

Air Liquide – Biogas & Fuel Cells

- Hydrogen Energy
- Biogas Upgrading Technology

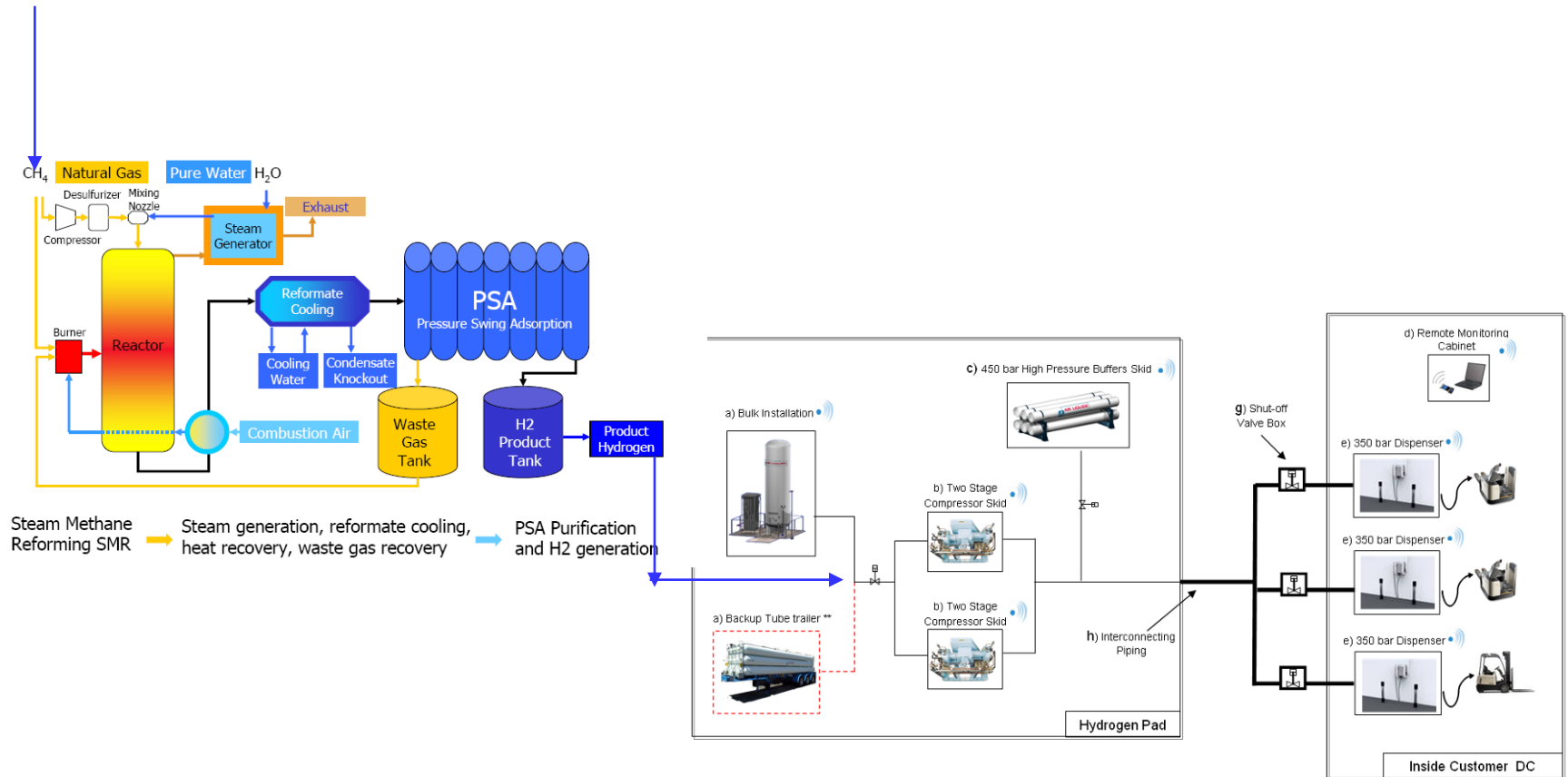
12 June 2012

Charlie.Anderson@airliquide.com

