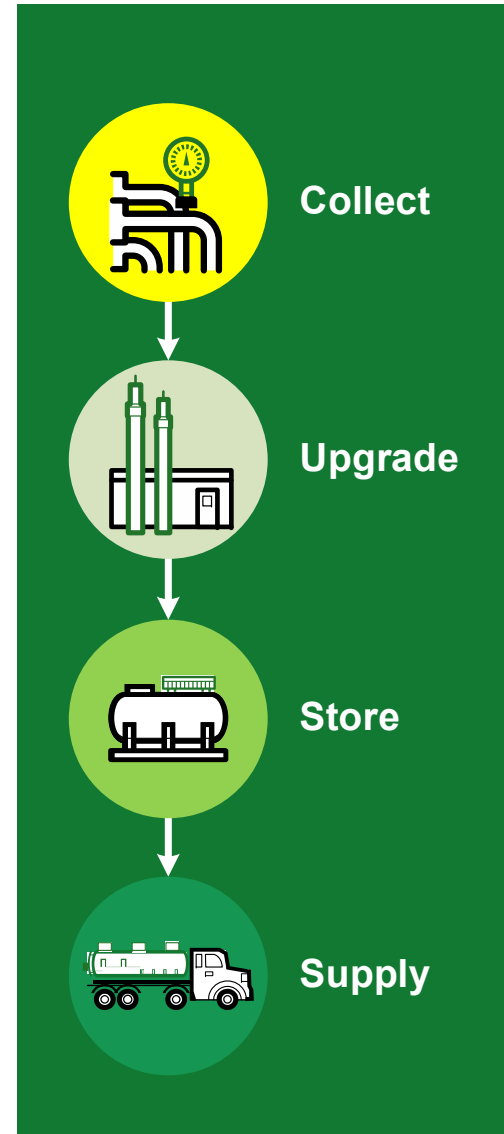


Supplying RNG from Landfill Gas (LFG)

Challenges and Solutions

Presented by:
Charles Tremblay,
President, Sysgaz Inc.





Company Profile



Headquartered in Montréal, Sysgaz is a Project Integrator and OEM Equipment Supplier.

As ***Project Integrator***, we are specializing in RNG project development from landfills or anaerobic digesters.

As ***OEM Equipment Supplier***, we are manufacturing standardized products supporting our RNG project solutions throughout the whole RNG value chain.



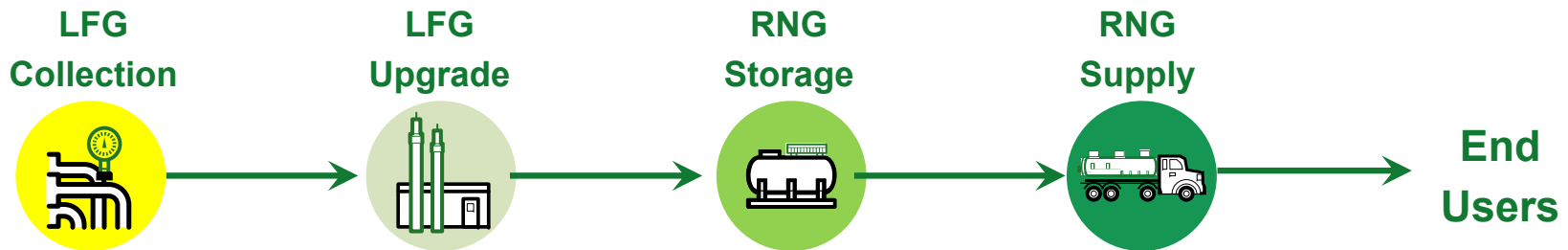
Contents

1. Key RNG Project Steps
2. Challenges - RNG from LFG
3. Solutions
 - ✓ LFG Collection
 - ✓ LFG Upgrade - N₂
4. Benefits
5. Markets

