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**Using Kinetic PSA to Upgrade N<sub>2</sub>-Rich LFG to Biomethane**

**13<sup>th</sup> Annual LMOP Conference**

Baltimore, MD

January 2010.

# Xebec Adsorption Inc. — Activity

## Industrial & Renewable Energy Markets:

- Natural gas dehydration for CNG infrastructure
- Hydrogen purification
- Biogas purification for pipeline injection or CNG vehicle fuel



Head Office & Mfg Facility  
Blainville, Canada

Sales Offices:  
Shanghai, Singapore,  
Vancouver, Newcastle (UK)

# Xebec High-Btu Installations

Project	Location	Biomethane		
		Feed Flow scfm	End-Use	Product Purity
Scenic View Dairy	Michigan	135	Pipeline	98%
Rumpke Landfill	Ohio	4200	Pipeline	96%
Widnau	Switzerland	120	Pipeline	96%
Lavigny Farm	Switzerland	70	Pipeline	96%
Bison Energy	Iowa	10,800	Pipeline	97%
<b>UNH</b>	<b>New Hampshire</b>	6000	Turbine	85%
SKS	Austria	25	CNG	99.8%
Swiss Farmer	Switzerland	135	Pipeline	99.5%
STEP	Switzerland	150	Pipeline	96%
Hilarides Dairy	California	160	CNG	98%
Daesung	Korea	150	CNG	81%
SKS	Austria	90	CNG	96%



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# The Value in Removing CO<sub>2</sub>, N<sub>2</sub> & O<sub>2</sub>

