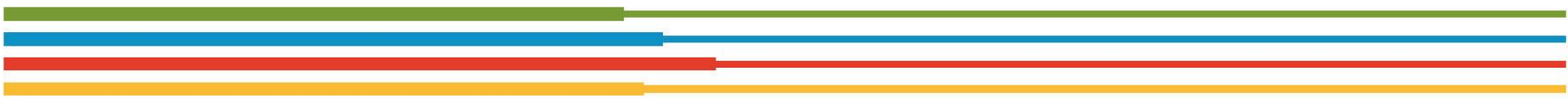


Role of Renewable Natural Gas in Closing the Carbon Cycle



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Principal Project Manager
Customer Strategy and Environmental
April 14, 2014



Agenda

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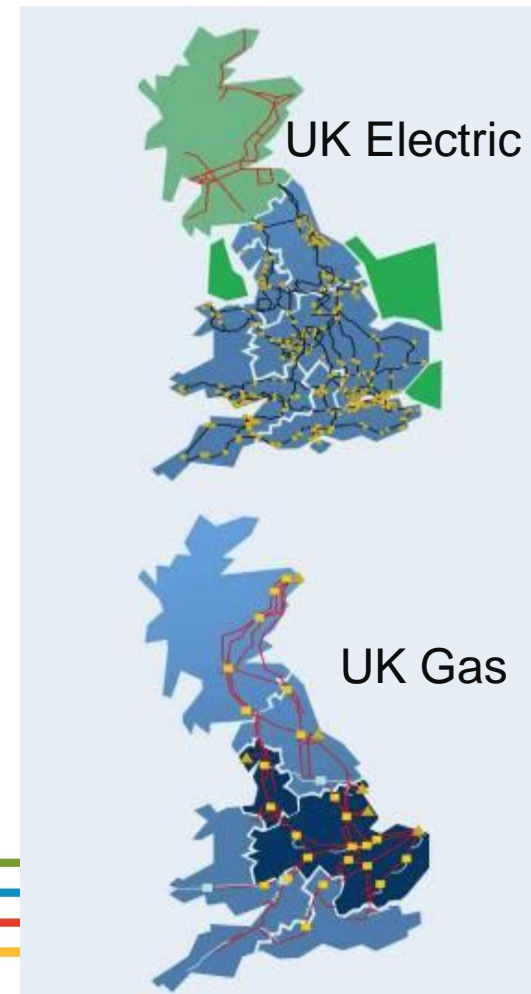
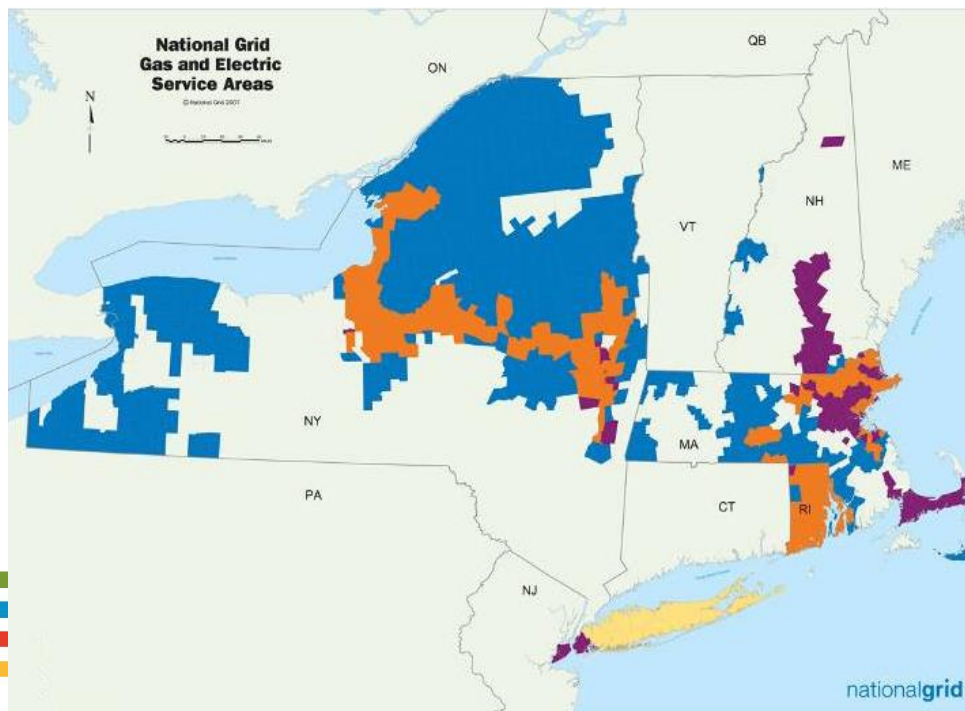
- Background on National Grid
- Renewable natural gas fundamentals
- Newtown Creek Wastewater Treatment Plant project and Micro CHP
- Conclusions

