
Virtual
SWANApalooza
2020
SWANA
SOLID WASTE ASSOCIATION OF NORTH AMERICA

LFG → RNG

Options for Upgrading High Nitrogen Landfill Gas

GREENLANE BIOGAS™

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GREENLANE BIOGAS

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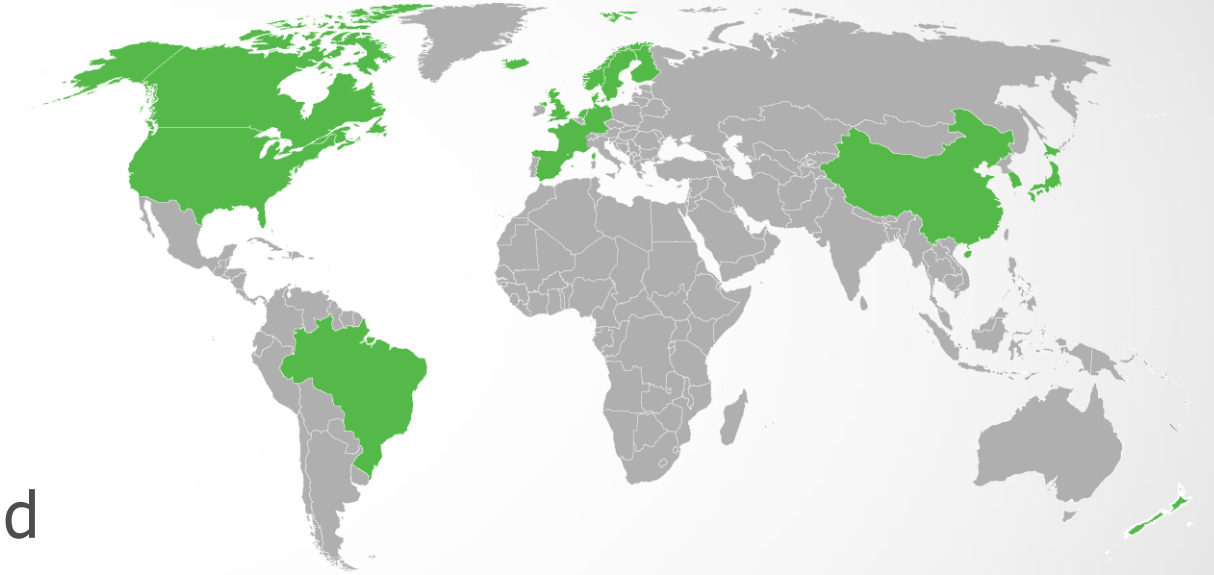
My Background

- BSME, Mechanical Engineering
- 15+ years in LFG compression & treatment

Company Background

GREENLANE BIOGAS™

- **100%** devoted to biogas upgrading
- **30+** years experience
- **110+** upgrading systems delivered
- **18** countries
- **1st** upgrading system in 11 countries
- **Largest** upgrading system in the world
- **1st** in global supplied capacity
- **All 3** primary upgrading technologies



Three Upgrading Technologies

Water Wash

Pressure Swing Adsorption (PSA)

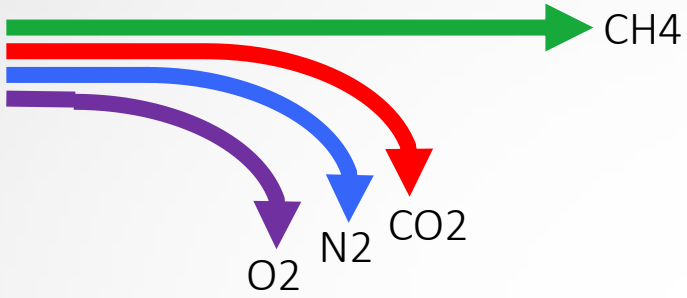
Membrane

- Unbiased technology comparisons
- Multiple technology solutions under a single guarantee