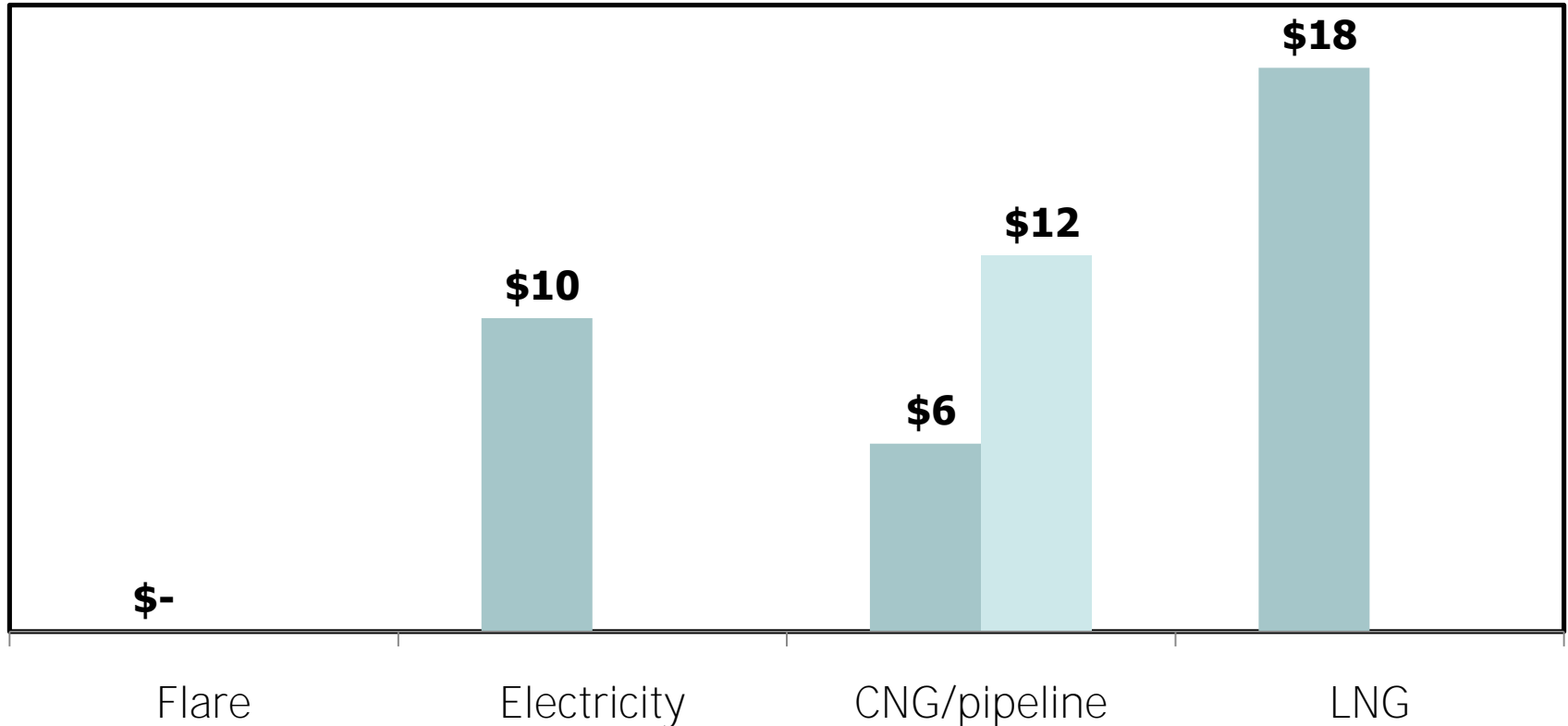
N/A

N/A

CO<sub>2</sub> + N<sub>2</sub> < 2.0%

O<sub>2</sub> < 0.2%

CO<sub>2</sub> < 50 ppmv



**Value of Landfill Gas Products per MMBtu**

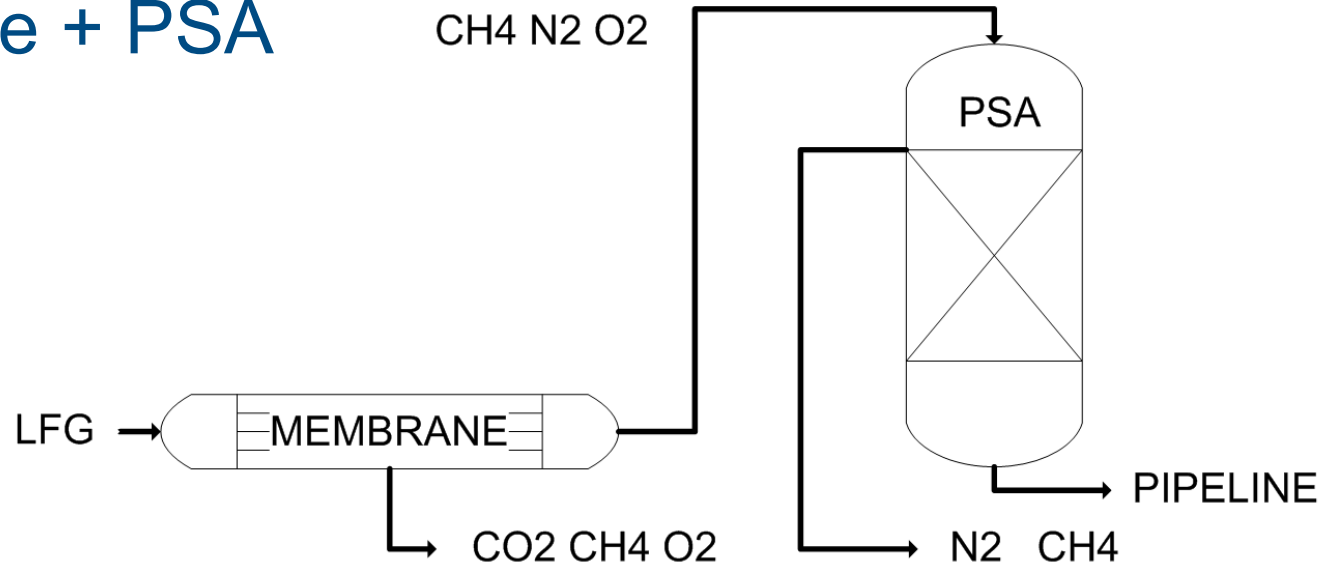
# CO<sub>2</sub>/N<sub>2</sub>/O<sub>2</sub> Removal Options

- ❑ Reduce ingress of air
  - Do this before anything else
  
- ❑ Selective Catalytic Reduction of O<sub>2</sub>
  - >2% O<sub>2</sub>, cooling costs high
  - Sensitive to siloxanes
  - Catalyst change-out 40% of CAPEX



# CO<sub>2</sub>/N<sub>2</sub>/O<sub>2</sub> Removal Options — membrane/PSA

## □ Membrane + PSA



- Recovery losses are compounded
  - $90\% \times 90\% = 81\%$  CH<sub>4</sub> recovery
- Limited to low O<sub>2</sub> concentrations
- Blending may be needed if <950 Btu/CF

# CO<sub>2</sub>/N<sub>2</sub>/O<sub>2</sub> Removal Options — LNG

- ❑ Cryogenic separation of N<sub>2</sub>/O<sub>2</sub> from CH<sub>4</sub>
  - CO<sub>2</sub> removal to <50 ppmv
  - Liquefying CH<sub>4</sub> simplifies N<sub>2</sub>/O<sub>2</sub> removal
  - Most costly, but highest ROI with LNG



# CO<sub>2</sub>/N<sub>2</sub>/O<sub>2</sub> Removal Options

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Can we do better?  
Yes, we can.



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# Xebec Adsorption Inc. — Operations

## World Class Adsorption Research & Development



**ExxonMobil**

Technology Center  
Vancouver, Canada  
11,300 ft<sup>2</sup>  
29 employees

**BALLARD**<sup>®</sup>



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# Xebec Adsorption Inc. — Technology Center



