NV5 RESPONSE TO TAG STAKEHOLDER FEEDBACK

On March 7, 2024, NV5 presented an overview of its initial modeling methodology and measure characterizations to the Clean Heat Standard ("CHS") Technical Advisory Group ("TAG") for stakeholder feedback. At the March 7 TAG meeting the Vermont Department of Public Service ("Department") requested feedback be provided by March 15, 2024. This document 1) describes how feedback will be incorporated, 2) identifies and 3) summarizes the feedback received, and 4) addresses questions received as understood by the Department and NV5.

I. INCORPORATION OF FEEDBACK INTO THE POTENTIAL STUDY DEVELOPMENT PROCESS

The purpose of the March 7 presentation was to inform—and receive feedback from—stakeholders on the initial draft Potential Study methodology and measure characterizations. Having received feedback, the Department has directed NV5 to modify its Potential Study methodology and measure characterizations as may be appropriate to reflect the feedback received. With this document, NV5 provides its response to the TAG as well as those that provided comments and information directly to the Department's Clean Heat Standard email.

II. IDENTIFICATION OF FEEDBACK RECEIVED

A number of parties provided comments and questions as feedback on the Potential Study presentation. This section acknowledges NV5 and the Department's receipt of feedback:

Date	Party	Org.[1]	Mode	Feedback
20240307	Individual	Self	Email	Greg Doremus Potential Study feedback
20240307	Individual	Self	Email	James Kelly Potential Study feedback
20240307	Individual	Self	Email	James Kelly Potential Study feedback
20240307	EAG	Self	Email	John Mandeville Potential Study feedback
20240307	Individual	Self	Email	Joyce George Potential Study feedback
20240307	Individual	Self	Meeting Chat	Raymond Albrecht comment from 20240307 TAG meeting chat
20240308	TAG	ANR	Phone	Brian Woods Potential Study feedback (phone call)
20240308	TAG	CFAA	Email	Floyd Vergara March 8 Potential Study feedback
20240308	TAG	CFAA	Email	Purdue Biodiesel induced land use changes_Final_V4 (CFAA support material)
20240308	Individual	Self	Email	Renee Carpenter Potential Study feedback

[1] Table Acronyms: Vermont Clean Heat Standard Technical Advisory Group (TAG); Vermont Agency of Natural Resources (ANR); Clean Fuels Alliance American (CFAA); Coalition for Renewable Natural Gas (CRNG); Vermont Fuel Dealer's Association (VFDA); Efficiency Vermont (EVT); Vermont Gas Systems (VGS)

20240308	TAG	CFAA	Email	xu-et-al-2022-life-cycle-greenhouse-gas-emissions-of-biodiesel-and-renewable-diesel-production-in-the-united-states [VFDA & CFAA support material]
20240311	TAG	CRNG	Email	Sam Lehr Potential Study feedback
20240314	EAG	Self	ePUC	Case No. 23-2220-RULE - Comments Document was filed by John Mandeville
20240314	TAG	VFDA	ePUC	Case No. 23-2220-RULE - Matt Cota VT DPS's CHS Potential Study Assumptions
20240314	TAG	EVT	Email	Emily Roscoe Potential Study feedback
20240314	TAG	CFAA	Email	Floyd Vergara Potential Study feedback
20240314	TAG	CFAA	Email	F[loyd] [V]ergara Notes to Matthew and Fellow Member of the TAG March 13 2024 (FINAL)
20240314	TAG	Self	Email	Ken Jones Comments on the NV5 Clean Heat Standard Potential Study
20240315	TAG	CFAA	ePUC	Case No. 23-2220-RULE - Floyd Vergara Reply Comments to Pike Porter's Reply Comments of 3/14/2024
20240315	EAG	Self	ePUC	Case No. 23-2220-RULE - Pike Porter Reply Comments to Fuel Dealers Association Comments of 3/14/2024
20240315	Individual	VGS	Email	Dylan Giambatista Potential Study feedback
20240315	Individual	Self	Email	Thomas Weiss MC 240316 Potential Study

III. FEEDBACK SUMMARY

NV5 and the Department appreciate the engagement of all parties who provided feedback, including offers of assistance in collecting data and market modeling. As summarized, feedback received:

A. Emphasized the need to include all eligible measures in the Potential Study, particularly renewable fuels including liquid biofuels from purpose grown crops and liquified biogas.

