Thomas Weiss
P. O. Box 512
Montpelier, Vermont 05601
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Senate Committee on Natural Resources and Energy
State House
Montpelier, Vermont

Subject: S.5 meeting the mandated greenhouse gas reductions for the thermal sector through electrification, decarbonization, efficiency, and weatherization measures.

Dear Committee:

I am Thomas Weiss, a civil engineer with a background in energy conservation.
- My master's thesis was on orientation of solar collectors: not the orientation for maximum output. Rather it was on the reduction of intercepted energy with off-peak orientations (meaning the roofs on our existing buildings).
- I was an energy auditor and a technical assistance analyst.
- I was an energy conservation engineer who helped a U. S. Army base win the energy conservation prize for most improved community in Europe.
- I have reduced my greenhouse gas emissions by 50% since 1990.

I choose not to use the terms "affordable" or "clean heat" in connection with this bill. The measures provided in this bill may be affordable in the long run of over a decade or more. Most are not affordable in the short term because of their initial capital costs. Many of the measures do not provide "clean" heat because they still have high greenhouse gas emissions.

I have misgivings about the wisdom of the approach in S.5. S.5 seems an overly complex system to force reductions in greenhouse gas emissions. I suggest changes that can be made to this bill to make it more effective.

<u>Give top priority to reducing thermal loads of buildings</u>

We need to reduce thermal loads of existing buildings. At the same time we need to keep thermal loads of new buildings from overwhelming the reductions at existing buildings.

The buzz going around the State House is that there is a need for 40,000 additional housing units in the next seven years. Those 40,000 housing units likely will house 80,000 to 100,000 individuals. That is a population growth of 15% or so. That compares to our highest growth amounts, which were in the decades 1960 to 1970 (14%) and 1970 to 1980 (15%). The potential population growth exceeds the amounts in those decades, which were 55,000 and 67,000 people respectively.

The first step in energy conservation (and for reducing greenhouse gas emissions) should always be reducing the amount of energy used: fewer square feet; more insulation; less infiltration). This is necessary no matter the source of the thermal energy. Unnecessary thermal load is wasteful, whether the heat source is emissions-free or not. Emissions-free energy has costs, too. If we have not reduced thermal load, we are cutting too much firewood and too many trees. Covering too many fields. Damming too many streams and rivers. Destroying too many mountain tops. Diverting too much farmland away from food crops.

<u>Energy codes</u>

Buildings built to the energy codes are the most energy-***<u>in</u>***efficient buildings it is legally permitted to build. Some codes are determined by consensus. Others are set by majority vote. That is why codes generally do not require the best available technology. In order to meet the needs of the Global Warming Solutions Act, we need to use the best available technology. Our existing energy standards are insufficient for our needs. Because we are not using best available technology, we are creating buildings with a life of 50 or 100 or 200 years that will be considered energy wastrels in 2050.

Vermont controls the thermal load of buildings through its Residential Building Energy Standards and the Commercial Building Energy Standards. Yet this bill does nothing to address these standards.

The Residential Building Energy Standards have a base code and a stretch code. The stretch code is used only in municipalities that have adopted the stretch code and in the few Act 250 applications that involve housing. The RBES requires larger buildings to have a lower thermal load per square foot than smaller buildings. And the RBES fails to provide a maximum thermal load for large residences.

I suggest a cap on the thermal load of residential structures. This cap would be equivalent to a certain thermal load. One of the examples used by the RBES and its handbook is a three-story building (including heated cellar) that is 20' x 40'. The thermal load of such a building using the stretch code is about 24,000 Btu/hr for a building with a total heated floor area of 2400 ft^2. One might set the cap for larger buildings at 24,000 Btu/hr. I am presenting this for the concept; numbers should be looked at more carefully to ensure that the standard is low enough so that emissions from new construction are significantly lower than reductions from weatherization. A cap will require larger residences, those 3,000 or 4,000, or 5,000 ft^2 to be extremely energy efficient.

I am focusing on the Residential Building Energy Standards because I do not know enough about the CBES to comment intelligently on them. However, I believe it likely that does not use best available technology, either,

<u>Weatherization</u>

Please consider modifying the weatherization program to have it deal with vermiculite. I have a friend whose residence is eligible for weatherization. The weatherization people came and started the inspection. They required that the building owner remove the items in the attic before completing the inspection. The weatherization people came back and found vermiculite in the attic. That put an immediate end to the weatherization project. Because of the vermiculite, none of the house could be weatherized under the program.

I know that some vermiculite was contaminated with asbestos. The Environmental Protection Agency recommends that vermiculite insulation be left in place undisturbed.