Process Testing



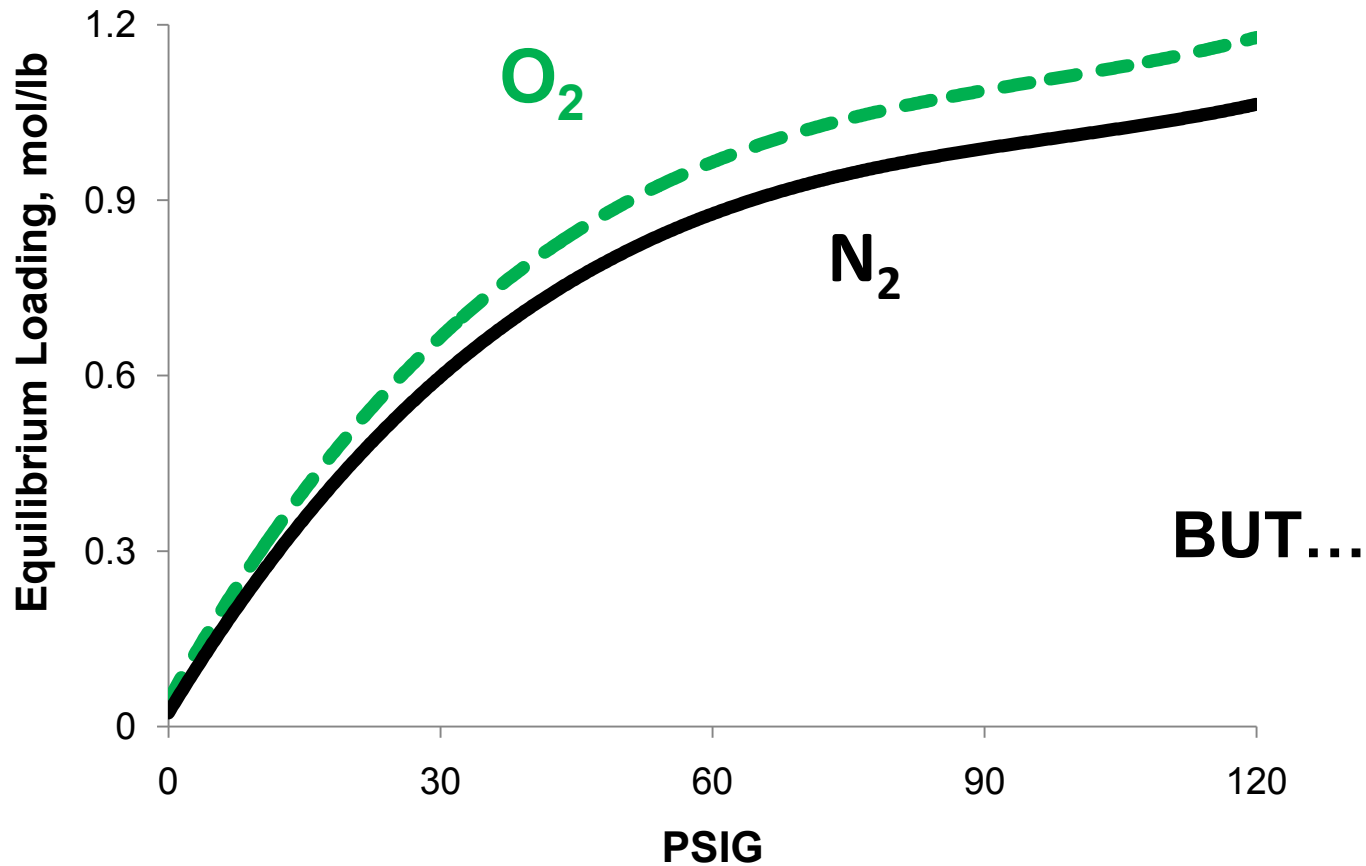
Durability Testing

Test Gas Recirculation



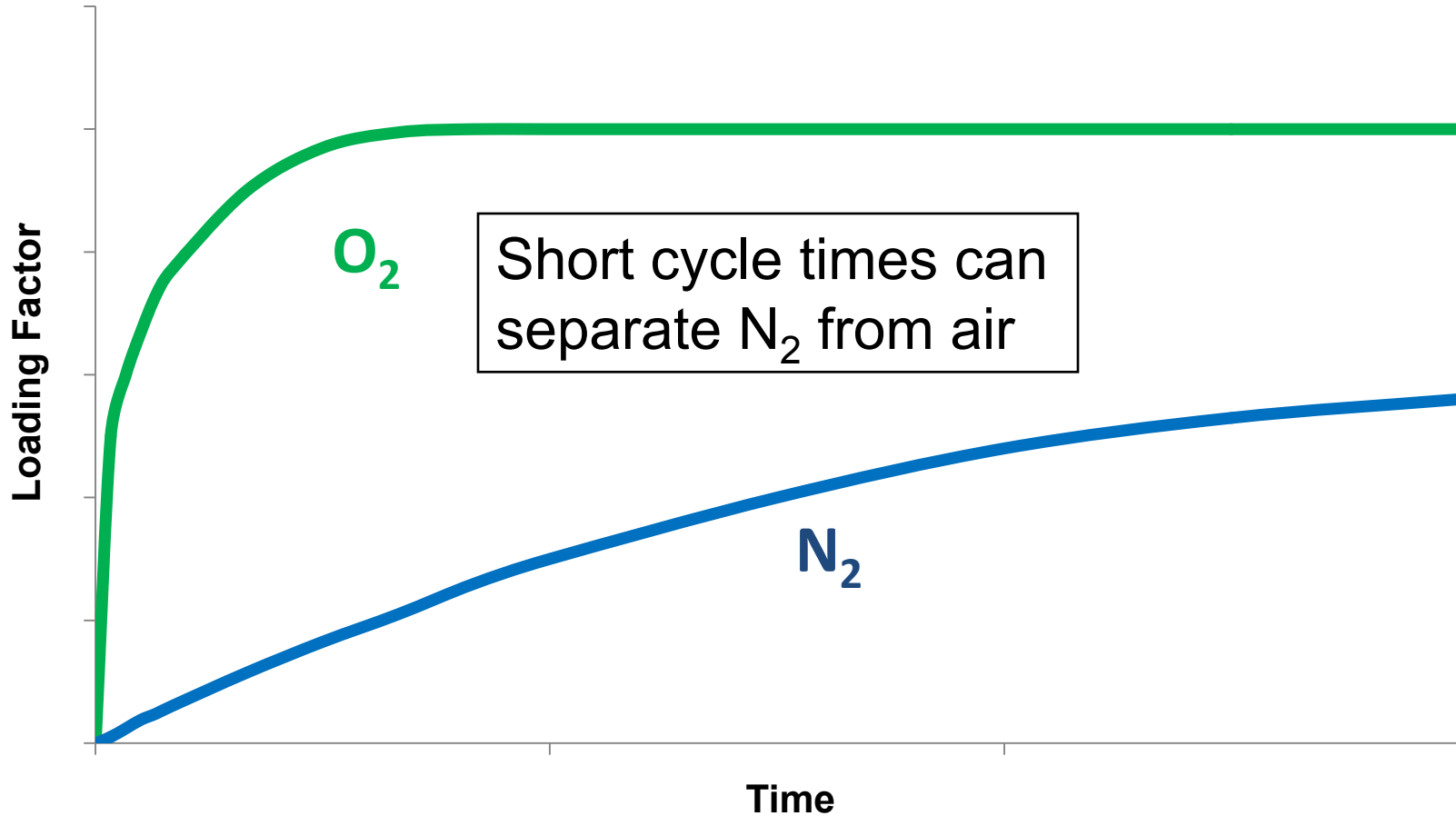
# Technology Center Seeks a New Solution

