

RNG WORKS



An Approach to Meeting Stringent Siloxane Standards

Evan Williams
President
Cambrian Energy



Overview

- ▶ What are Siloxanes and where do they come from?
- ▶ Why and under what circumstances are they a problem?
- ▶ What was the journey in California that gave rise to the adoption of a siloxane standard?
- ▶ Siloxanes Studies and Results
- ▶ This ain't that
- ▶ Are California pipelines and waste streams unique?
- ▶ California ain't Las Vegas
- ▶ Increase in Receptivity to RNG by California natural gas utilities
- ▶ An approach to a siloxane solution that facilitates RNG project investment and financing

What are Siloxanes and where do they come from?

- ▶ Any of a class of compounds having a short repeating unit of silicon and oxygen atoms (either in a chain or a ring) with organic side chains
- ▶ Widely used in household and commercial products
 - ▶ Washing agents
 - ▶ Cosmetics
 - ▶ Shampoo
 - ▶ Skin care products
 - ▶ Silicone oils
 - ▶ Lubricants
 - ▶ Waterproofing materials
 - ▶ Shoe Cream
 - ▶ Car wax
 - ▶ Agents used in food processing and directly applied to food

Are siloxanes harmful to humans or to natural gas pipelines?

▶ NO

- ▶ Utilities have expressed concern about the adverse effect of siloxanes when combusted in customers end-use equipment

How are siloxanes introduced into landfill gas or wastewater treatment plant biogas?

- ▶ Through the waste stream
- ▶ Introduced into landfill gas or biogas when siloxanes in waste are volatilized through the anaerobic digestion process

Why are siloxanes a problem?

- ▶ When combusted they form silicon dioxide, basically sand
- ▶ Problem for internal combustion engines since sand causes increased wear
- ▶ Problem for catalytic systems, such as in fuel cells or in catalytic systems sometimes used as emission control devices on engines, since sand will coat and render inoperative the catalyst
- ▶ Only demonstrated problems for siloxanes have been from **unprocessed** landfill gas and biogas fueling electric power projects
 - ▶ Problem with engine wear and poisoning of SCR catalysts
- ▶ **No evidence of any problems caused by siloxanes with RNG projects**

When did the journey in California begin that gave rise to the restrictive maximum allowable siloxane pipeline injection standard that has been adopted for RNG?

▶ 1988

Since it involved California, did it have a Hollywood beginning?