B. Suggested sources or data supporting the carbon intensities of fuels.

C. Emphasized the need for an equitable and deliberate process to ensure the outcome does not increase costs or result in negative externalities.

D. Included general opposition to the Affordable Heat Act (2023).

E. Asked what data sources would be used to characterize measure emissions, such as the carbon intensity of energy sources including fuels (liquid biofuels, biomass, and renewable natural gas) and electricity.

F. Asked how the low- and moderate-income ("LMI") measure requirements of the Act would be modeled.

G. Opposed the use of historic market pricing data and technology adoption projections in the context of recent inflation and higher prices.

H. Asked whether a credit market would be modeled and whether such modeling is expected to impact modeling results.

I. Suggested additional measures for consideration including efficient, but not advanced wood heating and on-bill financing.

J. Proposed implementation methods.

The remainder of this memo speaks to areas of feedback directly relevant to the potential study. For example, general opposition to the Affordable Heat Act is not addressed here, since it is outside of the scope of the Potential study.

A summary of sources for all fuel pathway potentials and emissions is included below:

Fuel	Feedstock	Potential	Emissions
Wood Pellets	Wood	VT GHGI; Billion-Ton Report	VT GHGI
Firewood, Commercial	Wood	VT GHGI; Billion-Ton Report	VT GHGI
Firewood, Non-Commercial	Wood	VT GHGI; Billion-Ton Report	VT GHGI
Wood Chips	Wood	VT GHGI; Billion-Ton Report	VT GHGI
Biomethane	Animal Manure	Billion-Ton Report; VT RNG Potential Study; AGF Study	CARB LCFS-Registered Projects
Biomethane	Landfill Gas	Billion-Ton Report; VT RNG Potential Study; AGF Study	CARB LCFS-Registered Projects
Biomethane	Residues and Waste	Billion-Ton Report; VT RNG Potential Study; AGF Study	CARB LCFS-Registered Projects
Biomethane	Wastewater	Billion-Ton Report; VT RNG Potential Study; AGF Study	CARB LCFS-Registered Projects
Renewable Diesel	Residues and Waste	Billion-Ton Report	CARB LCFS-Registered Projects

Renewable Diesel	Purpose-grown Oil Crops and Waste Oils	EIA SEDS	CARB LCFS-Registered Projects
Biodiesel	Purpose-grown Oil Crops and Waste Oils	EIA SEDS	CARB LCFS-Registered Projects
Hydrogen	Dedicated Renewables	N/A	CARB LCFS-Registered Projects

IV. ANSWERS TO CONSOLIDATED QUESTIONS RECEIVED AS UNDERSTOOD BY NV5

In consultation with the Department, NV5 identified specific questions relating to both the Potential Study methodology and measure characterizations. NV5's response to these questions are as follows:

1. **How will ANR's Draft Emissions Inventory's upstream values be used?**

   Based on conversations with the Department and the Vermont Agency of Natural Resources ("ANR"), the potential study proposes to use the ANR Draft Greenhouse Gas Emissions Inventory and Forecast Report, and its combustion emission factors to calculate measure emissions impacts for the non-emerging CHS measures.

   The Technical, Maximum Achievable and Economic Potential proposes to specifically use ANR upstream emission factors to represent lifecycle emissions for non-biofuel measures to align with the Clean Heat Standard's emissions definition. The VT GHG inventory combustion emission factors is proposed to be used for the GWSA target scenario to align with how emission factors were calculated for GWSA targets.

   Woody biomass and biodiesel (BD) pathway emissions are proposed to be based on the Vermont Agency of Natural Resources (ANR) Draft Greenhouse Gas Emissions Inventory and Forecast Report. In the case of biodiesel, this report has estimated Vermont-specific emission factors for fuel produced primarily out-of-state. Upstream woody biomass emission factors are similarly Vermont-specific but lack the effects of biomass regrowth and decomposition associated with the types of forests from which wood is obtained in Vermont. While these emission factors include contributions from transport and processing, the inventory assumes that the climate change impact of wood combustion is completely mitigated by forest regrowth.

