From: Richard Heede
To: Lazorchak, Jane
Cc: Rick Heede
Subject: Response to ANR"s RFI
Date: Tuesday, October 1, 2024 9:43:26 AM
Attachments: CAI ResponseRFI cvrltr Oct24.pdf
CAI ResponseRFI Oct24.pdf

Good morning, Jane – I am pleased to be able to respond to ANR' request for information.

I have thought through the process of identifying the companies that may qualify as responsible parties, provided some guidance on sources of data, described in some detail how the calculations should be made using the EPA emission factors, and suggested how to sum the emissions of responsible parties from 1995 to 2024 for companies that produce or refine crude oil as well as natural gas and coal (if applicable).

Do let me know if you have any questions or any suggested additions or changes.

Respectfully, -Rick

PS: You can ignore the first email with the string of previous emails. The attachments are identical.

****************@*******************

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In Response to Request for Information on: Development of a Climate Superfund Cost Recovery Program

By Richard Heede,
Director, Climate Mitigation Services
1 October 2024

To Jane Lazorchak
Director, Climate Action Office
Vermont Agency of Natural Resources
Montpelier, VT

Dear Ms. Lazorchak -

I am pleased to respond to the Agency's Request for Information. In the attached response I have focused on replying to Questionnaire #1:

> *Describe a stepwise process to identify responsible parties, determine their applicable share of covered greenhouse gas emissions, and determine the cost recovery demand amount as described in Act 122. In doing so, please identify the datasets (publicly available) and describe the methodology and research the approach is based on. Provide an evaluation of the comprehensiveness and accuracy of those data sets. If appropriate, evaluate the utility of using additional information not publicly available to determine cost recovery demands.*

I will make reference to the Act 122 as passed and its language so as to align my response with the specific intent and reporting requirements of the Act.

My intent, therefore, is to provide actionable information to the Agency of Natural Resources on how to identify the responsible parties, how to access information on the fossil fuel production of these parties, how to use the emission factors referenced in the Act, and guidance to resources available to determine which of the potential responsible parties have a business relationship with the State of Vermont and/or its citizens, consumers, or businesses.

I have no expertise in quantifying a cost estimate of the covered greenhouse gas emissions to the State of Vermont, and will leave that crucial step to other experts.

Please let me know if you have comments or questions.

Respectfully,

Richard Heede

Director, Climate Accountability Institute.

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The Agency of Natural Resources (ANR) has been given the task in Act 122 to identify the companies that produced or refined fossil fuels that cumulatively caused the emission of 1 billion tonnes or more of carbon dioxide-equivalent greenhouse gases ($GtCO_2e$) from 1995 to 2024.

This requires two distinct datasets, in stepwise order, and a crucial analysis in step #2:

1. A comprehensive list of domestic and international investor- or state-owned companies that extract or refine fossil fuel resources globally: crude oil and other fossil liquids, fossil gas, and fossil coal;
2. An analysis of which of the companies qualify as "responsible parties" from the perspective of meeting the definition of a constitutionally sound economic nexus with the State of Vermont;
3. Annual data on each company's extraction of fossil fuels or refining of petroleum products for distribution to global consumers over the covered period from 1995 to 2024. The list of included companies and their annual production shall also account for pertinent mergers and acquisitions.

The objective of Act 122 also requires a robust methodology to estimate and attribute emissions from production and/or refining for each responsible party, and on that basis allocate proportional responsibility for damages:

4. A methodology for estimating emissions by global consumers based on quantities of fossil fuel produced and refined;
5. As specified in (§596, 7; §597, 2), the proportional responsibility of "responsible parties" shall be determined on the basis of total "covered greenhouse gas emission" of each entity in the covered period in proportion to global fossil fuel emissions in the covered period.
6. Step #5 provides the allocation factors proportional to their emissions that can be used to quantify cost recovery demands.

In this response to the Request for Information I will discuss applicable data sources and methodological approaches to effectively inform the Agency's task. The results, once completed, can be applied to the cost recovery demands once the damages have been finalized.

1. Identifying major fossil fuel production or refining companies

A number of publicly available sources identify the companies that explore for and discover fossil fuel resources, make infrastructure investments to convert resources into recoverable reserves, extract that oil or natural gas or coal, process or refine that production into marketable carbon fuels, and sell those finished fuels to wholesalers or distribute the finished fuels through their own supply chains to global consumers. Identification of those companies is relatively straightforward, albeit piecemeal, and in my experience it takes reading and collating from diverse sources.[1]

Act 122 states that companies with emissions exceeding 1 billion tonnes CO_2 ($GtCO_2$) are included.

2. Selecting the companies that qualify on the basis of a constitutional nexus with Vermont

Most of the 70 to 80 companies in the list in Appendix Figure A-1 do not have a qualifying economic nexus with the State of Vermont or its citizens or businesses. Parsing the list to include only those companies that qualify, and can thus be legally served with a demand for payment, is a crucial time-saving step prior to the following step #3 of collecting data on prospective "responsible parties" and each of their production or refining of crude oil, natural gas, and coal.

A number of potential criteria need to be considered. For example, fossil fuel producers or refiners that distribute petroleum products such as gasoline, home heating oil, and jet fuel to the State or its citizens and businesses will qualify for inclusion. However, major oil producers and refiners sell petroleum products to independent service stations or through wholesalers/retailers of gasoline, diesel, jet fuel, and home heating oil. Should coal or gas producers that provide coal and fossil gas to out-of-state power plants serving customers in Vermont be included? These boundary definitions are important in setting a workable scope for the project. The objective is not to trace molecules of carbon fuels sold to Vermont consumers but to identify the fossil fuel producers and refiners that have an economic nexus to the State, or are suppliers of carbon fuels to companies that do.

ANR, through its comprehensive research on Vermont's greenhouse gas emissions, can identify many of the qualifying companies.[2] Vermont's State Treasurer can provide relevant information on which fossil fuel producers or refiners have an economic nexus or taxpayer status with the State. It is beyond the scope of the RFI response to define the criteria for determining which potentially "responsible parties" are to be included in the final list. I suggest to start with a provisional list of U.S. and international oil & gas producers or refiners that have retail gas stations in Vermont (Shell, Chevron, Exxon, Valero, Sunoco, etc.), and expand that list to include jet fuel suppliers (BP), home heating oil, natural gas companies (and their suppliers), gas suppliers to regional power plants and gas distributors, and so on. See Appendix Table A-1 for a provisional short list.

3a. Acquiring annual fossil fuel production data

Many published sources compile leading fossil fuel producers and provide at least partial data on annual production by fuel. Especially useful are the historical annual reports by *Oil & Gas Journal* (since ~1980s) and the US EIA *Annual Coal Report.* Bear in mind that most resource-tracking

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[1] Act 122 (§596, 13) defines fossil fuel business as "a business engaging in the extraction of fossil fuels or the refining of petroleum products." As a practical matter, the Act's focus is on large corporate entities, the parent companies, such as ExxonMobil Corp or Shell plc, and not the dozens or 100s of subsidiary companies (e.g., ExxonMobil Kazakhstan Ventures Inc., Imperial Oil Ltd [Canada], or Esso Trading of Abu Dhabi). We do not include or attribute emissions to the thousands of subcontractors that provide oil field services, mining equipment, product transport by pipeline, trucks, marine tankers, or rail companies, bulk fuel storage, or the many fuel distributors to consumers, such as Packard Fuels in Montpelier, VT.

[2] Vermont Agency of Natural Resources (2023) *Vermont GHG Emissions Inventory and Forecast: 1990-2020*, April, 33 pp. https://anr.vermont.gov/content/anr-climate-action-office-releases-annual-greenhouse-gas-emissions-inventory-vermont

publications focus on national and international fossil fuel production by *nations* (e.g., United Nations Statistical Division, and the respected BP *Statistical Review of World Energy* (since 1952, series now transferred to Energy Institute), but provide no data on *company* production. Other datasets include International Energy Agency, World Resources Institute (ClimateWatchData), and the European Commission's Emissions Database for Global Atmospheric Research (EDGAR).[3]

In my experience no single source provides comprehensive data on *company* production of any of the major fossil fuels, especially not historically since 1995 — except for the Carbon Majors dataset discussed below. Even the highly useful *Oil & Gas Journal* OGJ100 and OGJ150 data series that provides oil and gas production data for most domestic and international producers often has to show oil and gas production data as "not available" — especially for state-owned companies.

No single source lists company production across all fossil fuels either by carbon content or energy content (Btus or gigajoules, GJ), and none track companies' diverse production since 1995, as Act 122 requires. Useful, if incomplete, sources include:

Oil & Gas Journal OGJ150 (domestic) and OGJ100 (international).[4] www.ogj.com

World Coal, www.worldcoal.com

BP Energy Statistics / Energy Institute, www.energyinst.org

Global Energy Monitor, https://globalenergymonitor.org

Resource World, https://resourceworld.com/coal-production-update/

National Mining Association *Coal Producer Survey* (active 1990s-~2015; discontinued)

U.S. Energy Information Administration: *Annual Coal Report*, Table 10. Major U.S. Coal Producers, https://www.eia.gov/coal/annual/

U.S. EIA: *US refineries*, 1994-2022: https://www.eia.gov/petroleum/refinerycapacity/archive/

Urgewald, Germany: *2022 Global Coal Exit List: No Transition in Sight*, www.urgewald.org/en/medien/urgewalds-2022-global-coal-exit-list-no-transition-sight

Urgewald: Gogel (*Global Oil & Gas Exit List*): https://gogel.org/about (sign-in required)

One data source merits special mention. CDP (formerly Carbon Disclosure Project; www.cdp.net), accepts submissions from hundreds of companies on climate, energy, water, and so forth. Several dozen oil, gas, and coal companies submit answers to CDP questionnaires on energy production as well as scope 1, 2, and 3 emissions. Company submissions are only from ~2008 forwards, and limited to certain companies and years. CDP membership is required; data access is negotiable.[5]

In addition, other paywall subscriptions have data series on companies and fossil fuel production:[6]

Bloomberg Energy www.bloomberg.com,

IHS Global Insight www.energy.ihs.com,

WoodMacKenzie www.woodmacresearch.com,

Evaluate Energy; https://info.evaluateenergy.com/corporate-financial-operating-data/, and

Rystad Energy (Norway): www.rystadenergy.com.

In sum, publicly available sources report annual production, but none do so consistently for all companies since 1995.

[3] European Commission, *Emissions Database for Global Atmospheric Rsrch*, https://edgar.jrc.ec.europa.eu/dataset_ghg70 (no charge). >>> International Energy Agency, *Greenhouse Gas Emissions from Energy*, https://www.iea.org/data-and-statistics/data-product/greenhouse-gas-emissions-from-energy. Cost: 640 Euro. >>> United Nations Statistical Division (2021) *Energy Statistics Yearbook*, $90 PDF / $180 print. https://unstats.un.org/unsd/energystats/pubs/yearbook/

[4] Typically in OGJ's September issue.

[5] Katherine Camp, Cities, States, Regions & Public Authorities, CDP, katherine.camp@cdp.net.

[6] I have limited experience with these databases, and cannot evaluate their completeness or accuracy.

It is my opinion that a comprehensive dataset on corporate production of fossil oil, gas, and coal by year since 1995 is best based on original *company-reported* production data in annual reports and SEC 10-K filings; such material disclosure has been required since the U.S. Securities Exchange Act of 1934.[7] The data acquisition process requires downloading these reports at least every third year from 1997 to 2024, because companies typically report three years of financial and operating data. Company-reporting has the advantage of accuracy and completeness. ANR, or its contractor, would copy operational data into a spreadsheet or similar platform for each identified company, convert to annual production by type, and apply the EPA emission factors.[8] See guidance in section 4.

My non-profit institute — Climate Accountability Institute — has collected company-reported production data in its Carbon Majors dataset. That dataset attributed emissions to 100 oil, gas coal, and cement companies.[9] The Carbon Majors dataset will be discussed more fully below.

3b. Acquiring annual fossil fuel refinery output data

As with oil and gas production data, the most reliable and comprehensive data on refinery output is typically reported in company annual reports or SEC 10-Ks. I am not aware of an industry-wide data source that reports petroleum refinery output either in total output or by product type. A refinery dataset by company and each of its refineries is available from the EIA, but this contains data on refinery *capacity*, not utilization rate or output.[10]

Furthermore, some major refining companies are privately-held, such as Koch Industries / Flint Hills LP and Motiva (owned by Saudi Aramco), and privately-held companies are not required to publish actual refinery input, capacity, utilization, or refinery production data. Practically speaking, some integrated oil companies report only refinery capacity or utilization rate, whereas other companies report only partial output data, if at all, for several years from 1995 to 2024.

The paucity of actionable refinery output data can be ameliorated by the State formally requesting refinery data on refinery product output from each of the responsible parties, once that list has been finalized.

4a. Methodology for estimating emissions from production

A robust methodology has to be applied to fossil fuel production data in order to reasonably quantify emissions from production and/or refining and combustion of each carbon fuel by global consumers. Some oil and gas companies have in recent years estimated emissions from sold products — petroleum products and natural gas available for sale — but these are in the minority. Too few of the likely "responsible parties" that have a business nexus with the State of Vermont estimate their scope 3 emissions, and a methodology applicable to the ANR is required.

As stated in Act 122, the State is to estimate emissions attributable to fossil fuel producers using the US EPA "Emission Factor Hub" for specific factors, in the following manner:[11] See Appendix Fig. A-4.

Per million bbl of **crude oil production**:

Eq. 1. CO_2 from combustion: (10.29 $kgCO_2$/gallon) * 42 gal/bbl = 432.18 $kgCO_2$/bbl = 0.432 tCO_2/bbl = 0.432 million tonnes CO_2 per million bbl, or 0.432 $MtCO_2$/Mb.

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[7] 20-F reports for foreign companies, and 40-F reports for Canadian companies that have securities trading in the U.S.

[8] Companies report oil and liquids production in thousand bbl per day, gas in million cubic feet per day, and coal in short tons of metric tonnes per year. See the formulas in section 4.

[9] https://climateaccountability.org/carbon-majors-dataset-2020/

[10] Energy Information Administration (2024) *Refinery Capacity Report 1982-2024*. https://www.eia.gov/petroleum/refinerycapacity/

[11] U.S. Environmental Protection Agency (2024) *Emission Factor Hub for Greenhouse Gas Inventories*, last modified June. https://www.epa.gov/climateleadership/ghg-emission-factors-hub Note: we show EPA data in units commonly reported for oil production (thousand bbl per day * 0.365 = Mb/yr; million cf/day * 0.365 = Bcf/yr; 1.1023 shtons = 1 tonne).

Eq. 2. CH_4: (0.41 gCH_4/gallon) * 42 gal/bbl = (17.22 gCH_4/bbl) * GWP of 28*CO_2 = 0.482 $kgCO_2e$/bbl, or 0.00048 $MtCO_2e$/Mb.

Eq. 3. N_2O: (0.08 gN_2O/gallon) * 42 gal/bbl = (3.36 gN_2O/bbl) * GWP of 265*CO_2 = 0.890 $kgCO_2e$/bbl, or 0.00089 $MtCO_2e$/Mb.

Applying the EPA emission factors for methane and nitrous oxide and converted to CO_2-equivalent from the EPA-reported Global Warming Potential (GWP), each comprise less than 1% of the total emissions for crude oil (0.11% and 0.21%, respectively). Likewise, combustion of natural gas accounts for methane and nitrous oxide of 0.05% and 0.05%, respectively, and for coal methane and nitrous oxide account for 0.32% and 0.45%, respectively. In my opinion, these minor factors are *not material and should be eliminated from computation*.[12] If this recommendation is accepted, we need only refer to emissions CO_2 (not greenhouse gases), and ignore methane and nitrous oxide. If ANR wishes to follow Act 122's inclusion of all EPA combustion-related emissions and include methane and nitrous, the Agency can follow the formulas above.

Thus, for natural gas and coal we only show the formula for CO_2 from combustion:

Per billion cubic feet of **natural gas production** (scf: standard cubic feet, Bcf: billion cubic feet):

Eq. 4. CO_2 from combustion: 0.05444 $kgCO_2$/scf = 0.05444 $MtCO_2$/Bcf.

Per million metric tons (Mt) of **coal production** (utility sector) (EPA $kgCO_2$/short ton [sht]):

Eq. 5. CO_2 from combustion: 1,885 $kgCO_2$/sht = 1.885 $MtCO_2$/Msht/1.1023 sht/t = 1.710 $MtCO_2$/Mt.