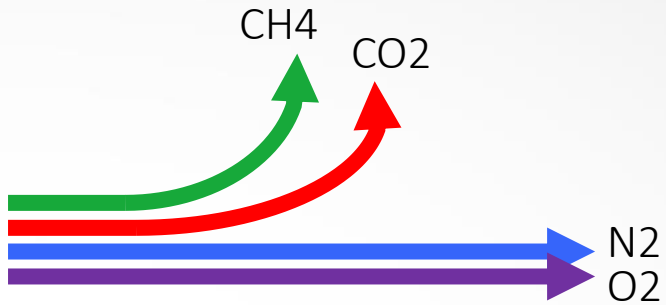
The Nitrogen Problem

- Typical LFG has 2 – 20% N_2 from air intrusion
- When you remove the CO_2 this value doubles
- N2 reduction is required to meet pipeline specs
- The technologies for N_2 reduction are:
  - PSA (Pressure Swing Adsorption)
  - NRU (Nitrogen Reduction Unit) PSA
  - N2R Membranes
  - Cryogenic process

“Standard” PSA vs. NRU PSA

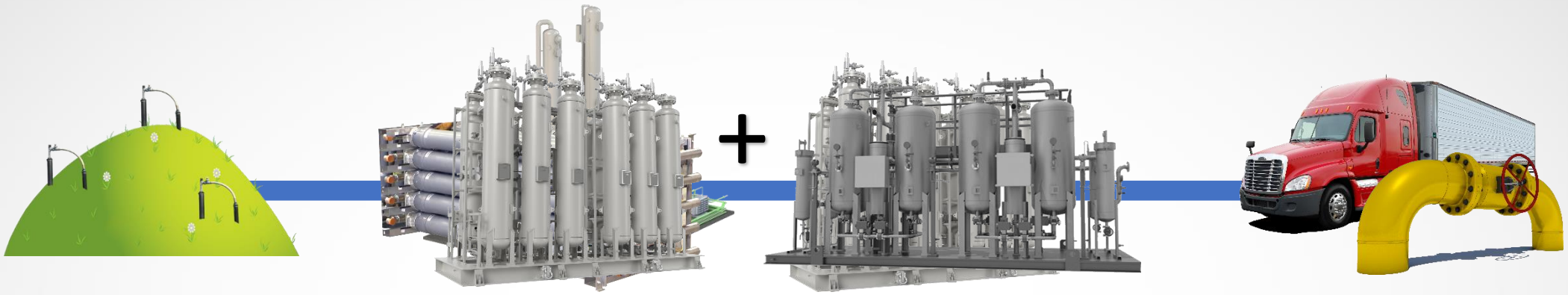


- Captures CO2, N2 & O2
- CH4 passes at pressure
- Lower CapEx & OpEx
- Lower Recovery
- Typically used on LFG with <5% N2



- Captures CH4 & CO2
- N2 & O2 pass at pressure
- Higher CapEx & OpEx
- Higher Recovery
- Typically used on LFG with >5% N2

The Six Options (above 5% N2)



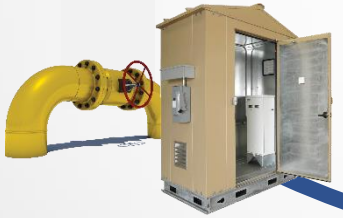
1. Water Wash + NRU
2. Membrane + NRU
3. Two Stage PSA
4. Amine Wash + NRU
5. Membrane + N2R Membrane
6. Cryogenic

1. Water Wash + NRU

Blower

Water Wash Upgrader
(Compression, Upgrading & Dehydration)

Thermal Oxidizer



Booster

NRU

1. Water Wash + NRU

Pros:

