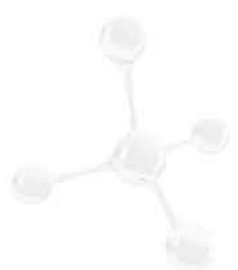
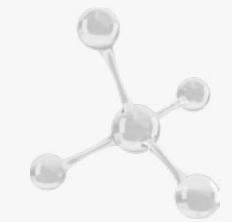
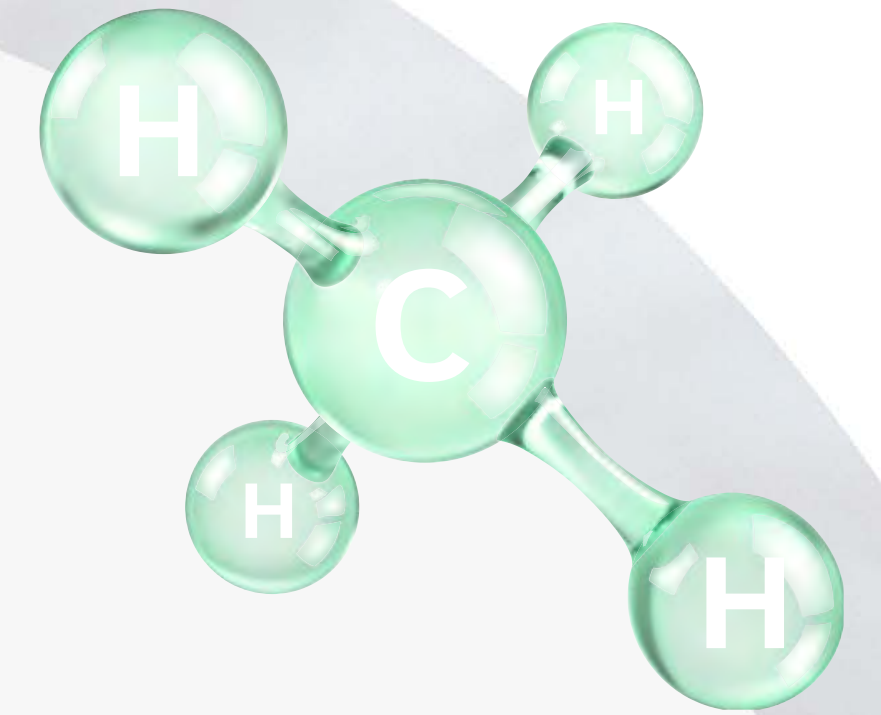




Taking Action on Methane Emissions

Untapping Canada's agricultural
biogas opportunity

Executive E-book | March 2024



Message from the authors

Why manure? Why biogas? And why now?

Canada has over 25 million cows and hogs, and over 155 million chickens. Together, they produce a lot of manure—and that manure produces a massive amount of methane, an especially powerful greenhouse gas.

Places such as California, Germany and Denmark have invested heavily in biodigesters to capture this methane. But Canada lags our peers in the United States and Europe.

CANZA was formed to spur action in helping Canada's agri-food sector reach net zero. Much good work is happening across the country. But we wondered why Canada has made only small steps in containing the methane gas produced by agri-food. That question launched the research behind this report.

What we learned confirms that manure is a big contributor of Canada's greenhouse gas emissions and must be dealt with to achieve our net zero targets.

Biodigesters are a proven technology that many countries are using successfully to contain emissions. Moreover, the use of biodigesters can unleash economic growth in multiple ways, aiding farmers, their local communities and the country as a whole.

Our takeaway, as you'll read in this report, is that biodigesters are a major opportunity that is ripe for Canada to seize.

We hope you find this report insightful and helpful as you navigate net zero agri-food within your organization. If you would like to get involved in the biogas opportunity, we would love to talk with you.

About this report

Methodology

This report was prepared leveraging industry knowledge from the Canadian Alliance for Net Zero Agri-food (CANZA), the Canadian Biogas Association (CBA) and BCG Centre for Canada's Future, supplemented by over 50 farmer and expert interviews across Canada and at CANZA's October 11, 2023 launch event.

Co-authors

This report was prepared by CANZA in close collaboration with our pro bono partners.




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Keith Halliday


John van Logtenstein


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Executive summary

01

We can't reach Canada's net zero targets without tackling methane

While CO₂ hogs the headlines, methane represented 14% of Canada's greenhouse gas emissions in 2021.¹

Tackling methane is especially important in reaching our 2030 targets, since its global warming potential is 81X that of CO₂ in its first 20 years in the atmosphere.

02

We can't tackle methane without tackling agriculture and manure

Methane from manure on Canadian farms contributed 4 megatonnes of CO₂e in 2021.^{1,2}

That's the equivalent of 900,000 cars on Canadian roads.

03

Biodigesters capture methane, and produce other important benefits

Biodigesters capture methane from manure and convert it into a source of electricity or a source of renewable natural gas (RNG), displacing fossil fuels.

The collateral benefits include new farmer revenue, easily-storable energy in the form of RNG for peak winter heat and power, as well as improved nutrient, water and pathogen management.

04

Canada is only capturing 4% of its agricultural biogas potential

While some leading farmers are building biodigesters, their numbers are few. Today, Canada has ~75,000 farms with animals, yet only 45 agricultural biodigesters.

We estimate the industry could be 25X bigger and displace 6–8 MT of agricultural methane and fossil fuel emissions.

05

Farms need significant help to achieve viable business cases for biodigesters

Biodigesters have scaled up dramatically in Europe and the US, but the market remains small in Canada due to the lack of robust incentives.

Biodigester economics have proven to be challenging, especially for smaller farms, without tools such as investment tax credits, RNG blend mandates for utilities and accessible clean-fuel credits.

06

The time is now

It takes years to design, permit and construct a biodigester. With 2030 approaching, Canada needs a concerted effort now to put robust incentives in place and resolve the other barriers covered in this report.

COP28's 'Methane Pledge' underlined the growing global momentum to address methane.

1. On a CO₂-equivalent basis; 2. Canada's national inventory report 'Greenhouse Gas Sources and Sinks'; Source: NIR 2023; Statistics Canada; EPA Greenhouse Gas Equivalencies Calculator; BCG analysis

Manure Methane 101

What is Canada's manure methane problem and how can biodigesters help?

Canadian Context

What is the agricultural biogas potential in Canada?

4 Key Questions

Future Potential

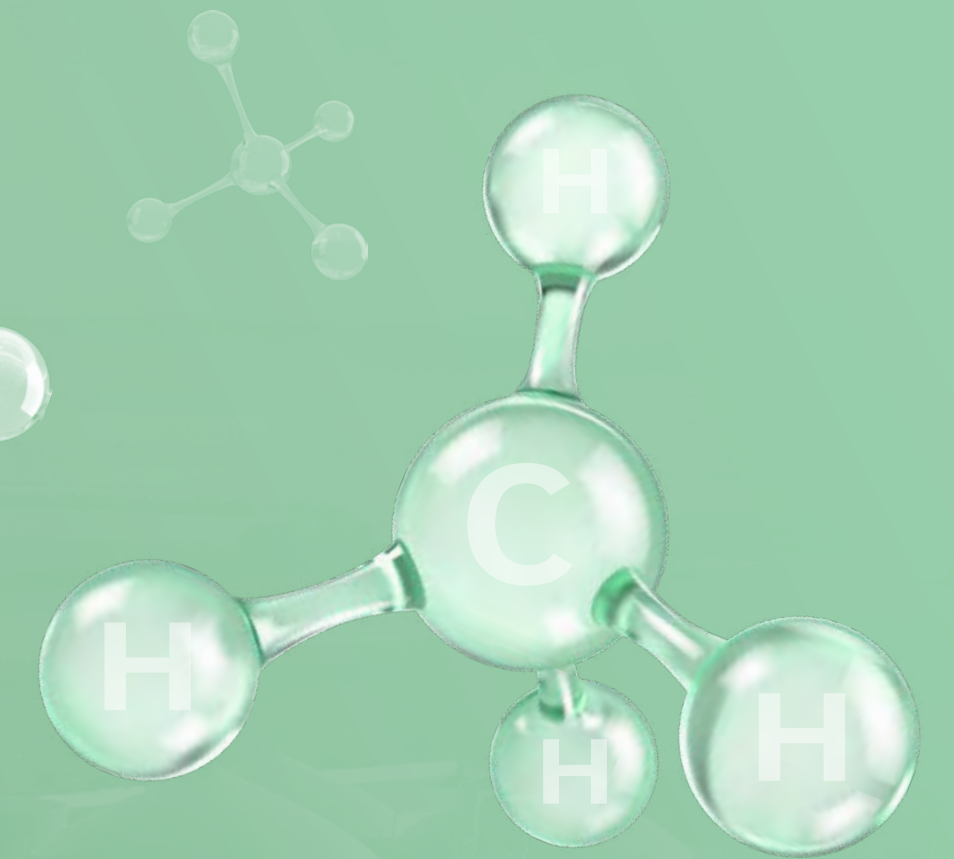
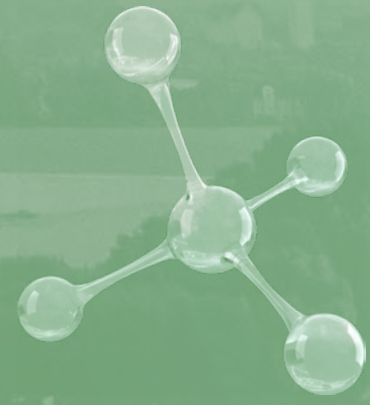
How could we unlock biogas success in Canada?

The Economics

What is the farmer's business case?

MANURE METHANE 101

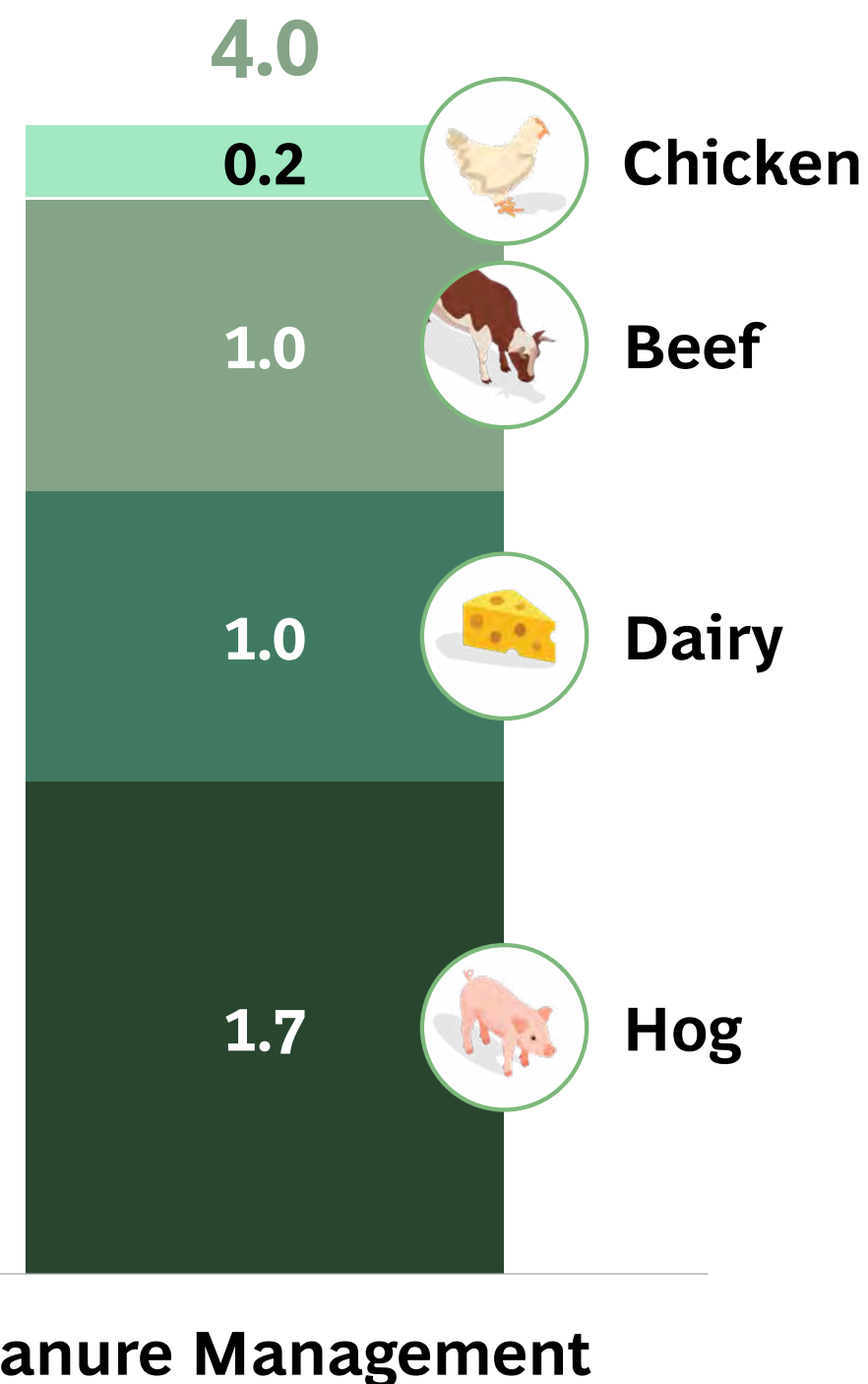
**What is Canada's
manure methane
problem and how can
biodigesters help?**