4b. Methodology for estimating emissions from refining

A methodology similar to the production-based calculations described above can be applied to each qualified crude oil refiner. The EPA emission factors will be applied to annual refinery output from each responsible party, based on reported categories of petroleum products refined each year. These data are reported, when reported, in company annual reports and SEC 10-K filings.

Common reported refined petroleum products include, and the EPA emission factor for each:

Motor gasoline	8.78 $kgCO_2$/gallon	=	0.36876 $MtCO_2$/Mb
Diesel (distillate) fuel	10.21 $kgCO_2$/gallon	=	0.42882 $MtCO_2$/Mb
Jet fuel	9.75 $kgCO_2$/gallon	=	0.40950 $MtCO_2$/Mb
Heating oil	10.21 $kgCO_2$/gallon	=	0.42882 $MtCO_2$/Mb
Crude Oil	10.29 $kgCO_2$/gallon	=	0.43218 $MtCO_2$/Mb

In addition, most oil & gas companies report a basket of "lubricants, specialty, and other petroleum products," an ill-defined category that may (or may not) include products intended for combustion, such as petroleum coke, propane, or aviation fuel. These "other products" range from ~8% to 15% of total refinery output, of which an unknown percentage is for combustion products. In theory, estimating emissions from company refinery output is straightforward. However, it is likely to under-estimate emissions due to the obscurity and lack of detail on the "other refinery products."

Alternatively, ANR could estimate emissions from refinery output on the basis of *crude oil inputs* to its refineries, but would then need to account for refinery production of petrochemical feedstocks, road oil, lubricants, and other non-energy uses. The percentage of non-energy products vary by season, by company, and by refinery.

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[12] These small factors are not from upstream or mid-stream emissions from production or refining, which are substantial, and exclude scope 1 operational emissions. EPA footnote: "The factors represented in the table above represent combustion emissions only and do not represent upstream emissions."

4c. Combining estimated emissions from production and refining

Many of the companies on the list of responsible parties will be both producers *and* refiners of crude oil. This analyst assumes that the State will want to develop datasets on emissions from both production and refining for each year from 1995 to 2024, and to count only the higher value for each year so as to avoid double-counting. This concerns crude oil production and refining only: natural gas is typically reported by companies as "gas available for sale" — in other words, post-processing of raw gas into marketable gas. A preliminary view of two companies' production-based and refinery-based emissions are in Appendix Figures A-6 (Chevron) and A-7 (ExxonMobil).

Oil and gas majors also owned or acquired coal-producing assets, including Chevron (1965-2012), BP (1960-1989), ExxonMobil (1970-2002), and Shell (1979-1999). It is my opinion that emissions from coal production for the salient years 1995-forward should be included.

5. Determining applicable shares of global emissions

In order to "determine their applicable share of covered greenhouse gas emissions for the covered period from 1995 to 2024" one needs to compare product-related or refined product emissions for each company to global fossil fuel emissions over the same "covered period." The gold standard historical record of global carbon content of fossil fuel production and emissions upon combustion of fossil fuels is the CDIAC / GCB database, which permits calculation of each entity's share of covered global greenhouse gas emissions for 1995-2024.[13] A more limited alternative dataset of historical global CO_2 emissions is available from the European Commission EDGAR website.[14]

As a preliminary note, the CDIAC / GCB data for global combustion of oil, gas, and coal for 1995-2022 totals 825 $GtCO_2$; adding global oil, gas, and coal emissions for 2023-2024 will add ~35 $GtCO_2$ per year, thus a 1995-2024 total of ~896 $GtCO_2$.

6. Determining applicable shares of Vermont climate damages

The Act defines how to calculate each responsible party's share of certain global emissions and the share of the cost to the State of Vermont, i.e., the same ratio for each party's emissions and costs:

> **(§ 598, b):** *With respect to each responsible party, the cost recovery demand shall be equal to an amount that bears the same ratio to the cost to the State of Vermont and its residents, as calculated by the State Treasurer pursuant to section 599c of this title, from the emission of covered greenhouse gases during the covered period as the responsible party's applicable share of covered greenhouse gas emissions bears to the aggregate applicable shares of covered greenhouse gas emissions resulting from the use of fossil fuels extracted or refined during the covered period*.

Therefore, for each fossil fuel producer and/or refiner, the attributed emissions using the formulas above for each fuel produced over the covered period from 1995 to 2024 is to be divided by the total global emissions from the combustion of fossil fuels over the same period. This excludes emissions from cement production, and of flaring emissions from production and processing of crude oil and natural gas.

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[13] Boden, Tom, Bob Andres, & Gregg Marland (2017) *Global CO_2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2014*. Carbon Dioxide Information Analysis Center, Oak Ridge National Lab., US Dept of Energy, Oak Ridge TN. This dataset has been updated by Global Carbon Budget (Univ Exeter, under the auspices of the Global Carbon Project, www.globalcarbonproject.org): Friedlingstein, Pierre, et al. (2023) Global Carbon Budget 2023, Global Carbon Budget, *Earth Syst. Sci. Data*, vol. 15:5301–5369, https://essd.copernicus.org/articles/15/5301/2023/

Note: this dataset covers fossil fuel solids, liquids, and gases, as well as carbon content of flaring and process emissions from cement production; in all, these are referred to as "industrial emissions" and exclude anthropogenic emissions from deforestation, soil carbon, other carbon cycle "interferences," and also exclude non-energy methane [rice fields, animal husbandry, landfills], nitrous oxide, and F-gases.

[14] European Commission (2023) *Global Greenhouse Gas Emissions, EDGAR v8.0*. details CO_2 emissions for every country, https://edgar.jrc.ec.europa.eu/dataset_ghg80 but the dataset lacks summation of global emissions and dataset begins in 1970-forward. Archived previous versions summed global emissions for fossil fuel CO_2 and methane.

As an example, using the Carbon Majors results, Chevron's production-related emissions from 1995 to 2022 are ~7.21 $GtCO_2$ for oil, ~3.25 $GtCO_2$ for gas, and ~0.43 $GtCO_2$ for coal. Chevron's share is 10.9 $GtCO_2$ / 825 $GtCO_2$ = 1.32% of global fossil fuel emissions. (ANR's calculation will differ once updated.)[15] This percentage can be applied to cost recovery demands from each responsible party.

Carbon Majors database: a source of publicly available fossil fuel production data

To my knowledge the only comprehensive historical database of fossil fuel production by fossil fuel producing *companies* (both investor-owned and state-owned) is the Carbon Majors database compiled by the Climate Accountability Institute. A pioneering peer-reviewed scientific paper presenting the methods and results was published in 2014.[16]

In brief, the Carbon Majors methodology identifies fossil fuel producers with production that meets the threshold of ~8 million tonnes carbon (MtC) in a recent year, acquires historical production data from each entity's SEC 10-K filings or its Annual Report or third-party sources from as early as available on production of crude oil (including condensate and natural gas liquids), natural gas, and coal (by rank or carbon content). Individual worksheets were prepared for each producing entity for data entry on production for each fuel: crude oil in thousand bbl/day, natural gas in million cubic feet/day, and coal in metric tonnes (or short tons) per year. These were converted to million bbl/year (Mb), billion cubic feet/year (Bcf), and million tonnes (Mt). Emissions factors per Mb, Bcf, and Mt were modified from international standards (IPCC, EPA, API) in order to account for net non-energy uses of each fuel, such as crude oil sequestered in petrochemicals, road oil, and lubricants (~8.0% of production), natural gas to produce fertilizers (~1.9%), and minor quantities of coal used for pigments and carbon fiber (~0.02%).

The Carbon Majors database identifies all of the world's largest producers of oil, gas, and coal, and include all of the companies that have a business nexus with Vermont *and* have cumulative production-related emissions exceeding 1 $GtCO_2$. The database also estimates scope 1 operational emissions —including emissions from flaring, CO_2 from gas processing, own fuel use, and leaked and fugitive methane — which Vermont's Act 122 excludes in favor of its more direct methodology of production times EPA emission factors for each fossil fuel.

The Carbon Majors fossil fuel production dataset can be shared with Vermont's Agency of Natural Resources. Climate Accountability Institute (CAI) has posted fossil fuel production for 100 state-owned and investor-owned oil, gas, coal, and cement companies up to the year 2020.[17] CAI has updated data to 2022, which I am personally happy to share with ANR.

In addition, CAI has transferred all future updating of the Carbon Majors database to InfluenceMap (London), and they will be able to share data with ANR as well.[18]

Regarding refinery emissions, CAI's gathering of data on refinery output and associated emissions is neither comprehensive nor historically complete (company reporting, as discussed above, is variable). The institute has established a methodology but the results are in development.

Respectfully,

Richard Heede

Director, Climate Accountability Institute.

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15 As discussed below, the Carbon Majors methodology includes scope 1 operational emissions such as CO_2 emissions from own fuel use, natural gas processing, and flaring.

16 Heede, Richard (2014) Tracing anthropogenic CO_2 and methane emissions to fossil fuel and cement producers 1854-2010, *Climatic Change*, vol. 122(1): 229-241; http://link.springer.com/article/10.1007/s10584-013-0986-y?view=classic

17 https://climateaccountability.org/carbon-majors-dataset-2020/

18 InfluenceMap (2024) *The Carbon Majors Database Launch Rpt*, April. http://influencemap.org & https://carbonmajors.org

Appendix

The methodology and math, in brief

The sequence and summary of calculations

1. Gather data on company production of crude oil (and condensate and natural gas liquids), natural gas (often reported as "gas available for sale"); and coal for each year 1995 to 2024. Use company *Annual Reports* or SEC Form 10-K (US companies), 20-F (Canadian), or 40-F (international); account for mergers and acquisitions over the period 1995 to 2024;
2. Create worksheet for each entity, enter data in clearly-marked columns, using standard units, convert daily production into annual production, cite data sources in cell notes; show the math (which facilitates verification of the results);
3. Multiply annual production of crude oil and liquids in million bbl/yr by the EPA Emission Factor of 0.432 $MtCO_2$/Mb. Use the formula in Eq. 1 above;
4. Multiply annual production of natural gas, in billion cubic feet per year (Bcf) by the EPA Emission Factor 0.05444 $MtCO_2$/Bcf. Use the formula in Eq. 4;
5. Multiply annual production of coal, in million metric tonnes, by the EPA Emission Factor 1.710 $MtCO_2$/Mt. Use the formula in Eq. 5;
6. Results should be shown in million tonnes CO_2 ($MtCO_2$) per year, by fuel, for each entity;
7. Exclude companies whose total emissions exceed 1 GtCO2 over the covered period 1995-2024.

Calculations for refinery output emissions

8. Gather data on refinery output (aka "outturn") by refined petroleum products, for each entity;
9. Convert daily refinery output to annual output, by petroleum product;
10. Multiply annual refinery output of each petroleum product by the corresponding EPA emission factor (see page 5) in $MtCO_2$ per million bbl ($MtCO_2$/Mb);
11. Sum annual emissions by petroleum product for each entity.
12. Alternate: if refiner only reports "crude oil input to refineries" then estimate emissions by using the crude oil emission factor (table p. 5) but account for typical non-combusted/sequestered "other and specialty products" of 14.3% by reducing the EF from 0.43218 * (1-0.143) = 0.37038 $MtCO_2$/Mb.[19]

Calculate net emissions from crude oil and liquids production to emission from refining output

13. Compare product-related emissions to refinery output emissions, show the larger result;
14. Count only the larger quantity for each year 1995 to 2024.

Add emissions from natural gas production and coal production to petroleum emissions

15. Add natural gas and coal emissions to the larger of emissions from oil production or refining emissions for each entity from 1995 to 2024.

Calculate global fossil fuel emissions 1995-2024 and the share of each responsible party

16. Calculate sum of all global oil, gas, and coal emissions from the CDIAC / GCB dataset referenced above for 1995 to 2024.
17. Determine the share of each "responsible party's" emissions as a percent of global fossil fuel emissions 1995-2024.
18. Apply these factors to the determined climate damages estimated by Vermont's Treasurer.

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[19] Analysis of average "other and specialty products" (all presumed non-combusted) of BP, Chevron, ExxonMobil, Shell, and TotalEnergies, various years 1995-2022 by Climate Accountability Institute.

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Figure A-1. *Preliminary* list of all Carbon Major entities whose attributed emissions, including operational scope 1 emissions of CO_2 and methane, exceed 1 $GtCO_2e$ from 1995 to 2022.[20]

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Climate Accountability Institute
3-Apr-24

Global Fossil Fuel & Cement CO2 + CH4	950,196	MtCO2e

Global FF/Global GHG	70.37%

	1995-2022	MtCO2 & MtCH4		% global FF	% global GHG
		MtCO2e	data range	% of global FF	% of global GHG
1	Saudi Aramco, Saudi Arabia	45,548	2022	4.79%	3.37%
2	Gazprom, Russia	40,521	2022	4.26%	3.00%
3	National Iranian Oil Co.	25,512	2022	2.68%	1.89%
4	Coal India, India	23,437	2022	2.47%	1.74%
5	ExxonMobil, USA	18,092	2022	1.90%	1.34%
6	Royal Dutch Shell, The Netherlands	16,485	2022	1.73%	1.22%
7	PetroChina, China	15,372	2022	1.62%	1.14%
8	Petroleos Mexicanos (Pemex)	15,109	2022	1.59%	1.12%
9	BP, UK	14,609	2022	1.54%	1.08%
10	Chevron, USA	13,430	2022	1.41%	0.99%
11	Abu Dhabi, United Arab Emirates	13,418	2022	1.41%	0.99%
12	Peabody Energy, USA	12,064	2022	1.27%	0.89%
13	Rosneft, Russian Federation	10,979	2022	1.16%	0.81%
14	Petroleos de Venezuela (PDVSA)	10,600	2022	1.12%	0.78%
15	Sonatrach, Algeria	10,402	2022	1.09%	0.77%
16	Kuwait Petroleum Corp., Kuwait	10,350	2022	1.09%	0.77%
17	TotalEnergies, France	10,060	2022	1.06%	0.74%
18	Iraq National Oil Co., Iraq	9,355	2022	0.98%	0.69%
19	Petroleo Brasileiro (Petrobras), Brazil	9,034	2022	0.95%	0.67%
20	BHP Billiton, Australia	8,430	2022	0.89%	0.62%
21	ConocoPhillips, USA	8,154	2022	0.86%	0.60%
22	Lukoil, Russia	7,808	2022	0.82%	0.58%
23	Petronas, Malaysia	7,455	2022	0.78%	0.55%
24	Qatar Petroleum, Qatar	7,158	2022	0.75%	0.53%
25	Nigerian National Petroleum, Nigeria	7,117	2022	0.75%	0.53%
26	Equinor, Norway	6,694	2022	0.70%	0.50%
27	ENI, Italy	6,364	2022	0.67%	0.47%
28	Glencore, Switzerland	6,286	2022	0.66%	0.47%
29	Arch Resources, USA	5,691	2022	0.60%	0.42%
30	Alpha Met / Contura Energy, USA	5,485	2022	0.58%	0.41%
31	Rio Tinto, UK	5,285	2019 divest	0.56%	0.39%
32	Occidental, USA	5,136	2022	0.54%	0.38%
33	Anglo American, UK	5,108	2022	0.54%	0.38%
34	Repsol, Spain	4,499	2022	0.47%	0.33%
35	Libya National Oil Corp., Libya	4,057	2022	0.43%	0.30%
36	Sinopec, China	3,915	2018	0.41%	0.29%
37	CNOOC (China National Offshore Oil Co.)	3,910	2022	0.41%	0.29%
38	Pertamina, Indonesia	3,721	2022	0.39%	0.28%
39	Petoro. Norway	3,583	2018	0.38%	0.27%
40	Oil & Gas Corp India, India	3,516	2018	0.37%	0.26%
41	CONSOL Energy, USA	3,503	2022	0.37%	0.26%
42	RWE, Germany	3,403	2022	0.36%	0.25%
43	Suncor, Canada	3,358	2018	0.35%	0.25%
44	Sasol, South Africa	3,328	2022	0.35%	0.25%
45	Novatek, Russian Federation	3,097	2018	0.33%	0.23%
46	TurkmenGaz, Turkmenistan	2,915	2018	0.31%	0.22%
47	Sonangol, Angola	2,852	2022	0.30%	0.21%
48	Petroleum Development Oman	2,675	2018	0.28%	0.20%
49	Canadian Natural Resources, Canada	2,614	2022	0.28%	0.19%
50	Egyptian General Petroleum, Egypt	2,590	2018	0.27%	0.19%
51	Devon Energy, USA	2,564	2018	0.27%	0.19%
52	Ecopetrol, Colombia	2,561	2018	0.27%	0.19%
53	Holcim, Switzerland	2,522	2018	0.27%	0.19%
54	Singareni Collieries Company, India	2,506	2018	0.26%	0.19%
55	Exxaro, South Africa	2,174	2022	0.23%	0.16%
56	Murray Coal Corporation, USA	2,165	2022	0.23%	0.16%
57	EnCana, Canada	2,030	2018	0.21%	0.15%
58	Apache, USA	1,892	2022	0.20%	0.14%
59	Alliance, USA	1,778	2022	0.19%	0.13%
60	EOG Resources, USA	1,733	2018	0.18%	0.13%
61	Navajo Cloud Peak	1,688	2021	0.18%	0.13%
62	Marathon, USA	1,682	2022	0.18%	0.12%
63	Chesapeake Energy, USA	1,536	2022	0.16%	0.11%
64	Hess, USA	1,497	2022	0.16%	0.11%
65	PetroEcuador	1,436	2018	0.15%	0.11%
66	Bahrain Petroleum Corp.	1,299	2022	0.14%	0.10%
67	Teck Resources, Canada	1,289	2018	0.14%	0.10%
68	HeidelbergCement, Germany	1,253	2018	0.13%	0.09%
69	Husky, Canada	1,243	2022	0.13%	0.09%
70	Westmoreland, USA	1,197	2018	0.13%	0.09%
71	North American Coal, USA	1,088	2022	0.11%	0.08%
72	Wintershall, Germany	1,002	2018	0.11%	0.07%

[20] This list includes production-based emissions only, and excludes refining companies such as Koch/Flint Hills and Valero, both of which likely exceed 1 $GtCO_2$ for 1995-2024.

