RENEWABLE NATURAL GAS TECHNOLOGY ROADMAP FOR CANADA

CANADIAN GAS ASSOCIATION
ASSOCIATION CANADIENNE DU GAZ

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Glenmore Landfill Biomethane plant in Kelowna, BC
Photo courtesy of FortisBC

Disclaimer

This Technology Roadmap provides the perspective of numerous stakeholders and was prepared under the direction of the Renewable Natural Gas Technology Roadmap Steering Committee. The contents, conclusions, and recommendations are not necessarily endorsed by all participating organizations and their employees or by the Government of Canada.

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Foreward

Society doesn't create the sunshine that energizes solar panels, or the rain that fills reservoirs for hydro-electric dams, or the wind that powers wind farms, but we do make a lot of waste and waste makes biogas and thus biomethane (collectively termed renewable natural gas or RNG).

Of all the types of renewable energy RNG has perhaps the best reasons to be supported and developed. Producing and using RNG will help eliminate what was otherwise a waste product and significant GHG emissions source by turning it into usable energy and in doing so make productive use of a greatly underutilized renewable resource. Turning this loss into an economical and environmental gain is the right thing to do both economically and environmentally. Success will be when RNG becomes business-as-usual for our natural gas networks.

But getting RNG into the grid is proving difficult. Like any "new" product or technology initial costs are higher than established incumbents, markets are uncertain and the way forward is not clearly defined.

Today's challenge is to find a model and approach that makes RNG viable. Technology needs to be understood, supply needs to be developed and to create a sustainable market there has to be real value. This will not happen by itself. To make RNG work, creative ideas need to be explored on all fronts — technological, commercial, social, regulatory and political.

This paper sets out an RNG technology roadmap. It is a step forward to bring us together and follow a common path to make the promise of RNG a reality.

Expertise from many different professions and interests has contributed to this project. So thanks to your efforts, your imagination and your know-how, this roadmap has recommended a way forward and fostered understanding between stakeholders that will help us make this vision real. To all the people who contributed, our sincere thanks.

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The Renewable Natural Gas Technology Roadmap

This Renewable Natural Gas (RNG) Technology Roadmap sets a vision of establishing a viable RNG sector in Canada and explores pathways to achieving the vision. Industry, academic and research groups, and governments have jointly identified market barriers, prioritized the opportunities and technologies and recommended the strategic research and development, and marketing and investment decisions needed for success.

This Roadmap begins by establishing a baseline that sets out the current status of the RNG market in Canada. It then goes on to identify the challenges and opportunities to achieving that vision, and makes recommendations on how to overcome the challenges and exploit the opportunity that is RNG in Canada.

The RNG Technology Roadmap is guided by a Steering Committee comprised of a Chair and leading RNG experts from across Canada. Steering Committee members contributed to Working Groups that addressed key issues identified through the process, the results of which are captured in this roadmap document. Steering Committee Members include:

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1.0 Executive Summary

The proposition for Canadian investment in Renewable Natural Gas (RNG) is strong.

RNG is considered to be a renewable energy form because it is methane produced from organic waste that is captured rather than released into the atmosphere and, as such is carbon-neutral. Once collected RNG can be cleaned to a level that meets pipeline specifications and mixed or used interchangeably with natural gas currently produced from wells.

There is little disputing the benefits that result from using cleaner forms of energy, like RNG, to meet our nation's needs. Reduced pollutants in the air, ensuring a future supply of clean water, and better management of our landmass all contribute to the economic, environmental and social well-being of Canadians.

Yet, the debate over which clean fuel sources are most suitable for the Canadian context continues to challenge investors and policy-makers, and the rapid pace of innovation introduces new and evolving energy solutions every day. Moreover the regional diversity of Canada's energy resource allocations further complicates the debate, with some regions having more fossil fuel resources while others are able to produce more renewable energy resources.

World-renown investor, Warren Buffet is quoted as saying *"Never invest in a business you don't understand".* In other words, play to your strengths. For Canada, this strength would be applying its century-old knowledge on investing and developing the fossil fuel sector toward the production of RNG supply. Add to this opportunity the benefits that Canada's agricultural sector, forestry sector, and municipalities would realize through cost-savings and new revenue streams, and the RNG proposition becomes even richer.

On May 31, 2012, members of Canada's private sector and government institutions gathered in Ottawa, Ontario to bring their collective strength to bear on the opportunity of RNG. The participating natural gas utilities, biogas producers, technology suppliers, research & technology development community, and federal and provincial governments assessed the current state of affairs, debated the hurdles, sought advice from experts across Canada, and charted a way forward.

Discussions between these experts were framed in a technology roadmap exercise with the intent of setting a course for Canada to achieve the vision of **Canada having a fully developed RNG marketplace by 2020 that helps meet the energy needs of Canadians, supports growth and innovation for business, and offers a solution to issues associated with waste and GHG emissions.**

Though the year 2020 may appear as an aggressive target for a fully functioning RNG marketplace in Canada, it's important to note that critical components are already in place. Over 480,000 kilometres of natural gas pipelines are in place to service more than 6.4 million Canadian customers. And growing awareness among consumers has already created opportunities to connect this existing infrastructure and customer base to renewable natural gas supplies.

For example, customers in Abbotsford, British Columbia, have been receiving RNG sourced primarily from on-farm agricultural waste, since 2010 as part of a project between Fraser Valley Biogas and FortisBC. A second project in BC was also opened up at the Salmon Arm landfill. In Ontario, the City of Hamilton established an arrangement with Union Gas in 2011, adding RNG produced from a waste water treatment plant into the utility's distribution network. Finally, green energy provider Bullfrog Power began to offer renewable natural gas environmental attributes to consumers across Canada, sourcing its supply from the EBI Énergie's Dépôt Rive-Nord landfill near Montreal.

Salmon Arm Plant

But many more opportunities are being held up for lack of the appropriate access to feedstock and understanding of the RNG potential. As the recommendations made within this technology roadmap are turned into actions, RNG projects will hopefully continue to multiply and the substantial economic, environmental, and social benefits will be realized by Canadians across the country.

Certainly innovations in pre-treatment facilities, gasification technologies, and upgrading systems will lead to new business opportunities, companies and jobs. Through RNG development value will be placed on low-value waste residues and no-value waste products, creating new revenue streams within the agricultural, forestry, municipal and waste management sectors. RNG, as a renewable energy source will help to offset negative environmental impacts within our energy supply network while extending the availability of our cleanest fossil fuel, natural gas. Communities involved in the sourcing and pre-treatment of feedstock for RNG will benefit from the training and local job creation that will come with a new green energy industry.

But before we can reap the rewards of a fully-developed RMG marketplace, Canada must attend to certain challenges.

- The current production cost premium faced by RNG energy will need to be reduced by a combination of targeted investments in the technology and the application of appropriate policy levers.
- A common understanding among stakeholders of the impacts and value of a RNG marketplace will need to emerge.
- Consistent industry standards and practices for managing feedstock and contractual expectations between renewable natural gas suppliers and distributers will have to be developed.

The challenges to scaling up production of renewable natural gas will vary by producer and chosen technology. It will also depend upon access to sufficient feedstocks.

There is an estimated 1,300 billion cubic feet of RNG supply potential in Canada (equal to 50 per cent of the natural gas consumption in 2012) albeit a much smaller portion would actually be made available to the market.

