RAISED BILL 354 AN ACT ESTABLISHING A GREEN NEW DEAL FOR CONNECTICUT
Testimony OPPOSED
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A Technical Response to the Raised Bill

This bill sets the following targets, among others:

"achieves zero state-wide greenhouse gas emissions attributable to the electricity sector;" by 2040

"achieves zero state-wide greenhouse gas emissions attributable to the transportation and building sectors" by 2050

Achieving these goals involve insurmountable physical and material barriers, however, that make these goals unrealistic, and puts the state at risk of lawsuits for failure to meet these reductions.

Electric Vehicles
First let's look at the conversion of the transportation sector to zero-emission vehicles. This would involve converting over 1.2 million passenger cars to electric vehicles (EVs) – we'll look at trucks and commercial vehicles later.

A study by the British Natural History Museum looked at the physical inputs to an EV, especially the battery, and concluded that there are not enough raw materials, especially so-called rare earths, to convert the world's transportation sector to zero emissions. Using their numbers, I've calculated the raw material consumption of various elements required to convert Connecticut's 1.2 million-plus passenger cars to EVs.

Minerals/Metals Required for Conversion of All CT Cars to EVs

	Metric Tons Needed	% of World	CT's Disproportionate Share
Cobalt	8,330	8%	176 times
Lithium Carbonate	10,666	3%	66 times
Neodymium, Dysprosium	290	4%	88 times
Copper	95,228	2%	44 times

Basis for numbers: https://www.nhm.ac.uk/press-office/press-releases/leading-scientists-set-out-resource-challenge-of-meeting-net-zer.html

Obviously, Connecticut does not directly use these materials since we don't manufacture EVs. But these represent the material inputs for any EVs that we must obtain to achieve an all-electric transportation sector, and our ability to purchase such EVs will be limited by the worldwide availability of these materials.

Let's look at what these numbers mean. "Metric tons needed" are the physical amounts of metals or minerals that have to be mined, extracted, and refined to final form for input into the manufacturing process of an EV. "% of World" represents the amount of these materials consumed by Connecticut EVs as a percentage of all such material currently available in the world today. For example, Connecticut will require 8% of the world's entire current production of cobalt in the EVs it must obtain. "CT's Disproportionate Share" refers to the fact that while Connecticut has only 0.046% of the world's population, it will attempt to consume 8% of the world's production of cobalt, for example, which means it consumes 176 times more than the proportionate share of cobalt in our EVs it can claim by its population relative to the rest of the world.

This last point is that Connecticut will be competing against the rest of the world for these rare products in the EVs we must obtain, as other countries (and states in the U.S. as well) also seek to de-carbonize their economies. Connecticut, given its size, would be at a disadvantage in securing EVs using these materials when attempting to purchase EVs from the manufacturers' supply chains and will likely be put low on the waiting list for EVs. Alternatively, assuming we still have a capitalist economy driven by supply and demand, prices for EVs will rise astronomically as demand far outstrips supply.