   NV5 proposes to use a GWP_{bio} factor of 0.3 to estimate the climate impacts of the slower Vermont regrowth cycle, based on the currently published Greenhouse Gas Emissions Inventory and Forecast Report and other sources.[2] NV5 proposes to determine wood fuel emissions by multiplying woody biomass combustion emissions by the GWP_{bio} factor. Vermont's forests have a regrowth cycle on the order of 50-100 years, which corresponds to a GWP_{bio} factor of 0.13-0.32. The factor range arises from estimating the radiative forcing of wood combustion emissions, which are subsequently reabsorbed by stand regrowth. This is compared to an estimate of radiative forcing arising from combustion emissions from a

[2] Analysis of the Global Warming Potential of Biogenic CO_2 Emission in Life Cycle Assessments. Liu, W.; Zhang, Z.; Xie, X.; Yu, Z.; von Gadow, K.; Xu, J.; Zhao, S; Yang, Y. https://www.nature.com/articles/srep39857.

generic fossil fuel that persists in the atmosphere and is not reabsorbed biologically. A GWP_{bio} factor of 0.3 was selected as a conservative value.

All other production pathways are proposed to use emission factors from existing California Air Resources Board (CARB) Low Carbon Fuel Standard (LCFS) projects. Each project must use the California GREET (CA-GREET) model to estimate the well-to-wheel lifecycle emissions for its respective fuel pathway in order to qualify for the LCFS program. These lifecycle emissions include emissions for fuel production and transportation. For some pathways, such as animal manure, CA-GREET accounts for avoided counterfactual emissions. Within a given pathway type, qualified projects display a distribution of emission factors, which will be used to select representative emission factors for this study.

2. **Act 18 provides for an enumerated list of measures, some of which were not included in the presentation. Will all eligible measures be included?**

A preliminary measure list was presented in the March 7 TAG meeting which at the time did not represent all the eligible Clean Heat Measures. Below is a more detailed measure list that represents all measure types listed in the Clean Heat Standard and that is proposed to be used in the Clean Heat Standard potential study.

Clean Heat Standard Measure #	Sector	Measure	Feed Stock (Applicable to Fuels Only)
1	RES	Advanced Thermostats	N/A
1	RES	Low Flow Faucet Aerator	N/A
1	RES	Low Flow Showerheads	N/A
1	RES	Envelope Improvements	N/A
1	RES	ERV/HRV	N/A
1	C&I	Advanced Thermostats	N/A
1	C&I	Low Flow Faucet Aerator	N/A
1	C&I	Low Flow Showerheads	N/A
1	C&I	Envelope Improvements	N/A
1	C&I	ERV/HRV	N/A
2	RES	Ground Source Heat Pump – Full Replacement	N/A
2	RES	Ductless Air Source Heat Pump – Full Replacement	N/A
2	RES	Ductless Air Source Heat Pump – Partial Replacement	N/A
2	RES	Centrally Ducted Air Source Heat Pump – Full Replacement	N/A
2	RES	Centrally Ducted Air Source Heat Pump – Partial Replacement	N/A
2	RES	Air to Water Heat Pumps	N/A
2	C&I	Variable Refrigerant Flow (VRF) Heat Pump	N/A
2	C&I	Heat Pump Rooftop Unit (RTU)	N/A
2	C&I	Ground Source/Water Source Heat Pump – Full Replacement	N/A
2	C&I	Ductless Air Source Heat Pump – Full Replacement	N/A