The forestry sector has the greatest supply potential at 51 per cent given its access to waste forestry biomass. The great potential within the forestry sector comes with great hurdles. Currently, there is no production of renewable natural gas within the forestry sector as the upgrading of gasified biomass to RNG is still an imperfect process requiring strategic technology investments.

Yet, much is being learned from the existing gasification projects and research and development investments in this technology continue. The forestry sector and the federal government are closely collaborating on innovative opportunities, as demonstrated in activities between Natural Resource Canada and FPInnovations, one of the world's largest private, not-for-profit forestry research centres.

The agricultural sector is expected to provide 36 per cent of the total RNG supply potential supported by its access to agricultural and feedlot waste streams. RNG production in this sector is largely based on anaerobic digestion technologies that are well understood and tested. As a result there are fewer

[1] *Potential Production of Methane from Canadian Wastes*, Alberta Innovates – Technology Futures, www.cga.ca/pdfs/RNGpotential.pdf

notable technology barriers to the production of biogas from this sector. However, the low-energy densities of agricultural feedstock, fragmented availability of feedstock resulting from smaller farm sizes, and regulatory barriers in many jurisdictions that prevent the mixing of off-farm feedstock are some of the issues that limit the RNG production potential of this sector. The costs associated with managing these issues, added to the capital costs of a renewable natural gas facility, are deterrents to farm-based RNG production.

The third major RNG supply sector is expected to be the municipal sector (13 per cent of potential supply) based on its access to the municipal landfill waste stream.[1] Municipalities will also play a unique role as a producer and consumer of RNG. Production comes with primary benefits of extracting value from municipal waste and waste diversion. Landfills, source separated organic treatment facilities, and wastewater treatment plants are potentially large sources of feedstock supply. Contaminants, such as the high concentration of nitrogen and oxygen in landfill gas collection systems, will pose some technical challenges to the quality of municipal waste based RNG production. This can be addressed with innovations in pre-treatment systems.

As consumers, municipalities can demonstrate leadership in sustainability by using RNG to heat public facilities and fuel their fleets. Policy levers can be applied to encourage uptake among residents and local industries, as well.

In parallel to scaling up RNG production is the need to raise the awareness among consumers of this carbon-neutral energy option and to apply policy levers that enable and encourage adoption. Among targeted adopters are municipalities, large industry and the power generation sector, and the transportation sector.

As potential RNG consumers that account for more than 50 per cent of current natural gas consumption in Canada, large industry and power generation can play a significant role in the growth of a viable RNG marketplace. Environment Canada's emissions regulation for coal power generation, introduced in 2012, is a signal to other large industry of the role they are expected to play in the federal government's greenhouse gas (GHG) agenda and RNG can be a key part of their response. While not prescribed by Environment Canada, industry's compliance options must be recognized and verified by the department. Currently, renewable natural gas is not recognized and should RNG be recognized, its interchangeability with natural gas would allow industry to become a major adopter and driver for RNG facilities in Canada.

In the transportation sector, renewable natural gas offers an interesting opportunity in that not only can it be blended or used as the exclusive fuel in various forms (CNG or LNG), it has the highest energy conversion of feedstock–to-fuel of the currently available sources of renewable transportation fuels.[2] In Canada, the means to validate the renewable natural gas composition for the transportation fuel sector is not yet established. To realize the benefits of this option, a reliable and transportable accounting mechanism needs to be established. Then, introducing renewable natural gas as a voluntary subscription product would be an attractive method for adoption in this sector.

Recommendations

To overcome the barriers, take advantage of the opportunities, and to realize the benefits presented by a vision of ***a fully-developed renewable natural gas marketplace by 2020,*** this technology roadmap makes the following recommendations:

Recommendation 1: Introduce Policy Tools to Incent the Market

Explore the introduction of government programs and policies that could spur the renewable natural gas marketplace. Further, ensure government recognition of renewable natural gas as an energy end user compliance option for reducing greenhouse gases.

Recommendation 2: Collaborate and Invest in Technology Solutions

Invest in technology priorities, the highest of which is applied biomass gasification research to bring this technology to full commercialization.

Recommendation 3: Provide Education/Awareness to Key Stakeholders

Research and source reliable data to strengthen

[2] Driving performance, measured as km/ha is 23,300 from biodiesel from canola, 24, 400 from corn ethanol, and 67,600 from biogas from corn silage. Data from Biomotion Biofuels, as quoted in *Vehicle Conversion to Natural Gas or Biogas*, Ontario Ministry of Agriculture, Food and Rural Affairs, August, 2012.

the renewable natural gas value proposition and effectively communicate the potential of renewable natural gas in a sustainable energy future for Canada. Further, the RNG industry should develop a central repository for information sharing as a tool to communicate RNG project success and best practices. This repository can be used by potential RNG hosts, project managers and others looking for the necessary steps and information that is critical for RNG project success.

Recommendation 4: Establish Necessary Rules and Standards between Utilities and Producers

Establish gas quality and metering standards, rules for pipeline connection, protocols for sharing data and conditions for accepting renewable natural gas at different points in the gas pipeline system.

Recommendation 5: Determine Green Attributes and Encourage Waste Diversion Policies to Support RNG

Develop a national standard to define, recognize and label the green attributes of renewable natural gas. Further, support energy recovery, and specifically renewable natural gas, as a component of the waste diversion hierarchy.

Recommendation 6: Explore the Use of Renewable Natural Gas for Vehicles

Investigate the natural gas and vehicle market impacts of a renewable natural gas supply for natural gas fuelled vehicles.

Next Steps

Given the recommendations above, the RNG Roadmap stakeholders and broader industry partners will have to assess and prioritize what of the recommendations they wish to implement and in what order. Ultimately, the RNG industry is committed and will work collectively towards achieving the RNG Roadmap vision, that is:

"By 2020, Canada has a fully developed RNG marketplace that meets the energy needs of Canadians, supports growth and innovation for business, and offers a solution to issues associated with waste and emissions."

2.0 What is Renewable Natural Gas

For the purposes of this Technology Roadmap, Renewable Natural Gas (RNG) is defined as methane gas derived from organic materials and waste streams that has been produced and cleaned (had impurities removed) to a level that meets current natural gas pipeline specifications set out by gas utility companies, or that meets natural gas vehicle fuel standards set out by engine manufacturers.

How RNG is produced

There are three main sources of inputs or "feedstocks" suitable for producing RNG:

1. Agricultural and agri-food sources such as unused crop residues, animal manure and food processing waste;
2. Forestry bi-products such as wood waste generated during harvest operations;
3. Municipal solid waste and bio-solids from wastewater.

RNG can be produced from these feedstocks using either *anaerobic digestion*, an established technology best suited for producing RNG from relatively wet feedstock and *gasification*, which is a rapidly developing technology best suited for producing RNG from relatively dry feedstock.

Anaerobic Digestion (microbial process)

Anaerobic digestion (AD) is a natural process of decomposition of organic materials by microbes in the absence of oxygen, in which biogas is produced. Anaerobic digestion occurs in landfills and sewage treatment and in industrial processes to convert manures, agri-food residues, industrial by-products and sorted municipal wastes to biogas.

