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How to Make Renewable Natural Gas

2018 AGA-EPA RNG Workshop

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DTE Biomass Energy is a full scope developer that owns or operates 21 landfill gas to energy projects, including five renewable natural gas facilities

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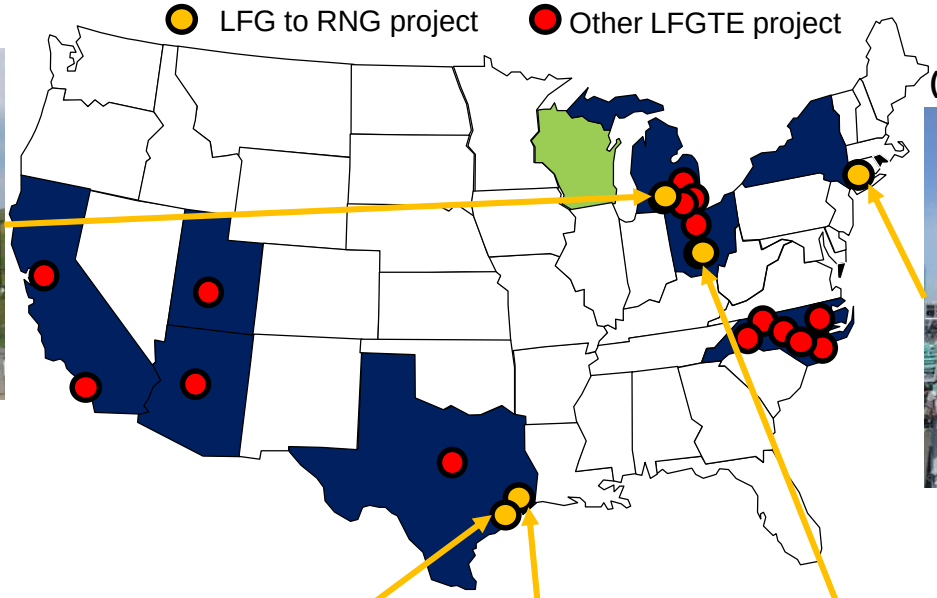
Westside (2001)



Fresh Kills (early 1980's)
(Owned by Dept. of Sanitation NYC)

Fort Bend (2014)

Seabreeze (2018)

Pinnacle (2002)

In 2019 DTEBE will be producing renewable natural gas from at least 8 dairy anaerobic digesters in Wisconsin

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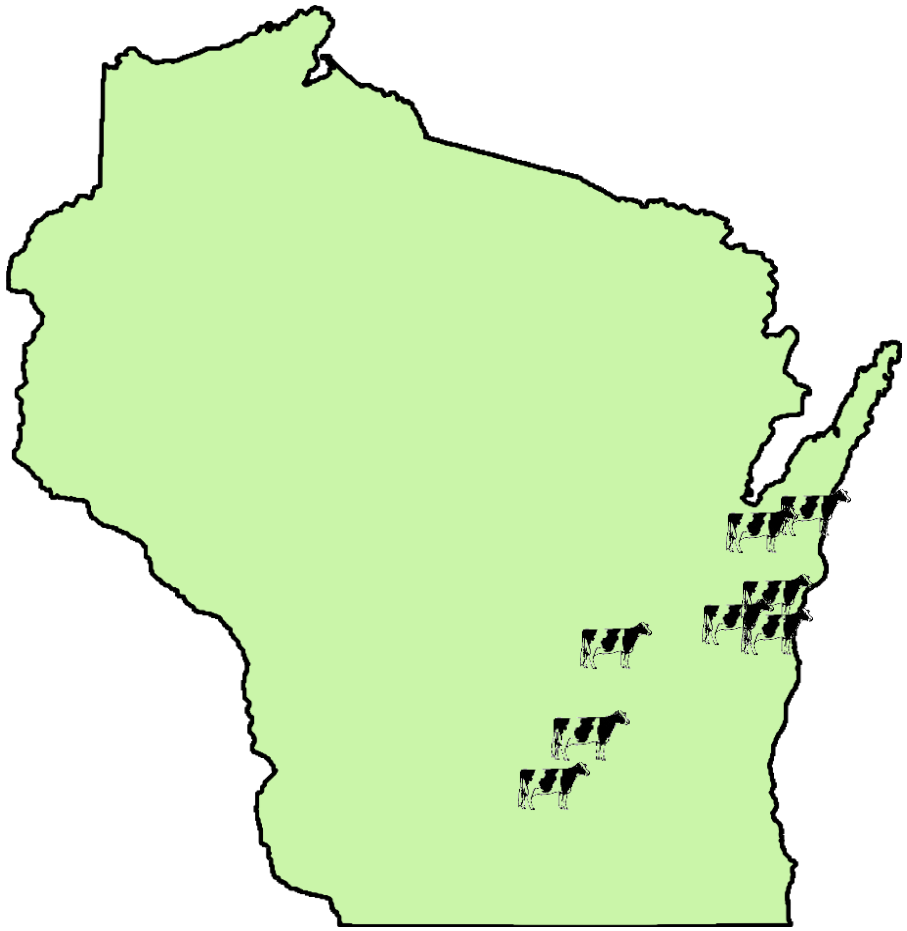