Material Demands of Renewables

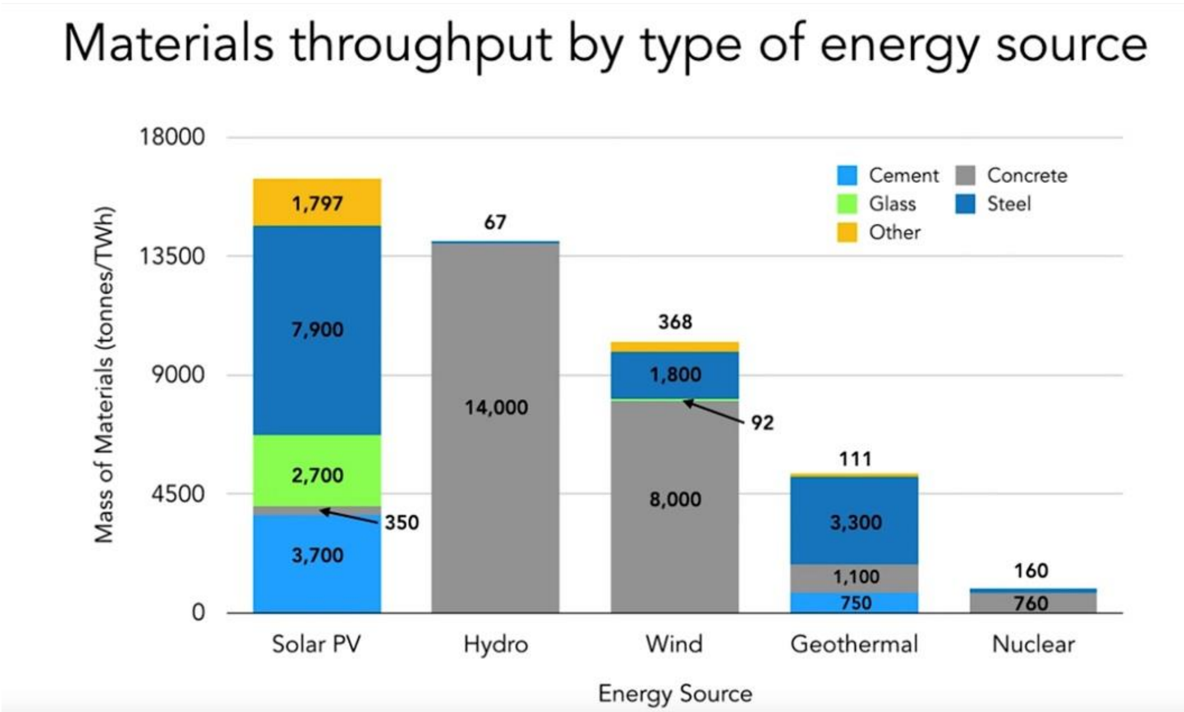
In 2017, the World Bank released a report that offered the first comprehensive look at the material demands of renewable power generation. It modeled the increase in material extraction that would be required to build enough solar and wind utilities to produce an annual output of about 7 terawatts of electricity by 2050. That's enough to power roughly half of the global economy. By doubling the World Bank figures, we can estimate what it will take to get all the way to zero emissions—and the results are staggering: 34 million metric tons of copper, 40 million tons of lead, 50 million tons of zinc, 162 million tons of aluminum, and no less than 4.8 billion tons of iron. Obviously these are not Connecticut numbers, but problems with the world supply of these products will create roadblocks to Connecticut's attempts to achieve net-zero emissions.

In some cases, the transition to renewables will require a massive increase over existing levels of extraction. For neodymium—an essential element in wind turbines—extraction will need to rise by nearly 35 percent over current levels. Higher-end estimates reported by the World Bank suggest it could double.

The same is true of silver, which is critical to solar panels. Silver extraction will go up 38 percent and perhaps as much as 105 percent. Demand for indium, also essential to solar technology, will more than triple and could end up skyrocketing by 920 percent.

And then there are all the batteries we're going to need for power storage. To keep energy flowing when the sun isn't shining and the wind isn't blowing will require enormous batteries at the grid level. This means 40 million tons of lithium—an eye-watering 2,700 percent increase over current levels of extraction. If you think all this will transpire, you should start buying stock in mining companies.

According to the *U.S. Department of Energy's 2015 Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities*, solar and wind generation use a lot of raw materials, much more than other power generators. The chart below is based on Table 10.4 of the DOE report and appears in a Tedx presentation.



The issue here isn't that these materials are hard to get or are in limited quantities such as the case with rare earths. Rather it's that these materials are carbon-intensive to produce, and so mitigate the zero-emissions claims of wind and solar power plants, once you look at their full life-cycle effects of production. For example, cement production is very carbon intensive. A ton of cement produces 1,980 pounds of CO2; and a ton of concrete, which uses cement, produces 225 pounds of CO2 (http://www.greenrationbook.org.uk/resources/footprints-concrete/) Steel is even worse, with 1.85 metric tons of CO2 produced for every metric ton of steel (https://www.worldsteel.org/publications/position-papers/steel-s-contribution-to-a-low-carbon-future.html).