The resulting biogas contains a much lower methane concentration than conventional natural gas[3] and can be used on-site with minor processing for its heating value or to run an electricity generator. However, upgrading technologies are available that can produce a clean, high energy RNG suitable for direct injection into existing natural gas pipeline infrastructure and able to be mixed with conventional natural gas.

Gasification (thermal process)

Biomass gasification is a high temperature (>500 °C) process in which organic material is converted into syngas in the presence of oxygen and/or steam. The syngas can be converted into RNG through a process called methanation and then be introduced into the natural gas pipeline infrastructure and mixed with conventional natural gas.

Gasification of coal is used on a large scale in power plants, where syngas is used as a fuel in gas turbines. Gasification of biomass material (such as wood waste) is in its development phase but progressing rapidly.

Gasification has some advantages over anaerobic digestion. First, a wider variety of non-homogeneous feedstocks that can be utilized, almost any type of organic material can be used as gasification feedstock, including forestry and agriculture residues, and sorted municipal waste. Second, the methane yield is higher. Production of methane from biogas through anaerobic digestion generally converts 20 per cent of the material while gasification, depending on the process and material utilized, can achieve from 65 per cent to 80 per cent conversion yield.

[3] Biogas is typically comprised of 50 per cent-60 per cent methane (CH4), 40 per cent-50 per cent carbon dioxide (CO2), with varying levels of hydrogen sulfide (H2S) and other trace compounds.

3.0 Canada's Renewable Natural Gas Opportunity

This section includes a vision for RNG in Canada, describes the infrastructure and supply foundations on which this vision can be realized and outlines some of the operational RNG projects in Canada for context.

Vision for RNG in Canada

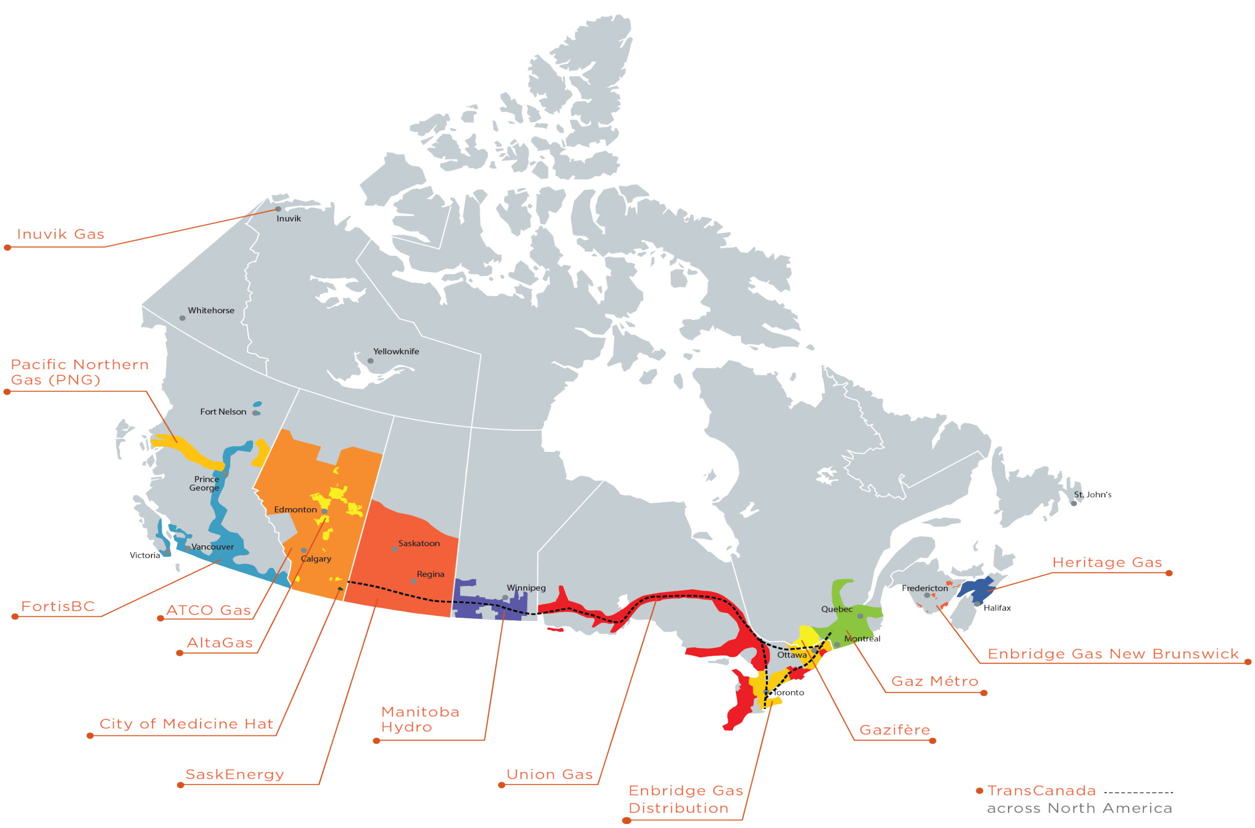
By 2020, Canada has a fully developed RNG marketplace that meets the energy needs of Canadians, supports growth and innovation for business, and offers a solution to issues associated with waste and emissions.

The Foundation – The Natural Gas Pipeline Infrastructure

The Canadian natural gas pipeline system is part of the larger North American natural gas market – a fully integrated system connected by over 4 million kilometres of natural gas transmission and distribution pipelines that fuel over 200 million homes, businesses, institutions, and industries all over the continent. This system links vast natural gas supply sources to demand centres across North America, and the pipeline transmission and distribution network operates with nearly 100 per cent reliability.

Natural gas has an established history in Canada, with the first well being drilled in Alberta over 125 years ago. Since this time, Canada has grown to be both a significant producer and consumer of natural gas. In fact, Canada ranks third globally in natural gas production. Currently, natural gas meets over 30 per cent of Canadian domestic energy needs, second only to petroleum products.[4] This versatile fuel is the single largest source of energy for Canadian homes and industry and is a growing source of input fuel for the generation of electricity and in transportation.

The extensive Canadian pipeline and underground gas storage network and the interchangeability of RNG with conventional natural gas means that in many cases, RNG can be introduced at its point of production, and transported and transported/delivered to the end user without a significant modification to pipeline infrastructure or to the end user's natural gas burning equipment.



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[4] "The Facts on Canadian Natural Gas", Canadian Natural Gas, www.canadiannaturalgas.ca/media-library/factsheets/natural-gas-fact-book

The Foundation – Canada's RNG Production Potential

Over the past 25 years, governments and industry have made significant investments in developing and producing energy from renewable sources including biomass, solar and wind. However, there has yet to be a targeted push towards harnessing renewable energy in the form of RNG despite the size and potential of the RNG resource as a renewable fuel option for Canada.