If the weatherization cannot be completed with the vermiculite in place, then I suggest that the weatherization program could test the vermiculite for asbestos and give the test results to the building's owner. Then, if the vermiculite does not contain asbestos, the weatherization program would weatherize the residence. If the vermiculite does have asbestos and needs to be removed to adequately weatherize the building, then that would become part of the weatherization project by the weatherization program.

Suggestions for reducing thermal loads:

- Make reducing the thermal load the first priority.
- Abandon the base code and require the stretch code under the RBES. Better yet, go straight to Passive House Standards. Still better is to go straight to zero emissions (not net-zero).
- Set a cap on the thermal load of residences that are larger than a certain size. Better yet, require zero emissions for all new buildings and additions.
- Modify the weatherization program so it can work in residences with vermiculite.
- Require reduction of thermal load before giving credit to measures that require installation of equipment needed for fuel switching.
- Give priority to weatherizing residences of recipients of LIHEAP. This means that owners of buildings where LIHEAP recipients live will receive the priority. This funding will be in the form of grants if the owner is the LIHEAP recipient. If the recipient is a tenant, the funding is a long-term loan, due when the building is sold. This will reduce the amount of assistance needed by the LIHEAP program.

Prohibit fuel switching when it does not significantly reduce greenhouse gas emissions

Most of the eligible measures (10 of 11) are about fuel switching. Several of those measures are to switch from one fuel that emits greenhouse gas to another that also emits greenhouse gases, sometimes the same amount of emissions.

With thermal load as the highest priority of this bill, then fuel switching is of course a lesser priority.

Biodiesel and an air-source heat pump for hot water are the two fuel-switching measures that I have taken.

Biodiesel

Biodiesel releases the same amount of carbon dioxide as does #2 heating oil. Biodiesel costs me 30% more than heating oil would. Switching to biodiesel should not be allowed under this program, because it does not reduce emissions of carbon dioxide.

I began adding biodiesel into my oil tank in November 2005. I did this in order to reduce oil imports. I did not do this to reduce my carbon emissions. I did not expect to save money by doing this.

Heating with biodiesel does not reduce emissions of carbon dioxide. Instead, heating with biodiesel gets one more use out of cooking oil, avoids sending it to the landfill, and generates glycerin as a marketable by-product. Or, growing crops to go straight to biodiesel increases food prices. (More land used to grow oil seed crops means less land used to grow food.) Over six heating seasons, I experimented with the concentration of biodiesel in the heating fuel. I have been heating with pure biodiesel since then, this being my 12th heating season on pure biodiesel.

Biodiesel has the same base carbon intensity as #2 heating oil: 84. Thus, converting to biodiesel from heating oil does not meet the criterion of an eligible measure. This value does not include the carbon intensity of the pathway used to bring the biodiesel into Vermont. Even if the pathway's intensity is zero, converting to biodiesel is not a solution under this program.

I use "base carbon intensity" as the carbon intensity value of the fuel itself. This is the amount of greenhouse gas emissions produced from the burning of the fuel. The carbon intensity value as defined in the bill starts with the base value, then makes adjustments for the life cycle emissions. Emissions due to production and transportation add to the value. If the process pulls carbon dioxide out of the air, then there would be a reduction in the value. The slides on the Oregon program report on the savings due to the program. Unfortunately, the slides do not indicate whether Oregon's total emissions are going up or going down. I tried to look at the Argonne National Laboratory's GREET program to determine how it calculates values for biodiesel. I was unsuccessful in that endeavor. This, I cannot evaluate how life cycle carbon intensity values of biodiesel can be around 20 when the base value is 84. That means that I cannot concur that switching to biodiesel will reduce emissions.

I acknowledge that there are studies that claim to show that biodiesel is carbon neutral. The greenhouse gas emissions put into the atmosphere during the heating season are balanced the next growing season by the plants grown for the next year's biodiesel. The studies that I have seen differ widely: some say it is carbon neutral, others say not. It depends on how widely the study looks. What fuel does the farm equipment use? What fuel does the processing plant use? What is the transportation distance? I also acknowledge that the carbon intensity of the pathway is intended to take this into account.

Biodiesel generates 20.7 lb. of CO_2 per gallon when it is burned. Heating oil generates 22.6. Biodiesel takes 9% more gallons than heating oil to generate the same amount of heat when burned. Thus for an equal amount of heating, biodiesel generates the same amount of CO_2 as does #2 heating oil.

My experience this heating season is that pure biodiesel is more expensive than heating oil. (I have not compared prices in previous seasons.) I have had two deliveries this season at $5.895 and $5.095 per gallon without taxes and other fees. According to the Public Service Department's reports, the average price of heating oil at those times was $4.92 and $4.24, respectively. Converting the biodiesel to an equivalent heat value, biodiesel's prices were 30% more than heating oil. My experience is contrary to the hopes expressed in your committee that the price of biodiesel would be lower than the price of heating oil.