An International Energy Company

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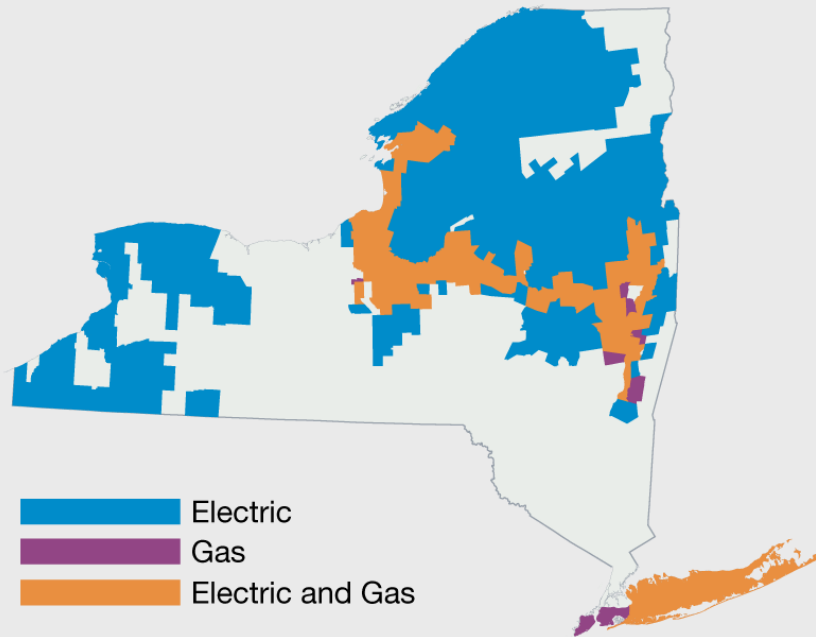
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- Based in US and UK
 - One of world's largest utilities
 - 19 million customers
 - 27,000 employees



...Yet, a Very Local NY Business

New York represents
60% of National Grid's
US business



10,500
employees

2.3 million
gas customers

1.6 million
electric customers

3,700 MW
electric generation

Nearly **\$1 billion**
in annual capital investment

What is Renewable Natural Gas?

- Pipeline quality gas derived from biomass resources that is injected into the gas distribution network
- Sources of biomass include wastewater treatment plants, landfills, livestock manure, municipal solid waste, agricultural residues and energy crops

Feedstock



Anaerobic Digestion / Gasification



Upgrading, clean-up, methanation



Injection of pipeline quality gas



How is Renewable Natural Gas Produced?

Anaerobic Digestion (AD)

- High-moisture organic material such as wastewater, food waste & certain livestock manure
- Microorganisms convert organic matter into biogas
- Commercially available and in use today

Thermal Gasification (TG)

- Low-moisture feedstock such as forestry waste, crop residue, municipal solid waste and energy crops
- Thermal breakdown of solid biomass into syngas and converted to methane
- A proven technology likely to reach commercial-scale implementation within 10 years

Why Should It Be Considered?

