

**STATE OF VERMONT
PUBLIC UTILITIES COMMISSION**

Case No. 24-3359-INV

Investigation of the standard-offer contract)
Between Vermont Renewable Gas, LLC and)
the Standard Offer Facilitator)
)

PREFILED TESTIMONY OF
ALEXANDER SKOROKHODOV
ON BEHALF OF

VERMONT RENEWABLE GAS, LLC

Summary of Testimony

Mr. Skorokhodov's testimony addresses Questions 2 through 5 in the Information Request directed to Vermont Renewable Gas, LLC in the Vermont Public Utility Commission's Order Opening an Investigation of the Standard-Offer Contract (Case No. 24-2797-PET and Case No. 24-3359-INV).

EXHIBIT LIST

Ex. VRG-INV-AS-0	Alexander Skorokhodov Resume
Ex. VRG-INV-AS-1	HTAP Fuel Gas Specifications
Ex. VRG-INV-AS-2	Wood Waste and Anaerobic Digestion
Ex. VRG-INV-AS-3	Digester Gas Composition
Ex. VRG-INV-AS-4	Comparison of Conversion Efficiencies
Ex. VRG-INV-AS-5	Recovery Efficiencies
Ex. VRG-INV-AS-6	HTAP Full Specifications

1 **Q1: Please state your name and position relative to this matter.**

2 A1: My name is Alexander Skorokhodov. I am Director of Technology and Engineering for
3 Clean Energy Technologies, Inc. (CETY), a NASDAQ publicly traded company on the
4 New York Stock Exchange. CETY's wholly owned subsidiary CETY Capital, LLC is a
5 minority owner in Vermont Renewable Gas, LLC ("VRG"), a Vermont limited liability
6 company with its principal place of business at 145 Pine Haven Shores #1000A
7 Shelburne, Vermont 05482. CETY is also serving as project Engineering, Procurement,
8 and Construction (EPC) contractor for the biogas production facility and related 2.2 MW
9 electric generation facility to be known as Vermont Renewable Gas – Lyndon in Lyndon
10 Vermont proposed in Case No. 24-2797-PET ("the Project").

11 CETY designs, builds, and markets renewable energy and energy efficient
12 solutions. We offer a suite of zero emission heat recovery solutions, combined heat to
13 power, and biomass energy products. As Director of Technology and Engineering for
14 CETY, I lead the CETY Renewables Division. In this capacity I lead engineering and
15 development of the Project and my team will oversee construction and commissioning of
16 the Project. We will also perform long-term service and maintenance of the facility
17 equipment.

18

19 **Q2: Please describe your qualifications and experience.**

20 A2: I am a graduate of Moscow Aviation University where I earned a degree in automated
21 control systems engineering. I also hold a Masters of Business Administration in

1 International Business from Antwerp University's School of Management. I am an
2 inventor and developer of CETY's High Temperature Ablative Pyrolysis (HTAP)
3 renewable fuel gas technology. Over 18 years, I have developed and implemented more
4 than 250 onsite power generation projects for major energy and industrial customers. To
5 date I have developed 6 projects in Europe which rely on the HTAP technology to be
6 used at VRG's Lyndon site. My resume is attached as **Exhibit VRG-INV-AS-0**.

7

8 **Q3: What is the purpose of this Testimony?**

9 A3: My testimony seeks to provide detailed, expert responses concerning Information
10 Requests numbered 2 through 5 asked by the Vermont Public Utilities Commission in its
11 Order dated November 7, 2024 in this matter. Please see the testimony of Evan Dell'Olio
12 concerning agriculturally derived feedstocks associated with the VRG facility, posed by
13 the Public Utilities Commission as Information Request 1.

14

15 **Q4: Please respond to Information Request 2, which states: "Page 7 of Mr.**
16 **Skorokhodov's testimony states that a high-temperature ablative pyrolysis system**
17 **decomposes organic waste in an oxygen-free environment to produce a renewable**
18 **fuel gas containing methane. Please describe the constituency of the fuel gas**
19 **produced, identifying the types and percentage amounts of each gas produced,**
20 **including the percentage of the fuel gas that is methane."**

1 A4: I have attached the HTAP generated fuel gas specification. Please see **VRG-INV-AS-1**. I
2 drafted this exhibit based on requisite experience in developing similar projects in
3 Europe. As EPC, CETY is sourcing plant generator units that will operate directly on this
4 specific gas specification. HTAP recovers a significantly higher percentage of methane
5 from lignocellulosic biomass when compared to other pyrolysis systems available in
6 today's commercial market. HTAP also recovers significantly more methane per ton of
7 dry input of feedstock than an anaerobic digester.