Estimates from the 2010 Alberta Innovates Technology Futures (formerly the Alberta Research Council) study, *"Potential Production of Methane from Canadian Wastes"*, suggest the Canadian potential is equivalent to 1300 billion cubic feet (bcf) per year[5] – slightly over half the current annual consumption of gas (2500 bcf/year) in Canada.[6]

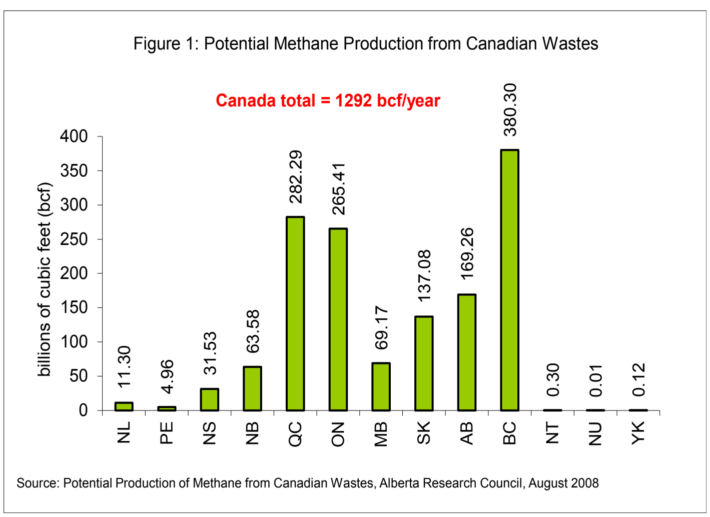
The use of gasification has the potential to produce most of the RNG in Canada (84 per cent of the total) while anaerobic digestion has the potential to produce 16 per cent of total. While AD could ultimately contribute a much lower percentage of the total RNG supply, it is still significant because of the greater availability and lower cost of AD-based RNG production technology.

From a regional perspective, the largest potential for RNG exists in British Columbia, followed by Ontario and Quebec due primarily to their large biomass resource base.

From a GHG reduction perspective, Canada's RNG potential could offer reductions of 108 metric tonnes of carbon dioxide equivalent (MT CO2/eq). If just 10 per cent of this total was realized it would be equal to the removal of 1 million cars from Canadian roads or meeting approximately 10 per cent of Canada's Copenhagen Climate Change Commitment to reduce GHG's by 17 per cent by 2020 (from 2005 as a baseline year).

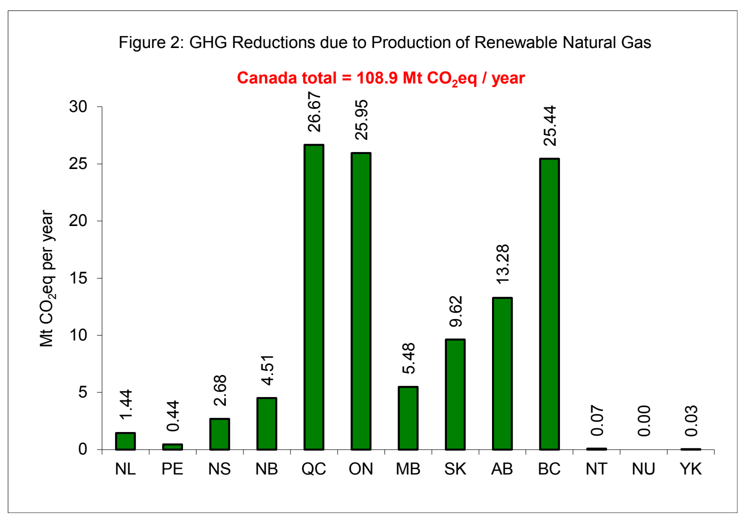
CANADA's RNG POTENTIAL

RNG Production Potential



10 per cent of the potential is gas for 1 million homes in Canada

RNG Carbon Offset Potential



10 per cent of the potential = 1.8 million cars off the roads

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[5] *Potential Production of Methane from Canadian Wastes,* Alberta Innovates – Technology Futures, www.cga.ca/pdfs/RNGpotential.pdf

[6] Salim Abboud et autres, Alberta Research Council et Association canadienne du Gaz, *Potential Production of Methane from Canadian Wastes*, septembre 2010, p. viii

The Foundation – Building on Current Operational RNG Projects

While the potential for production of RNG in Canada is significant, the number of projects in operation remains limited due to lack of awareness and higher initial costs associated with the early phase of RNG development in Canada. The current projects in Canada are summarized in Table 1.

The Berthierville project was the first to begin operation in Canada and is currently injecting RNG into the Trans-Quebec Maritime (TQM) pipeline in Quebec.

Fraser Valley Biogas in Abbotsford (formerly Catalyst Power Inc.) combines anaerobic digestion and a biogas upgrading plant to produce RNG primarily from on-farm agricultural waste. A small amount of off-farm waste is delivered from a local food-processing plant. FortisBC operates the interconnection facility at this project, monitoring gas quality and connecting this source of RNG directly to its customers. It began producing RNG in 2010.

The City of Hamilton, ON has been utilizing the biogas from the anaerobic sludge digestion at the Woodward Avenue Wastewater Treatment Plant to generate electricity since 2006. In 2011, the City of Hamilton began producing RNG with excess biogas generated at the site and injecting it into Union Gas's nearby distribution system.

At the Salmon Arm, BC landfill, FortisBC and the Columbia Shuswap Regional District (CSRD) partnered to upgrade and inject RNG derived from landfill gas into the local distribution system. In this case, FortisBC is purchasing raw landfill gas from the CSRD and it will own and operate the gas purification plant in addition to the interconnection facility and gas quality monitoring. It was commissioned in 2012 and first injected RNG into the pipeline in March 2013.

Table 1. List of Canadian RNG Projects

PLACE	SUPPLIER	SUBSTRATE	TECHNOLOGY	PLANT CAPACITY (Nm3/h raw gas)	iN OPERATION SINCE
Berthierville (QC)	UOP	Landfill gas	Membrane		2003
Abbotsford (BC)	Greenlane	Codigestion	Water wash	750	2010
Hamilton (ON)	Greenlane	Wastewater treatment gas	Water wash	800	2011
Salmon Arm (BC)	Xebec	Landfill gas	PSA	300	2013
Kelowna (BC)	ARC Technologies	Landfill gas	PSA	900	2014
PLANNED					
Delta (BC)	Greenlane	Codigestion	Water wash	400	2014
Chilliwack (BC)	Unknown	Codegestion	Unknown	400	2015
Richmond (BC)	Unknown	Wastewater treatment gas	Unknown	150	2016

4.0 Challenges to Meeting Market Potential

Successful RNG projects are those for which there is a positive alignment of a range of factors. This chapter outlines the challenges associated with building stakeholder awareness and around individual factors of project economics and costs, regional differences, pipeline access, feedstock, and technology.

Stakeholder Awareness

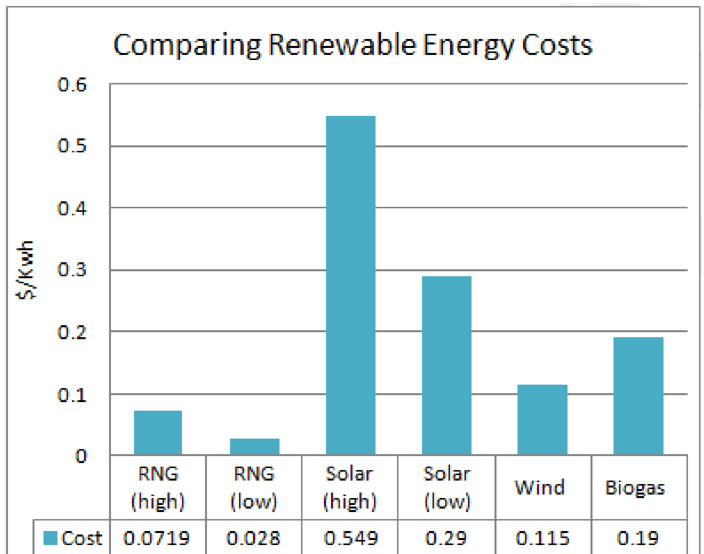
Building awareness around the potential for RNG in a sustainable Canadian energy future will be front and center to the long term success of RNG. While the waste management potential of producing RNG from manures, residues, agri-food wastes and sorted wastes is attractive, both public opinion and regulations indicate concerns about contamination of the environment and the proliferation of pathogens. As indicated in the recommendations of this report, the RNG industry should collaborate to develop a common set of messages and materials that could be used by the industry to engage and educate the key decision-makers and stakeholders who will be instrumental in realizing Canada's RNG potential.