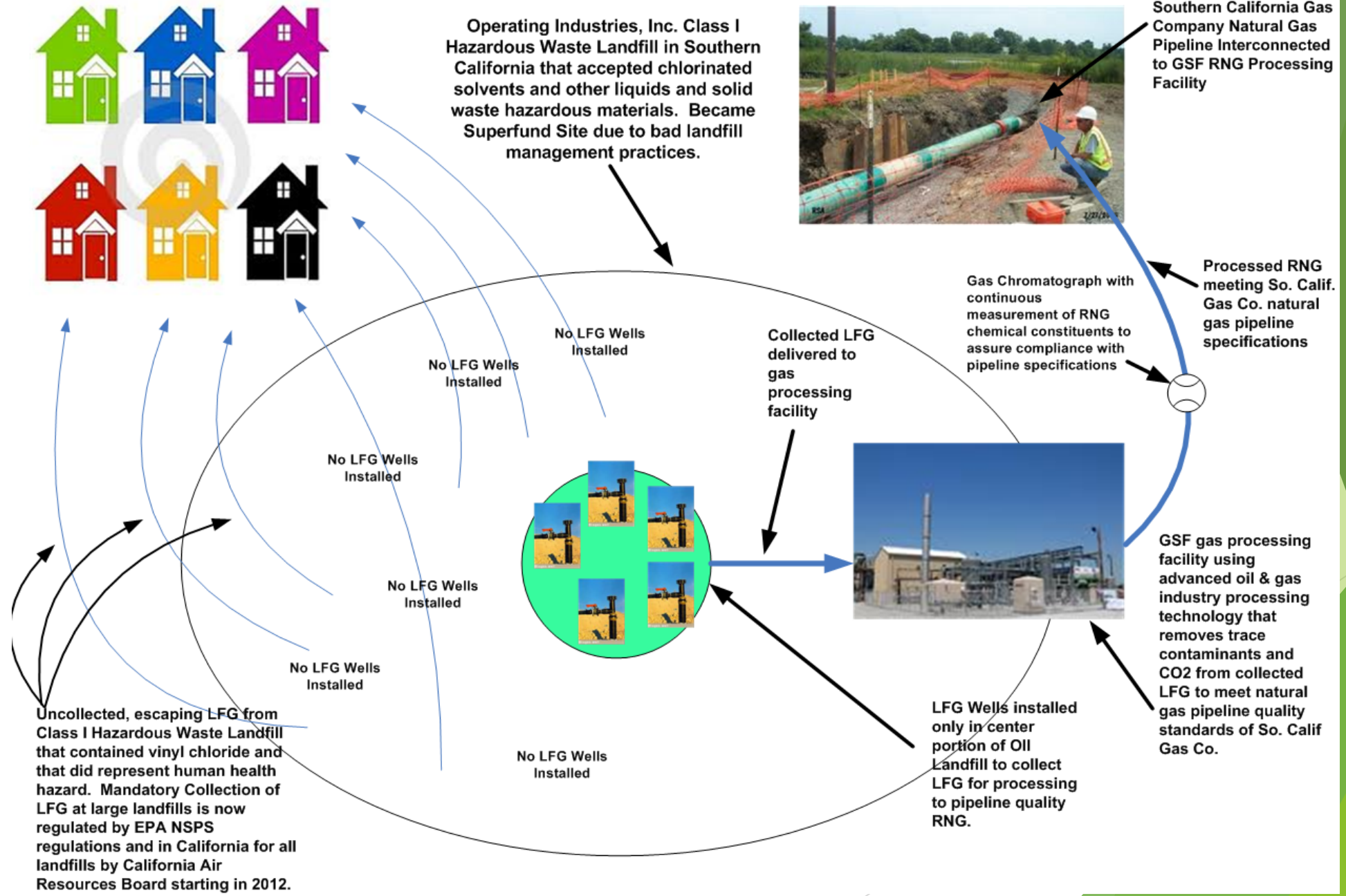
**Assembly
Member
Tom
Hayden**

**Actress
Wife
Jane Fonda**

So what happened in 1988?

- ▶ California adopted into law California Health & Safety Code Section 25421 sponsored by Assembly Member Tom Hayden, a bill that became known as the 'Hayden Amendment'
- ▶ What were the facts that gave rise to the Hayden Amendment?

Hayden Amendment (Calif. Health & Safety Code Sections 25420 & 25421) Factual Circumstances



What was the Hayden Amendment intended to regulate in Biomethane or RNG?

Why did it regulate the wrong thing?

- ▶ Intended to restrict presence of vinyl chloride, a known carcinogen
- ▶ Problem at the landfill was with **uncollected** landfill gas escaping into nearby homes that contained vinyl chloride, but Hayden Amendment regulated landfill gas that was **collected and processed** before being introduced into a natural gas pipeline
- ▶ Battelle Pacific Northwest Laboratories released study in 1988 timeframe concluding that vinyl chloride was likely **produced in landfills by microbial action on chlorinated solvents**
 - ▶ The only landfills into which chlorinated solvents could be legally disposed were **hazardous waste landfills**, such as the Operating Industries Landfill in Southern California from which the escaping landfill gas gave rise to adoption of the Hayden Amendment

Why were Hayden Amendment scope and penalties overkill? What resulted?

- ▶ Hayden Amendment applied to all landfills and not just hazardous waste landfills
- ▶ Hayden Amendment imposed criminal penalties not only on the producer of RNG derived from landfill gas that exceeded the maximum allowable concentration of vinyl chloride but also on the natural gas pipeline that accepted such RNG
- ▶ All California pipelines amended their tariffs to prohibit the introduction of landfill gas and landfill gas-derived fuels into their pipelines, even though the technical standard established for vinyl chloride could easily have been achieved

What was California's AB 1900 intended to accomplish?

- ▶ Adopted in 2012 and sponsored by the Coalition for Renewable Natural Gas, its intent was to repeal and rewrite Health and Safety Code Section 25421 (the Hayden Amendment)
- ▶ Goal was to promote the production and utilization of RNG from a variety of sources

What obstacles to RNG projects in California existed from 2012 through 2020 that have since been resolved?

