Hitting Canada's Climate Targets with Biogas & RNG

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Canadian Biogas Association
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Executive Summary

Biogas & Renewable Natural Gas (RNG) is a proven climate solution, with 279 projects across Canada already preventing more than 8 Mt CO_2e of greenhouse gas emissions from reaching the atmosphere every year. But how much greater a role can biogas & RNG play in supporting Canada's 2030 and 2050 climate goals?

To determine this, the Canadian Biogas Association commissioned Navius Research to model the impact of a number of potential government policies on the GHG reductions happening through biogas & RNG. This report presents and interprets the key findings of that modelling.

Previous analysis established that we are harnessing just 14 percent of Canada's feasible biogas & RNG potential. This report's new modelling finds that the right mix of policies could harness much of this untapped potential and give a significant boost to Canada's 2030 and 2050 climate goals.

When it comes to hitting Canada's first climate target, to reduce emissions 40 to 45 percent below 2005 levels by 2030, the right mix of policies could deliver 26.7 Mt CO_2e in emissions reduction through biogas & RNG by 2030. This is a potentially critical building block in filling the 66 Mt CO_2e gap between Canada's 2030 goals and what current climate plans are able to deliver.

Biogas & RNG can also play an instrumental role in hitting Canada's second climate target, to reduce methane emissions 30 percent below 2020 levels by 2030. With swift action in the waste and agricultural sectors, biogas & RNG could cut 642 kt of methane, or 16.5 percent of all Canada's methane emissions. When added to the government's targeted cuts from the oil and gas sector, biogas & RNG could help Canada achieve a 44.5 percent reduction in total methane emissions by 2030, far exceeding its 30 percent target.

Finally, biogas & RNG can play a foundational role in achieving net zero emissions by 2050, delivering up to 40.2 Mt CO_2e in emissions reduction and, together with hydrogen over the longer term, helping decarbonize Canada's natural gas distribution networks and transportation systems.

Potential Contribution of Biogas & RNG to Canada's Climate Targets

Climate Target #1: 40-45% GHG reduction by 2030

Climate Target #2: 30% methane reduction by 2030

Climate Target #3: Net zero by 2050

The optimal policy mix for leveraging biogas & RNG to meet Canada's climate goals is a renewable gas mandate combined with a carbon offsets system that allows credits to be generated for methane destruction and utilization in landfills and agriculture. This policy mix, which is modelled on precedents at the provincial level, delivers the maximum emissions reduction: 26.7 Mt CO_2e in 2030 and 40.2 Mt CO_2e in 2050.

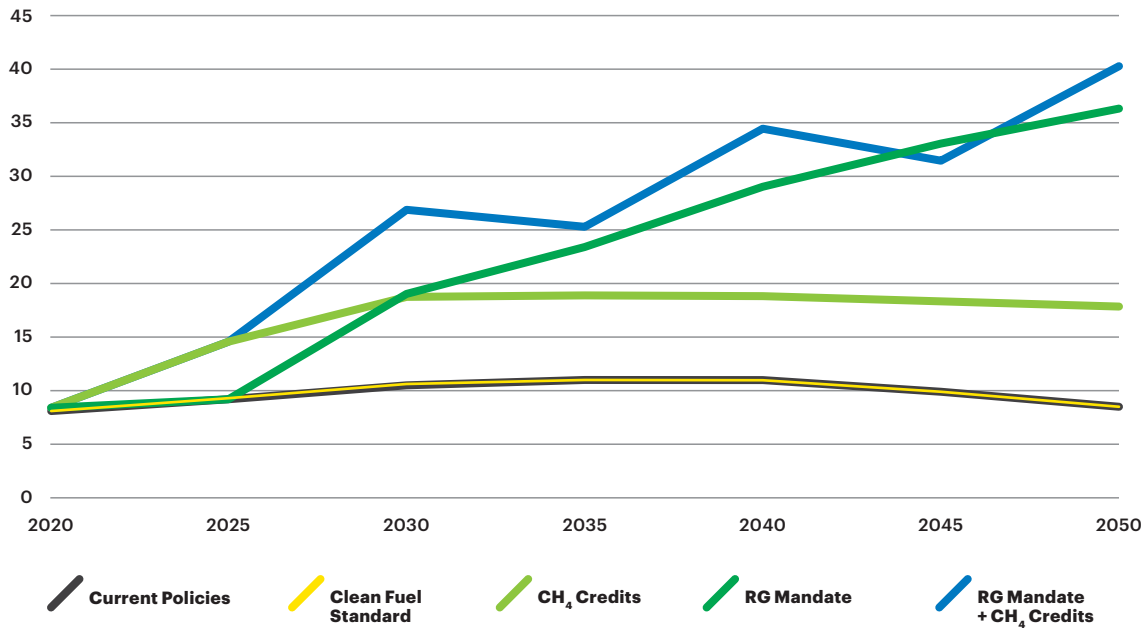
On its own, a nationwide renewable gas mandate, with a minimum blend of 15 percent in 2030 rising to 30 percent in 2040, achieves 18.9 Mt CO_2e of reductions in 2030 and 36.2 Mt CO_2e in 2050.

A carbon offsets system that allows credits to be generated for methane destruction and utilization in landfills and agriculture, when designed well, can achieve major methane reductions in the short term, resulting in reductions of 18.7 Mt CO_2e by 2030. But that policy's effect quickly plateaus and it achieves no additional emissions reduction after 2035.

Current policies, including with the proposed federal Clean Fuel Standard, only capture a small fraction of biogas & RNG's potential climate contributions.

The optimal policy mix of a renewable gas mandate combined with carbon credits for methane destruction and utilization in landfills and agriculture also delivers other important benefits. These include 544 PJ in clean energy production in 2050, compared with just 50 PJ through biogas & RNG under current policies. It also delivers 35,900 jobs, $2.9 billion in private investment, and $9.8 billion in annual GDP by 2050.

GHG Reductions Through Biogas & RNG Under Different Policies



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Section 1

Biogas & RNG as a Climate Solution

Section 1
Key takeaways:

1. **Biogas & RNG energy is a climate solution, already responsible for reducing 8 Mt every year**

2. **Biogas & RNG energy is actively abating methane from landfills, organic waste, agriculture and wastewater treatment**

3. **Clean energy production from biogas & RNG displaces fossil fuels, achieving further GHG reductions**

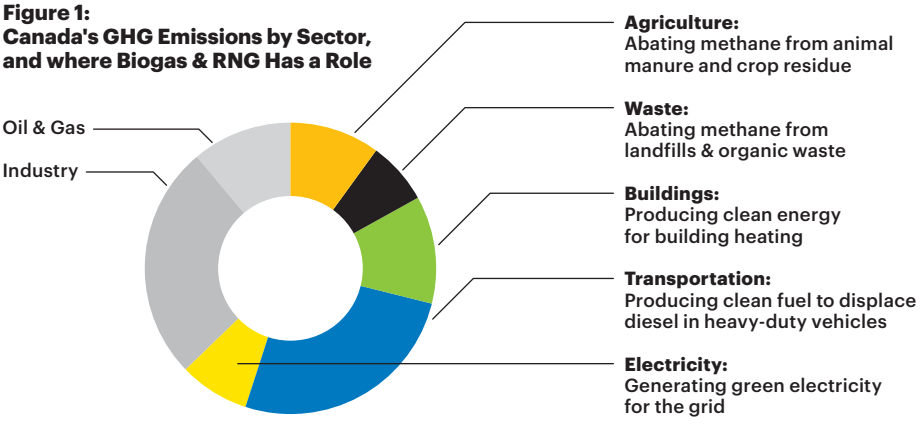
4. **Canada's biogas & RNG potential is sensitive to government policy directions**

If you ask the developers of Canada's 279 existing biogas & RNG projects what is spurring their investments, they will cite a number of drivers.

The production of biogas & RNG, which begins with the treatment of emissions from agricultural, municipal and industrial waste through anaerobic digestion, generates benefits ranging from energy production to waste management to agricultural land enrichment. However, biogas & RNG developers will also highlight a trio of drivers that makes biogas & RNG an essential climate solution: (1) The abatement of methane and other greenhouse gas emissions, (2) the production of clean energy, and (3) the creation of jobs, businesses and enhanced Canadian competitiveness in the low-carbon economy.

This report hardly needs to make the case for the importance of these climate solutions. Not only have warnings from the world's scientists reached a fever pitch, culminating in a "code red for humanity" issued by the Intergovernmental Panel on Climate Change[1], but the frightening impacts of climate change are also increasingly on our doorsteps. Thankfully, we know the solution. All countries, but particularly industrialized countries like Canada, need to move swiftly to reduce greenhouse gas emissions in order to keep global temperatures within 1.5 degrees above pre-industrial levels.

Figure 1:
Canada's GHG Emissions by Sector, and where Biogas & RNG Has a Role



Both internationally and across Canada, governments are stepping up their actions. Canada now has a national commitment to reduce emissions up to 45 percent below 2005 levels by 2030, a complementary goal to reduce methane emissions 30 percent below 2020 levels by 2030, and a legislated target to achieve net-zero emissions by the year 2050. We also have a pan-Canadian framework, signed on to by federal and provincial governments, designed to ensure that we are unified in reducing greenhouse gas emissions, developing clean energy sources, and seizing the global economic opportunities of clean growth.

Canada's Climate Targets

Target #1
40–45%
GHG reductions by 2030

Target #2
30%
Methane reductions by 2030

Target #3
Net zero
emissions by 2050

Canada's biogas & RNG sector is already supporting Canada's climate goals in the following three ways:

- **Methane and GHG abatement**
- **Clean energy production**
- **Clean economic growth**

1.1 Methane and GHG Abatement

The fundamental feature of biogas & RNG projects is the capture and utilization of methane (CH_4) emissions. Methane is a powerful greenhouse gas with a global warming effect 80 times stronger than carbon dioxide (CO_2) over the short term, and that has contributed to roughly one quarter of all global warming to date.[2] In Canada, methane is responsible for about 13 percent of all greenhouse gas emissions.[3]

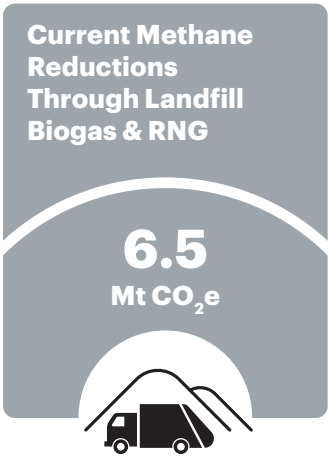
Current Methane Abatement Through Biogas & RNG

Biogas & RNG projects are already abating almost 300 kilotonnes of methane emissions in Canada, equating to about 7.3 megatonnes of carbon dioxide equivalent (Mt CO_2e). These methane emissions are being captured from three key sources: (i) Landfills, (ii) agricultural waste, and (iii) wastewater treatment.

i. Landfills

Canadian landfills generated 1483 kilotonnes of methane emissions in 2019. Of this total, 920 kt were released to the atmosphere, contributing 23.5 percent of all Canada's methane emissions. In broader greenhouse gas terms, these landfill methane emissions equate to almost 23 Mt CO_2e and account for 3.1 percent of all Canada's greenhouse gas emissions.[4]

Current Methane Reductions Through Landfill Biogas & RNG



These emissions, which are dangerous from a climate perspective, are routine feedstock for biogas & RNG systems, and can be treated using landfill gas systems or, in the case of diverted food and organic waste, industrial anaerobic digestion facilities.

There are currently 59 such biogas & RNG systems in operation across Canada.

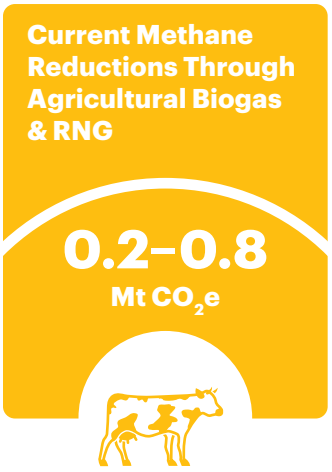
The majority of these systems – 50 in all – are landfill gas (LFG) systems, which are successfully turning almost 18 percent of Canada's landfill methane emissions into biogas & RNG energy and, in so doing, preventing 6.5 Mt CO_2e from ever reaching the atmosphere.[5]

Increasingly, however, these emissions are being captured and treated offsite at industrial anaerobic digestion facilities. These facilities, which accept source-separated organics diverted from landfill through both municipal green bin programs as well as through diversion from business, institutional and industrial waste streams, are more efficient at converting methane into biogas & RNG energy. They also support other important environmental goals, such as the circular economy and extending the lifespan of landfill sites.