Carbon Majors list of emissions attributable to oil and gas producers that exceed 1 $GtCO_2$ from 1995 to 2022.[21]

The tables below list the entities shown in Figure A-1 after potentially responsible parties that are unlikely to meet the economic nexus with Vermont requirement are removed. A number of the companies listed in Table A-2 are potential additional "responsible parties" in Table A-1. Emissions attributed to each entity in million tonnes CO_2.

Table A-1. List of highly likely "responsible parties," in $MtCO_2$

ExxonMobil, USA (Exxon and Mobil)	18,092
Shell, UK	16,485
BP, UK	14,609
Chevron, USA (also Texaco)	13,430
Valero, USA	na
Sunoco, USA	na
Citgo (PDVSA)	na
Add companies that supply fossil gas to Vermont Gas Systems Inc.	
Add companies that supply gas or coal to regional (not in-state) power plants?	

Table A-2. List of potential additional "responsible parties," in $MtCO_2$

Saudi Aramco, Saudi Arabia	45,548
Petroleos Mexicanos (Pemex)	15,109
Peabody Energy, USA	12,064
Citgo / Petroleos de Venezuela (PDVSA)	10,600
TotalEnergies, France	10,060
ConocoPhillips, USA	8,154
Equinor, Norway	6,694
ENI, Italy	6,364
Arch Resources, USA	5,691
Alpha Met / Contura Energy, USA	5,485
Occidental, USA	5,136
Devon Energy, USA	2,564
Murray Coal Corporation, USA	2,165
Ovintiv (EnCana), Canada	2,030
Apache, USA	1,892
Alliance, USA	1,778
EOG Resources, USA	1,733
CONSOL Energy, USA	3,503
Suncor, Canada	3,358
Marathon Oil Corp., USA	1,682
Chesapeake Energy, USA	1,536
Hess, USA	1,497
North American Coal, USA	1,088
Koch Industries / Flint Hills LP	na
Marathon Petroleum (refining)	na
Motiva (Saudi Aramco)	na

[21] The Carbon Majors methodology includes scope 1 operational emissions from fugitive methane and CO_2 from own fuel use, flaring, and vented CO_2, and also deduct for net non-energy uses of each fuel. The attributed emissions are thus somewhat higher than the methodology specified in Act 122, as are the global emissions.

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Figure A-2. Carbon Majors' coal production data for Peabody Energy, 1945-2022.[22]

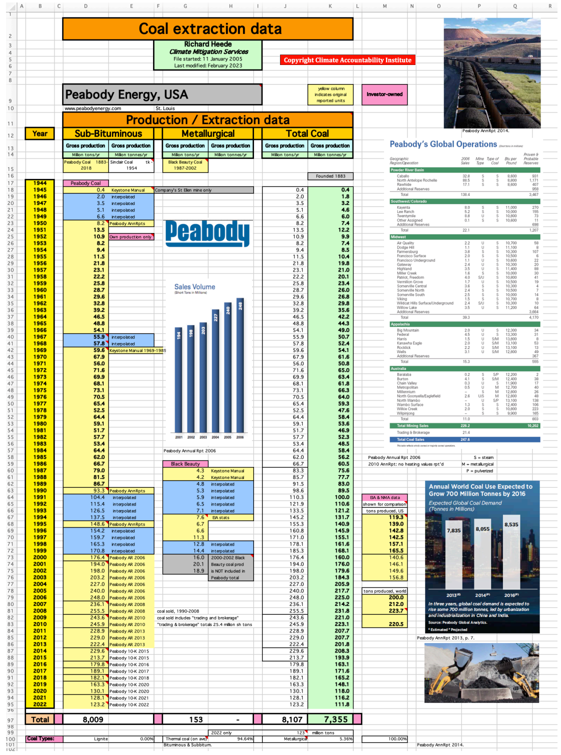
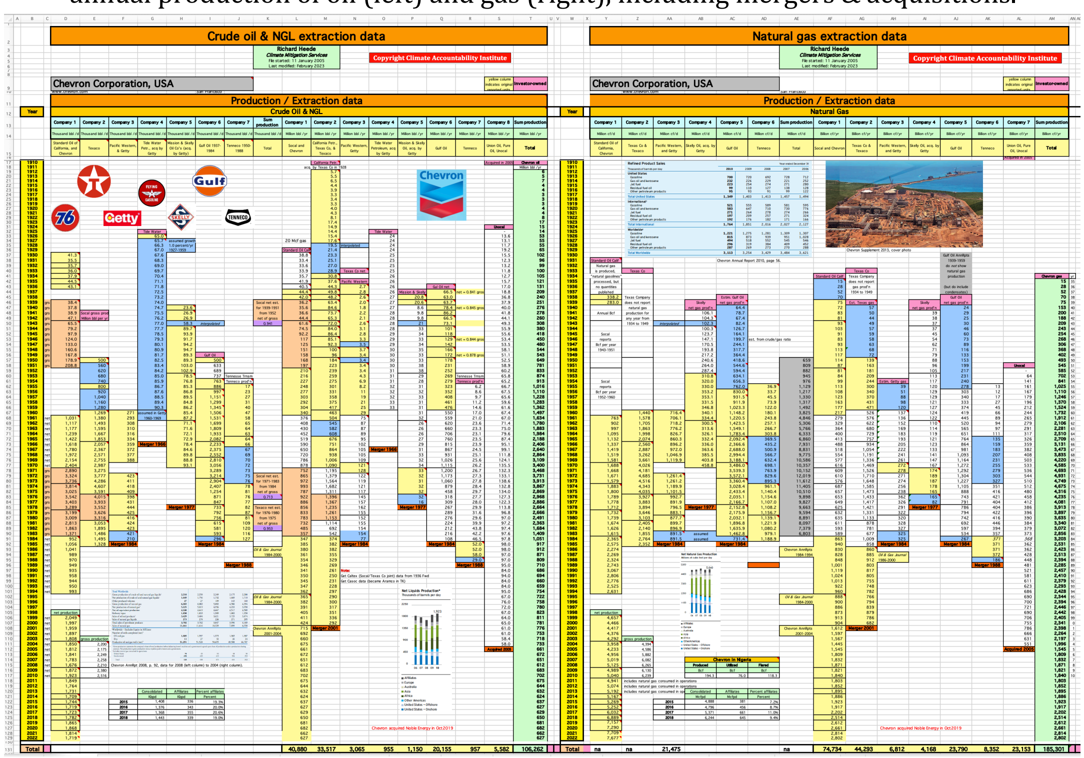


Figure A-3. Carbon Majors' oil & gas production data for Chevron, 1912-2022. The green columns sum annual production of oil (left) and gas (right), including mergers & acquisitions.



[22] Full PDF versions available at: https://climateaccountability.org/carbon-majors-dataset-2020/

Figure A-4. US EPA emission factors referenced in Act 122.[23]

Fuel Type	Heat Content (HHV)	CO_2 Factor	CH_4 Factor	N_2O Factor	CO_2 Factor	CH_4 Factor	N_2O Factor
	mmBtu per short ton	kg CO_2 per mmBtu	g CH_4 per mmBtu	g N_2O per mmBtu	kg CO_2 per short ton	g CH_4 per short ton	g N_2O per short ton
Coal and Coke							
Anthracite	25.09	103.69	11	1.6	2,602	276	40
Bituminous	24.93	93.28	11	1.6	2,325	274	40
Sub-bituminous	17.25	97.17	11	1.6	1,676	190	28
Lignite	14.21	97.72	11	1.6	1,389	156	23
Mixed (Commercial Sector)	21.39	94.27	11	1.6	2,016	235	34
Mixed (Electric Power Sector)	19.73	95.52	11	1.6	1,885	217	32
Mixed (Industrial Coking)	26.28	93.90	11	1.6	2,468	289	42
Mixed (Industrial Sector)	22.35	94.67	11	1.6	2,116	246	36
Coal Coke	24.80	113.67	11	1.6	2,819	273	40
Other Fuels - Solid							
Municipal Solid Waste	9.95	90.70	32	4.2	902	318	42
Petroleum Coke (Solid)	30.00	102.41	32	4.2	3,072	960	126
Plastics	38.00	75.00	32	4.2	2,850	1,216	160
Tires	28.00	85.97	32	4.2	2,407	896	118
Biomass Fuels - Solid							
Agricultural Byproducts	8.25	118.17	32	4.2	975	264	35
Peat	8.00	111.84	32	4.2	895	256	34
Solid Byproducts	10.39	105.51	32	4.2	1,096	332	44
Wood and Wood Residuals	17.48	93.80	7.2	3.6	1,640	126	63
	mmBtu per scf	kg CO_2 per mmBtu	g CH_4 per mmBtu	g N_2O per mmBtu	kg CO_2 per scf	g CH_4 per scf	g N_2O per scf
Natural Gas							
Natural Gas	0.001026	53.06	1.0	0.10	0.05444	0.00103	0.00010
Other Fuels - Gaseous							
Blast Furnace Gas	0.000092	274.32	0.022	0.10	0.02524	0.000002	0.000009
Coke Oven Gas	0.000599	46.85	0.48	0.10	0.02806	0.000288	0.000060
Fuel Gas	0.001388	59.00	3.0	0.60	0.08189	0.004164	0.000833
Propane Gas	0.002516	61.46	3.0	0.60	0.15463	0.007548	0.001510
Biomass Fuels - Gaseous							
Landfill Gas	0.000485	52.07	3.2	0.63	0.025254	0.001552	0.000306
Other Biomass Gases	0.000655	52.07	3.2	0.63	0.034106	0.002096	0.000413
	mmBtu per gallon	kg CO_2 per mmBtu	g CH_4 per mmBtu	g N_2O per mmBtu	kg CO_2 per gallon	g CH_4 per gallon	g N_2O per gallon
Petroleum Products							
Asphalt and Road Oil	0.158	75.36	3.0	0.60	11.91	0.47	0.09
Aviation Gasoline	0.120	69.25	3.0	0.60	8.31	0.36	0.07
Butane	0.103	64.77	3.0	0.60	6.67	0.31	0.06
Butylene	0.105	68.72	3.0	0.60	7.22	0.32	0.06
Crude Oil	0.138	74.54	3.0	0.60	10.29	0.41	0.08
Distillate Fuel Oil No. 1	0.139	73.25	3.0	0.60	10.18	0.42	0.08
Distillate Fuel Oil No. 2	0.138	73.96	3.0	0.60	10.21	0.41	0.08
Distillate Fuel Oil No. 4	0.146	75.04	3.0	0.60	10.96	0.44	0.09
Ethane	0.068	59.60	3.0	0.60	4.05	0.20	0.04
Ethylene	0.058	65.96	3.0	0.60	3.83	0.17	0.03
Heavy Gas Oils	0.148	74.92	3.0	0.60	11.09	0.44	0.09
Isobutane	0.099	64.94	3.0	0.60	6.43	0.30	0.06
Isobutylene	0.103	68.86	3.0	0.60	7.09	0.31	0.06
Kerosene	0.135	75.20	3.0	0.60	10.15	0.41	0.08
Kerosene-Type Jet Fuel	0.135	72.22	3.0	0.60	9.75	0.41	0.08
Liquefied Petroleum Gases (LPG)	0.092	61.71	3.0	0.60	5.68	0.28	0.06
Lubricants	0.144	74.27	3.0	0.60	10.69	0.43	0.09
Motor Gasoline	0.125	70.22	3.0	0.60	8.78	0.38	0.08
Naphtha (<401 deg F)	0.125	68.02	3.0	0.60	8.50	0.38	0.08
Natural Gasoline	0.110	66.88	3.0	0.60	7.36	0.33	0.07
Other Oil (>401 deg F)	0.139	76.22	3.0	0.60	10.59	0.42	0.08
Pentanes Plus	0.110	70.02	3.0	0.60	7.70	0.33	0.07
Petrochemical Feedstocks	0.125	71.02	3.0	0.60	8.88	0.38	0.08
Propane	0.091	62.87	3.0	0.60	5.72	0.27	0.05
Propylene	0.091	67.77	3.0	0.60	6.17	0.27	0.05
Residual Fuel Oil No. 5	0.140	72.93	3.0	0.60	10.21	0.42	0.08
Residual Fuel Oil No. 6	0.150	75.10	3.0	0.60	11.27	0.45	0.09
Special Naphtha	0.125	72.34	3.0	0.60	9.04	0.38	0.08
Unfinished Oils	0.139	74.54	3.0	0.60	10.36	0.42	0.08
Used Oil	0.138	74.00	3.0	0.60	10.21	0.41	0.08

Gas	100-Year GWP
CH_4	28
N_2O	265

Source: Intergovernmental Panel on Climate Change (IPCC), Fifth Assessment Report (AR5), 2013. See the source note to Table 11 for further explanation.