RNG Project Economics & Costs

The cost of RNG varies significantly depending on the scale and location of a project. Generally, larger landfill projects have RNG supply cost estimates as low as $8/GJ. RNG supply costs for smaller projects, such as small-scale farm-based anaerobic digestion projects, are upwards of $15-20/GJ. The main drivers for the higher cost of RNG include costs associated with collecting feedstock and the capital equipment costs to removing impurities from the biogas in order to bring it to pipeline quality RNG. In the case of landfills, costs are associated with collecting and upgrading raw biogas and connecting to the pipeline. For other applications, costs can be broadly categorized into four components: converting feedstock to gas; upgrading; metering and monitoring; and connecting to the pipeline. The costs associated with each of these components will vary depending on the volume of gas and location of the facility.

Access to the gas pipeline network is an important cost consideration. Terrain and existing local conditions such as roads and existing infrastructure, also need to be understood. For projects that are too distant from the pipeline system, there is the option of compressing the RNG to use on site or for delivery by truck to natural as consuming markets.

To understand the full value of any RNG project the cost of RNG should be compared to other renewable energy options in addition to comparisons with the current market prices for natural gas.[7] The figure below presents various renewable energy costs include large and small scale RNG projects, wind power, solar power (small and large scale) and electricity generated from biogas. What is shown is that RNG is a cost effective renewable energy option when compared to prices offered for renewable feed in tariff (FIT) electricity sources.



Sources: RNG costs are estimates ($8/GJ and $20/GJ) based on various project sizes. The RNG $/Kwh values, above, are based on heating value of the gas. All other renewable costs are from Ontario's FIT Program for electricity.

Regional Differences

RNG is a new commodity in Canada and regional differences persist. Variations in provincial regulation of local distribution companies, terminology, and RNG quality management requirements are all challenges facing the RNG sector. But since utilities operate within a regulated environment, tariffs and rates to recover costs from customers must be approved by regulators. This includes and

[7] The market/spot price for natural gas varies depending on continental supply and demand. The average price in 2008 was $8/GJ and has fallen in recent years to $3/GJ due to robust supplies of natural gas. More information on the affordability of natural gas prices can be found here: http://www.cga.ca/

tariffs for treatment of RNG. Not surprisingly most Canadian utilities and regulatory authorities have not established tariff structures specific to RNG and the investment required to connect RNG into the natural gas system. Without an approved tariff, utilities cannot recover any associated cost such as any price differential between RNG gas supply and conventional natural gas supply.

Given that energy utility regulation is largely a provincial concern, there is no commonly accepted approach or standard to guide RNG suppliers looking to connect to the existing natural gas systems. Each project can have significant differences in items like supply pressure, piping material, safety features and connection points that can vary across utilities. Further, RNG projects face different jurisdictional codes, standards and environmental regulations including codes for pressure vessels, pressurized equipment, and environmental approvals and permits. Some of these codes and standards are well understood having been well established and used in industrial applications for many years. Other requirements may be imposed on an ad hoc basis by jurisdictions that have less experience with natural gas or that are unfamiliar with RNG.

Pipeline Access

Gaining access to the pipeline distribution network is a key hurdle for any RNG project. Access must be facilitated by a willingness of the gas utilities to have RNG in their networks. Canadian gas utilities Enbridge Gas Distribution, FortisBC, GazMétro, and Union Gas have all demonstrated willingness to accept RNG, though each has their own technical specifications for gas quality, grid connection and capacity management.

Utilities need to ensure the quality of the gas in their systems as this affects the reliability and potentially the safety of the system. Utilities must consider the impacts of the RNG product on their pipeline networks before considering RNG additions to the pipeline.

Prior to RNG being injected into a pipeline, it must meet the pipeline's established gas quality standards, particularly any limits regarding trace components, and heating value of the RNG. The technical specifications in the Bureau de normalisation du Québec (BNQ) standard[8] and Canadian Gas Association (CGA) guidelines[9] are very similar and a number of utilities have a list of criteria available. The CGA guidelines are available on the CGA website.

Responsibility for gas quality analysis, metering of the volumes accepted and its odourization and other safety measures are also the responsibility of the utilities. Analysis and metering can become a barrier if it is not clear what the measurement standards are or what the required protocol are for access by the utility to RNG metering equipment and other exchanges of data between the RNG producer and the utility distributor.

A further element affecting RNG access to the distribution network is capacity management. Capacity management refers to the ability of the grid at the injection point to accept the full RNG production at all times of the year. Grid connection becomes a barrier if there are no clear and appropriate criteria defining when and how a producer can get connected, or what volume of RNG they can inject into the network. This would include criteria for handling potential interruptions in RNG injection and rules for compensation in those situations. The grid carrying capacity must be accurately evaluated particularly to understand situations when gas consumption is at its lowest (warm summer nights, for example) and RNG production may be at its peak. It is reasonable to expect times when no RNG can be injected due to scheduled network downtime, breakdown, capacity-sharing, or quality reasons.

Feedstock

Achieving Canada's RNG supply potential will require a dedicated effort by the industry to contract with and compete for available RNG feedstock supply. Feedstocks such as biomass are already valued for their ability to generate other forms of energy, namely power and heat.

The potential limitation to achieving crucial economies of scale that is imposed by feedstock supply is most notable in the agricultural and agri-food sectors. Scale can be increased by

[8] *BNQ 3672-100/2012 Biométhane : spécifications de la qualité pour injection dans les réseaux de distribution et de transport de gaz naturel, Bureau de normalisation du Québec,* juillet 2012

[9] *Biomethane Guidelines for the Introduction of Biomethane into Existing Natural Gas Distribution and Transmission Systems*, Association canadienne du gaz, février 2012.

acquiring low cost feedstock. However, many Canadian jurisdictions do not have clear regulatory pathways to mix off-farm material with manure and agricultural bi-products while still maintaining the agricultural designation of the farm or of the effluent digestate. Those jurisdictions that do have clear regulations require pre-processing of the off-farm material to neutralize pathogens which adds a processing cost.

In general, manure has a low energy density, meaning that if you want to consolidate larger volumes for RNG feedstock it may only be economical to transport it less than two kilometres. Similarly, agricultural crop residues are generally light and fluffy, and also of low energy density. Consolidating sufficiently large volumes of agricultural-residue RNG feedstock from several producers to one site can be expensive.

Courtesy of FortisBC

Urban organic waste and food processing bi-products are feedstocks that can be available on a larger scale, enabling larger biogas systems that match the scale needed for economic biogas upgrading.