Gas will be purified using membrane technology, compressed, and either directly injected into a pipeline or transferred to a pipeline injection station via CNG trailer

Agenda

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- Choosing the right technology
- Solving contamination issues
- Problems to Avoid

The Disclaimer

- This presentation is not meant to favor one technology or a vendor
- Data presented is what I have seen as ”typical”. There are several companies making improvements to the systems described that may yield better results than shown
- Every plant, pipeline specification, and landfill is different and the configurations may need to be different from what is shown in this presentation
- Make sure to do your due diligence on any new project

Unless you are filling CNG vehicles without a pipeline, you will need to meet a pipeline specification for delivery via a NG pipeline

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Criteria	Typical Raw LFG	Manure Based Digester Gas	Pipeline Specification Range (Varies)
BTU/CF	450 to 600	520 to 630	900 to 1000
Oxygen	0.05% to 2%	Very low	Zero to 0.3%
Carbon Dioxide	40% to 55%	50% to 40%	Total inert gas no more than 3% to 7%
Nitrogen	0.5% to 14%	Very low	
Hydrogen Sulfide	5 – 5,000 PPM	1,000 - 10,000 PPM	Less than 4 PPM
Water	Fully Saturated	Fully Saturated	5 to 7 lbs/MMCF
Siloxanes	5-125 PPM	Non Detect[1]	Non detect to 4 PPM

Other Considerations: Pipeline pressure, VOC's, dust, bacteria, gas temperature, hydrogen, Wobbe Index

The largest risk any project has is not being able to make pipeline specification RNG

1. If pure manure – addition of food waste or other waste can produce siloxanes

Carbon Dioxide Removal: There are four "mainstream" competing technologies used to remove CO_2

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Membrane System	Polymer membranes with tiny "tunnels" that separate carbon dioxide from methane	
Solvent System	Vessels filled with liquid that absorbs carbon dioxide and lets methane pass through. The solvent is regenerated by releasing the carbon dioxide	
Pressure Swing Absorption (PSA)	Uses an absorbent material (molecular sieve) that separates the carbon dioxide from the methane then releases it when the pressure in the vessel changes	
Water Absorption	Uses large amounts of water to absorb the carbon dioxide, letting the methane pass through	