2	C&I	Ductless Air Source Heat Pump – Partial Replacement	N/A
2	C&I	Centrally Ducted Air Source Heat Pump – Full Replacement	N/A
2	C&I	Centrally Ducted Air Source Heat Pump – Partial Replacement	N/A
2	C&I	Air to Water Heat Pumps	N/A
2, 8	All	Networked Geothermal	N/A
3	RES	Heat Pump Water Heater	N/A
3	RES	Heat Pump Pool Water Heater	N/A
3	C&I	Heat Pump Water Heater	N/A
3	C&I	Heat Pump Pool Water Heater	N/A
4	RES	Utility-Controlled Electric Water Heater	N/A
4	C&I	Utility-Controlled Electric Water Heater	N/A
5	RES	Solar Water Heater	N/A
5	C&I	Solar Water Heater	N/A
6	RES	Induction Stovetop	N/A
6	RES	Heat Pump Clothes Dryer	N/A
6	C&I	Induction Stovetop	N/A
6	C&I	Heat Pump Clothes Dryer	N/A
7	RES	Advanced Wood Heating	N/A
7	C&I	Boiler (Advanced Wood Heating)	N/A
7	C&I	Advanced Wood Heating	N/A
9	RES	Wood Pellets	Wood
9	RES	Firewood, Commercial	Wood
9	RES	Firewood, Non-Commercial	Wood
9	IND	Wood Chips	Wood
9	COM	Wood Chips	Wood
9	All	Biomethane	Animal Manure
9	All	Biomethane	Landfill Gas
9	All	Biomethane	Residues and Waste
9	All	Biomethane	Wastewater
9	All	Renewable Diesel	Residues and Waste
9	All	Renewable Diesel	Purpose-grown Oil Crops and Waste Oils
9	All	Biodiesel	Purpose-grown Oil Crops and Waste Oils
10	All	Hydrogen	Dedicated Renewables
11	RES	Efficient and Electric Manufactured Home	N/A
12	C&I	Line Extensions (Custom)	N/A

Note that for Clean Heat Standard Measure #12 "*line extensions that connect facilities with thermal loads to the grid*" the potential study proposes to characterize this as a custom measure due to the varying market scenarios that could be represented under this category. This custom measure will incorporate different scenarios into one modeled line-item. There may be other custom measures necessary within existing Clean Heat Standard measure categories as needed. NV5 will continue to analyze the most representative conditions for Measure #12 and other custom measures as they are identified. Documentation and sources on the make-up of all custom measures will be available upon completion of our measure characterization.

NV5 is also working closely with the Vermont Public Utility Commission ("PUC") contractor on the Measure Characterization project to ensure that we are aligned as best as possible on measure lists and measure assumptions. A separate Coordination Memo is currently being developed which will document this coordination and include aspects of our measure characterization work where alignment is possible and where alignment may not be possible due to conflicting timelines and the different scopes of each respective project.

3. **How will the carbon intensity of biofuels/mass be modeled?**

Life-cycle emission factors are proposed to be primarily used to characterize each pathway. Because the results of life-cycle emission modeling depend heavily on project location, feedstock type, counterfactual or baseline practices, and renewable fuel end use and sector, NV5 proposes to use archetypes to capture a range of fuel pathway emissions. NV5 intends to primarily use data from existing projects when available. When such data is unavailable, NV5 will use data produced for the state of Vermont.

Oil-based renewable diesel (RD), advanced RD, renewable natural gas (RNG), and hydrogen pathways are proposed to be sourced from the list of currently certified projects for CARB's LCFS program. This database contains GREET-estimated emission factors for a wide range of project types, so it can serve as a source for a reasonable range of emission factors for biofuel pathways. Where possible, NV5 will attempt to estimate low and high emission factors from a given pathway by approximating the 25th and 75th percentiles of the distribution of observed emission factors for that pathway.

Woody biomass and biodiesel (BD) pathway emissions are proposed to be based on the Vermont Agency of Natural Resources (ANR) Draft Greenhouse Gas Emissions Inventory and Forecast Report. In the case of biodiesel, this report has estimated Vermont-specific emission factors for fuel produced primarily out-of-state. Upstream woody biomass emission factors are similarly Vermont-specific but lack the effects of biomass regrowth and decomposition associated with the types of forests from which wood is obtained in Vermont. While these emission factors include contributions from transport and processing, the inventory assumes that the climate change impact of wood combustion is completely mitigated by forest regrowth.