8
9 **Q5: Please respond to Information Request 3, which states: "Please compare the**
10 **constituency of the fuel gas that would be produced by the Facility to the**
11 **constituency of biogas produced by the organic decomposition of farm waste in an**
12 **anaerobic digester."**

13 A5: Biochemical (anaerobic digestion) and thermochemical (pyrolysis, such as VRG's
14 proposed HTAP) processes are the primary available methods for value added products
15 recovery (including methane from agricultural waste (AW) and crops).¹ The technical
16 possibility and efficiency of recovering products from AW or crops depends on the
17 properties of that AW. To illustrate this, I developed the explanation and diagrams
18 provided in **Exhibit VRG-INV-AS-2 (Wood Waste and Anaerobic Digestion)**.

¹ Saida Tayibi, Florian Monlau, A. Bargaz, R. Jimenez, Abdellatif Barakat. Synergy of anaerobic digestion and pyrolysis processes for sustainable waste management: A critical review and future perspectives. Renewable and Sustainable Energy Reviews, 2021, 152, ff10.1016/j.rser.2021.111603ff. fffal-03463924. <https://hal.inrae.fr/hal-03463924/document>.

1 Livestock AW is generated from animals, primarily in the form of manure. Vegetation
2 AW is generated from crops such as husks, hulls, straw, branches, trunks, and roots.²
3 Vegetation AW is also called lignocellulosic biomass.³ Energy crops are also
4 lignocellulosic. Lignocellulosic biomass cannot be adequately processed via anaerobic
5 digestion due to the lignite covering wood fiber as well as the cellulose and hemicellulose
6 within. **VRG-INV-AS-2**. It is difficult for anaerobic microbes to break down these
7 materials.⁴ Therefore, anaerobic digestion (AD) is estimated to be only 5% to 20%
8 effective in converting vegetation AW into useful energy.⁵ More efficient conversion rates
9 cannot be achieved without employing cost-prohibitive, uncommon pre-treatment options
10 such as steam explosion or chemical treatment technologies that break down lignin in the
11 biomass as part of the production process (not typical of an AD system operating in
12 Vermont or in most commercially operating facilities).⁶ Therefore, pyrolysis is a

² United States Energy Information Administration, Biomass Explained:

<https://www.eia.gov/energyexplained/biomass/>

³ Patchiya Phanthong, Prasert Reubroycharoen, Xiaogang Hao, Guangwen Xu, Abuliti Abudula, Guoqing Guan, Nanocellulose: Extraction and application, Carbon Resources Conversion, Volume 1, Issue 1, 2018, Pages 32-43:

<https://www.sciencedirect.com/topics/engineering/lignocellulosic-biomass#:~:text=Lignocellulosic%20biomass%20includes%20various%20natural,human%20and%20animal%20food%20chains.>

⁴ Saida Tayibi, Florian Monlau, A. Bargaz, R. Jimenez, Abdellatif Barakat. Synergy of anaerobic digestion and pyrolysis processes for sustainable waste management: A critical review and future perspectives. *Renewable and Sustainable Energy Reviews*, 2021, 152, ff10.1016/j.rser.2021.111603ff. fffhal-03463924f: <https://hal.inrae.fr/hal-03463924/document>.

⁵ Milke, M., Fang, Y., John, S. (2010) Anaerobic biodegradability of wood: a preliminary review. Christchurch, New Zealand: 2010 Water New Zealand Annual Conference, 22-24 Sep 2010.