Typical Landfill Gas Pipeline-Quality Membrane System

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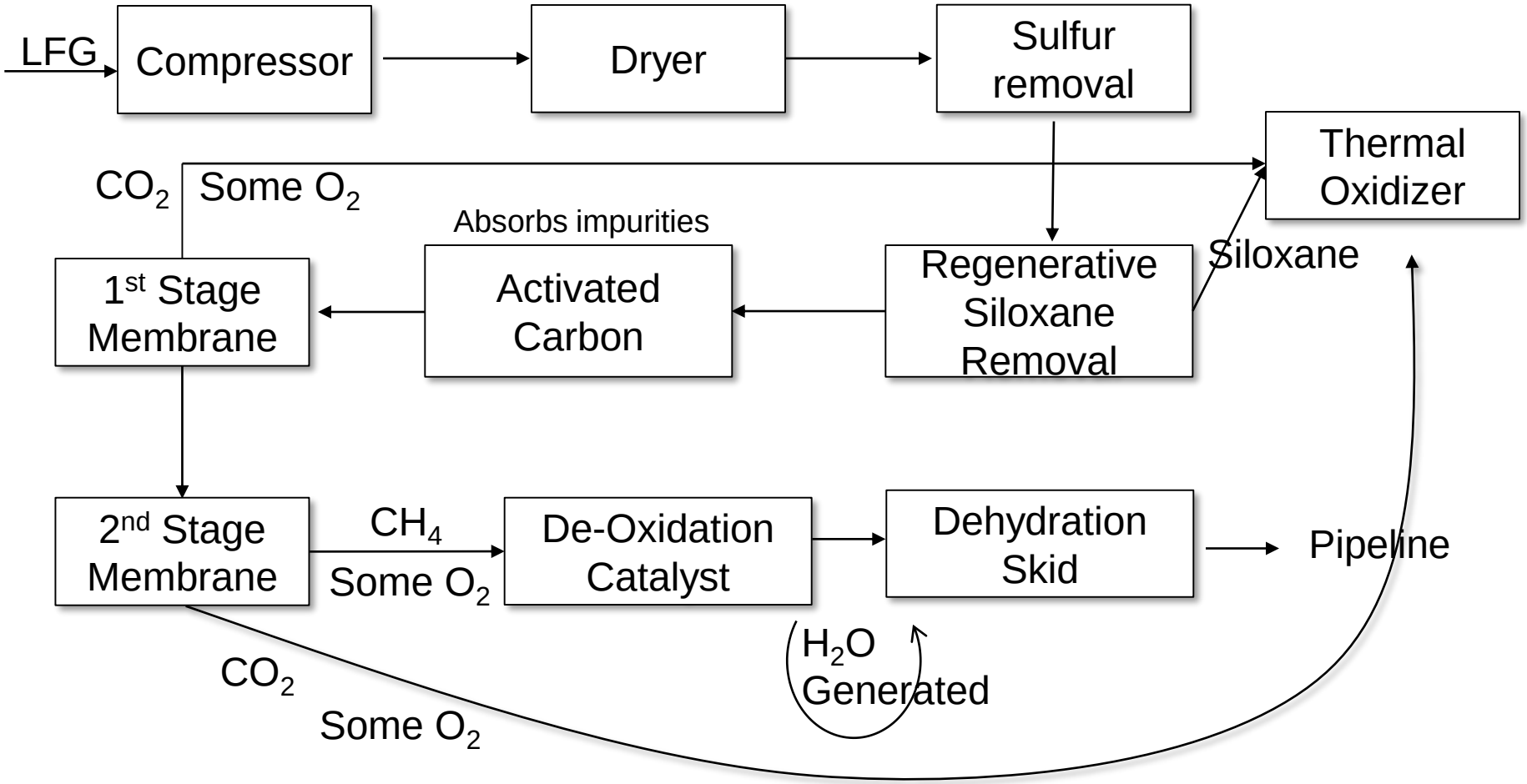


