RNG WORKS

Pressure Swing Adsorption

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Overview

1. Goal
2. What Pressure Swing Adsorption Is / Is Not
3. Why Use It?
4. Suggestions For Technical Evaluations

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Goal

- Given this year's format, we're going to err on the side of keeping things simple.
- **If**, by the end of this presentation:
  - You know 10% more about PSA than you know right now,

    -And-

  - You will consider PSA for your next project, we will be pleased.

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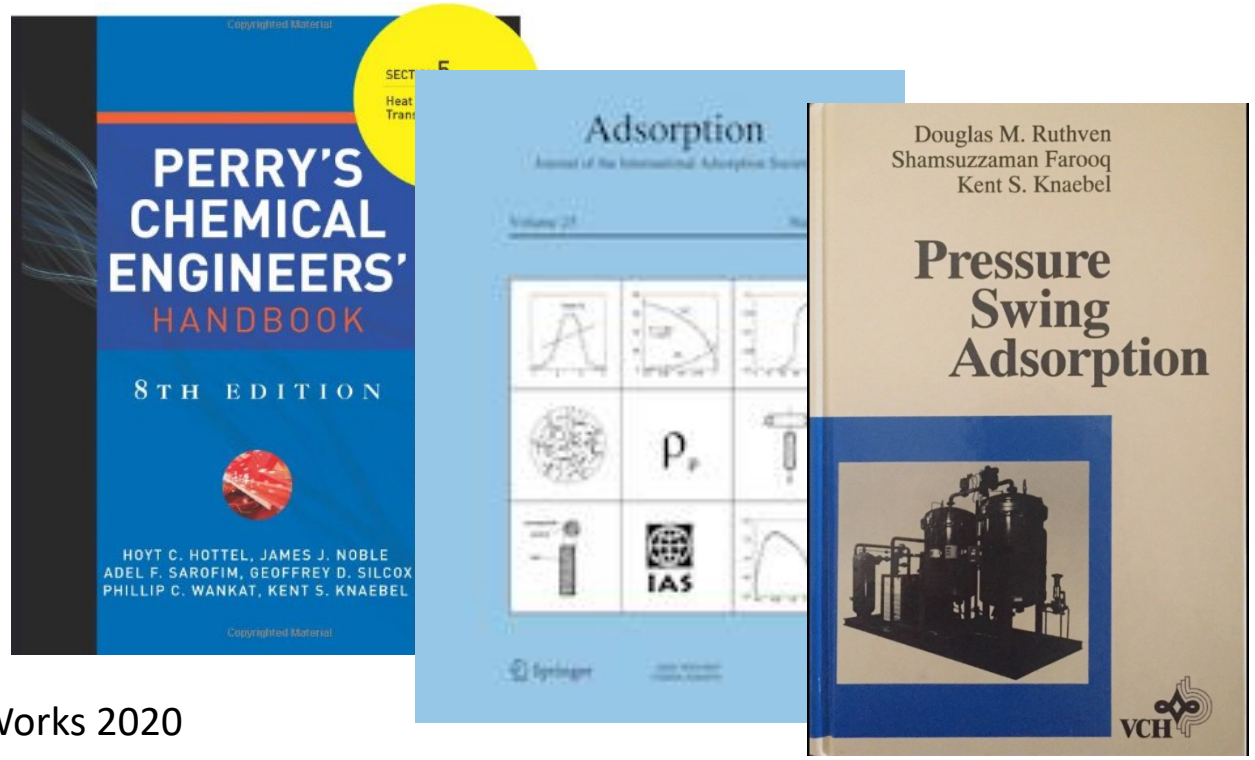
What PSA Is

- **Adsorption** is a natural phenomenon where gas molecules stick to a solid surface (adsorbent), based on differences in their natural tendencies to stick to the adsorbent.
- Adsorption is used is to separate a mixture, usually into a product and byproduct.
- Pressure Swing Adsorption (PSA) uses high pressure to force adsorption, then lower pressure to force desorption (regeneration of the media).



There are several good sources of knowledge on adsorption; we have contributed directly to many of them.