The problem: Manure from farm animals produces methane, which is a potent greenhouse gas

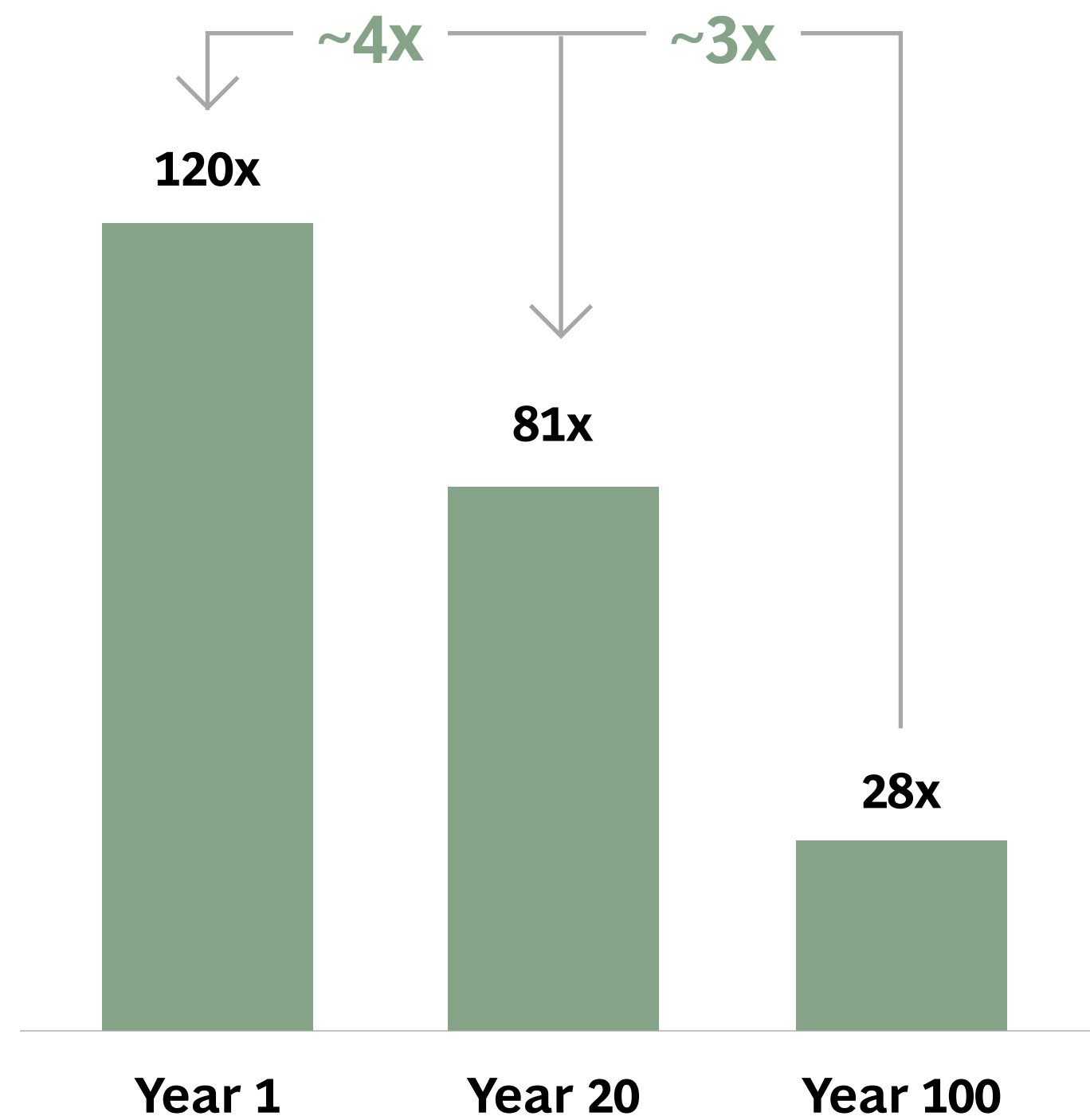
Manure management produces 4MT CO₂e of methane (0.5–1% of Canada's total emissions)...

2021 Emissions MT CO₂e



...Which is especially important to abate given methane's higher short-term climate impact

Global Warming Potential Versus CO₂

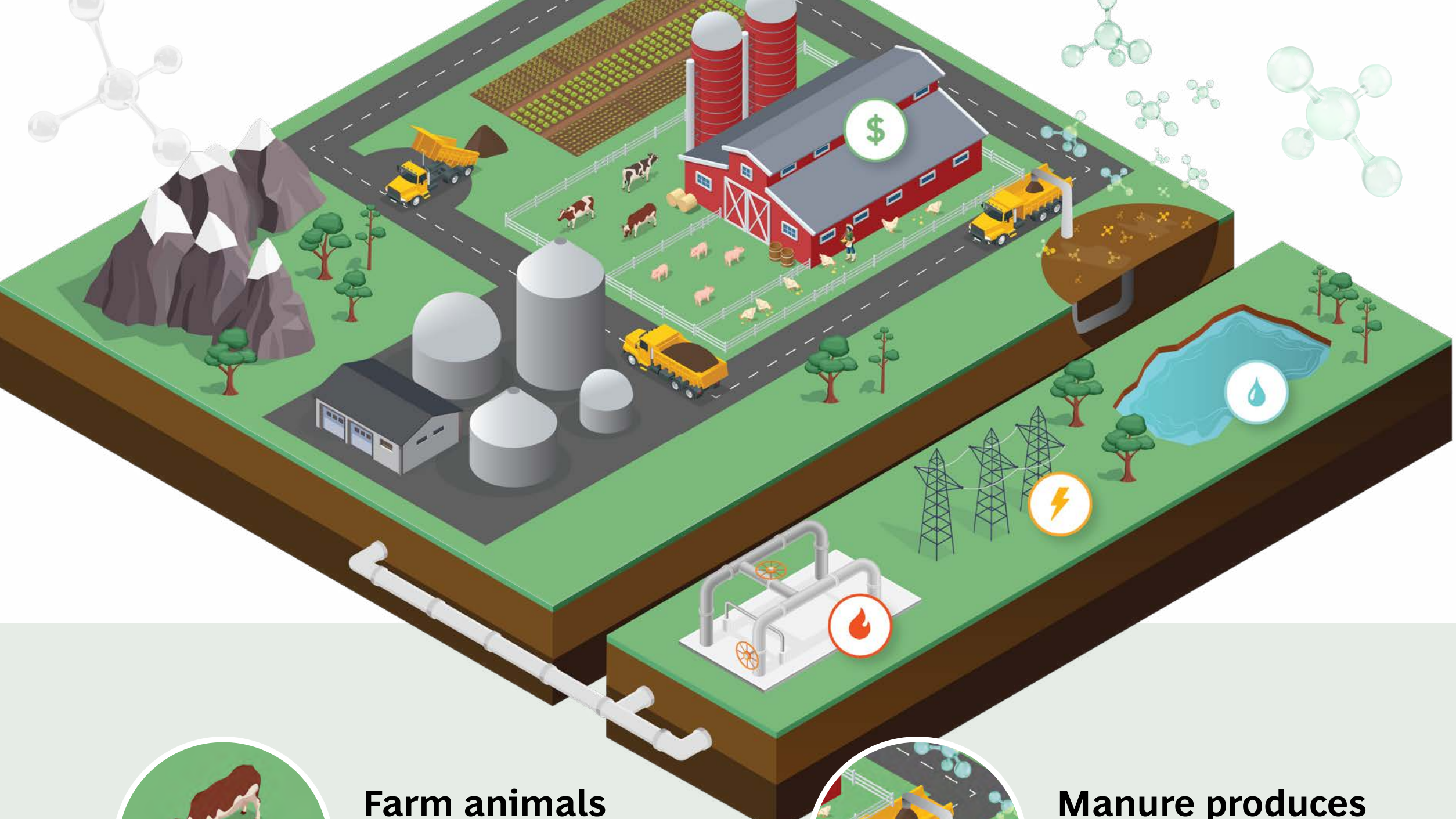


Canada has ~180M beef cattle, dairy cows, hogs, and chickens combined. And the management of the manure these animals create leads to 4MT CO₂e of methane today.

Throughout this document we will discuss biodigesters, which are a proven technology to address these emissions and are ready to scale with the right Canadian supports.

However, methane's impact (and therefore biodigesters') is significantly front-loaded. Accounting for this near-term potency makes biodigesters 3-4X more meaningful an abatement lever for delivering on 2030 and 2050 reduction goals compared to when viewed using 100-year CO₂e projections.

Canada is a champion of the Global Methane Pledge and has an opportunity to make significant progress with biodigesters.

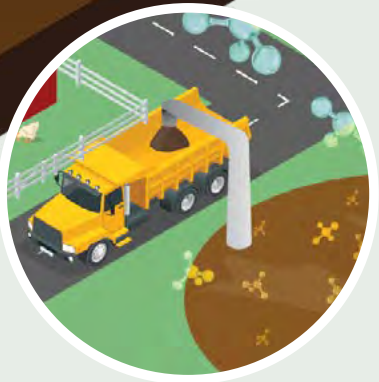


What is an agricultural biodigester?

A large enclosed tank in which bacteria digest manure and other organic waste in an anaerobic or oxygen-free environment to produce a fossil fuel replacement called biogas and nutrient-rich digestate.



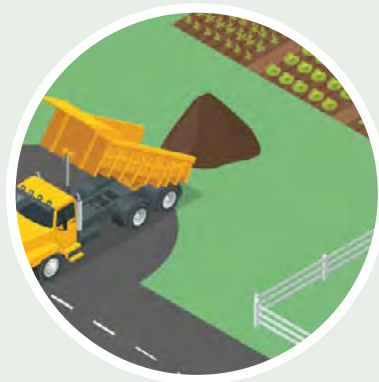
Farm animals produce manure in large quantities



Manure produces methane, a potent greenhouse gas



Biodigesters digest manure and capture the methane...



... producing biogas, RNG, electricity, digestate and more

DID YOU KNOW?