Municipal solid waste operations are not yet contributing to RNG supply. There is a growing trend to sort municipal wastes and to assign particular waste streams to different processing. While the intention is to relieve landfill capacity by such waste diversion, the sorting and processing is more costly than previous landfilling. For large municipal waste-based biogas systems the difficultly may be to find suitable locations because of zoning limitations and proximity to concerned neighbours. The added costs of extensive odour control systems or significant setback distances are required to minimize potential odour impacts for neighbours. Of particular concern are the material unloading and handling buildings. Environmental assessments and meeting the requirements to have authorization certificates can be a significant expense.

For facilities that look to use gasification of biomass to produce RNG, challenges arise from the reduced scale of production and the wide variety in the quality of the biomass feedstock. Even with seemingly uniform biomass inputs like wood chips, a premium forestry sector feedstock, there can be major differences in characteristics and properties among batches, due to different chippers, different material, and different moisture content. The cost to securing an acceptable consistent quality of long term biomass supply is a key barrier to RNG production from gasification.

Technology Limitations

Each RNG project site is different and most project developers will have specific priorities for their project, including integration into existing farm or waste treatment facility operations. The financial viability of RNG projects must be clearly established at a project's outset to attract funding. In general, the adoption of low-cost AD-based systems that result in lower energy yields or RNG projects that require more operational effort (for instance, when controls are not all automated) put the viability of these projects at risk. Technology solutions do exist for these shortcomings. Developers can retrofit advanced controls or equipment onto systems but this changes the economics of projects that were initially lower cost.

The RNG production technologies, process design, and facility layout to produce pipeline quality RNG vary depending upon the biogas stream that is available. Processing of both the biomass inputs and biogas output continues to be a significant capital and operating expense for any RNG project. The size of available commercial RNG upgrading equipment does not reflect the scale of farms that operate in many parts of the country. The lack of smaller sized upgrading equipment limits the number of farms that can collaborate to produce RNG. There is an identified need for the fabrication of smaller units to meet smaller amounts of available on-site RNG feedstock.

A key technical challenge to biomass gasification is in raw syngas cleaning to remove chemical and solid impurities that impact the process of converting the syngas to methane and, in turn, RNG. The most challenging contaminant to deal with are the tars that are formed during the chemical reactions in the gasification process. While the use of very high temperatures for gasification generally reduces the amounts of tar produced, this increases the cost of the equipment and the operation. Ongoing research into making the gasification of biomass into syngas suitable for an RNG process is focusing on using oxygen and chemical reactor designs that reduce the formation of tars by retaining the tar precursors for longer periods at high temperatures. Syngas cleaning can cost more than feedstock procurement and initial gasification.[10]

Current research activities in gasification reactors and the cleaning of raw syngas in biomass gasification are looking to respond to these performance concerns.

[10] Salim Abboud et Brent Scorfield, Potential Production of Renewable Natural Gas from Ontario Wastes, Alberta Innovates Technology Futures, mai 2011

5.0 Achieving the Renewable Natural Gas Vision

This section describes the contributions that potential RNG producing and consuming sectors can make to achieving Canada's RNG market potential. The sectors discussed below include large industry and power generation; transportation; residents and businesses; farms and the agri-industry; forestry; and municipalities. Municipalities can act both as consumers and producers and are treated separately.

Large Industry and Power Generation

Large industry is a significant consumer of energy, accounting for 30 per cent of all Canadian energy demand in 2011.[11] The dominant fuel used is natural gas, which meets a third of industrial energy needs, mainly for heat requirements.

This energy use profile of large industry, combined with its existing pipeline connection to natural gas supply, make this sector ideal for RNG consumption. Further, by 2020 many large energy consuming sectors will be required by federal regulation, led by Environment Canada (EC), to reduce their greenhouse gas emissions, again making them a perfect target for RNG use. The first such regulations came into force in 2012 for coal-fired power plants. The next sectors to be regulated include oil and gas (oil sands, gas processing plants, oil refineries) and natural gas-fired power plants, followed by various large industrial sectors. The method, or compliance options, by which an industry reduces its emissions is not prescribed by EC, however compliance options must be recognized and verified by EC.

Plant

In addition to federal GHG reduction regulations, a number of provinces have in place or are advancing regulatory mechanisms to reduce GHG's including in British Columbia, Alberta and Quebec where carbon taxes are paid by consumers and/or industry. Also, Quebec is part of the Western Climate Initiative, a carbon cap and trade system with California. Further, most provinces and territories have or are examining commitments to reduce the GHG emission levels.

For industry, RNG is an attractive low carbon option given it is 100 per cent interchangeable with natural gas. This interchangeability would allow industry to remain in operation without having to shut down to replace or upgrade equipment. Using RNG also does not trigger the technology risk associated with changing a successful process and/or introducing new equipment or process steps. This is a significant consideration in a capital constrained financial environment. Further, industry would be supporting a renewable, domestic, green energy source while helping to monetize and manage waste streams.

However, there are a number of challenges and barriers that must be addressed before large industry can become significant consumers of RNG in Canada. RNG is relatively new in Canada and to date there has not been a concerted effort to educate Canadian policy makers and the general public on the product. There is a considerable lack of understanding about what RNG is, what the RNG potential for Canada is and the role RNG can play as a carbon-neutral fuel. Simply put, raising RNG awareness has not been a focus for government bodies and the use of RNG as a method to meet GHG reduction regulations has not been accepted by most governments in Canada. Second, there is the need for more fulsome dissemination of RNG project economics and costing information to allow potential RNG end users and customers to compare the cost of buying RNG or financing an RNG project to alternative compliance options such as new equipment upgrades or other efficiency investments and programs.

[11] Statistics Canada, Report on Energy Supply and Demand

Transportation

RNG is increasingly being used as a transportation fuel. The drivers for this are regulation and taxes on waste disposal, increasing the need for renewable fuel sources. In Europe, the European Commission's Biofuels Directive measures to improve local air quality, and the need for clean transportation fuels in urban areas has helped push RNG adoption.[12] Similar regulations and treatment for transportation uses of RNG compared to natural gas and fossil fuel options are not established in Canada.

That said, natural gas is currently significantly cheaper than gasoline and diesel fuel in Canada and as a result there is already a significant supply side response to the increasing market interest in using CNG and LNG for heavy duty and light duty vehicles. But given the lack of public refueling infrastructure, companies that invest in these vehicles must also install refueling stations. Return-to-base vehicles, usually fleets, are well suited to CNG or LNG and would enjoy similar cost savings.

Since RNG can be used interchangeably for natural gas and since RNG can be injected anywhere on the natural gas grid and wheeled to LCNG filling stations through gas marketing contracts, the demand potential for RNG from this market is apparent.

RNG is the environmentally preferable vehicle fuel because it essentially captures and neutralizes previously emitted methane and converts it into a high energy fuel. This methane capture and neutralization means a little RNG goes a long way in reducing GHG emissions. For example, if a transportation end user were to blend just 10 per cent RNG to their CNG or LNG, the carbon reduction benefit of switching from diesel to LNG or CNG is enhanced, bringing the total GHG benefit to approximately 50 per cent versus diesel or gasoline.