Kinetic adsorbents are known to adsorb  $N_2$  &  $O_2$

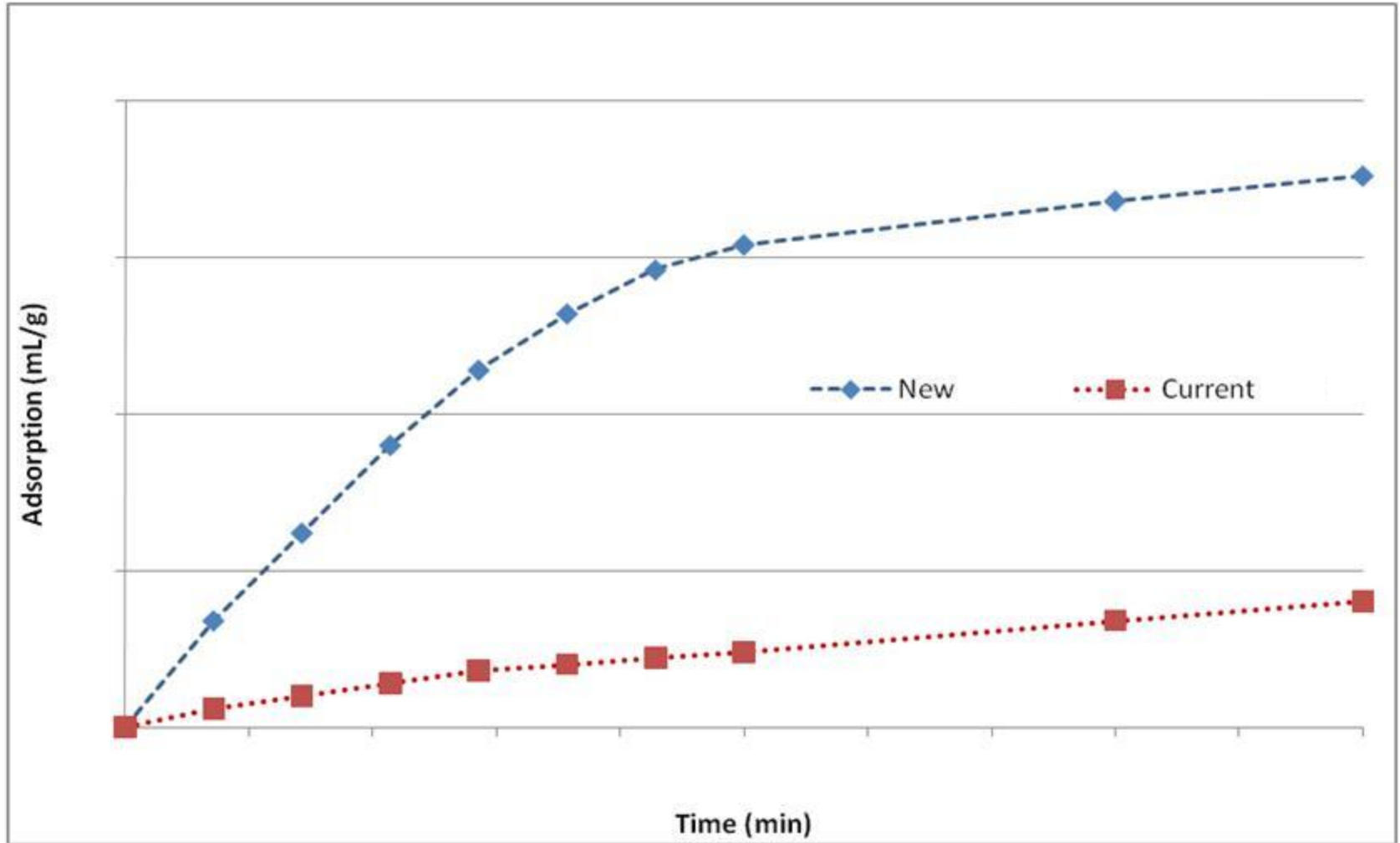


# Existing Kinetic PSA Technology (kPSA)

$O_2$  is adsorbed much faster than  $N_2$

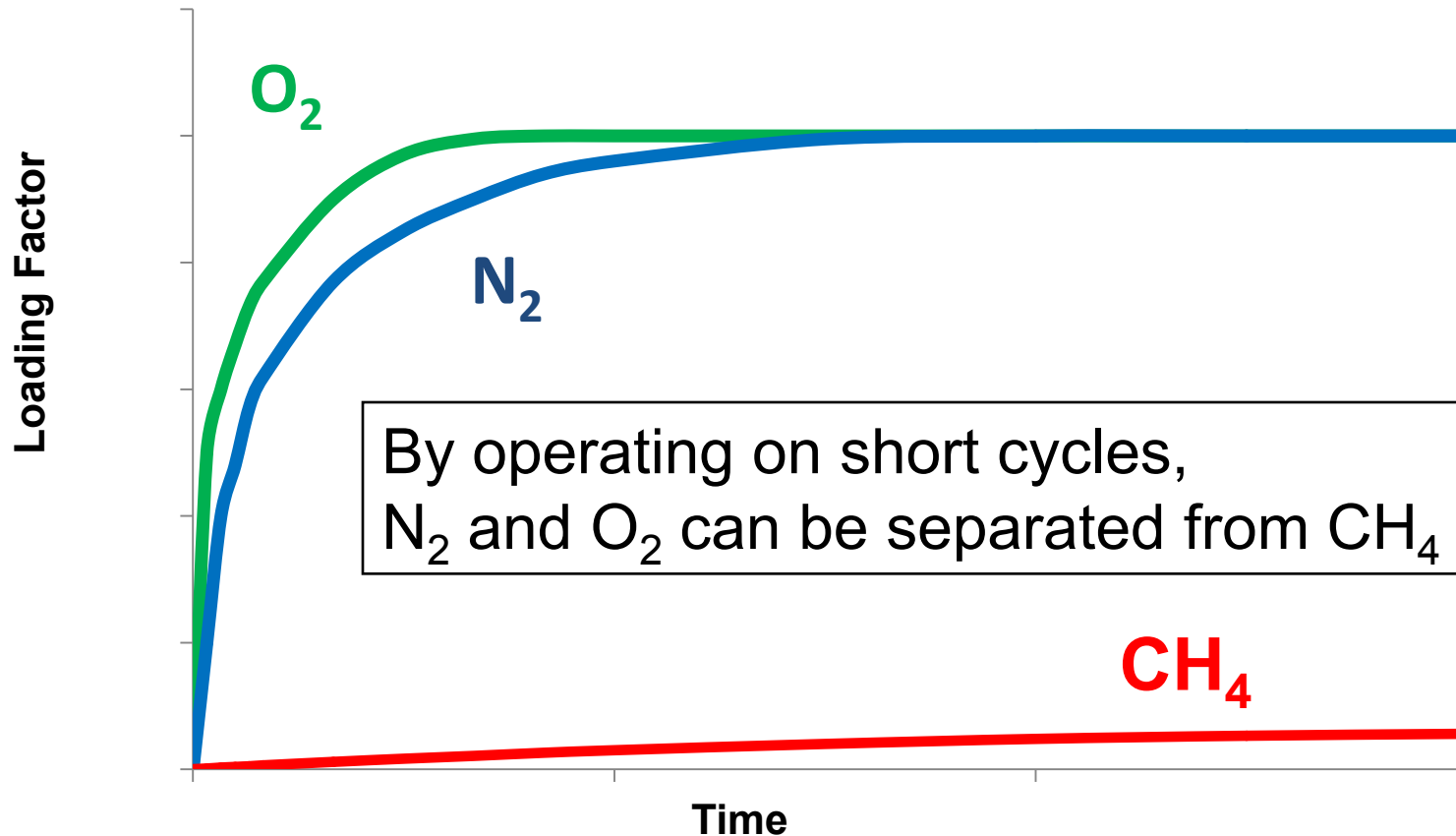


# Modified Adsorbent for LFG Enhances N<sub>2</sub> Uptake



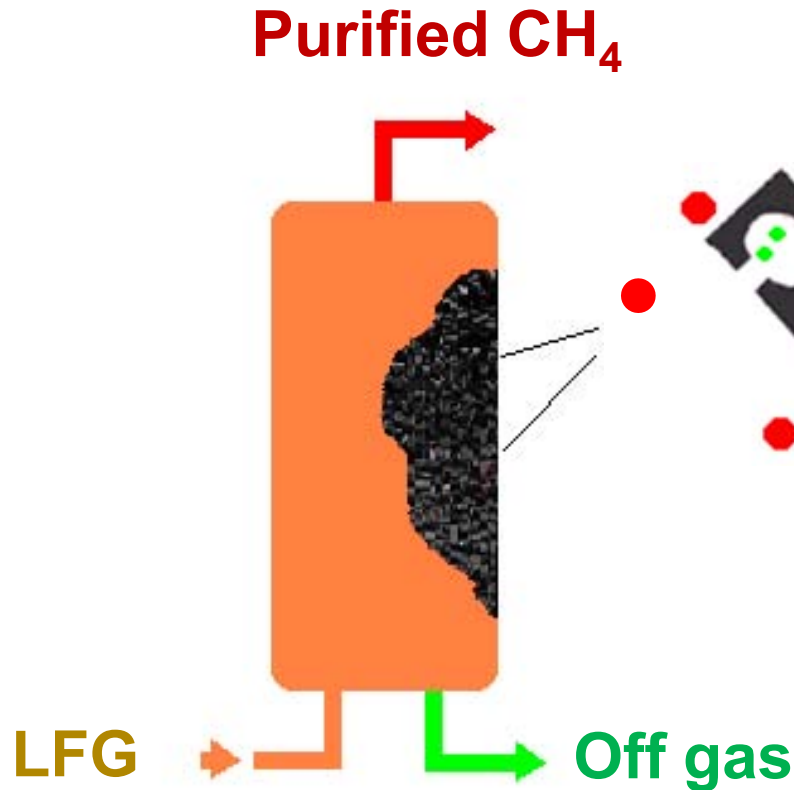
# kPSA Adapted for LFG

$N_2$  is now adsorbed almost as fast as  $O_2$