<https://ir.canterbury.ac.nz/items/ef8c65c2-f69f-481a-8fe7-d951c3b2eadb>

⁶ Agregán, R.; Lorenzo, J.M.; Kumar, M.; Shariati, M.A.; Khan, M.U.; Sarwar, A.; Sultan, M.; Rebezov, M.; Usman, M. Anaerobic Digestion of Lignocellulose Components: Challenges and Novel Approaches. *Energies* **2022**, *15*, 8413. <https://doi.org/10.3390/en15228413>. <https://www.mdpi.com/1996-1073/15/22/8413>

1 commercially appropriate approach to recovering volatiles including methane from
2 vegetation AW. HTAP for example is 70% effective in converting vegetation AW or
3 energy crops into useful energy. Other important reasons for AD's lack of efficiency in
4 converting lignocellulosic biomass are carbon-to-nitrogen (C/N) ratios.⁷ Wood fiber
5 typically has a very high C/N ratio, which can limit microbial activity in anerobic
6 digestion. Wood fiber's C/N ratio is typically between 100:1 and 500:1.⁸ However a
7 balanced C/N ratio between 20:1 and 30:1 is ideal for efficient digestion.⁹ Therefore, it is
8 technically inefficient to employ AD for vegetation agricultural crops and AW. Pyrolysis
9 is the appropriate and efficient technology for processing woody vegetation AW for Farm
10 Methane projects.

11 Biogas from AD that is recovered from livestock AW consists of varying degrees
12 of methane (CH₄), typically between 50% and 70%.¹⁰ This gas also contains between
13 25% and 50% carbon dioxide (CO₂), and may contain 2% to 8% nitrogen (N₂).¹¹ Smaller
14 quantities of sulfur, silicone, ammonia, halogenated compounds and VOCs are present.

⁷ <https://homesteadontherange.com/2018/08/27/cn-ratios-of-common-organic-materials/>

⁸ Cornell Composting Science and Engineering: Compost Chemistry:
<https://compost.css.cornell.edu/chemistry.html>

⁹ Ghaedi, M., Nasab, H., Ehrampoush, M.H. *et al.* Evaluation of the efficiency of dry anaerobic digester in the production of biogas and fertilizer using activated sludge and plant waste. *Sci Rep* **14**, 24727 (2024). <https://doi.org/10.1038/s41598-024-75504-z>: <https://www.nature.com/articles/s41598-024-75504-z#:~:text=The%20present%20study%20showed%20that,the%20optimal%20ratio33%2C34>.

¹⁰ Yang, Liangcheng, and Yebo Li, Biogas Cleaning and Upgrading Technologies, Ohio State University Extension <https://ohioline.osu.edu/factsheet/AEX-653.1-14>

¹¹ European Biogas Association Biomethane fact sheet: https://www.europeanbiogas.eu/wp-content/uploads/files/2013/10/eba_biomethane_factsheet.pdf

1 Because these other elements and compounds are present, biogas from AD must be
2 cleaned before it can be used for power generation.¹²

3 In addition, with AD only a small percentage of the manure is actually converted
4 to biogas. Dairy cow manure is about 85% water and 15% solids. Of these solids, about
5 91% are volatile, and AD converts from 20% to 30% of those volatile solids to biogas.¹³
6 A dairy cow produces around 17 pounds (7.7 kilograms (kg)) of volatile solids a day, of
7 which one-fourth is converted to biogas. Consequently, an anaerobic digester is a system
8 for manure treatment, not manure disposal. As indicated above, AD biogas from livestock
9 AW has the potential to be equally as much comprised of non-methane gases as it is
10 methane.

11 AD Biogas has a slightly higher heating value than the fuel gas to be produced by
12 VRG. However, it is important to compare technology applications and resultant gases
13 using VRG's chosen input of lignocellulosic biomass. Manure-sourced biogas is not a
14 comparable option when the agricultural waste being used at VRG is not manure.

15 VRG is not using livestock AW as its feedstock. The facility will use vegetation
16 AW and vegetation crops. If using vegetative AW as feedstock for an AD system, the
17 resultant gas will likely contain only 30% to 40% CH₄ under the best scenario. With poor
18 pretreatment (usually hydrolysis) or none at all, CH₄ content could easily be in the range

¹² Homan, Eve, Biogas from Manure, March 9, 2023:

<https://dec.vermont.gov/sites/dec/files/documents/Biogas%20from%20Manure.pdf>

¹³ Homan, Eve, Biogas from Manure, March 9, 2023: <https://extension.psu.edu/biogas-from-manure#:~:text=Of%20these%20solids%2C%20about%2091,fourth%20is%20converted%20to%20biogas>

1 of 10% to 20% because methanogens (methane-producing bacteria) struggle to access
2 and process lignocellulosic materials. 60% to 70% (or more in the case of poor
3 hydrolysis¹⁴) of this gas will be in the form of CO₂ and other minor constituencies.