[23] 23 U.S. Environmental Protection Agency (2024) *Emission Factor Hub for Greenhouse Gas Inventories*, last modified June. https://www.epa.gov/climateleadership/ghg-emission-factors-hub

Figure A-5. Vermont Historic Greenhouse Gas Emissions by Sector, 1990-2020.[24]

Appendix A – Vermont Historic Greenhouse Gas Emissions by Sector[23]

Sector	Million Metric Tons CO_2 Equivalent: $MMTCO_2e$																					
	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Electricity Supply & Demand (consumption based)	**1.09**	**0.77**	**0.43**	**0.52**	**0.55**	**0.64**	**0.76**	**0.64**	**0.54**	**0.35**	**0.34**	**0.39**	**0.43**	**0.43**	**0.93**	**0.81**	**0.84**	**1.00**	**0.92**	**0.62**	**0.31**	**0.25**	**0.18**
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.05	0.00	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00
Oil	0.01	0.01	0.06	0.03	0.01	0.02	0.02	0.01	0.02	0.02	0.03	0.04	0.04	0.04	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00
Wood (CH_4 & N_2O)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Residual System Mix	1.03	0.75	0.35	0.47	0.51	0.59	0.71	0.62	0.51	0.31	0.29	0.34	0.36	0.37	0.90	0.78	0.81	0.96	0.90	0.60	0.30	0.24	0.16
Residential / Commercial / Industrial (RCI) Fuel Use	**2.54**	**2.51**	**3.02**	**2.95**	**2.78**	**2.98**	**3.32**	**3.06**	**2.89**	**2.79**	**2.54**	**2.74**	**2.56**	**2.58**	**2.32**	**2.54**	**2.74**	**2.94**	**2.70**	**2.70**	**2.94**	**3.00**	**2.87**
Coal	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.31	0.37	0.50	0.42	0.44	0.45	0.47	0.45	0.43	0.48	0.46	0.46	0.45	0.46	0.43	0.51	0.57	0.64	0.65	0.65	0.75	0.76	0.71
Oil, Propane & Other Petroleum	2.14	2.05	2.45	2.46	2.27	2.46	2.78	2.53	2.38	2.24	2.00	2.20	2.02	2.04	1.80	1.94	2.07	2.20	1.96	1.96	2.10	2.15	2.08
Wood (CH_4 & N_2O)	0.07	0.07	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.09
Wood combustion (biogenic CO_2 - not included in gross totals)	1.15	1.24	1.11	1.10	1.06	1.04	1.10	1.23	1.26	1.22	1.21	1.23	1.28	1.32	1.32	1.37	1.43	1.43	1.44	1.47	1.52	1.51	1.32
Transportation	**3.25**	**3.85**	**3.80**	**3.96**	**3.92**	**4.07**	**4.10**	**4.05**	**4.02**	**3.95**	**3.62**	**3.70**	**3.58**	**3.54**	**3.44**	**3.41**	**3.33**	**3.50**	**3.49**	**3.40**	**3.40**	**3.34**	**2.85**
Motor Gasoline (Onroad and Nonroad) (CO_2)	2.57	2.77	3.03	3.00	3.07	3.21	3.17	3.14	3.02	3.02	2.77	2.73	2.68	2.64	2.56	2.53	2.46	2.55	2.52	2.50	2.52	2.50	2.09
Diesel (Onroad and Nonroad) (CO_2)	0.45	0.85	0.54	0.73	0.66	0.67	0.65	0.65	0.70	0.68	0.63	0.66	0.73	0.72	0.71	0.72	0.71	0.79	0.81	0.76	0.75	0.71	0.65
Hydrocarbon Gas Liquids, Residual Fuel, Natural Gas (CO_2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jet Fuel & Aviation Gasoline (CO_2)	0.08	0.06	0.07	0.06	0.03	0.03	0.13	0.13	0.16	0.14	0.11	0.21	0.07	0.08	0.08	0.07	0.08	0.08	0.09	0.06	0.07	0.07	0.06
Non-Energy Consumption - Lubricants (CO_2)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
All Mobile (CH_4, N_2O)	0.13	0.15	0.14	0.15	0.14	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.08	0.07	0.07	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04
Ethanol + Biodiesel (biogenic CO2 - not included in gross totals)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.13	0.18	0.17	0.17	0.18	0.20	0.19	0.19	0.22	0.22	0.19	0.19	0.17
Fossil Fuel Industry	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**
Natural Gas Distribution	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas Transmission	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Industrial Processes	**0.21**	**0.40**	**0.53**	**0.43**	**0.45**	**0.44**	**0.45**	**0.44**	**0.46**	**0.45**	**0.44**	**0.40**	**0.47**	**0.67**	**0.64**	**0.60**	**0.60**	**0.62**	**0.61**	**0.60**	**0.59**	**0.63**	**0.65**
ODS Substitutes	0.00	0.05	0.13	0.15	0.15	0.16	0.17	0.18	0.20	0.21	0.22	0.23	0.25	0.26	0.28	0.29	0.31	0.32	0.33	0.34	0.34	0.36	0.37
Electric Utilities (SF_6)	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Semiconductor Manufacturing (HFCs, PFCs & SF_6)	0.16	0.28	0.34	0.24	0.25	0.24	0.22	0.21	0.23	0.21	0.20	0.14	0.18	0.37	0.33	0.27	0.25	0.26	0.24	0.23	0.22	0.23	0.24
Limestone & Dolomite Use	0.00	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.04	0.03	0.03	0.02	0.02	0.03	0.03
Soda Ash Use	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urea Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Management	**0.27**	**0.33**	**0.36**	**0.36**	**0.35**	**0.35**	**0.35**	**0.35**	**0.35**	**0.35**	**0.35**	**0.28**	**0.29**	**0.30**	**0.25**	**0.23**	**0.21**	**0.17**	**0.15**	**0.15**	**0.16**	**0.16**	**0.16**
Solid Waste	0.21	0.27	0.30	0.29	0.29	0.28	0.28	0.28	0.28	0.27	0.27	0.21	0.21	0.23	0.18	0.15	0.14	0.10	0.08	0.07	0.08	0.08	0.08
Composting	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Wastewater	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.07
Agriculture	**1.24**	**1.16**	**1.24**	**1.30**	**1.27**	**1.28**	**1.29**	**1.27**	**1.26**	**1.38**	**1.29**	**1.31**	**1.28**	**1.28**	**1.23**	**1.34**	**1.37**	**1.42**	**1.41**	**1.40**	**1.40**	**1.38**	**1.26**
Enteric Fermentation	0.70	0.67	0.69	0.68	0.67	0.66	0.65	0.63	0.63	0.64	0.64	0.64	0.62	0.63	0.62	0.64	0.64	0.63	0.64	0.64	0.64	0.63	0.61
Manure Management	0.18	0.19	0.26	0.29	0.30	0.32	0.31	0.33	0.32	0.33	0.34	0.33	0.33	0.33	0.32	0.32	0.32	0.34	0.36	0.35	0.36	0.35	0.33
Agricultural Soils	0.36	0.31	0.28	0.32	0.29	0.29	0.32	0.30	0.30	0.31	0.30	0.33	0.33	0.31	0.28	0.37	0.39	0.40	0.37	0.35	0.36	0.37	0.29
Liming and Urea Fertilization	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.01	0.01	0.00	0.00	0.01	0.03	0.05	0.05	0.05	0.04	0.04	0.03
TOTAL GROSS EMISSIONS	**8.61**	**9.03**	**9.39**	**9.53**	**9.33**	**9.77**	**10.27**	**9.83**	**9.54**	**9.30**	**8.59**	**8.84**	**8.62**	**8.82**	**8.82**	**8.95**	**9.12**	**9.66**	**9.31**	**8.90**	**8.83**	**8.79**	**7.99**
Land-use, Land Use Change, and Forestry (LULUCF)	-9.14	-8.52	-7.83	-7.70	-7.36	-7.45	-7.43	-7.24	-7.09	-7.18	-6.84	-6.94	-6.84	-6.56	-6.46	-6.31	-6.39	-6.27	-6.22	-6.10	-6.02	-5.94	-5.92
Estimated Net Emissions Total	-0.53	0.52	1.56	1.83	1.97	2.32	2.84	2.59	2.45	2.12	1.76	1.90	1.78	2.26	2.36	2.64	2.73	3.39	3.09	2.80	2.82	2.86	2.07

[24] Vermont Agency of Natural Resources (2023) *Vermont GHG Emissions Inventory and Forecast: 1990-2020*, ANR, April, 33 pp. Appendix A. https://anr.vermont.gov/content/anr-climate-action-office-releases-annual-greenhouse-gas-emissions-inventory-vermont

Note: these figures are preliminary and with partial data, but are included as examples of Chevron's and ExxonMobil's differential emissions from production and refining. In Fig A-7 we show Esso/SONJ/Exxon data since 1950, but lack Mobil refinery data prior to its merger with Exxon in 1999. The Chevron data is more complete from 1990 forward, and shows that refinery output product emissions are in some years lower than production-based emissions.

Figure A-6. Chevron's estimated emissions from petroleum production, refinery output, and product sales 1950-2022; excludes natural gas and coal.

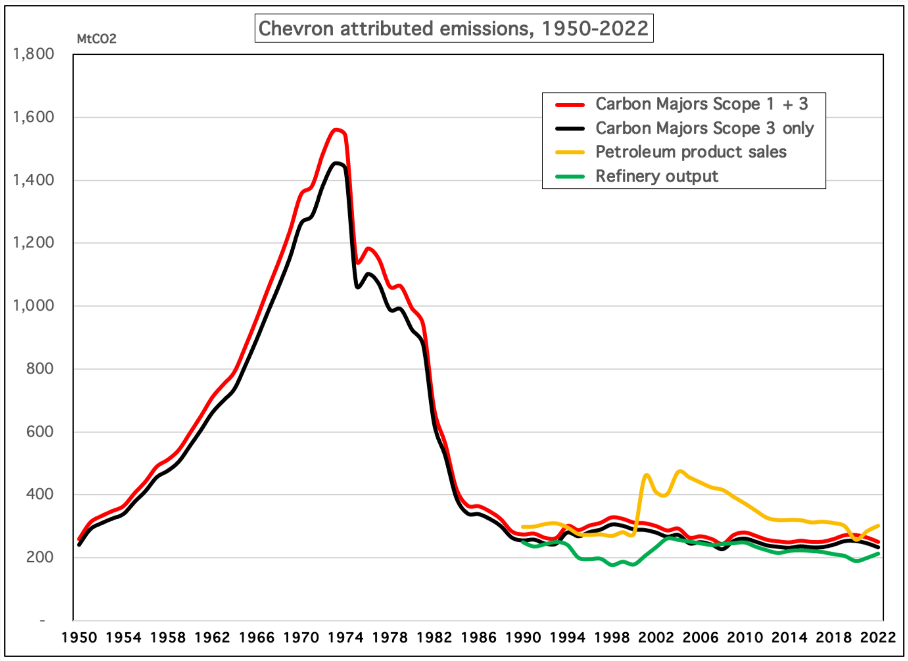
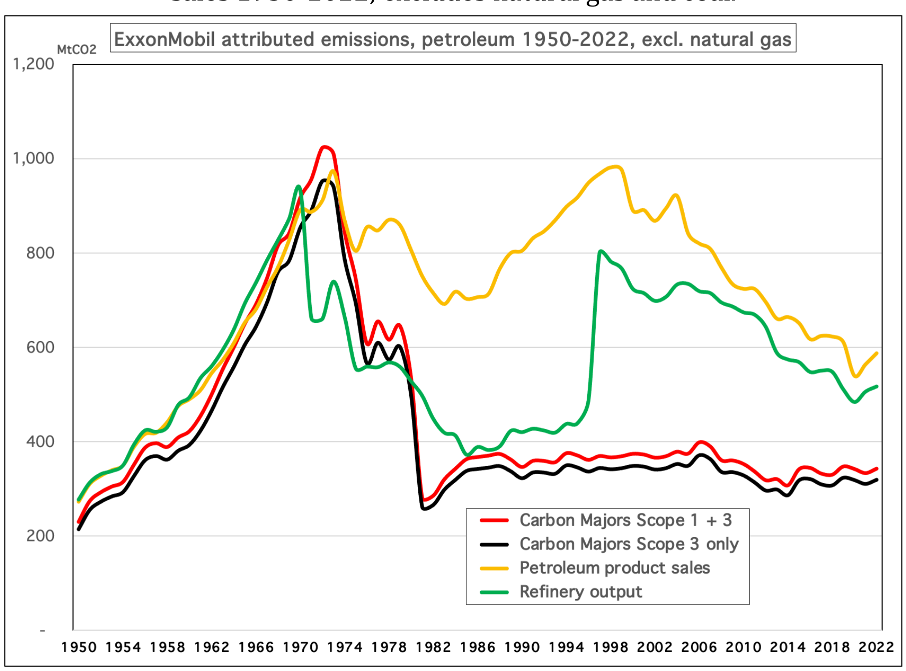


Figure A-7. ExxonMobil's estimated emissions from petroleum production, refinery output, and product sales 1950-2022; excludes natural gas and coal.



From:	Lazorchak, Jane
To:	Anthony Iarrapino
Cc:	Ben Edgerly Walsh
Subject:	Climate Superfund
Date:	Wednesday, August 7, 2024 7:29:00 AM
Attachments:	image001.png

Hi Anthony and Ben,

Hope you are having a nice summer. I wanted to make sure you both saw this and would share widely: Vermont Business Registry and Bid System - Bid Detail

Please let me know if you have any questions.

Thanks,
Jane

VERMONT

Jane Lazorchak (she/her) | Climate Action Office
Vermont Agency of Natural Resources
Davis 2, 1 National Life Drive, Montpelier, VT 05602
802-505-0561
anr.vermont.gov

Request for Information
Development of a Climate Superfund Cost Recovery Program

Release Date: July 22, 20224
Responses Due: October 14, 2024
Contact: Jane Lazorchak at the Vermont Agency of Natural Resources
(jane.lazorchak@vermont.gov)

Purpose

This Request for Information (RFI) is issued for the State of Vermont, Agency of Natural Resources ('the Agency') to gather input and obtain information for the Agency and the Treasurer's Office to use in the development and issuance of a Request for Proposals (RFP) to retain a contractor or team of contractors to provide consulting services related to the implementation of the Climate Superfund Act, Act 122 (2024), an act relating to climate change cost recovery.

Through this RFI, the State seeks input on the process and contractual services available to advise and assist the Agency with Act 122 in establishing the Climate Superfund Cost Recovery Program. The purposes of the Program are the following:

> (1) to secure compensatory payments from responsible parties based on a standard of strict liability to provide a source of revenue for climate change adaptation projects within the State;
>
> (2) to determine proportional liability of responsible parties;
>
> (3) to impose cost recovery demands on responsible parties and issue notices of cost recovery demands;
>
> (4) to accept and collect payment from responsible parties;
>
> (5) to develop, adopt, implement, and update the Resilience Implementation Strategy that will identify and prioritize climate change adaptation projects; and
>
> (6) to disperse funds to implement climate change adaptation projects identified in the Strategy.

The State therefore seeks information from consultants with the expertise and ability to support the State in completing the work required by Act 122. This RFI is also an opportunity for organizations that might have general or specific knowledge of the items discussed within to share their knowledge, expertise and/or thoughts with the State. It is not directed solely at potential bidders for a subsequent RFP.

The State intends to evaluate the submissions by Respondents to explore how they would support the Agency and Treasurer's Office in establishing the Climate Superfund Cost Recovery Program and understand the cost associated with this support. The State shall not be held liable for any costs incurred by the vendors in the preparation of their submissions, or for any work performed prior to contract issuance.

Disclaimer

THIS IS A REQUEST FOR INFORMATION (RFI) ONLY. This RFI is issued solely for information and planning purposes – it does not constitute a Request for Proposal (RFP) or a promise to issue an RFP in the future. This request for information does not commit the State to contract for any materials or service whatsoever. Further, the State is not at this time seeking proposals and will not accept unsolicited proposals. Respondents are advised that the State will not pay for any information or administrative costs incurred in response to this RFI; all costs associated with responding to this RFI will be solely at the interested party's expense. Not responding to this RFI does not preclude participation in any future RFP, if any is issued. If an RFP is released, it will be posted on the State of Vermont bid opportunities website: http://www.bgs.state.vt.us/pca/bids/bids.php. It is the responsibility of the potential offerors to monitor this site for additional information.

Confidentiality

The State retains the right to promote transparency and to place this RFI into the public domain, and to make a copy of the RFI available as a provision of the Vermont access to public records laws. Please do not include any information in your RFI response that is confidential or proprietary, as the State assumes no responsibility for excluding information in response to records requests. Any request for information made by a third party will be examined in light of the exemptions provided in the Vermont access to public records laws. The solicitation of this RFI does not commit the State, Treasurer's Office, or the State of Vermont to award a contract. This RFI is for information gathering purposes only and no vendor will be selected, pre-qualified, or exempted based upon their RFI participation.

Background Information

The Climate Superfund Act, Act 122 (2024), requires the Agency's Climate Action Office to establish and administer a Climate Superfund Cost Recovery Program. This Program includes several components, not all of which are part of this RFI. A copy of the Act which includes a detailed explanation of the components of the Program is included in Attachment A and available online here. All Respondents are expected to review and consider the statutory language in the Act when preparing their responses.

- **Resilience Implementation Strategy (not part of this RFI):** The Act requires the Agency to adopt a Strategy to outline the practices and projects needed to make Vermont resilient to climate change, as well as the criteria and procedures for prioritizing and implementing these practices and projects.
- **State Treasurer's Report:** The Act requires the Treasurer's Office to develop an assessment of the cost to the State of Vermont and its residents of the emission of covered greenhouse gases for the period that began on January 1, 1995 and ended on December 31, 2024 ("the covered period").
- **Liability of Responsible Parties:** The Act requires the Agency to adopt methodologies using available science and publicly available data to identify "responsible parties" engaged in the trade or business of extracting fossil fuel or refining crude oil and determine their applicable share of covered greenhouse gas emissions during the covered period. These responsible parties are strictly liable for a share of the costs calculated by the Treasurer's Report.
- **Issue Cost Recovery Demands (not part of this RFI):** Once the Agency has determined the liability of responsible parties and calculated the cost recovery demand, the Agency must issue cost recovery demands.
- **Administer the Climate Superfund Cost Recovery Fund (not part of this RFI):** The Act created a Fund to receive the cost recovery demand payments and provide funding for climate change adaptation projects in the State.

Requested Information

Each submission prepared in response to this RFI should include the elements listed below.