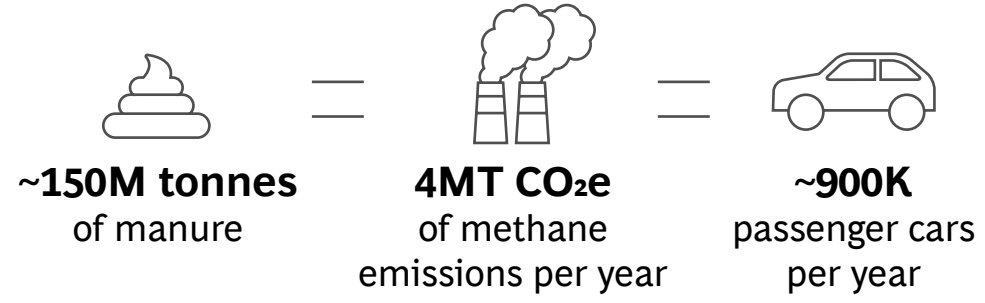
Canada has **~180M** beef cattle, dairy cows, hogs, and chickens combined



This totals about **4** for each Canadian

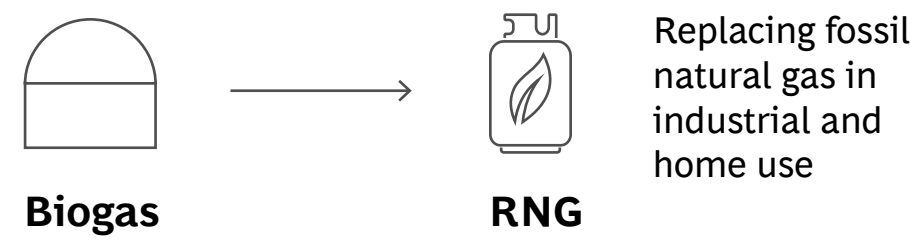
DID YOU KNOW?

Agricultural activity produces about 150M tonnes of manure per year



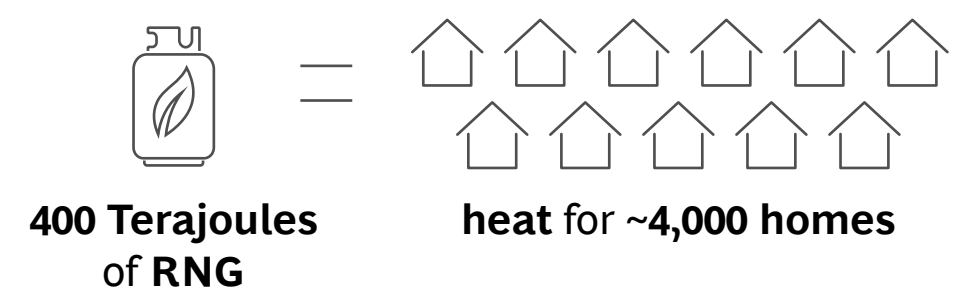
DID YOU KNOW?

The methane can be converted to energy on farm as biogas, electricity, or upgraded to RNG



DID YOU KNOW?

The annual output of a large biodigester could be...



ADDITIONAL BENEFITS
Providing manure to biodigesters creates a **new income stream** for farmers.

ADDITIONAL BENEFITS
Biodigesters can improve water quality and pathogen management when manure is collected and digested.

ADDITIONAL BENEFITS
The remaining organic material is a fertilizer called digestate and is re-used on farms.

Why agricultural biogas is important to Canada

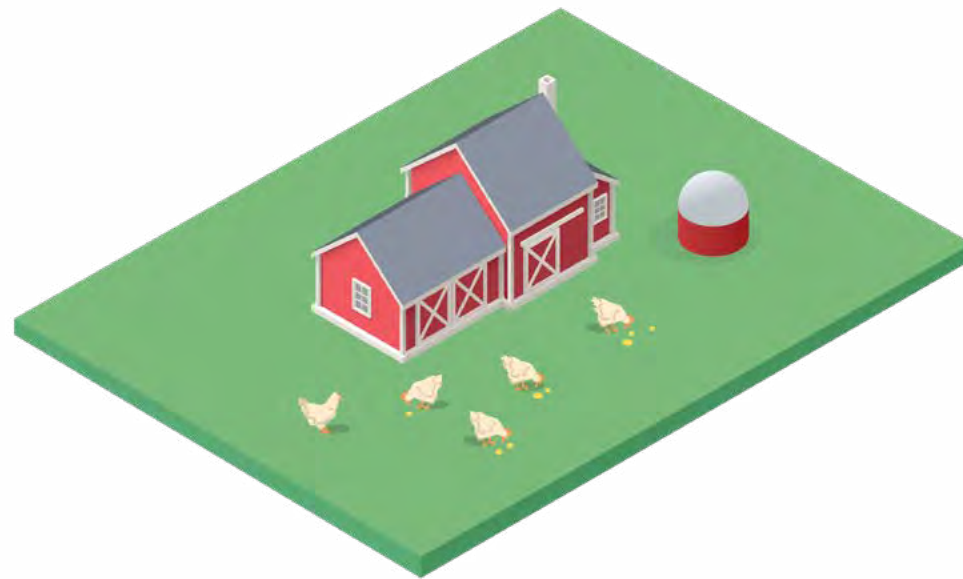


	Why is biogas important?	Potential impact
 Slashes methane emissions	Biodigesters enable the methane emissions reductions crucial for Canada to achieve its 2030 interim and net zero targets	6–8 MT of CO₂e climate impact from manure methane capture and fossil fuel displacement ¹
 Boosts farm and rural income	Biodigesters offer farmers a new income stream, rural job creation, and economic growth	\$1–\$2B in GDP across Canada
 Stabilizes net zero energy system	RNG is critical in winter to supplement intermittent renewables	5% of winter peaking addressed through ~50 petajoules of agricultural RNG ²
 Increases feasibility of meeting 2030 targets	Biodigesters are a proven technology that can be quickly scaled by 2030	Additional impact due to methane's front-loaded climate effects
 Drives local ecological benefits	Biodigesters manage water quality and lower pathogen risks in traditional manure management	Impact real but not yet quantifiable
 Supports circular economies	Biodigesters produce digestate, a high-quality fertilizer that can be recirculated onto farms	Impact real but not yet quantifiable

1. Hitting Canada's Climate Targets (including Navius modeling); 2. Statistics Canada Consolidated Energy Statistics; BCG Analysis

Diverse operating models put biodigesters within reach of small and large farms

1



Very Small Biodigester

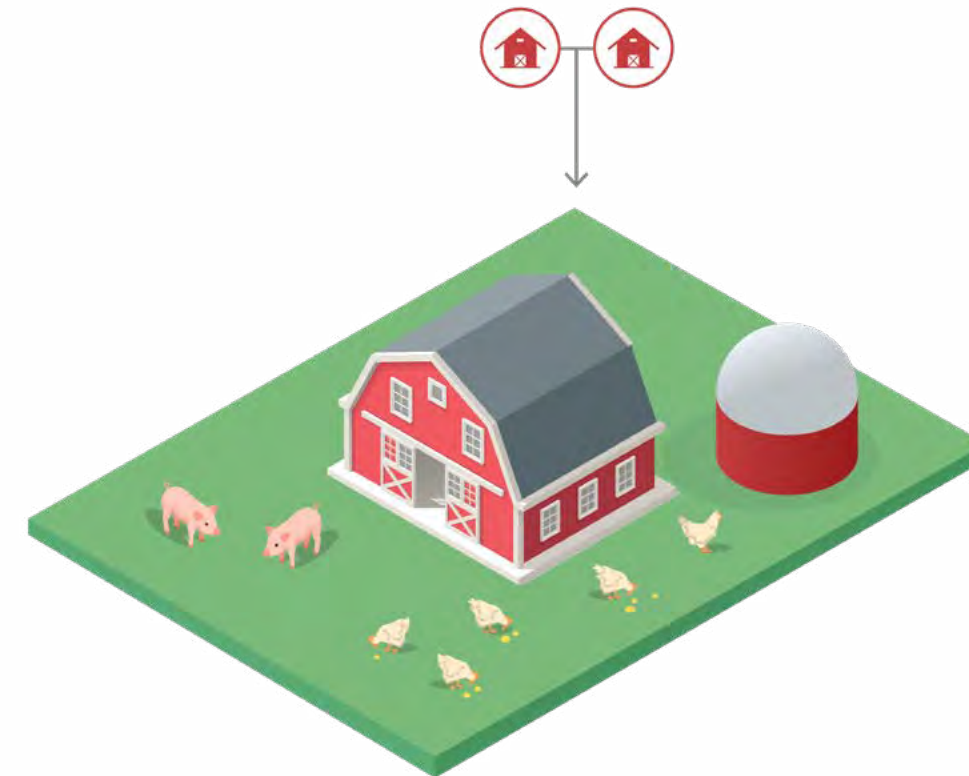
On-farm digestion and energy creation

~20 kilotonnes feedstock

Small to medium farm owns all digestion equipment and produces electricity and/or heat from manure available on site and nearby off-farm organics as available.

Biogas electricity or heat offsets reliance on external energy sources (or feeds electricity into provincial grid where applicable).

2



Small Biodigester

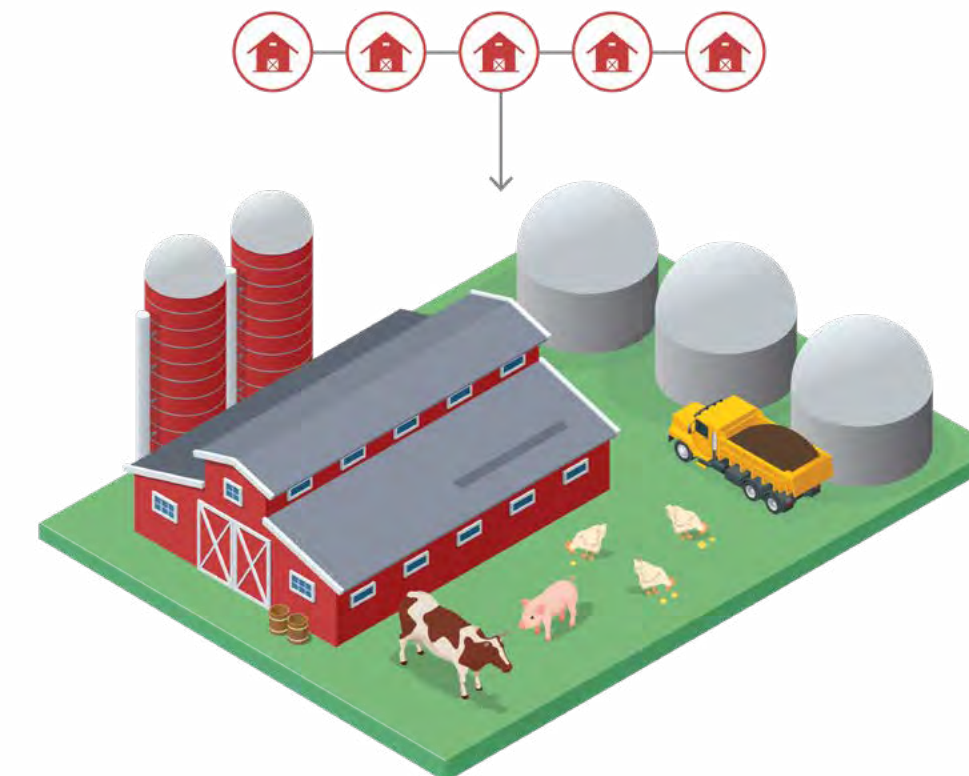
On-farm digestion and RNG processing

~60 kilotonnes feedstock

Medium to large farm owns and operates biodigester on site and takes feedstock from 1-2 nearby farms including nearby off-farm organics as available.

Farm invests in RNG upgrader, with small pipeline connection to a utility that purchases RNG.