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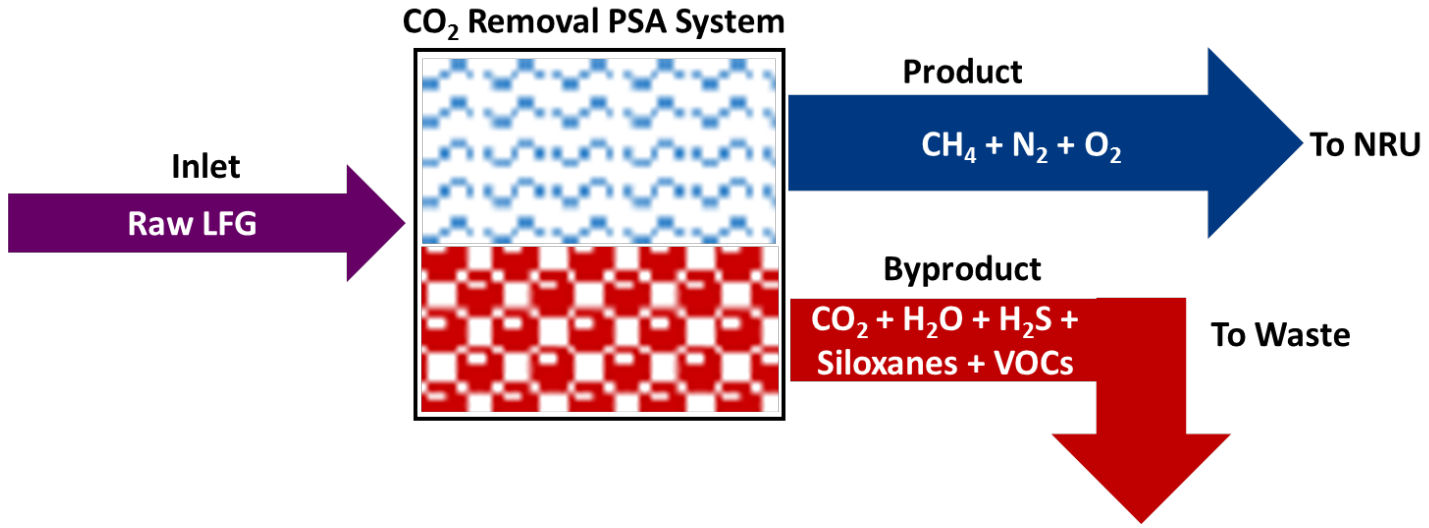
What PSA Is

Landfill Gas Upgrading Application—Stage 1



- To separate $CO_2 + H_2O + H_2S + VOCs + Siloxanes + N_2 + O_2$ from CH_4, 2 Stages are required.
- Stage 1 removes the contaminants that adsorb more strongly than methane ($CO_2 + H_2O + H_2S + Siloxanes + VOCs$).
  - They are depicted as ***red*** in above diagram = Byproduct or Waste.
- The $CH_4 + N_2 + O_2$ pass through the adsorbent.
  - They are depicted as ***blue*** in above diagram = Product.

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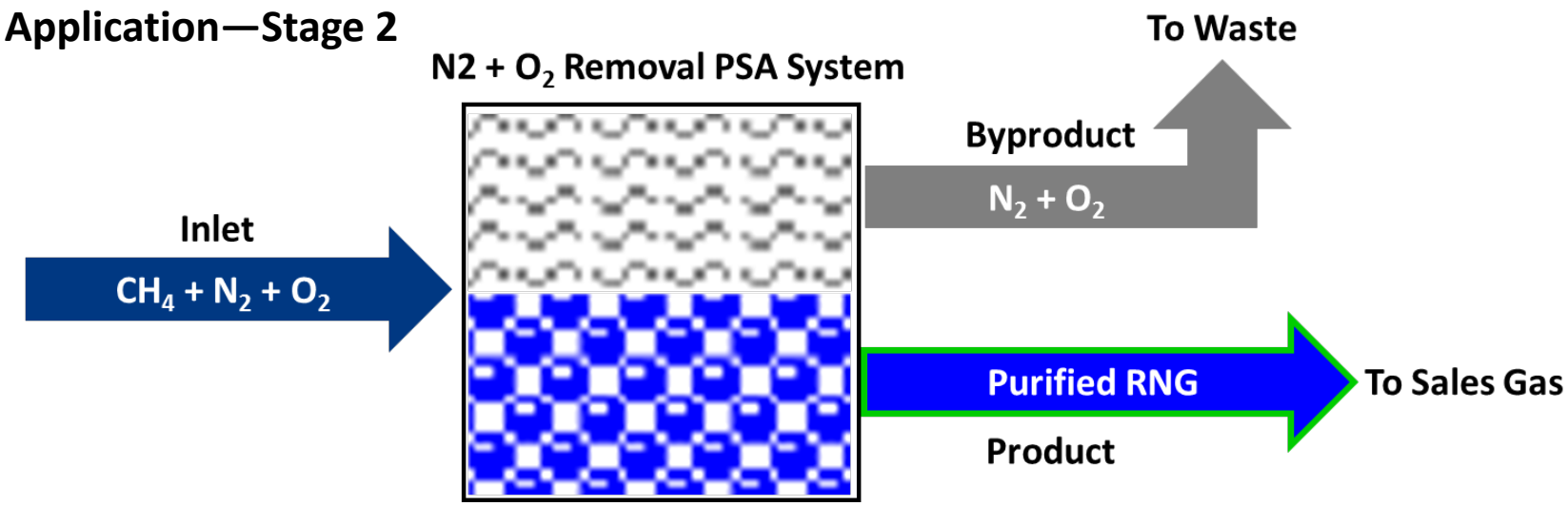
What PSA Is