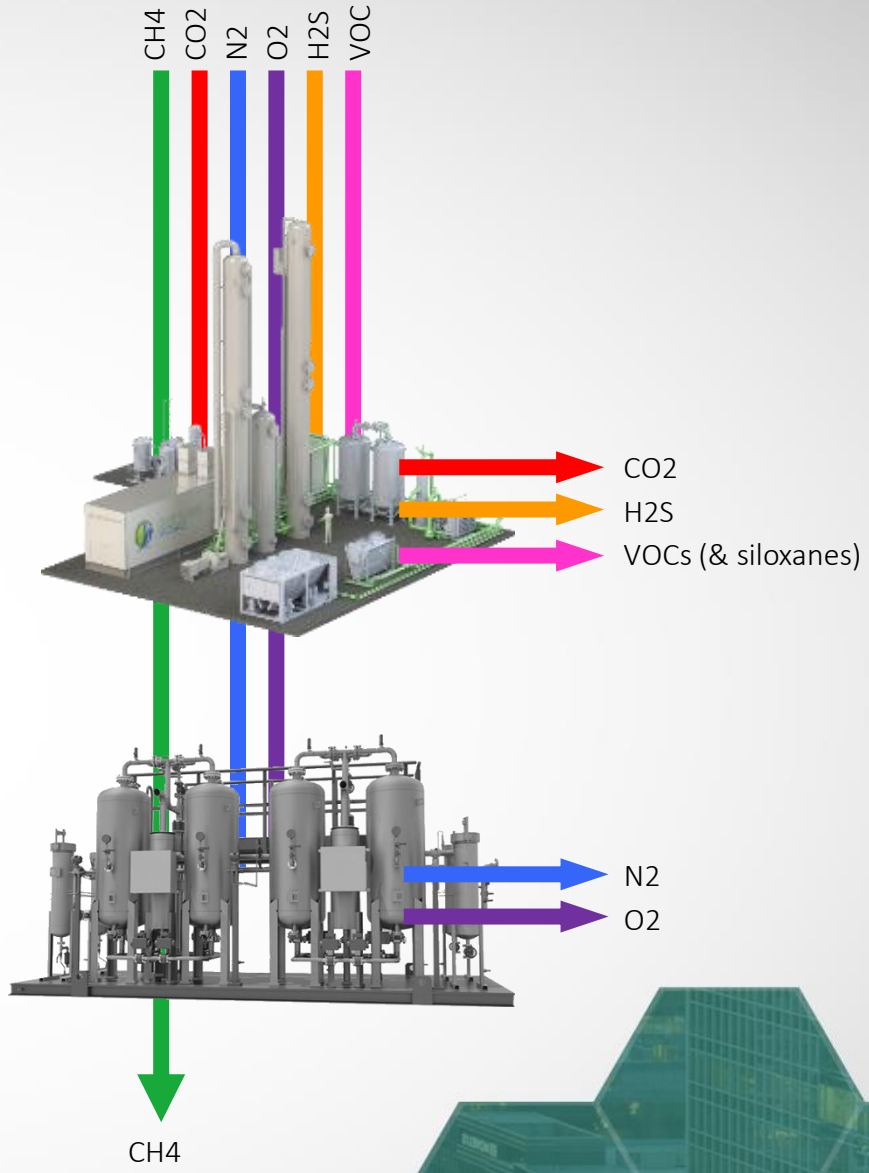
- High Recovery — About 98%
- Low Consumables — No pre-treatment
- Lowest LFG Compression — Low pressure & no recycle
- Lowest Risk — Water is inexpensive

Cons:

- High CapEx — NRU is expensive
- High RNG Compression — Post NRU recompression

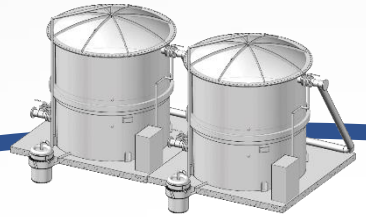
Best Applied to:

- Large landfills with high H2S, siloxane & VOC levels.



2. Membrane + NRU

Blower



H2S Reduction

Compression

Chilling & Dehydration

Siloxane & VOC Reduction

Carbon Polisher

Membrane Upgrader

NRU

Booster

2. Membrane + NRU

Pros:

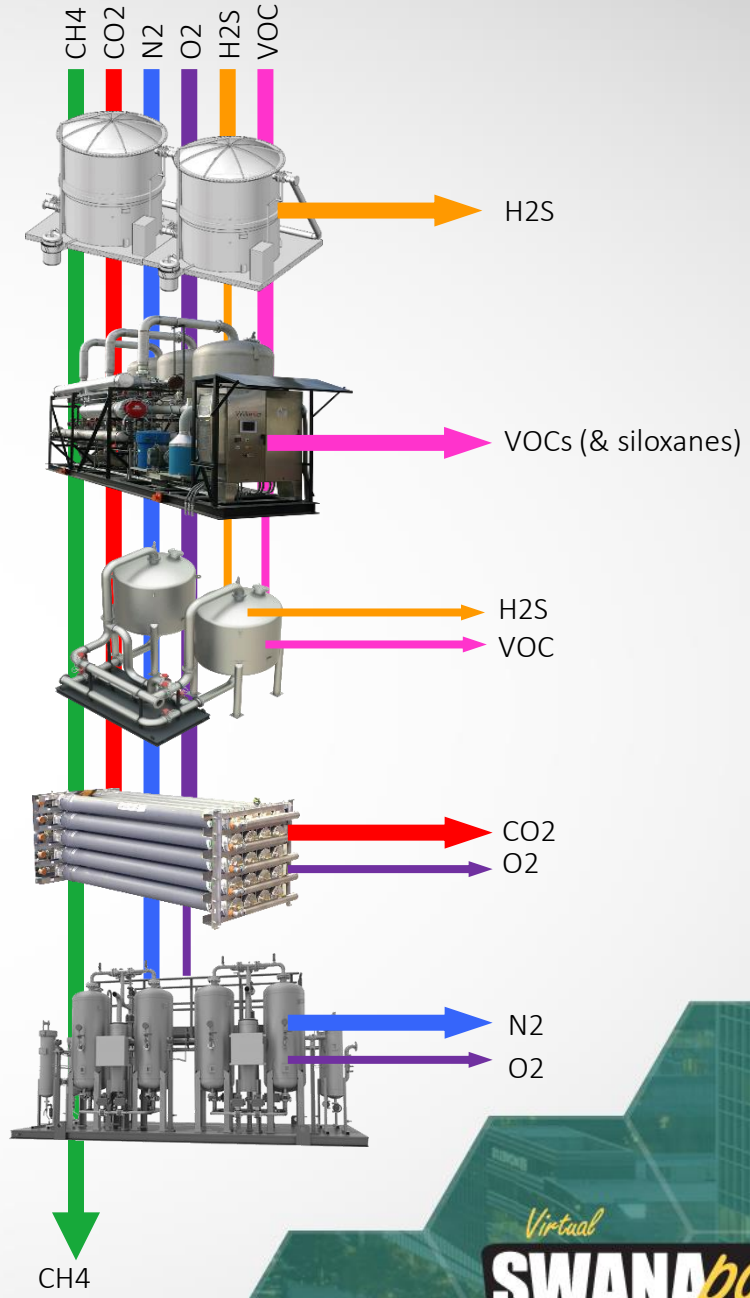
- High Recovery — About 98%

Cons:

- High CapEx — NRU is expensive
- Highest Consumables — H2S, VOCs & Carbon
- Highest LFG Compression — Highest pressure & recycle
- High RNG Compression — Post NRU recompression
- Highest Risk — Membranes are expensive

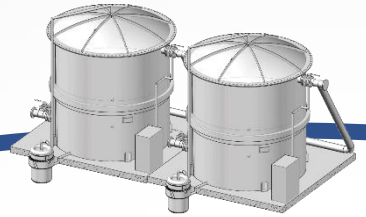
Best Applied to:

- Smaller landfills with lower H2S, siloxane & VOC levels.



3. Two Stage PSA

Blower



H2S Reduction

Compression

Chilling & Dehydration

Siloxane & VOC Reduction

PSA Upgrader

PSA Polisher

Booster

3. Two Stage PSA

Pros:

- Lowest CapEx — No NRU
- Lowest RNG Compression — No NRU, no recompression

"In betweens":