▶ **Minimum Heating Value:**

- ▶ SB 840
- ▶ Rule 30 natural gas pipeline injection minimum heating value of 990 btus/scf, an issue for RNG, was resolved by SB 840 study completed by California Council on Science and Technology with recommended minimum heating of 970 btus/scf

▶ **High Costs of Pipeline Interconnection:**

- ▶ AB 3187 (companion bill to SB 1440) and SB 1383
- ▶ Costs of pipeline extensions from RNG project and metering station and other costs of interconnection all or in part to be paid by utility and included in its rate base

When and how did siloxanes become an included constituent for RNG in California pipeline injection standards?

- ▶ 2 years of hearings through several California agencies after passage of AB 1900
- ▶ During hearings California natural gas pipeline utilities requested the adoption of a siloxane standard of 0.1 mg Si/m³.
- ▶ Utilities provided **no empirical data** as to siloxanes presenting a problem caused by RNG injected into a natural gas pipeline or why the siloxane concentration at that level was needed
- ▶ RNG industry, through the Coalition for Renewable Natural Gas, was not opposed to a siloxane standard, but stated one was not needed, but if established, should be at a measurable and reasonably achievable level of 2.5 mg Si/m³.
- ▶ CPUC Order was issued in January 2014, pursuant to AB 1900 proceedings, that adopted the unilateral request of the California natural gas pipeline utilities and added the requested 0.1 mg Si/M³ maximum allowable concentration of siloxanes to the pipeline injection of RNG tariff.

In December 2015 at RNG Conference of Coalition for RNG request made of RNG industry by Commissioner Carla Peterman of CPUC

- ▶ She noted that no new RNG projects had been initiated in California in the nearly two years since the CPUC Order was issued on January 22, 2014
- ▶ Commissioner Peterman: “Perhaps we didn’t get things right in the 2014 Order, so please provide the CPUC with information as to what you feel needs to be changed and support it with documentation and data.”
- ▶ March 11, 2016 Coalition for Renewable Natural Gas filed with the CPUC, in response to Commissioner Peterman’s request, a 479 page document entitled: ***“Revisiting CPUC AB 1900 Biomethane Pipeline Injection Regulations to Remove Barriers Preventing Biomethane Project Development in California.”***
 - ▶ If interested, ask to receive a link to download this filing with the CPUC
- ▶ Filing included a long section on siloxane standard adopted and discussion of industry evidence that siloxanes from RNG had created no problems for either pipelines or downstream customers and where siloxane standards did exist, they were at much higher concentrations of siloxanes than adopted by California.



May 12, 2012 Gas Technology Institute *Guidance Document for the Introduction of Landfill-Derived Renewable Gas into Natural Gas Pipelines*

- ▶ Guidance Document set forth results of a study by GTI of biomethane (RNG) from 8 operating RNG projects located throughout the U.S.
- ▶ Multiple samples taken throughout the year from each project that were then analyzed in GTI lab for constituents, including siloxanes
- ▶ Result from report for siloxanes on Page 2 of such report: “Siloxane was below detectable levels in 22 of 27 samples and ranged from 0.1 to 0.4 mg Si/m³ in 5 of the 27 samples. The only species found was D4 (octamethylcyclotetrasiloxane)”

Exhibit 1 to 2016 Coalition Filing with CPUC was a table of all 50 operating RNG projects in U.S., identified by name, pipeline into which injected, minimum heating value standard and maximum allowable siloxane standard, if any

- ▶ Of the 50 RNG projects listed, **none** of the projects that were injecting RNG into a pipeline **was required to meet a siloxane standard**
- ▶ Those projects that did take into account a siloxane standard were delivering RNG for direct fueling of CNG vehicles, and the siloxane standard accommodated was the engine warranty fuel standard of no greater than 12 mg Si/m³ established by Cummins Westport for its natural gas engines

Letter from Atmos Pipeline-Texas, the largest intrastate pipeline in Texas, that has been accepting RNG from the McCommas Bluff Landfill RNG project, the largest producing project in U.S., since 1999