1. Key RNG Project Steps

The RNG Value Chain

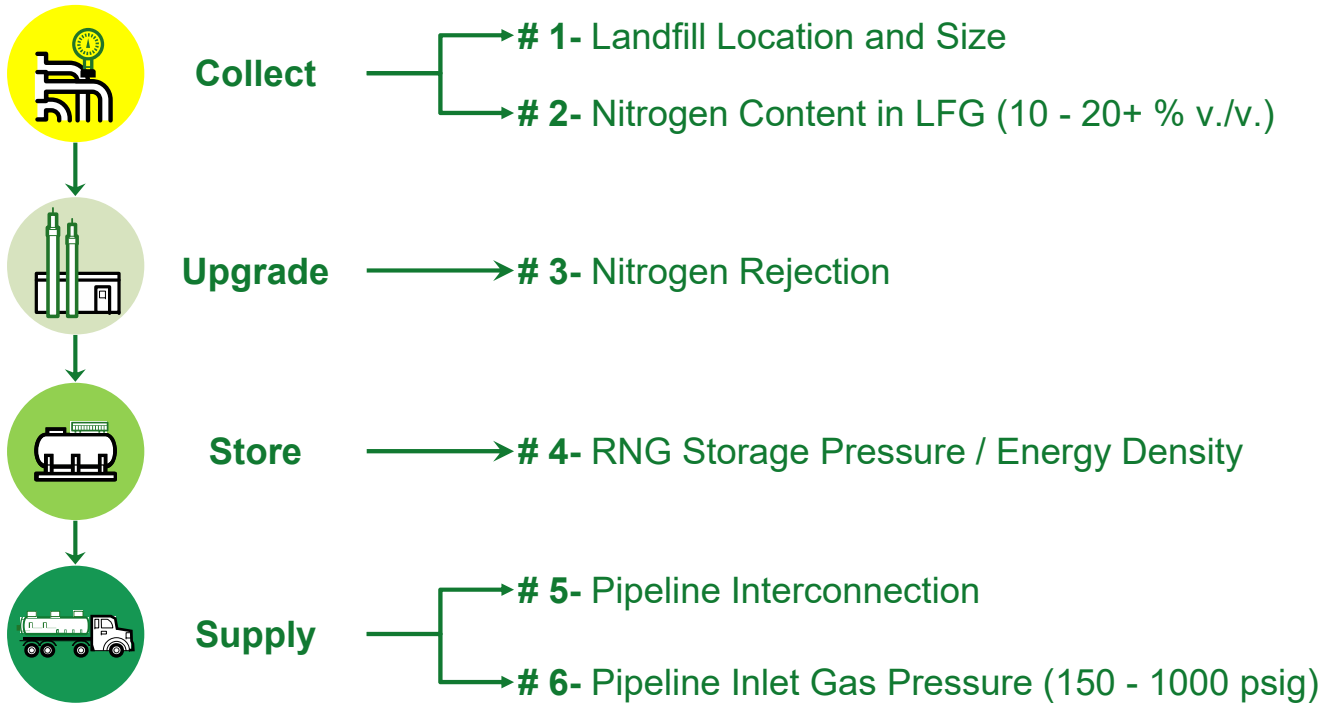
- Four main steps dictate RNG project profitability = “RNG Value Chain”
- The more integrated the RNG Value Chain, the more profitable the project will be
- Sysgaz provides solutions and products integrating Collection / Upgrade / Storage / Supply of RNG



