APPP 506 Capstone Project

Instructor: Dr. Vladan Prodanovic

Final Report

The Role of Renewable Natural Gas at UBC

Prepared for: Sustainability and Engineering

Submitted by:

Name: Haifeng Yang

Contents

1. Executive Summary

1.1 Background and Objectives

The University of British Columbia (UBC) is committed to achieving its ambitious Climate Action Plan 2030 (CAP2030) goals, including reducing greenhouse gas (GHG) emissions by 85% by 2030. Renewable Natural Gas (RNG) plays a pivotal role in decarbonization, particularly in areas where electrification is not feasible.

This project explores RNG's potential to address specific energy challenges at UBC, such as steam production in laboratories and peak winter heating demands, while complementing the university's biomass energy systems. The study aims to provide strategic recommendations for RNG integration at UBC, ensuring its effective deployment to maximize environmental and economic benefits while aligning with CAP2030 objectives.

1.2 Key Findings

a) **Strategic Role of RNG**: RNG serves as a low-carbon alternative for high-intensity applications, such as lab steam systems and district energy heating, where electrification is limited by infrastructure or operational constraints.

b) **Emission Reductions**: RNG's negative carbon intensity significantly reduces methane emissions and replaces conventional natural gas, contributing directly to UBC's decarbonization goals.

c) **Energy Transition at UBC**: From 2007 to 2023, UBC reduced its dependence on fossil fuels, with natural gas usage declining from 64% to 14% (projected by

2030). RNG is expected to account for 9% of total energy demand by 2030, offering a sustainable transition within existing infrastructure.

d) **Cost Comparison**: While RNG is more expensive than conventional natural gas, its long-term economic and environmental benefits, such as tax savings and reduced offsets, justify its adoption in strategic applications.

1.3 Key Recommendations

a) **Prioritize High-Value Applications**: Deploy RNG in labs, steam systems, and peak winter heating where it provides the most impact.

b) **Phased Integration**: Begin with sourcing RNG from FortisBC, scaling to additional sources such as landfills and agricultural waste, to reach 10%-15% of natural gas use by 2025 and 20%-25% by 2030.

c) **Leverage Existing Infrastructure**: Utilize RNG within current systems to avoid expensive retrofits while enhancing operational efficiency and system reliability.

d) **Monitor and Optimize**: Implement lifecycle assessment (LCA) tools to track RNG usage and GHG reductions, ensuring alignment with CAP2030 goals.

e) **Policy Advocacy**: Collaborate with stakeholders to secure stronger policy incentives and support RNG adoption in both campus and provincial energy strategies.

2. Regulatory and Policy Landscape

2.1 Key RNG Policies in BC & Canada

2.1.1 Canadian Federal Policies

The Carbon Pricing Mechanism, introduced in 2019, is a cornerstone of Canada's efforts to reduce greenhouse gas emissions. Under this framework, enterprises that exceed emissions thresholds are required to pay a carbon price, thereby incentivizing the adoption of low-carbon alternatives. RNG is exempt from this pricing due to its substantial greenhouse gas reduction benefits, making it an attractive and cost-effective solution for sectors such as transportation and industrial applications. This exemption not only improves the economic feasibility of RNG but also encourages its integration into energy systems, accelerating decarbonization across key industries.

Key incentives further support the development and adoption of RNG. The Clean Fuels Fund allocates $1.5 billion to facilitate the establishment of RNG facilities, feedstock infrastructure, and research and development initiatives, driving innovation and scalability in the sector. Additionally, the Accelerated Capital Cost Allowance (ACCA) offers financial benefits by enabling faster depreciation of RNG-related equipment. This significantly reduces tax burdens for project developers, fostering investment in RNG technologies and reinforcing Canada's transition to a low-carbon economy.

2.1.2 British Columbia Policies

The CleanBC Plan is a pivotal component of British Columbia's strategy to combat climate change, aiming for a 40% reduction in GHG emissions by 2030 and achieving net-zero emissions by 2050. Within this framework, RNG is prioritized as a low-carbon energy source, playing a crucial role in replacing fossil natural gas across key sectors, including buildings, transportation, and industry. By leveraging RNG's potential to significantly reduce GHG emissions, the CleanBC Plan underscores the importance of integrating sustainable energy solutions to meet ambitious climate targets.

The Greenhouse Gas Reduction Standard (GGRS) supports this transition by mandating a gradual increase in RNG's share within the natural gas supply. FortisBC, the province's leading energy provider, is required to ensure that RNG constitutes 15% of its natural gas portfolio by 2024. This regulatory requirement not only incentivizes the production and distribution of RNG but also aligns with broader provincial goals to diversify energy sources and reduce dependency on fossil fuels, fostering a resilient and sustainable energy system.

To further accelerate the development of RNG, the CleanBC Industry Innovation Fund provides critical financial support for innovative production projects. This includes initiatives such as landfill gas capture and agricultural waste digestion, which are key to expanding RNG supply chains. By enabling scalable RNG solutions, the fund fosters technological advancements and encourages investment, positioning British Columbia as a leader in low-carbon energy innovation.

2.2 RNG's Role in the USA

2.2.1 Low Carbon Fuel Standard:

Introduced in California in 2011, the Low Carbon Fuel Standard (LCFS) aims to reduce the carbon intensity of transportation fuels and promote the adoption of RNG and other low-carbon alternatives. Its credit mechanism allows RNG producers to earn tradable credits by supplying fuels with lower carbon intensity than the baseline, fostering economic viability.

The LCFS demonstrates the effectiveness of market-driven approaches, such as credit trading, to balance low-carbon fuel supply and demand. Tools like the CA-GREET model ensure transparency and accountability, making the LCFS a credible framework for reducing emissions and supporting clean energy adoption.

2.2.2 Renewable Fuel Standard:

Established under the Energy Policy Act of 2005, the Renewable Fuel Standard (RFS) mandates the increasing use of renewable fuels in transportation, with RNG recognized as an advanced biofuel. Its incentive structure provides higher support for fuels with substantial greenhouse gas reduction potential, driving the development of advanced RNG production. Additionally, the RFS promotes long-term contracts between producers and suppliers, enhancing economic scalability and fostering a more robust and reliable renewable fuel supply chain.

2.3 RNG in Europe

Under the framework of the European Green Deal and RED II Directives, RNG is promoted as a key tool for decarbonization, reducing reliance on imported fossil fuels, particularly from Russia. These directives advocate for RNG adoption in sectors like transportation and industrial heat, where electrification faces significant challenges. Looking ahead, Europe aims to meet 10%-15% of its natural gas demand with RNG by 2030, driven by advanced production technologies and supportive policy incentives.

3. RNG Production Technologies and Lifecycle Emissions

3.1 Key Production Technologies and Processes

The production of RNG involves several key stages that convert organic waste into a clean, sustainable energy source. The process begins with feedstock collection and pre-treatment, where materials such as landfill waste, agricultural residues, municipal organic waste, and industrial by-products are gathered. These feedstocks undergo essential pre-treatment steps, including screening to remove contaminants, crushing to break down larger particles, and dewatering to reduce moisture content. These steps are crucial for optimizing the efficiency of subsequent processes by ensuring that the feedstock is uniform and manageable.

The next stage is gas generation, which utilizes two primary methods: anaerobic digestion and thermochemical gasification. Anaerobic digestion involves the decomposition of organic material by microorganisms in an oxygen-free environment. This process is ideal for treating wet organic waste and produces biogas primarily composed of methane (CH_4) and carbon dioxide (CO_2). Thermochemical gasification, on the other hand, is suited for dry or woody biomass. It involves exposing the feedstock to high temperatures and low oxygen levels, converting it into a syngas mixture of hydrogen (H_2), carbon monoxide (CO), and methane.