2016 Coalition Filing with CPUC re Common Equipment Maximum Allowable Siloxane Standards for engines commonly fueled by **raw** landfill gas or biogas

| Engine Manufacturer | Siloxane (mg/m ³) Maximum Limit | Multiple of PUC Biomethane Implementation Decision Lower Action Level Siloxane Concentration Limit (x) |
|---|---|--|
| Caterpillar | 10.6 | 106x |
| Waukesha | 25 | 250x |
| Jenbacher | 20 | 200x |
| MWM (formerly Deutz) | 5 | 50x |
| Solar Turbines - unrecuperated turbines | 10 | 100x |
| Solar Turbines - recuperated Mercury 50 turbine | 5 | 50x |
| Vehicle Fuel (Cummins Westport) | 11.43 | 114x |
| IR Microturbines | 0.06 | .6x |
| Capstone Microturbines | 0.03 | .3x |

The gas delivered from this...



Isn't the same as the gas delivered from this...



What are the practical problems that arise from the 0.1 mg Si/m³ maximum allowable concentration in RNG in California?

- ▶ RNG Developers, processing equipment vendors, equity investors and lenders view current sampling and lab testing techniques for siloxanes in RNG at 0.1 mg Si/m³ concentration as neither accurate, reliable nor repeatable
- ▶ At this level, errors in analytical results can result from **sampling errors**
 - ▶ Pure nitrogen sample sent to a lab for analysis by a siloxane measurement equipment manufacturer showed results of high concentrations of siloxanes
 - ▶ Reason: lubricant used to seal sample bag had silicon which volatilized into sample
- ▶ Commercial suppliers of biogas and landfill gas processing equipment and siloxane removal equipment are unwilling to provide equipment performance guarantees at such a low concentration of siloxane

What is the Consequence if any pipeline injection standard for RNG is not met?

- ▶ RNG is shut out of the pipeline
- ▶ All revenue is lost

With existing California siloxane standard, neither Equity Investors nor Project Finance Lenders will “Show Me the Money”

- ▶ Risk is viewed as too high for loss of revenue where siloxane pipeline standard is so low that measurement of siloxane concentration is neither reliable nor results repeatable
- ▶ Unwillingness of equipment suppliers to provide performance guarantee of siloxane removal to meet 0.1 mg Si/m³ concentration with affordable operating expenses represents too high a risk for both equity investors and project finance lenders
 - ▶ The Financial Community requires **certainty of technical outcome** --- not a Crapshoot!
- ▶ No Money = No Projects

If SB 840 was intended to resolve both the Minimum Heating Value and Siloxanes barriers to RNG development in California, what happened?

- ▶ **Minimum Heating Value:** the California Council on Science and Technology (through Stanford University) recommend to the CPUC that the minimum heating value for RNG injected into California pipelines be reduced to 970 btus/scf, a standard that the CPUC adopted
- ▶ **Siloxanes:** The CCST stated that there was insufficient evidence for it to recommend a change to the 0.1 mg Si/m³ maximum allowable concentration for injection of RNG into California pipelines.
- ▶ **Result:** the siloxane barrier to California RNG project development continues
- ▶ What does this mean outside of California?

California Ain't Las Vegas

- ▶ Unfortunately, what happens in California doesn't stay in California
 - ▶ One of California's largest exports --- Regulations
 - ▶ An exception being the Hayden Amendment
- ▶ Other natural gas pipelines have looked to Rule 30 RNG injection standards as instructive

Increase in Receptivity to RNG by California natural gas utilities - California's passage of SB 100

- ▶ SB 100 provides that no fossil fuel will be used to generate electric power in California by 2045
- ▶ Today, 45% of natural gas, a fossil fuel, is used to generate electric power in California
- ▶ Connecting the dots: unless a renewable substitute fuel can be found to replace natural gas, Southern California Gas Company, the largest natural gas distribution company in the United States, will be nearly one-half its size by 2045
- ▶ In 2019 SoCalGas announced that it intends to become the “cleanest” natural gas utility in the U.S., strongly supports RNG, and has included that as a commitment to the shareholders of Sempra, its parent company
 - ▶ **Announced Goals:** 5% of its gas will be renewable by 2022 and 20% of its gas will be renewable by 2030
 - ▶ Using 2017 SoCalGas gas sales of 300.55 BCF, 5% goal would be 15.03 Bcf by 2022 & 20% goal would be 60.11 Bcf by 2030
 - ▶ In 2019 McCommas Bluff project was producing approximately 2.37 Bcf of RNG per year
- ▶ So, to meet announced RNG goals, SoCalGas would have to purchase full RNG output of 6.33 McCommas Bluff size projects by 2022 and 25.34 McCommas Bluff size projects by 2030.