Environmental Waste Impact of Green Energy

Solar

Solar panels are manufactured using hazardous materials, such as sulfuric acid and phosphine gas, which make them difficult to recycle. They cannot be stored in landfills without protections against contamination. They contain toxic metals like lead, which can damage the nervous system, as well as chromium and cadmium, known carcinogens that can leak out of existing e-waste dumps into drinking water supplies. Solar panels create about 300 times more toxic waste per unit of electricity generated than nuclear power plants. Solar panels have relatively short operational lifespans (20 to 30 years), so their disposal will become a problem in the next few decades. For example, in China, there could be [20 million metric tons] of solar panel waste, or 2,000 times the weight of the Eiffel Tower, by 2050. Source https://www.instituteforenergyresearch.org/uncategorized/will-solar-power-fault-next-environmental-crisis/

Wind

Wind turbines are designed to last approximately 20 to 25 years. While the main cores of wind turbines are made from steel and copper, which are recyclable materials, turbine blades are made from composite glass or carbon material and resins, which are not as valued and are generally disposed at landfills. Turbine blades span up to 260 feet and weigh an average of 36 tons, posing a difficult disposal problem. Because of their size and weight, turbine blades typically need to be cut up before they can be moved. According to NPR, more than 720,000 tons of blade material will be disposed of over the next 20 years in the United States—a figure that does not include newer, taller higher-capacity turbines. Disposal of these blades—a byproduct of increasing wind generation—is becoming a growing problem.

EVs

According to a University of Birmingham paper published in Nature https://www.nature.com/articles/s41586-019-1682-5 , in 2017 sales of electric vehicles exceeded one million cars per year worldwide for the first time. Making conservative assumptions of an average battery pack weight of 250 kg and volume of half a cubic meter, the resultant pack wastes would comprise around 250,000 metric tons and half a million cubic meters of unprocessed pack waste, when these vehicles reach the end of their lives. In addition to their disposal, just handling expired EV batteries for disassembly is hazardous. It requires high-voltage training and insulated tools to prevent electrocution of operators or short-circuiting of the pack. Short-circuiting results in rapid discharge, which may lead to heating and thermal runaway. Thermal runaway may result in the generation of particularly noxious byproducts, including HF gas, which along with other product gases may become trapped and ultimately result in cells exploding. The cells also present a chemical hazard owing to the flammable electrolyte, toxic and carcinogenic electrolyte additives, and the potentially toxic or carcinogenic electrode materials.

An All-Electric Economy in Connecticut Will Require More Than Twice Today's Electric Capacity

According to ISO-New England, which manages the region's electric grid, the energy supply situation today is as follows: "Both renewable and natural gas-based generation technologies rely on the "just-in-time" delivery of their input energy sources. Given the system's evolving resource mix and fuel delivery infrastructure, there may be insufficient energy available to the New England power system during extended cold winter weather conditions to satisfy electricity demand." https://www.iso-ne.com/committees/key-projects/energy-security-improvements. That's the situation today: energy security (as ISO-NE puts it) is on tenterhooks. The addition of millions of EVs and hundreds of thousands of homes to the electric grid will require a massive investment in power generation infrastructure.

This discussion will be the first in Connecticut to address this issue.