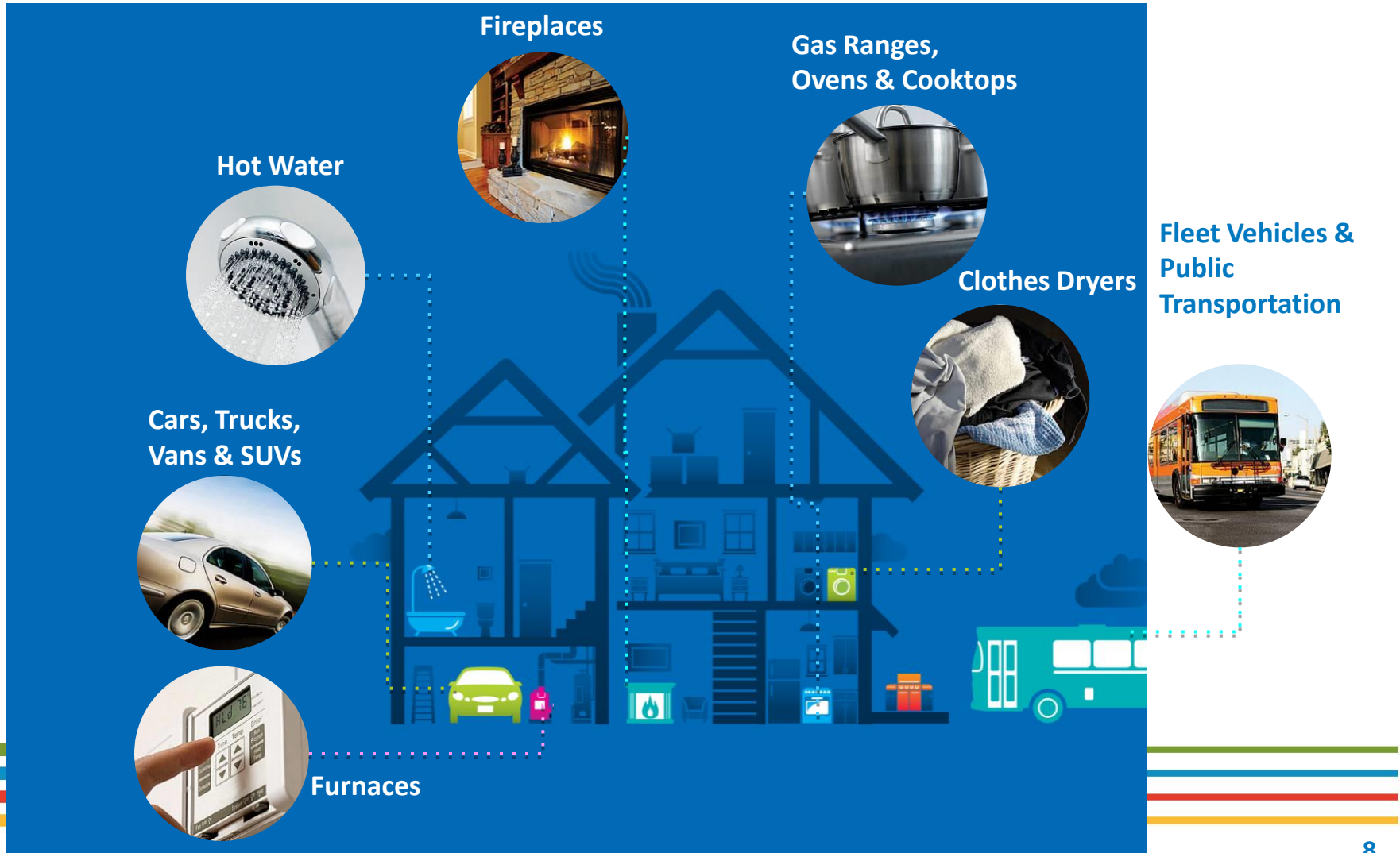
Renewable Natural Gas is a here and now energy solution that delivers the following benefits:

- Lowers greenhouse gas (GHG) emissions by offsetting the use of natural gas (and in some instances capturing methane that would have otherwise entered the atmosphere)
- Provides a real option for managing and using local waste resources to produce renewable energy
- Leverages the existing natural gas network to deliver a renewable fuel for homes, business, industrial, and transportation needs
- Stimulates the local economy and creates jobs
- Enhances diversity of supply with a local and domestic resource

Renewable Natural Gas Is Interchangeable With Natural Gas for Everyday Uses in Our Homes and Businesses

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What Is the Potential?

Recent study by American Gas Foundation (released Sept. 2011)

Finding: Under a reasonable long-term scenario, Renewable Natural Gas could be used to meet the natural gas needs of half of all American homes.

Category	AGF Study Scenario		
	Non-Aggressive	Aggressive	Technical Potential
Energy Potential (billion cubic feet /yr)	967	2,485	9,450
Potential as a Percentage of Overall Demand*	4%	10%	40%
CO₂ Abatement (million tons/yr)	57	146	556
Direct Jobs Created (low – high range)	8,825 – 32,189	22,692 – 82,765	86,732 – 316,338

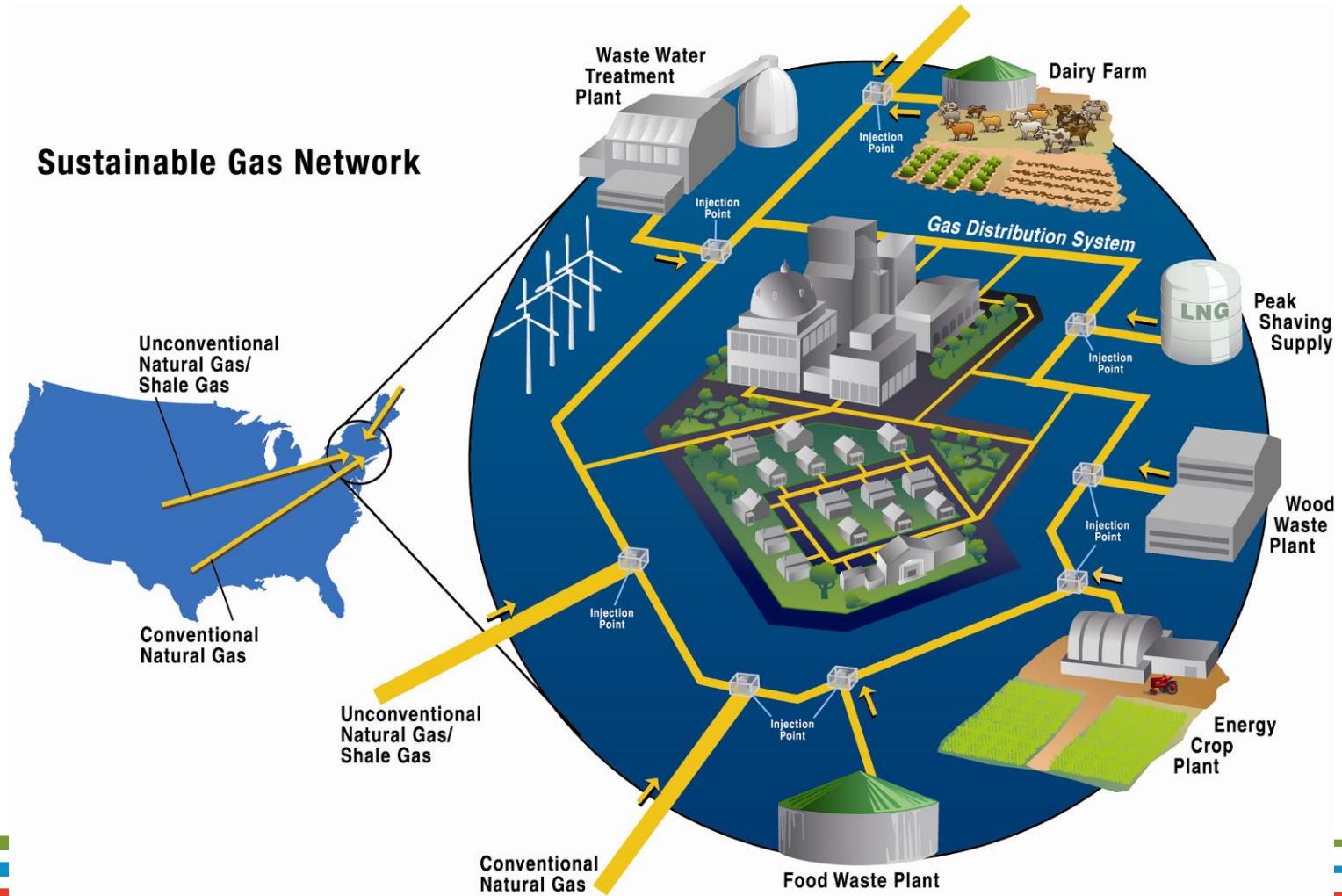
* Based on a national usage of approximately 24 TCF of natural gas (for 2010), source EIA