2. Challenges: RNG from LFG

Challenges Impacting RNG Project Profitability

- They spread throughout the whole RNG Value Chain





3. Solutions: LFG Collection

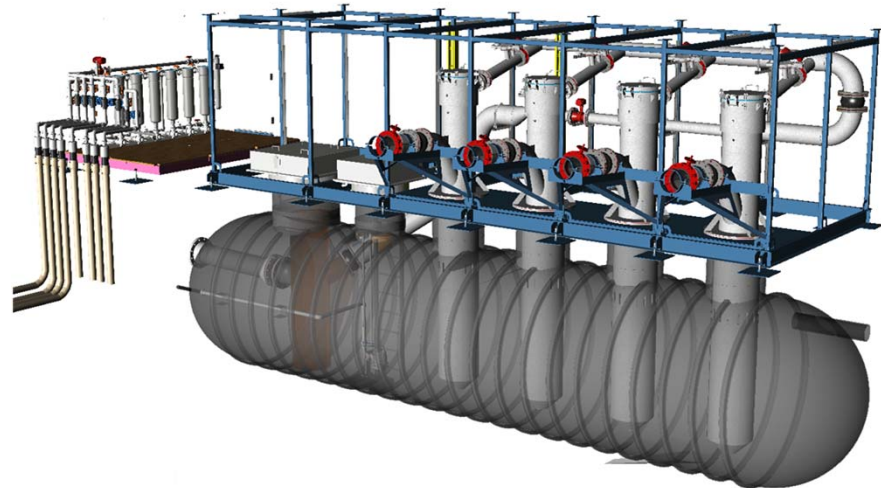
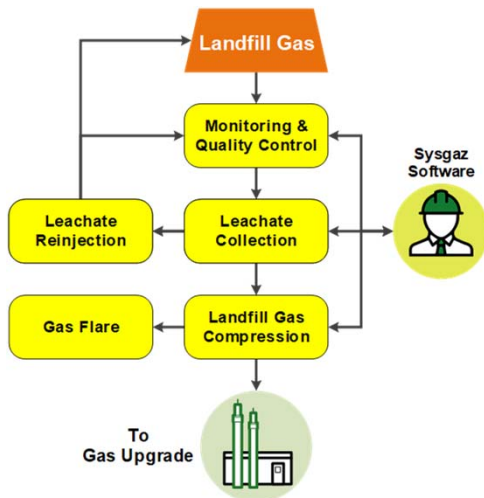


Collect

Nitrogen Content in LFG (10 - 20+ % v./v.)

- Nitrogen is always related to air infiltration. It impacts the LFG quality by reducing its CH₄ content
- The most profitable way for reducing nitrogen content in LFG is to minimize air infiltration using real-time Gas Monitoring & Control Systems
- Sysgaz / LMOP, March 10, 2022, [epa.gov/lmop/webinar-leveraging-untapped-landfill-gas-potential](https://www.epa.gov/lmop/webinar-leveraging-untapped-landfill-gas-potential)

Sysgaz's Gas Monitoring & Control Systems



3. Solutions: LFG Upgrade - N₂

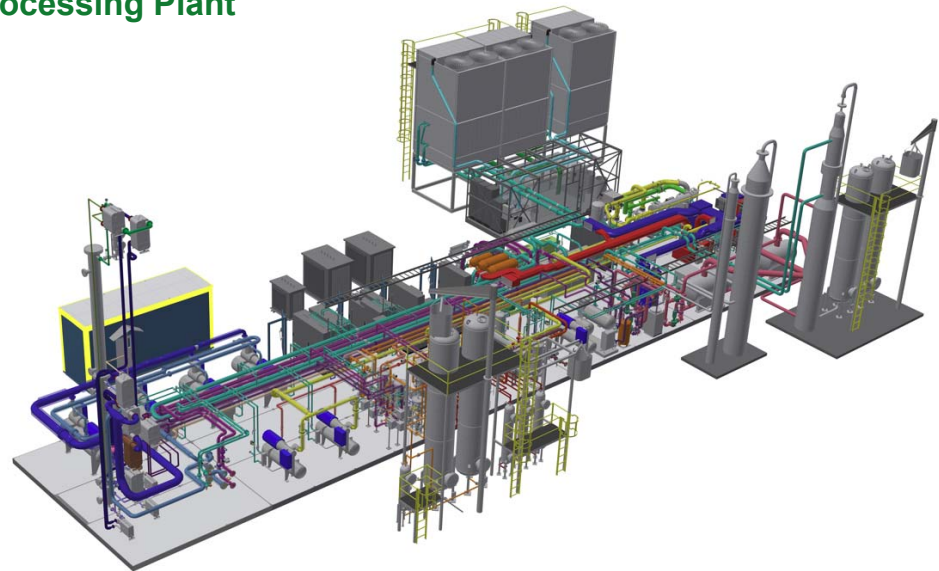
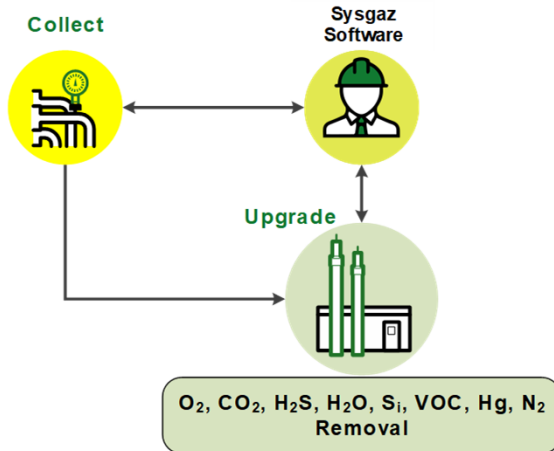