There is opportunity for much more methane reduction through these kinds of biogas & RNG systems. A 2020 study commissioned by Natural Resources Canada calculates that Canada is utilizing less than one third of easily available landfill gas.[6] Section 2 calculates how many more methane emissions from landfills could be abated and utilized through biogas & RNG on our way to meeting Canada's climate goals.

ii. Agriculture

Agricultural waste, including from animal manure and crop residues, is responsible for 4 percent of Canada's methane emissions. It's also responsible for 11 percent of its nitrous oxide emissions, another potent greenhouse gas. In total, agricultural waste produces 8 Mt CO_2e, or roughly 1 percent of Canada's total greenhouse gas emissions.[7]

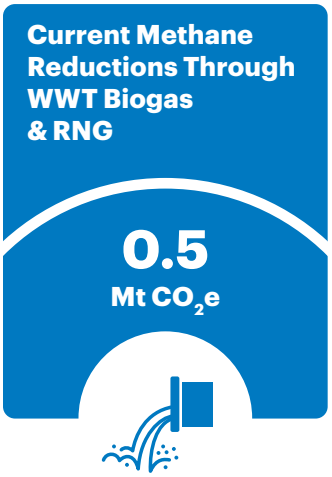


These emissions can be abated through biogas & RNG systems. Canada currently has 45 agricultural biogas & RNG systems abating 0.2-0.8 Mt CO_2e. These systems are situated on farms and in agricultural communities across Canada, including in every province, and use anaerobic digesters to destroy methane from animal manure and crop residues while producing a valuable bi-product in digestate. Right now these systems process up to 1.1 million tonnes of waste every year, primarily dairy manure[8]. Meanwhile, when the resulting digestate is used as part of an effective nutrient management plan, it can significantly displace nitrous oxide emissions as well.[9]

There is opportunity to abate many more emissions through agricultural biogas & RNG. Estimates are that we're tapping as little as 1.3 percent of Canada's available agricultural biogas & RNG feedstock.[10] Section 2 calculates how many more emissions from agricultural waste could be abated through biogas & RNG energy.

iii. Wastewater treatment (WWT)

Wastewater treatment and discharge accounts for 21 kilotonnes of methane emissions according to Canada's latest inventory of emissions. This translates into 0.5 Mt CO_2e.[11]



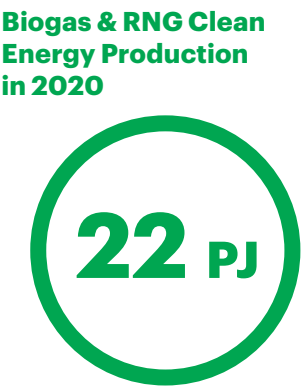
These emissions originate from both municipal wastewater treatment facilities, where the primary source is sewage sludge, as well as manufacturing wastewater treatment processes, where the dominant source is food processing wastes. These emissions, again, can be routinely recovered and utilized through biogas & RNG systems.

Currently there are 126 wastewater treatment facilities (WWTFs) with biogas & RNG systems across Canada, including in every province. Fully 108 of these facilities are municipal WWTFs and 18 of these systems are at manufacturing facilities.

Here again, there is the opportunity for more methane abatement to happen. Analysis shows that only 20 percent of municipal WWTF potential is being tapped while only 14 percent of eligible manufacturing WWTFs are abating methane through biogas & RNG systems.[12] Section 2 calculates how many of the remaining emissions from WWTFs could be abated through biogas & RNG energy on our way to meeting Canada's climate goals.

1.2 Clean Energy Production

The second fundamental way in which biogas & RNG is supporting Canada's climate goals is through the production of clean energy. When biogas & RNG systems recover methane emissions, as described above, they do not only destroy that methane but they also utilize it, resulting in the production of low-carbon energy. This low-carbon energy then displaces fossil fuel-based energy in Canada's electricity, heating and transportation systems, resulting in additional greenhouse gas reductions. Today biogas & RNG systems are displacing roughly 0.8 Mt CO_2e of emissions through clean energy production.



In 2020, Canadian biogas & RNG systems produced a total of 22 petajoules (PJ) of low-carbon energy - the equivalent of fourteen large hydro dams or 440,000,000 m^3 of solar panels. This energy comes in the form of (i) renewable natural gas (RNG), (ii) electricity, and (iii) heat and direct use.

i. Renewable Natural Gas (RNG)

Renewable Natural Gas (RNG) currently accounts for 27 percent of biogas energy in Canada. A total of 11 projects are in operation - in British Columbia, Alberta, Ontario and Québec - producing 6 PJ of clean energy per year. Another 16 projects are currently in development.

Also known as biomethane, RNG is produced by purifying biogas, resulting in a gas that is interchangeable with conventional fossil-based natural gas. Consequently, RNG can be injected into energy networks as a substitute for conventional natural gas. While conventional natural gas is used extensively across Canada, ultimately meeting 35 percent of all Canadian energy needs,[13] it is also responsible for 160 Mt CO_2e – more than one fifth of Canada's total emissions.[14] Blending RNG into Canada's natural gas distribution networks and transportation systems, which is already being done in British Columbia, Québec and Ontario, displaces conventional natural gas and reduces these emissions.

RNG substitutes for conventional natural gas, which accounts for 160 Mt, or 20%, of Canada's emissions

In addition to displacing conventional natural gas, RNG is also increasingly used to displace diesel and other fossil-based transportation fuels. In 2021, the City of Hamilton introduced Ontario's first "carbon negative" transit bus, fuelled by landfill gas-derived RNG. And, on a larger scale, BC's TransLink is reducing emissions by fueling 20 percent of its bus fleet with RNG by 2025.

ii. Electricity

Almost one half (49%) of biogas energy being produced in Canada today is in the form of clean electricity. About 50 projects currently provide 196 Megawatts (MW) of electricity generation capacity, or 11 PJ of energy.

Biogas displaces dirtier forms of electricity, which account for 69 Mt of emissions

Biogas-to-electricity applications displace dirtier sources of electricity, helping reduce the 69 Mt CO_2e of climate pollution originating from Canada's electricity sector.

While biogas-to-electricity projects grew quickly from 2011 to 2015, thanks to favourable policy in Ontario, they are increasingly being overtaken by biogas-to-RNG as a preferred energy output.[15]

iii. Heat and direct use

Twenty-four percent (24%) of Canada's current biogas energy production is in the form of heat and direct use, producing the equivalent of 5 PJ of energy per year.

This energy gets used at, or near, the site where the biogas is being produced. The biogas energy in these instances is typically used for water and space heating or for powering on-site equipment and operations. But some biogas systems think creatively about how to use on-site energy. For example, the Salmon Arm landfill in British Columbia distributes its excess heat to an adjacent subdivision, providing the heating needs for 300 homes. Also as an illustration, Pelee Hydroponics in Ontario uses the excess heat from its biogas system to heat on-site and neighbouring greenhouses.

In all cases, biogas energy used for heat and direct use can help displace fossil fuel-based energy sources and further reduce greenhouse gas emissions to support Canada's climate goals.

1.3 Clean Economic Growth

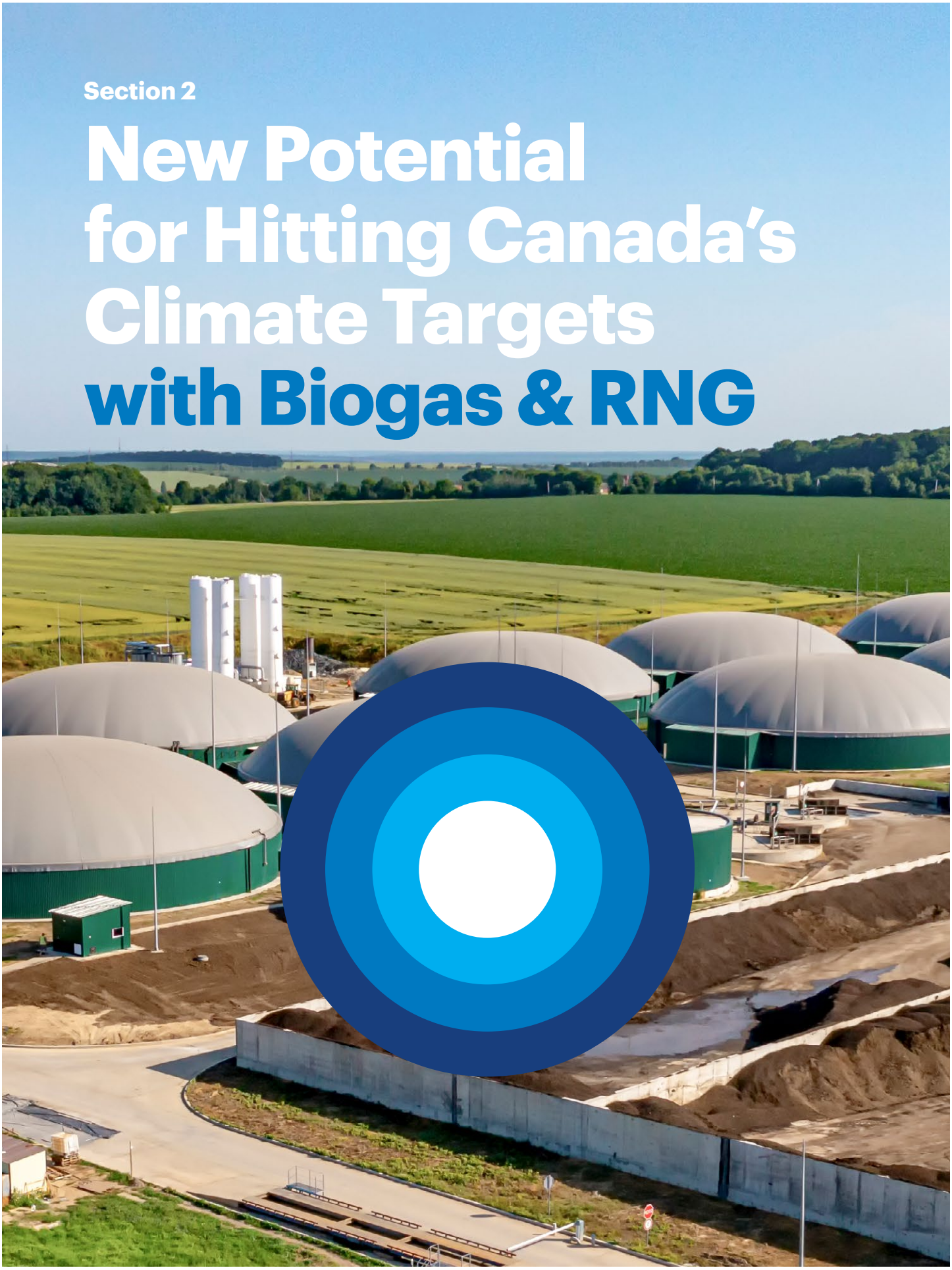
The third fundamental way in which biogas & RNG supports Canada's climate goals is through clean economic growth.

The Pan-Canadian Framework on Clean Growth and Climate Change, signed by federal, provincial and territorial governments in 2017, identifies economic growth as a key opportunity and corollary to climate action.[16] Indeed, estimates peg the global low-carbon transition as high as US$26-trillion over this decade[17] – more than ten times Canada's annual GDP.

The development of biogas & RNG can continue to play a role in capturing this clean growth opportunity for Canada. Already the industry is delivering economic benefits by driving private investment, generating green jobs, and spurring new businesses in almost every part of the country. And a recent report from the Canadian Climate Institute suggests these economic benefits will increase, highlighting that "bioproducts and bioenergy", including biogas & RNG energy, are a major "opportunity sector" for Canada's economy as it seizes the low-carbon transition.[18]

Section 2

New Potential for Hitting Canada's Climate Targets with Biogas & RNG



Section 2
Key takeaways:

1. **Biogas & RNG can give an immediate boost to Canada's 2030 climate goals while supporting net zero emissions in 2050**

2. **The right policy mix could deliver 26.7 Mt in emissions reduction in 2030 and 40.2 Mt in emissions reduction in 2050, with every province playing a role**

3. **Biogas & RNG can cut total methane emissions 16.5% in 2030, achieving more than half of Canada's methane goal**

4. **The optimal policy mix is: (1) a renewable gas mandate, combined with (2) carbon credits for methane destruction and utilization in landfills and agriculture**

Biogas & RNG is a proven climate solution. Through methane abatement, clean energy production, and the generation of clean economic growth opportunities, biogas & RNG is making an important contribution to Canada's climate goals.