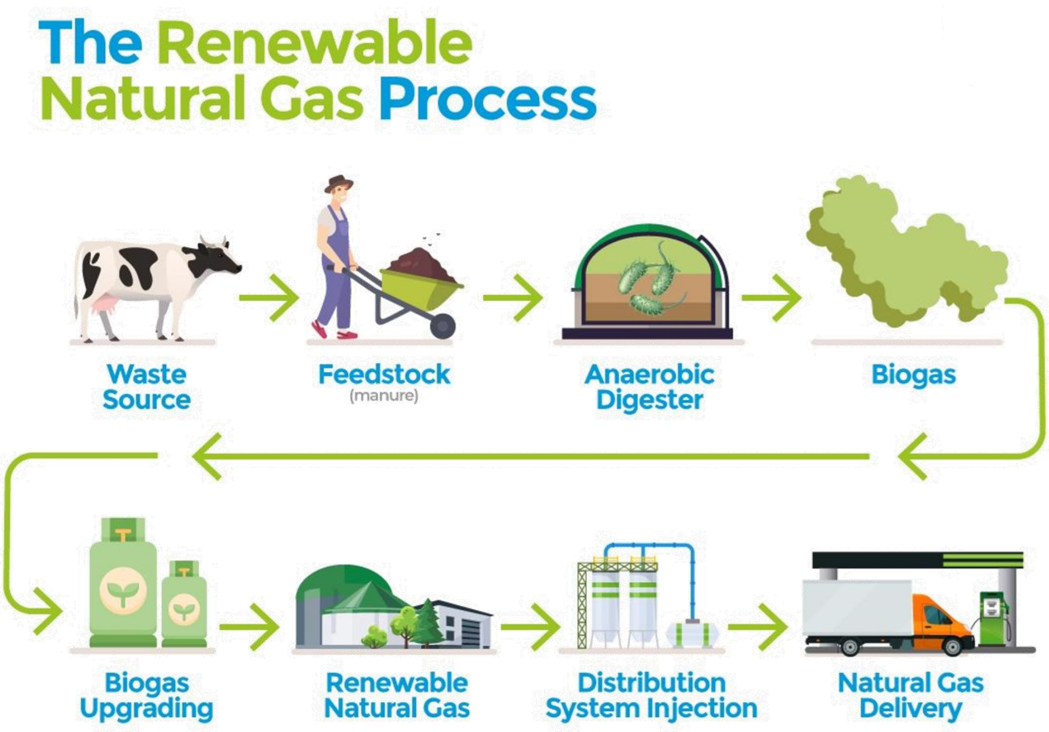


Figure 1. The Renewable Natural Gas Process (Source: The Coalition For Renewable Natural Gas)

Once biogas or syngas is generated, it undergoes gas purification and upgrading to remove impurities such as carbon dioxide, hydrogen sulfide (H_2S), nitrogen oxides (NO_x), and water vapor. Advanced purification technologies ensure that the final product meets stringent pipeline standards. The upgraded RNG achieves a high methane content, typically above 90%, making it suitable for various energy applications.

The final stage is distribution and utilization, where the purified RNG is either injected into existing natural gas grids or compressed and liquefied for specialized uses. Injection into the natural gas grid allows RNG to be seamlessly integrated with conventional natural gas, leveraging existing infrastructure for distribution to residential, commercial, and industrial customers. Alternatively, compressed or liquefied RNG can be used as a low-carbon transportation fuel or in industrial processes, offering a versatile solution for reducing greenhouse gas emissions across multiple sectors. This comprehensive process transforms organic waste into a valuable energy resource, supporting global decarbonization efforts.

3.2 Key Technologies

Table 1. Comparison of Technological Pathways for Renewable Natural Gas Production

Technological Pathway	Advantages	Limitations	Applicability
Anaerobic Digestion	High maturity, low cost, suitable for various organic waste	Limited feedstock availability, requires large-scale collection	Agricultural waste, municipal sludge
Thermochemical Gasification	Broad applicability, capable of processing high-carbon-density	High upfront investment, technically complex	Forestry residues, construction waste
Electrolysis & Methanation	Near-zero carbon emissions, enables energy storage	Economic feasibility depends on electricity costs	Regions with surplus renewable electricity

RNG production can utilize several technological pathways, each with its unique advantages, limitations, and areas of applicability. Anaerobic digestion is a mature and cost-effective method ideal for processing agricultural waste and municipal sludge. It is widely adopted due to its simplicity and efficiency, but it relies heavily on the availability of large-scale feedstock collection systems, which can limit its application in regions with scattered or insufficient organic waste sources.

Thermochemical gasification, on the other hand, is particularly suitable for high-carbon-density materials such as forestry residues and construction waste. This pathway offers broad applicability and the ability to handle more challenging feedstocks, but it comes with significant drawbacks, including high upfront investment costs and technical complexity, making it more suitable for regions or industries with robust financial and technical capacity.

Finally, electrolysis and methanation present a near-zero emissions solution, making it an excellent option for regions with a surplus of renewable electricity. This pathway is particularly effective for hydrogen production and long-term energy storage. However, its economic feasibility is closely tied to the cost of renewable electricity, which can be a limiting factor in areas without well-established renewable energy infrastructure. These diverse technological pathways underscore the importance of tailoring RNG production strategies to regional resources and energy needs.

3.3 RNG Lifecycle Assessment

The lifecycle of RNG can be broken down into several key stages, each contributing to its overall sustainability and emission reduction potential.

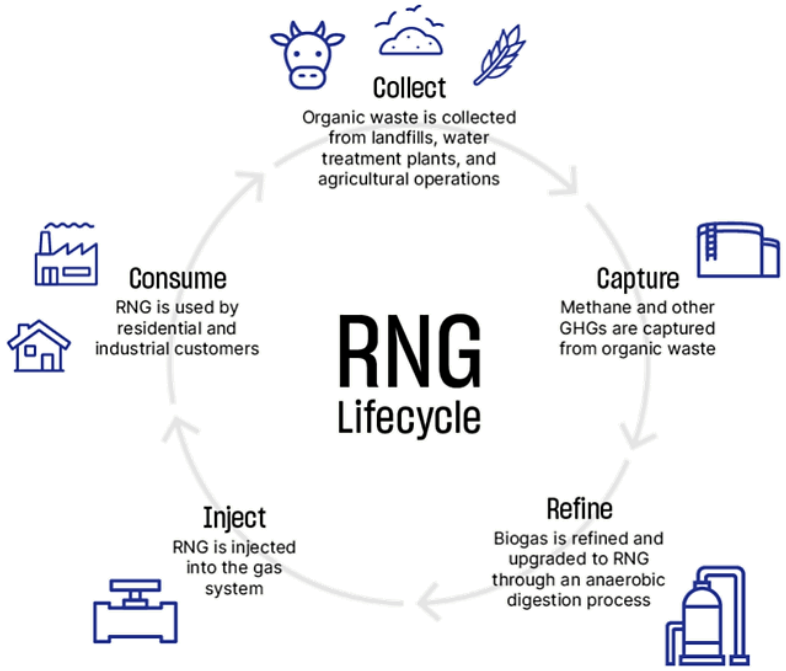


Figure 2. The Renewable Natural Gas Lifecycle (Source: The RNG Lifecycle, ATCO)

a) **Collection**: The process begins with the collection of organic waste from diverse sources such as landfills, agricultural operations, and water treatment plants. These wastes, which would otherwise release methane into the atmosphere, are repurposed as valuable feedstock for energy production.

b) **Capture**: Methane and other greenhouse gases (GHGs) are extracted from the organic waste during the anaerobic digestion process. This stage is critical for reducing emissions by preventing methane, a potent GHG, from escaping into the environment.

c) **Refinement**: The captured biogas undergoes a purification process, removing impurities such as carbon dioxide (CO_2) and hydrogen sulfide (H_2S). This step ensures that the resulting RNG meets pipeline-quality standards, making it compatible with existing natural gas infrastructure.

d) **Injection**: The upgraded RNG is injected into the existing natural gas grid, seamlessly integrating with the current energy distribution network. It can also be compressed or liquefied for use in transportation.

e) **Consumption**: Finally, RNG is used by residential and industrial customers for heating, electricity generation, and other applications, providing a cleaner and more sustainable energy alternative.