Suggestion for biodiesel: Do not allow switching to biodiesel, no matter its source, to be an eligible measure.

<u>Air source heat pump water heater</u>

I installed an air-source, heat-pump hot water heater in 2015. My motivation was to reduce greenhouse gas emissions. I failed to do that. Let me tell you why.

The heat pump water heater succeeded a propane-fired water heater that ran well 23 years. It burned about 80 gallons of propane each year. At a generation rate of 12.67 gal. of CO_2 per pound of propane, that is about 1,000 lbs. of CO_2 per year. This water heater needed no maintenance during its life. A few years later, the water heater went to Bolduc's (scrap metal dealer in Middlesex) and it had a nominal scrap value..

The air source heat pump water heater was installed in 2015 in the boiler room. That is where the propane water heater had been. The heat pump's installed cost was almost $3100 after the rebate from Efficiency Vermont. I'd been tracking my CO_2 emissions over many years. I happened to have a water meter lying around. I had the plumber install the water meter on the inlet side of the water heater. I had the electrician install an electric meter on the 240-volt circuit he installed for the water heater. And the gas fitter had to close off the supply line to the water heater. The water heater has a small (1500 Watt) resistance heating element for back-up use. All other air pump water heaters back then had full size heating elements in the 13,000 W to 17,000 W range. I chose the pump with the small element partly so I can run it off my battery back-up if I choose.

I read (past tense) the water meter and electric meter weekly to determine kWh per gallon and kWh per day. The system was working well and I stopped reading the meters after two years. The water heater was providing 10 to 20 gallons of hot water per kWh of electricity. And it used an average of 1 kWh per day. The variation depends on the temperature in the boiler room: warmer in summer and cooler in winter. (The heat pump is more efficient with warmer air temperatures.) The variation also depends on the amount of hot water used. (When more hot water is used, the heat loss from the heater to the cellar is a smaller proportion of the total heat used.) Yes, in the winter the heat pump's source is the heat lost from the boiler to the air in the boiler room. So in the winter the source of heat is biodiesel by way of the heat loss from the boiler. The heat pump also dehumidifies the air in the boiler room, which is an advantage.

Four months later I decided to resume reading the meters. The system was providing 4 to 5 gallons of hot water per kWh. It was using about 2 to 3 kWh per day. I had it investigated. It turns out the the water heater was leaking refrigerant. The refrigerant is R-134a (1,1,1,2-Tetrafluoroethane). The California Air Resources Board lists one pound of this refrigerant as having a global warming potential equal to 1430 pounds of CO_2.

It was thought that the leak was from a valve that was then replaced. It turns out that the water heater is still leaking refrigerant. Refrigerant has been added thrice. The service technician has not found the leak. The water heater is again low on refrigerant. Instead of recharging the refrigerant, the heating is from the back-up resistance heating element. The total refrigerant added in those three times was 4 pounds. In order to recharge the system, it'll need another 1 1/2 pounds of refrigerant. This means 5 1/2 pounds of refrigerant has leaked from the water heater in 7 1/2 years. This is an average 3/4 of a pound of refrigerant leaked per year. The CO_2 equivalent of this amount of refrigerant is about 1,000 pounds per year. The reduction in emissions from burning propane has been offset by emissions of refrigerant 134a.

The costs to investigate the leak and have the water heater recharged has been $1200. (Most of that cost is the labor.)

When it is time to dispose of the water heater, there will be a charge to remove the refrigerant and dispose of it.

Where does the refrigerant from my water heater go? Likely it went into the air in the boiler room. (Possibly it went into the hot water, although that is unlikely.) During the heating season, much of the refrigerant likely gets drawn into the boiler as combustion air, and sent up the chimney. What doesn't go up the chimney remains in the cellar. Eventually it gets carried outside by infiltration. (The cellar has not yet been fully sealed for various reasons.)

Summary
- The propane water heater had an installation cost, no maintenance cost, and a scrap metal value at the end.
- The heat pump water heater had an installation cost, has recurring maintenance costs, and will have an end-of-life cost to remove and dispose of the refrigerant (offsetting some or all of any scrap metal value).
- Heat pumps are not emissions free. They contain refrigerants with high global warming potential.
  - heat pump water heaters have higher greenhouse gas emissions than electric water heaters
  - heat pump water heaters have lower greenhouse gas emissions than propane water heaters reduces and do not eliminate them entirely.