But Canadian biogas & RNG is far from meeting its full potential. A 2020 report commissioned by Natural Resources Canada finds that the vast majority of Canada's biogas & RNG resources is currently unutilized.[19] In all, Canada is tapping only about 14 percent of its easily available biogas & RNG potential. And, when Canada's broader and less-commercially proven biogas & RNG feedstocks are taken in to account, we are tapping just 3 percent.[20]

In other words, there is significant room for abating more methane, for producing more clean energy, and for making bigger strides towards Canada's climate goals using biogas & RNG.

But just how much?

In January 2022, the Canadian Biogas Association retained Navius Research to undertake a major modelling exercise using Navius' gTech energy-economy model to address this paramount question. The modelling provides us with improved visibility on a number of timely questions, such as: how many additional greenhouse gas emissions could be cut with biogas & RNG? How do these reductions support Canada's 2030, 2050 and methane-related climate goals? How much clean economic growth could be generated? And, ultimately, what are the government policies that can unleash this potential?

The following sub-sections address these questions by organizing the modelling results and analysis around Canada's three major climate targets: first, its target to reduce GHG emissions 40 to 45 percent below 2005 levels by 2030; second, its target to reduce methane emissions 30 percent below 2020 levels by 2030; and third, its legislated target to achieve net zero GHG emissions by 2050.

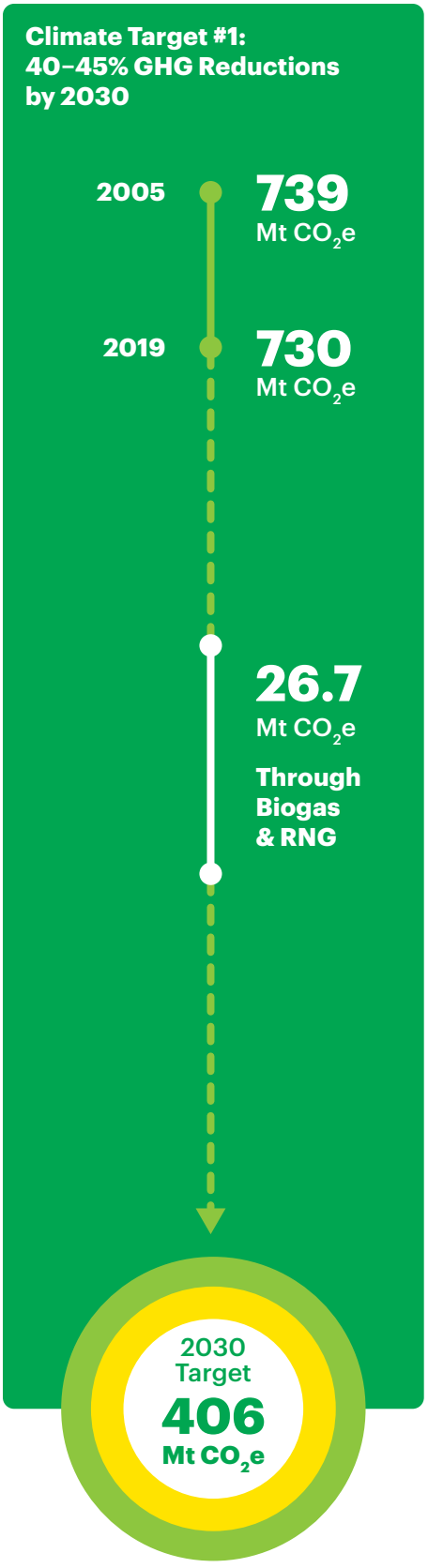
Naturally these targets are all interdependent and interrelated. But because they each have individual importance – both as building blocks for Canada's long-term climate progress and as incremental tests of government accountability – this report shows the contributions of biogas & RNG to each of them. The result is overlapping tiles that show unequivocally that biogas & RNG is an important piece of the puzzle for Canada's short-term and long-term climate success.

2.1 Climate Target #1:

Reducing GHG Emissions 40–45% By 2030

In signing on to the Paris Agreement in 2015, Canada initially committed to a 30 percent reduction in greenhouse gas emissions below 2005 levels by 2030. In 2021, Canada formally ratcheted up this target in the lead up to the COP26 international climate meeting in Glasgow. The official commitment now is to reducing emissions 40 to 45 percent below 2005 levels by 2030.

This updated target requires Canada to cut annual GHG emissions up to 332 Mt CO_2e beyond the most recent measurements by 2030. Meanwhile, Canada's existing climate plans are only able to deliver 266 Mt CO_2e in reductions, leaving a still sizeable 66-Mt gap needing to be filled with new policy measures.[21]



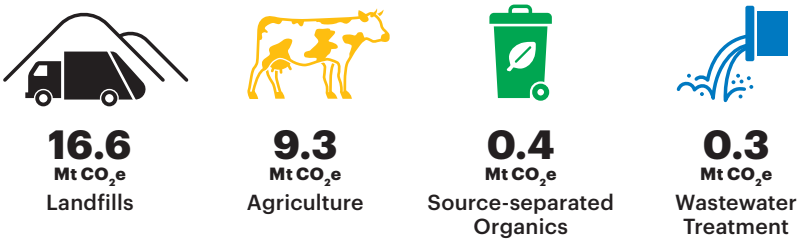
i. Biogas & RNG potential contribution to Climate Target #1

Modelling shows that with the right policies in place, biogas & RNG could cut 26.7 Mt CO_2e by 2030. This is compared to just 10.4 Mt CO_2e in reductions from biogas & RNG by 2030 under existing policies. In other words, biogas & RNG could fill 25 percent of the 66-Mt gap in policy measures needed to hit Canada's updated 2030 climate target.

Achieving these additional emission reductions in a short time period, and in an economically efficient way, requires relying on immediately accessible biogas & RNG sources in all sectors. See Figure 2 for a breakdown of how each sector contributes to the 26.7 Mt CO_2e of total reductions by 2030.

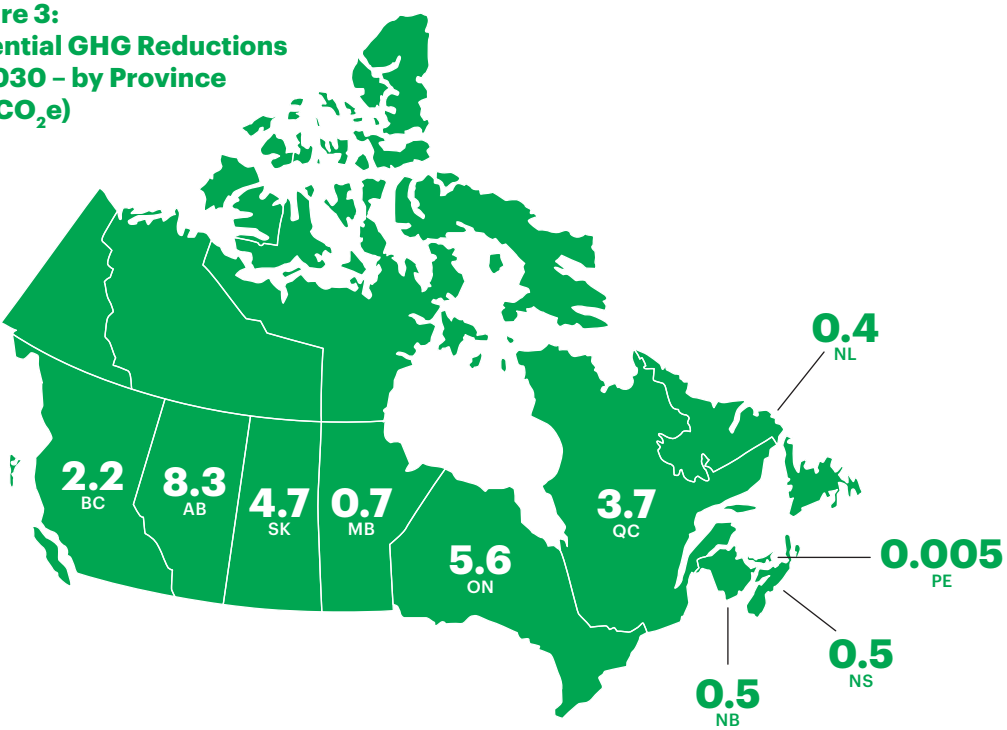
Biogas & RNG could cut 26.7 Mt CO_2e by 2030

Figure 2:
Biogas & RNG Contributions to Climate Target #1 by Source



When it comes to the geography of achieving 26.7 Mt CO_2e of reductions through biogas & RNG by 2030, every province in Canada has a role to play. See Figure 3 for a breakdown of how each province contributes to that total figure.

Figure 3:
Potential GHG Reductions in 2030 – by Province (Mt CO_2e)



ii. Contribution to clean economic growth

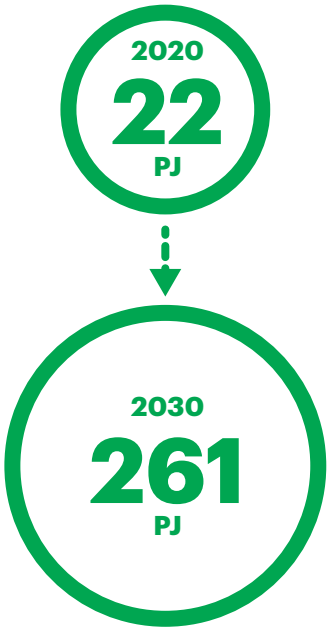
In addition to reducing Canada's greenhouse gas emissions and helping fill the gap to Canada's 2030 target, modelling shows that biogas & RNG can have an important impact on clean economic growth. The indicators modelled include energy produced, new full-time equivalent (FTE) jobs, new private investment and GDP.

Clean Energy Production: In terms of clean energy production, the same policies that achieve 26.7 Mt CO_2e in emissions reduction by 2030 will also harness 261 PJ of clean energy from biogas & RNG. This is more than ten times the 22 PJ being produced today. This potential 261 PJ of clean energy production is composed of approximately 241 PJ in the form of RNG, 16 PJ in the form of clean electricity and the remainder being used for direct heat.

Jobs: When it comes to jobs, biogas & RNG can create 19,900 FTE jobs by 2030, the vast majority (96%) of which are related to biogas & RNG development in the agriculture sector.

Investment & GDP: Finally, the same optimal policy mix leads to almost $2.2 billion in private investment, mostly originating from development in the agriculture sector. It also leads to more than $5 billion in annual GDP compared with just $1.2 billion under current policies.

Growth in Clean Energy from Biogas & RNG



Green Jobs Through Biogas & RNG in 2030

2.2 Climate Target #2:

Reducing Methane Emissions 30% By 2030

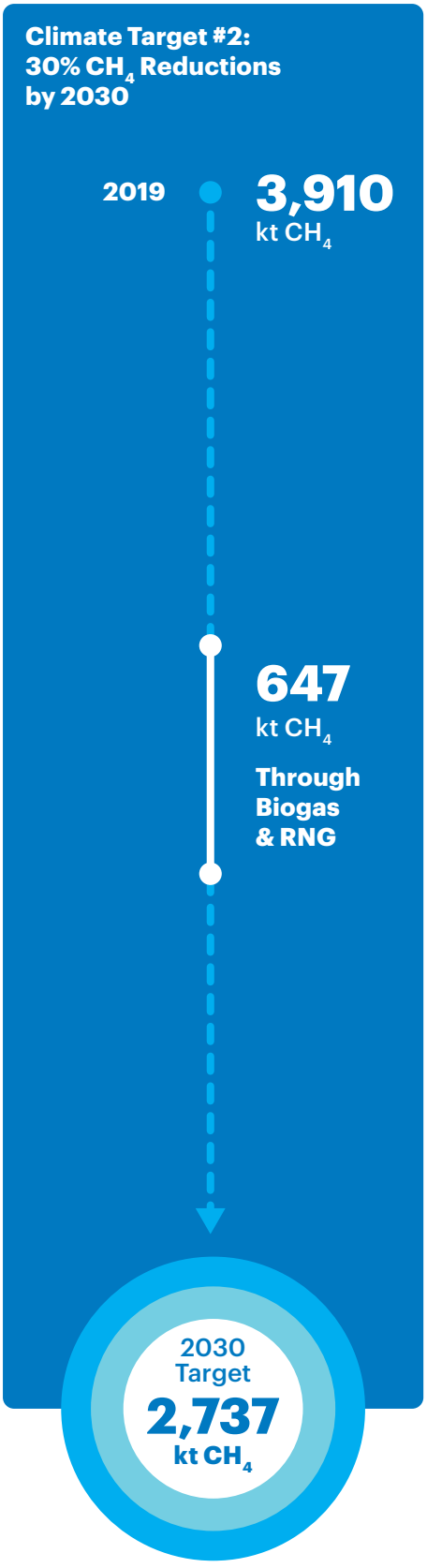
In addition to ratcheting up its overall GHG commitments under the Paris Agreement in 2021, the Government of Canada also joined 110 countries in signing on to the Global Methane Pledge.