Vision

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Sustainable Gas Network



Transportation Sector Is Well Positioned to Embrace Renewable Natural Gas

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- The environmental attributes of renewable gas can be recognized through Renewable Fuel Standard (RFS) – EPA program
 - RFS sets annual mandates for renewable transportation fuels in the United States
- RFS program was created under the Energy Policy Act (EPACT) of 2005 & it was expanded and extended by the Energy Independence & Security Act (EISA) of 2007
 - Requires 36 billion gallons of renewable fuel by 2022
- RFS2 also established new RINs that are differentiated by type of biofuel
 - Renewable natural gas is considered an advanced biofuel

Newtown Creek Demonstration Project

- National Grid and New York City Department of Environmental Protection are working together to deliver renewable gas from the largest wastewater treatment plant in New York City
- Once operational, the project will inject enough gas to provide heat to approximately 2,500 homes and reduce CO₂ emissions by about 16,000 tons annually (equal to CO₂ emissions of approximately 3,000 cars)



Picture of Newtown Creek wastewater treatment plant in Brooklyn, NY.

Source: New York City Department of Environmental Protection

Typical Clean-up System Components

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- Source
- Gas compression/Liquids knock-out
- H₂S Removal – Various Options
- Pretreatment TSA or PSA
- CO₂ Separation
 - Multiple systems (Dry, Wet, PSA, Membrane)
- Thermal Oxidizer/Flare
- Balance of plant
 - Meters
 - Chromatographs
 - Gas sampling
 - Odorizers