4 Please see **Exhibit VRG-INV-AS-3 (Digester Gas Composition (livestock wastes v.
5 lignocellulosic wastes))**.

6 Meanwhile Fuel gas recovered by HTAP is 27% CH₄, 30% carbon monoxide
7 (CO), and 36% hydrogen (H₂). Please see **VRG-INV-AS-1**. Relatively insignificant
8 components of other gases including CO₂ and N₂ are present.

9 In summary, the CH₄ content in both processes is relatively similar when
10 processing vegetation AW. The CH₄ content of the gas produced using HTAP is
11 estimated to be 27%, and the CH₄ content of the gas from the anaerobic digestion of
12 vegetation AD is typically in the 10-20% range unless advanced pre-treatment is used, in
13 which case the CH₄ content may be as high as 40%. Please see **VRG-INV-AS-3**.

14 Merely comparing CH₄ content differences between AD and HTAP, however, is
15 not a full or appropriate measure of the ability for VRG to recover methane under the
16 Farm Methane program or contribute to climate action. Biologicals, the microorganisms
17 responsible for breaking down organic matter in an AD system have a short lifespan, and
18 on average, such systems are capable of recovering approximately 227.5 kg of biogas by

¹⁴ Georgia Southern University, Survey of Chemistry II 5.4 Hydrolysis:
[https://chem.libretexts.org/Courses/Georgia_Southern_University/CHEM_1152%3A_Survey_of_Chemistry_II_\(GSU_-_Dr._Osborne\)/05%3A_Organic_Chemical_Reactions/5.04%3A_Hydrolysis_Reactions](https://chem.libretexts.org/Courses/Georgia_Southern_University/CHEM_1152%3A_Survey_of_Chemistry_II_(GSU_-_Dr._Osborne)/05%3A_Organic_Chemical_Reactions/5.04%3A_Hydrolysis_Reactions)

1 volume. Assuming biogas from livestock AW is 60% methane and 40% CO₂, each cubic
2 meter of biogas contains 27 moles of biogas equal to 86 kg of methane per 1 dry metric
3 ton of livestock AW. This calculation is based on an average of 20% to 30% conversion
4 effectiveness.¹⁵ However, when converting vegetation AW or crops into gas using AD,
5 this conversion effectiveness is much lower (5% to 20%, as mentioned above), resulting
6 in the conversion of 1 metric ton of vegetation AW into an average of just 80 kg of
7 biogas, of which 30 kg is methane. VRG's HTAP, by contrast, is capable of recovering
8 approximately 165 kg of methane from 1 metric ton of vegetation AW. Therefore, HTAP
9 recovers more methane per ton of dry feedstock than any scenario involving an AD
10 system, whether that AD system processes vegetation AW like VRG or livestock AW in
11 the form of manure. Please see **Exhibit VRG-INV-AS-4 (Comparison of Conversion**
12 **Efficiencies)**, which shows a table that I created to illustrate these figures.

13 Another important consideration is that HTAP has a higher yield of volatiles
14 recovery per volume of feedstock, with 15% converted into a high-carbon biochar
15 (approximately 86% carbon by volume). Therefore, when comparing AD of livestock AW
16 to VRG's HTAP application for vegetation AW, the adjusted HTAP methane recovery
17 percentage is actually 42%. This is because only 15% of the vegetation AW results in
18 non-volatiles (biochar), compared to 30% of the livestock AW in an AD system resulting

¹⁵ Homan, Eve, Biogas from Manure, March 9, 2023: <https://extension.psu.edu/biogas-from-manure>

1 in non-volatiles (digestate¹⁶). Please see **Exhibit VRG-INV-AS-5 (Recovery**
2 **Efficiencies)**, which includes tables that I created to illustrate these figures. This methane
3 recovery volume fits directly into the range of landfill methane recovery, such as in
4 Vermont’s Standard Offer for Landfill Methane Facilities.¹⁷ When comparing AD of
5 vegetation AW to VRG’s HTAP application for vegetation AW, the effective HTAP
6 methane recovery percentage is 550% higher. Please see **Exhibit VRG-INV-AS-4**. This
7 demonstrates that pyrolysis processes like HTAP are more effective than AD at
8 recovering methane from vegetation AW and crops.