Upgrade

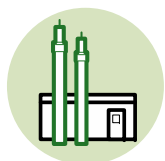
Nitrogen Rejection

- Even the best Gas Monitoring & Control Systems will collect LFG containing nitrogen
- The nitrogen content in LFG will constantly vary over time
- Nitrogen content variations will impact the system's sizing design and power consumption

Sysgaz's Gas Processing Plant



3. Solutions: LFG Upgrade - N₂



Upgrade

Nitrogen Rejection

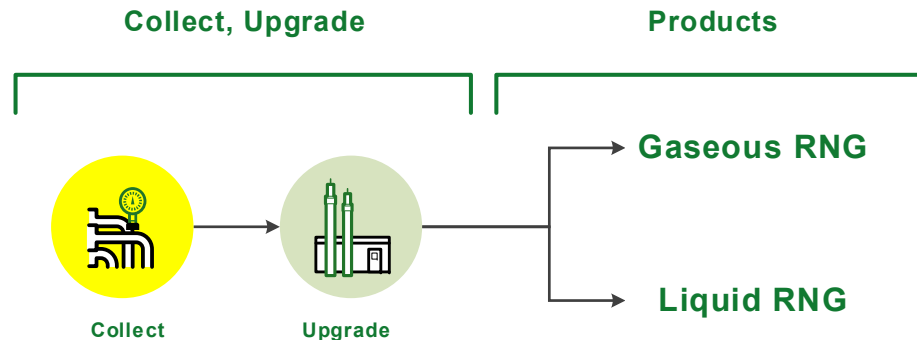
- Commercially Available Technologies

Technologies	Types	Feed Pressure	CH ₄ Recovery	RNG Types	Benefits	Drawbacks
PSA ¹	Kinetic	Moderate (150 - 200 psig)	90 %	Gaseous	- High Feed N ₂ - CO ₂ co-adsorption	- Impurities impact adsorption - Low recovery
	Equilibrium	Moderate (150 - 200 psig)	96 %	Gaseous	- High Feed N ₂ - Rejects O ₂	- Impurities impact adsorption - Multiple Compression stages
Membrane ¹	PEEK-Sep™	High (150 - 200 psig)	96+ %	Gaseous	- Turndown flexibility - Robust / No moving part	- Multiple Compression stages - N ₂ / Recycle direct correlation
Cryogenic	Liquid Nitrogen ¹	Moderate (150 - 200 psig)	96 %	Gaseous	- High flow range - Reject CO ₂ , O ₂ , N ₂	- Impurities impact adsorption - Liquid nitrogen required
	Mixed Refrigerant	Moderate (150 - 200 psig)	98+ %	Gaseous / Liquid	- High flow range - Easy to vaporize and compress	- Cryogenic compressors required

1: Source: Air Liquide, Nitrogen Rejection via Membrane technology, LMOP Webinar, November 16th, 2021

Why Cryogenic Distillation Using Mixed Refrigerant ?