# kPSA Animation

- $\text{CO}_2$ ,  $\text{O}_2$  &  $\text{N}_2$
- $\text{CH}_4$

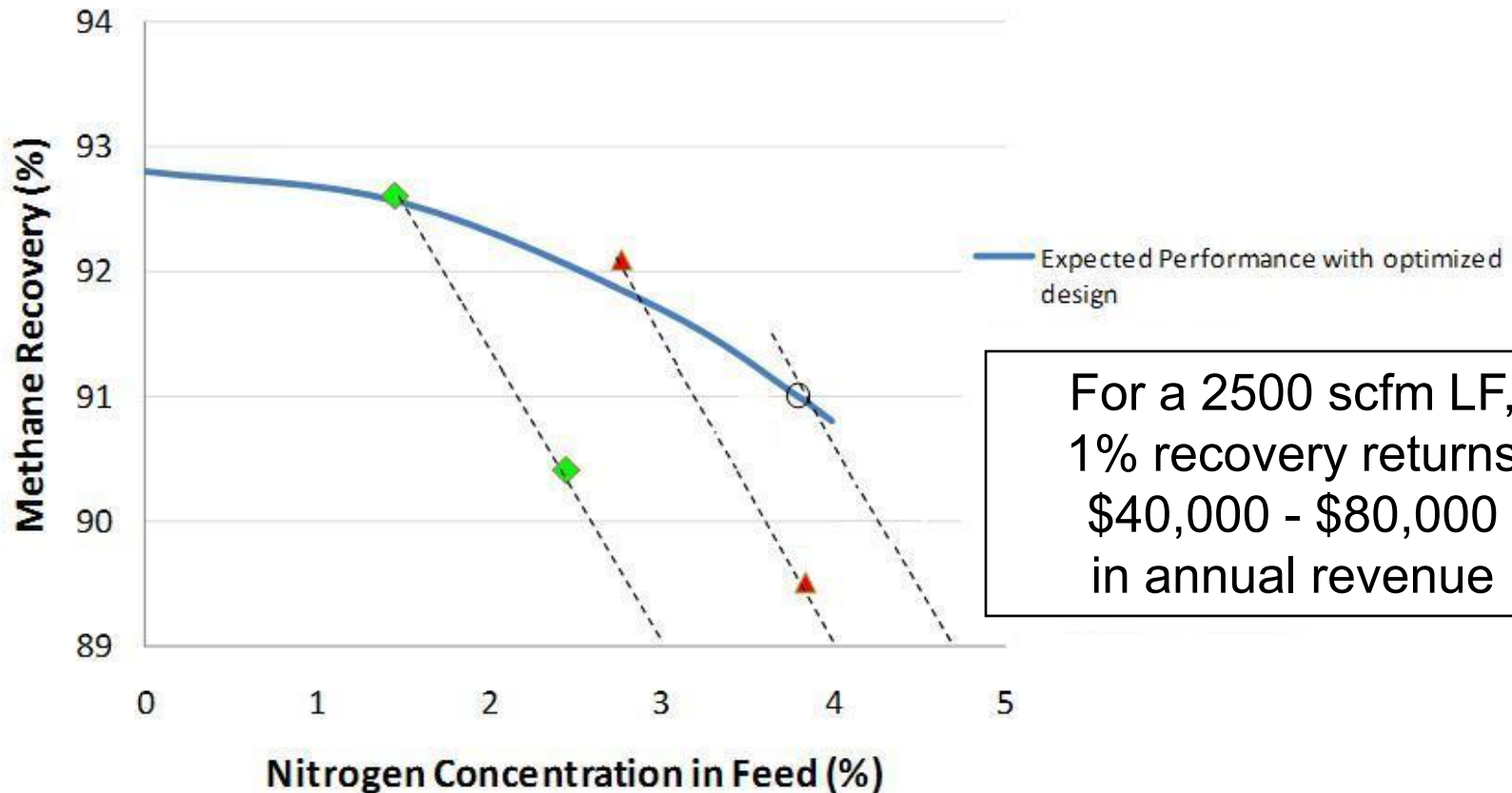


Pore size slows  
diffusion of  $\text{CH}_4$

# Test Results for New Xebec System

## Xebec's Solution for CO<sub>2</sub> and N<sub>2</sub> Removal from LFG

Expected Performance versus Preliminary Lab Testing Results



# M-3200 enhanced 9-bed kPSA for Landfills

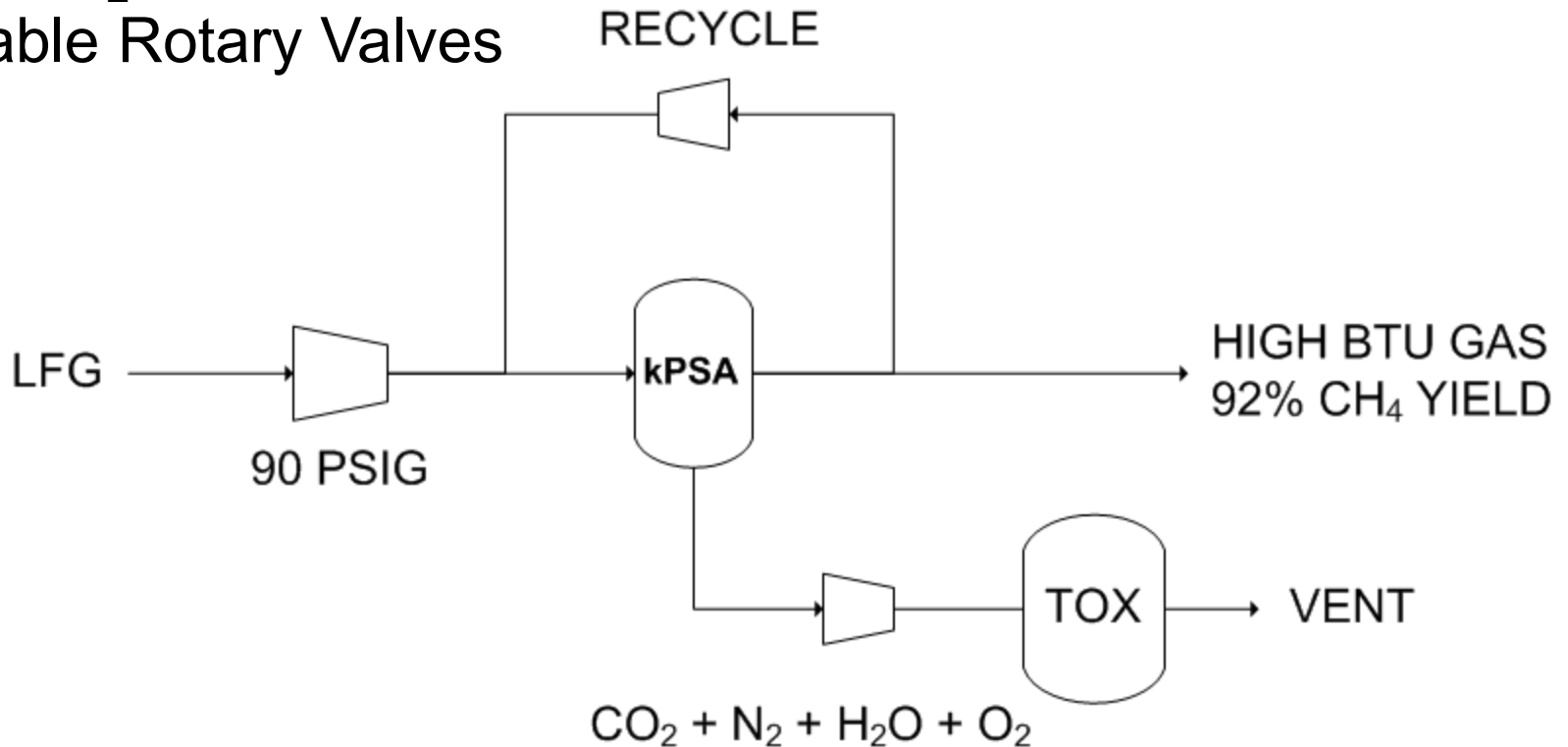