By following this lifecycle, RNG not only repurposes waste but also contributes to significant GHG emission reductions, aligning with broader climate action and decarbonization goals.

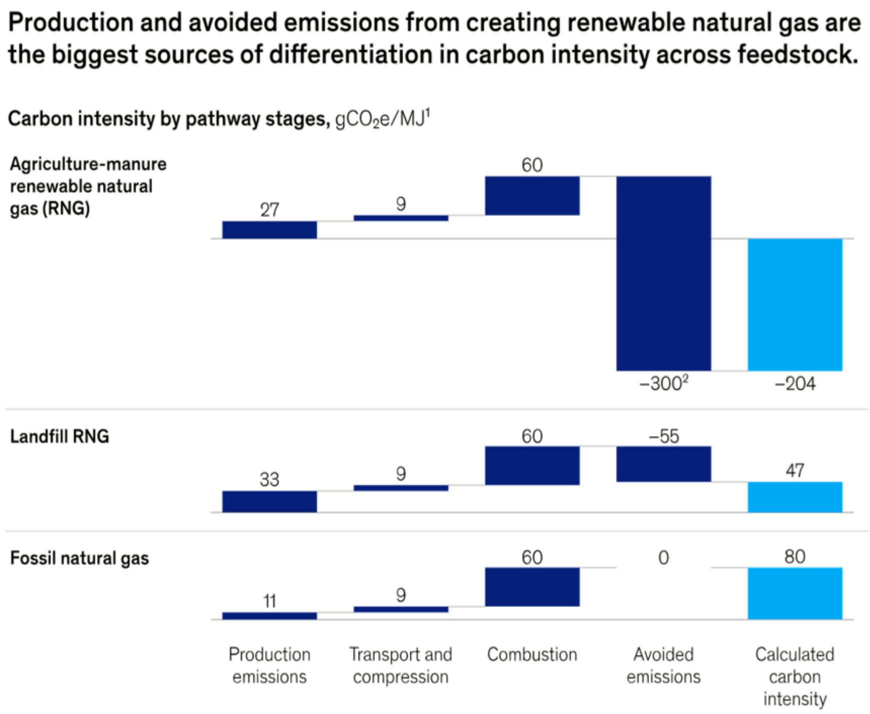


Figure 3. Carbon Intensity by Pathway Stages for Different Feedstocks (Source: Canadian Gas Association Pre-Budget Submission on Renewable Natural Gas Investment Tax Credit)

The chart highlights the carbon intensity differences between RNG sources and fossil natural gas. Agriculture-manure RNG showcases the highest impact, achieving negative emissions at -204 gCO2e/MJ due to substantial avoided methane emissions during production. Landfill RNG, while less impactful, still presents a significant improvement with a carbon intensity of 47 gCO2e/MJ. In contrast, fossil natural gas exhibits a lifecycle intensity of 80 gCO2e/MJ, lacking any avoided emissions. These comparisons underscore RNG's vital role in decarbonization strategies, particularly in sectors like agriculture and waste management, where methane capture dramatically reduces emissions.

3.4 Carbon Capture and Storage Technologies

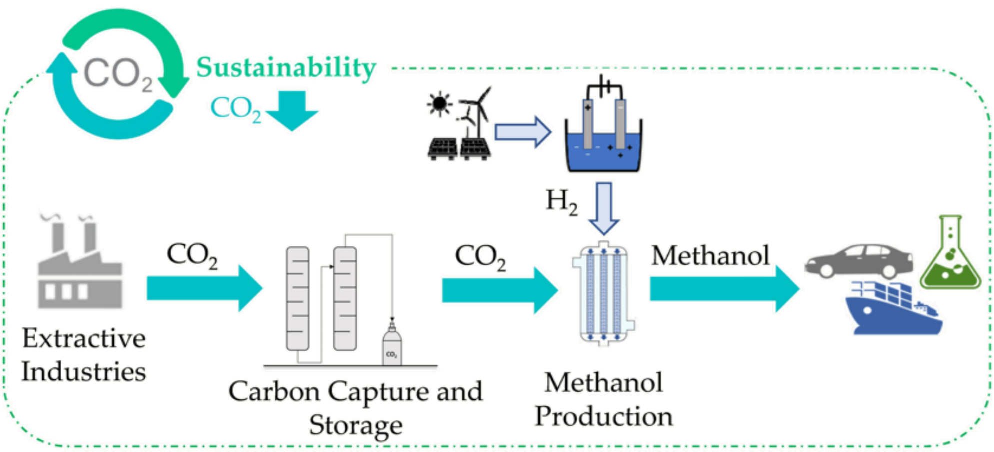


Figure 4. Carbon Capture and Methanol Production Process (Source: Methanol Production Process Using CO_2 from Carbon Capture and Storage)

a) **Role of CCS in RNG:** CCS enables the capture of CO_2 emissions during RNG production, either for secure storage or repurposing in applications like methanol production. When combined with biomass technologies, CCS can achieve carbon-negative outcomes, significantly reducing RNG's lifecycle carbon footprint.

b) **Synergies with Clean Energy:** Integrating CCS with RNG production complements hydrogen generation and other renewable energy systems, expanding carbon reduction potential.

c) **Economic and Policy Support:** Financial incentives and carbon tax credits for CCS deployment encourage its integration into RNG production, enhancing the overall sustainability of the value chain.

4. Local Case Studies

4.1 FortisBC RNG Projects: Achievements and Challenges

4.1.1 Overview of FortisBC's Leadership

FortisBC is a key player in advancing RNG as a sustainable energy solution in British Columbia, actively collaborating with suppliers to expand its RNG network. Since the 2017 amendment to BC's Greenhouse Gas Reduction Regulation, which introduced a renewable portfolio allowance for up to 5% RNG in the natural gas system, FortisBC has significantly scaled its RNG initiatives. By integrating RNG, FortisBC provides a cleaner alternative to traditional natural gas, directly supporting BC's decarbonization goals.

4.1.2 Key RNG Projects

FortisBC is taking a leadership role in advancing renewable energy solutions across British Columbia by actively collaborating with suppliers to expand the availability of RNG. The map illustrates key locations where FortisBC is implementing active and upcoming RNG projects. These sites represent a strategic network aimed at capturing and processing biogas from diverse sources such as agricultural operations and landfills, transforming waste into a sustainable energy resource for BC residents and businesses.