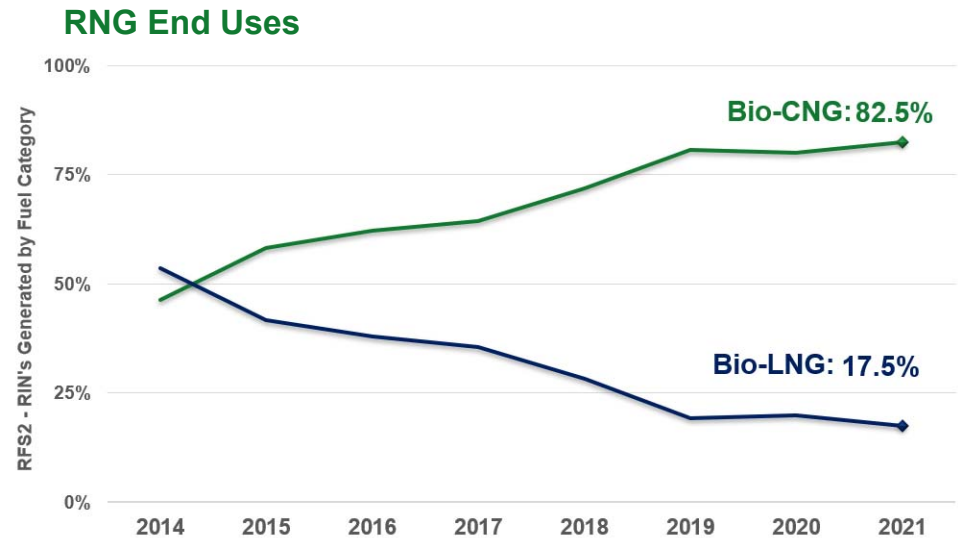
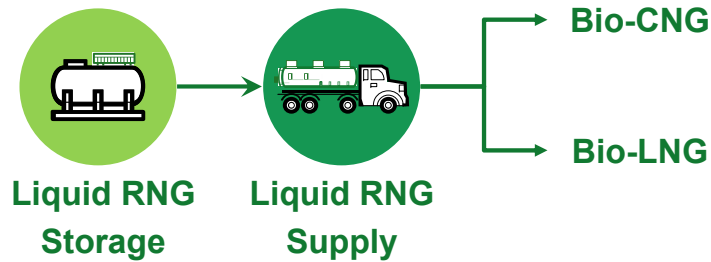
- Because its **Flexible**
 - ✓ Cryogenic distillation is a proven natural gas technology featuring stable performances over time
 - ✓ Power consumption is according to nitrogen content in raw LFG (1% to 20+ % v./v.)
 - ✓ The technology can produce either **Gaseous RNG** or **Liquid RNG**



3. Solutions: LFG Upgrade - N₂

Why Liquid RNG ?

- For stranded landfills, liquid RNG is the best way to Store and Transport RNG
- This is Not Related to its end use as Bio-CNG or Bio-LNG



Source: EPA, Public Data for the RFS, RINs Total Net Generation Report

4. Technical Benefits

Cryogenic Distillation Using Mixed Refrigerant

- For stranded landfills, the technology enables RNG Project development without pipeline interconnection



Collect

- ✓ Liquid RNG can be stored at 15 psig compared to 3600 psig for RNG as CNG



Upgrade

- ✓ Liquid RNG stores 2 times the energy / volume compared to CNG at 3600 psig
- ✓ Liquid RNG can be easily remotely transported using standard LNG trailers



Store

- ✓ For remote pipeline injection, power for vaporizing liquid RNG and injecting gaseous RNG is very low
- ✓ For off-grid end users, liquid RNG is easy to drop into standard LNG tanks



Supply

4. Financial Benefits

Cryogenic Distillation Using Mixed Refrigerant

- The most profitable solution for nitrogen rejection



Collect

- ✓ Cryogenic distillation offers the best CAPEX-OPEX for landfills collecting 800+ SCFM of LFG



Upgrade

- ✓ RNG can be directly marketed as either Quality-Pipeline Biomethane or Transportation Fuels

- ✓ For Liquid RNG:

- Storage is 75% cheaper compared to RNG storage at 3600 psig
- Transportation requires 50% less trip than compressed RNG
- RNG payload is always 100% of the LNG trailer net capacity



Store

- ✓ For pipeline injection, vaporizing liquid RNG and injecting gaseous RNG requires 85% less power



Supply

- ✓ Without pipeline interconnection requirements, third parties' expenses can be reduced by up to 50%

