



Vermont Life Cycle Analysis of GHG Emissions Lifecycle Task Group Meeting

March 17, 2023



Project Goal

To support the Climate Action Plan, this work will conduct lifecycle accounting of emissions attributable to the use of energy in Vermont to supplement the state's current GHG Inventory. This analysis primarily covers GHG gas emissions outside the boundaries of the state that are caused by the use of energy in Vermont, but will be connected to in-state fuel consumption activity and emissions.

Agenda

1. Introductions - All
2. Update on energy pathway identification
3. Update on data source review
4. Discussion
5. Re-envisioning Engagement
6. Discussion

Energy Pathway Identification

- Resources reviewed to identify energy pathways:
 - Energy Information Administration (EIA) State Energy Data System (SEDS)
 - 2022 VT Comprehensive Energy Plan
 - Initial VT Climate Action Plan, Dec 2021
 - VT GHG Emissions Inventory and Forecast: 1990 – 2017 & Most Recent 2020 Draft

Pathways: Fossil Fuels

Category	Pathway	Type	Prevalence	Reference Sources	Abbv	Definition
Natural Gas Products	Natural Gas	EGEN, RCI	Established	CEP, INV, SEDS	SEDS	State Energy Data Systems
	Natural Gas, Liquid	RCI, TXPT			CAP	Climate Action Plan
	Natural Gas, Compressed			CEP	Comprehensive Energy Plan	
	Propane	RCI		INV	Vermont GHG Inventory	
Petroleum Products	Motor Gasoline	TXPT		CAP, CEP, INV, SEDS	RCI	Residential, Industrial, Commercial Fuel Use
	Diesel (On-road & Non-Road)				TXPT	Transportation & Mobile Combustion
	Jet Fuel & Aviation Gasoline			CAP, INV, SEDS	EGEN	Electricity Generation
	Kerosene	RCI, TXPT		CAP, CEP, SEDS		
	Distillate Fuel Oils	EGEN, RCI		CAP, CEP, INV, SEDS		
Coal	Coal			INV, SEDS		

Pathways: Biofuel Blends, Renewables, and Other

Category	Pathway	Type	Prevalence	Reference Sources
Biofuel Blends	Biodiesel (soybean, waste oils)	RCI, TXPT	Established	CEP, SEDS
	Ethanol (corn)	TXPT		
	Cellulosic Ethanol (ag. waste and grass)	TXPT	Emerging	CEP
Nuclear	Nuclear Power (Imported)	EGEN	Established	INV, SEDS
Renewables	Solar Photovoltaic			CAP, CEP, INV, SEDS
	On-Shore Wind			
	Off-Shore Wind			
	HydroQuebec Mix			
	Regional Hydroelectric		Established	
	Woody Biomass			
Renewable Natural Gas	Landfill Methane	EGEN, RCI	Emerging	CAP, CEP
	RNG from Animal Waste			

Abbv	Definition
SEDS	State Energy Data Systems
CAP	Climate Action Plan
CEP	Comprehensive Energy Plan
INV	Vermont GHG Inventory
RCI	Residential, Industrial, Commercial Fuel Use
TXPT	Transportation & Mobile Combustion
EGEN	Electricity Generation

Pathways: Criteria for Dataset Selection

Table to be populated for each energy pathway

Activity	Pathway
Approach	Tools, resources, models, and/or literature used to inform inventories and emission factors (GHG plus others) pertaining to the pathway. Outline of system scope represented by the method for the given pathway. Other key details favoring this method for performing the pathway life cycle assessment.
Source Category References	Sectors affected by or relevant to the pathway (e.g., Electricity, Residential). In some cases, data for fuel distribution is impacted by the target source category.
Result	How results from these methods will be presented, including species of greenhouse gases covered and available life cycle stages
Technological Scope	Details on the technological coverage of the modeled approach, such as the life cycle stages covered.
Geographic Scope	The geography pertaining to the pathway life cycle system(s), e.g., Global; National; Province/State; County/City; and Site specific.
Temporal Scope	The time period represented by the data source.
Alternate approaches considered*	Other methods of calculation considered, but not pursued for energy pathway life cycle assessment

*ERG will provide initial recommendations for data source, with alternative options included. Final data source selected after review by full VT project team.

Sample Table (DRAFT): Petroleum Fuels

Activity	Pathway
Approach	Argonne National Laboratory: Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) model.
Source Category References	Transportation, Residential, Commercial, Industrial, Electricity
Result	Emission factors, by major greenhouse gas species (CO ₂ , CH ₄ , N ₂ O), will be produced for each petroleum product consumed in Vermont. Results are available separately for crude production, petroleum refining, and product distribution.
Technological Scope	GREET models crude oil extraction using a weighted average approach for conventional crude and shale oil. GREET models transportation using average transmission distance and mode data for imported crudes and petroleum products circulating in the United States.
Geographic Scope	GREET results for petroleum products reflect the average mix of foreign and domestic crudes processed by U.S. refineries. For the purposes of this project, the default transportation parameters for crude oil in GREET are used. Petroleum refining reflects average U.S. conditions.
Temporal Scope	GREET results are presented in a time-series format, with some extending back to 1990. Parameters that vary across the time series relevant to petroleum product supply chains include: sources of crude oil, combustion emission factors (e.g., industrial boilers), refinery efficiency, and national electricity mix
Alternate approaches considered	Alternative models for extraction and refining include the <i>Oil Production Greenhouse Gas Emissions Estimator</i> , <i>Petroleum Refining Life Cycle Inventory Model</i> , respectively. Both models require large amounts of input data that are unavailable for specific crudes used for fuels consumed in Vermont.

Pathways: Emissions Factor Format

Sector	Sub-Sector Category	Pathway	Stage	Greenhouse Gas	1990	1991	...	2019	2020
Energy	Residential	Natural Gas	Production	CO ₂	E.F.	E.F.		E.F.	E.F.
Energy	Residential	Natural Gas	Production	CH ₄	E.F.	E.F.		E.F.	E.F.
Energy	Residential	Natural Gas	Production	N ₂ O	E.F.	E.F.		E.F.	E.F.
Energy	Residential	Natural Gas	Transmission	CO ₂	E.F.	E.F.		E.F.	E.F.
Energy	Residential	Natural Gas	Transmission	CH ₄	E.F.	E.F.		E.F.	E.F.
Energy	Residential	Natural Gas	Transmission	N ₂ O	E.F.	E.F.		E.F.	E.F.
...								...	

- Where “E.F.” is an emission factor value
- Stage categories will vary by pathway

Sensitivity Analyses

- Global warming potential factor (20y, 100y; different Assessment Report versions)
- Inclusion / exclusion of biogenic carbon dioxide
- Transportation distance assumptions
- Key pathway-specific modeling sensitivities (e.g., allocation methods for biomass co-products, methane emissions during upstream natural gas stages, type of biofuel feedstock)

Pathways: Questions and Discussion

Activity
Approach
Source Category References
Result
Technological Scope
Geographic Scope
Temporal Scope
Alternate approaches considered

- Questions on choice of energy pathways?
- Questions on criteria for selecting life cycle data?
- Fields that would be helpful additions?
- Additional data source criteria?