- Cover Page
- Responses to Questionnaire Below
- Optional Additional Materials

COVER PAGE

The first page of the RFI response must be a cover page displaying at least the following:

- Response of RFI Title
- Respondent's Name
- Contact Person
- Telephone Number
- Mailing Address
- Email Address

All subsequent pages of the RFI response must be numbered.

QUESTIONNAIRE

The State is seeking to gather input and obtain information about the development of (i) a liability and cost recovery demand approach for "responsible parties" as defined in Act 122 and (ii) the Treasurer's report on the cost to Vermont of covered greenhouse gas emissions. We expect the Respondents to consider and estimate the effort and cost in engaging contractor support in meeting the specific requirements of Act 122 included here. Respondents to this RFI may choose to respond to one or both of the questions below.

1. Describe a stepwise process to identify responsible parties, determine their applicable share of covered greenhouse gas emissions, and determine the cost recovery demand amount as described in Act 122. In doing so, please identify the datasets (publicly available) and describe the methodology and research the approach is based on. Provide an evaluation of the comprehensiveness and accuracy of those data sets. If appropriate, evaluate the utility of using additional information not publicly available to determine cost recovery demands.

2. Describe a stepwise process to develop the cost to Vermont of the covered greenhouse gas emissions. In doing so, identify the data sets available and describe the methodology and research approach to develop:

   (1) a summary of the various cost-driving effects of covered greenhouse gas emissions on the State of Vermont including effects on public health, natural resources, biodiversity, agriculture, economic development, flood preparedness and safety, housing, and any other effects that may be relevant;

   (2) a categorized calculation of the costs that have been incurred and are projected to be incurred in the future within the State of Vermont of each of the effects identified under subdivision (1) of this section; and

   (3) a categorized calculation of the costs that have been incurred and are projected to be incurred in the future within the State of Vermont to abate the effects of covered greenhouse gas emissions from between January 1, 1995 and December 31, 2024 on the State of Vermont and its residents.

   Provide an evaluation of the comprehensiveness and accuracy of available data sets, methodology, and research to develop the cost to Vermont of the covered greenhouse gas emissions.

3. Please provide any other materials, suggestions, cost, and discussion you deem appropriate.

Timeline and Communications

This RFI is being issued by the State of Vermont, Agency of Natural Resources. Additional copies of the RFI can be obtained from the Vermont Climate Action Office website: www.climatechange.vermont.gov

All communications concerning this RFI are to be submitted in writing, via e- mail, to Jane Lazorchak at the Vermont Agency of Natural Resources (jane.lazorchak@vermont.gov).

DEADLINE FOR QUESTIONS

Potential Respondents may submit questions regarding this RFI. Questions must be submitted in writing, via e-mail, to Jane Lazorchak (jane.lazorchak@vermont.gov) and must be received by 4:00PM Eastern Time on August 30, 2024. Responses to any questions received will be published on the Vermont Climate Action Office website on a rolling basis, with all responses posted by 12:00 PM on September 9, 2024.

RFI RESPONSE SUBMISSION

The closing date for the receipt of RFI responses is 4:00PM Eastern Time on October 14, 2024. Responses must be delivered via e-mail to jane.lazorchak@vermont.gov prior to that time. Responses should be labeled, "Response to RFI –Development of a Climate Superfund Cost Recovery Program." The responses received will be reviewed by ANR staff and the Treasurer's Office.

From:	Shirin Ermis
To:	Lazorchak, Jane
Cc:	Rupert Stuart-Smith; Benjamin Franta
Subject:	Response to RFI –Development of a Climate Superfund Cost Recovery Program
Date:	Saturday, September 28, 2024 1:39:17 PM
Attachments:	RFI_VT_Ermis_Stuart-Smith_Franta.pdf

Dear Ms Lazorchak,

Please find attached our response to the RFI on the Development of a Climate Superfund Cost Recovery Program. We hope you find it helpful.

Kind regards,
Shirin

Shirin Ermis (she/her)
Doctoral Researcher in Atmospheric Physics
Research Assistant for Climate Damages Analysis
NERC DTP, University of Oxford
LinkedIn | Personal Website | shirin.ermis@env-res.ox.ac.uk

Possible methods for the estimation of flood damages in the State of Vermont

Authors: Shirin Ermis, Dr. Rupert Stuart-Smith, Prof. Benjamin Franta

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benjamin.franta@smithschool.ox.ac.uk

Summary

With this submission, we are replying to question (2) posed in the questionnaire of the Request for Information issued by the State of Vermont. We focus on economic damages from flood events as one of the most common impacts from climate change in the State.

We discuss three scientific, peer-reviewed methods which can estimate economic damages from flooding. Using these approaches, a damage quantification of the economic impacts from flooding that are attributable to human-induced climate change can be achieved for the State of Vermont.

'Event attribution' has developed as a scientific field in the past two decades and includes scientific methods that can quantify the effects of climate change on changes in the probability or intensity of a wide variety of extreme weather events, including extreme precipitation. Recent scientific developments allow these methods to be extended to assess climate change impacts on economic losses and human health. Our submission explains how these methods could be applied to support the State to develop a Climate Superfund Cost Recovery Program. Our own expertise lies in performing extreme event attribution studies and is outlined separately to the discussion of methods below.

References to relevant peer-reviewed studies can be found at the end of the submission.

The science of damage quantification for flood events

Factors influencing the development of flood events

The development of flood events depends on multiple local factors. Following, we summarise some of the factors that can determine flood severity, including antecedent conditions and meteorological regimes that lead to extreme precipitation.

- Antecedent effects in the catchment area include the **soil moisture anomaly and ground water height** which might be higher due to high rain or snowfall in the leadup to the event. This effect can be further exacerbated by **cold spells** which can freeze the water content in the upper soil layers. Freezing temperatures can thereby "lock" water in the upper soil layers and increase further runoff. This was one of the factors leading up to the 1996 north-central Pennsylvania floods[1].

- **Freezing temperatures** before the event can lead to thick ice cover on rivers which can subsequently **form ice jams on rivers** when floods break up the ice cover[2].
- Atmospheric conditions that lead to disastrous flooding events in the mid-latitudes include **atmospheric blocking** which can lead to multiple storms being steered into the same region, leading to long-lasting precipitation events[3].
- **Atmospheric rivers** are elongated regions of high water content in the atmosphere transporting large water masses into higher latitudes where they can rain out. The moisture in them is estimated to increase with climate change[4].
- In Vermont, extreme rainfall can also be associated with **remnants of hurricanes in the summer and autumn months**. It is likely (e.g. ref[5]) that these storms are able to transport more moisture as both atmosphere and sea surface temperatures warm with climate change.

The severity of floods is determined by various factors including their return time in a given location, speed of onset, velocity of water flow, and water depth[6]. Because of the inhomogeneity of flood events, it might be helpful to define them according to their impacts rather than rainfall amounts[7].

Macroeconomic approach to damage quantification

Callahan and Mankin[8] developed an approach that connects the emissions of individual actors to damages on a national level. For example, to relate heat damages to individual emitters, Callahan and Mankin[9] describe a full causal chain from emissions to impacts. First, the emissions from one emitter are

[1] Leathers, Kluck, and Kroczynski, ‘The Severe Flooding Event of January 1996 across North-Central Pennsylvania’.
[2] Merz et al., ‘Causes, Impacts and Patterns of Disastrous River Floods’.
[3] Merz et al.
[4] Payne et al., ‘Responses and Impacts of Atmospheric Rivers to Climate Change’.
[5] Zhu, Emanuel, and Quiring, ‘Elevated Risk of Tropical Cyclone Precipitation and Pluvial Flood in Houston under Global Warming’; Guzman and Jiang, ‘Global Increase in Tropical Cyclone Rain Rate’.
[6] Brown and Murray, ‘Examining the Relationship between Infectious Diseases and Flooding in Europe’.
[7] Delforge et al., ‘EM-DAT’.
[8] Callahan and Mankin, ‘National Attribution of Historical Climate Damages’.
[9] Callahan and Mankin.

linked to an increase in global mean surface temperature (GMST). This is done using a simple carbon climate model such as FaIRv1.3[10]. This change in global temperature due to one emitter's share of emissions can subsequently be linked to a local change in mean temperature or an increase in magnitude of an event such as the mean of the five hottest days in a year[11]. In a final step, Callahan and Mankin[12] use relationships between local temperature changes and economic growth to estimate the damages from the warming associated with one emitter. We are not aware of studies which extend this analysis to flooding, but it can be done in principle.

The benefit of this method is that it does not require the user to perform detailed case studies (see e.g. ref[13]). Instead, the overall cost of climate change is estimated using a damage function which is based on a regression analysis between climate inputs such as temperatures and GDP (e.g. ref[14]). The method's simplicity makes it straightforward to use.

Fraction of attributable risk (FAR) approach to damage quantification

Risk-based extreme event attribution can quantify the impact of climate change on a class of extreme events by calculating the fraction of attributable risk (FAR). This approach uses climate model simulations with anthropogenic and natural climate forcings (called "ALL") and only natural forcings ("NAT"). The probability of exceedance of an event threshold is estimated for both sets of simulations, from which the FAR can be calculated.

Studies by Frame et al.[15] use this approach on pluvial (rainfall-related) flooding events in New Zealand, as well as for Hurricane Harvey, which caused widespread flooding (also mostly pluvial) in Houston, Texas. Frame et al.[16] use existing estimates of FAR from previous studies. In cases where there are no

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[10] Millar et al., 'A Modified Impulse-Response Representation of the Global near-Surface Air Temperature and Atmospheric Concentration Response to Carbon Dioxide Emissions'; Smith et al., 'FAIR v1.3'.
[11] Eyring et al., 'Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) Experimental Design and Organization'.
[12] Callahan and Mankin, 'National Attribution of Historical Climate Damages'.
[13] Merz et al., 'Review Article "Assessment of Economic Flood Damage"'.
[14] Callahan and Mankin, 'Globally Unequal Effect of Extreme Heat on Economic Growth'.
[15] Frame et al., 'Climate Change Attribution and the Economic Costs of Extreme Weather Events'; Frame et al., 'The Economic Costs of Hurricane Harvey Attributable to Climate Change'.
[16] Frame et al., 'Climate Change Attribution and the Economic Costs of Extreme Weather Events'.

existing studies calculating FAR, climate models (e.g. ref[17]) could be used to calculate FAR for the event of interest.

Using damage estimations from multiple sources such as the US National Oceanic and Atmospheric Administration (NOAA), estimates from re-insurance datasets, and the international emergency database (EM-DAT[18]), Frame et al. calculate the fraction of the damages that can be attributed to climate change.

One limitation of this approach is that models that are typically used to calculate FAR can struggle to represent certain weather types such as extreme precipitation. Therefore, studies often focus on the probability of exceedance of an extreme event threshold[19].

Hydraulic model approach to damage quantification

Another approach is provided by Wehner and Sampson[20] and has been used to estimate climate-change-attributable flood damage from Hurricane Harvey. The authors use a hydraulic model at 30 metre resolution[21] to estimate the change in flooded area attributable to climate change. To drive simulations of the hydraulic model for Hurricane Harvey, the authors use observed precipitation over the Houston, Texas area during the event and decrease it using a best estimate of precipitation changes attributable to climate change from previous attribution studies. To calculate the damage estimate, the authors in this study assumed that assets were evenly distributed in the flooded area and that antecedent conditions would not change the event outcome. These assumptions were sensible for Hurricane Harvey due to the amount of precipitation, but this might not be the case for other case studies where urban and rural areas are considered at the same time or when climate change is assumed to have an impact on antecedent conditions such as soil moisture and river flow. In these cases, models using asset locations could be

[17] Eyring et al., ‘Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) Experimental Design and Organization’.
[18] Delforge et al., ‘EM-DAT’.
[19] Perkins-Kirkpatrick et al., ‘On the Attribution of the Impacts of Extreme Weather Events to Anthropogenic Climate Change’.
[20] Wehner and Sampson, ‘Attributable Human-Induced Changes in the Magnitude of Flooding in the Houston, Texas Region during Hurricane Harvey’.
[21] Wing et al., ‘Validation of a 30 m Resolution Flood Hazard Model of the Conterminous United States.

more suitable. Using their approach, Wehner and Sampson[22] estimated damages attributable to climate change that were significantly lower than the estimate found using the FAR approach discussed above.

One limitation of the hydraulic model approach is that the perturbations in precipitation used to drive the hydraulic model depend on large-scale climate model simulations whose skill varies for extreme precipitation events. There are, however, now methods that can more reliably model changes in extreme precipitation. This includes multiple methods under what is called the “storyline approach" for event attribution. While risk-based event attribution considers an event class defined by a threshold, the aim of storyline attribution is to consider the specific dynamics of a unique event and answer the question of how the event magnitude was changed due to climate change *given* the dynamical conditions of the atmosphere. Forecast-based event attribution[23] and pseudo-global warming simulations[24] (both storyline approaches) are promising for damage attribution as they involve high-resolution, initialised datasets. The output from such simulations could then be used to drive a hydraulic flood model in much the same way as in Wehner and Sampson’s work on Harvey[25]. Forecast-based attribution might be useful because weather forecast models are often already integrated with early warning systems such as for flood warnings. This might simplify the setup of case studies and yield synergies with national agencies such as NOAA. One potential limitation of storyline attribution methods is that they are conditioned on the meteorological conditions before the event and so do not consider the potential effects of climate change on these antecedent conditions.

[22] Wehner and Sampson, ‘Attributable Human-Induced Changes in the Magnitude of Flooding in the Houston, Texas Region during Hurricane Harvey’.
[23] Leach et al., ‘Forecast-Based Attribution of a Winter Heatwave within the Limit of Predictability’; Leach et al., ‘Heatwave Attribution Based on Reliable Operational Weather Forecasts’; Ermis et al., ‘Event Attribution of a Midlatitude Windstorm Using Ensemble Weather Forecasts’.
[24] Patricola and Wehner, ‘Anthropogenic Influences on Major Tropical Cyclone Events’; Lackmann, ‘Hurricane Sandy before 1900 and after 2100’; Wehner, Zarzycki, and Patricola, ‘Estimating the Human Influence on Tropical Cyclone Intensity as the Climate Changes’.
[25] Wehner and Sampson, ‘Attributable Human-Induced Changes in the Magnitude of Flooding in the Houston, Texas Region during Hurricane Harvey’.

Expertise of our group

We are an interdisciplinary group of physical climate scientists and lawyers. Our group has experience in preparing extreme event attribution studies for publication in peer-reviewed journals and translating scientific findings for legal use. Our prior work includes studies on slow-onset events such as glacial retreat[26] and developing new methods for storyline attribution of complex events such as windstorms[27]. Our work aims to support legislation, litigation, and public policy with rigorous scientific evidence.

Contributors

Shirin Ermis is a doctoral student in Physics at the University of Oxford focusing on extreme event attribution for midlatitude storms. She has published on increased risks from extreme windstorms and worked on tropical cyclone risks in the past. Shirin is also a research assistant for the Oxford Sustainable Law Program where she studies methods for the estimation of economic damages from climate change, in particular from flood events in the United States. Shirin holds a BSc in Physics from the University of Heidelberg (Germany) and a MSc in Physics with Extended Research from Imperial College London (UK).

Dr. Rupert Stuart-Smith is a Senior Research Associate in Climate Science and the Law at the Oxford Sustainable Law Programme. In his research, Rupert advances methods in attribution science to shed new light on the impacts of climate change on health, glaciers, and extreme weather events. He studies how climate science can be leveraged to enhance legal scrutiny of corporate and state climate action and accountability for the impacts of greenhouse gas emissions. Rupert also publishes on the implications of burgeoning climate litigation on climate-related financial risk. His research has been published in leading scientific journals including Science, Nature Geoscience and Nature Climate Change.

Prof. Ben Franta is an Associate Professor of Climate Litigation at the Oxford Sustainable Law Programme and the founding head of the Climate Litigation Lab. His research focuses on applying

[26] Stuart-Smith et al., 'Increased Outburst Flood Hazard from Lake Palcacocha Due to Human-Induced Glacier Retreat'.
[27] Ermis et al., 'Event Attribution of a Midlatitude Windstorm Using Ensemble Weather Forecasts'.

rigorous methods to practical challenges presented by climate litigation worldwide and has been published in *Nature Climate Change*, *Global Environmental Change*, *The Guardian*, and more, translated into 10 languages, and cited in the US Congressional Record. Dr. Franta holds a PhD in Applied Physics from Harvard University, a separate PhD in History (History of Science) from Stanford University, a JD from Stanford Law School, an MSc in Archaeological Science from the University of Oxford, and a BA in Physics and Mathematics from Coe College in Cedar Rapids, Iowa. He is also a licensed attorney and a member of the State Bar of California.