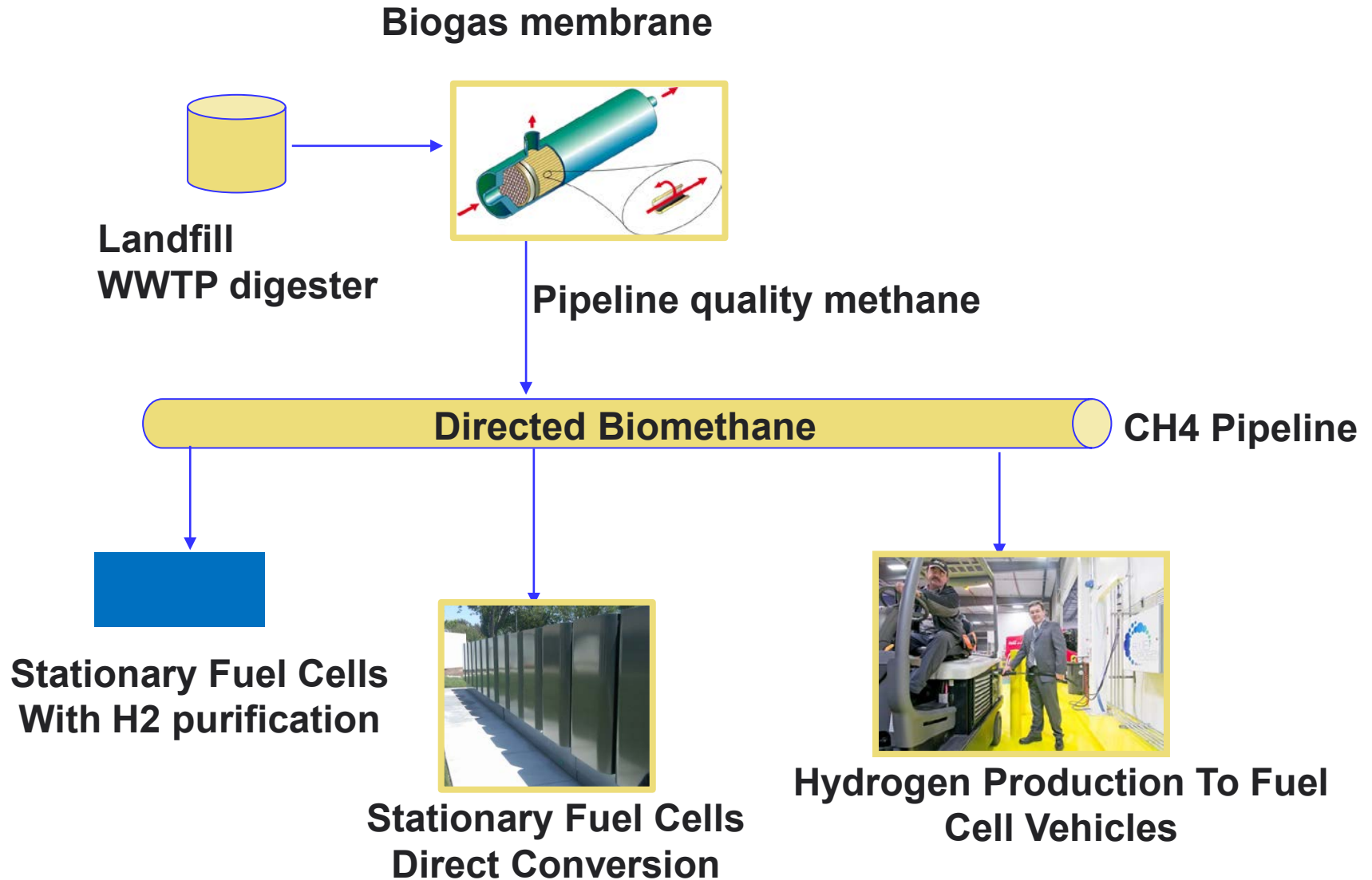


Renewable H₂ to Fuel Cell, Integrated Concept

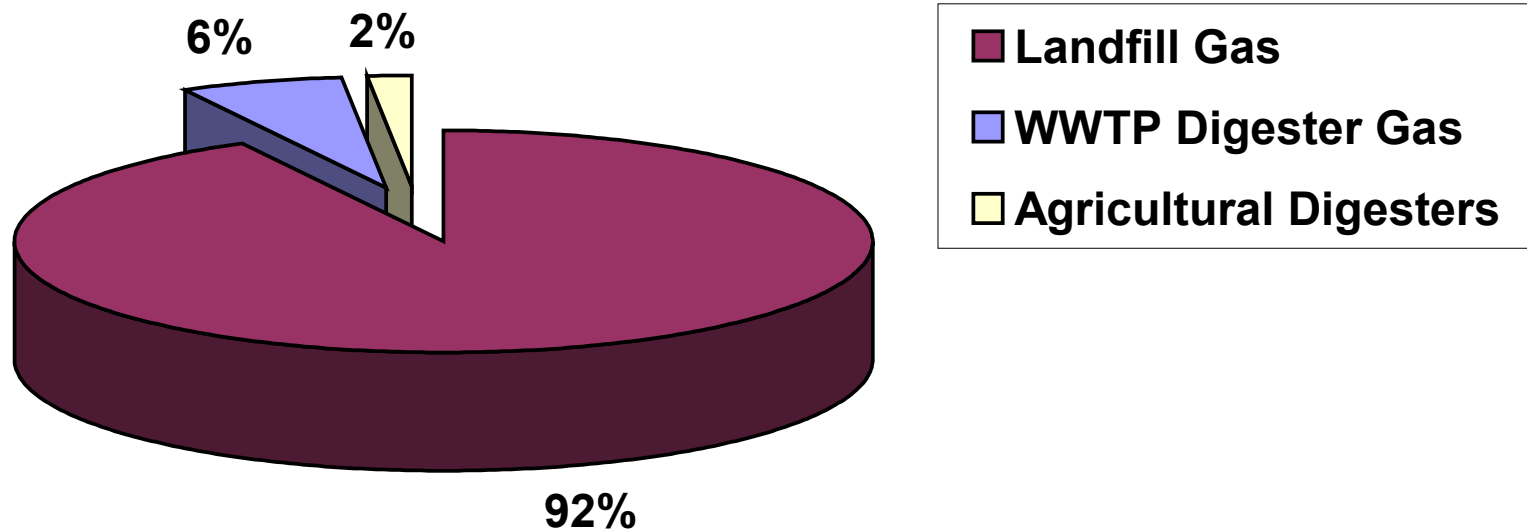
Purified Biogas