What challenges does SoCalGas face to achieving its announced goals

- ▶ Provisions of California's AB 2196, passed at same time as AB 1900, reduces the value of out-of-state RNG used to produce renewable electric power for meeting California electric utility Renewable Portfolio Standard requirements
- ▶ Non-California natural gas pipeline utilities have established voluntary RNG goals since they see risk of an SB 100 being passed in their states, so there will be competition for out-of-state RNG
- ▶ Procurement of RNG from California projects presents highest likelihood for SoCalGas and other California natural gas pipelines to meet their RNG procurement goals

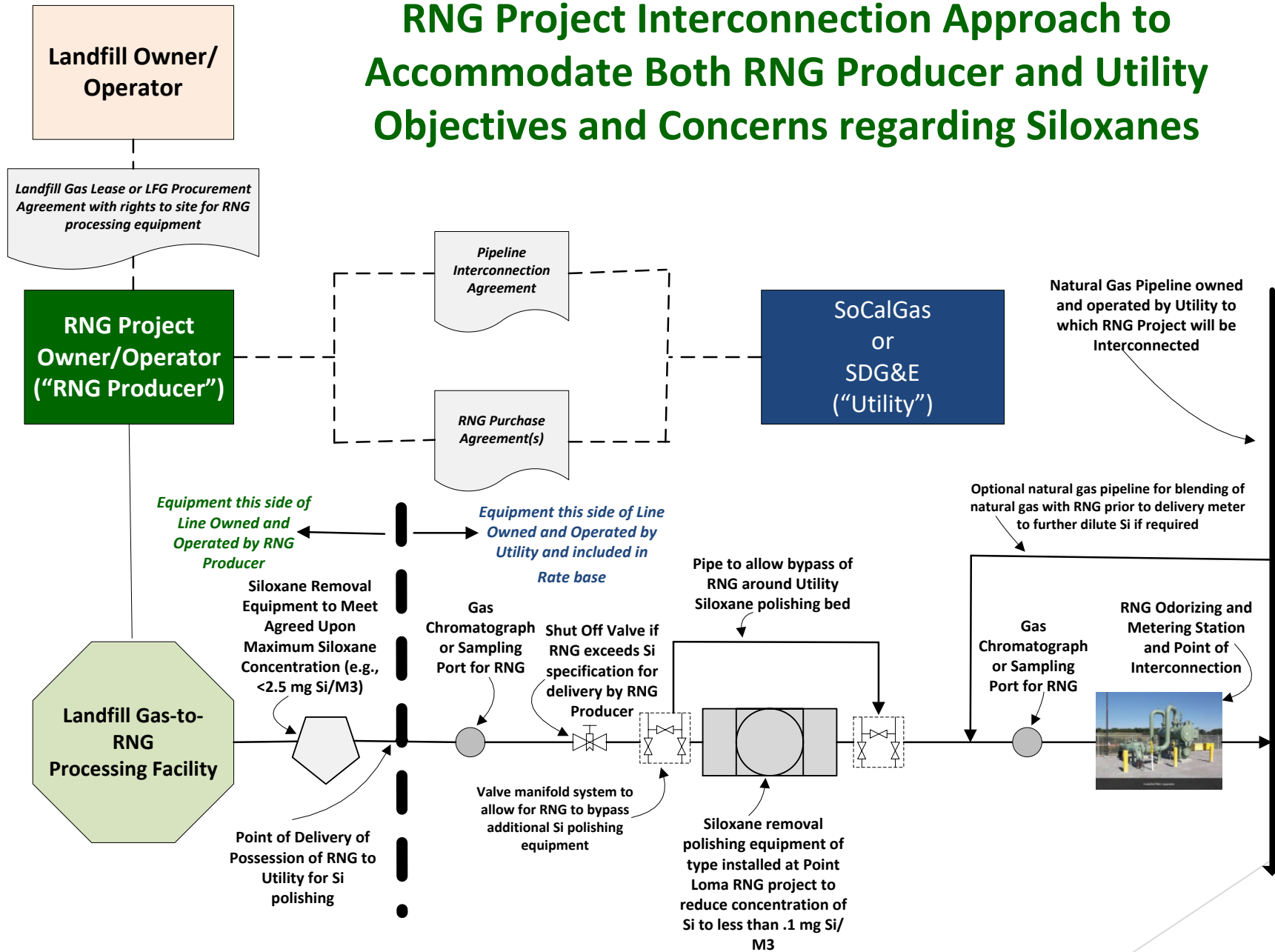
Why is new approach needed for California Natural Gas Utilities to participate in California RNG Pilot Projects with Relationships that Solve for Stringent Siloxane Standard Left Unchanged by CCST Study under SB 840?