Figure 5. Key RNG Projects in British Columbia (Source: FortisBC)

Since the 2017 amendment to BC's Greenhouse Gas Reduction Regulation, which introduced a renewable portfolio allowance for up to 5% RNG in the natural gas system, FortisBC has leveraged this policy to scale its RNG initiatives. By integrating RNG into the energy mix, FortisBC is providing a cleaner alternative to traditional natural gas, significantly reducing greenhouse gas emissions.

a) **Seabreeze Dairy Farm (Delta)**: Generates 45,000 GJ of RNG annually, sufficient to heat about 500 homes. This project transforms agricultural waste into valuable energy, demonstrating the potential of farm-based RNG production.

Figure 5. Seabreeze Dairy Farm Projects

b) **Fraser Valley Biogas Facility (Abbotsford)**: Produces 90,000 GJ of RNG annually, heating over 1,000 homes. This highlights the scalability of RNG from organic farming waste.

Figure 6. Fraser Valley Biogas Facility Projects

c) **Glenmore Landfill (Kelowna)**: 45,000 GJ of RNG in the first full year of operation, which is enough to heat more than 500 homes Over the project life.

Figure 7. Glenmore Landfill Projects

4.1.3 Achievements and Challenges in FortisBC's RNG Development

FortisBC has made remarkable strides in expanding its Renewable Natural Gas (RNG) production. Currently, the company produces 6 petajoules (PJ) of RNG annually and has secured contracts for an additional 18 PJ, aiming to achieve 30 PJ by 2030. This ambitious growth aligns with its 30BY30 initiative, which seeks to reduce GHG emissions by 30% by 2030. With a lifecycle carbon intensity of -22 kg CO_2e per gigajoule, RNG substantially outperforms traditional natural gas in mitigating emissions. For every PJ of RNG integrated into the energy system, approximately 50,000 tonnes of CO_2e are offset, showcasing its pivotal role in reducing environmental impact.

Despite these achievements, several challenges remain in scaling RNG production. One significant hurdle is the high production cost, which surpasses that of conventional natural gas and relies heavily on policy incentives to remain competitive. Additionally, inefficiencies in the collection and transportation of organic waste feedstocks pose logistical challenges, limiting the scalability of RNG projects. Furthermore, market uncertainties, including early-stage demand growth and the need for commercial scalability, require substantial investment to build infrastructure and ensure a stable supply chain. Addressing these obstacles will be essential for FortisBC to fully realize its RNG potential and meet its decarbonization targets.

4.1.4 Future Outlook

FortisBC's strategic initiatives focus on scaling RNG production through advanced contracts, facility expansions, and technological investments, complemented by cross-border collaborations. This positions RNG as a crucial element in British Columbia's energy transition and global decarbonization efforts.

However, challenges such as higher costs compared to conventional natural gas, inefficiencies in feedstock supply, and market uncertainty due to early demand growth requiring time and investment persist. Despite these obstacles, significant opportunities exist, including FortisBC's ambitious plans to expand RNG supply and align projects with decarbonization goals and regulatory frameworks, ensuring RNG not only meets energy demands but also plays a pivotal role in reducing greenhouse gas emissions.

4.2 Cost Comparison: RNG vs. Conventional Natural Gas

The cost of producing Renewable Natural Gas (RNG) remains significantly higher than that of conventional natural gas, with current production costs ranging from CAD 15–30 per GJ compared to the conventional range of CAD 3–5 per GJ. In

British Columbia, RNG contracts are priced between CAD 20–25 per GJ, with policy incentives and carbon credits playing a crucial role in bridging this cost gap. Despite its higher upfront costs, RNG offers unique advantages that position it as a key component of decarbonization strategies.

Conventional natural gas remains economically favorable in BC, with prices averaging CAD 0.20 per GJ at Spectra stations, among the lowest globally. However, this pricing model faces challenges due to the anticipated impact of new LNG projects, which are expected to drive up costs. This creates a window of opportunity for RNG to become more competitive as policies and markets evolve.

From an environmental perspective, RNG demonstrates clear advantages, with its negative carbon intensity of -22 kg CO_2e per GJ offering substantial greenhouse gas reductions compared to fossil natural gas, which emits 80 g CO_2e per MJ. These reductions highlight RNG's potential to deliver meaningful contributions to BC's climate goals.

Economically, RNG provides a strategic advantage by helping users avoid escalating carbon taxes. It also reduces the need for carbon offsets, making RNG an attractive choice for high-intensity energy applications where decarbonization is most challenging. This combination of economic and environmental benefits underscores RNG's value in supporting both financial sustainability and climate action.

5. The Role of RNG in Decarbonization

5.1 RNG’s Role in the General Economy and BC

5.1.1 Strategic High-Value Applications

RNG's limited supply necessitates its deployment in high-value applications where electrification proves infeasible or inefficient. Key sectors include industrial processes requiring high-temperature heat and systems managing seasonal peak energy demands. Introba underscores the importance of prioritizing these applications strategically to maximize RNG's impact while reducing carbon emissions. For new developments, electrification should take precedence wherever possible, with RNG serving as a supplementary energy source to address gaps and enhance energy resilience.

5.1.2 Balancing Costs and Electrification Challenges

Navigant highlights RNG as a practical and cost-efficient solution for decarbonizing sectors that face economic and technical barriers to electrification. Specifically, industrial heating and winter peak energy needs benefit significantly from RNG’s flexibility and scalability. Furthermore, combining RNG with electrification creates diversified energy pathways that optimize costs while ensuring reliable energy supply during peak demand. This dual strategy not only supports BC's GHG reduction targets but also strengthens renewable energy integration by leveraging both RNG and electrification technologies effectively.

5.2 RNG Credit Mechanism Framework: A Comparison to VPPA

To better understand UBC's RNG mechanism and its strategic role in decarbonization, we can draw an analogy to Virtual Power Purchase Agreements (VPPAs). This comparison highlights how RNG supports UBC's sustainability goals while leveraging market mechanisms to promote clean energy. Both strategies aim to facilitate the integration of renewable energy into existing systems, ensuring decarbonization while addressing operational and environmental challenges.

VPPAs operate through financial contracts, enabling organizations to add renewable energy to the grid without directly consuming the generated electricity. Buyers secure fixed prices to manage financial risks while obtaining Renewable Energy Certificates (RECs) to offset carbon emissions. Similarly, UBC’s RNG mechanism involves contracting to purchase RNG and ensuring it is injected into the natural gas system. Although UBC might not directly consume this specific RNG, the process supports clean energy production and aligns with the university’s decarbonization objectives.

The analogy extends to shared decarbonization strategies. VPPAs enable organizations to support renewable energy projects, increasing the grid's share of clean energy while reducing reliance on fossil fuels. Likewise, UBC's RNG mechanism reduces carbon emissions by displacing fossil natural gas and is particularly effective for applications like high-temperature heating or laboratory energy needs, where electrification may face significant challenges.

One key distinction between the two mechanisms lies in the approach to credits. VPPAs rely heavily on Renewable Energy Certificates to certify the renewable nature of energy consumption and enable carbon offset claims. In contrast, UBC's RNG mechanism emphasizes practical carbon reduction benefits and the assurance that RNG contributes to the energy system. By focusing on tangible decarbonization outcomes rather than credit trading, UBC simplifies the narrative and highlights the operational benefits of RNG integration.

In conclusion, comparing UBC's RNG mechanism to a VPPA underscores its effectiveness in achieving decarbonization goals. This analogy demonstrates how RNG can optimize the use of existing infrastructure while advancing UBC's sustainability objectives. It provides a robust framework for communicating RNG's importance and ensures that discussions remain focused on operational and environmental outcomes rather than financial complexities.