Greenlane Biogas Upgrading System



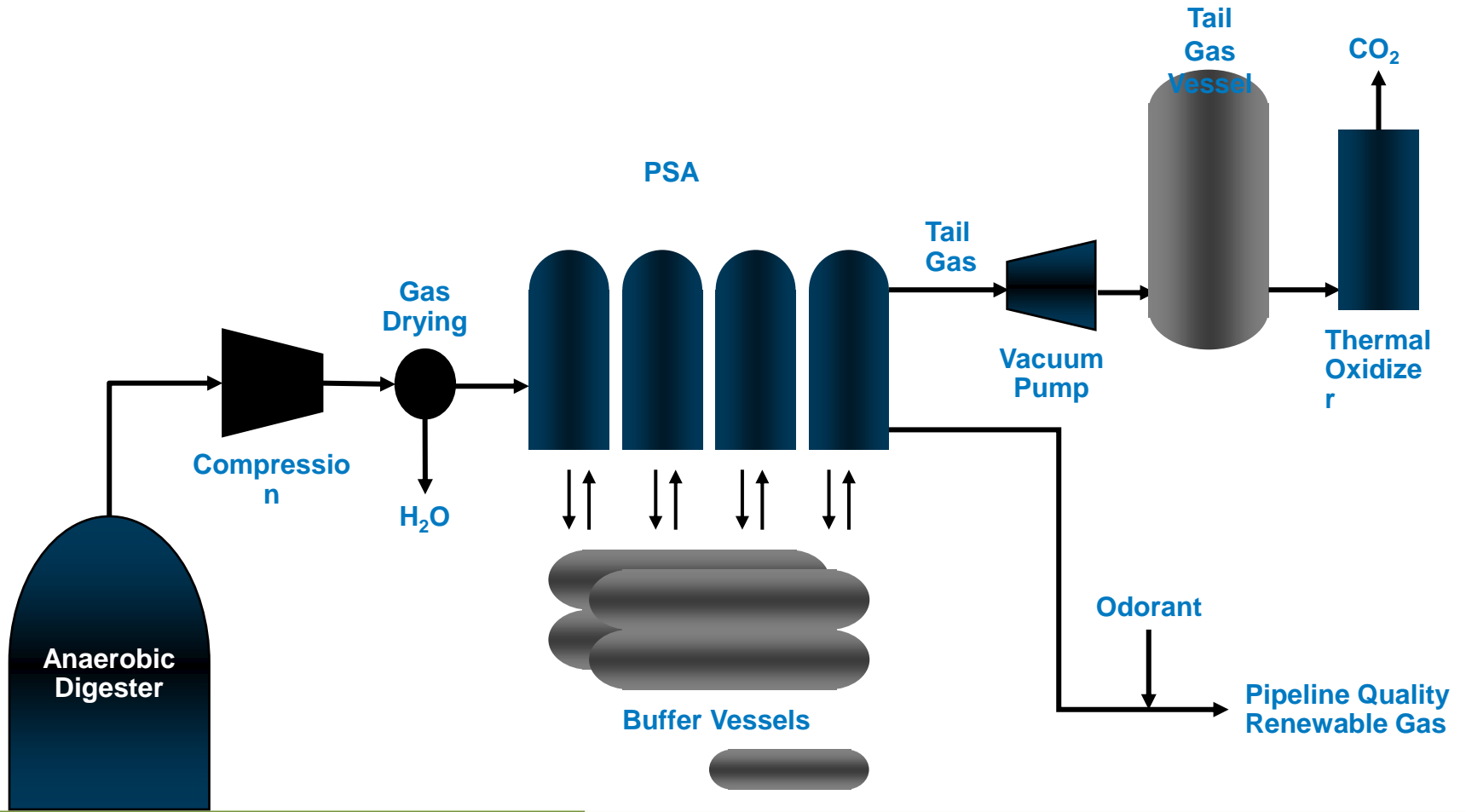
TSA: Temperature Swing Adsorption
PSA: Pressure Swing Adsorption

Courtesy of Air Liquide

Simplified Process Flow

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Net-Zero Emissions Buildings

- *“Net-Zero Emissions: A net-zero emissions building produces (or purchases) enough emissions-free RE to offset emissions from all energy used in the building”* NREL/TP-550-44586
- Enabling Technologies – Renewable Pipeline Gas + Efficient Buildings



- Infrastructure required
 - Gas and electric? Gas or Electric?
 - NRG’s CEO predicts there will be one; the gas infrastructure.
 - The gas infrastructure will also be able to transport CO₂

Conclusions

- Energy is critical to human well being
 - Direct correlation to reduction of poverty and economic growth
- Need to develop collaborative regulatory and government approaches
- Energy can be clean
 - Scale is challenge
- Natural gas utilities can play a critical role in the future
 - Net zero concept
 - Asset management expertise in a CCS world