3



Medium Hub-and-Spoke

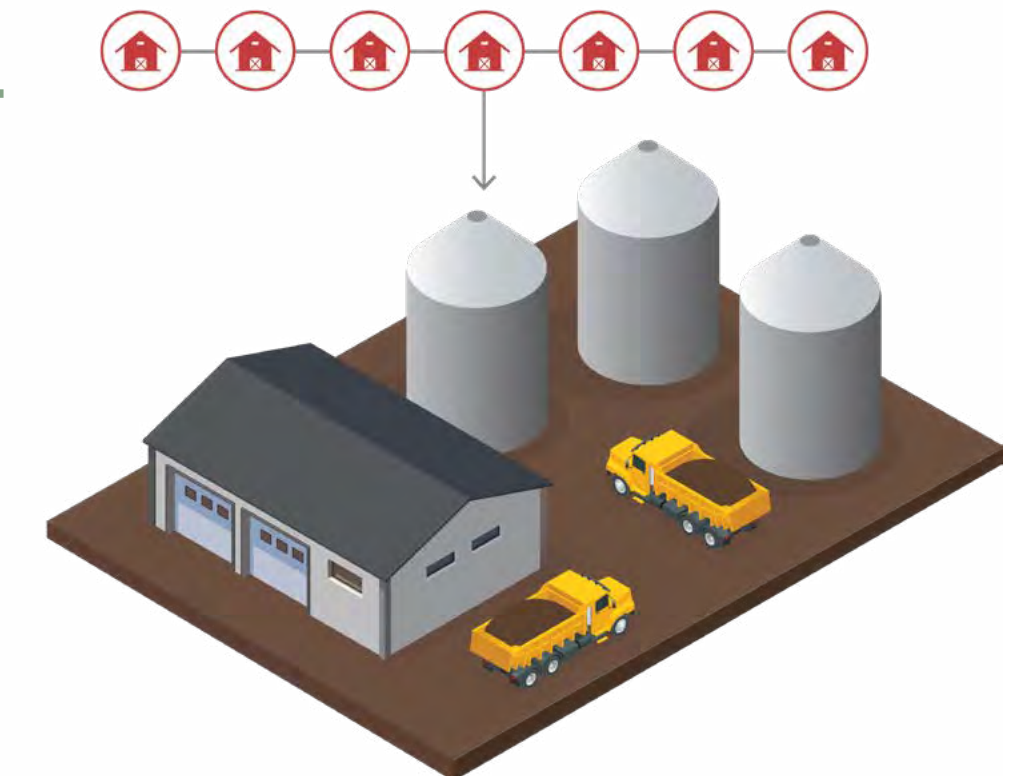
Centralized digestion and RNG processing

~200 kilotonnes feedstock

Large anchor farm owns and operates biodigester on site and takes feedstock from a few nearby providers including nearby off-farm organics as available.

Centralized biodigester upgrades and injects RNG into utility pipeline.

4



Large Hub-and-Spoke

Centralized digestion and RNG processing

~600 kilotonnes feedstock

Off-site biodigester trucks in feedstocks from many nearby feedstock providers including nearby off-farm organics as available.

Centralized biodigester upgrades and injects RNG into utility pipeline.

Farmer Control

Operational Complexity and Feedstock Efficiency

Canada's future will include all these models. Each is well suited for its niche, depending on geography, feedstock and pipeline availability

CANADIAN CONTEXT

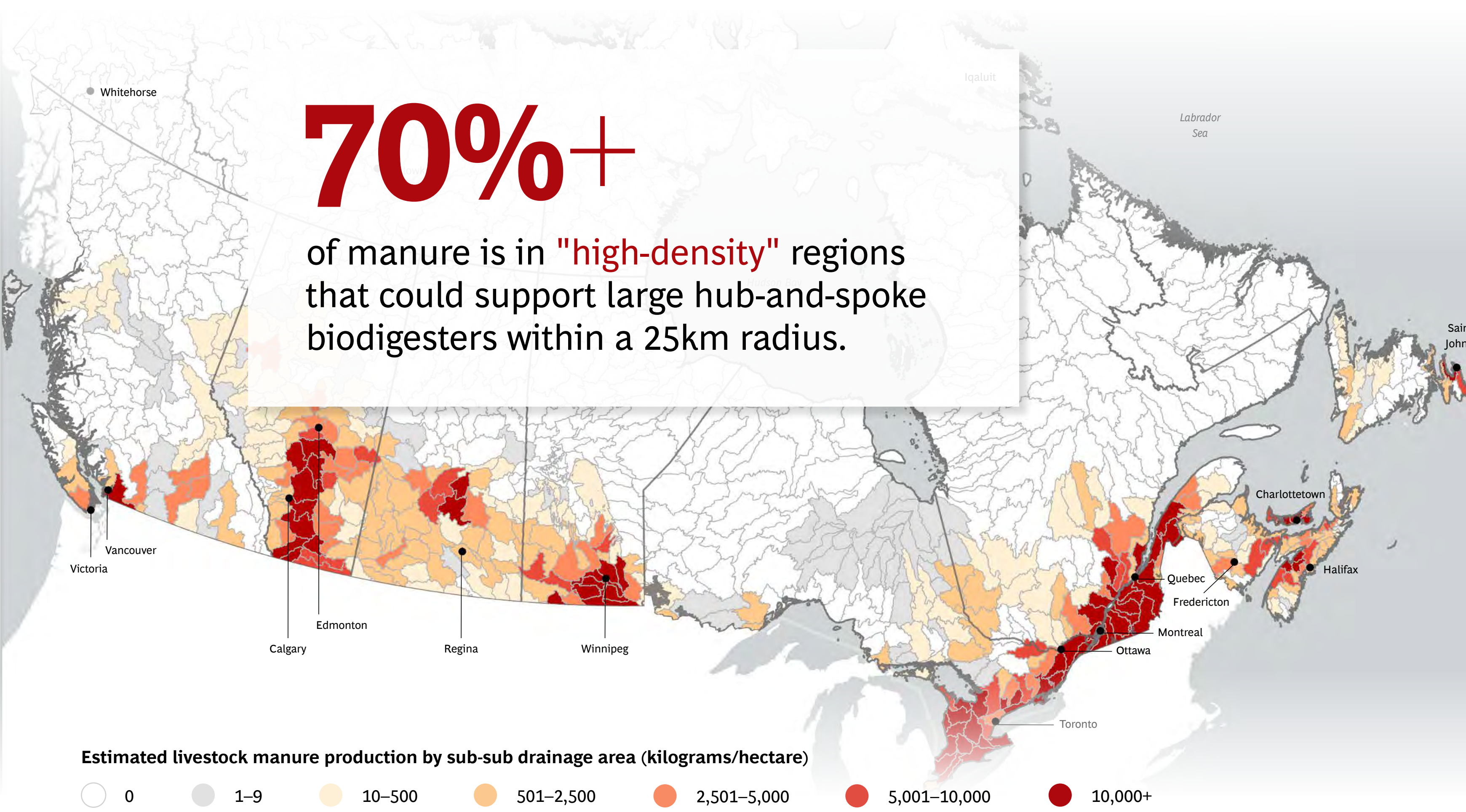
**What is the agricultural
biogas potential
in Canada?**



Canada's large agri-food industry makes manure an abundant commodity

70%+

of manure is in "high-density" regions that could support large hub-and-spoke biodigesters within a 25km radius.



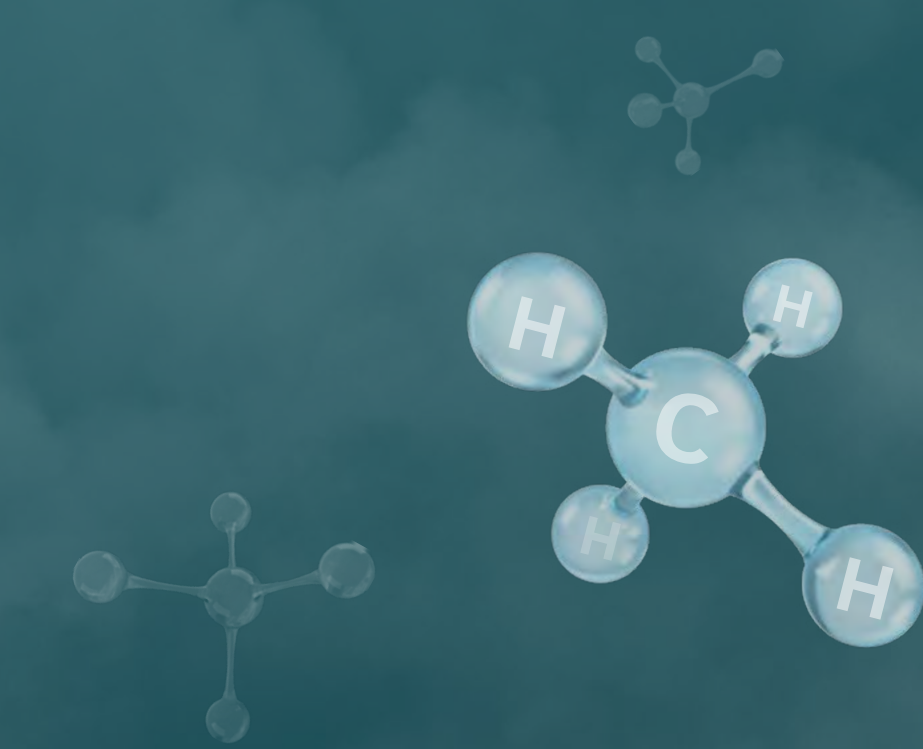
Source: Statistics Canada; BCG analysis

Biodigesters benefit from economies of scale. It is cheaper to process large amounts of manure that is aggregated in one place.

While Canada's farms are small on average—relative to our international peers—they are often located close to each other. This opens the possibility of 'hub-and-spoke' models, where a central biodigester takes manure from nearby farms and then ships the digestate to the same or other nearby farms.

Our analysis shows that 70%+ of manure is in regions where enough manure exists to support large hub-and-spoke biodigesters. Four provinces representing 80% of RNG potential have over three-quarters of their manure in high-density regions.

The remaining manure, a still sizeable quantity, is in lower-density regions. In these cases, single and small multi-farm operating models can be employed. Building this infrastructure will require additional policy support.



CASE STUDIES

Pioneers are leading the growing biogas industry today, but there is 25X more potential

The work has been rewarding but challenging...

"I'm pro biogas and biogas development. And the benefit to my farm has been meaningful. But it was a crazy learning experience and a hard journey. I'm kind of worn out."

BC FARMER

"It's always been tough. With regulatory, financing, and grid access challenges just to name a few. However, despite these challenges, I'm looking to double the size of my plant."

ALBERTA FARMER

...And the projects that have had success have been advantaged and policy supported

"Our project was possible thanks to our province's previous feed-in-tariff program. But to be successful we have been fortunate and worked hard to secure long term off-farm feedstock."

MARITIMES FARMER

"They have lots of off-farm organics. Taking manure alone would bankrupt our client in a week."

BC DEVELOPER

There are barriers to the market growing without more supports...

"It's difficult without support and clarity on what we can or can't get from carbon credits."

QUEBEC FARMER

"Figuring out if you should build a biodigester on your farm is complex. I worked with the utility, but they just sent me a 100-page PDF and there weren't really the farmer supports that I needed."

ONTARIO FARMER

...But climate focused farms see biodigesters as a mandatory part of the solution

"My goal is to sell pigs that are carbon neutral, and I can't do that without biodigesters."

QUEBEC FARMER

"I built my biodigester because it felt like the right thing to do. Circularity and all that, but of course it needed to make sense financially too."