The Global Methane Pledge is a complementary and voluntary initiative in which signatory countries are committed to a 30 percent cut in methane emissions below 2020 levels by 2030. For Canada, then, this means cutting 1173 kilotonnes (kt) of methane emissions from our annual total by 2030.* Canada's target also includes a specific carve-out for the oil and gas sector, which is targeted for a 75-percent reduction in methane emissions.

While the oil and gas sector is a major source of methane, the majority of Canada's methane emissions originate from the waste and agriculture sectors, and these latter sources are prime targets for reductions through biogas & RNG. In all, 28.5 percent of Canada's current methane emissions are eligible feedstocks for biogas & RNG.[22]

Figure 4:
Canada's methane emissions by source, with biogas & RNG opportunities highlighted

1. Oil and gas: 37%
2. Agriculture (enteric fermentation): 25%
3. **Landfills: 24%**
4. **Agriculture (waste): 4%**
5. Energy production: 4%
6. Other waste: 3%
7. Forestry and land use: 0.6%
8. **Wastewater: 0.5%**



* Based on 2019 methane emissions due to 2020 calculations not being available at time of publication

i. Biogas & RNG potential contribution to Climate Target #2

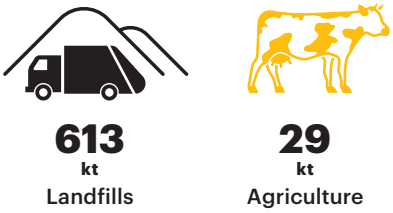
Modelling shows that with the right policies in place, biogas & RNG could cut 642 kilotonnes (kt) of methane emissions per year by 2030. This is compared to just 330 kt per year under current policies.

In other words, biogas & RNG projects in the waste and agriculture sectors could cut more than 16.5 percent of Canada's current methane emissions all on their own. And, when added to the targeted cuts from the oil and gas sector, biogas & RNG could help Canada achieve a 44.5 percent reduction in total methane emissions, far exceeding its 30 percent target under the Global Methane Pledge and making an even bigger contribution to Canada's climate efforts.

Biogas & RNG could cut 642 kt CH_4 by 2030

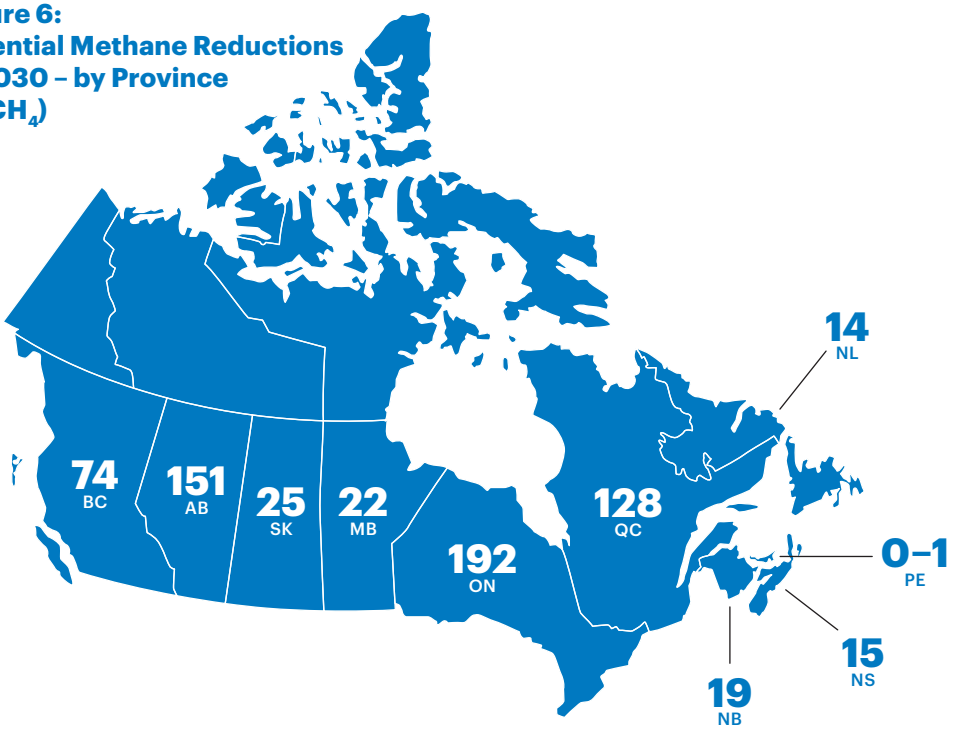
This optimal reduction in methane emissions from the waste and agriculture sectors by 2030 is achieved through the breakdown in Figure 5.

Figure 5:
Biogas & RNG Contributions to Climate Target #2 by Source



Every province has important opportunities for reducing methane emissions through biogas & RNG. Figure 6 shows how each province could contribute to Canada's 2030 methane goal under optimal government policies.

Figure 6:
Potential Methane Reductions in 2030 – by Province (kt CH_4)

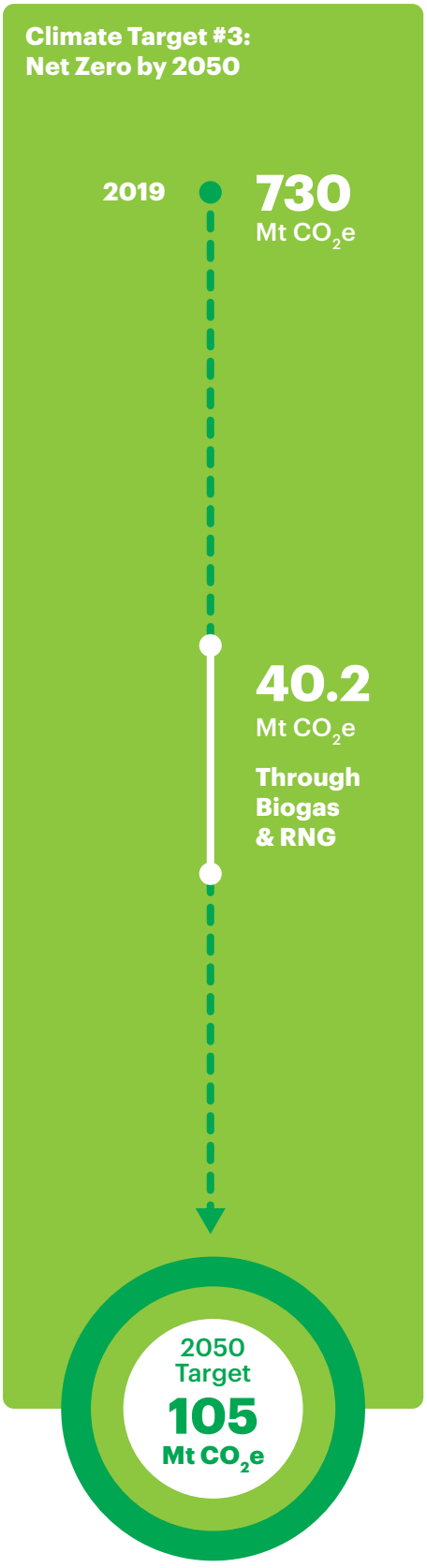


2.3 Climate Target #3:

Achieving Net Zero Emissions By 2050

In its special 2018 report on what needs to happen for the world to keep within 1.5 degrees of global warming, the Intergovernmental Panel on Climate Change called for reaching "net zero" greenhouse gas emissions globally by 2050.[23] Since then, more than 130 countries have begun setting individual targets to achieve net-zero emissions by 2050.[24] In Canada, this target has been legislated through the Canadian Net-Zero Emissions Accountability Act, which also adds the requirement to establish supporting incremental targets in 2035, 2040 and 2045.

What does it mean to be "net zero"? It means that GHG emissions are reduced to the point that remaining emissions can be balanced out by new activities that remove emissions from the atmosphere, such that the net result is no added GHG pollution. It's expected that Canada could achieve this goal by reducing its emissions to 105 Mt CO_2e, with nature-based and other carbon removal solutions offsetting the remainder.[25] That means, to achieve its net zero goal, Canada needs to cut its emissions 625 Mt CO_2e from 2019 levels. [26]



There are multiple viable pathways to net-zero emissions for Canada. The Canadian Climate Institute has identified no fewer than 62 such pathways. While each pathway modelled by the Institute draws on a different combination of climate solutions, every single one calls upon biogas & RNG. Indeed, the report says renewable gases, including but not exclusive to biogas & RNG, could achieve a total of 62 Mt CO_2e in 2050, making a sizeable contribution to Canada's 2050 net zero goal. It also recommends that "safe bet" solutions like biogas & RNG be deployed "without delay".[27]

Canada will not be alone in drawing on some measure of biogas & RNG to meet its net-zero targets. The International Energy Agency sees global biogas & RNG demand growing 6.5 times, from 2.1 EJ to 13.7 EJ, as the world moves to a net-zero emissions energy system by 2050.[28] Many countries already have biogas & RNG explicitly built in to their 2050 strategies.[29]

i. Biogas & RNG potential contribution to Climate Target #3

Biogas & RNG could cut 40.2 Mt CO_2e by 2050

Modelling shows that with the right mix of policies, biogas & RNG could cut Canada's GHG emissions 40.2 Mt CO_2e per year by 2050. This is compared to just 8.4 Mt CO_2e in reductions from biogas & RNG by 2050 under existing policies. In other words, biogas & RNG can fill more than 6 percent of the gap between Canada's current emissions and its 2050 target. This makes biogas & RNG a potentially valuable part of a "silver buckshot" approach to achieving net zero emissions by 2050. A silver buckshot approach, as opposed to a "silver bullet" one, is the most realistic for Canada according to the Canadian Institute for Climate Choices, which concludes that "many solutions will likely be part of Canada's net zero story no matter which pathway we take". [30]

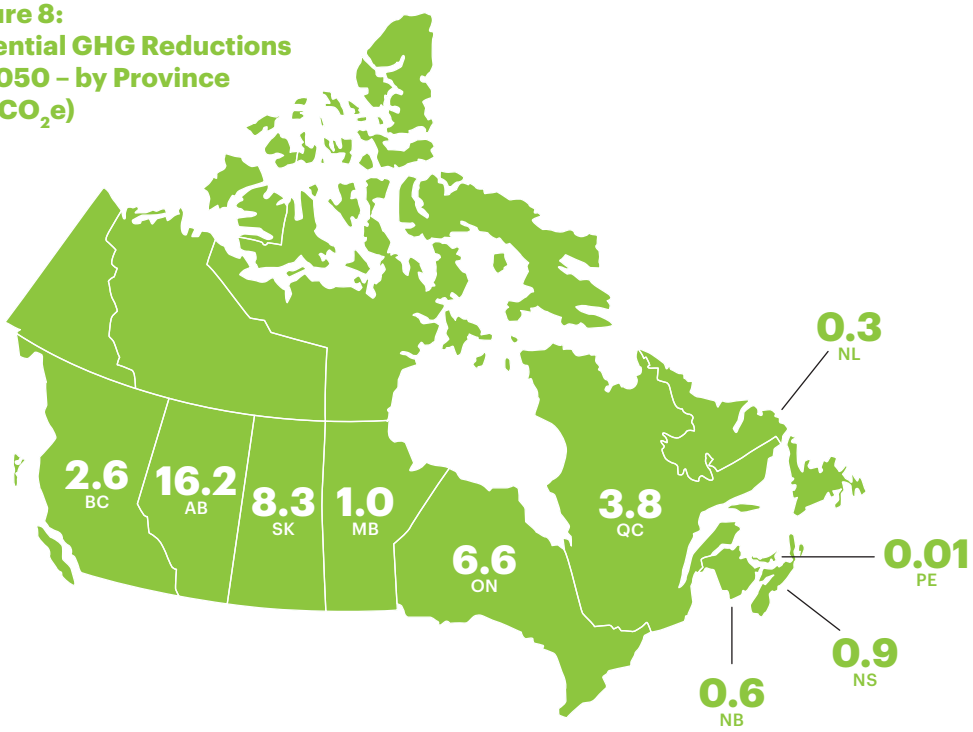
Achieving a 40.2 Mt CO_2e reduction in Canada's greenhouse gas emissions through biogas & RNG will involve ambitious action in all viable sectors. In particular, it involves a steady draw on methane from landfills and source separated organics on top of a major ramp up in agricultural biogas & RNG production through both maximum utilization of methane from animal manure and crop residues as well as cultivation of dedicated energy crops. Figure 7 shows the breakdown of reductions by source.

