highlighted as crucial drivers for the growth of the RNG industry in NL.

In essence, the research underscores the need for a paradigm shift in NL's approach to organic waste management, advocating for a more collaborative, environmentally conscious, and economically viable strategy centered around the adoption of RNG. While the proposed policy recommendations provide a roadmap for stakeholders to navigate the challenges and unlock the potential of RNG as a sustainable solution for organic waste in Newfoundland and Labrador, it is essential to acknowledge the unique policy reality of the region. Given NL's distinct context,

characterized by factors such as the absence of a natural gas grid, sparse population, and constrained government funds, the implementation of RNG projects may face significant hurdles.

Therefore, it becomes essential to pinpoint practical initial actions and strategies customized to the specific conditions of NL. These steps could include prioritizing organic waste source separation and establishing pilot RNG projects in select municipalities to assess feasibility and showcase potential benefits. Additionally, leveraging federal and provincial funding opportunities, such as climate change adaptation grants or rural development programs, can provide crucial financial support for RNG initiatives. By focusing on incremental progress and aligning policy interventions with NL's unique context, stakeholders can lay the groundwork for sustainable organic waste management practices while mitigating potential challenges associated with RNG development.

Chapter 6: Conclusion

This study comprehensively evaluates the existing policies governing organic waste management in NL, particularly those affecting the production of RNG from organic waste sources. Despite Newfoundland's emissions surpassing the national average and the prevalent disposal of organic waste in landfills, the full implementation of the ISWMS Hierarchy, especially with regards to source separation, remains a challenge in NL. The research assessed the current landscape to advance strategies for sustainable RNG development in NL.

The research questions addressed in this study were:

- What is the legal and regulatory framework for the RNG industry in NL? [descriptive]
- What are the effects of this framework on RNG development in NL? [explanatory]
- How does this framework compare to legal and regulatory frameworks for RNG in other jurisdictions? [comparative]
- How can policies and legislation be enhanced to promote growth of RNG industry in NL towards reducing GHG emissions? [prescriptive]

The strategic approach of this research aimed to propel the waste management system toward achieving net-zero emissions, concurrently generating revenue, and offering diverse benefits. The main data collection methods included a targeted document review and semi-structured interviews. The research employed qualitative analysis to interpret the data and answer the research questions. Engaging key stakeholders and government participants involved in organic waste management in NL and other parts of Canada was challenging, with many expressing a lack of information about the subject.

Initial steps involved delineating the existing legal, regulatory, and policy framework around RNG production, followed by an exploration of its impacts on the RNG industry. A policy comparison with other jurisdictions, particularly in Atlantic Canada, Ontario, Quebec, and global samples, provided insights. Noteworthy findings include: the success of Prince Edward Island in organic waste diversion through sorting systems and waste-to-energy projects, ongoing challenges in Nova Scotia despite landfill bans on compostable organic materials, the commitment of New Brunswick to reduce landfill waste by 40,000 tonnes annually by 2030 without clarified plans for organic waste management, the significant progress in RNG projects in Quebec driven by financial support for feasibility studies and initial investments, and finally, Denmark's ambitious goals leading the rapid expansion of the RNG industry in Europe, aiming for high percentages of RNG in the grid by 2030. Nova Scotia emerged as a potential model for NL, while Quebec, Ontario, and BC stand out as RNG leaders in Canada.

The research resulted in several key findings and recommendations, including supporting a ban on organic waste disposal, presenting the rationale for RNG projects, emphasizing the need to address environmental aspects in RNG initiatives, regulatory impacts on RNG expansion, and highlighting the significance of funding and compliance measures in the future of this industry. Based on the findings across the research questions, it is evident that NL faces significant challenges in organic waste management and RNG adoption. Criticisms of backyard composting underscore the need for more comprehensive solutions.

Barriers blocking RNG projects in NL include government inertia, legal and financial obstacles, and a lack of interest in intricate bioenergy initiatives. The absence of a natural gas grid and geographical and economic constraints further complicate RNG adoption. Collaborative

action involving provincial and local governments, corporations, and industries is essential to develop a more environmentally friendly and profitable approach to organic waste management.

Policy recommendations tailored to NL's unique circumstances include:

- Implementing a ban on organic waste disposal in landfills.
- Developing a business case for RNG projects that consider environmental and social benefits.
- Emphasizing environmental considerations in project planning.

Funding and compliance mechanisms, such as grants and tax incentives, are also crucial for RNG industry growth in NL. Given NL's distinct context, practical initial actions or preventive measures are essential. These may include prioritizing organic waste source separation, establishing pilot RNG projects in select municipalities, and leveraging federal and provincial funding opportunities. Incremental progress and policy interventions aligned with NL's unique context can lay the groundwork for sustainable organic waste management practices and mitigate challenges associated with RNG development.