An attractive method to encourage the uptake of RNG as a transportation fuel is to include RNG as a "voluntary subscription" product. Since the RNG would be sold through the established mechanism of gas market contracts, any "subscribed" percentage of renewable RNG content can be blended in to accommodate the consumer's needs for a specific RNG content. Any percentage of RNG content in the vehicle fuel can be accounted for directly at the fuel pump. As this would be an optional product offering, pricing will be determined by market-driven demand. In jurisdictions like BC and Quebec where carbon taxes or emission caps are in place, consumers can benefit from avoided carbon costs, currently at \$30/ton CO_2e and \$10/ton CO_2e respectively.

Creating a flexible and transportable RNG product aligns with the initiatives outlined in the "*Deployment Roadmap for Natural Gas Use in the Canadian Transportation Sector*", which was facilitated by Natural Resources Canada, and involved a range of stakeholders. Some organizations and associations are helping promote RNG as a vehicle fuel such as the Biogas Association who has published a guide for the agricultural sector in 2013 called "*Farm to Fuel: Developers' Guide to Biogas as a Vehicle Fuel*". Despite the significant potential for natural gas and RNG to make a meaningful contribution to Canada's commitment to reducing GHG's, there remain technical, cost and policy impediments to large scale market adoption. Through this Roadmap, the industry will look to collaborate on solutions that will eliminate the technical and market barriers to wider adoption of natural gas and RNG for vehicles in Canada.

Residents and Businesses

Currently a number of individual consumers and businesses voluntarily pay a premium to certain renewable energy providers or their local utility to support and actively participate in the growth of renewable energy in Canada. In 2011, Bullfrog Power became the first entity to launch a RNG environmental attributes offering to consumers across Canada. FortisBC also offers its customers an option to buy RNG. The growing voluntary market for renewable energy in Canada and the US proves

12 National Society for Clean Air and Environmental Protection, Biogas as a Transport Fuel, juin 2006 http://www.cleanvehicle.eu/fileadmin/downloads/UK/nsca_biogas_as_a_road_transport__084926300_1011_24042007.pdf

that consumer demand can play a vital role in the development of the RNG market in Canada.

The biggest barriers to widespread adoption of RNG among residential and small and medium enterprise (SME) customers are the cost, the availability of RNG, and the lack of awareness among consumers. Several specific strategies and tactics can be used to overcome these barriers and increase RNG adoption in these sectors.

One of the easiest ways to reduce the cost barrier is to offer a blended product. This is possible because of the interchangeability of RNG with natural gas. This could be achieved in a manner similar to what FortisBC has done, where customers choose to pay for a 10 per cent blend of RNG. Or it could be achieved by blending RNG into the overall gas supply. In either case, the full price premium of RNG is diluted by mixing it with the costs of conventional natural gas. By overcoming the cost barrier in these ways, utilities can make RNG available to their customers.

Awareness can be tackled in a similar manner to any new product introduction. FortisBC began marketing RNG by targeting messages to those customers who are more likely to take action – namely, their "green" customers. By targeting those early adopters, it is easier to build support for broader uptake. Customer recognition for early adoption and participation can also be a good tool.

Targeting customers in areas where RNG is produced can also be effective, since residential customers are likely to have a stronger connection with the projects, and a stronger interest when they feel they are investing where they live.

Producers

The main sectors that have potential to produce RNG are the farm, agri-industry and forestry sectors and municipalities.

Farms and Agri-Industry

Farm-based and agri-industrial biogas systems will be an important near-term contributor to the supply of RNG. While other sources of RNG are limited in their number and location (landfill and sewage biogas), or maturity of technology (gasification), the opportunity to deploy farm and agri-industry biogas systems widely today is largely limited by RNG offtake prices. Experience with electricity-based biogas systems in Europe has shown that feedstock supply, technology scale, and access to capital are not significant barriers when suitable financial incentives are in place.

Building farm-based and agri-industrial biogas systems at a large enough size to achieve improved economies of scale will be an important first step in this sector becoming a significant RNG production source. There are two potential approaches to achieve this critical size:.

1. Develop Large Farm-Based Systems
Securing sufficient feedstock supply in rural areas to achieve minimum efficient size can be achieved in several proven ways:

- *Mix off-farm materials with agricultural inputs*: Certain jurisdictions in Canada have established regulatory approvals which allow the mixing with up to 50 per cent off-farm materials. Although uncommon today, several medium-sized livestock facilities can economically combine their manure, transporting it by either by pipe or by truck, as long as they are within approximately five km of each other. Farms can also secure larger supplies of off-farm materials from food processors and organic waste suppliers, potentially enabling many mid-sized livestock farms to establish RNG projects. Thus, supply of inputs is not constraining in this context.
- *Use high-output agricultural energy crops:* Germany has paved the way demonstrating the use of corn silage as an energy crop fed directly into the RNG system. Using energy crops as an input means the siting of the RNG system is relatively independent of other constraints and can be sited according to where pipeline capacity allows interconnection. In general, using energy crops as the input to RNG production results in a higher cost of production because of crop production costs, compared to waste inputs.

2. Develop Large Agri-Industrial Systems
Recent developments in the regulations that control waste processing combined with the costs associated with conventional processing of wastes (i.e., landfilling of the entire unsorted municipal waste stream) have created an opportunity to use anaerobic digestion technology to process sorted wet organic wastes to create biogas suitable for RNG production.

Building biogas and associated RNG production systems at host waste generation sites or in industrial areas has the advantage of capitalizing on on-site synergies such as waste heat sharing, availability of existing on-site advanced technology for waste management and handling, or separating different streams of mixed waste. There are several models for this approach:

- *Locate at host waste generation sites*: Using on-site generated waste such as brewery or slaughterhouse waste, and reducing organics in wastewater, can build on cost savings from reduced sewer discharge fees. Typically, food companies will not bring in waste streams from other locations because of various limitations (space, waste approvals, non-core business activity), resulting in limits on the size of possible RNG systems.
- *Create waste management biogas systems*: Large waste management biogas systems have the opportunity to install large-scale materials separation equipment allowing variable waste streams to be used, including those with plastics and packaging contamination. By being located in existing industrial areas, there will often already be significant air emissions controls in place to minimize nearby nuisance issues. This type of system can be built large enough to employ existing biogas upgrading equipment competitively, and is generally only constrained by the market value of RNG compared to other green energy opportunities such as electricity generation.


Digester Pipes

Technology Considerations

RNG technology for the farm based and agri-industrial sectors is reasonably mature. These sectors have witnessed significant growth of RNG production around the world since the 1990's which has in turn signalled the market to develop innovative products. However, there remain opportunities to improve RNG project economics and the biogas and RNG production/cleaning processes through the development of more standardized equipment, for both AD and upgrading. Further, other areas for AD technology improvements include N2/O2 removal efficiency for landfill gas and improved digester stability and efficiency.

Forestry

Forest products residue streams can be used to produce RNG through both gasification and methanation. While this is a longer term opportunity, it has the potential to deliver significant domestic value, and should be considered an alternative to producing and shipping wood pellets to distant markets.

The gasification pathway would be the process of choice for RNG production from forestry residue. Gasifier manufacturers, which include some Canadian companies, could team up with Canadian consultants, research centres and universities to develop a first Canadian forestry-residue based RNG gasification demonstration project. Such collaboration could benefit from European experience in RNG production from biomass. A demonstration project would contribute to improving the Canadian RNG production portfolio and help the commercialization of this technology pathway for RNG production in Canada. It would also serve to address the remaining technological issues, which consist mainly of feedstock quality management, gas cleaning, and process integration.