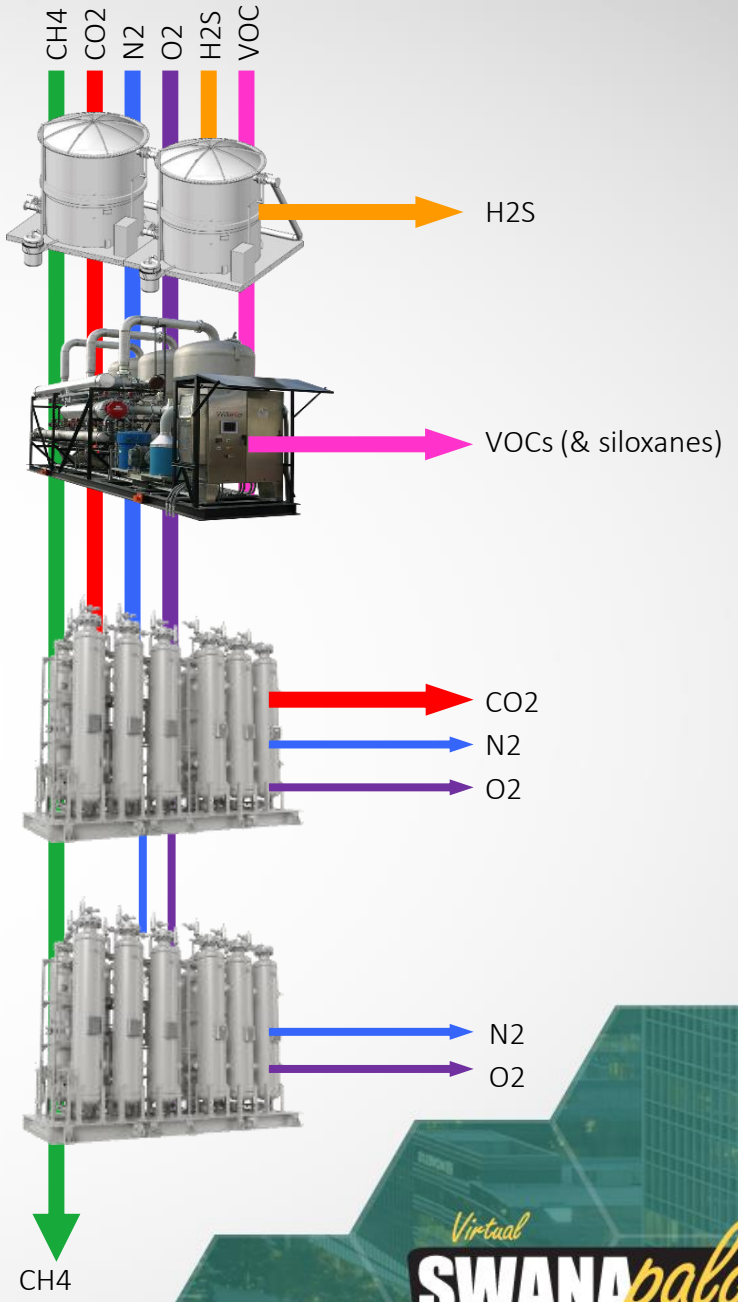
- Consumables — H2S & VOCs (but no carbon)
- LFG Compression — Low pressure, some recycle
- Risk — Water < media < membranes

Cons:

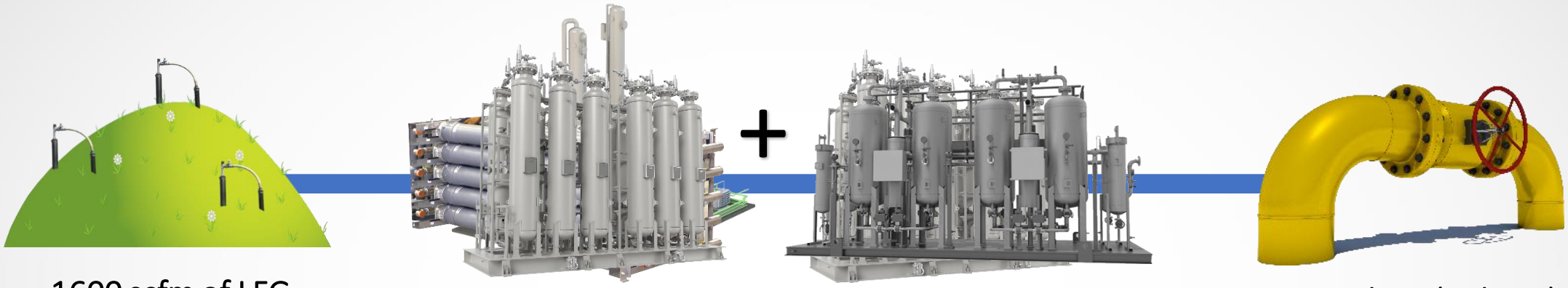
- Lowest Recovery — About 90 - 95%

Best Applied to:

- Anywhere with a use for low methane off-gas



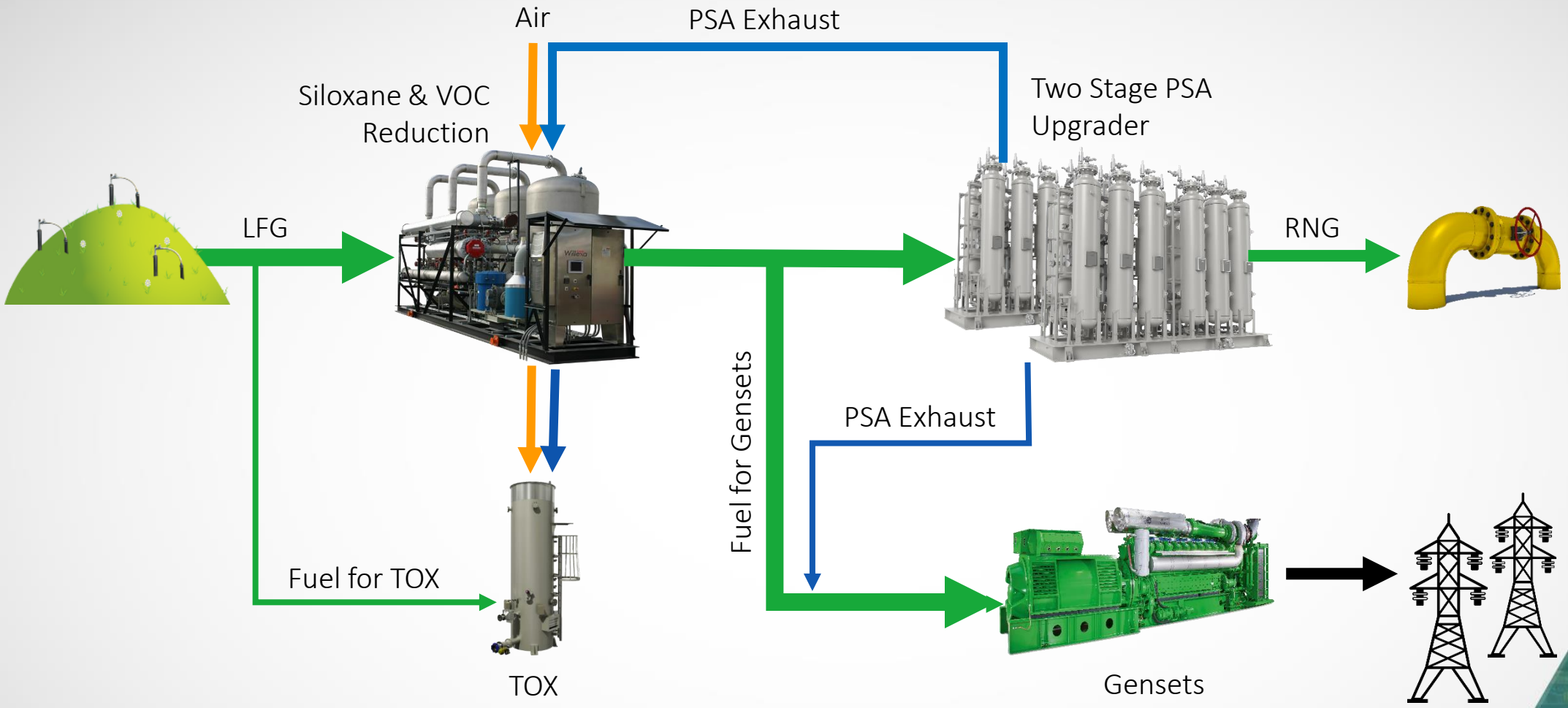
Case Study: LFG to RNG in California



1600 scfm of LFG

SoCalGas (Rule 30)

1. ~~Water Wash + NRU~~
2. ~~Membrane + NRU~~
3. Two Stage PSA


Air
PSA Exhaust
Siloxane & VOC
Reduction
Two Stage PSA
Upgrader
LFG
RNG
Fuel for Gensets
PSA Exhaust
Fuel for TOX
TOX
Gensets

Summary

- Tune the wellfield
- Get an unbiased technology comparison
- Optimize each step of the process
- Integrate the entire process
- Think outside the box

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