9 The percentage of methane in VRG’s fuel gas (presently at 27% without adjusting
10 for efficiency as discussed above) could be increased substantially by certain technical
11 modifications to the system. The use of a nickel catalyst in the HTAP process, for
12 example, could increase the fuel gas methane content to 50% and reduce the CO and H₂
13 content, giving the resulting gas a methane content on par with AD produced biogas from
14 livestock AW and even higher than some landfills. For example, landfill gas has a
15 common methane content of as low as 30% and as high as 65%, dependent on various
16 landfill conditions.¹⁸ Another important consideration, when comparing the relative gas
17 production from HTAP, is the carbon budget. When agricultural activities presently

¹⁶ Digestate is the material left after anaerobic digestion, a wet mixture that is composed of both solid and liquid portions. U.S. EPA, Basic Information About Anaerobic Digestion: <https://www.epa.gov/anaerobic-digestion/basic-information-about-anaerobic-digestion>

¹⁷ Yang, Liangcheng, and Yebo Li, Biogas Cleaning and Upgrading Technologies, Ohio State University Extension: <https://ohioline.osu.edu/factsheet/AEX-653.1-14>

¹⁸ U.S. Environmental Protection Agency, Landfill Gas Emissions Model (LandGEM) Version 3.02 User’s Guide, May 2005: <https://www3.epa.gov/ttnatc1/dir1/landgem-v302-guide.pdf>

1 produce vegetative AW, such material is left to rot and decay or may be burned.

2 Vegetative AW that would otherwise rot and decay produces significant greenhouse gas
3 emissions on farms and within the larger working landscape over time.¹⁹ Open burning of
4 vegetation AW results in vaporizing of nutrients, generation of pollutants, altering soil
5 properties, and releasing significant quantities of greenhouse gas to the atmosphere.²⁰

6 Presently Vermont's only viable commercial option for vegetative AW and non-AW
7 vegetation is incineration in biomass boiler plants. Biomass combustion releases 90% to
8 100% of the CO₂ present in the vegetative AW. No methane or carbon is recovered in this
9 process like with an HTAP system.

10 Carbon recovery and storage is equally as important in the context of HTAP as is
11 methane recovery. Because solid carbon in lignocellulosic biomass is recovered in
12 HTAP's biochar stream, at least 150 kg of carbon are recovered per metric ton of dry
13 woody AW or crop-based granulate input into the HTAP system, totaling approximately
14 1,400 metric tons of solid carbon stored in soils, primarily in Vermont, per year. As
15 demonstrated by Mr. Eric Kingsley of Innovative Natural Resource Solutions in that
16 firm's Feedstock Assessment and Greenhouse Gas Emissions Benefits analysis, this

¹⁹ Amonette, J.E., J.G. Archuleta, M.R. Fuchs, K.M. Hills, G.G. Yorgey, G. Flora, J. Hunt, H.-S. Han, B.T. Jobson, T.R. Miles, D.S. Page-Dumroese, S. Thompson, K.M. Trippe, K. Wilson, R. Baltar, K. Carloni, C. Christoforou, D.P. Collins, J. Dooley, D. Drinkard, M. Garcia-Pérez, G. Glass, K. Hoffman-Krull, M. Kauffman, D.A. Laird, W. Lei, J. Miedema, J. O'Donnell, A. Kiser, B. Pecha, C. Rodriguez-Franco, G.E. Scheve, C. Sprenger, B. Springsteen, and E. Wheeler. 2021. *Biomass to Biochar: Maximizing the Carbon Value*. Report by Center for Sustaining Agriculture and Natural Resources, Washington State University, Pullman WA.

https://wpcdn.web.wsu.edu/cahnrs/uploads/sites/44/Biomass2Biochar-Chapter1_1.1.pdf

²⁰ U.S. EPA, Agriculture and Air Quality: <https://www.epa.gov/agriculture/agriculture-and-air-quality>