- Stage 2 treats the partly purified LFG ($CH_4 + N_2 + O_2$).
- Stage 2 removes the contaminants that adsorb less strongly than methane ($N_2 + O_2$)
  - This is depicted as ***blue*** in above diagram = Product (RNG).
- The $N_2 + O_2$ pass through the adsorbent
  - They are depicted as ***grey*** in above diagram = Byproduct or Waste.

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What PSA Is Not

Adsorption is:

- Not Expensive – relative to other separation methods:
  - CO_2 separation from LFG via PSA typically costs less than competing technologies.
  - N_2 & O_2 separation via PSA is expensive relative to the CO_2 separation, but it's also a more difficult separation.
  - PSA is the only technology that can accomplish both the CO_2 separation from CH_4 and the N_2 + O_2 separation from CH_4, in a practical manner.
- Not Easy To Design – it requires experience, knowledge, and data. Achieving high-performance (product purity, methane recovery, efficiency, reliability, and economy) requires and expert!

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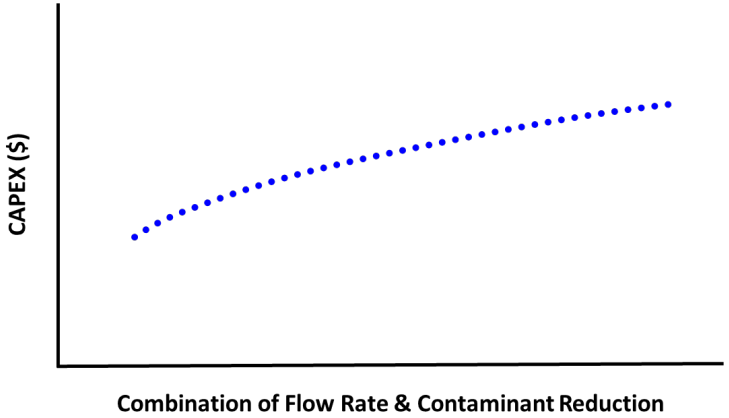
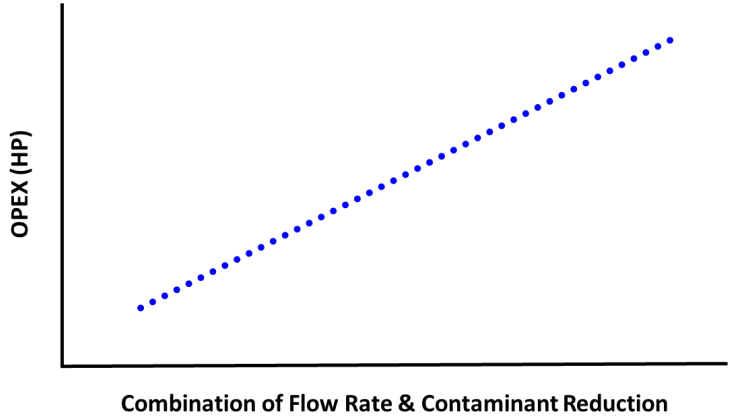
Why Use PSA?

CO_2 Removal PSA System & N2 + O2 Removal PSA System





- While the raw numbers differ, the shapes of the curves are nearly identical for both stages.
- CAPEX:
  - Typically tied to flow rate & contaminant reduction.
  - Relative cost of small systems can seem high due to fixed costs (e.g., controls), but it scales gradually.
  - There are opportunities for significant Balance of Plant savings.
- OPEX:
  - Typically tied more to flow rate, so it's pretty linear.
  - Relatively low operating pressures (~100 psi) means relatively low overall HP. (Stage 1)

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Technical Evaluation

When comparing process alternatives, we suggest a holistic approach:

- CAPEX
- OPEX
  - Horsepower (be sure to include feed and product compression requirements)
  - Media—life & replacement cost
- Recovery = Revenue
- Technical Support—types, availability, expected uptime
- Adaptability—how does the process handle changes in LFG flow rate, composition, and ambient conditions?

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Thank You!

If you have questions about this presentation, adsorption, or how ARI can help you, please contact:

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Stay Safe