# 6-bed M-3100 cPSA at Rumpke Landfill



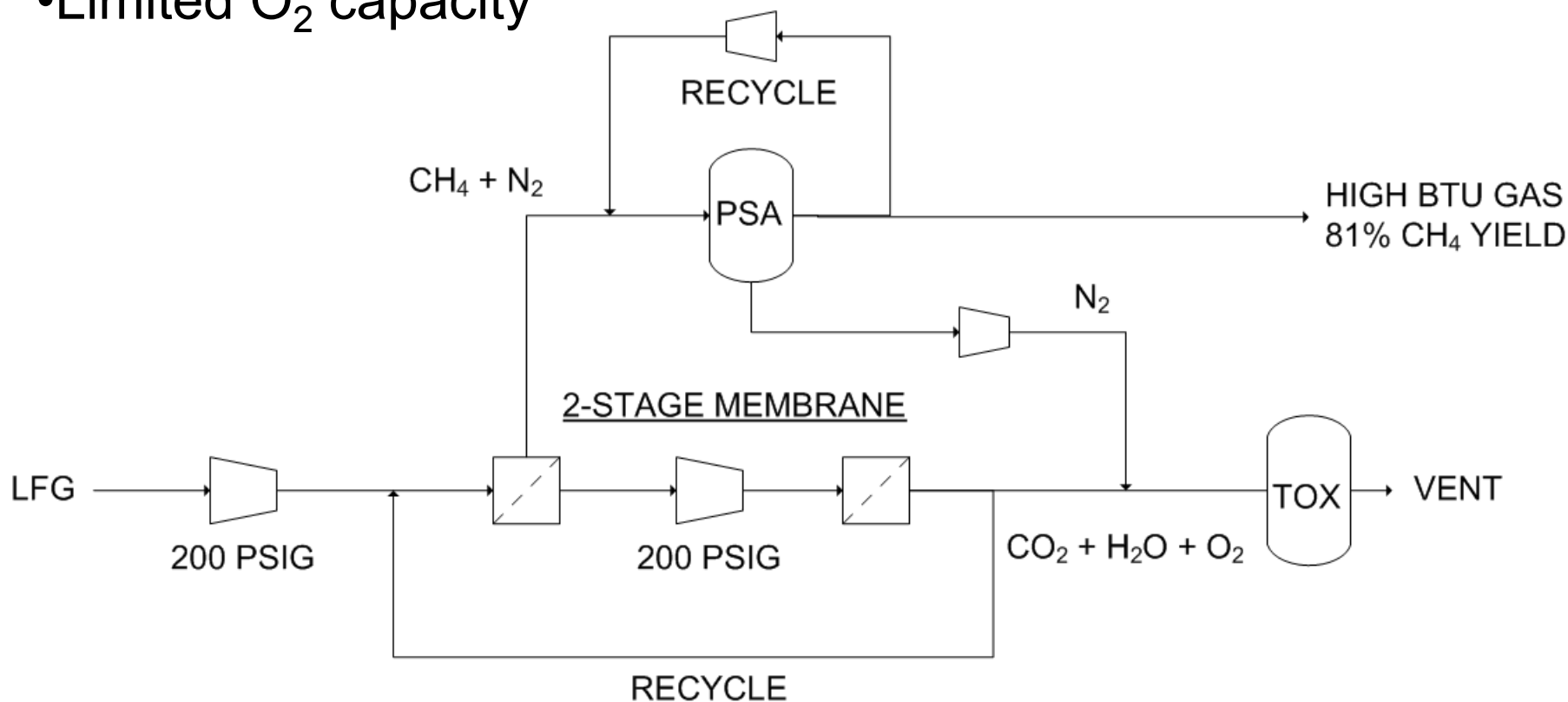
# Xebec kPSA Is a Less Complicated Design

- Higher yield 92%
- Complexity reduction
- Better O<sub>2</sub> capacity
- Reliable Rotary Valves



# Membrane/PSA Adds Complexity, Reduces Yield

- Less CH<sub>4</sub> yield: 81%
- More equipment
- Limited O<sub>2</sub> capacity



# Summary

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- ❑ Higher product value with pipeline/CNG
- ❑ CO<sub>2</sub>/O<sub>2</sub>/N<sub>2</sub> separation from methane
  - First reduce ingress of air
  - kPSA removes H<sub>2</sub>O, CO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub> in one step
  - Maximize recovery and revenue



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