The study encountered limitations, including difficulties in reaching out to many individuals in the field. Several potential participants expressed concerns about their knowledge level for the interview. Another challenge was the reluctance of governmental organizations to participate in research studies. Even those interested cited the novelty of the topic as a reason for hesitation in sharing their ideas. NL's unique combination of factors complicates the generalization of most results.

I believe this study establishes a strong foundation for scientists, industry leaders, and governmental employees, especially those in NL's provincial government or local municipalities actively seeking solutions for organic waste management. Drawing from personal experiences,

particularly from living on the west coast of NL, practical actions such as sorting and separating organic waste could serve as a starting point for this extensive RNG journey. RNG is just one of the many solutions for organic waste, and using this study as a foundation, future decision-makers may opt for a mix of solutions for their organic waste management needs.

Low-cost industrial composters or micro-scale digestion facilities equipped with anaerobic digesters could be considered on a small scale in NL's west or east coast after conducting a feasibility study and a pilot project. This feasibility study would analyze the practicality and potential success of a proposed project or endeavor and assess various specific factors in NL, such as economic, technical, and legal considerations. Most importantly, it would determine whether the project is viable.

The involvement of municipalities and the provincial government, however, is imperative for a RNG project's feasibility. A comprehensive feasibility study conducted by experienced companies in the pre-selected area is essential to address questions related to project implementation, technology selection, legislative considerations, available financial assistance, profitability, and more. Project definition, market analysis, and technical analysis for a feasibility study could be considered as the next step here; however, all need strong support from local organizations. Banning organic waste disposal, developing business cases for RNG projects, and considering environmental concerns and regulatory impacts are key recommendations. Future studies should also focus on the varied impacts and benefits of different RNG feedstocks, such as landfill biogas, agricultural manure, and food waste processing. Each feedstock contributes uniquely, and a detailed comparative analysis is necessary.

NL faces significant challenges in organic waste management and RNG adoption, with barriers including federal, provincial, and local government inertia, as well as economic

constraints. Collaboration among stakeholders is crucial for developing environmentally friendly waste management approaches. Funding and compliance mechanisms are vital for RNG industry growth. Prioritizing organic waste separation and leveraging funding opportunities can facilitate progress. Incremental progress aligned with NL's context can pave the way for sustainable waste management practices and overcome challenges in RNG development.

One insight gained from this study is that many people in NL are interested in this topic. Moreover, successful projects in any part of NL tend to quickly expand across the region.

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Appendix A: Email Request Sent to Potential Interviewees

Subject

Invitation: Interview for Research Project on Organic Waste/Renewable natural gas (RNG)

Initial Text

Dear [potential participant's name OR potential participant group],

My name is Mohammad Chehreh Ghani, and I am a Master of Arts in Environmental Policy student at the Environmental Policy Institute at Grenfell Campus, Memorial University of Newfoundland. I am the principal investigator for a study entitled "Evaluating policies affecting renewable natural gas production from municipal solid organic waste in Newfoundland and Labrador." Its purpose is to study the policies and legislation relevant to renewable natural gas production and consumption in the province. Renewable natural gas (RNG) is a pipeline-quality gas that is fully interchangeable with conventional natural gas. RNG is essentially biogas (the gaseous product of the decomposition of organic matter) that has been processed to purity standards.

We are looking for participants who: are currently involved with organic waste-related activities (Organic Waste, Composting, Biogas, or RNG), have been involved with organic waste-related activities in the past, or are interested in becoming involved with organic waste-related activities in the future. If any of this applies to you, I would like to formally invite you to participate in a short interview about your own interest and involvement in RNG.

The interview would be by telephone or remotely using video conferencing (using Skype, Zoom, or MS teams)., and would be about 30-60 minutes long. Participation is voluntary, and the confidentiality of your comments will be protected to the greatest extent possible. If you are interested in participating (or have any questions or concerns), please contact me (mchehrehghan@grenfell.mun.ca; 709-216-8402) or my supervisor, Dr. Garrett Richards (grichards@grenfell.mun.ca; 709 639 6534). You may also direct questions and concerns to the Grenfell Campus Research Ethics Board (gcethics@grenfell.mun.ca), which has reviewed and approved this project. I will provide you with additional details and a consent form before confirming your participation.

Thank you very much!

Follow-Up Text for Positive Responses

Hello [interested person's first name],

Thank you for your interest in this project! I have attached a consent form with more information about what your participation in the interview will entail, including the broad topics that will be covered (see the top of Page 2). You can review it (and ask questions, if you

have any) now, but I will need to collect your signature electronically before the beginning of the interview. Note that you have the option to provide us with additional materials (e.g., documents on organic waste management) before or after the interview.

If everything looks acceptable, I would like to schedule a time and place for the interview (at minimum a 30-minute block but ideally at least 60 minutes to provide some buffer time). In this case, the interview will likely be [by phone/Skype/Zoom/MS Teams]. My availability is [describe availability in the near future].

Please let me know what time and place would be most convenient for you.

Thanks again!