1 carbon recovered through VRG’s HTAP has the potential to permanently remove between
2 2,700 and 3,450 metric tons of CO2 equivalent every year., for the duration of the plant’s
3 operation. Please see **VRG-EK-1 in 24-2797-PET**. All biogas engines whether operating
4 on AD gas or gas from VRG’s HTAP produce biogenic CO2 emissions (part of the
5 natural carbon cycle, and not carbon positive). However, AD systems do not also remove
6 carbon, and then return that carbon back to Vermont’s farms. This cycle has the potential
7 to make VRG’s HTAP system carbon negative, while AD systems will always be carbon
8 neutral at best. For this reason, systems like VRG’s proposed HTAP are among some of
9 the only cost-competitive or commercially available options for implementation of
10 carbon removal technology for climate action.²¹ Please see the prefiled testimony of Evan
11 Dell’Olio filed in this investigation docket for more details on this topic.

12
13 **Q6: Please respond to Information Request 4, which states: “Page 9 of Skorokhodov’s**
14 **testimony states that the Facility uses dual organics-to-energy reactor vessels. In the**
15 **first vessel, the self-contained high temperature occurring in the reactor vessel**
16 **extracts volatiles from the organic matter in an anaerobic environment, and in the**
17 **second vessel, thermos-catalytic cracking of the volatiles occurs, creating a tar-free,**
18 **high-heating value fuel gas. Please provide additional information on the high-**

²¹ World Economic Forum, Biochar is carbon removal's jack of all trades. Here's why, November 23, 2023:
<https://www.weforum.org/stories/2023/11/biochar-carbon-removals-jack-of-all-trades-for-immediate-climate-action/#:~:text=For%20net%2Dzero%20targets%2C%20BCR,t%20across%20all%20CDR%20approaches>

1 **temperature ablative pyrolysis process, including the pressures, temperatures, and**
2 **energy source needed for the process.”**

3 A6: The HTAP system operates at low pressure (below 1 barg).²² Pressure is created by a
4 biogas compressor installed at the end on a fuel gas cleaning line, just before the feeding
5 of the gensets. Genset fuel gas supply pressure is 0.32 barg. HTAP is a dual vessel
6 continuous process reactor system. The first vessel operates at about 950 deg. C
7 temperature. The second vessel operates at 850 to 900 deg. C. Auxiliary electrical power
8 consumption of the plant is some 15% of the installed power of the gensets. At normal
9 operation, the energy source for the plant is waste heat from the HTAP unit and the
10 gensets as well as electrical energy from the gensets themselves (as referenced above).
11 Maintenance stops for the reactor vessels occur every 4,000 hours (every 6 months). In
12 case of a short-term grid failure, the Facility will continue operation at reduced power in
13 a standalone mode to cover auxiliary needs (one of 3 gensets running, with reduced
14 feedstock consumption). Please see **Exh-VRG-INV-AS-6 (HTAP Full Specifications)**.

15
16 **Q7: Please respond to Information Request 5, which states: “Please describe how the**
17 **pyrolysis process differs from combustion. Please address the risks of introducing**
18 **accidental combustion of organic material due to contact with oxygen or high**
19 **temperature, including what measures are enacted to achieve process control.”**

²² Barg pressure is the pressure, in units of bars, above or below atmospheric pressure.

1 A7: Combustion is the process of burning fuel in the presence of oxygen. Some 1.2 kg of
2 oxygen is needed for combustion of 1 kg of woody biomass. Combustion generates
3 carbon dioxide as the main component and some water. Pyrolysis is the heating of
4 biomass in the absence of oxygen. Pyrolysis is not combustion.²³ Because combustion
5 requires heat, fuel, and an oxidizer, combustion cannot occur within an HTAP system due
6 to the oxygen-free environment. In an HTAP cold start scenario, biomass is heated
7 externally with assistance of an induction heater. At normal operation, the HTAP
8 pyrolysis vessel is maintained via autothermal conditions in the vessel (feeding
9 preliminary dried biomass granulate, in a fast process, and at high temperature) with
10 induction heating used as a supporting source of heat to compensate possible variations in
11 moisture and quantity of biomass, if needed. The HTAP pyrolysis process generates a
12 mixture of volatile gases—methane, hydrogen, and carbon monoxide. CO₂ is a minor
13 component. Biochar (non-volatile, solid carbon) is a co-product of the system.