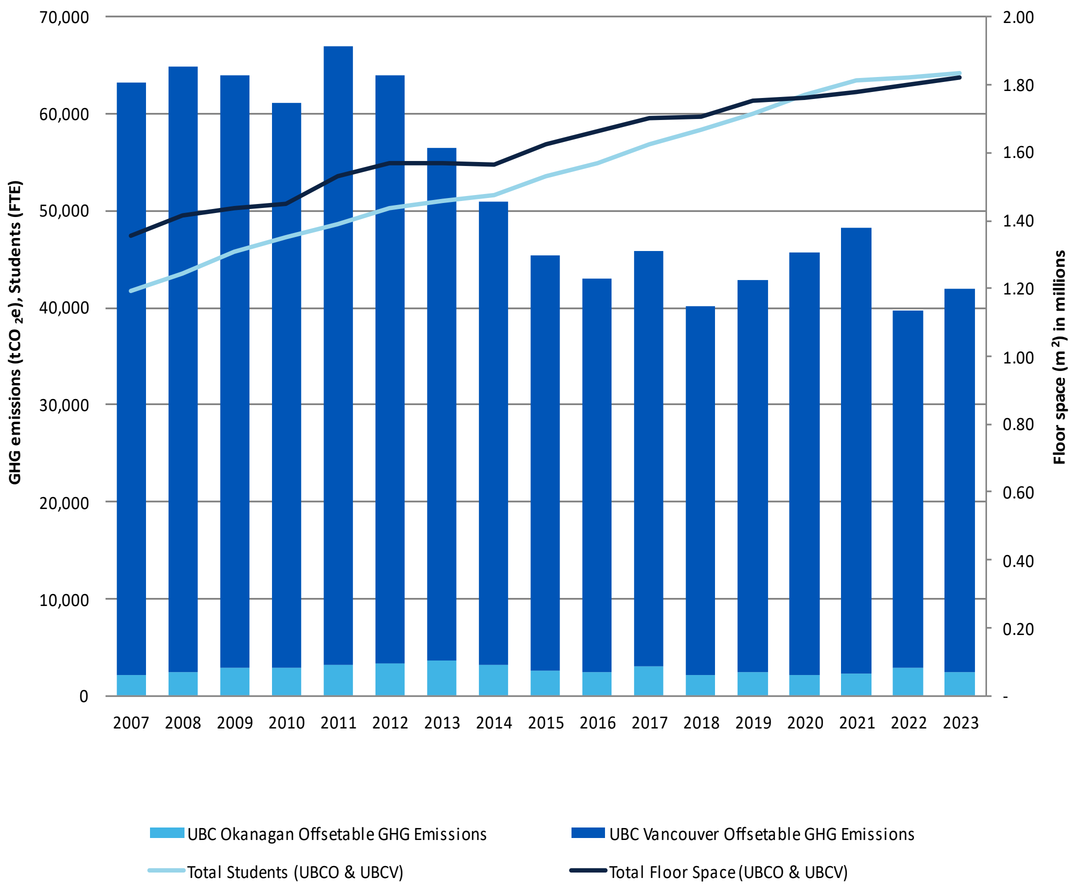
5.3 RNG's Role at UBC

At UBC, RNG plays a pivotal role in tackling specific energy challenges. It provides a low-carbon alternative for steam production in research labs and ensures clean energy supply during peak winter demand through its integration with the District Energy System. These applications demonstrate RNG's versatility in addressing energy needs that are hard to electrify, offering sustainable solutions where traditional natural gas once dominated.

Additionally, RNG complements UBC's biomass energy system by filling seasonal energy gaps, particularly during high-demand winter periods. This synergy enhances the university's overall energy resilience while maintaining sustainability. These strategies align closely with UBC's CAP2030, focusing on applications like district heating and peak energy demands to meet long-term decarbonization goals. In the following slides, I will share integrated data from my project to provide a deeper understanding of UBC's relationship with RNG and its strategic contributions to sustainability.

5.3.1 UBC's Path to Sustainability: Balancing Growth and Emissions Reductions

Table 2. UBC Growth and Emissions for Carbon Offsets



This chart illustrates UBC's remarkable efforts in reducing greenhouse gas emissions while simultaneously managing campus growth between 2007 and 2023. Over this period, both the Vancouver and Okanagan campuses experienced substantial increases in student enrollment and expanded floor space, reflecting the university's evolving academic and infrastructure needs.

Despite these growing demands, UBC achieved a consistent decline in offsettable GHG emissions. This progress is a testament to the university's proactive adoption of energy-efficient technologies, building retrofits, and integration of renewable energy sources such as RNG. These initiatives have enabled UBC to address emissions effectively while supporting its operational expansion.

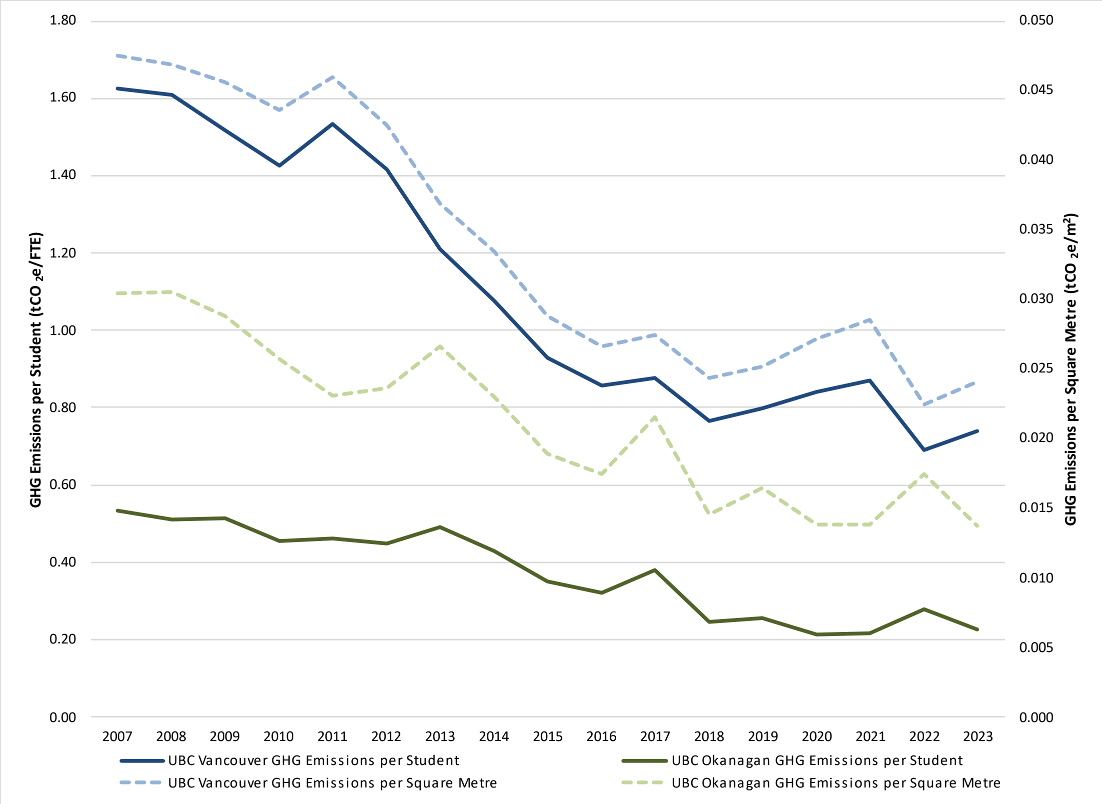
Aligned with the Climate Change Accountability Act, UBC's strategies demonstrate its commitment to decarbonization and sustainability. The significant emissions reductions achieved amidst increasing operational capacity highlight UBC's role as a leader in sustainable campus development and its dedication to long-term climate goals.