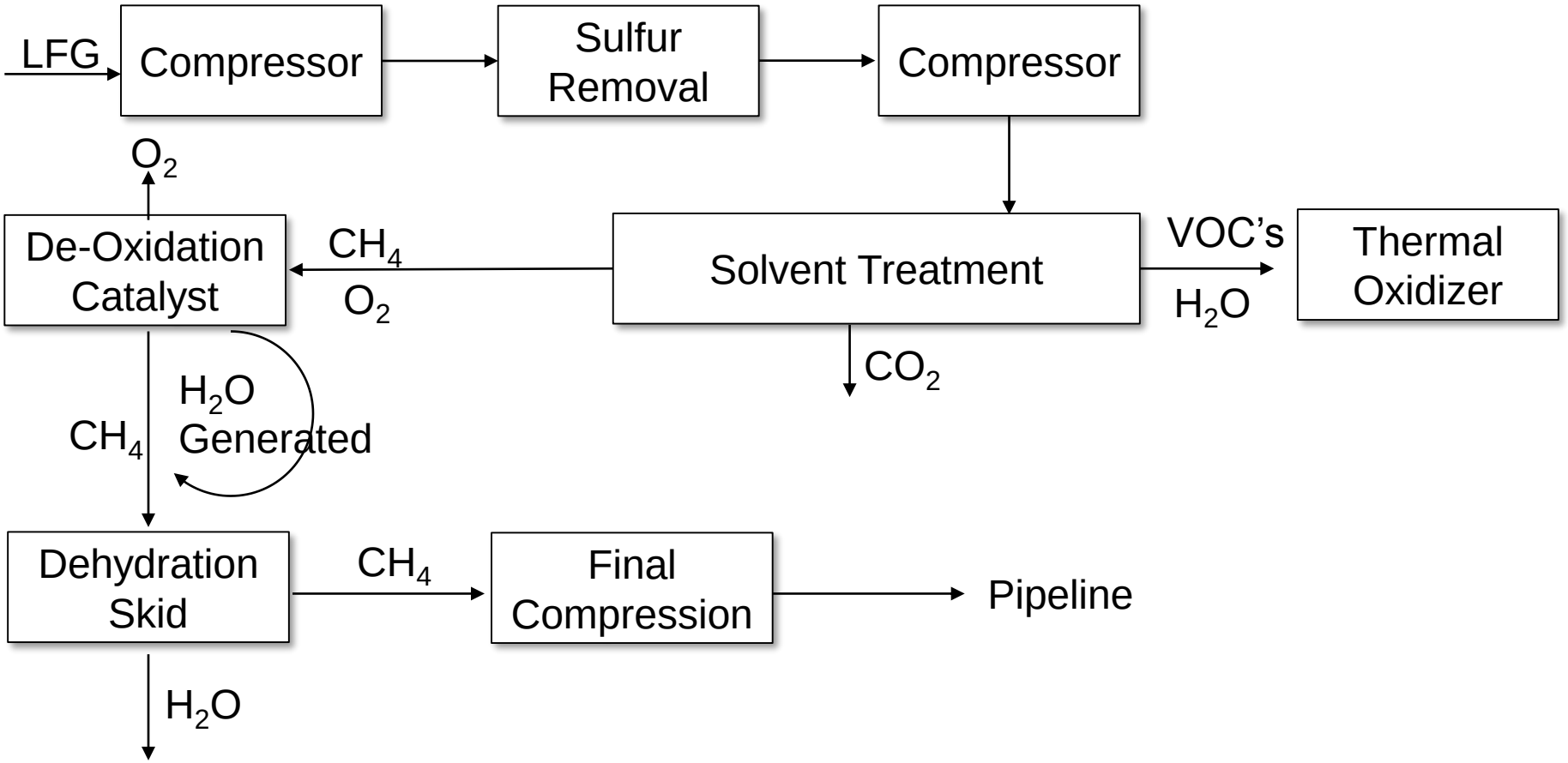
Dairy Anaerobic Digestion Membrane Plant

Pagel's Ponderosa Dairy – Casco, WI

Differences vs. LFG Plant

- No siloxanes in dairy derived AD gas (but there may be in food waste), thus no siloxane removal is needed
- Low VOC levels compared to LFG
- High H_2S levels require more treatment media or a membrane system that can strip H_2S
- Lower flows and less equipment result in a compact plant