- ▶ CCST left unchanged the 0.1 mg Si/m³ maximum allowable concentration for injection of RNG into California pipeline
- ▶ CCST stated more information is needed in order to change such standard
- ▶ California natural gas utilities have argued that **California's natural gas pipelines** and apparently the **waste streams** that go into landfills and WWTPs are **unique**
- ▶ **Conclusion:** Only information regarding concentration of siloxanes contained in **RNG produced and collected at California landfills and WWTPs** could provide relevant data to inform decision makers about changing siloxane standard
- ▶ **Current Financing Roadblock:** If RNG developers are required to meet existing Rule 30 siloxane standard, they may be unable to attract equity and debt capital required to construct and operate California RNG projects
- ▶ So.....how does this conundrum get solved?

Approach Suggested for Establishment of California RNG Pilot Projects Proposed to California Utilities with Unique Solution to Solving for Meeting Siloxane Standard and Allowing Investment in and Financing of RNG Projects to occur



RNG Project Interconnection Approach to Accommodate Both RNG Producer and Utility Objectives and Concerns regarding Siloxanes



Key Elements of California RNG Pilot Project Proposal as to **RNG Producer Duties**

- ▶ At RNG Producer's cost, design, install, finance and operate an RNG production facility using landfill gas, digester gas or biogas from other California organic resources
- ▶ Deliver RNG meeting all of the maximum allowable constituent requirements included in Rule 30 for Sempra Utilities or Rule 21 for PG&E other than siloxanes
- ▶ Deliver RNG to the pipeline utility at the RNG Processing Point of Delivery having a **maximum allowable siloxane content of 2.5 mg Si/m³**

Key Elements of California RNG Pilot Project Proposal as to Natural Gas Pipeline Utility Duties

- ▶ Design construct and operate Siloxane Polishing Equipment to remove siloxanes from RNG received from RNG Producer to 0.1 mg Si/m³ or less
 - ▶ Equipment would be the same activated carbon bed as was installed and is being operated at the Point Loma WWPT RNG project in San Diego
- ▶ Agree with RNG Producer to provide siloxane processing service to RNG Producer after its receipt of RNG that meets pipeline tariff standards for all constituents other than siloxanes and with a siloxane concentration of no greater than 2.5 mg Si/m³ at the RNG Processing Point of Delivery, process it to a concentration of no greater than 0.1 mg Si/m³ and, on behalf of the RNG Producer deliver such processed RNG to the point of interconnection with the natural gas pipeline
- ▶ Capital and Operating Expenses for providing siloxane processing service would be included in rate base of natural gas utility

Objectives Realized by Suggested Approach

- ▶ **RNG Producer:** The commitment by a California natural gas pipeline utility to install and operate Siloxane Polishing Equipment and to process the RNG it receives to meet the 0.1 mg Si/m³ maximum concentration of siloxanes will allow for equity investment and debt financing of California RNG projects
 - ▶ The risks of unreliable and unrepeatable measurement of low siloxane concentrations would now be transferred to the California pipeline utility
- ▶ **California Pipeline Utility:**
 - ▶ The California natural gas pipeline utilities would be able to introduce California-produced RNG into their pipelines to meet announced goals
 - ▶ This will facilitate California utilities to acquire RNG needed to replace natural gas demand that will be lost over time due to SB 100

Thanks for Listening!

- ▶ **Evan Williams**
- ▶ **President**
- ▶ **Cambrian Energy**
- ▶ (213) 628-8312
- ▶ evan@cambrianenergy.com