5.3.2 UBC's Path to Reduced Emissions and Energy Efficiency

This chart illustrates UBC's significant progress in reducing greenhouse gas emissions intensity between 2007 and 2023, focusing on emissions per student and per square meter for both the Vancouver and Okanagan campuses.

The consistent downward trend across all metrics underscores UBC's effective strategies to mitigate emissions despite the growth in campus size and student population.

Table 3. UBC Offsetable GHG Emissions Intensity

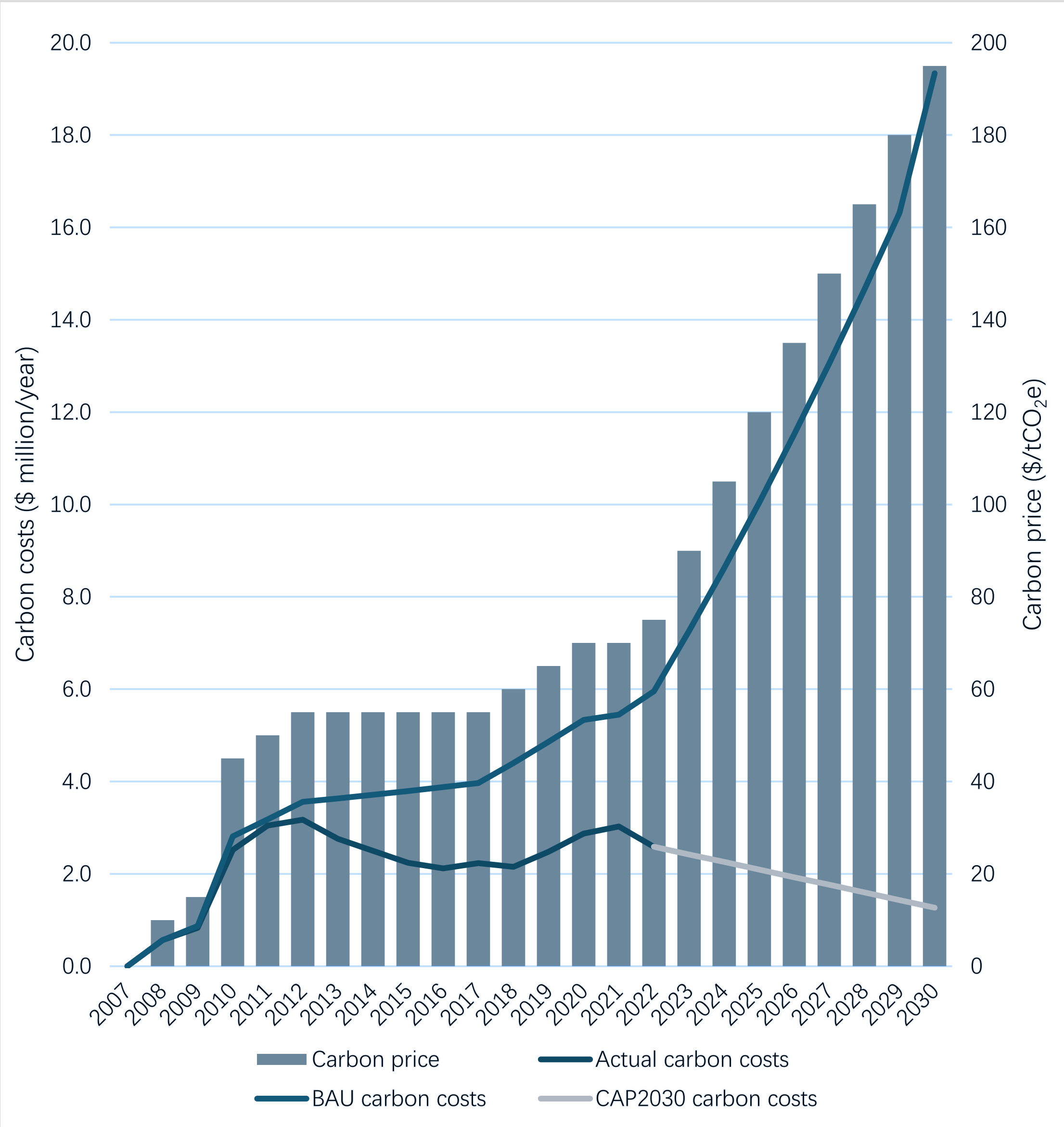


The reduction in GHG emissions intensity reflects UBC's commitment to improving energy efficiency through operational optimization and the adoption of renewable energy sources like RNG. These efforts have helped decrease reliance on natural gas, a major contributor to emissions, while maintaining energy demands for its academic and research activities.

UBC's achievements in emissions reductions align closely with its long-term decarbonization goals and sustainability commitments. By continuously enhancing its energy systems, UBC has set a strong example for how institutions can balance growth and sustainability, reinforcing its role as a leader in climate action and energy management.

5.3.3 UBC's Path to Carbon Cost Stability

Table 4. UBC Carbon Cost Trends and Projections



This chart captures UBC's carbon cost trends from 2007 and projects potential financial outcomes through 2030, emphasizing the impact of emissions reduction strategies. In a Business-as-Usual scenario, carbon costs are projected to escalate dramatically, reaching approximately $18–20 million annually by 2030. This sharp increase is driven by the rising carbon price, which is expected to peak at $200 per tonne by the end of the decade. Such a scenario underscores the economic risks of delaying further emissions reductions.

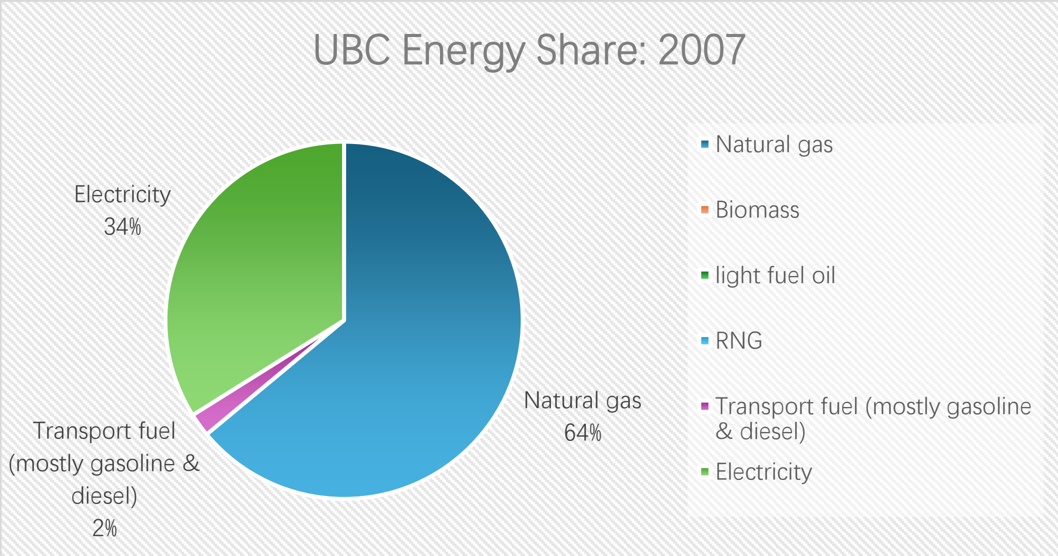
In contrast, UBC's actual carbon costs have remained notably lower due to its proactive approach to emissions management. Since 2016, measures such as integrating RNG and implementing energy efficiency programs have significantly mitigated financial pressures, showcasing the cost-saving potential of sustainable practices. These initiatives not only reduce emissions but also stabilize operational expenses in the face of increasing carbon prices.