Renewable H₂ to Fuel Cell, Non-Integrated Concept

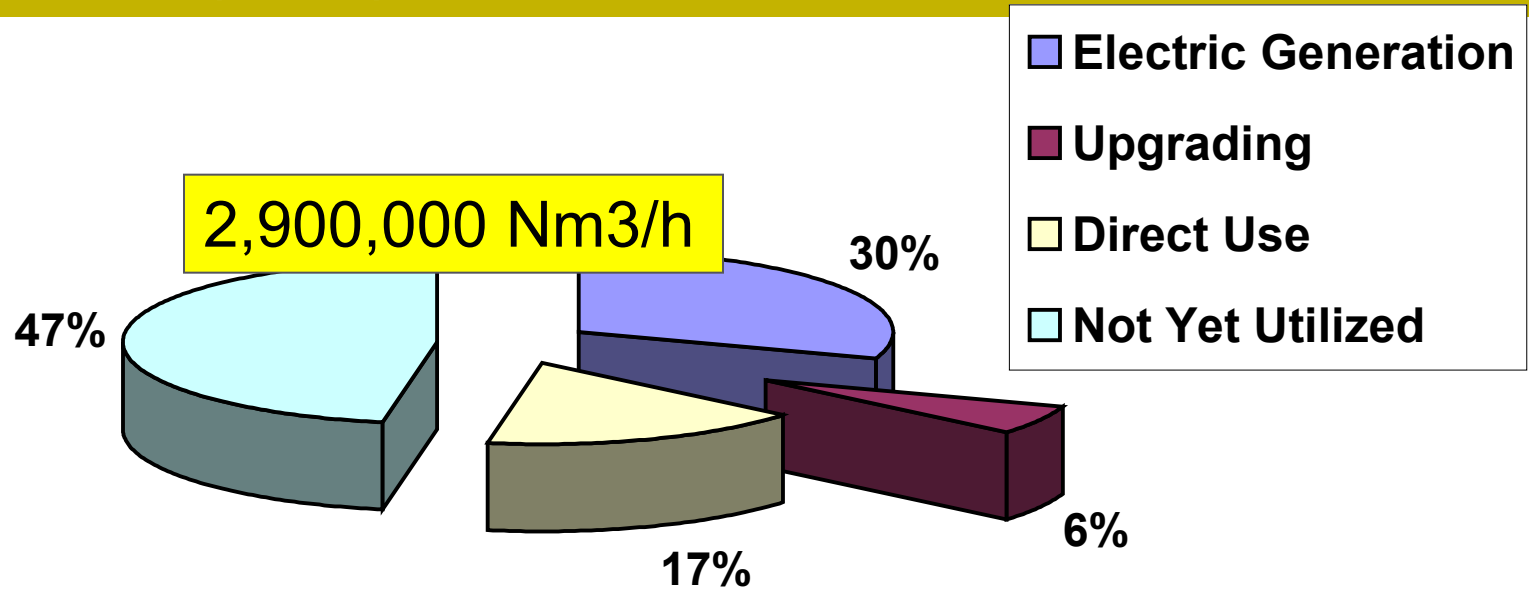


Biogas Sources in the US



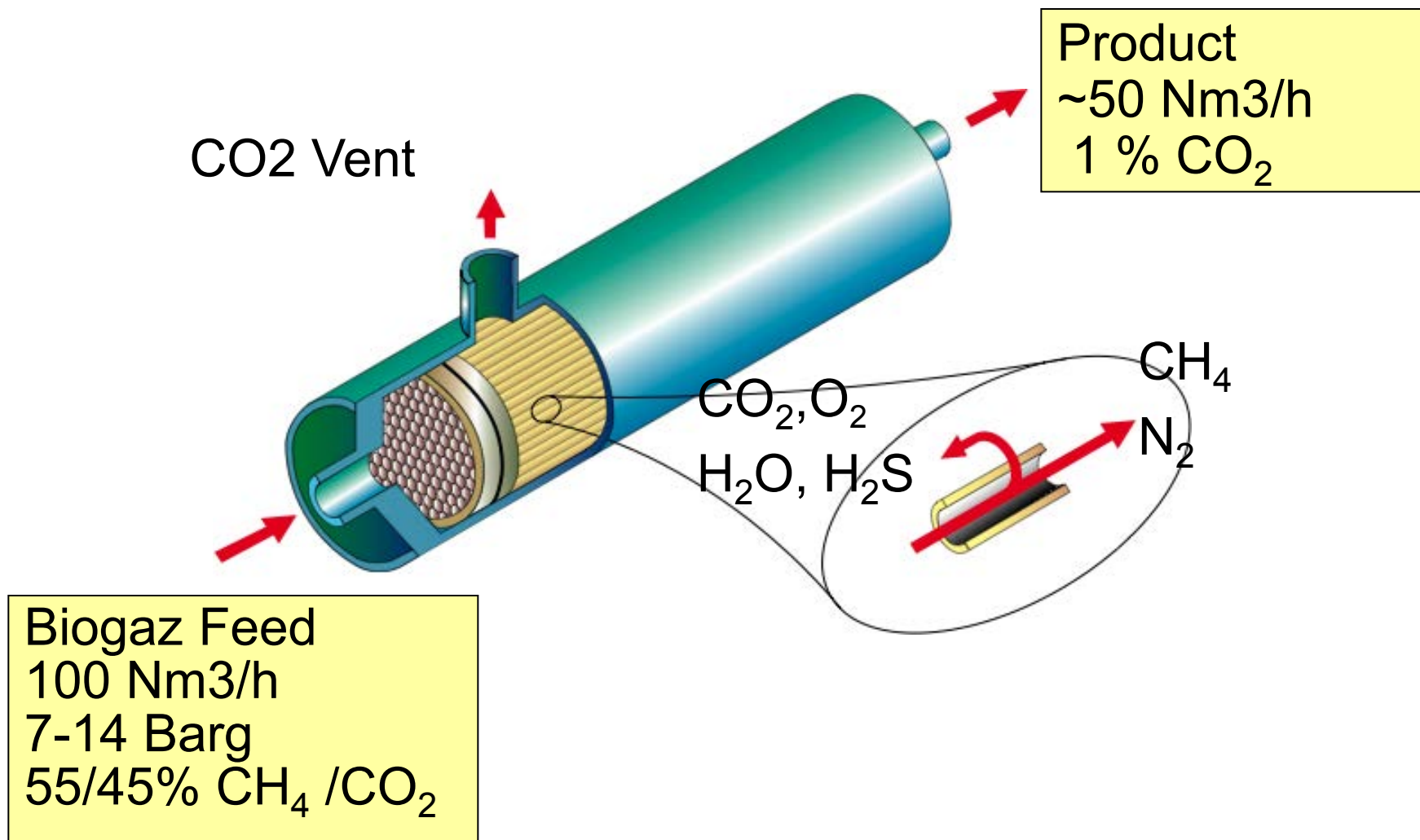
- Landfill gas dominates (~4,000 Nm³/h typical)
- WWTP digester gas (~1,500 Nm³/h typical)
 - Easier to process
- Agricultural Digesters (~300 Nm³/h typical)
 - Added cost of digester
 - Rarely upgraded.