About the Oxford Sustainable Law Program

The Oxford Sustainable Law Programme, based at the University of Oxford, is a joint initiative of the Smith School of Enterprise and the Environment and the Faculty of Law. Founded in 2021 by Prof. Thom Wetzer, we draw on wide-ranging expertise from across the University of Oxford and collaborate intensively with our international partners in the academic, public, private, and not-for-profit sectors.

Our work is multidisciplinary, rigorous, and informed by practice. We are impact-oriented thinkers who see the law as a tool to catalyse the sustainability transition.

The SLP works to:

- conduct world-leading and actionable research that facilitates the systemic changes needed to equitably address the world's biggest sustainability challenges;
- deliver impact-focused education to students at Oxford and partner organisations, and to the wider legal and scientific communities through our executive education programmes;
- engage with a wide range of partners in the public, private, and not-for-profit sectors to translate research insight into practical application.

Our ongoing research covers the following priority areas:

- **Climate science and law**: conducting scientific research that is relevant to emerging issues in climate litigation and policy, including supporting the improved use of scientific evidence in the court room, understanding the impacts of climate change on health, and evaluating mitigation consistent with legal norms and associated state and corporate obligations.
- **Strategic litigation**: supporting the development of climate lawsuits designed to effect systemic change by quantifying losses attributable to policy delays, scoping legal opportunities to bring climate-related legal actions through international courts, and developing resources to support lawyers identify attributable climate impacts and potential defendants.
- **Net zero law and governance**: address emerging legal challenges related to the net-zero transition, including management of carbon sinks and carbon markets.
- **Sustainable finance**: shaping the way the financial sector responds to the risks associated with climate change, including pioneering research into emerging climate-related legal risks.

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From:	Kelly Sanks
To:	Lazorchak, Jane
Subject:	Response to RFI –Development of a Climate Superfund Cost Recovery Program
Date:	Monday, September 30, 2024 2:04:22 PM
Attachments:	Sanks_et_al_Response_to_RFI_Climate_Superfund_Cost_Recovery_Program.pdf

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Hi Jane,

Attached is our response to RFI –Development of a Climate Superfund Cost Recovery Program. Please let me know if you have any questions.

Warm Regards,
Kelly

--

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Response of RFI Title:

Calculating the cost of implementing climate change adaptation and resilience measures in Vermont

Respondent's Names:

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QUESTIONNAIRE

The State is seeking to gather input and obtain information about the development of (i) a liability and cost recovery demand approach for "responsible parties" as defined in Act 122 and (ii) the Treasurer's report on the cost to Vermont of covered greenhouse gas emissions. We expect the Respondents to consider and estimate the effort and cost in engaging contractor support in meeting the specific requirements of Act 122 included here. Respondents to this RFI may choose to respond to one or both of the questions below.

1. Describe a stepwise process to identify responsible parties, determine their applicable share of covered greenhouse gas emissions, and determine the cost recovery demand amount as described in Act 122. In doing so, please identify the datasets (publicly available) and describe the methodology and research the approach is based on. Provide an evaluation of the comprehensiveness and accuracy of those data sets. If appropriate, evaluate the utility of using additional information not publicly available to determine cost recovery demands.

We do not outline a method for attributing emissions to responsible parties, as we do not specialize in this field of science. However, the adaptation and resilience costs from our methodology below can be attributed to responsible parties if we know the percentage of emissions each party emitted during the study period.

2. Describe a stepwise process to develop the cost to Vermont of the covered greenhouse gas emissions. In doing so, identify the data sets available and describe the methodology and research approach to develop:

(1) a summary of the various cost-driving effects of covered greenhouse gas emissions on the State of Vermont including effects on public health, natural resources, biodiversity, agriculture, economic development, flood preparedness and safety, housing, and any other effects that may be relevant;

To determine the cost recovery demand of responsible parties, the first step is to determine the cost of the climate change adaptation projects specified in the bill. The Vermont Climate Superfund Act states that a "climate change adaptation project" means a project designed to respond to, avoid, moderate, repair, or adapt to negative impacts caused by climate change and to assist human and natural communities, households, and businesses in preparing for future climate-change driven disruptions. This definition describes three very different costs and should be broken down into both (1) climate change adaptation or resilience projects, (2) responding, repairing, and/or recovering from damage due to extreme weather and climate events, and (3) general sector-wide impacts (e.g., impacts on the food system). The detailed methodology presented below describes a defensible methodology for estimating the cost of implementing climate change adaptation and resilience projects.

The cost of climate change adaptation or resilience projects typically refers to projects that aim to avoid, moderate, or adapt to the worsening impacts of climate change; think sea walls, improved stormwater drainage, or increased cooling costs for government buildings. The cost of implementing certain climate change adaptation or resilience projects is well studied and defensible. The following climate change adaptation and resilience projects outlined in the Vermont Climate Superfund Act already have established methodology:[1]

- Implementing nature-based solutions and flood protections;
  - ☑ Installing green stormwater infrastructure;
  - ☑ Installing flood protection systems, like levees, in rural communities;

- Home buyouts;

- Upgrading stormwater drainage systems;
  - ☑ Installing green stormwater infrastructure;

- Making defensive upgrades to roads, bridges, railroads, and transit systems;
  - ☑ Making defensive (proactive) upgrades and reactive repairs to roads;
  - ☑ Making defensive upgrades to bridges;[2]
  - ☑ Making railroads more resilient to heat by painting tracks with reflective painting;

- Relocating, elevating, or retrofitting sewage treatment plants and other infrastructure vulnerable to flooding;

- Installing energy efficient cooling systems and other weatherization and energy efficiency upgrades and retrofits in public and private buildings, including schools and public housing, designed to reduce the public health effects of more frequent heat waves and forest fire smoke;
  - ☑ Installing and upgrading HVAC systems in public buildings;
  - ☑ Net change in energy costs to heat and cool public buildings;

- Upgrading parts of the electrical grid to increase stability and resilience, including supporting the creation of self-sufficient microgrids.

(2) a categorized calculation of the costs that have been incurred and are projected to be incurred in the future within the State of Vermont of each of the effects identified under subdivision (1) of this section; and

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[1] Center for Climate Integrity, Resilient Analytics, and Scioto Analysis, "Confronting Wisconsin's Climate Costs: At Least $16.7 Billion to Protect Communities from Climate Change through 2040," 2024, https://climateintegrity.org/uploads/media/Wisconsin-ClimateCostStudy-2024.pdf.

[2] Len Wright et al., "Estimated Effects of Climate Change on Flood Vulnerability of U.S. Bridges," *Mitigation and Adaptation Strategies for Global Change* 17, no. 8 (December 1, 2012): 939–55, https://doi.org/10.1007/s11027-011-9354-2.

(3) a categorized calculation of the costs that have been incurred and are projected to be incurred in the future within the State of Vermont to abate the effects of covered greenhouse gas emissions from between January 1, 1995 and December 31, 2024 on the State of Vermont and its residents. Provide an evaluation of the comprehensiveness and accuracy of available data sets, methodology, and research to develop the cost to Vermont of the covered greenhouse gas emissions.

To estimate climate adaptation and resilience projects, we will use a baseline climate period (1973-1993) and the climate period from the bill (1994-2024). We also recommend using a projection climate period (2024-2060) to ensure that the implemented adaptation and resilience projects are built to protect communities across Vermont in the coming decades. We will use publicly-available climate data to determine temperature, precipitation, and other climate indices as needed for analysis for both periods. Estimating adaptation costs follows a relatively simple methodology that:

1. Determines the change in the climate variable of interest (average temperature, days above 90°F, inches of precipitation during a wet weather event, wildfire days, etc.) between the baseline and study period, as well as the baseline and projection time period.
2. Determines the cost to adapt to the change in the climate variable (increased cooling costs in public buildings, installing green stormwater infrastructure, etc.) because of climate change.

The exact cost data used for each climate adaptation and resilience project will vary. In the bulleted list of adaptation projects, you will find links to relevant peer-reviewed publications and other reports that detail the methodology for each adaptation project. New methodologies can be developed for other adaptation projects that do not have an existing methodology, if viable. However, we note that these methodologies will be based on the same general process described above. Below we detail a sample methodology for implementing green stormwater infrastructure to adapt to the increase in extreme wet weather events expected in Vermont because of climate change.

First, we will gather the relevant climate data. The climate data will be derived from the U.S. Geological Survey National Climate Change Viewer,[3] which utilizes Localized Constructed Analogs (LOCA) statistically downscaled Coupled Model Intercomparison Project Phase 6 (CMIP6) climate projections for North America. We select the climate projections for a moderate greenhouse gas and aerosol emission scenario (Shared Socioeconomic Pathway 2-4.5 [SSP2-4.5]).

[3] "USGS National Climate Change Viewer," 2024, https://apps.usgs.gov/nccv/loca2/nccv2_loca2_counties.html.

The climate baseline for temperature-related analyses can be derived from Livneh et al. (2015).[4] The climate baseline for precipitation-related analyses can be derived from Pierce et al. (2021).[5] We will use a 20-year baseline time period centered on 1983 (1973-1993) for all climate adaptation analyses. A shapefile for Vermont municipalities will be used to determine municipal bounds throughout the study.[6] Note that costs for some adaptations will be computed as a time series and costs for other adaptations will be assessed once in 2024 (study period) and then again in 2060 (projection period).

To estimate the cost to install green stormwater infrastructure, we need to determine how much worse extreme wet weather events were during the study period as compared to the baseline, and the projection period as compared to the baseline. We determine the increase in storm intensity using the U.S. Environmental Protection Agency Climate Resilience Evaluation and Awareness Tool (CREAT).[7] An increase in storm intensity due to climate change will cause large increases of inflow into the wastewater treatment plants.

We calculate the percent change in these events from the change in rainfall depth (inches) for a certain percentile between the two distributions (baseline distribution and the study and projected distribution). For example, if the baseline wet weather event is 3 inches and the projected wet weather event is 3.3 inches, then we would say the extreme wet weather event increased by 10%.

Given a change in wet weather events, we assume that the municipality must invest to offset additional runoff (thus infiltration and inflow) into the wastewater treatment plant. We assume the offset is proportional to the change in wet weather events. For example, if the wet weather events are increasing by 10%, then 10% of the developed impervious area needs to be offset by drainage infrastructure. We derived the per-unit cost for green stormwater infrastructure from the following equation:[8]

- $Cost = A * \mathbf{\Delta} WWE * GSI$
- Where:

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[4] Ben Livneh et al., “A Spatially Comprehensive, Hydrometeorological Data Set for Mexico, the U.S., and Southern Canada 1950–2013,” *Scientific Data* 2, no. 1 (August 18, 2015): 150042, https://doi.org/10.1038/sdata.2015.42.

[5] David W. Pierce et al., “An Extreme-Preserving Long-Term Gridded Daily Precipitation Dataset for the Conterminous United States,” *Journal of Hydrometeorology* 22, no. 7 (July 1, 2021): 1883–95, https://doi.org/10.1175/JHM-D-20-0212.1.

[6] “Vermont Data - Town Boundaries,” 2024, https://geodata.vermont.gov/datasets/3f464b0e1980450e9026430a635bff0a.

[7] US EPA, “Creating Resilient Water Utilities,” Data and Tools, August 13, 2021, https://www.epa.gov/crwu/access-data-creating-resilient-water-utilities.

[8] Allegheny County Sanitary Authority, “Staring at the Source: How Our Region Can Work Together for Clean Water - Appendix E-3: GIS Cost Literature Review,” 2015, https://www.alcosan.org/docs/default-source/clean-water-plan-documents/cwp-appendixe/cwp-appendix-e-3_gsi-cost-literature-review.pdf?sfvrsn=6d863977_2.

- A is area of developed impervious surfaces (acres)
- ΔWWE is the change in wet weather events (%)
- GSI is the unit cost of implementing green stormwater infrastructure

GSI unit costs will be based on local green infrastructure projects to ensure localized pricing is used in the analysis.

A similar approach can be applied to determine the cost of implementing other adaptation projects of interest.[9]

Table 1: Outline of method for computing the cost of implementing 15 other adaptation measures with existing methodology.

Impact	Adaptation	Explanation	Data
Increased temperature	Installing and upgrading heating and cooling infrastructure in public buildings	The cost to install or upgrade HVAC systems in public buildings.	Cooling Degree Days;[10] Vermont building footprints[11]
Increased temperature	Combating heat islands	Planting trees can help decrease ambient air temperature by cooling the air through evapotranspiration. The adaptation is planting and maintaining trees in urban areas and accounts for both initial costs and yearly maintenance costs. The initial costs include labor and materials. The maintenance costs include water, fertilizer, pruning, and pest spraying.	National Land Cover Database[12] of Land Use[13] and Canopy Coverage[14]
Increased temperature	Proactively and reactively fixing	When pavement temperature rises above its mixture threshold, increased degradation	7-day ambient temperatures;

[9] Center for Climate Integrity, "Los Angeles County's Climate Cost Challenge," 2024, https://climateintegrity.org/uploads/media/LACounty-ClimateCosts-2024.pdf; Center for Climate Integrity, Resilient Analytics, and Scioto Analysis, "Confronting Wisconsin's Climate Costs: At Least $16.7 Billion to Protect Communities from Climate Change through 2040."
[10] Cooling degree days (CDD) is a measure of how much (in degrees), and for how long (in days), the outside air temperature is above a specified temperature threshold.
[11] State of Vermont, "VT Building Footprints," 2023, https://geodata.vermont.gov/datasets/VCGI::vt-building-footprints/about.
[12] National Land Cover Database, "National Land Cover Database Class Legend and Description," Multi-Resolution Land Characteristics (MRLC) Consortium, (accessed June 21, 2023), https://www.mrlc.gov/data/legends/national-land-cover-database-class-legend-and-description.
[13] National Land Cover Database, Land Cover/CONUS/2019, (2019), distributed by Multi-Resolution Land Characteristics Consortium, https://www.mrlc.gov/data.
[14] National Land Cover Database, "NLCD 2016 Tree Canopy Cover (CONUS)," distributed by Multi-Resolution Land Characteristics Consortium, https://www.mrlc.gov/data/nlcd-2016-tree-canopy-cover-conus.

and increased precipitation	roads	occurs. In the reactive scenario, this increased cracking requires more maintenance to avoid a decrease in the projected lifespan of the road. In the proactive scenario, adaptation includes installation of roads with pavement rated to projected future temperatures. Excess precipitation above what the road was designed to handle can also increase degradation. Road maintenance costs are informed by the percentage decrease in lifespan based on the level of projected damage as compared to the climate baseline. In the proactive road scenario, adaptation requires strengthening the roadbase to resist the increased potential for erosion. In the reactive road scenario, adaptation is fixing roads after precipitation-induced damage.	maximum monthly precipitation rates; Vermont roads database[15]
Increased precipitation	Maintaining bridges	As rivers flow faster during extreme precipitation events, bridges will degrade faster due to enhanced scour. To combat enhanced damage to bridges, we estimate the cost to proactively rehabilitate bridges in order to prevent disruption. Rehabilitation consists of applying riprap to stabilize bridges and additional concrete to strengthen piers and abutments.	24-hour precipitation rates; National Bridge Inventory[16] subsetting to include only inland bridges spanning bodies of water; 8-digit Hydrologic Unit Code boundaries[17]
Increased temperature	Protecting residents during heatwaves	To help residents escape the increasing summer heat, cooling centers will need to be expanded and operated. The cost of opening and operating cooling centers due to increased days with temperatures above 85°F, as compared to the climate baseline are estimated.	U.S. Census Block Groups; report on operational costs of cooling centers[18]
Increased precipitation	Protecting public roads from landslides	Increased precipitation falling on unstable slopes across Vermont threaten infrastructure and roads. To establish the cost to protect high-risk areas from increasing landslide risk, we will estimate appropriate mitigation measures based on the current FEMA and State of Vermont practices[19] in vulnerable areas.	Vermont landslide vulnerability inventory and maps[20]

[15] State of Vermont, "VT Road Centerline," 2021, https://geodata.vermont.gov/maps/VTrans::vt-road-centerline.
[16] Federal Highway Administration, National Bridge Inspection ASCII files, (2022), distributed by United States Department of Transportation, https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm.
[17] United States Geological Survey, Hydrologic Unit Maps, (n.d.), distributed by United States Department of the Interior, https://water.usgs.gov/GIS/huc.html.
[18] Carol Parks, "Cooling Center Operations in Los Angeles City," City of Los Angeles Emergency Management Department (2002), https://clkrep.lacity.org/onlinedocs/2021/21-1277_rpt_07-29-22.pdf.
[19] Agency of Natural Resources, "Landslides, Rockfalls and Erosion," Government, 2024, https://dec.vermont.gov/geological-survey/hazards/landslides.
[20] Benjamin B. Mirus et al., "Landslides across the USA: Occurrence, Susceptibility, and Data Limitations," *Landslides* 17, no. 10 (October 2020): 2271–85, https://doi.org/10.1007/s10346-020-01424-4.