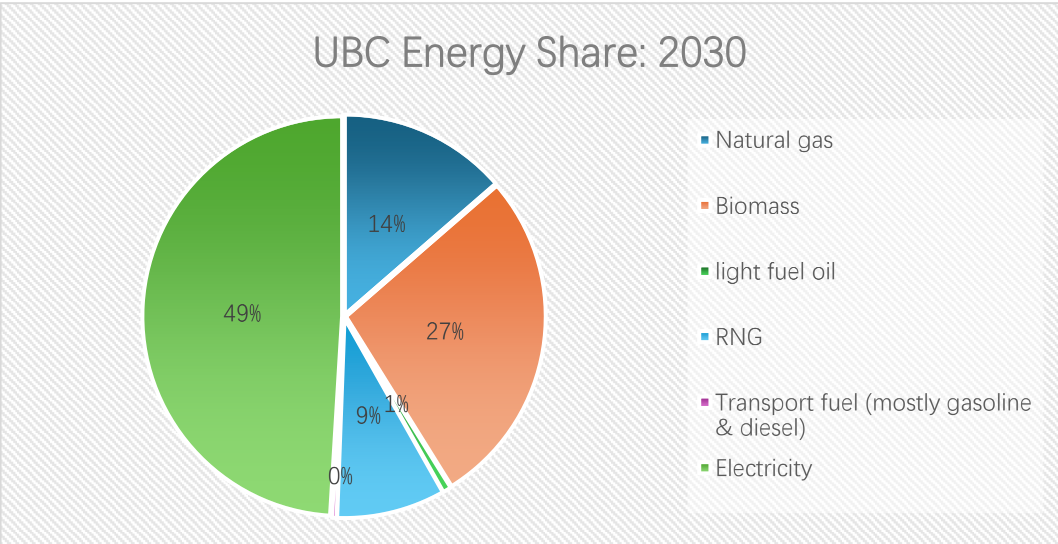
Looking ahead, aligning with the CAP2030 targets offers the most cost-effective pathway for UBC. By intensifying decarbonization efforts and leveraging renewable energy solutions, UBC can achieve the lowest projected carbon costs while reinforcing its commitment to long-term environmental and financial sustainability. This trajectory highlights the dual benefits of environmental stewardship and economic resilience.

5.3.4 UBC’s Energy Transition Towards Sustainability

The evolution of UBC's energy portfolio from 2007 to the projections for 2030 showcases a remarkable shift in its approach to energy sustainability. In 2007, the university’s energy consumption was heavily reliant on natural gas, which accounted for a substantial 64% of the total energy mix. Electricity comprised 34%, while contributions from other energy sources were negligible. This dependence on fossil fuels underscored the challenges of high greenhouse gas emissions and limited diversity in energy sourcing.

Table 5. UBC Energy Transition: 2007 vs. 2030 Projections





By 2030, UBC envisions a transformative change in its energy landscape. Electricity is projected to dominate at 49%, reflecting significant investments in renewable energy and the decarbonization of power supply. Biomass emerges as a critical contributor, making up 27% of the energy mix, filling the seasonal gaps and supporting heating demands. RNG, a cornerstone of UBC's decarbonization strategy, is anticipated to account for 9%, showcasing its role in reducing fossil fuel dependence while leveraging existing infrastructure for cost-effective emission reductions.

Meanwhile, the reliance on natural gas is expected to drop drastically to just 14%, demonstrating a clear commitment to reducing carbon emissions and transitioning away from traditional fossil fuels. This shift not only reflects UBC's alignment with its CAPl 2030 goals but also highlights its strategic efforts to build a more resilient and diversified energy system capable of meeting future sustainability demands.

5.4 UBC Energy Transition: Insights and RNG Impact

In 2007, natural gas was the cornerstone of UBC's energy supply, making up a substantial 64% of the total energy portfolio. This heavy reliance highlighted the university's dependence on fossil fuels, underscoring the challenges posed by high carbon emissions and limited diversification in its energy mix. Historical data confirms this trend, painting a picture of an energy-intensive campus environment reliant on natural gas for heating, power, and other operations.

Over time, UBC has made steady progress in reducing its natural gas dependence. Data from the Climate Change Accountability Reports (CCAR) reveals a consistent downward trend in both natural gas consumption and associated emissions from 2007 to 2023. These reductions reflect UBC's commitment to sustainable energy practices and its proactive steps toward decarbonization. Despite these advances, natural gas remains a significant, though diminishing, component of UBC's energy strategy.

A key aspect of UBC's decarbonization efforts is the integration of RNG. This transition plays a strategic role in leveraging existing infrastructure while achieving emissions reductions. RNG is particularly valuable for meeting high-intensity energy needs where electrification is less feasible. Highlighted in UBC’s Climate Action Plan and CCAR reports, RNG is positioned as a critical solution to bridge the gap between traditional energy use and future sustainability goals.

Looking ahead, RNG usage at UBC is projected to reach approximately 150,000 kilograms, constituting up to 10% of the university’s total energy demand. This estimation, grounded in current data and modeling, aligns seamlessly with UBC's broader energy transition strategy. By incorporating RNG into its energy portfolio, UBC is not only addressing current carbon challenges but also setting a robust foundation for long-term sustainability and resilience.

5.5 The Strategic Benefits of RNG for UBC

RNG offers significant cost-saving advantages for UBC by leveraging its low carbon intensity to minimize carbon taxes and offset expenses. As BC’s carbon tax is set to increase from 65 CAD per ton in 2023 to 170 CAD per ton by 2030, the adoption of RNG becomes a cost-effective solution for the university’s energy needs. This shift not only reduces financial pressures but also aligns with UBC’s broader goals of sustainability and economic efficiency.

A key advantage of RNG is its seamless integration into existing infrastructure, eliminating the need for costly retrofitting. While UBC has steadily reduced its reliance on natural gas, as evidenced by Climate Change Accountability Reports (CCAR) tracking usage and emissions from 2007 to 2023, natural gas remains a critical component of the energy system. RNG provides a direct pathway to decarbonization without disrupting current operations.

Additionally, RNG strengthens UBC's energy resilience by ensuring a reliable supply during peak heating periods or unexpected equipment failures. This reliability supports the university's operational efficiency while maintaining its commitment to sustainability. By incorporating RNG into its energy strategy, UBC effectively balances economic, environmental, and practical considerations, paving the way for a more resilient and sustainable future.

6. Recommendations and Next Steps

6.1 Strategic RNG Deployment at UBC

To successfully incorporate Renewable Natural Gas (RNG) into UBC's energy systems, targeted applications must be identified to maximize impact. RNG should be prioritized for high-temperature steam applications in labs, such as sterilization and specialized equipment operations. Additionally, integrating RNG into centralized steam systems and using it for winter heating during peak demand will stabilize energy supply while significantly reducing emissions.

A phased approach is essential for effective implementation. During the initial phase, UBC should focus on securing RNG supply from reliable providers like FortisBC and deploying it in high-demand areas such as labs and steam systems. In subsequent phases, the use of RNG can be progressively expanded across the campus, supported by diverse sources such as organic waste, landfills, and wastewater, to ensure a reliable and scalable supply.