Landfill Gas (LFG) Utilization in the US

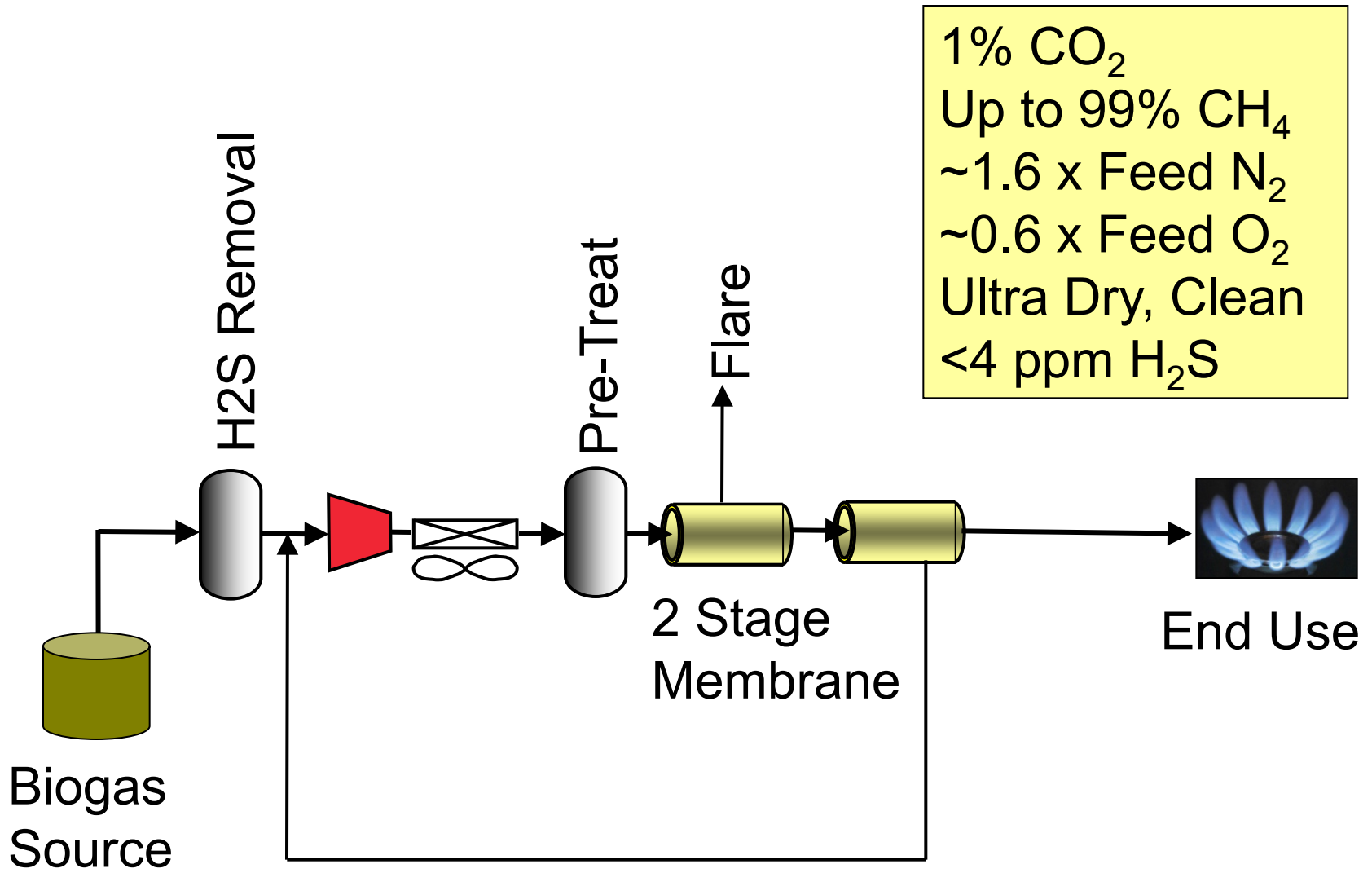


- Electric generation is most common
 - ▣ Incentives for electric (fed gov't grants, tax credits)
- Upgrading
 - ▣ Typically to pipeline quality
 - ▣ Zero US federal government incentives
 - ▣ Some states (California) offer added "renewable value"
- Almost ½ the US LFG is still not utilized