ONTARIO FARMER



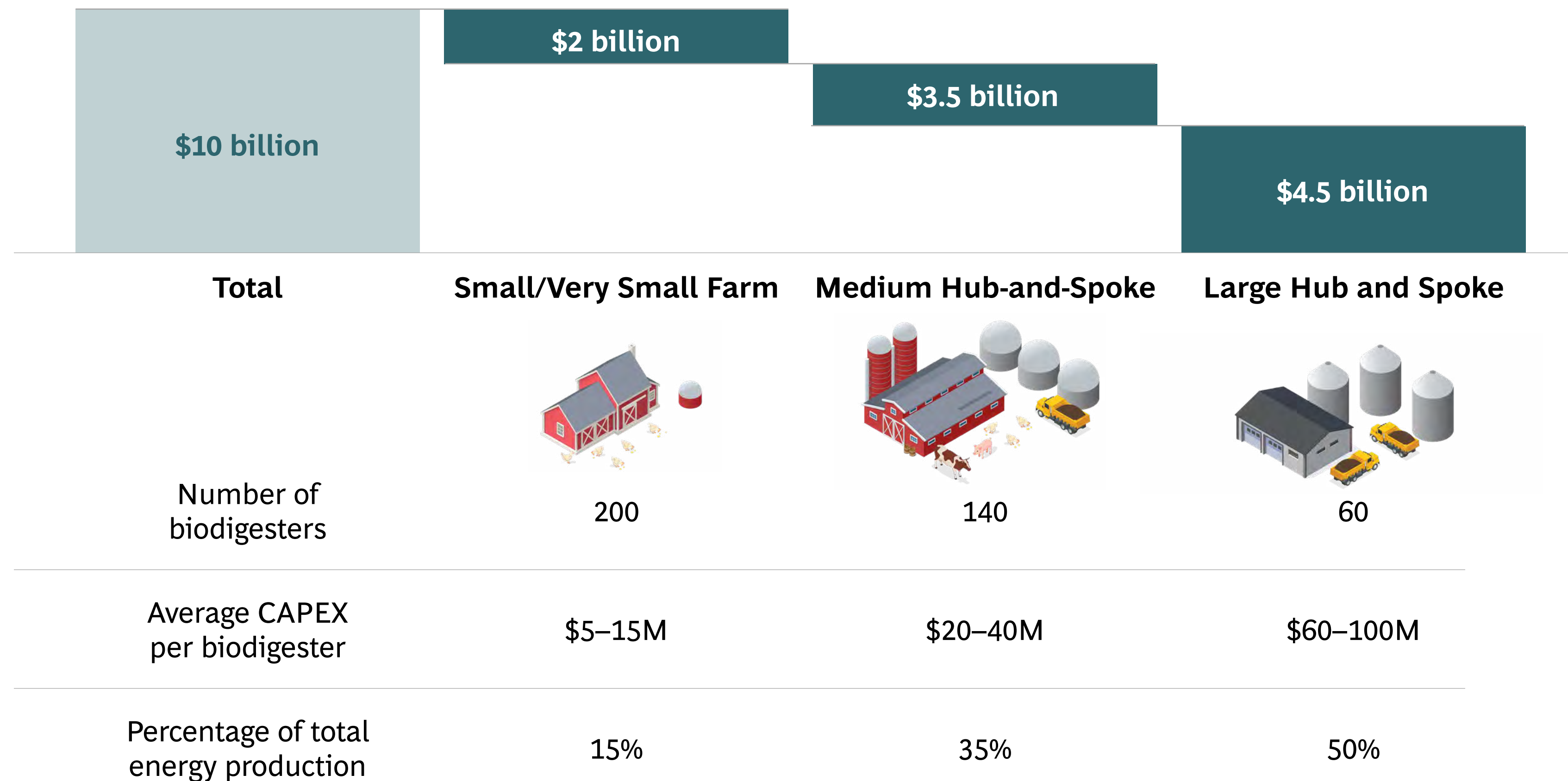
Although there are ~45 existing projects today, most of them have been highly advantaged and benefited from past policy supports. Many of these projects have been farms intent on reducing their emissions and feel biodigesters are a key tool in their path to decarbonization.

However, the challenges these farms have experienced today show why the market hasn't matured yet. More supports will be needed to help this market grow to its potential to be 25X larger.

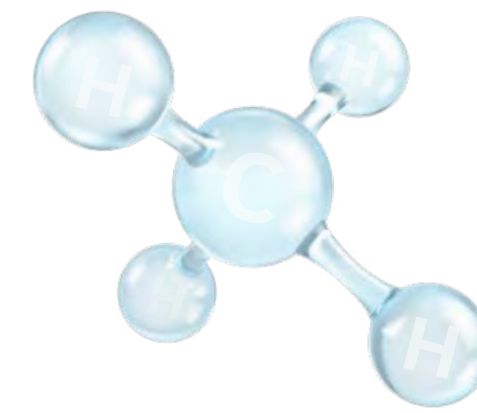


Vision with the right policy in place: Canada could have ~400 biodigesters of all sizes

CAPEX required to scale, total and by size of biodigesters



Note: Estimates based on team manure geo-analytics and proprietary CANZA biodigester model, based on BCG case experience, CBA reports and industry knowledge, and interviews conducted for this e-book.

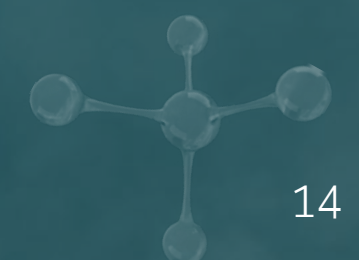


We asked ourselves what a fully developed biodigester industry in Canada could look like.

Consider this potential vision, based on the synthesis of many reports and expert interviews as well as top-down modeling and assumptions by our team:

- About 400 biodigesters in action, up from 45 today
- ~60 of these could be large hub-and-spoke models sharing the benefits with a large number of farmers
- Another ~200 would be single-farm biodigesters serving a few neighboring farms
- Total capital of over \$10B invested on farms across Canada, abating 6–8 MT of CO₂e
- Creating ~50 PJ of RNG

Of course, this is just one possible future. But we think it illustrates the enormous potential of biodigesters in Canada.



Achieving Canada's biogas potential will require resolving some key challenges



Biodigester profitability and feedstock availability



Economics are fundamentally challenging

Small biodigesters are especially impacted, given limited proximity to gas grid and poor economies of scale impacting CAPEX and market access

Small average farm sizes in Canada necessitate hub-and-spoke feedstock aggregation (and associated logistical costs) to achieve scale

Many farms lack sufficient proximity to the natural gas grid making connecting to the gas grid less economically feasible or requiring electrification

Frequent dependence on off-farm feedstock to support economics, but increasing competition for a limited supply of off-farm feedstock

Limited Canadian-specific tech enhancement activity (including cold weather cost optimization) and sharing of technical learnings

Industry support

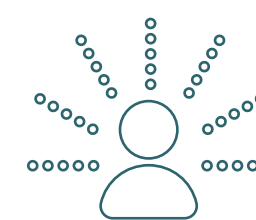


Policy support has major gaps (e.g., investment tax credit, blend mandate, RNG price supports, unclear and evolving carbon market support)

Lack of certainty / risk in long term RNG and credit prices leads to financing being limited to a subset of advantaged projects

Challenges and lack of standardization in local permitting, project regulations, and grid access processes are costly and time consuming

Awareness and capability



General lack of public understanding of industry and need to address manure emissions slows national dialogue and creates "NIMBY"¹ challenges

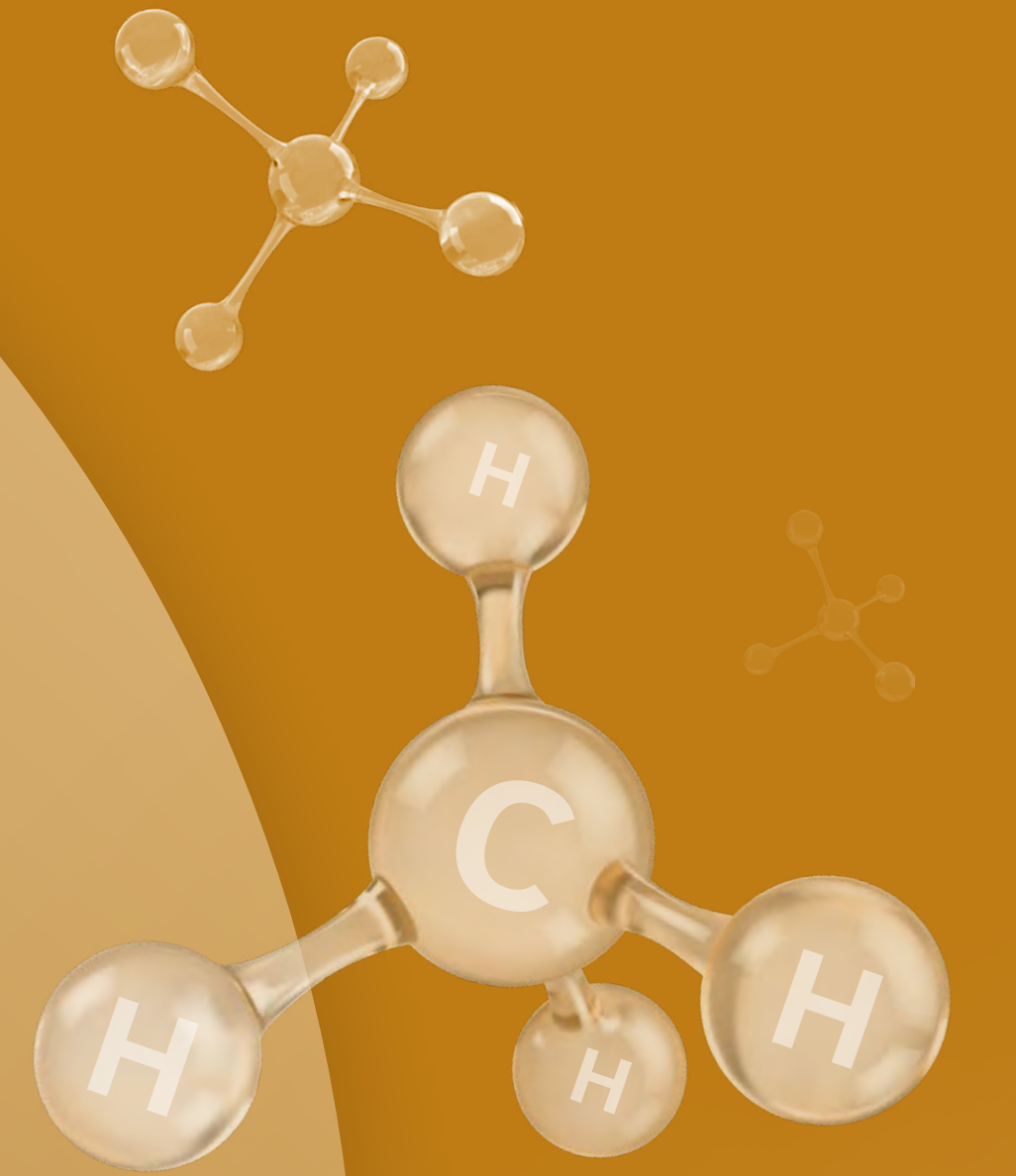
Common misunderstandings of industry pull RNG into broader national debate on the role of natural gas in Canada's decarbonization pathway

Lack of Canadian specific biodigester training limits size and capability of talent pool to support engineering and operations