Figure 7:
Biogas & RNG Contributions to Climate Target #3 by Source

16.5	22.2	0.7	0.3
Mt CO_2e	Mt CO_2e	Mt CO_2e	Mt CO_2e
Landfills	Agriculture	Source-separated Organics	Wastewater Treatment

Every province plays an important role in driving emissions through biogas & RNG on our way to achieving net zero emissions in 2050. Figure 8 shows a breakdown.

Figure 8:
Potential GHG Reductions in 2050 – by Province (Mt CO_2e)



ii. Contribution to clean economic growth

In addition to reducing Canada's greenhouse gas emissions and helping achieve Canada's 2050 net-zero emissions target, biogas & RNG can have an important impact on clean economic growth, including clean energy production, new full-time equivalent (FTE) jobs, new private investment and GDP.

Clean Energy Production: In terms of clean energy production, the same policies that achieve 40.2 Mt CO_2e in emission reductions by 2050 also harness 544 PJ of clean energy from biogas & RNG. This is compared to just 50 PJ in energy production by 2050 modelled under current policies. In other words, focused government policy could help unleash over 10 times more energy than otherwise would be produced from made-in-Canada biogas & RNG over the next thirty years.

In 2050, biogas & RNG could fuel all of Canada's current urban transit needs thirteen times over

The vast majority of the 544 PJ clean energy potential from biogas & RNG in 2050 comes in the form of RNG, at 524 PJ. For comparison, RNG's contribution of 524 PJ in 2050 would be enough to displace 16.5 percent of today's total demand for natural gas[31], or to fuel all of Canada's current urban transit needs thirteen times over.[32]

Jobs: When it comes to jobs, biogas & RNG can create 35,900 FTE jobs by 2050. The vast majority (97%) of these jobs are related to biogas & RNG development in the agriculture sector. This is compared with just 5,200 FTE jobs by 2050 through biogas & RNG under current policies.

Biogas & RNG could create 35,900 jobs in 2050

Investment & GDP: Finally, the same optimal policy mix leads to approximately $2.9 billion in private investment and generates $9.8 billion in annual GDP by 2050.

iii. Biogas & RNG in a net-zero energy system

While experts agree that achieving Canada's 2050 net-zero target will require piecing together multiple climate solutions, that does not mean that every single kind of climate solution should be pursued. Canada's Net Zero Advisory Body warns against "dead-end" solutions that reduce emissions in the short term but that "entrench systems and technologies that will eventually have to be replaced" in a longer-term net-zero energy system.[33]

Biogas & RNG is not one of these dead ends. As noted earlier, every single one of the 62 pathways explored by the Canadian Institute for Climate Choices for achieving net zero includes some measure of "safe bet" biogas & RNG.[34] That's because biogas & RNG is foundational for reducing the 89 Mt CO_2e of annual emissions, or 12 percent of Canada's total,[35] that come from space and water heating in buildings, most of which are born from the use of conventional natural gas for these services. While there are other low-carbon alternatives to conventional natural gas for building heating, few are both technically feasible and cost-effective.[36] Instead, there is growing consensus that displacing conventional natural gas using both biogas & RNG and, over the longer term, blending biogas & RNG with hydrogen and other renewable gases, will play a major role in solving emissions from building heating.[37] [38]

In addition to its foundational role in advancing net-zero building heating, biogas & RNG also provides a zero-emission electricity option and can help Canada achieve a 100 percent clean electricity grid.

Lastly, biogas & RNG is also part of Canada's net-zero transportation future. This is particularly true for heavy duty road transportation such as freight, waste collection fleets and urban transit, where RNG is already increasingly relied on as a clean fuel. The long-term dynamics between RNG and other low-carbon transportation fuel solutions like hydrogen, liquid biofuels and electrification are still evolving,[39] but biogas & RNG is an important option for Canada's net-zero transportation system.

2.4 Which Policies Will Unlock Biogas & RNG?

Biogas & RNG has the potential to make significant contributions to Canada's climate goals, including towards GHG and methane reductions by 2030 as well as towards achieving net-zero emissions by 2050. Tapping this potential will require smart policy leadership by Canada's federal and provincial governments. Modelling shows that only an optimal policy mix is capable of achieving the full scope of GHG reductions and clean economic growth highlighted above.

This section examines five different policy scenarios and draws on simulations modelled by Navius Research to display and compare the impact of these different policy scenarios on emissions reduction through biogas & RNG. The policy scenarios here have been selected based on their feasibility in the Canadian context. They are all policies that have Canadian precedent and that are consistent with current federal and provincial policy directions.

They are ordered from the most impactful to the least impactful:

1. **Renewable gas mandate + Carbon credits for methane destruction and utilization in landfills and agriculture**
2. **Renewable gas mandate**
3. **Carbon credits for methane destruction and utilization in landfills and agriculture**
4. **Clean fuel standard as currently proposed by the federal government**
5. **Current policies**

The policy mix of a renewable gas mandate combined with carbon credits for methane destruction and utilization in landfills and agriculture clearly leverages the most additional emissions reduction. It reduces annual GHG emissions 16.3 Mt CO_2e more than existing policies in 2030, and reduces annual GHG emissions 31.7 Mt CO_2e more than existing policies in 2050.

Figure 9:
Summary of Policy Impact

	2030		2050	
	Reductions (Mt CO_2e/yr)	Additional reductions compared w/ existing policies (Mt CO_2e/yr)	Reductions (Mt CO_2e/yr)	Additional reductions compared w/ existing policies (Mt CO_2e/yr)
Renewable Gas Mandate + Credits for CH_4 destruction	**26.7**	**+16.3**	**40.2**	**+31.7**
Renewable Gas Mandate	**18.9**	**+8.5**	**36.2**	**+27.7**
Credits for CH_4 destruction in landfills and agriculture	**18.7**	**+8.3**	**17.7**	**+9.2**
Clean Fuel Standard	**10.5**	**+0.1**	**8.4**	**-0.1**
Current Policies	**10.4**	**0**	**8.5**	**0**

1. Renewable gas mandate + Carbon credits for methane destruction and utilization in landfills and agriculture

The modelling shows that the strongest policy mix for leveraging biogas & RNG to meet Canada's climate goals is a combination of two policies: (i) a nationwide renewable gas mandate, and (ii) a carbon offsets system that allows carbon credits to be generated for methane destruction and utilization in landfills and agriculture.

i. A renewable gas mandate has important precedents in Canada, including in Québec and British Columbia. These precedents are explained in more detail in Appendix D.

The renewable gas mandate modelled for this report follows the schedule in BC's emerging policy, requiring 15 percent minimum renewable gas in natural gas distribution networks by 2030. After 2030, the renewable gas mandate increases steadily to a 30 percent minimum renewable blend by 2040-2050. Similar to British Columbia, the modelled policy scenario allows for a variety of renewable gases to contribute to the mandate, including biogas & RNG, low-carbon hydrogen and synthetic natural gas.

The outcome in this policy scenario could be achieved through a single federal renewable gas mandate, acting as a backstop, or through multiple new provincial mandates in those provinces that have not yet implemented one.

ii. A carbon offsets system that allows credits to be generated for methane destruction and utilization in landfills and agriculture also has important precedents in Canada, including in Alberta and Québec.*

The policy modelled here is based on the emerging Federal GHG Offset System, which allows offsets to be used by industrial firms regulated under the Output Based Pricing System. Approved activities can generate offsets that are sold according to the OBPS price schedule, which rises incrementally to $170/tCO$_2$e in 2030.

At time of publication, the federal government is developing a protocol under the Federal GHG Offsets System that is similar to what is modelled here. However, that protocol is exclusively for landfill methane and does not apply to agricultural methane. It is also unclear whether the emerging protocol will enable biogas & RNG by allowing destruction through utilization.

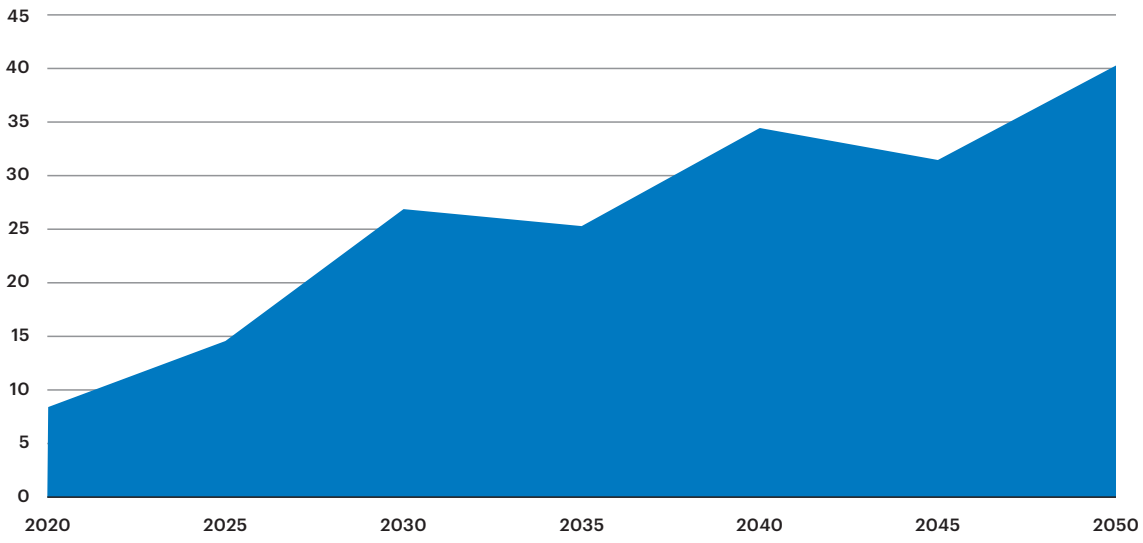
In summary, a nationwide renewable gas mandate combined with a carbon offsets system that allows carbon credits to be generated for methane destruction and utilization in landfills and agriculture results in:

26.7 Mt CO_2e
GHG Reductions Through Biogas & RNG in 2030

642 kt
Methane Reduction Through Biogas & RNG in 2030

40.2 Mt CO_2e
GHG Reductions Through Biogas & RNG in 2050

Figure 10:
Emissions Reductions Between Now and 2050 Under RG Mandate + CH_4 Credits Policy Scenario



* See Section 1.4 for more background on these precedents

2. Renewable gas mandate

The strongest single policy over the medium and long term for leveraging biogas & RNG is a nationwide renewable gas mandate.