NV5 proposes to use a GWP_{bio} factor of 0.3 to estimate the climate impacts of the slower Vermont regrowth cycle, based on the currently published Greenhouse Gas Emissions

Inventory and Forecast Report and other sources.[3] NV5 proposes to determine wood fuel emissions by multiplying woody biomass combustion emissions by the GWP_{bio} factor. Vermont's forests have a regrowth cycle on the order of 50-100 years, which corresponds to a GWP_{bio} factor of 0.13-0.32. The factor range arises from estimating the radiative forcing of wood combustion emissions, which are subsequently reabsorbed by stand regrowth. This is compared to an estimate of radiative forcing arising from combustion emissions from a generic fossil fuel that persists in the atmosphere and is not reabsorbed biologically. A GWP_{bio} factor of 0.3 was selected as a conservative value.

4. **What data source is being used for grid carbon intensity and how will electric load growth be modeled?**

   For grid electric emission factors, NV5 proposes to use the sum of the combustion and upstream marginal emissions rates for the electric sector as modeled in the Avoided Energy Supply Components in New England: 2024 Report. To reflect the hourly variability in electric sector emissions, CHS measure electric energy impacts will be aggregated to four "energy periods" (i.e., Winter On-Peak, Winter Off-Peak, Summer On-Peak, Summer Off-Peak) such that the appropriate marginal emissions rates from AESC 2024 can be applied. Electric load growth will be a function of our overall modeling analysis (i.e., any electrification opportunities will result in increased electric loads). Load growth is also incorporated in utility-supplied load forecasts that are used in combination with our measure characterizations to forecast potential over the model's full time horizon.

5. **What data source is being used to estimate supply for each RNG category?**

   Assumptions for all forms of RNG as well as for advanced RD will be primarily sourced from the Department of Energy 2016 Billion-Ton Report and supplemented by the Vermont Gas Systems (VGS) RNG potential study and American Gas Foundation Renewable Sources of Natural Gas study. NV5 proposes to use the E3 Biofuels Module to set the annual potentials of different types of biofuels. This model allocates biomass feedstocks to final fuels by minimizing net cost, where the net cost is defined as the difference between the total production cost of the renewable fuel and the cost of the fossil fuel that it could replace. The results of this optimization exercise will determine the maximum potential of each final fuel.

   NV5 proposes to also assume that anaerobic digestion RNG and advanced RD will be available throughout the entirety of the study period, while RNG produced via thermal gasification will only be available starting in 2030 due to the latter process's current low rate of commercialization.

   Oil-based biodiesel and RD are assumed to be mature, scalable fuel pathways. Since Vermont residential, commercial, and industrial (RCI) fuel oil consumption is small relative to national biodiesel and RD consumption, NV5 will consider the practically accessible biodiesel availability for Vermont to be equal to today's RCI fuel oil consumption, derived from the Energy Information Agency's (EIA) State Energy Data System (SEDS).

[3] Analysis of the Global Warming Potential of Biogenic CO_2 Emission in Life Cycle Assessments. Liu, W.; Zhang, Z.; Xie, X.; Yu, Z.; von Gadow, K.; Xu, J.; Zhao, S; Yang, Y. https://www.nature.com/articles/srep39857.

Green hydrogen is an emerging clean fuel. However, there is little green hydrogen production with minimum transportation infrastructure today in the northeastern United States. Given its nascent status in the region, we will assume that green hydrogen is unavailable to Vermont until 2028. After that, green hydrogen potential will be limited to blending into Vermont's local distribution gas systems at 7% by energy or 20% by volume. Hydrogen will be assumed to be produced from one of two sources:

1. **Locally in Vermont**. This would entail small-scale hydrogen production sited within or close to local gas distribution systems.

2. **Remote Hydrogen.** Hydrogen could be delivered to Vermont via pipeline from outside of the state. Given the size of the Vermont market, this would likely require a more substantial build-out of hydrogen infrastructure both upstream and within New England to be feasible. For modeling purposes, NV5 proposes to assume that additional green hydrogen will be produced in Western Pennsylvania with wind resources, stored in salt caverns in Western Pennsylvania, and transported in dedicated hydrogen pipelines to Vermont.