14 HTAP has the following risk controls mentioned in the question:

15 1) There is no direct feeding of biomass granulate from the holding silo to the
16 pyrolysis vessel. Connection is established through an enclosed auger with two dose leak-
17 proof rotary valves on both sides. On the pyrolysis vessel side, there is a high temperature
18 valve installed. Valves are sourced from a German company, Barl Maschinenbau.²⁴ The

²³ Encyclopedia Britannica, Nov. 16, 2024: <https://www.britannica.com/science/pyrolysis>

²⁴ Barl Maschinenbau website: <https://www.barl-mb.de/en/>

1 same valves are installed on the biochar discharge line in the pyrolysis vessel, biochar
2 inlet, and discharge lines of the cracking vessel.

3 2) The HTAP reactor is equipped with an automated control system based on
4 Siemens Programmable Logic Control (PLC), a small ruggedized computer that controls
5 plant machinery, devices, and sensors. This control system receives signals from a total of
6 28 different sensors installed at the following locations: A) syngas gas temperature, B)
7 biochar temperature, C) syngas pressure, D) biomass granulate levels in granulate silos,
8 E) biochar level in cracking vessel, and E) biochar level in biochar storage silos. This
9 control system has certain set points for temperature and pressure to activate emergency
10 stop (“e-stop”) of the HTAP system. During e-stop, syngas is discharged into the
11 emergency flare installed outside the plant building. On the plant building level there are
12 automated systems with e-stop activation for A) combustible gases leakage detection and
13 B) firefighting equipped with dust and smoke detection. Our HTAP vessels are made
14 from special steel alloy Inconel 696 with high resistance to high temperature corrosion
15 assuring long-term continuous operation. All auger conveyors are covered by insulation
16 mats to isolate from the ambient environment.

17
18 **Q8: Please describe the cost comparison between an anaerobic digestion system and**
19 **VRG’s proposed HTAP plant when considering the \$0.145/Kwh price set by the**
20 **Commission for Farm Methane Projects?**

1 A8: The \$0.145/Kwh price set by the Commission is adequate for both technologies. The
2 assumed \$20 million cost for a 2.2 MW anerobic digestion-based biogas plant is in-line
3 with the costs of VRG’s HTAP plant. Both facilities have similar operations and
4 maintenance costs (O&M) costs for electricity generation due to their shared use of
5 biogas engine technology. Likewise, both types of systems have similar capital costs, of
6 approximately \$9,000/kW on an installed basis. In VRG’s case, retention of renewable
7 energy certificates (RECs) is impactful as such revenues are returned to farmers in the
8 form of payments for chipping and delivery of vegetative AW and crops to the VRG
9 facility. Such vegetative AW and crops would either be low-value or no-value waste
10 without a market like VRG.

11

12 **Q8: Why did CETY hire a subcontracted engineering firm to calculate and certify the**
13 **efficiency of the Vermont Renewable Gas – Lyndon plant?**

14 A8: It was CETY’s understanding that Vermont Section 248 requires any plant that converts
15 woody biomass into electricity to achieve the highest commercially available, feasible,
16 cost-effective efficiency for the type and design of the proposed facility. While Vermont
17 Renewable Gas – Lyndon will convert vegetative AW which may be characterized as
18 “woody” into fuel gas before use as an energy fuel, we thought it best to demonstrate the
19 efficiency of the plant at a high 62%+ in our Certificate of Public Good petition as the
20 AW for this project has woody characteristics. We recognize that this may have been
21 more information than was needed by the PUC.

1

2 **Q9: Does this conclude your testimony?**

3 A28: Yes.



Alexander Skorokhodov

**STATE OF VERMONT
PUBLIC UTILITY COMMISSION**

Case No. 24-3359-INV

Investigation of the standard-offer contract)
Between Vermont Renewable Gas, LLC)
and the Standard Offer Facilitator)

DECLARATION OF ALEXANDER SKOROKHODOV

I declare that the testimony and exhibits that I have sponsored are true and accurate to the best of my knowledge and belief and were prepared by me or under my direct supervision. I understand that if the above statement is false, I may be subject to sanctions by the Commission pursuant to 30 V.S.A. § 30.

Dated at Herzliya, Israel this 12th day of December, 2024.



Alexander Skorokhodov