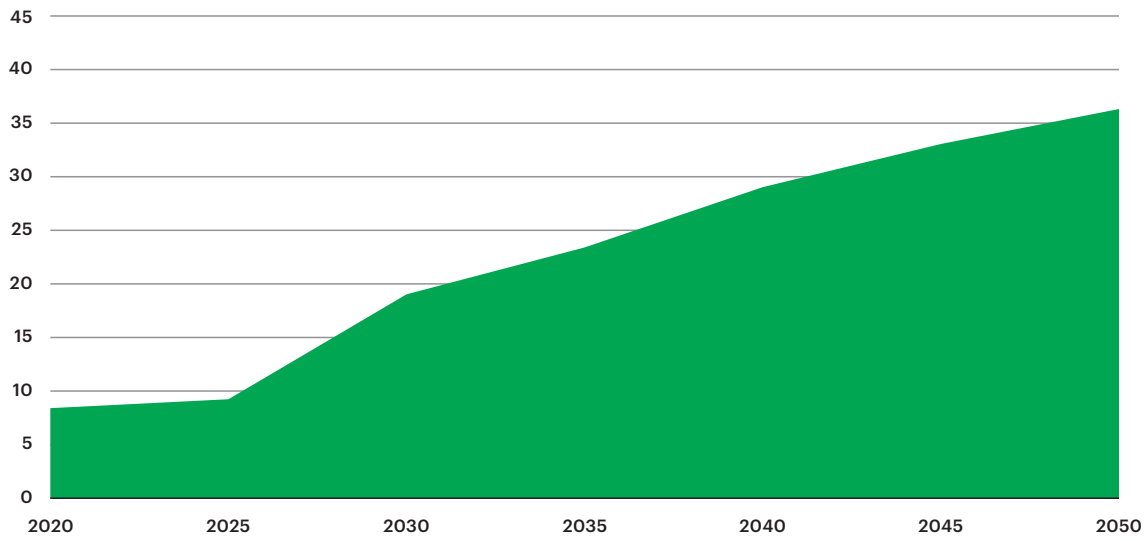
A nationwide renewable gas mandate can deliver significant GHG emission reductions. According to the modelling, it succeeds in reducing 82 percent more GHGs by 2030 and 326 percent more GHGs by 2050 than current policies. While it is comparable to the Carbon Credit policy in achieving emissions reductions by 2030, it diverges dramatically from this policy trajectory after 2030, unlocking a vast stock of otherwise untapped emissions reductions between 2030 and 2050. In summary, a federal renewable gas mandate leads to:

18.9
Mt CO_2e
GHG Reductions Through Biogas & RNG in 2030

356
kt
Methane Reduction Through Biogas & RNG in 2030

36.2
Mt CO_2e
GHG Reductions Through Biogas & RNG in 2050

Figure 11:
Emissions Reductions Between Now and 2050 Under RG Mandate Scenario



3. Carbon credits for methane destruction and utilization in landfills and agriculture

A carbon offsets system that allows carbon credits to be generated for methane destruction, including through utilization, in landfills and agriculture, on its own, is capable of driving important emissions reductions.

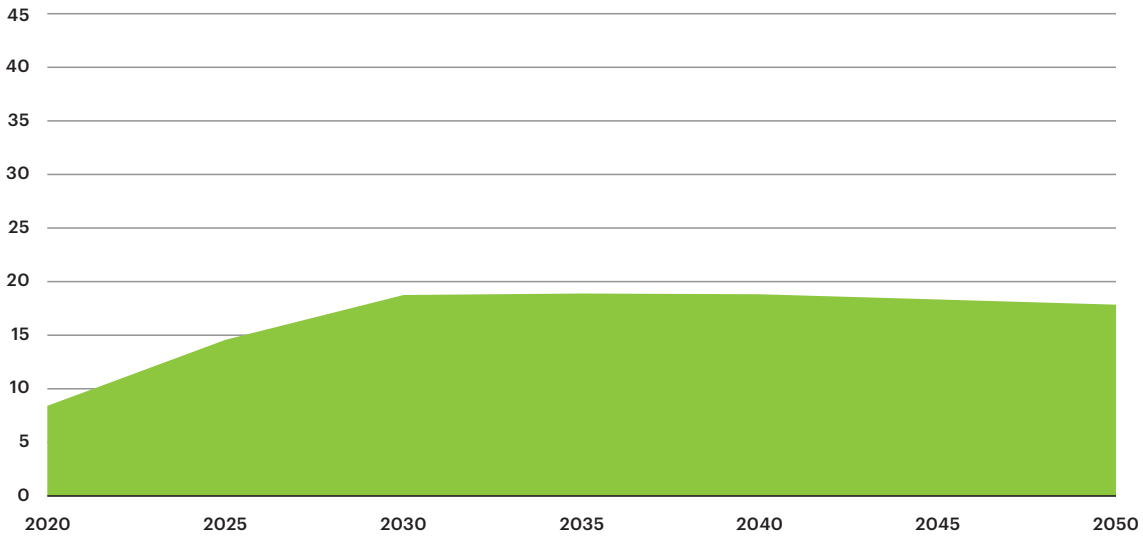
In particular, this policy scenario has a significant impact on emission reductions through biogas & RNG over the short term, achieving 80 percent more emissions reduction by 2030 than current policies alone. However, this effect tapers off quickly after 2030, and its contribution to annual emission reductions drops by 2045-2050. In other words, this carbon credit policy could deliver rapid and significant reductions towards Canada's 2030 GHG and methane targets, although with little additional contributions to Canada's longer-term net-zero targets after that.

18.7 Mt CO_2e
GHG Reductions Through Biogas & RNG in 2030

635 kt
Methane Reduction Through Biogas & RNG in 2030

17.7 Mt CO_2e
GHG Reductions Through Biogas & RNG in 2050

Figure 12:
Emissions Reductions Between Now and 2050 Under CH_4 Credits Policy Scenario



4. Clean fuel standard

The fourth policy scenario modelled for this report layers a clean fuel standard on to existing policies. This scenario is expected to materialize shortly, with the federal government's Clean Fuel Standard scheduled to come into effect in 2022. This regulation has undergone significant adjustments since its initial design, including the elimination of a dedicated gaseous stream and the move to an exclusive focus on liquid fuels. However, the federal government's latest design allows for suppliers to meet up to 10 percent of their liquid fuel improvements through gaseous fuels. This is the policy scenario modelled here.

The modelling shows that the federal Clean Fuel Standard, as currently designed, will have a negligible effect on emission reductions through biogas & RNG, adding only 0.1 Mt CO_2e beyond what existing policies already achieve by 2030.

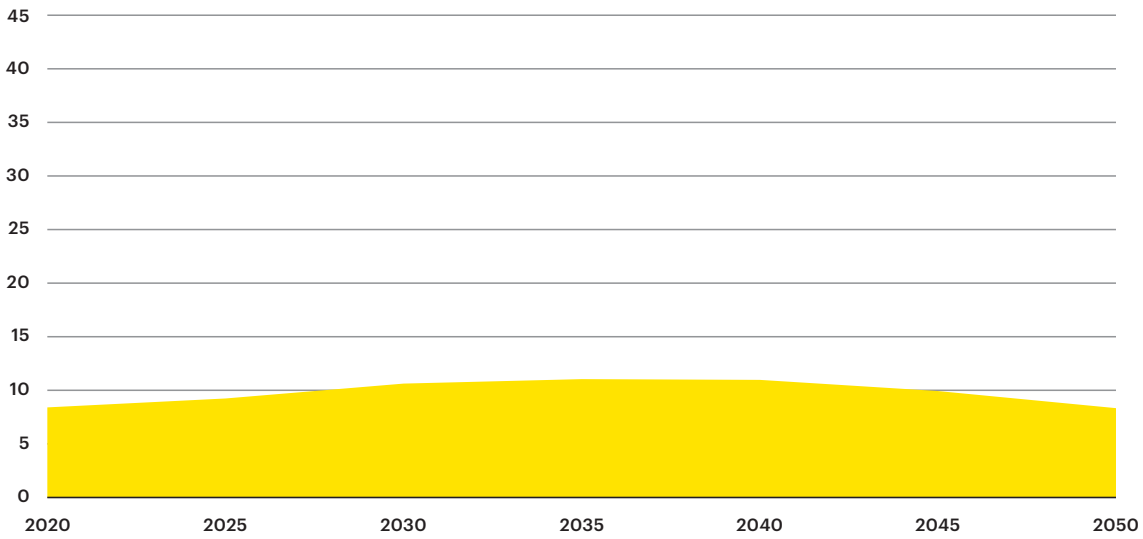
The Clean Fuel Standard, with a 10 percent allowance for gaseous fuels, result in:

10.5 Mt CO_2e
GHG Reductions Through Biogas & RNG in 2030

330 kt
Methane Reduction Through Biogas & RNG in 2030

8.4 Mt CO_2e
GHG Reductions Through Biogas & RNG in 2050

Figure 13:
Emissions Reductions Between Now and 2050 Under CFS Scenario



5. Current policies

The current policy scenario modelled here includes federal and provincial policies that are already implemented. Most notably, they include:

Carbon pricing, including the Output Based Pricing System, in which the price of carbon pollution rises incrementally according to the announced federal schedule, reaching $\$170/tCO_2e$ in 2030, and then remains at that level until 2050;

Renewable gas mandates in British Columbia (15% by 2030) and Québec (5% by 2025-2026 and 10% by 2030); and

Provincial landfill gas controls and organic diversion targets, including in BC, Manitoba, Ontario, Québec and Nova Scotia.

One thing the modelling makes clear is that current policies are not sufficient for capturing biogas & RNG's potential contribution to Canada's climate goals. They deliver only 21 percent of the GHG reductions available through biogas & RNG compared with the optimal policy scenario. They lead to:

10.4 Mt CO_2e
GHG Reductions Through Biogas & RNG in 2030

330 kt
Methane Reduction Through Biogas & RNG in 2030

8.5 Mt CO_2e
GHG Reductions Through Biogas & RNG in 2050

Figure 14:
Emissions Reductions Between Now and 2050 Under Current Policies Scenario

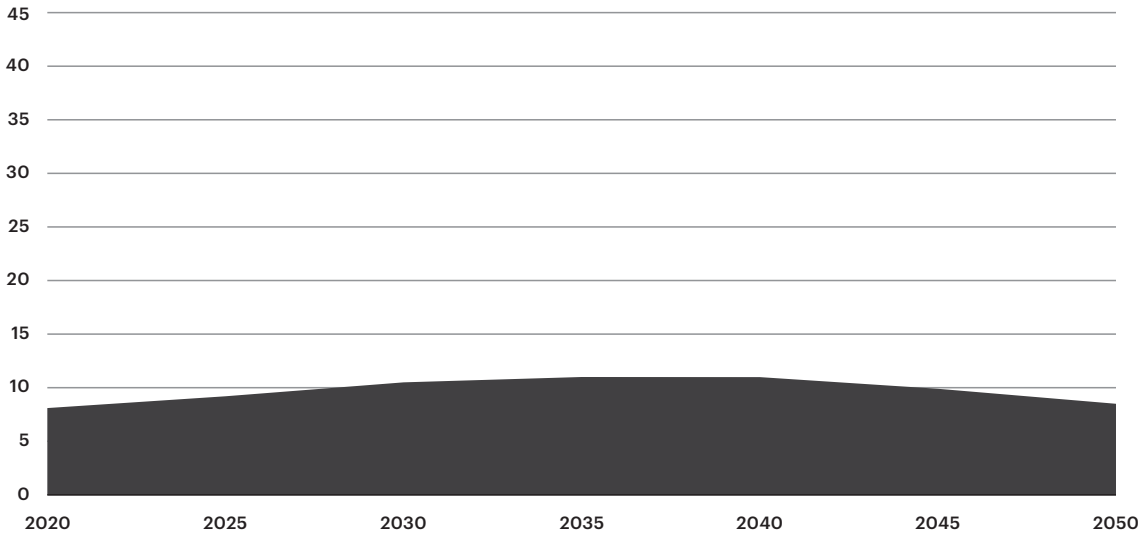
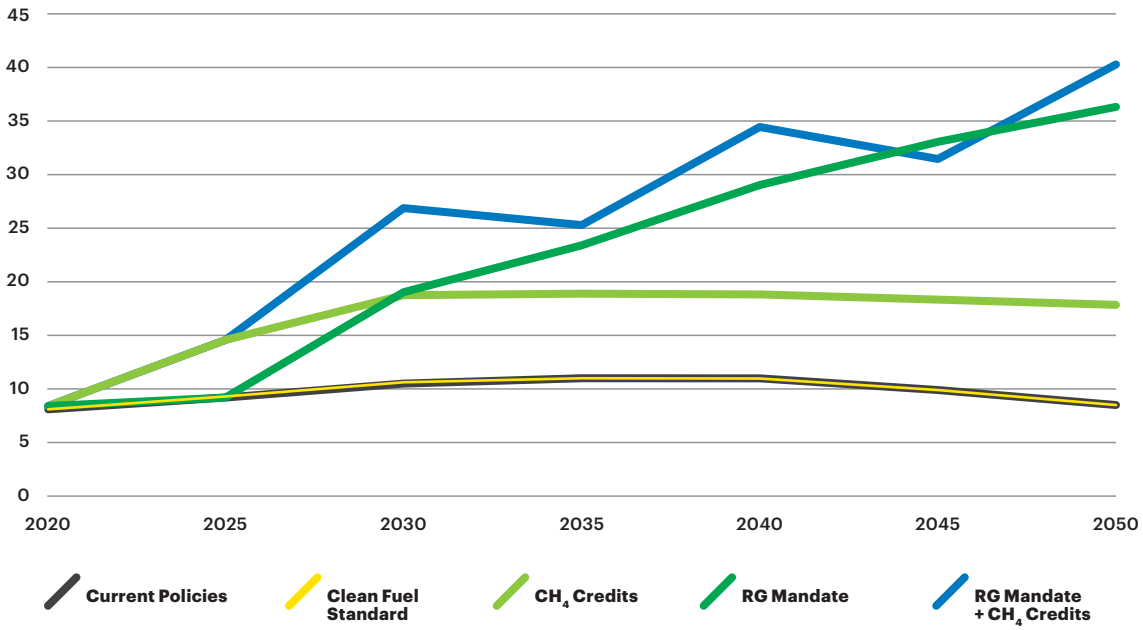