Managing Feedstock Supply

RNG production from forestry residue on a large scale should be done in partnership with the regional forest products industry. RNG production should not adversely impact the forest products industry, but rather act as a revitalizing element.

Stakeholders have identified inconsistent feedstock quality as a concern given the range in woody biomass sources. One solution would be to implement a feedstock quality control process.

The integration of RNG production in this sector with existing combined heat and power (CHP) plants or pulp mills should be evaluated as potential approaches for utilizing excess heat from the RNG process. A co-location site will likely offer numerous advantages for an early demonstration plant, such as sharing existing infrastructure and skilled technical support, and providing additional revenue streams to the site. Co-location within an existing facility is likely to reduce both technical and financial risk. The costs of large-scale future plants will decrease with additional large-scale experience.

Technology Considerations

Forestry-residue based gasification technologies are being pilot tested in several jurisdictions. The International Energy Agency (IEA) Task Force 33, has an interactive map/database of gasification projects and the associated manufacturers around the world. A technology brief is included in each project summary.

Priority areas for collaboration among governments and industry include applied research and technology development related to biomass gasification, non-precious metal catalysts, syngas cleaning technologies, and integration of biomass gasification systems

It is important to consider that within the forest sector that RNG will need to compete with the other uses for the forestry-residue biomass. This includes uses such as combined heat and power production and/or the production of other bio-fuel and bio-products. Ultimately, the successful technology will be the one that offers the highest rate of return.

The forest sector is continually evaluating technologies and products which will improve the profitability of their operations. Therefore, improving technologies that gasify, methanate and clean biomass syngas are technology priorities for the RNG industry.

Municipalities

RNG has multiple benefits for municipalities, both from the supply side and the demand side. On the supply side the main benefits are extracting value from waste, reducing liability for landfill operations through waste diversion, cutting landfill GHG emissions and strengthening the local infrastructure and economy. As sustainability and good stewardship choices are top of mind for many local governments, the main benefit will be the possibility of greening their operations, for example by using RNG in heating of buildings or for transportation.

Municipal RNG Supply

Landfills, source separated organic (SSO) treatment facilities, and wastewater treatment plants (WWTP) have, collectively, been identified as large sources of biomass feedstock and in turn RNG supply in Canada.

Raw landfill gas is already being produced at large scale, and is the most cost-effective near-term source of RNG. Currently, landfill gas is usually captured and flared to meet environmental regulations, or burnt for its heating value, or used to generate electricity on-site. However, for landfills that are located near a natural gas pipeline and are of sufficient scale, RNG production may be the preferred option. Harnessing the energy content of urban organic waste allows municipalities to realize the economic, environmental and social benefits for residents and businesses.

Landfills are considered to be a preferred location for municipal digesters because of the following factors: preferential zoning; existing collection infrastructure; less concerns about odour and more experience with its control and containment; existing waste management expertise and equipment; availability of space and generally lower cost of land; ability to handle condensate; and integration with existing landfill gas collection improves economies of scale.

In Quebec, the provincial government is investing in municipal AD facilities and is phasing in a ban on sending biodegradable organics to landfills. This will help divert this material towards RNG production in that province. In Ontario, some industry associations are working with relevant government ministries on examining a similar ban on putting biodegradable organics in landfills. In BC, leading municipalities such as Metro Vancouver and Surrey are phasing in bans on biodegradable organic waste.

The small scale collection of SSO in many

Canadian communities limits the usefulness of this waste stream for RNG development. Communities that allow the mixing of yard waste with SSO may render the SSO unusable for AD, so separate SSO collection is best for RNG. Further, new SSO facilities can be located close to suitable pipelines.

Landfills have established collection infrastructure and many have collection systems already in place that can be used for RNG production, provided they are located near a suitable natural gas pipeline. SSO treatment facilities can also be co-located with landfills to maximize the economic investment in upgrading, compression and injection equipment. MSW gasification plants may also be well suited to these locations.

The energy potential from WWTP will continue to grow with population growth. The feedstock challenge in this case is that some communities prefer to operate smaller, decentralized treatment facilities, which affect the economics of RNG production.

Technology Considerations

Landfill gas has high concentrations of nitrogen and oxygen due to the intake of air by the gas collection system. This restricts the technologies that can be used to produce RNG from this feedstock source, driving their capital and operating costs higher. This can be mitigated by the scale of landfills because larger landfill projects are more cost effective.

Some SSO collection systems are heavily contaminated with material such as plastic bags, diapers and personal hygiene products. However, technology providers have developed pre-treatment technologies to overcome this hurdle, so municipalities can accept a wide range of organic waste and maximize resident participation.

Municipal RNG Consumption

Municipalities are potentially large RNG consumers as well. Some of the challenges to increasing RNG consumption within municipalities centre on the higher cost of RNG versus incumbent energy options and a general lack of awareness of the RNG option.

As described previously, blending strategies can be used to reduce the cost impact of RNG adoption. Additionally, a municipality could designate 100 per cent RNG for use at a single facility such as a community centre or City Hall, while still using traditional natural gas at its other facilities. A municipality could also promote access to RNG for local industries to draw in new businesses to their locality. Local industries would be able to use RNG to meet any upcoming GHG regulations without threatening their competitive position with having to make large capital investments in other forms of emissions abatement.

Improved RNG awareness can be built around the benefits of closing the loop for municipalities between treating the waste generated by their residents and businesses, and generating RNG based energy for local use. The production of RNG from diverted wastes should be identified as superior to other processes that do not produce an energy stream. An example of this approach can be seen in Surrey, BC where the plan is to use the RNG produced from feedstock provided by its source separated organics (SSO) facility to fuel waste trucks, starting in 2014.

Educating municipalities about the environmental, economic and social benefits of RNG, and pointing to other jurisdictions that have taken the lead, will encourage other municipalities to take action. This can be done through meetings with officials and elected representatives, presentations at conferences, tradeshows, and through targeted strategies carried out in partnership with associations of `municipalities, industry organizations, and not-for-profit organizations.

Woodward Water Wash Plant Photo

List of Definitions

Anaerobic Digestion

Conversion of biomass feedstocks to biogas through the action of microbial digestion of the biomass in the absence of air.

Biogas

An unpurified gas produced during the process of microbial digestion, typically consisting of 50-60 per cent methane.

Biomethane

Purified biogas, which meets industry standards that can be burned in existing equipment. Biomethane and Renewable Natural Gas are used interchangeably.

LCNG

Liquefied-compressed natural gas (LCNG) vehicle fuelling stations which combine LNG and CNG in one station.

Methanation

A chemical process to generate methane from syngas.

RNG

Renewable Natural Gas is another word for biomethane. The term ‘renewable’ refers to the recycling of carbon already present in the atmosphere, which makes RNG a carbon neutral energy source. RNG has identical performance compared to pipeline natural gas.

Syngas

Produced during the process of gasification. Syngas is converted to methane through the process of methanation.

Wheeling

Movement of gas from a producer to a customer using shared infrastructure. Because RNG is a “drop-in” substitute for natural gas, trade transactions of RNG from a producer to a customer through the natural gas pipeline infrastructure can be created.