How the Biogaz Membrane Works

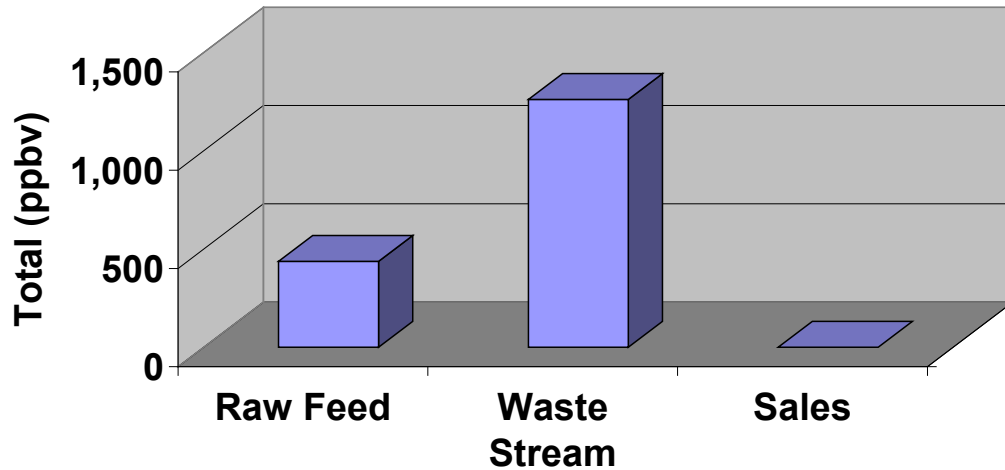


Air Liquide Simplified Biogaz System

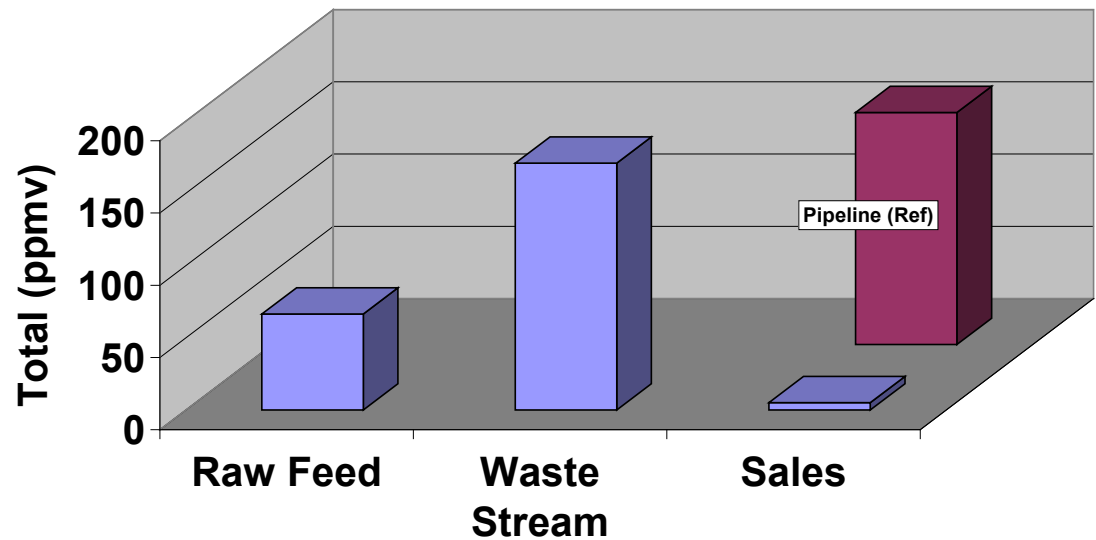


Cleaner Than Pipeline Gas

Siloxanes



VOCs



Air Liquide US Biogaz Reference List

Project/Location	Start-up	Raw Feed (MMSCFD)	Sales Gas Destination
Laurel Highlands (Raeger Mtn, PA)	Jul-06	4	Dominion pipeline system
Iris Glen (Johnson City, TN)	Nov-06	2	Mountain Home VA Center co-gen facility
Greentree (Kersey, PA)	Jul-07	12	Interstate Pipeline System of National Fuel Gas Supply Corp
Imperial (Imperial, PA)	Sep-07	6	Interstate Pipeline System of National Fuel Gas Supply Corp
Shade (Cairnbrook, PA)	Jun-07	4	Dominion pipeline system
Southern (Davidsville, PA)	Jun-07	2	Dominion pipeline system
Oklahoma City (OKC, OK)	May-08	2	Southern Star Pipeline
Carter Valley (Church Hill, TN)	Nov-08	2	Intrastate pipeline system of Targasco, Inc.
Winder (Winder, GA)	Dec-08	6	Municipal Gas Authority of Georgia Local Distribution
Live Oak (Atlanta, GA)	Feb-09	7	Atlanta Gas & Light Local Distribuion
Cedar Hills (Seattle, WA)	Feb-09	16	Puget Sound Energy Local Distribution