Increased temperature	Estimating the change in energy costs to heat and cool public buildings	Changes in energy costs are estimated based on the number of days below (heating) or above (cooling) a certain threshold as compared to the climate baseline.	Cooling and heating degree days; Vermont Building Footprint
Increased temperature	Implementing cool pavements in public parking lots	Converting existing areas of pavement to high-albedo (light reflecting) cool pavement has been shown to decrease proximal ambient temperature and is a complementary approach to combat increased summer temperatures in urban areas. The cost to convert public parking lots to cool pavements is estimated.	Environmental Protection Agency (EPA) study on cool pavement costs;[21] Vermont roads database
Increased temperature	Painting rail tracks with high-albedo paint	Rail slow downs and shutdowns can be avoided by painting the tracks with a high-albedo paint to keep the tracks cool. Australia, Italy, and Switzerland already implement this technique with success.	USGS National Transportation Dataset for Vermont[22]
Increased precipitation	Constructing flood protection systems in rural areas	Increased wet weather events, which increase the flow in rivers, threaten rural areas that are not protected from overbank flooding. To combat damage to rural communities, we assess the cost to install flood protection systems.	Federal Emergency Management Agency (FEMA) 100-year floodplain maps from the National Flood Hazard Layer (NFHL;,[23] National Land Cover Database (NLCD); 8-digit Hydrologic Unit Code boundaries
Public Health: Increased temperature	Increased costs from pediatric asthma hospital visits	Increased temperatures correlates to increased pollen levels, which lead to more cases of pediatric asthma that require emergency room visits. We estimate the government-incurred cost of increased pediatric asthma visits as compared to the climate baseline.	National Environmental Public Health Tracking Network[24]
Public Health: Increased temperature and increased precipitation	Initial and long-term costs to treat increased West Nile Virus manifestations	Mosquitoes thrive in warm temperatures and near water, so increased temperatures and precipitation due to climate change will make West Nile Virus more prevalent. We estimate the increased government-incurred cost to treat both initial and long-term manifestations	West Nile Virus Historic Data[25]

[21] U.S. Environmental Protection Agency, *Reducing Urban Heat Islands: Compendium of Strategies. Cool Pavements.*, 2012, https://www.epa.gov/sites/default/files/2017-05/documents/reducing_urban_heat_islands_ch_5.pdf.
[22] USGS, “USGS National Transportation Dataset (NTD) for Vermont,” 2024, https://www.sciencebase.gov/catalog/item/5a61c940e4b06e28e9c3bdcc.
[23] Federal Emergency Management Agency, “National Flood Hazard Layer,” August 26, 2021, https://www.fema.gov/flood-maps/national-flood-hazard-layer.
[24] Centers for Disease Control and Prevention, “National Environmental Public Health Tracking Network,” n.d., https://ephtracking.cdc.gov/DataExplorer/.
[25] Centers for Disease Control and Prevention, “West Nile Virus Historic Data (1999-2022),” June 13, 2023, https://www.cdc.gov/westnile/statsmaps/historic-data.html.

		of West Nile Virus.	
Public Health: Increased temperature	Initial and long-term cost to treat Lyme disease	The range of ticks has expanded due to increased temperatures. As the climate continues to warm, increased Lyme disease from ticks is expected.	Lyme disease incidence data[26]

Although we do not outline a methodology for attributing the amount of emissions to each responsible party during the study period, the percentage of emissions for each company, determined via other researchers methods, can be multiplied by the total cost of implementing the resilience and adaptation projects to attribute costs accordingly.

3. Please provide any other materials, suggestions, cost, and discussion you deem appropriate

The methodology described above is only viable for implementing climate change adaptation and resilience measures. The bill also aims to determine the cost of recovering from extreme weather events. To do this, the State must determine if there were any extreme weather events in Vermont during the study period that can be attributable to climate change. This would entail conducting an extreme event attribution[27] study for each potential event. Where extreme weather events occurred that are attributable to climate change, the cost of recovery can be divided into two components: direct physical recovery and indirect economic recovery. In terms of the direct costs, data from local officials is needed to summarize repair requirements to physical systems including transportation, power, telecommunications, and water. This data should be available from city, county, and state emergency management as well as sector-specific oversight authorities. In terms of indirect costs, this would focus on business interruption which can be characterized by loss of tax revenue or similar measurement. Once again, this data is available through appropriate economic offices as well as tax assessors or similar positions.

The bill also aims to determine the cost of sector-wide impacts. For example, the cost of the loss of topsoil or the cost of impacts to the food system. To do this, the State must determine if these impacts are attributable to climate change in Vermont during the study period. If the impacts are attributable to climate change, an economic model should be considered to determine the loss of revenue and gross domestic product related to these sector-wide impacts.

[26] Centers for Disease Control and Prevention, "Lyme Disease Surveillance and Available Data," November 15, 2022, https://www.cdc.gov/lyme/stats/survfaq.html.
[27] "World Weather Attribution – Exploring the Contribution of Climate Change to Extreme Weather Events," 2024, https://www.worldweatherattribution.org/.

From:	Lazorchak, Jane
To:	Richard Heede
Subject:	RE: Carbon Majors Database and the InfluenceMap Team
Date:	Wednesday, August 7, 2024 7:31:00 AM
Attachments:	image001.png

Morning Rick,

Hope you are well and having a nice summer. I wanted to draw your attention to a RFI we have open regarding the development of the climate superfund in Vermont. You can find it posted here: [Vermont Business Registry and Bid System - Bid Detail]

Please consider sharing information with us this way and/or sharing with others you think would have something to contribute.

Best,
Jane

From: Richard Heede <heede@climateaccountability.org>
Sent: Tuesday, April 30, 2024 6:23 PM
To: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>; Ramirez-Richer, Emma <Emma.Ramirez-Richer@vermont.gov>; Moore, Julie <Julie.Moore@vermont.gov>; Woods, Brian <Brian.Woods@vermont.gov>; Wolz, Marian <Marian.Wolz@vermont.gov>
Cc: Rick Heede <heede@climateaccountability.org>
Subject: Re: Carbon Majors Database and the InfluenceMap Team

EXTERNAL SENDER: Do not open attachments or click on links unless you recognize and trust the sender.

Hi Jane and Julie and Brian – thanks for your interest and your questions. I look forward to hearing from you again as this legislation moves forward and reaches the implementation stages. Meanwhile, if you have any other questions, do let me know.

I am attaching my original paper in Climatic Change, as well as the full documentation of Methods & Results, the InfluenceMap Carbon Majors update report, and the preliminary list of companies that are attributed > 1 GtCO2e from 1995 to 2022. Note that a few smaller companies are not fully accounted to 2022 (instead 2018 or 2020), which also means that one or more companies that now barely miss the threshold may qualify once we complete the accounting to 2022 and, later, to 2024. Then again, this is just the Carbon Majors methodology, and ANR will follow the legislative language and base emissions on crude oil, natural gas, and coal either produced (and delivered to global consumers), or refined, or sold to consumers. I am more than happy to discuss with you the various methodologies in more detail as needed down the road. We should also be aware of the necessity of avoiding double-counting emissions from, say, production *and* refining.

Respectfully, -Rick

***************@******************
Richard Heede <heede@climateaccountability.org>
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From: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>
Date: Tuesday, April 30, 2024 at 10:06 AM
To: Richard Heede <heede@climateaccountability.org>, Ramirez-Richer, Emma <Emma.Ramirez-Richer@vermont.gov>, Moore, Julie <Julie.Moore@vermont.gov>, Woods, Brian <Brian.Woods@vermont.gov>, Wolz, Marian <Marian.Wolz@vermont.gov>
Subject: RE: Carbon Majors Database and the InfluenceMap Team

Thank you for sending this and again for your time to meet and discuss. I am sure we will be in touch in the coming months.

Best,
Jane

VERMONT
Jane Lazorchak (she/her) | Climate Action Office
Vermont Agency of Natural Resources
Davis 2, 1 National Life Drive, Montpelier, VT 05602
802-505-0561
anr.vermont.gov

From: Richard Heede <heede@climateaccountability.org>
Sent: Tuesday, April 30, 2024 11:26 AM
To: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>; Ramirez-Richer, Emma <Emma.Ramirez-Richer@vermont.gov>; Moore, Julie <Julie.Moore@vermont.gov>; Woods, Brian <Brian.Woods@vermont.gov>; Wolz, Marian <Marian.Wolz@vermont.gov>
Subject: Re: Carbon Majors Database and the InfluenceMap Team

EXTERNAL SENDER: Do not open attachments or click on links unless you recognize and trust the sender.
All – here is my testimony to House Judiciary Cmtee 11 April, FYI.

From: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>
Date: Monday, April 29, 2024 at 12:01 PM
To: Ramirez-Richer, Emma <Emma.Ramirez-Richer@vermont.gov>, Richard Heede

<heede@climateaccountability.org>, Moore, Julie <Julie.Moore@vermont.gov>, Woods, Brian <Brian.Woods@vermont.gov>, Wolz, Marian <Marian.Wolz@vermont.gov>
Subject: RE: Carbon Majors Database and the InfluenceMap Team

Done! We met with Rachel this morning on this topic and had briefed her on this meeting.

From: Ramirez-Richer, Emma <Emma.Ramirez-Richer@vermont.gov>
Sent: Monday, April 29, 2024 1:04 PM
To: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>; Richard Heede <heede@climateaccountability.org>; Moore, Julie <Julie.Moore@vermont.gov>; Woods, Brian <Brian.Woods@vermont.gov>; Wolz, Marian <Marian.Wolz@vermont.gov>
Subject: Re: Carbon Majors Database and the InfluenceMap Team

Hi Jane and all,

Julie requested that you please invite Rachel Stevens to this meeting.

Thanks!
Emma

Emma Ramirez-Richer | Executive Assistant (she/her)

Vermont Agency of Natural Resources Secretary's Office

1 National Life Drive, Davis 2, Montpelier, VT 05620

802-828-0316 (o) | 802-261-5920 (c) | emma.ramirez-richer@vermont.gov

---

From: Lazorchak, Jane
Sent: Friday, April 26, 2024 7:20 AM
To: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>; Richard Heede <heede@climateaccountability.org>; Moore, Julie <Julie.Moore@vermont.gov>; Woods, Brian <Brian.Woods@vermont.gov>; Wolz, Marian <Marian.Wolz@vermont.gov>
Subject: Carbon Majors Database and the InfluenceMap Team
When: Tuesday, April 30, 2024 11:00 AM-11:30 AM.

Where: zoom

Updating with a Zoom link at the request of Rick – thanks!

Topic: My Meeting

Time: Apr 30, 2024 11:00 AM Eastern Time (US and Canada)

Join Zoom Meeting

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• +1 312 626 6799 US (Chicago)

• +1 253 205 0468 US

• +1 253 215 8782 US (Tacoma)

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• +1 386 347 5053 US

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• +1 564 217 2000 US

• +1 669 444 9171 US

• +1 689 278 1000 US

• +1 719 359 4580 US

• +1 720 707 2699 US (Denver)

Meeting ID: 825 6096 6752

Passcode: 674805

Find your local number: https://us06web.zoom.us/u/kdZdCxPF6n

From: [Lazorchak, Jane](#)
To: [Brian Brunskole](#)
Subject: RE: Development of a Climate Superfund Cost Recovery Program RFI
Date: Monday, July 29, 2024 2:55:00 PM
Attachments: image001.png
image002.png

Yes, this is a new request and there are no open RFPs or contracts.

From: Brian Brunskole <BrianBrunskole@deltek.com>
Sent: Monday, July 29, 2024 2:54 PM
To: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>
Subject: Development of a Climate Superfund Cost Recovery Program RFI

You don't often get email from brianbrunskole@deltek.com. Learn why this is important

EXTERNAL SENDER: Do not open attachments or click on links unless you recognize and trust the sender.

Hey Jane,

Hope you're doing well. Regarding the RFI mentioned above, I just wanted to get confirmation that this is a new requirement and there's no related incumbent contract(s). Any info you can provide is appreciated.

Thanks for your time,

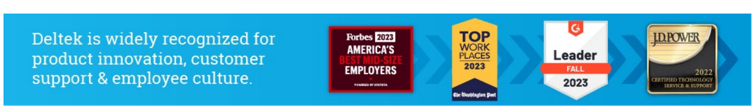
Brian

Brian Brunskole
Associate Research Analyst
-
brianbrunskole@deltek.com
T: 702.468.9553

Deltek.

2291 Wood Oak Drive,
Herndon, VA 20171

Deltek.com
-



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From:	Elena Mihaly
To:	Lazorchak, Jane
Cc:	Anthony Iarrapino; Gjessing, Catherine; Stevens, Rachel
Subject:	RE: Meeting w/you re: Climate Superfund implementation support?
Date:	Wednesday, September 25, 2024 5:23:32 PM
Attachments:	image001.png

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Thanks, Jane. We were thinking along the same lines in terms of timing (that is, to not meet until after the RFI period had closed). I just figured with so many peoples' schedules to navigate, it could be easier to schedule something now for a date out in late October/early November while calendars are relatively open for those weeks. If you'd prefer to wait to schedule something, I'd gladly circle back after the RFI deadline closes. I'll take your lead.

Appreciatively,
Elena

From: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>
Sent: Wednesday, September 25, 2024 4:56 PM
To: Elena Mihaly <emihaly@clf.org>
Cc: Anthony Iarrapino <anthony@ilovt.net>; Gjessing, Catherine <Catherine.Gjessing@vermont.gov>; Stevens, Rachel <Rachel.Stevens@vermont.gov>
Subject: RE: Meeting w/you re: Climate Superfund implementation support?

CAUTION: Email from outside CLF.

Afternoon Elena,

Thanks for reaching out. At this juncture, we would like to wait for the RFI to close and see the responses we get prior to meeting. If your group submits your response early, then we can advance a meeting once we have received it. We did have a question-and-answer period but didn't get any questions.

Hope that will work for you and the others you are working with.

Thanks,
Jane

From: Elena Mihaly <emihaly@clf.org>
Sent: Wednesday, September 25, 2024 3:11 PM

To: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>
Cc: Anthony Iarrapino <anthony@ilovt.net>; Gjessing, Catherine <Catherine.Gjessing@vermont.gov>
Subject: Meeting w/you re: Climate Superfund implementation support?

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Dear Jane,

It was nice to see you at the EAN event last week. I'm reaching out on behalf of a group of folks I've been meeting with who are committed to assisting the State with Act 122 (Climate Superfund) Implementation. The group includes local and national experts in the field of law, policy, and climate attribution science. We've been working recently on helping to disseminate and draw responses to ANR's July 22nd Request for Information.

We met with the Treasurer's Office a few weeks ago to share our goals/skillset/offers of support. We would like to line up a similar meeting with you and the relevant folks at the Climate Action Office/ANR who are working on implementation of Act 122.

If you are interested in such a meeting, perhaps you could offer a few times in late October that would work and I can run by folks on my end?

Thanks,
Elena

p.s., I'm cc'ing Catherine Gjessing just in case she wants to be kept in the loop on this correspondence.

Elena Mihaly (she/her)
Vice President, Vermont
Conservation Law Foundation

P: 802-622-3012 **C**: 415-717-2056
E: emihaly@clf.org

clf
Conservation
Law Foundation

From: Anthony Iarrapino
To: Lazorchak, Jane
Subject: Re: Updated due date RFI
Date: Monday, September 23, 2024 2:40:25 PM

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Thanks for letting me know, Jane.

From: Lazorchak, Jane <Jane.Lazorchak@vermont.gov>
Sent: Monday, September 23, 2024 12:53 PM
To: Anthony Iarrapino <anthony@ilovt.net>
Subject: Updated due date RFI

Hi Anthony,

We've extended the due date to 10/14/24. Thanks for touching base on that!

Jane

From: Jared Kelson
To: Lazorchak, Jane
Cc: marc@environmentalaccountability.org
Subject: Response to RFI –Development of a Climate Superfund Cost Recovery Program
Date: Monday, September 30, 2024 3:58:25 PM
Attachments: VT RFI Response (FINAL).pdf

Jane,

Please see the attached response from the Center for Environmental Accountability.