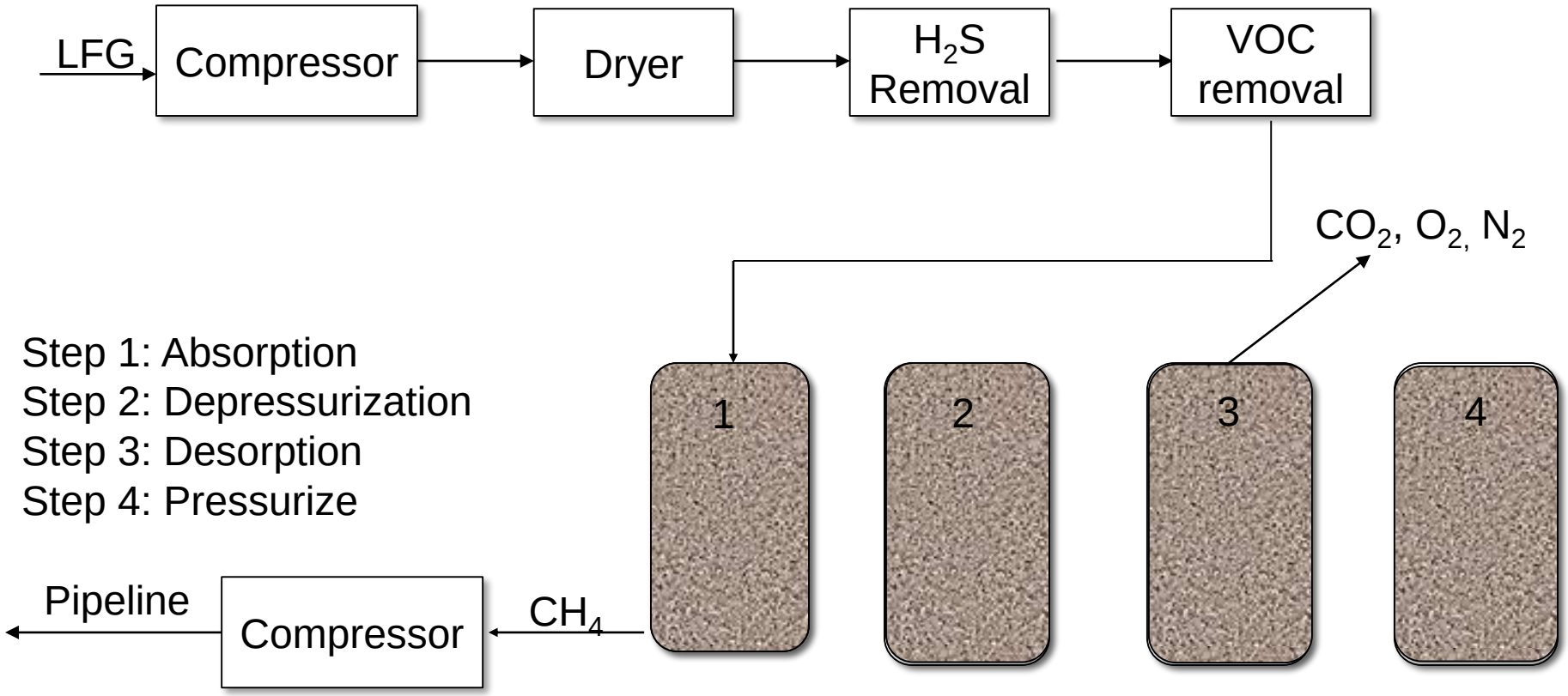
Typical Solvent System Flow Diagram



Example of a Solvent Plant[1]

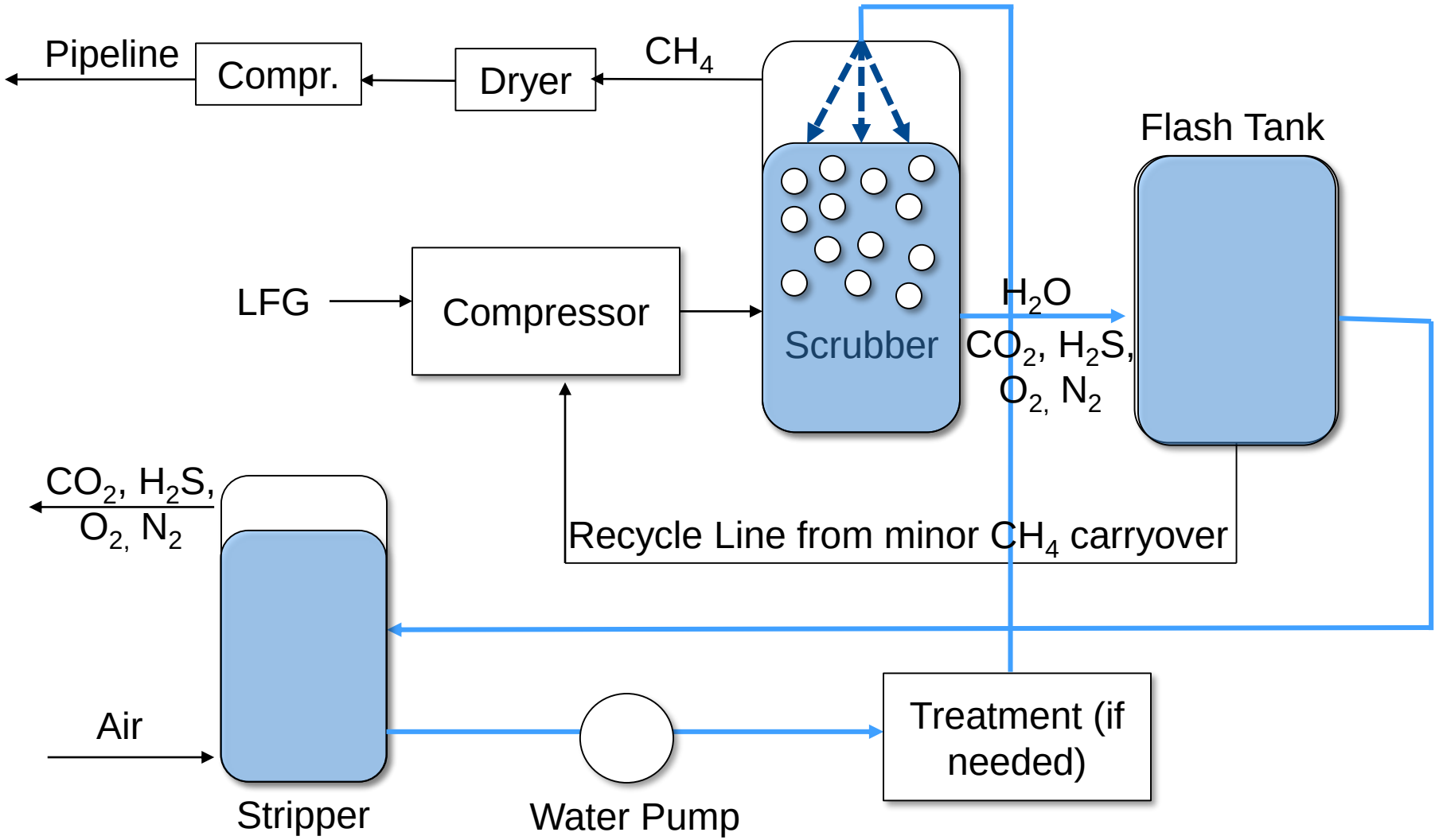
1. Rainbows require additional equipment