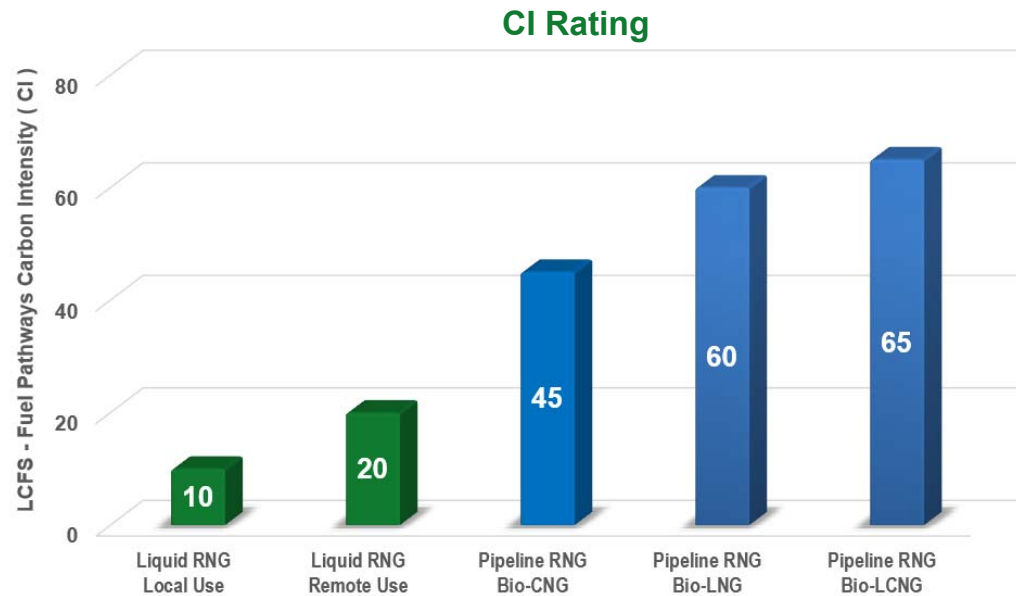
4. Environmental Benefits

Green House Gas Reduction

- Liquid RNG presents the lowest fuel pathway carbon intensity rating (CI)
- The lower the CI, the higher revenues will be from carbon market programs (120\$ - 300\$ / T.M. CO₂e)

