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Revisiting the Incremental Cost of Nitrogen Removal for Landfill Gas-to-RNG Projects

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Nitrogen Removal Historic Development

- The renewable natural gas (RNG) business began as the high-Btu business in the early-1980s
- RNG plants relied only on carbon dioxide (CO_2) removal – employing Selexol or pressure swing adsorption (PSA) technology
- Pipeline energy content limits were satisfied by holding RNG plant inlet landfill gas (LFG) nitrogen (N_2) content to the vicinity of 1.5 to 2.0 percent
- Some of the early RNG plants are still successfully operating, with their wellfields in full environmental compliance (e.g., McCarty Road, TX – since 1986)
- Refusal of wellfield operators/managers in recent years to shift from "business as usual" operation, to support lower wellfield N_2 content, has resulted in the addition of N_2 removal equipment to virtually all recent LFG RNG plants
- Project developers have acquiesced to this demand because high RNG prices have allowed projects to carry the added financial burden of N_2 removal
- With the softening of RNG prices, the wisdom of this acquiescence should be reconsidered

Nitrogen Removal Technologies

- The earliest deployment of N_2 removal was the dynamic PSA (e.g., Cedar Hills, WA – 2010)
- A drawback to the dynamic PSA was high methane (CH_4) loss -- the loss was about 15 percent
- Equilibrium PSAs currently govern the market due to a significant reduction in CH_4 loss -- the loss is in the range of 1.5 to 4 percent
- While equilibrium PSAs govern the market, one cryogenic N_2 removal unit and one membrane N_2 removal unit has been placed in service
- Currently cryogenic N_2 removal appears to fit a niche for very large projects and membrane N_2 removal fits a niche for somewhat elevated wellfield N_2
- The following presentation will be based on equilibrium PSA technology

Typical RNG Plant without N_2 Removal

- Inlet blowers and cooler
- Non-regenerative hydrogen sulfide removal
- Chilling
- LFG compression
- Membrane CO_2 removal
- Thermal oxidizer
- Off-specification gas flare
- Product gas compression
- Principal equipment in a building

Typical RNG Plant with N_2 Removal

- Inlet blowers and cooler
- Non-regenerative hydrogen sulfide removal
- Chilling
- LFG compression
- Membrane CO_2 removal
- PSA N_2 removal system (PSA vessels, valve skid, vacuum compressors, recycle compressors and equalization vessels)
- Thermal oxidizer
- Off-specification gas flare
- Product gas compression
- Principal equipment in a building

What Financial Benefits Arise from Elimination of Nitrogen Removal?

- The capital cost of the N_2 removal system, including all of its support (power supply, larger building, etc.) is eliminated
- Power consumption decreases
- CH_4 recovery increases
- The entire "front end" of the RNG plant is downsized because of a reduction in inlet LFG flow rate, as a result of the elimination of the processing of inert gas all of the way through to the inlet of the N_2 PSA system

Where a Disadvantage Arises

- When a wellfield is retuned to lower N_2 from a "normal" level of N_2 (say 8 to 10 percent), to the level required to avoid an N2 removal system, the amount of LFG recovered from the landfill decreases
- The inlet LFG N_2 level required is a function of the pipeline's energy content (Btu) specification. The lower the allowed Btu content, the higher the RNG plant inlet LFG N_2 content which can be tolerated
- To the author's knowledge, this lost CH_4 has not proven to be a surface emissions regulatory problem at sites without N_2 removal; perhaps, due to a soil cover's ability to attenuate CH_4 and volatile organic compound emissions
- A decrease in LFG recovery in the vicinity of 25 percent, on a CH_4 flow basis, can be expected when conversion of a wellfield from "normal" to a "high Btu" mode of operation is made
- The decrease will occur even after improving the wellfield's well density
- A project without N_2 removal will generate a higher internal rate of return, but probably a lower net cash flow, depending on RNG price and RNG plant size

Basis of Comparison

- Very rough cost and performance comparisons were run on a 4,000 scfm RNG plant – with and without N_2 removal
- The cost and performance of a 2,800 scfm plant was also estimated to account for the likely "haircut" in LFG recovery associated with conversion from "normal" wellfield to "high-Btu" wellfield operation
- As a side note, SCS Engineers has a proprietary LFG recovery model that accounts for LFG recovery both in the "normal" wellfield operation mode and in the "high-Btu" wellfield operation mode

Comparison of Alternatives

	4,000 scfm with N_2 Removal	4,000 scfm without N_2 Removal	2,800 scfm without N_2 Removal
Construction Cost	$30,000,000	$19,000,000	$16,000,000
Power Consumption	3,600 kW	2,800 kW	1,900 kW
Percent CH_4 Recovery	94%	96%	96%
Product Gas (mmBtu/year)	975,000	995,000	740,000

Notes:

1. Typical LFG and pipeline quality gas specifications.
2. Costs and performance are indicative and are based on several assumptions. SCS Energy can provide project specific evaluations.
3. Column 2 assumes that additional LFG will be sourced (e.g., by increased LFG flow over time) to offset the methane lost by wellfield retuning. Column 2 was prepared primarily to quantify the incremental cost of nitrogen removal.

Conclusions

- The financial burden of including nitrogen removal in LFG RNG projects is significant; however, improvements in methane recovery and in power consumption, over the last decade, have mitigated the financial burden
- At 4,000 scfm, elimination of nitrogen removal offers a risk mitigation strategy for RNG price uncertainty, since this improves payback and debt/investment coverage. Net revenue is decreased, however, because a smaller RNG plant is built, due to a reduction in the available LFG
- At 4,000 scfm, about 37 percent of the construction cost and about 22 percent of the power consumption is tied up in nitrogen removal
- RNG plant construction costs suffer from economy of scale as capacity drops below 4,000 scfm, and disproportionally so for nitrogen removal. The attractiveness of eliminating nitrogen removal increases significantly at smaller RNG plant sizes. At some size, elimination of nitrogen removal becomes a necessity

About SCS Energy

- SCS Energy has completed, or currently has underway, the design or design/construction of 10 LFG RNG plants with an aggregated capacity of 41,000 scfm. SCS Energy's first RNG plant was completed in 2009.
- SCS Energy has completed, or currently has underway, the design or design/construction of 15 digester gas (DG) RNG plants with an aggregated capacity of 28,000, including the first municipal WWTP DG and the first dairy DG project to meet SoCalGas Rule 30 pipeline standards. SCS Energy's first DG RNG plant was completed in 2012.
- SCS Energy has operated seven RNG plants, on a contract basis, for as long as 11 years
- SCS Energy is currently designing/constructing two CO_2 removal (only) LFG RNG plants and recently completed design/construction of another CO_2 removal (only) LFG RNG plant