Leveraging existing infrastructure will streamline RNG integration. Utilizing current natural gas systems minimizes the need for costly retrofits, enhancing both reliability and cost-efficiency. Implementing monitoring tools to track RNG usage and emissions reductions will further optimize operations and demonstrate measurable progress toward sustainability goals.

The economic benefits of adopting RNG are significant. As BC's carbon tax increases, RNG will help reduce carbon tax liabilities while maintaining operational redundancy. This ensures UBC's energy systems remain resilient, capable of withstanding equipment failures or extreme weather events, and aligned with long-term decarbonization objectives.

6.2 Timeline for Implementation

In the initial stages, UBC's focus will be on establishing RNG supply agreements with FortisBC to secure a reliable source of renewable natural gas. Pilot projects will be conducted in high-demand areas like labs and steam systems to test RNG integration and assess its feasibility. Additionally, the development of campus-wide energy monitoring systems will be prioritized to effectively track emissions reductions and performance metrics, ensuring a data-driven approach to RNG adoption.

As the implementation progresses, UBC can expand RNG usage to additional facilities and critical systems, such as winter heating, while pursuing partnerships to diversify its RNG sources, including biogas from landfills and wastewater projects. A key milestone during this period will be the integration of RNG into UBC's district energy system, enabling broader adoption and supporting the university's decarbonization objectives.

In the long term, UBC aims to achieve its long-term goal of using RNG for 20%–25% of the university's total natural gas demand. Infrastructure upgrades will be finalized to ensure sustained RNG deployment, providing a resilient and low-carbon energy system. UBC will also report on its progress, using lifecycle assessment (LCA) data to evaluate the impact of RNG and refine strategies as needed to align with the evolving energy landscape and campus requirements.

6.3 Advocacy for Policy Support

A critical step in UBC's RNG strategy is strengthening partnerships with key stakeholders like FortisBC, CleanBC, and others involved in provincial decarbonization efforts. Collaborating closely with these organizations will ensure a stable and reliable RNG supply, while also aligning UBC's energy transition with British Columbia's broader climate goals.

Advocating for policy incentives is equally important to drive RNG adoption. UBC should work to secure increased funding for RNG projects through initiatives like CleanBC's Industry Innovation Fund. Additionally, leveraging carbon credits and related incentives will help offset the upfront costs of RNG integration, improving the economic feasibility of these projects and supporting long-term sustainability.

Engaging stakeholders is essential for fostering widespread support for RNG initiatives. By sharing success stories of RNG adoption and its impact on emissions reductions, UBC can inspire confidence among students, faculty, and policymakers. Clear communication about the benefits of RNG will play a pivotal role in building momentum for the university's decarbonization strategy.

6.4 Future Research Opportunities

A comprehensive approach to improving RNG integration at UBC begins with advancing Life Cycle Analysis (LCA) studies. Detailed LCA evaluations are essential to refine RNG's carbon intensity metrics, ensuring its environmental benefits are accurately quantified and its long-term impact validated. These insights will strengthen the case for RNG as a viable decarbonization tool.

Investing in technology innovation is another vital step. Advancements in anaerobic digestion and gasification technologies can significantly enhance RNG production efficiency while reducing associated costs. Additionally, exploring the integration of Carbon Capture and Storage (CCS) with RNG systems could enable UBC to achieve negative emissions, pushing the boundaries of sustainable solutions.

Economic feasibility studies are necessary to evaluate RNG's cost-effectiveness relative to other renewable energy options, including full electrification. These analyses should account for both operational and capital costs to provide a holistic understanding of RNG's financial viability and long-term sustainability.

Finally, scalability assessments will guide RNG deployment across diverse campus facilities. By analyzing various adoption scenarios, UBC can identify the most effective strategies for integrating RNG into its energy systems, ensuring that the transition is both efficient and impactful. These efforts will position UBC as a leader in innovative and sustainable energy solutions.

Reference

[1] Introba. (2023). Renewable Natural Gas Availability in BC: Whitepaper. Introba.

[2] Navigant. (2020). Clean Growth Pathway to 2050: Pathways for BC to Reduce Greenhouse Gas Emissions. Prepared for FortisBC.

[3] UBC Energy & Water Services. (2023). TES Concept Definition Report. University of British Columbia.

[4] FortisBC. (2022). Renewable Natural Gas Program: Annual Report. FortisBC.

[5] CleanBC. (2023). Roadmap to 2030: Decarbonization Strategies for British Columbia. BC Government.

[6] Intergovernmental Panel on Climate Change (IPCC). (2022). Climate Change 2022: Mitigation of Climate Change. IPCC.

[7] Canadian Gas Association. (2021). Renewable Natural Gas in Canada: Current Status and Opportunities. CGA.

[8] Energy Futures Lab. (2021). Decarbonizing Natural Gas: RNG and Hydrogen Pathways. Energy Futures Lab.

[9] Pembina Institute. (2023). The Role of Renewable Natural Gas in Achieving Net-Zero in Canada. Pembina Institute.

[10] University of British Columbia. (2022). Climate Action Plan 2030: Progress Report. UBC Sustainability.

[11] Government of Canada. (2021). Hydrogen Strategy for Canada: Seizing Opportunities for Canadian Decarbonization. Government of Canada.

[12] BC Hydro. (2023). Industrial Electrification: Opportunities for GHG Reductions.

BC Hydro.

[13] American Gas Foundation. (2020). Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment. AGF.

[14] Canadian Energy Regulator. (2022). Canada's Energy Future 2022: RNG Market Projections. CER.

[15] IEA Bioenergy. (2021). The Role of Biogas and RNG in a Decarbonized Energy System. International Energy Agency.

[16] City of Vancouver. (2022). Renewable Natural Gas Use in Municipal Energy Systems. City of Vancouver.

[17] Natural Resources Canada. (2023). Renewable Energy Pathways: Exploring RNG's Potential. NRCan.

[18] International Energy Agency (IEA). (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. IEA.

[19] Union of Concerned Scientists. (2020). Biogas and Renewable Natural Gas for Clean Energy and GHG Reduction. UCS.

[20] FortisBC. (2021). Renewable Natural Gas: The Path to Sustainable Energy. FortisBC.

[21] Energy Transitions Commission. (2021). The Role of RNG in Hard-to-Decarbonize Sectors. ETC.

[22] UBC Sustainability Office. (2022). UBC's Energy Optimization Strategy: Renewable Natural Gas Integration. UBC.

[23] Biogas World. (2022). Biogas and RNG Market Report: Trends and

Opportunities. Biogas World.

[24] Canadian Renewable Energy Association. (2021). Renewable Energy in Canada: RNG's Role in Achieving Net-Zero. CanREA.

[25] BC Utilities Commission. (2022). Regulatory Frameworks for RNG Integration in BC. BCUC.

[26] International Renewable Energy Agency (IRENA). (2020). Renewable Natural Gas: Innovation Outlook. IRENA.

[27] FortisBC. (2023). 30BY30: Reducing GHG Emissions with Renewable Natural Gas. FortisBC.

[28] Carbon Management Canada. (2021). RNG, Carbon Capture, and Net-Zero Strategies. Carbon Management Canada.

[29] Climate Smart. (2023). The Economic Case for Renewable Natural Gas in BC. Climate Smart.

[30] BC Ministry of Energy, Mines and Low Carbon Innovation. (2022). RNG in BC's Low-Carbon Economy. BC Government.