Thanks,
Jared

Jared M. Kelson
Counsel | Boyden Gray PLLC
800 Connecticut Ave NW, Suite 900
Washington, DC 20006
(202) 955-0620
jkelson@boydengray.com

Response to Request for Information

Development of a Climate Superfund Cost Recovery Program

Center for Environmental Accountability
Marc Marie
(240) 505-0486
729 Grapevine HWY
PMB 2019
Hurst, TX 76054
marc@environmentalaccountability.org

On July 22, 2024, the Vermont Agency of Natural Resources ("Agency") requested information relevant to its implementation of the state's Climate Superfund Cost Recovery Program ("Program").[1] The ostensive purpose of the Program is "to secure compensatory payments from responsible parties … to provide a source of revenue for climate change adaptation projects" in Vermont.[2] The term "responsible parties" in the statute refers to any entity, with sufficient connections to the state to satisfy the requirements of the U.S. Constitution, that "engaged in the trade or business of extracting fossil fuel or refining crude oil" between January 1, 1995, and December 31, 2024, and which the Agency determines is responsible for more than 1 billion metric tons of covered greenhouse-gas emissions during that period.[3] Such responsible parties must pay their proportional "share of the costs of climate change adaptation projects and all qualifying expenditures supported by" the Program.[4]

This response provides input for the Agency to consider in developing processes to identify responsible parties, determine their applicable shares of greenhouse-gas emissions, and calculate the associated cost to Vermont.

I. Climate Change and the Program Are Too Important to Get Wrong.

Any estimates related to the extent and costs of anthropogenic climate change ("climate change") must be robust and reliable to maintain Program integrity. This is especially true because of the significant financial liability that the Agency may assess based on those determinations.

The Agency must therefore account for the wide range of scientific opinions on the impact of climate change on meteorological phenomena. The U.N.'s International Panel on Climate Change ("IPCC"), for example, has reported low confidence that climate change has affected past droughts, floods, and storms.[5] And while damages from extreme weather have increased, such losses have *decreased* as a percentage of gross domestic product

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[1] Vermont Agency of Natural Resources, *Request for Information: Development of a Climate Superfund Recovery Program* (July 22, 2024), https://www.vermontbusinessregistry.com/bidAttachments/61438/Climate_Superfund_Request_For_Information.pdf.

[2] 10 V.S.A. § 597.

[3] *Id.* § 596(22).

[4] *Id.* § 598(a)(1).

[5] IPCC, *Climate Change 2021: The Physical Science Basis* 1856 (2021) (Table 12.12: Emergence of CIDs in Different Time Periods, As Assessed in This Section), https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FullReport_small.pdf.

("GDP").[6] This strongly suggests that economic growth, rather than any climate change related effect, is the cause of such increases.[7] The Agency must account for the possibility that Vermont has not suffered harm from climate change and may have even experienced positive impacts.

As discussed below, recent studies estimating the extent and costs of past and future climate change have demonstrated that attempts to quantify such a number are susceptible to manipulation and distortion. Noah Kaufman, who served as a Senior Economist at the White House Council of Economic Advisers in the Biden Administration, and as Deputy Associate Director of Energy & Climate Change at the White House Council on Environmental Quality in the Obama Administration, noted that "[t]he value of climate damages is not a thing we can estimate. There is no consensus. Never will be."[8] Disaggregating the effects of a global phenomenon like climate change on Vermont specifically is an even more fraught endeavor.

II. The Agency Must Avoid Obvious Pitfalls When Estimating Harms Attributable to Climate Change.

When developing its processes, the Agency must be careful to avoid certain obvious pitfalls. Its processes cannot rely on unsubstantiated or incorrect assumptions.

Accurate emissions scenarios are fundamental to reliable climate change projections because they are one of the primary drivers of the extraordinarily complex modeling. Many of the sensational climate harms projected by media and certain academic research, such as rapidly melting ice caps leading to rising sea levels and raging wildfires leading to deforestation, are based on RCP8.5, an outdated emissions scenario that projects a temperature rise of around 5°C by 2100.[9] RCP8.5 lacks scientific credibility and becomes demonstrably more implausible with each passing year. The latest projections of the

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[6] Roger Pielke Jr., *Tracking Progress on the Economic Costs of Disasters Under the Indicators of the Sustainable Development Goals*, 18 Envt'l Hazards 1, 1–6 (Mar. 2019), https://doi.org/10.1080/17477891.2018.1540343.

[7] *Id.*

[8] Noah Kaufman (@noahqk), X (June 3, 2024, 10:26 PM), https://x.com/noahqk/status/1797817256493412800.

[9] *Id.*; Zeke Hausfather & Glen P. Peters, Comment, *Emissions—The "Business as Usual" Story Is Misleading*, 577 Nature 618, 618 (2020), https://doi.org/10.1038/d41586-020-00177-3; Zeke Hausfather, *Explainer: The High-Emissions 'RCP8.5' Global Warming Scenario*, CarbonBrief (Aug. 21, 2019), https://www.carbonbrief.org/explainer-the-high-emissions-rcp8-5-global-warming-scenario.

International Energy Agency, expect a median warming of around only 2.4°C by 2100.[10] As Zeke Hausfather and Glen Peters explain, the "[e]mission pathways to get to RCP8.5 generally require an unprecedented fivefold increase in coal use by the end of the century, an amount larger than some estimates of recoverable coal reserves."[11]

But despite the now well-known shortcomings of RCP8.5, it continues to appear as a central input in climate modeling and research, undermining the role this work could otherwise play in informing the policymaking process.[12] The use of models or research that rely on RCP8.5—or any equivalent—as a baseline scenario of the impacts of climate change would be a fatal error. As described below, this applies equally to climate damage functions based on RCP8.5

Professor Justin Mankin testified before the Vermont legislature that "scientists can quantify the economic losses a region like Vermont has endured from the impacts of global warming to date."[13] His methods are equally flawed. He relies heavily on a GDP correlation method from a 2015 *Nature* article by Marshall Burke et al.[14] Recent analysis by David Barker, however, explains how Burke and his co-authors "cherrypick" and "use data with characteristics that are known to create spurious regression results without making proper adjustments or even acknowledging these characteristics."[15] Others have made similar methodological criticisms.[16]

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[10] *World Energy Outlook 2023*, Int'l Energy Agency, at 22 (2023), https://www.iea.org/reports/world-energy-outlook-2023/executive-summary; *see also* Hausfather & Peters, Comment, *supra* note 9.

[11] Hausfather & Peters, Comment, *supra* note 9, at 619.

[12] Roger Pielke & Justin Ritchi, *Systemic Misuse of Scenarios in Climate Research & Assessment* (Apr. 21, 2020), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3581777.

[13] Written Testimony from Dr. Justin S. Mankin Before the Vt. S. Judiciary Comm., at 1 (Feb. 22, 2024), https://legislature.vermont.gov/Documents/2024/WorkGroups/Senate%20Judiciary/Bills/S.259/Witness%20Documents/S.259~Justin%20Mankin~Written%20Testimony~2-22-2024.pdf.

[14] Marshall Burke et al., *Global Non-linear Effect of Temperature on Economic Production*, 527 Nature 235 (2015), https://doi.org/10.1038/nature15725.

[15] David Barker, *Global Non-linear Effect of Temperature on Economic Production: Comment on Burke, Hsiang, and Miguel*, 21 Econ. J. Watch, Mar. 2024, at 35–36, https://econjwatch.org/File%20download/1297/BarkerMar2024.pdf.

[16] *Id.* at 36–37 (discussing Richard G. Newell et al., *The GDP-Temperature Relationship: Implications for Climate Change Damages*, 108 J. Env't Econ. & Mgmt., July 2021, art. no. 102445, https://doi.org/10.1016/j.jeem.2021.102445; Richard A. Rosen, Letter, *Temperature Impact on GDP Growth Is Overestimated*, 116 PNAS 16170 (2019), https://doi.org/10.1073/pnas.1908081116; Richard S.J. Tol, *A Social Cost of Carbon for (Almost) Every Country*, 83 Energy Econ. 555 (2019), https://doi.org/10.1016/j.eneco.2019.07.006).

Mankin further relies on the controversial social cost of carbon ("SCC") to estimate damages.[17] That tool is highly suspect and easy to manipulate,[18] continues to rely upon the implausible RCP8.5 scenario, and uses arbitrary discount rates to inflate the cost of predicted harms.[19] One recent paper, relying on RCP8.5, claims that the SCC should properly be set at $1,056 per metric ton of CO_2 emitted.[20] The Breakthrough Institute immediately criticized the paper's reliance on "conceptually bizarre, poorly justified economic methods."[21] By contrast, the U.S. Environmental Protection Agency ("EPA") estimated the SCC at $130 per ton of CO_2,[22] and Nobel laureate William D. Nordhaus estimated the SCC at $31 per ton of CO_2.[23]

Kaufman has observed that "[t]he use of SCCs to make whatever point one would make without SCCs remains undefeated."[24] Hausfather similarly noted that "the SCC is, generally speaking, just a thin veneer of objectivity covering what is ultimately a naked value judgement."[25] And Arvind Ravikumar, co-director of the Energy Emissions Modeling

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[17] Written Testimony from Dr. Justin S. Mankin, *supra* note 13, at 2.

[18] Kevin Dayaratna et al., *Empirically Constrained Climate Sensitivity and the Social Cost of Carbon*, 8 Climate Change Econ., art. no. 1750006 (2017), https://doi.org/10.1142/S2010007817500063; Kevin Dayaratna & David Kreutzer, *Environment: Social Cost of Carbon Statistical Modeling Is Smoke and Mirrors*, 30 Nat. Gas & Elec., Issue 12, at 7 (2014), https://doi.org/10.1002/gas.21771.

[19] *See, e.g.*, Roger Pielke Jr., *Secret Sauce: You'll Never Guess What Drives the Biden Administration's Social Cost of Carbon*, The Honest Broker (Dec. 4, 2023), https://rogerpielkejr.substack.com/p/secret-sauce (addressing the role of RCP8.5 in the damage functions of EPA's SCC).

[20] Adrien Bilal & Diego Känzig, *The Macroeconomic Impact of Climate Change: Global vs. Local Temperature* 1, Nat'l Bureau of Econ. Rsch, Working Paper No. 32450 (2024), https://www.nber.org/papers/w32450.

[21] Alex Trembath & Patrick Brown, *When Activist Research Contradicts the Consensus*, Breakthrough Inst. (Jun. 3, 2024), https://thebreakthroughjournal.substack.com/p/when-activist-research-contradicts.

[22] EPA, *Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances* 101 (Nov. 2023) (Table 4.1.1), www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf.

[23] William D. Nordhaus, *Revisiting the Social Cost of Carbon*, 114 PNAS 1518, 1518 (2017), https://doi.org/10.1073/pnas.1609244114,

[24] Noah Kaufman (@noahqk), X (Jun. 4, 2024, 8:52 AM), https://x.com/noahqk/status/1797974627832205575.

[25] Zeke Hausfather (@hausfath), X (Jun. 4, 2024, 2:25 PM), https://x.com/hausfath/status/1798058427274658291.

and Data Lab at the University of Texas, called the SCC "a ~useless metric."[26] He continued that calculating a "consensus" figure for the SCC "is a fool's errand" that is "90% value judgment."[27]

In addition, the SCC calculated by EPA and others often purports to estimate *global* harms. Without methodologically credible modification, such SCC figures would wildly overstate the harms to Vermont.

In an effort to assess the harms climate change might have in specific geographic regions, on specific economic sectors, and on specific population demographics, the EPA has also developed a tool called FrEDI, the "Framework for Evaluating Damages and Impacts."[28] EPA advertises the tool as a "quantitative storyline of physical and economic impacts of climate change in the U.S., by degree of warming or custom temperature trajectory, region, and sector."[29] But, like the SCC, the tool is fundamentally flawed.

The Center for Environmental Accountability ("CEA") prepared comprehensive critique of FrEDI that it filed as a comment on the EPA's most recent revision of the tool.[30] As with many SCC calculations, FrEDI uses RCP8.5 to predict future harms, undermining its scientific validity from the outset and calling into question its use in the policymaking context. Given this and other flaws, use of FrEDI would be CEA strongly urges the Agency not to use it in an attempt to calculate climate damages specific to Vermont.

Finally, any modeling must be careful to account for *all* potential causes of climate change, including natural causes. It must also account for changing demographic patterns. To the extent property damage from storms may have increased, this likely reflects increased growth and exposure from the independent acts of third parties, i.e., more homes and more expensive homes being built on coastlines and in vulnerable areas.[31] Any

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[26] Arvind Ravikumar (@arvindpawan1), X (Jun. 4, 2024, 2:48 PM), https://x.com/arvindpawan1/status/1798064300130779553.

[27] *Id.*

[28] EPA, *Draft Technical Documentation for the Framework for Evaluating Damages and Impacts (FrEDI)* (Feb. 2024), https://www.epa.gov/system/files/documents/2024-02/technical-documentation-for-fredi_feb2024_0.pdf.

[29] *Id*. at 2.

[30] CEA, *Comment on Technical Documentation for the Framework for Evaluating Damages and Impacts (FrEDI)* (April 24, 2024), https://www.regulations.gov/comment/EPA-HQ-OAR-2023-0614-0005.

[31] Philip J. Klotzbach et al., *Trends in Global Tropical Cyclone Activity: 1990–2021*, 49 Geophysical Rsch. Letters, Issue 6, Mar. 14, 2022, https://doi.org/10.1029/2021GL095774; *see also* Adam B. Smith & Richard W. Katz, *US Billion-Dollar Weather and Climate Disasters: Data Sources, Trends, Accuracy and Biases*, 67 Nat. Hazards 387, 408 (2013), https://doi.org/

modeling must account for and exclude voluntary, knowing exposure to alleged climate harms.

III. The Agency Must Considering Constitutional and Federal Limits on the Program.

The Agency should be mindful of constitutional limitations on the Program when developing its processes. American law incorporates an "antiretroactivity principle" that "finds expression in several provisions of [the U.S.] Constitution," including the Due Process Clause, Ex Post Facto Clause, Takings Clause, and prohibition on bills of attainder.[32] The U.S. Constitution also "implicitly forbids" state power when the "interstate … nature of the controversy makes it inappropriate for state law to control."[33] Disputes that "deal with air and water in their ambient or interstate aspects" are thus the domain of federal law.[34] Such considerations are even stronger for international emissions.

Congress likewise passed the Clean Air Act to balance "the environmental benefit potentially achievable" against "our Nation's energy needs and the possibility of economic disruption."[35] The Clean Air Act leaves no room for states to impose their laws on out-of-state emissions.

In addition, not all entities that have engaged in extracting fossil fuel or refining crude oil have a sufficient connection with Vermont to satisfy the nexus requirements of the U.S. Constitution.[36] This is an especially important consideration when considering liability for out-of-state emissions that cannot be traced to within Vermont's borders. These limitations are important to resolve before expending taxpayer resources to implement the Program further.

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The myriad challenges associated with developing accurate models to implement the Program make it crucial for the Agency to engage experienced and knowledgeable consultants to help with implementation of the Program. Experts such as Roger Pielke Jr.

10.1007/s11069-013-0566-5 ("[I]t is difficult to attribute any part of the trends in losses to climate variations or change, especially in the case of billion-dollar disasters."); Roger Pielke Jr., *"Billion Dollar Disasters" Are a National Embarrassment*, The Honest Broker (Jan. 8, 2023), https://rogerpielkejr.substack.com/p/billion-dollar-disasters-are-a-national.

[32] *Landgraf v. USI Film Prod.*, 511 U.S. 244, 266 (1994).

[33] *Franchise Tax Bd. of Cal. v. Hyatt*, 587 U.S. 230, 246 (2019) (cleaned up).

[34] *Illinois v. City of Milwaukee*, 406 U.S. 91, 99–100, 103 (1972).

[35] *Am. Elec. Power Co. v. Connecticut*, 564 U.S. 410, 427 (2011).

[36] *Cf.* 10 V.S.A. § 596.

and David Barker have already proven their ability to identify obvious errors in existing climate models, and therefore would be prudent experts to engage in this endeavor.

CEA is also well equipped to assist the Agency as it develops processes to administer the Program. CEA is a 501(c)(3) organization devoted to educating the public and government on the importance of transparency and accountability in the areas of environmental and energy policy, and has consistently participated in government rulemakings related to emissions and climate modeling.[37]

[37] *See, e.g.*, CEA, *supra* note 30.