Woody biomass potentials will be based on a mixture of (1) current woody biomass consumption, derived from the Vermont Agency of Natural Resources Draft Vermont Greenhouse Gas Emissions Inventory and Forecast Report, and (2) forest residues from the Billion-Ton Study and (3) the 2022 Updated Advanced Wood Heat Sector in Vermont and Wood Heat Use in Vermont reports. In-state woody biomass, such as forest residues and thinnings, will be assigned to wood chip and pellet production. This biomass will be allocated to wood chip and pellet potential, proportional to today's in-state wood chip and pellet consumption. The largest of the woody biomass potential from (1) and (2) is proposed to be used to estimate the potential of wood pellets, wood chips, and firewood.

6. **How will LMI measures be modeled?**

The CHS Potential Study will incorporate analysis to determine impacts on LMI households with high energy burdens, manufactured homes, and renter households with tenant-paid energy bills. Many of the measures identified in the measure list above (IV.2.) will be applicable to the LMI sector and will be modeled assuming some type of program intervention covers up to 100% of the measure costs for LMI customers in the program achievable scenarios. Incentives for market rate customers will be modeled to cover a lower percentage (to be determined based on alignment with current programs and feedback from the Equity Advisory Group ("EAG")) of measure costs. Furthermore, LMI will be modeled as a specific market segment in the analysis.

NV5 is also conducting a review of Workforce Development regarding the current state of workforce as well as a forecast of workforce needed to support the CHS to determine potential gaps in workforce capacity between the current-state and future-state workforce needed to support potential study results. This analysis will include coordination with Vermont regional trade organizations (e.g. Heating & Cooling Contractors of Vermont and Vermont Fuel Dealers Association) and trade schools (e.g. Vermont Technical College, Green Mountain Technology and Career Center) to supplement any quantitative data from existing secondary VT workforce reports or analysis. This coordination will provide further insight on

hiring or enrollment trends that will inform both current state conditions as well as highlight any barriers or difficulties in job market capacity. NV5 will also review federal and state policy relating to clean energy workforce development to help complete the overall current-state workforce landscape.

Finally, NV5 will be working with the EAG to get feedback on our project and our LMI approach and will be discussing this project in more detail in an upcoming April EAG meeting.

7. **Will assumptions about the market for clean heat credits be made and are those assumptions expected to impact model results?**

   NV5 will incorporate assumptions on market conditions that impact Clean Heat Standard measure adoption including fuel sales forecasts, disaggregation of fuel sales forecast by fuel type and sector, customer counts and demographics, and other general baseline market characteristics. NV5 will not incorporate assumptions about clean heat credit market value as that is outside of the scope of the potential study project.

8. **What data source will be used for measure cost and how will it account for inflation?**

   NV5 will be using measure costs from the 2023 Vermont Energy Efficiency Utility TRM and the Tier III TRM as these represent the best available existing cost data at the time of this project. All measure costs will be reviewed and verified and for those measures where NV5 determines that existing cost sources may not represent current market conditions, supplemental data may be used. NV5 will also be applying inflation values to measure costs.

9. **How will measure loading order be modeled and will weatherization be loaded first?**

   The potential study uses loading orders to determine which technologies are given priority in each building type and application. This order could be based on factors such as the lifecycle emissions reductions, cost effectiveness ratios, customer economics, and/or policy priorities. NV5 will be considering the benefits of weatherization as one of the considerations in prioritization.

10. **How are measures that can easily be undone (aerators) going to be modeled?**

    There are several ways to model measures that are easily undone. An “in-service rate” can be used if it’s quantified in the TRM algorithm for measures that were installed via a kit. This factor assumes a certain percentage of kit items like aerators don’t ever get installed. For direct install measures, a lower adjusted measure life can account for uninstalled measures. Finally, some measures will have net-to-gross factors which also account for the early uninstallation of a measure. NV5 will work with the Department to determine which method is appropriate for these types of measures.

NV5 and the Department thank all commenters for participating in the development of the Potential Study modeling inputs and parameters. The Department will provide an updated working version of the Potential Study methodology and measure characterization memo to the TAG, and on its Clean Heat Standard web page on or before April 30, 2024.