Figure 15:
GHG Reductions Through Biogas & RNG Under Different Policies



Appendices

Appendix A:
GHG Reductions by Province

Figure 16:
GHG Reductions Under the Optimal Policy Mix in 2030 – by Province:

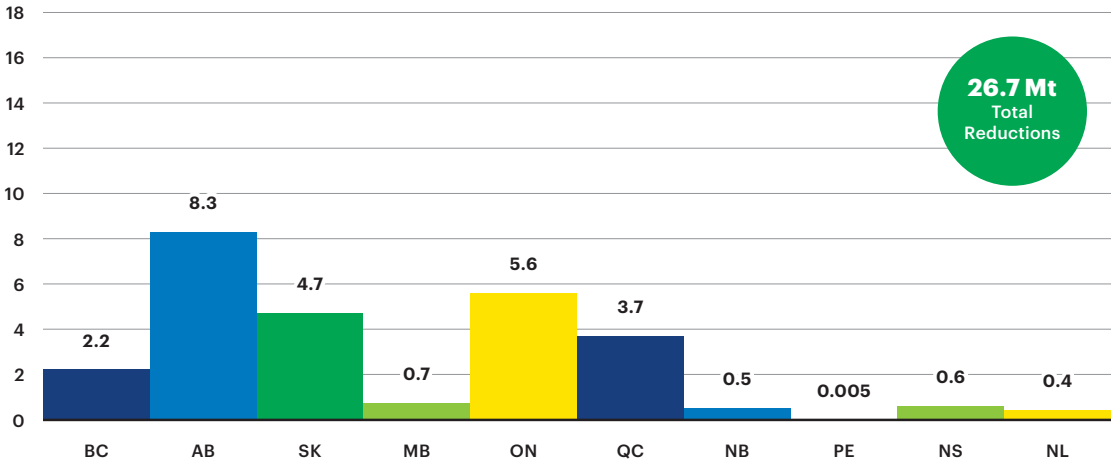


Figure 17:
GHG Reductions Under the Optimal Policy Mix in 2040 – by Province:

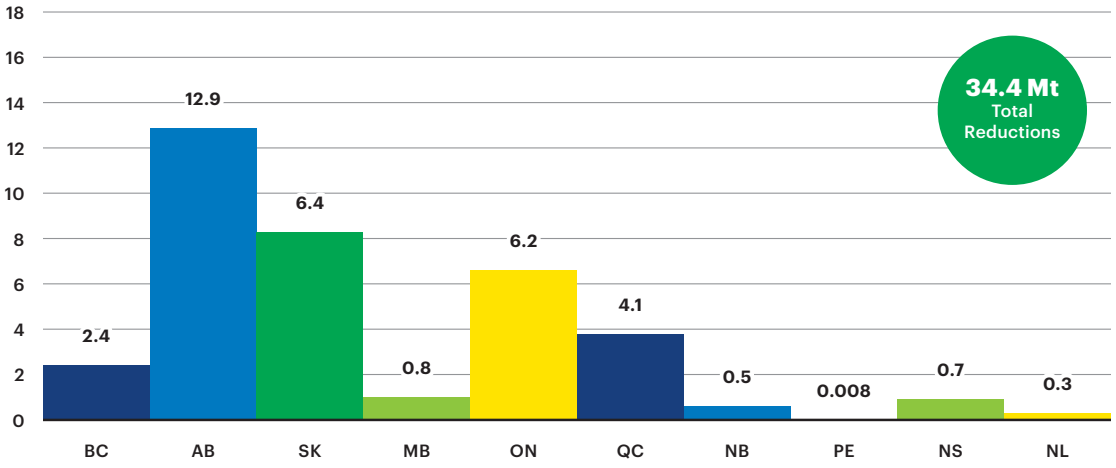
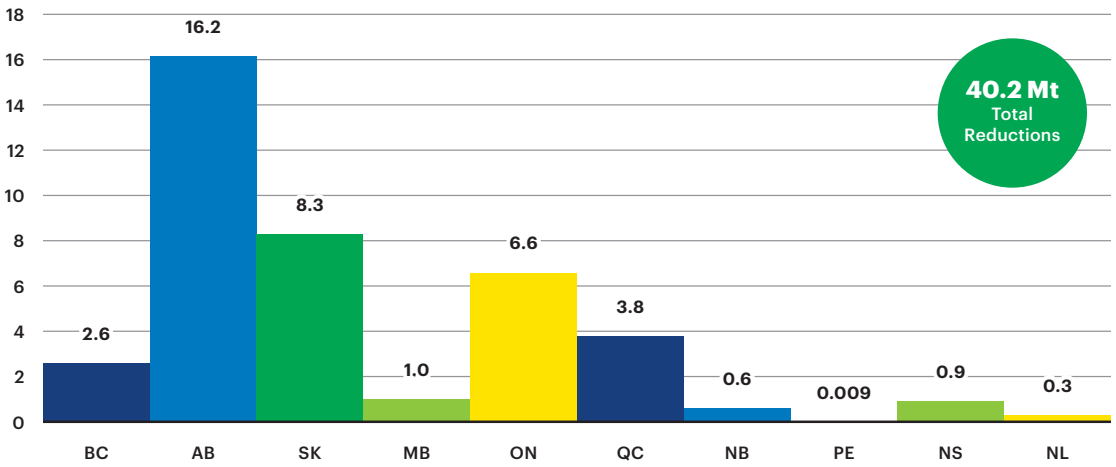
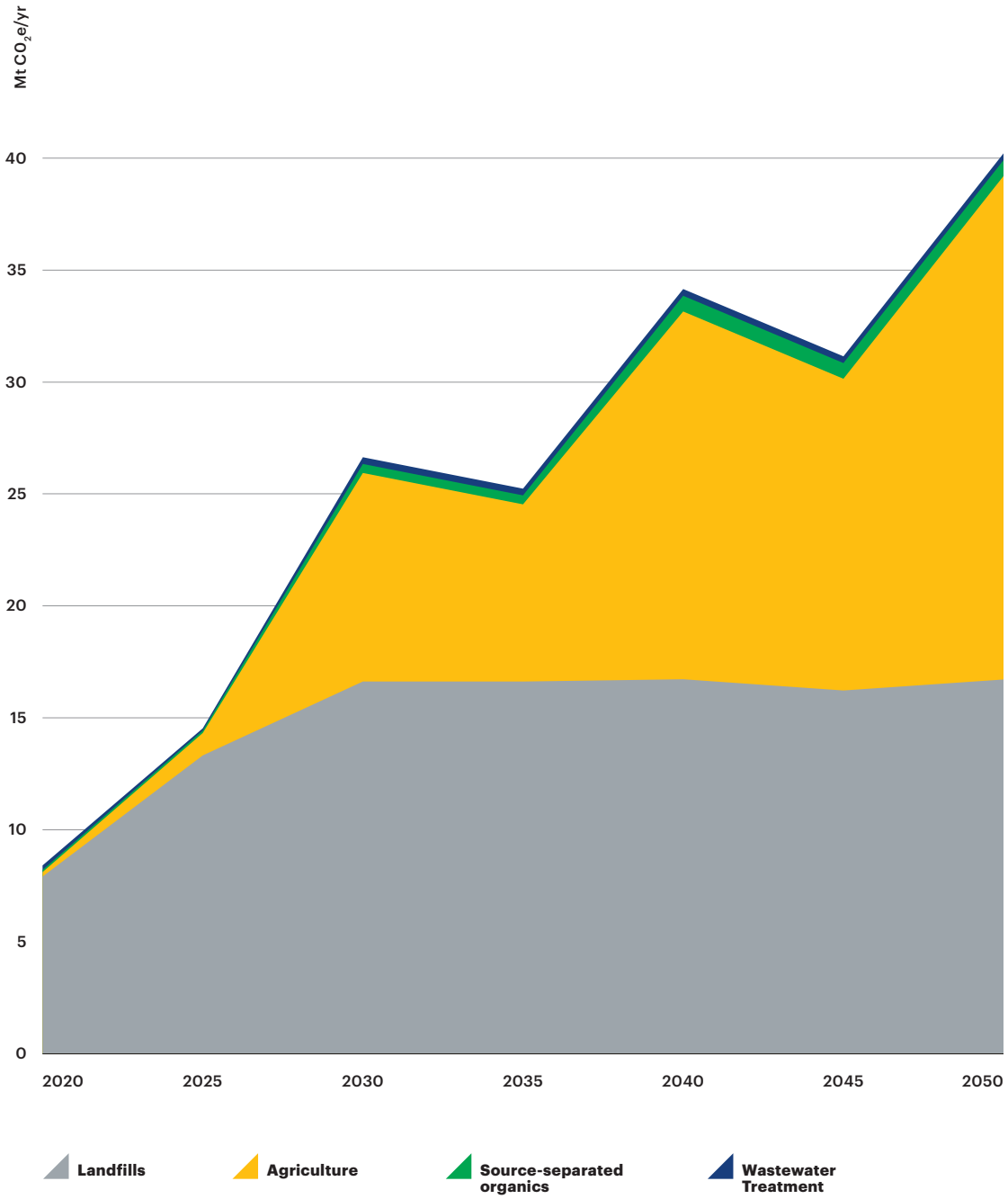


Figure 18:
GHG Reductions Under the Optimal Policy Mix in 2050 – by Province:



Appendix B:
GHG Reductions by Source

Figure 19:
GHG Reductions Through Biogas & RNG Under the Optimal Policy Mix, 2020–2050 by Source



Appendix C:
Current Policy Drivers

Like other climate solutions, biogas & RNG is sensitive to government policy. That's because, as environmental economists point out, climate solutions have not traditionally had an intrinsic market value.[40] This means that biogas & RNG is less cost competitive against its polluting fossil-fuel equivalents (see Figure 20), simply because its significant climate advantage isn't reflected in the price. Government policies at the federal and provincial levels are helping correct this market failure.

Figure 20:
Without Smart Government Policy, Biogas & RNG Can't Compete with Polluting Fossil Fuels

Fuel	Cost	Climate friendly?
Natural Gas	2.36 $/GJ[41]	No
Diesel	29.79 $/GJ	No
Biogas & RNG	6.70 – 55.00 $/GJ*	Yes

i. Carbon pricing

Carbon pricing has a positive effect on biogas & RNG energy development since it levels the playing field by increasing the cost of high-pollution fossil fuel alternatives.

The Government of Canada introduced a nationwide price on carbon pollution in 2018. The federal pricing system acts as a backstop to provincial systems, ensuring there is a minimum price being applied across Canada. In 2020, the federal government committed to a medium-term schedule whereby the carbon price will rise incrementally from $30/tonne in 2020 to $170/tonne in 2030. As the price rises, it will have a correspondingly positive effect on the development of biogas & RNG.

ii. Renewable gas mandates

Renewable fuel mandates require fossil fuel suppliers to blend in a minimum percentage of renewable content. This kind of regulation has existed at the federal and provincial levels for liquid fuels since 2011.[42] More recently it has been used at the provincial level for gaseous fuels, with British Columbia and Québec both using RNG mandates to require that provincial natural gas suppliers add renewable content to their supplies of conventional natural gas. This in turn has stimulated the adoption of biogas & RNG alongside other renewable gases.

* See Appendix D-II for Production Costs calculated by Navius Research

British Columbia: BC's emerging renewable gas mandate will require natural gas suppliers to blend at least 15 percent renewable content by 2030.[43]

Québec: Québec's RNG mandate, implemented in 2019, aims to achieve a 5 percent renewable blend by 2025 and 10 percent renewable blend by 2030.[44]

For more on renewable gas mandates, see Appendix C.

iii. Landfill gas controls

Many provincial governments have regulations governing methane emissions from landfills. Because landfill gas is a major feedstock for biogas & RNG energy, these regulations can stimulate biogas & RNG development. However, the impact of these regulations is limited by the fact that they can often be met through simple methane collection and flaring, without utilization through biogas & RNG energy.