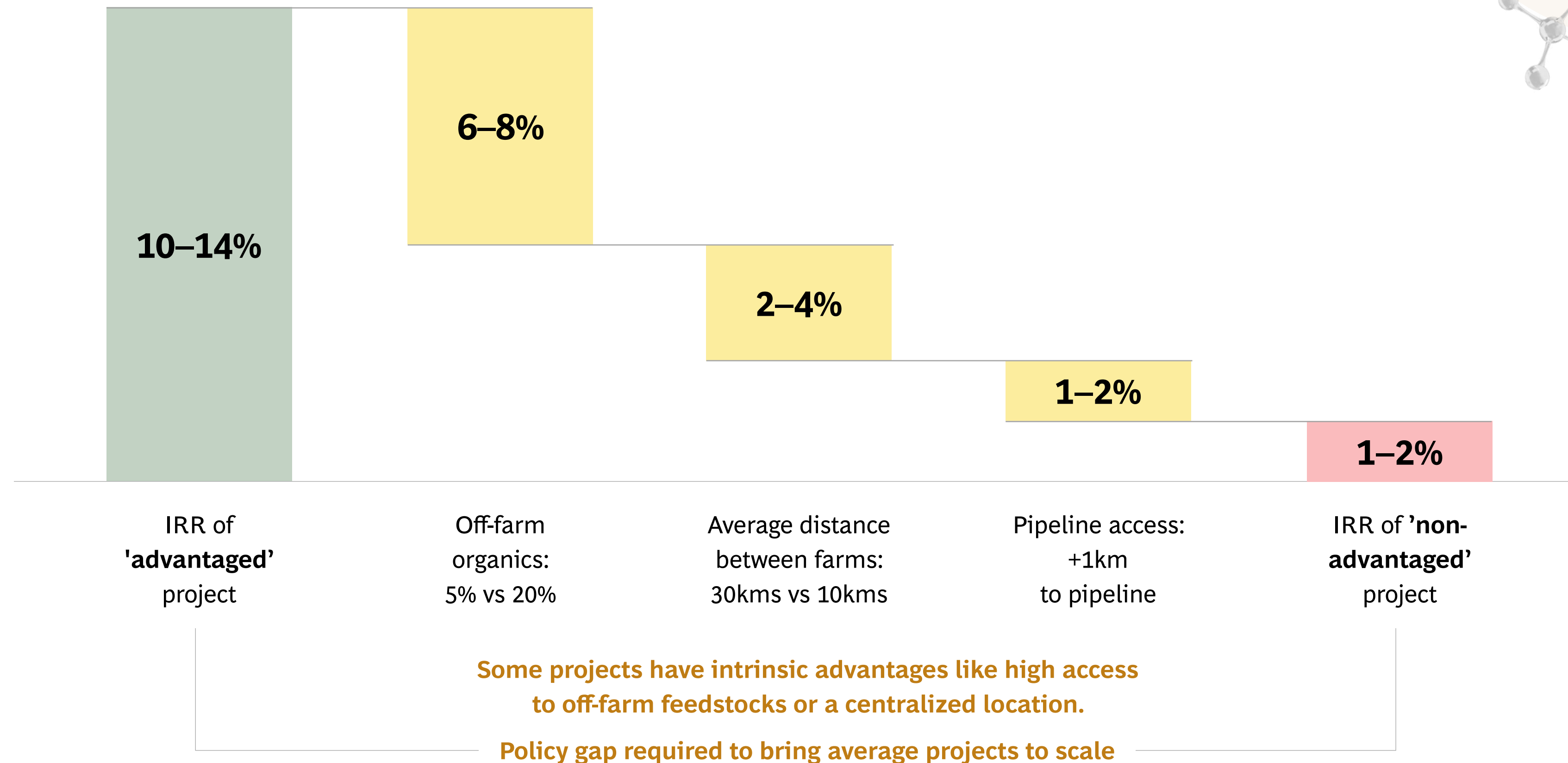
THE ECONOMICS

**What is the farmer's
business case?**

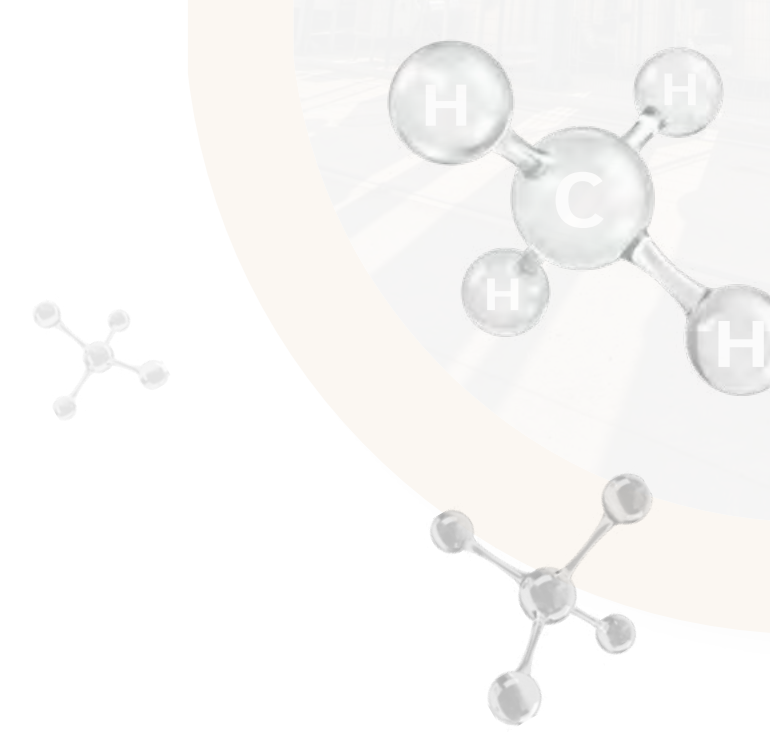


Only intrinsically advantaged biodigesters are profitable in today's policy landscape

Internal rate of return (IRR) of illustrative project: Large 600,000 tonne hub and spoke



Note: Estimates based on manure geo-analytics and proprietary CANZA biodigester model, based on BCG case experience, CBA reports and industry knowledge, and interviews conducted for this e-book.

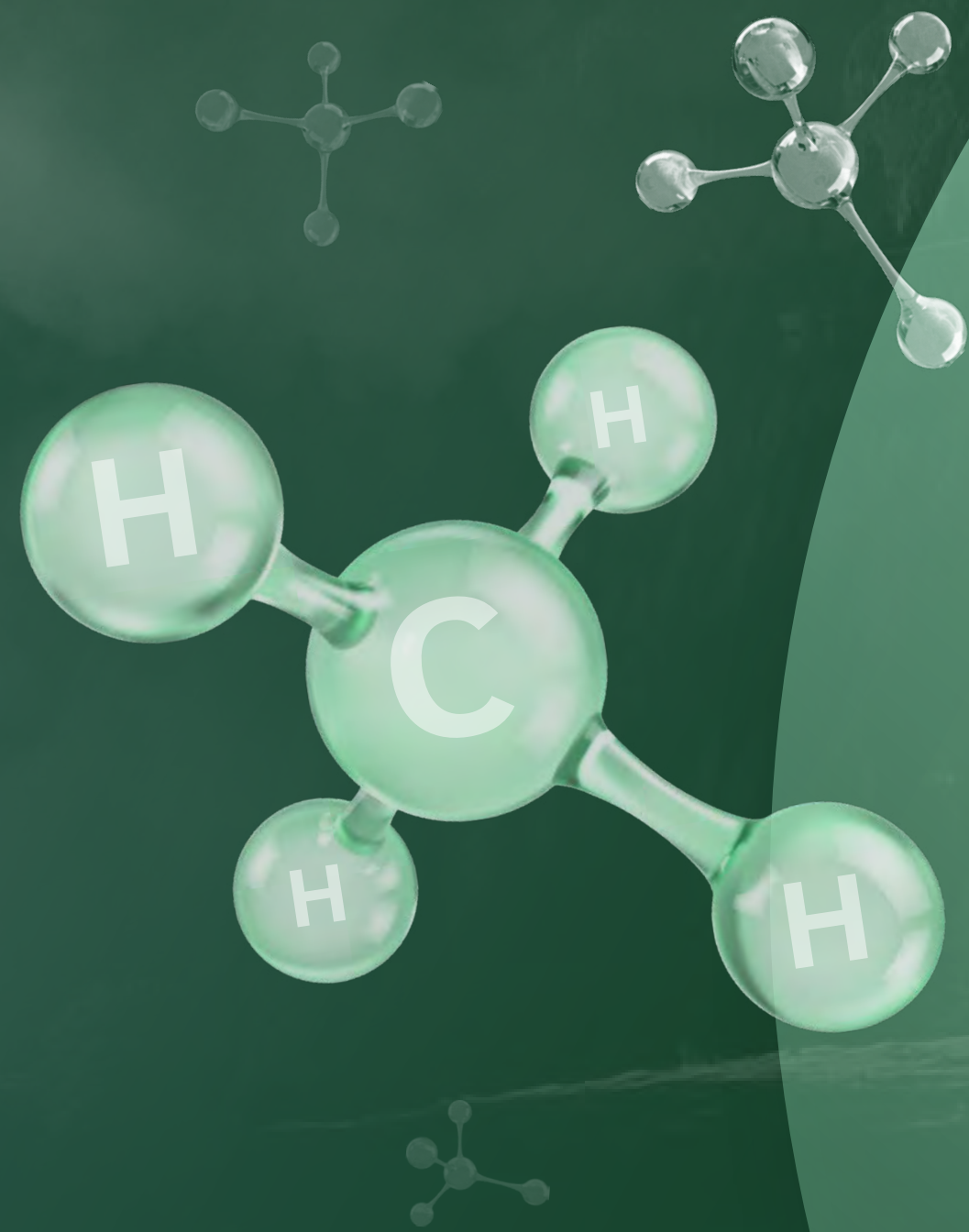


To understand the attractiveness of biodigesters to farmers and investors, we prepared a simple top-down model. This involved synthesizing learnings from academic papers and industry interviews.

Our model is not perfect. Every biodigester project is different. But it gives some insights into the economic drivers of biodigesters.

One of the main learnings is that profitability varies significantly based on how advantaged a project is in accessing feedstock, including manure, and the level of CAPEX required for pipeline access. These factors explain why today only the most highly advantaged projects are in operation

The implication here is that scaling the biodigester market to achieve the climate targets discussed will require expanded policy supports.



FUTURE POTENTIAL

**How could we
unlock biogas success
in Canada?**





Four impactful start-up and operating support themes we've seen abroad

Archetype

Revenue support: Credits



Methane or CO₂e compliance credit systems



VCMs¹ or Guarantees of Origin



Blend mandates or clean gas standards



Price supports such as FITs³ or CfDs⁴



Tax and other incentives



ITC⁵ or tax credits



Waste management

Description

Methane abatement or production of RNG generates either clean-fuel or industrial carbon pricing credits

Opt-in programs to allow users to offset their carbon footprint by buying methane credits or GoOs²

Requires utilities to provide a set level of RNG usage as a total of natural gas used

State subsidy or tariff or price guarantees relative to volumes injected into gas or electric grid

Tax reductions and other price-based incentives to support biodigester implementation

A refundable tax credit of up to a certain percentage of investment cost for related infrastructure

Mandate waste producers to use bio-digestion for waste types like food and manure

Illustrative countries/states implementing



California



California



California



California



Denmark



Denmark



Denmark



Denmark



Denmark



Italy



Denmark⁶



Finland



Finland



Germany



Germany



Netherlands



Germany⁶



France⁶

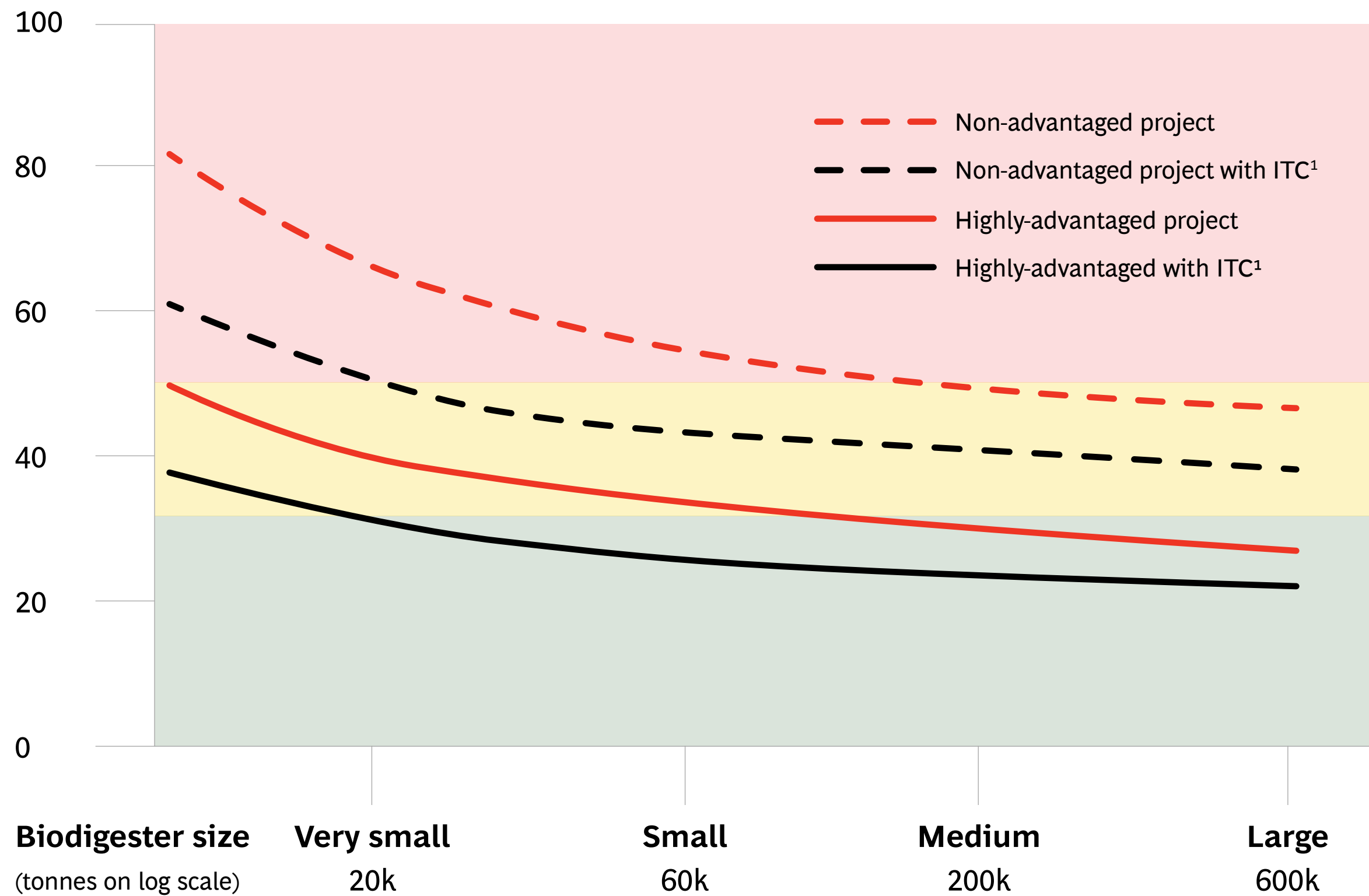


US

1. Voluntary Carbon Market; 2. Guarantees of Origin; 3. Feed-in-tariffs; 4. Contracts for Difference; 5. Investment Tax Credit; 6. Not being used in this country anymore
 Note: List of countries implementing policies is non-exhaustive; EU countries may have different policies and incentives
 Source: Government of Canada; IEA; S&P Global; World Biogas Association; BCG analysis