Seneca (Pittsburgh, PA)	Dec-10	4	Dominion pipeline system
River Birch (New Orleans, LA)	May-10	9	ATMOS Pipeline, LDC
Meadow Branch (Athens, TN)	Aug-11	3	Spectra Energy's East Tennessee Pipeline
Pt Loma WWTP (San Diego, CA)	Mar-12	2	SDG&E
Fresno WWTP (Fresno, CA)	Mar-12	2	Local plant use
Midwest Landfill	Est'd 2013	5	Pipeline, eventual CNG vehicle
	TOTAL	88	

JRE, Laurel Highlands LF, Johnstown, PA



Timberline Energy, Oklahoma City



Austria, WWTP



- Raw gas: 250 Nm³/h
- Product gas: 98,5% CH₄, 5 bar g
- Offgas burner: Zero odors, Zero CH₄ emissions

PT Loma WWTP, Biogas to Fuel Cell Power



- BioFuels Energy
- Biogas to BioMethane to 4.5 MW Fuel Cell Power
- 3 FCE Fuel Cells
 - 2 via directed Biomethane
 - 1 on-site consuming actual biomethane
- Gas processing by Air Liquide
- Total plant built and operated by SCS

Air Liquide Live Oak Biomethane Plant



- LFG from WM Live Oak Landfill, Conley, GA
- 2000 MMBtu/Day into pipeline as directed biomethane
- Platform for continuing biomethane related developments

End of presentation

- Thank you for your attention