Pressure Swing Absorption uses media to absorb and release gases. This process is more energy intensive than others



4 Tanks each going through a stage in cycle

The water absorption process uses only water to remove the H_2S and CO_2, may require large amounts of water that may require extensive treatment



There is no one correct answer on which technology to choose – it is dependent upon your LFG gas quality, pipeline specification, and long term plans

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Tech	Advantages	Disadvantages
Membrane	• Simple "black box" technology with few moving parts other than compressors • Removes some O_2 – may help meet looser O_2 specs • Historically good on-stream rates • Easily expandable • Smaller plant footprint	• Beholden to membrane manufacturer • 94% methane recovery • Activated carbon and H2S removal are expensive • Membranes do not "like" contaminants • Separate siloxane removal system needed
Solvent	• Plant components are widely used in the oil/gas industry – spares are readily available • 98 to 99% methane recovery • Historically good on-stream rates • Typical solvent removes Siloxanes and VOC's without needing disposable media	• Expansion may require new towers and compressors • Typical Solvent does not remove any oxygen or nitrogen • Larger/taller plant footprint • Does not remove any oxygen • Because of low CH_4 loss, additional fuel needed for TOX • More things to break (pumps, vacuum blowers, etc)
PSA	• May remove other components of the gas stream, including some nitrogen and oxygen • Few moving parts other than valves and compressors	• ~95% methane recovery • Pressurization/depressurization/re-pressurization process is energy intensive • Leaky valves can create serious issues
Water Absorption	• Simple process that just uses water • ~96% methane recovery • Removes some N_2 and O_2	• Uses a lot of water – treatment of water may be costly and complicated • Large foot print with large vessels • Can only handle a certain level of N_2 and O_2 • More moving parts (pumps, valves, etc)

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Choosing the right technology

Solving contamination issues

Problems to Avoid

Siloxane removal is needed for membrane systems and potentially others. Regenerative systems are usually paired with an activated carbon polisher

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Regenerative

- High rate of siloxane removal if proper sizing and media is selected. However, it is not 99.9% effective - which is sometimes necessary to achieve
- One vessel in service while others are being purged using LFG and/or air. Often these tail gases require a flare/TOX.
- Additional electric load and compression needed, as is gas drying
- System needs to be tuned and tested for siloxane removal effectiveness