 : Liquid RNG, Averaged Bio-LNG / Bio-LNG

 : Quality-Pipeline Biomethane

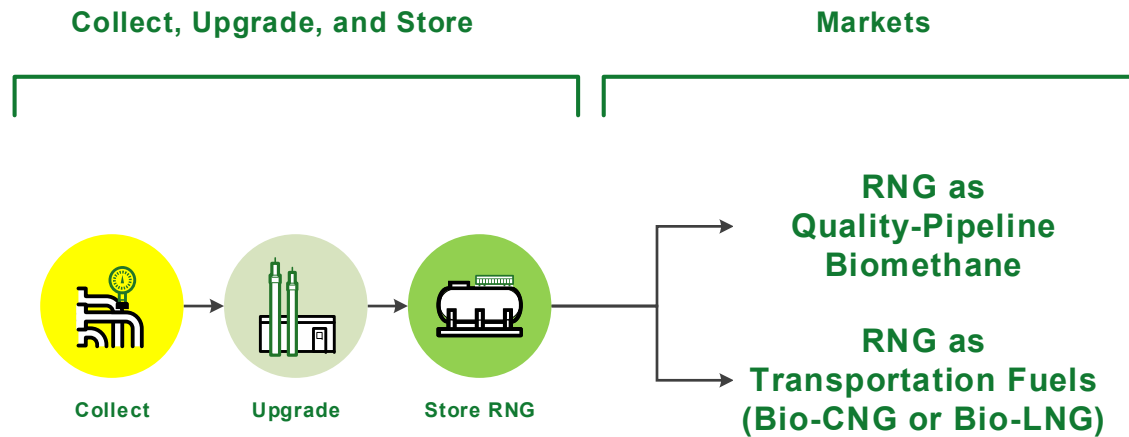


Source: CARB-LCFS, Current Fuel Pathways, March 10, 2022

5. Markets

Cryogenic Distillation Produce High-Quality RNG

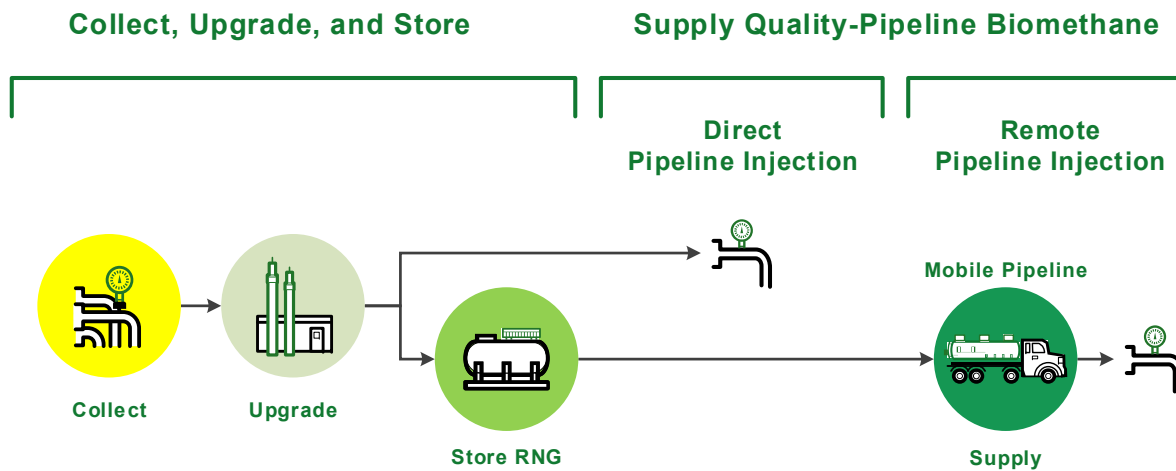
- The RNG is ready to be supplied in two markets



5. Markets

RNG as Quality-Pipeline Biomethane

- The RNG can be directly injected into a pipeline or, for stranded landfills, transported to a remote injection site

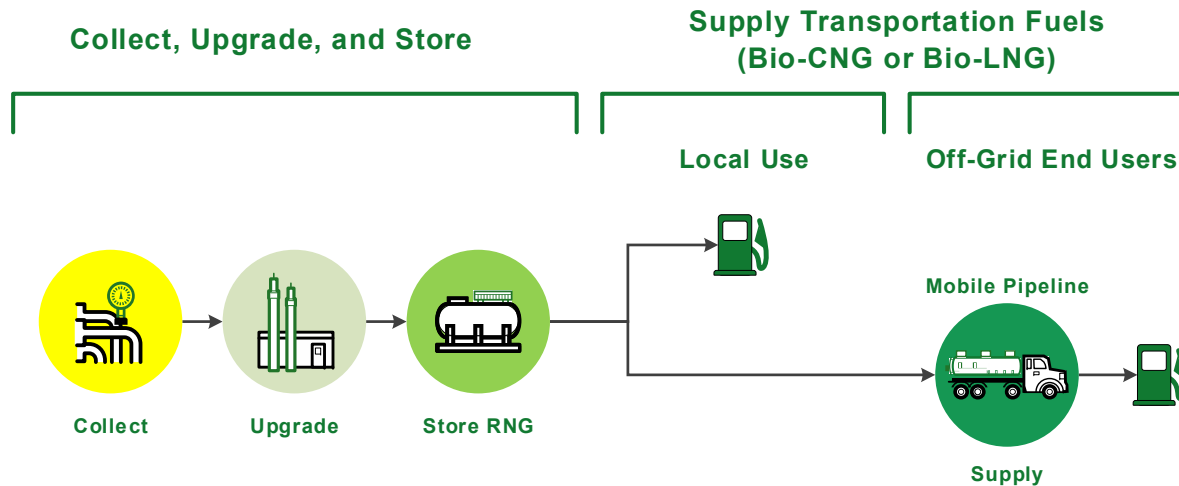


Sysgaz's RNG Plant production capacities are from **180 000 to 360 000 MMBtu / year**

5. Markets

RNG as Renewable Transportation Fuels (Bio-LNG, Bio-CNG)