Revenue and capital supports both required for biogas to reach scale and 6-8MT of emission reduction

RNG price (\$/GJ) to hit 10% IRR



Competitiveness of RNG for end users

>\$50 per gigajoule

RNG uncompetitive for most utilities, end users

\$30–50 per gigajoule

Some uptake, but industry doesn't reach potential

<\$30 per gigajoule

Positioned for success with hard-to-abate sectors

We used our top-down model from the previous section to understand the types of policy supports essential to scale this industry and which biodigester archetypes are most likely to be stimulated. From that a few key insights came to light.

The industry requires both capital and revenue support to catalyze an average project and help the market reach scale. The often-discussed investment tax credit will not alone cover the gap between an advantaged and non-advantaged project.

Large projects will require fewer policy supports than small ones. Farmers with very small projects will require significant support on top of an ITC in the form of energy or carbon credit pricing support.

Highly advantaged projects are viable today across Canada, and ~45 are up and running. However, there likely are not many more highly advantaged projects. Therefore, scaling the industry to its full potential will require further policy support.

1. Assuming 40% investment tax credit; Note: Based on CANZA model, with a non-advantaged vs advantaged project defined as 5% vs 20% off-farm organic feedstock, ~1 vs 0 kms from gas pipeline, with average manure trucking distances of 30 vs 10 kms as relevant. Manure from central farm varies by model. Large projects: 10%, Medium: 30%, Small: 50%, Very Small: 100%

Unlocking full industry potential requires capital, revenue and other supports



Must haves

	Federal	Provincial	Municipal
Capital supports	★ 40% ITC in line with clean hydrogen	Grant programs for gas grid connection	
Revenue supports (Volume and price certainty)	★ Clean gas standard	★ Blend mandate in all provinces (BC and QC today)	
	★ CFR refinement (inc. gaseous credit price floor)	RNG pricing enabled by all utility regulators	
		Electrical FIT ¹ program for off gas grid farms	
	★ Agricultural biogas protocols in OBPS and provincial compliance systems where missing (notably Ontario)		
Capacity supports and debottlenecking	Tech optimization fund to support profitability improvements		
	Regulatory streamlining		
	Regional training / skills programs		
Long term feedstock security	Increased off-farm organic feedback accessibility		

★ Highest priority: Mix of most impactful and feasible

Biodigesters are already cutting methane, producing RNG and delivering rural income and jobs in leading countries.

Canada has the ingredients for a similar surge in investment, but the economic gap remains too large for most farmers and investors.

We have identified three policy levers with potential high and immediate catalytic effect:

- A 40% refundable investment tax credit on biodigesters and related infrastructure such as pipelines, trucks and farm infrastructure.
- An RNG equivalent to recent government actions to support carbon prices for industrial projects. This could be Contracts for Difference or price floors for agricultural biodigester RNG and Clean Fuel Regulation gaseous credits.
- An expansion of blend mandates in provinces such as Quebec and British Columbia to all provinces.

Some or all of these policies would have a major positive effect. Each has different budgetary implications and implementation pathways, but all have been done before for other industries in Canada or abroad.

Policies supporting capacity building, tech innovation, and regulatory de-bottlenecking would also be helpful once the 'must haves' are in place. In the longer run, policies supporting more widespread municipal and industrial organic waste collection would also be a major tailwind.

With Canada's ambitious climate policy, including the growing focus on methane, we believe the time is now for Canada to follow the biodigester leaders in ramping up this important industry.

1. Feed-in-Tariff

What success looks like



Cutting methane and replacing fossil natural gas with 6–8 MT in climate impact in time for 2050 targets



Generate \$1–2B in GDP with farmers and rural communities



Generating ~50 PJ of RNG for hard-to-abate sectors and winter peaking



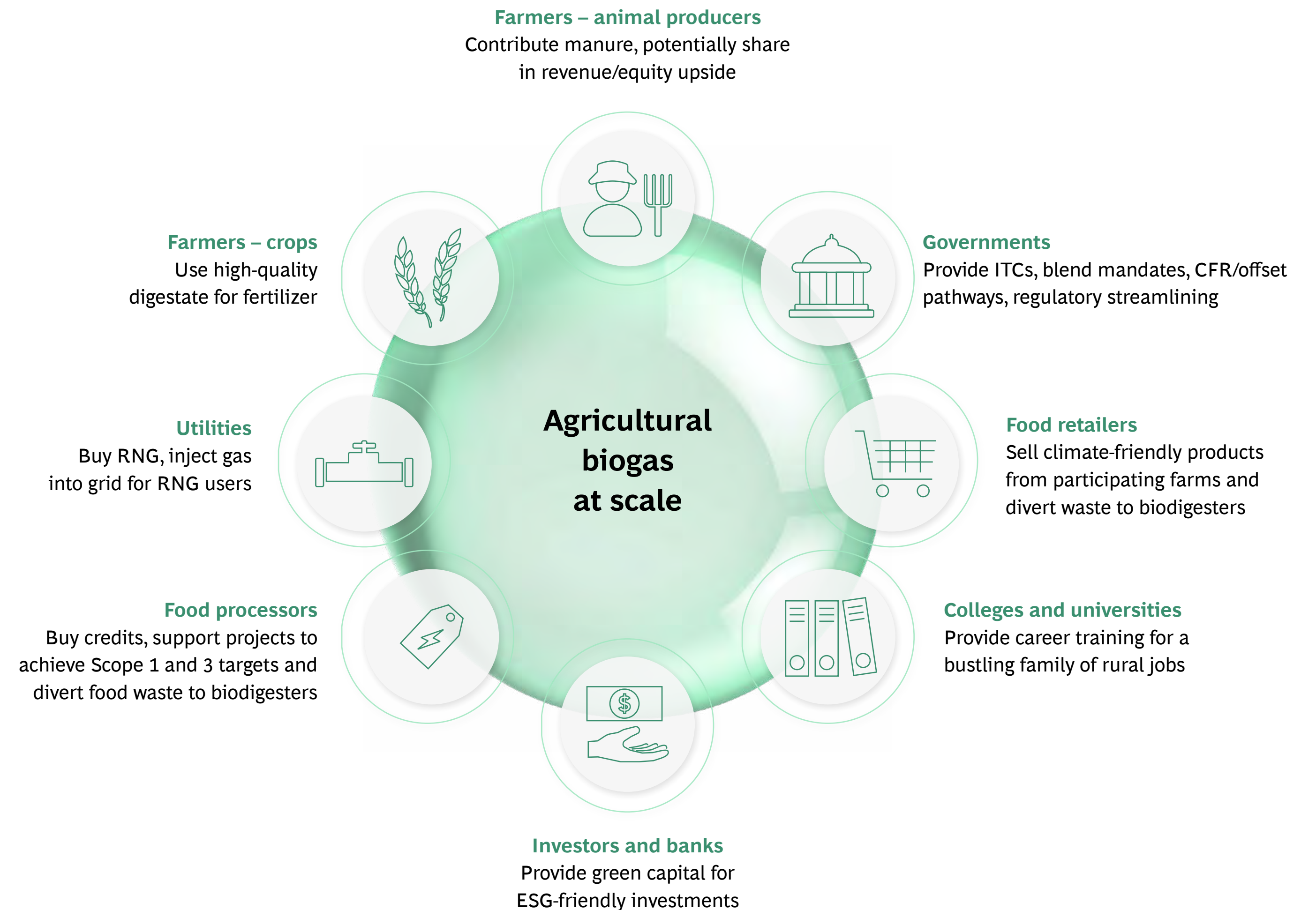
Produce high-quality digestate for farmers to fertilize their crops



Improve water quality and pathogen management

A Team Canada approach to biogas

Bring together farmers, innovators, industry, governments, and other key stakeholders under a shared vision and coordinated approach to enable large-scale deployment of biodigesters to cut methane, boost farmer incomes and generate RNG for net zero



About



The Canadian Alliance for Net Zero Agri-food (CANZA) was co-founded in 2023 by a diverse group of leading organizations who are deeply committed to taking action – and leveraging their extensive networks and value-chain partners – to achieve a shared vision: a net zero agri-food system for Canada. Providing a platform for action-oriented research, thought leadership and collaboration, CANZA helps to harness the ingenuity, entrepreneurship and resources of Canada's complex but critical agricultural ecosystem to achieve this ambitious mission.



The Canadian Biogas Association (CBA) is a member-driven industry organization that supports the diverse needs of the biogas and renewable natural gas (RNG) sector with the goal of building a strong, robust biogas and RNG industry in Canada.



BCG established the Centre for Canada's Future (CCF) on Canada's 150th anniversary in 2017. CCF's mandate is to bring the best of BCG's consulting capabilities to Canada's most pressing issues, working in partnership with the corporate, non-profit and government sectors. BCG and CCF are proud to be founding members of CANZA.