Non-regenerative

Activated Carbon

- Highly effective at removing nearly everything – including siloxanes
- Expensive if the sole means for removing siloxanes
- Other impurities, such as H2S, can reduce effective life of activated carbon that is targeting siloxane
- Free liquids can reduce effectiveness of media

Hydrogen Sulfide (H_2S) Removal

Non-NRU plants (very low O_2 in inlet gas)

Sulfur removal vessels at a Solvent plant

Typically use Sulfurtrap, Sulfatreat, Darco BG-1[1], activated carbon or similar disposable media

Can be very expensive if inlet H_2S levels are high– factor this into economics of a project

Ensure you have a backup vessel so that you are able to meet pipeline quality if media becomes exhausted

NRU Plants (moderate O_2 in inlet gas)

Iron sponge media being loaded into vessels

Can use any of the removal systems shown with non-NRU plants

May also explore using a less expensive iron-sponge media that is mounted on wood chips. This system requires low levels of oxygen, which would not be compatible with a non-NRU plant

1. Darco BG-1 requires an approximately 4:1 Oxygen/H2S ratio

An oxygen removal system is necessary if you have to hit a tight oxygen specification

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Typical system uses palladium or platinum catalyst at high temperatures

The oxygen and methane molecules react on the catalyst, form water, and strip out the oxygen from the gas stream

Dryer needed to remove water created by the process

Necessary at some sites with tight pipeline specifications, but expensive and energy intensive

Nitrogen Removal Unit (NRU)

Storage bladder for methane coming off of NRU

Typically uses pressure swing absorption technology to absorb CH_4 and let N_2 pass through and be vented/treated (other technologies than PSA exist)

Expensive to build and very energy intensive

Designed around a specific nitrogen amount and if that amount is exceeded the plant capacity rapidly drops

Methane yield drops to upper 80%'s due to methane slippage in NRU.

DTE Biomass Energy prefers to prevent nitrogen intrusion in the wellfield rather than go through the expense of removing it at the plant. However, if this is not possible, an NRU will be necessary to meet "tight" pipeline specifications

Meeting a “tight” BTU/CF pipeline specification

If your plant is falling short of a high BTU/CF pipeline specification, there are a few things you can do:

1) Fix the wellfield! Many cases where a plant fails to meet the BTU specification emanate from atmospheric intrusion into the gas collection system. **Having a well-run, low atmospheric intrusion wellfield is the most important part of a successful RNG project**

2) Expensive equipment (eg. amine unit or NRU) to remove remaining carbon dioxide or nitrogen

“Tight” pipeline specifications often create more energy usage and costs to meet the required specification. Pipeline transmission companies that offer more tolerant specifications will attract more RNG projects with stronger environmental benefits

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Producing pipeline quality gas from landfill gas is really easy to mess up…

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"Learn from past mistakes – preferably someone else's" - Fred Brooks (IBM Computer Architect)

Many projects fail due to poor quality of gas from the wellfield

- NRU's are not "bulletproof" and require moderate levels of Nitrogen
- Oxygen intrusion and poor methane quality will make RNG production near impossible regardless of technology used
- Developers frequently want control of the wellfield to ensure their tens of millions of dollars spent on the plant are not wasted. With the right developer, this can lead to continued NSPS compliance, lower electric usage (no NRU needed), and higher royalty payments (a larger pie to share)

Hire the right operations team

- Typically a very small team that has to be good at everything
- Do not be "cheap" with poor quality wellfield technicians – they are the most important component to a successful project
- Ensure you have an instrumentation and controls tech and a compressor tech
- Manager needs to be multifaceted – environmental compliance, knowledge of commercial contracts, and knowledge of both plant and welllfied are key

Pitfalls to avoid

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Metering LFG is very difficult

- Must take into account specific gravity changes, moisture content, heat, pressure, etc.
- Failure to properly place, program, calibrate, and record flow data can jeopardize creation of RIN's and LCFS

Build redundancy around media vessels and be ready for more pressure loss

- Activated carbon and sulfur removal media may be exhausted prematurely, make sure to have back-up vessels ready
- As media ages, differential pressure frequently increase. Build in additional compression capacity to take this higher differential pressure into account

Do not undersize the NRU (if needed)

- If the NRU is built for 4% nitrogen, and you experience 14% nitrogen, plant capacity could be cut in half

Feel free to contact our team with further questions

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