- The RNG can be marketed for local use or remotely transported to an off-grid end users

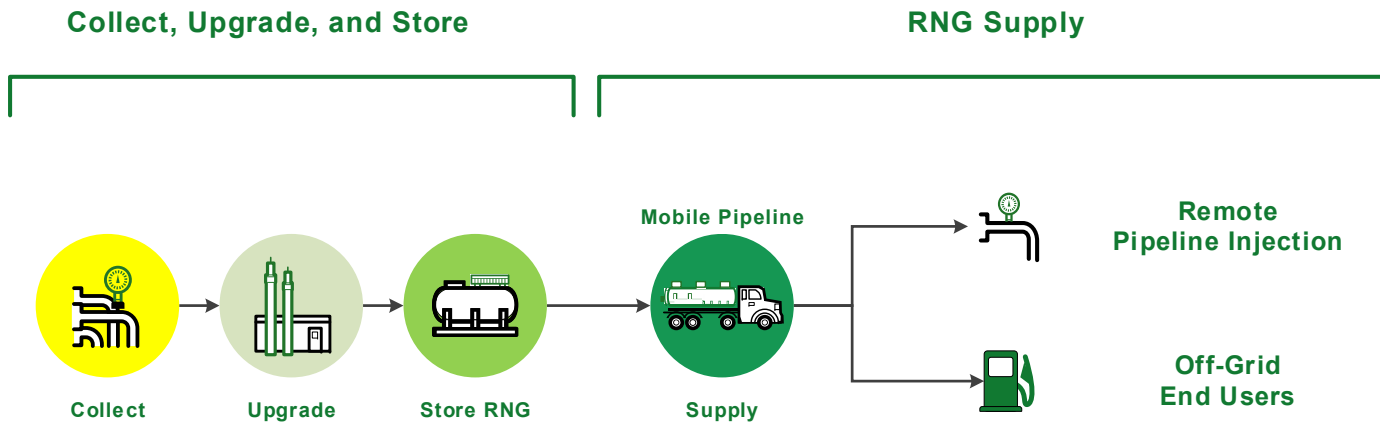


Sysgaz's RNG Plant production capacities are from **1,3 to 2,6 M DGE / year**

5. Markets

Forest Biomass

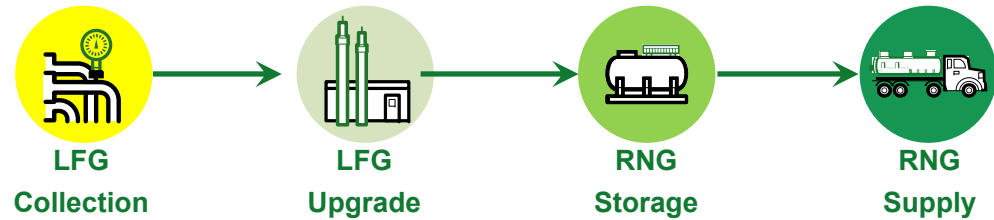
- In Québec, 80% of the RNG techno-economic potential is associated with Forest Biomass ¹
- In general, wood processing facilities are not close to a pipeline
- Liquid RNG is the most profitable solution to bring this RNG to markets



1: AVISEO CONSEIL, January 2019



In Summary



1. The more integrated the RNG Value Chain, the more profitable the project will be
2. The most profitable way for reducing nitrogen in LFG is to minimize its infiltration into the gas recovery system
3. Cryogenic distillation using mixed refrigerant offers the best CAPEX-OPEX for landfills collecting 800+ SCFM of LFG
4. Cryogenic distillation using mixed refrigerant can produce either Gaseous RNG or Liquid RNG
5. Liquid RNG is the best way to store and transport RNG. This is not related to its end uses.
6. Cryogenic distillation using mixed refrigerant is a flexible and profitable solution for producing High-Quality RNG:
 - ✓ Quality-Pipeline Biomethane
 - ✓ Renewable Transportation Fuels (Bio-LNG, Bio-CNG)
7. Sysgaz provides solutions and products integrating Collection / Upgrade / Storage / Supply of RNG

Merci / Thank you

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