Suggestions for heat pump water heaters
- Take testimony on maintenance and refrigerant leaks from those who actually install and maintain heat pumps and heat pump water heaters, before you include heat pumps and heat pump water heaters as eligible measures in S.5. I believe none of your witnesses has testified on this aspect. Find out what maintenance the technicians do and what is the prevalence of leaks. It is possible that my heat pump is an anomaly. It is possible that mine is typical.
- If my experience is typical and leaks of refrigerant are common, then also find out the ramifications of installing a heat pump water heater in a tight building.
- Require that use of refrigerants be tracked. Include refrigerant loss in the GHG calculations. No one has provided testimony on GHG emissions of refrigerants from heat pumps.
- Do not allow converting from an electric water heater to a heat pump water heater to be an eligible measure.

<u>Wood heat</u>

Let's look at heating with wood. What happens when one cuts down a 100-year-old tree for heating? The carbon dioxide is released in one heating season. And it takes 100 years to get another tree storing that much carbon. Yes, one can play games by planting faster growing trees and more of them. The conversion of carbon dioxide to wood is slow in the first years, the seedlings are so small. Switching to wood will not reach a steady state in the 27 years left until 2050.

Suggestion for wood heat: Do not allow switching to advanced wood heat as an eligible measure unless the switch is from other wood heat to advanced wood heat.

<u>non-fossil gas and propane</u>

Non-fossil gas from landfills is not really renewable. Production is only maintained because we keep throwing more trash on the landfill. And as we take food wastes and compostables out of what goes onto the landfill, production will go down. It'll probably last until 2050, maybe not. non-fossil gas and propane are in the same situation as biodiesel. They emit carbon dioxide when burned. They do not reduce carbon dioxide, merely change the source.

The requirement for a contractual pathway for the gas seems to add an unnecessary expense. Vermont Gas System would have to buy the gas, pay for the unused pathway, and then pay its supplier for the gas that actually gets delivered to the customers.

One of the witnesses mentioned renewable propane being used out west. That also involves the mere displacement of fossil propane with a non-fossil form of propane. The two emit the same amount of carbon dioxide when burned.

Suggestions for non-fossil gas and propane:

- Take testimony from Washington Electric Co-operative on the decrease they have experienced in gas production at their system in Coventry.
- Do not allow switching to non-fossil methane or non-fossil propane as an eligible measure.
- Expand the definition of heating fuel to include all heating fuels that emit carbon dioxide when burned, fossil or non-fossil. Wood in all forms, biodiesel, and landfill gas and farm methane come to mind quickly.

Credit market

S.5 allows purchase of market credits if a fuel dealer is unable to persuade enough customers to implement eligible measures. The credit market as an alternative to eligible measures has several drawbacks.

S.5 anticipates that there will be a shortage of credits and undue financial impacts. (§ 8124 (a)(4)).

Over the years, we have heard the refrain that sending money out of state for fossil fuels is bad. We should be keeping that money in state. This bill wants us to believe that sending money out of state to buy credits is good. Huh? Money going out of state is going out of state. It seems odd that one is good and the other not. Let's avoid the question by not getting into a credit market. We'll be sending lots of money out of state to buy the materials and equipment needed to meet the required emissions reductions. So let's send our money out of state for something physical that will actually help us meet our goals instead of a flimsy piece of paper that won't help us meet our goals.

Suggestion for credit market: Do not participate in a credit market.

List of eligible measures

S.5 lists eligible measures. I suggest placing them in priority order. I also suggest clarifying some. And removing others from the list.

Suggestion for eligible measures:

(c) List of eligible measures. Eligible clean heat measures delivered to or installed in Vermont shall include:

(1) thermal energy efficiency improvements and weatherization;

(2) buildings with a thermal load less than __ Btu / (hr · ft^2), may use one or more of the following eligible measures.

(A)~~(2)~~ cold-climate air, ground source, and other heat pumps, including district, network, grid, microgrid, and building geothermal systems;
(B)~~(3)~~ heat pump water heaters if they are not supplanting an electric water heater;
(C)~~(4)~~ controlled electric water heaters;
(D)~~(5)~~ solar hot water systems;
(E)~~(6)~~ electric appliances providing thermal end uses,
(F)~~(7)~~ renewable electricity systems paired with heat pumps or electric appliances providing thermal end uses, including on-site and community-scale renewable electricity systems;
(G)~~(8)~~ advanced wood heating; only if it is supplanting less efficient wood heating;
(H)~~(9)~~ noncombustion or renewable energy-based district heating services;
~~(10) the supply of sustainably sourced biofuels; and~~
(I)~~(11)~~ the supply of green hydrogen.

Thank you for reading this testimony. My suggestions are placed throughout this letter.

Sincerely,
Thomas Weiss