British Columbia: Large landfills producing over 1000 tonnes of methane per year are required to collect landfill gas.

Manitoba: Three largest landfills are required to collect landfill gas.

Ontario: Landfills larger than 1.5 million cubic metres are required to collect landfill gas and to flare it or to utilize it for electricity generation.

Québec: Large landfills collecting more than 50,000 tonnes of residual materials per year are required to collect landfill gas and to flare it or utilize it.

iv. Clean fuel standards

Clean fuel standards force fossil fuel suppliers to gradually reduce the GHG intensity of their fuels while allowing for a range of compliance pathways to help them achieve that. One tool permitted is the integration of cleaner fuel alternatives. As a result, depending on how they are designed, clean fuel standards can stimulate biogas & RNG activity.

Canada: The federal government's Clean Fuel Standard, set to come into effect in 2022, will have a negligible impact on biogas & RNG. After initial design drafts that included a dedicated gaseous stream, the government reduced the proposed regulation to only liquid fuels. However, a minimal allowance for gaseous fuels could have a small effect on biogas & RNG.

British Columbia: BC's Low Carbon Fuel Standard, initially introduced in 2008, aims to achieve a 20 percent reduction in the carbon intensity of transportation fuels by 2030. In 2019, RNG was approved for inclusion as a transportation fuel, which sends a positive signal to biogas & RNG developers, though confined to its use for transportation.

California: California's Low Carbon Fuel Standard, which also applies only to transportation fuels, allows for compliance credits to be generated outside of the jurisdiction. As a result, it has stimulated a small amount of biogas & RNG activity in Canada.

v. Offset systems

Government-regulated GHG offset systems allow credits to be generated by approved activities that voluntarily reduce emissions. These credits can then be sold to firms to help them comply with regulated emissions reduction targets. Offset systems that allow credits to be generated through methane destruction in the waste or agriculture sectors can be effective at stimulating biogas & RNG development so long as they allow utilization through biogas & RNG as an eligible destruction device.

Alberta: The Alberta Emission Offset System allows credits to be generated by biogas & RNG projects – including landfill gas, diverted organic waste, animal manure and wastewater projects – and sold to firms regulated under the TIER (Technology Innovation and Emissions Reduction) regulation.[45]

Québec: Firms regulated under the province's cap-and-trade system can purchase offsets, including through landfill and manure-based biogas & RNG projects.[46]

Under Development: Relevant offset protocols are also currently under development at the federal level and by governments in British Columbia and Saskatchewan, though these are not yet in effect at time of publication.

Appendix D:
Background on a Renewable Gas Mandate

The number one policy identified in this report for maximizing the role of biogas & RNG in helping Canada meet its 2050 climate goals is a renewable gas mandate. Renewable gas mandates require natural gas suppliers to blend in a minimum percentage of renewable content. This appendix provides additional background on this policy option, including its precedents in Canada and observations on its broad base of support.

Precedents:
Renewable fuel mandates are a policy tool already being used across Canada and internationally. They are frequently used in relation to liquid fuels and increasingly used for gaseous fuels. The following are notable precedents across Canada and internationally.

Renewable Fuels Regulations (2011): The Renewable Fuels Regulations,[47] initially introduced by the federal government in 2011, apply a renewable content mandate to liquid fossil fuels. They include a minimum average volumetric content requirement of 5 percent for gasoline and 2 percent for diesel fuel and heating distillate oil. The regulation applies to producers and importers of liquid fossil fuels, such that by the time the fuel reaches the retail customer, it is compliant with the mandate. Select fuel uses are exempted in the regulation. For more information on the details of the regulatory design, see Environment and Climate Change Canada's "Federal RFR Overview".[48]

A key design feature of the federal Renewable Fuels Regulations (2011) was to make it complementary to provincial systems. The renewable content minimums outlined in the Renewable Fuels Regulations serve as a baseline, which five provinces (BC, AB, SK, MB and ON) are either meeting or exceeding with their own provincial-level renewable liquid fuel mandates.[49]

Where the federal Renewable Fuels Regulations have fallen short is in gradually ratcheting up the minimum content requirement over time. At the provincial level, only British Columbia has regulated an increase in the minimum content requirement since its renewable liquid fuel mandate came into effect in 2010.[50] At the federal level, the baseline requirements have never increased since the regulation was implemented in 2011.[51]

Nevertheless, the federal Renewable Fuels Regulations has proven successful. It is credited with achieving an estimated 4 Mt CO_2e per year in emissions reduction[52] and for driving significant growth in the development of biofuels like ethanol and biodiesel, almost doubling Canadian biofuel demand over its first four years.[53]

The Renewable Fuels Regulations have more recently been incorporated into the federal government's proposed Clean Fuel Regulations, which layer a clean fuel standard for liquid fuels on to the renewable fuel mandate.[54]

Québec Renewable Gas Mandate: In 2019, the Government of Québec introduced a renewable gas mandate that built on existing voluntary industry commitments.[55] The regulation requires natural gas suppliers in the province to blend in a minimum 1 percent of renewable gas by 2020-2021 and a minimum 5 percent renewable gas by 2025-2026. The government also indicated in its latest climate plan (2020) that it expects to increase the renewable gas mandate to 10 percent by 2030.[56] Unlike the federal Renewable Fuels Regulations, a clear and predictable schedule for increasing minimum content requirements both optimizes the environmental benefits and the economic benefits of the regulation.

BC Renewable Gas Mandate: British Columbia's CleanBC plan (2018) identified an "RNG mandate" as an important policy for achieving its 2030 climate targets. The proposed RNG mandate would require that the province's natural gas distributors blend in a minimum 15 percent renewable content into their supply by 2030.[57] The renewable content permitted is not limited to biogas-based RNG, as the policy name denotes, but is open to a range of renewable gases, including low-carbon hydrogen, synthesis gas and lignin.

The province has since paved the way to formally implementing this mandate with an amendment to the Greenhouse Gas Reduction Regulation in June 2021, which allows natural gas utilities to increase the amount of renewable gas they may acquire and supply from 5 percent to 15 percent of their total annual supply of natural gas.[58]

California Renewable Natural Gas Standard (2022): In Februrary 2022, the California Public Utilities Commission announced a renewable gas mandate that applies to California's four major natural gas distributors as well as its many smaller ones. The California mandate is specific to biogas-sourced RNG, as opposed to hydrogen or biomethanized RNG, and requires a 12.8 percent minimum renewable blend by 2030.

EU RED I: The European Union's initial Renewable Energy Directive (RED I, 2009) established a renewable fuel mandate, requiring that 10 percent of all energy used for transportation come from renewable

sources by 2020. This target has since been increased to 14 percent by 2030.[59] While the Renewable Energy Directive policy allows for electrification of transportation as a pathway, the majority of the target so far has been met through the blending of renewable content into conventional liquid fuels, similar to the outcome of Canada's renewable liquid fuel mandates.[60]

US Liquid Fuel Mandates: Seven US states have renewable liquid fuel mandates in place.[61]

Looking Ahead:
There is broad acceptance at the industry, political and civil society levels that a renewable gas mandate is a valuable policy tool for reducing Canada's GHG emissions.

Industry: The Canadian Gas Association, which represents the 17 local natural gas distributors across the country, has established a voluntary target of minimum 5 percent renewable content in the natural gas supply by 2025 and minimum 10 percent renewable content by 2030.[62] This voluntary target is just one example of the industry's support for increasing renewable content in its supply.

Political: There appears to be support for renewable gas mandates across the political spectrum. Canada's existing renewable gas mandates have been implemented and supported by NDP, Liberal and conservative-striped governments. Canada's existing renewable liquid fuels mandates were implemented federally and provincially by Liberal, Conservative and NDP governments. Meanwhile the 2021 Conservative election platform proposed a federal renewable gas mandate.

Civil Society: Important civil society of groups have endorsed renewable gas mandates as a policy. In 2021, seven of Canada's leading environmental groups advocated for a renewable gas mandate for reaching and exceeding Canada's 2030 climate targets.[63]

Appendix E:
Modelling by Navius Research

The analysis in this report is based on an extensive modelling exercise conducted by Navius Research from November 2021 to February 2022 using its gTech environment-economy model. Below is a summary of the key assumptions used in the model.

i. Biogas & RNG Production Potential

The model factors in a maximum potential for biogas & RNG production. This potential considers, and is sometimes directly calibrated with, the results of a comprehensive study of RNG feedstocks published by TorchLight Bioresources in 2020.[64] This potential is measured in terms of the total quantity of biogas energy (PJ/yr) that could be produced. Within this study's analysis, the quantity of actual biogas production that occurs is a subset of this maximum. How much of the maximum potential is realized is a function of biogas production costs, and the extent to which energy markets and policies incentivize biogas production.

Figure 21:
Biogas & RNG Energy Production Potential by Source

	Maximum potential used by Navius	"Theoretical" and "feasible" potential identified by Torchlight	Notes
Dairy (manure co-digestion)	7 PJ/yr	Theoretical: 9 PJ/yr Feasible: 5 PJ/yr	Navius value higher than "feasible" because it includes all utilization of biogas, not just RNG. Navius potential scales for sector growth.
Other animals (manure co-digestion)	24 PJ/yr	Theoretical: 31 PJ/yr Feasible: 16 PJ/yr	Navius value higher than "feasible" because it includes all utilization of biogas, not just RNG. Navius potential scales for sector growth.
Landfills	47 PJ/yr	Theoretical: 49 PJ/yr Feasible: 33 PJ/yr	Navius value set higher than "feasible" because it includes all utilization of biogas, not just RNG.
Corn silage and crop residue	No fixed maximum, constrained only by physical and economic factors	Theoretical: 537 PJ/yr Feasible: 155 PJ/yr	Torchlight notes that under current conditions, likely production is 0 PJ/yr.
Municipal wastewater treatment	10 PJ/yr	Feasible: 10 PJ/yr	Navius values aligned with Torchlight estimates for 2020 model period, scaling for population growth.
Source separated organics	11 PJ/yr	Feasible: 6 PJ/yr	Torchlight estimate considers only urban organics. Navius values incorporate ICI waste streams identified in Kelleher et al (2013)[65], scaling both for population growth and increased organic diversion.
Pulp mill effluent	6 PJ/yr	Feasible: 6 PJ/yr	Navius values aligned with Torchlight estimates, scaling for sector growth.

ii. Biogas Production Costs

To determine biogas & RNG production costs, Navius Research consulted a wide range of literature and analysis.[66, 67, 68, 69, 70, 71, 72, 73, 74]

Navius evaluated the range of costs for two key sources: (i) landfill gas, and (ii) anaerobic digestion (AD), where the AD production costs are differentiated by the production pathway and feedstocks, including on-farm manure co-digestion versus digestion primarily of crop residues or silage, as well as AD of source separated organics (SSO) and AD at wastewater treatment (WWT) facilities. Production costs were also differentiated by energy outputs, including RNG production, electricity and direct heat.

Figure 22:
Production Costs (2020 CAD) implied by Model inputs

	RNG $/GJ	Electricity $/GJ	Direct Heat $/GJ
AD on Farms	17.50–25.60	39.00–55.00	13.00–18.00
AD with SSO & WWT	19.80–28.00	39.00–55.00	13.00–18.00
Landfill Gas (Collection & Utilization)	12.00	33.60	Not included
Landfill Gas (Only utilization, LFG already collected)	6.70	19.10	Not included

iii. Carbon Intensities

Carbon intensities (CI) exist within the gTech model in two ways. First, they are used to define credit generation potential per unit of RNG supplied under policies such as clean fuel standards. Second, and more importantly, they define the parameterization of biogas production pathways in terms of how much energy those pathways consume and what methane or other GHG emissions they produce or emit per unit of energy produced.

These are the CI values used in the Navius modelling:

Figure 23:
Biogas & RNG Carbon intensities Used in Modelling

Anaerobic Digestion	10–40 gCO_2e/MJ_{RNG} excluding any credit given for methane abatement
Landfills	30–40 gCO_2e/MJ_{RNG} excluding any credit given for methane abatement

* Carbon Intensity ranges are a function of cross-Canada variation in upstream electricity GHG emissions. They reflect the GHG intensity of electricity grids today. As grids become cleaner, implied CI values will lower.
* Carbon Intensity values also reflect methane leaks during biogas utilization. This study assumes 2.5% leakage for AD and 7% for landfills.

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Canadian Biogas Association
canadienne de biogaz

Canadian Biogas Association
275 Slater Street
Suite 900
Ottawa ON
K1P 5H9
Canada

biogasassociation.ca