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More on CANZA

To find out more about CANZA and our work, visit www.canza.ca or email us at info@canza.ca

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Supporting details

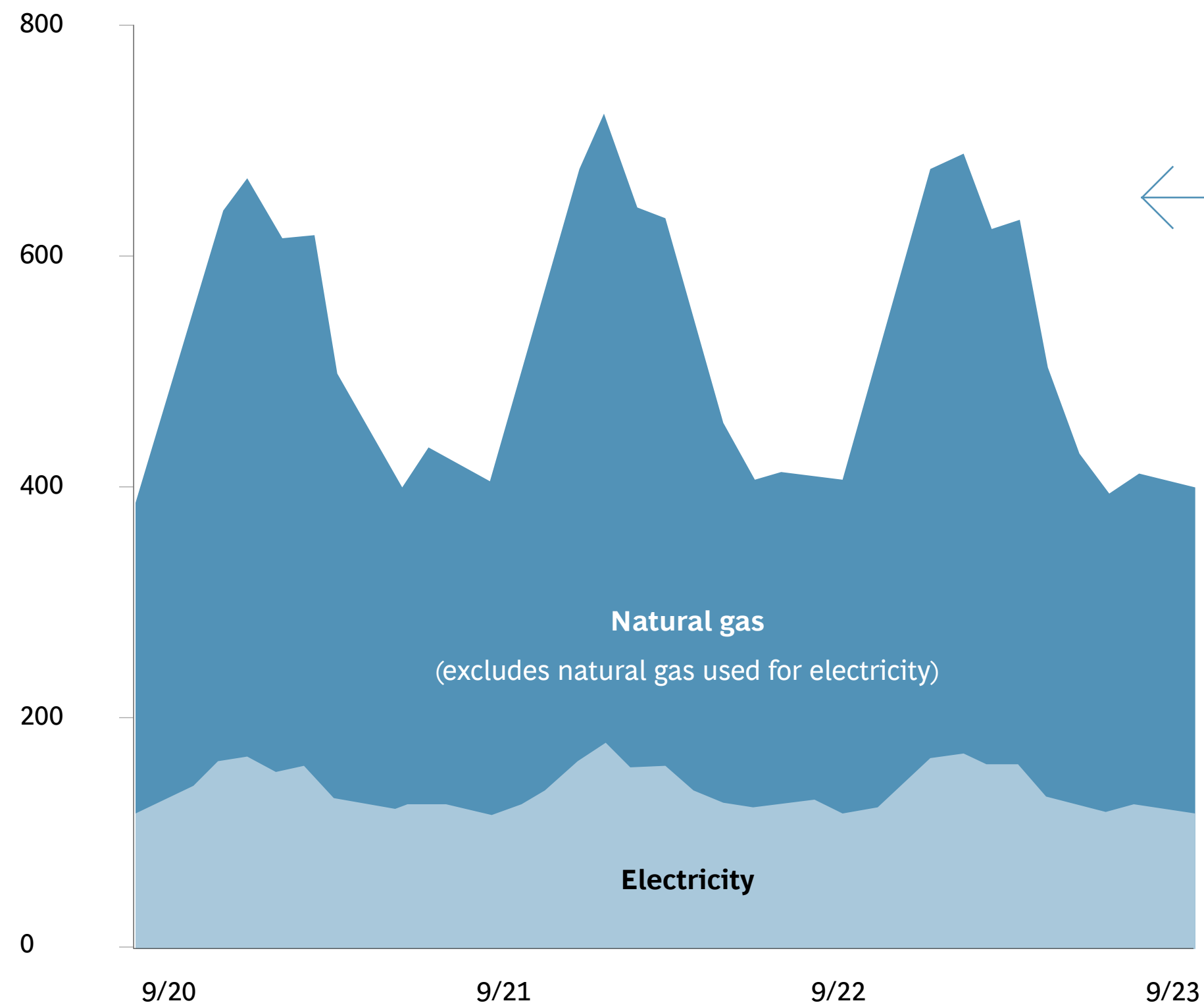


DEEP DIVE: THE BENEFITS OF RNG

RNG is a critical part of Canada's path to net zero

Example: Winter Peaking

Monthly Variability in Canadian Electricity and Natural Gas Supply
(Supply net of international trade, inventories; PJ)



Net Zero challenges

01

Meeting winter peaks without gas, using only electricity, would require billions of investment in renewable electricity generation, storage and grid capacity that would only be used some days or weeks of the year. This added system cost would be passed on to families and businesses.

02

To replace Canada's high reliance on fossil fuels, many analysts think we will need to double or triple renewable electricity capacity – a massive challenge. Every petajoule of fossil energy that RNG can replace helps ease the challenge to ramp up renewable power.



Renewable natural gas (RNG) plays an important role in Canada's long-term energy decarbonization journey.

Biodigesters could serve seasonal peaks in an economic and climate-conscious way.

Manure and other inputs produce low-carbon RNG, which is easy to store and uses our existing pipeline network. This reduces the need to build renewable electricity and grid capacity that will be used only on the coldest winter days.

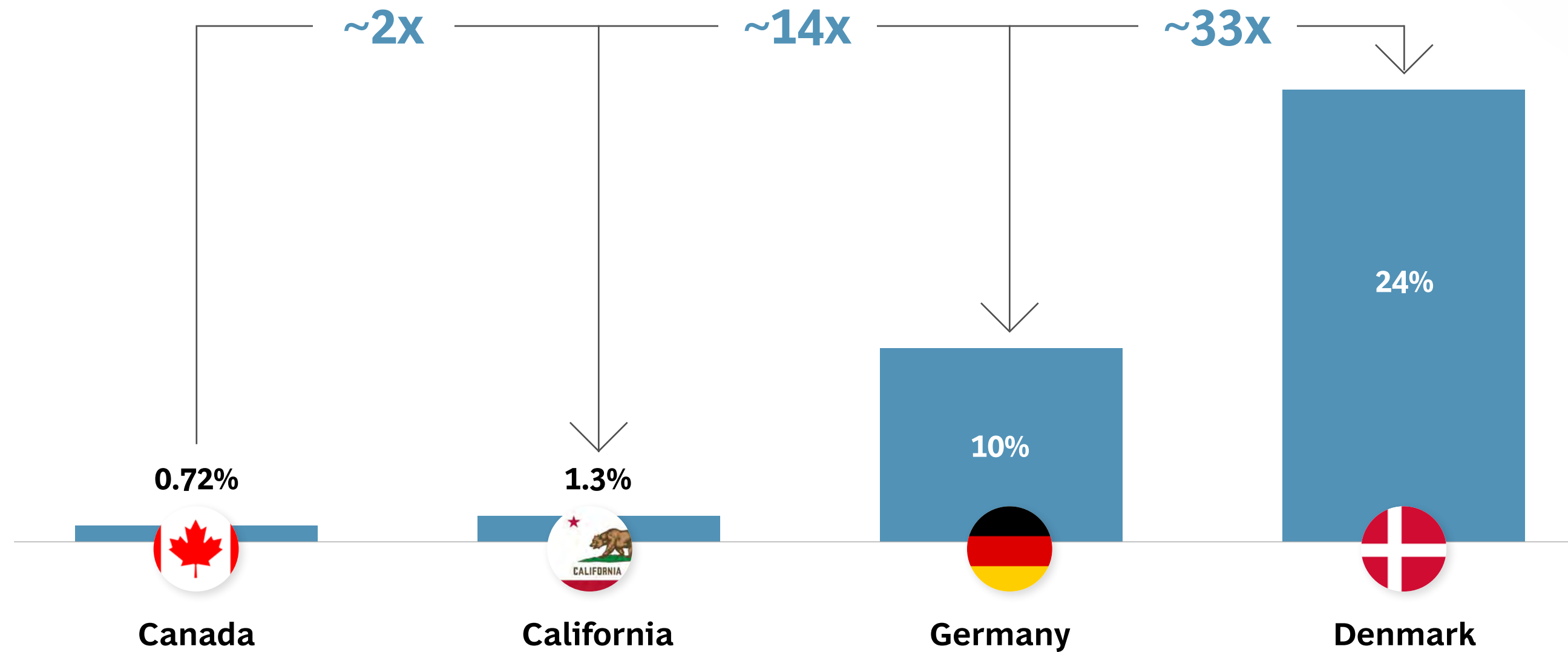
At-scale production could allow Canada to address 5% of winter peaking needs.

Combined with the potential of synthetic low-carbon gas, also known as e-NG, RNG could play a permanent role in Canada's net zero energy system

DEEP DIVE: IMMEDIATE IMPACT

Biodigesters are already having major impact abroad

RNG/biogas production as a % of total gas consumption: Selected examples

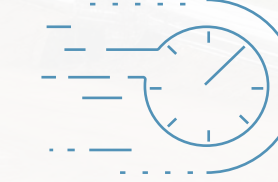


Percentage of current biogas production sourced from agriculture

Canada: ~20% California: >50% Germany: >45% Denmark: >60%

Natural gas as a percentage of total energy supply

Canada: 39% California: 31% Germany: 27% Denmark: 11%



The challenge of meeting Canada's 2030 targets becomes increasingly stark. Biodigesters are ready to help now.

Often, promising climate solutions require years of incremental research and development as well as policy experimentation to encourage adoption.

Biodigesters, on the other hand, are ready to implement.

A large number of jurisdictions have already seen dramatic ramp ups in manure processed, RNG produced and rural jobs created. In California, for example, RNG production from dairy and swine manure was 2.6 times higher in Q2 2023 compared to two years earlier.

Each jurisdiction has major differences in climate, agriculture sector structure, energy mix and policy landscape. None of them are suitable for a simple 'copy and paste' into Canada.

But they all show that biodigester technology is ready to scale and has significant upside in Canada.

DEEP DIVE: CRITIQUES AND TRADE OFFS

Biodigesters have been criticized, but on balance should be an important part of Canada's future energy system



Common critiques of biodigesters

Our point of view



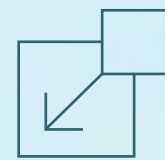
High abatement cost per tonne of CO₂e compared to other levers and high capital costs

Biodigesters are the only lever with a path to address manure methane at scale by 2030. And cost per tonne of CO₂e is only part of the story, since biodigesters also deliver major benefits in terms of RNG for hard-to-abate sectors, farm income and water/pathogen management



Overstated emissions reductions given pre / mid digestion leakage and manure transport diesel burning

Emission reductions can be maximized with high frequency manure collection, biodigester design and RNG/electric transport



Limited small farm applicability given difficulty of scaling down operations

Hub-and-spoke model addresses scale problems for many (but not all) small farms



Indirectly supports oil and gas industry by supplying RNG to pipeline grid

RNG is critical to decarbonizing Canada via its role in hard-to-abate sectors, winter heat/power peaking



Potential food security risks from land used to grow feedstock for biodigesters

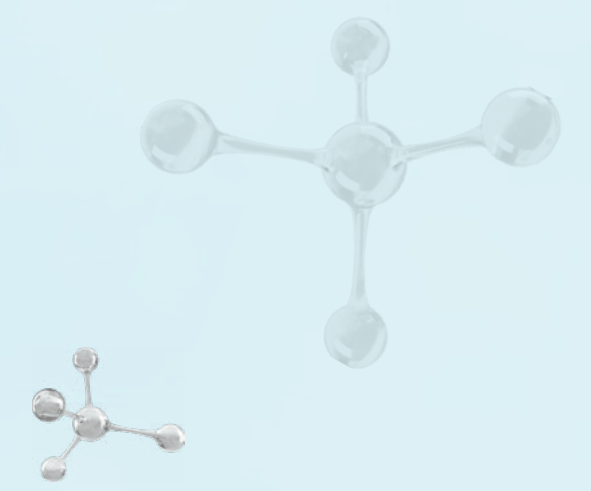
Policy measures can easily limit incentives for purpose-grown crops



Other, cheaper manure management techniques can replace biodigesters

Acidification, cover application, daily spread, etc., are promising prospects, but face economic headwinds without RNG revenues and are not currently on track to scale

Source: interviews with industry stakeholders; BCG analysis



DEEP DIVE: CANADIAN CHALLENGES

There are some unique Canadian challenges where tech optimization can help



	Identified challenges	Hypothetical examples of tech optimization activities
Canada-specific challenges	Cold weather climate Lower temperatures decrease efficiency and complicate logistics / manure management	Test heat exchangers to take heat from digestate output to warm manure input
	RNG market access and pipeline capacity Many remote farms or farms on the wrong side of pressure gradients can't access RNG grid	Market study on feasibility of virtual RNG pipelines (e.g., using tube trailers to transport)
	Economics of sub-scale biogas upgrading Challenging upgrading economics for the many sub-scale farms in Canada (even those near the grid)	Assess feasibility of California model (decentralized digestion but centralized upgrading)
General Challenges	Local RNG storage Seasonality of energy needs limits RNG demand in summer months despite non-seasonal production	Assess feasibility of converting RNG to CNG ¹ or LNG ² and storing
	Impurity management of off-farm organic feedstocks Most farms source off-farm feedstock containing impurities that reduce yield and require treatment	Test biodigester designs to increase ability to work on feedstocks of variable quality
	Marketability of digestate Poor economics for digestate management (e.g., nutrient recovery, dewatering, transport)	Continue testing processing procedures (e.g., dewatering digestate into pellets for fertilizer)

Biodigesters are a well-established technology operating at scale in many countries.

However, there are some uniquely challenging aspects to operating biodigesters in the Canadian context. This includes, but is not limited to, cold climate biodigestion.

These challenges are not 'game stoppers,' but each adds to the cost of operating biodigesters and undermines business cases.

We believe there is an opportunity for Canada to set up a biodigester-focused tech optimization program involving farmers, governments and innovators to address some of these challenges.

1. Compressed Natural Gas; 2. Liquefied Natural Gas