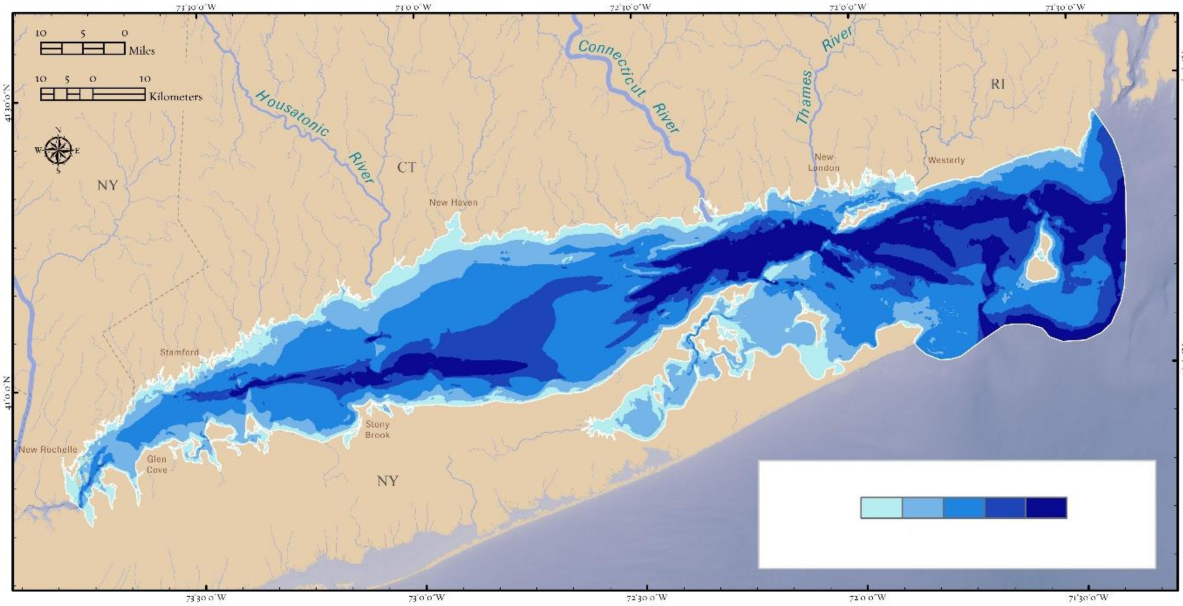
EVs
Adding some 1.3 million electric vehicles (passenger cars and commercial vehicles) will require some 2,736 MW of additional electric capacity, according to a study by Exergy, Inc. (spreadsheet available upon request).

Thermal Heating
Converting all natural gas, fuel oil, and propane-heated residential, commercial and industrial properties in the state to electric heat pumps, which is the state's plan, will require an estimated 8,127 MW of additional capacity to our electric grid.

So a total electric economy will require an additional 10,863 MW of additional electric power generation. Currently, our capacity is some 8,904 MW of which some 17% according to ISO-NE is hydro or renewable generated. This means 7,390 of existing fossil fuel and nuclear electric capacity needs to be replaced by renewables by 2040 per Raised Bill 340. Adding this to the 10,863 MW of new capacity to convert the transportation and heating sector to electricity by 2050, we get a total of 18,253 new capacity needed by 2050. Obviously such capacity can't be natural gas, since that's prohibited by the bill, and nuclear is distasteful to almost everyone. So this new capacity has to be wind or solar. But the problem with wind and solar is that Connecticut is a small state, and these kinds of power plants are very space-intensive. Let's consider each with some hypothetical extrapolations of current facilities.

Offshore Wind Farms

Pictured above is one of the world's largest offshore wind farms, the Walney Extension, off the coast of the United Kingdom in the North Sea. It has a capacity of 659 MW and covers an expanse of 145 sq. km. To replace the 18,253 MW of new power generation noted above, we'd need 28 wind farms the size of Walney, covering over 4,000 sq. km. If we place these offshore from Connecticut in Long Island Sound, it would cover the entire Sound, which measures only some 3000 sq. km. and spill out into the Atlantic, as shown in the blue shaded area in the map of the Sound below.

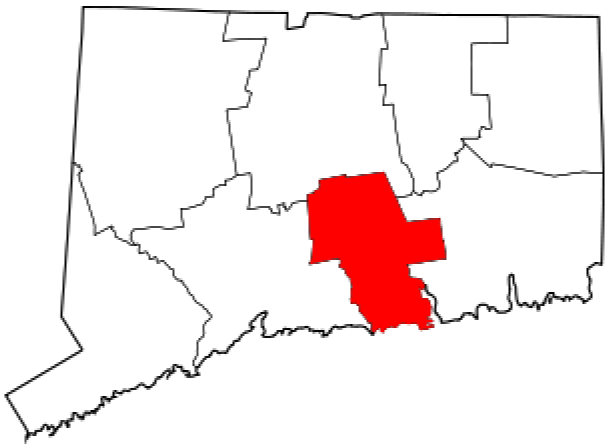


Long Island Sound filled to overflowing with wind farms (blue shaded area)

Solar Farms

Desert Sunlight Solar Farm, Mohave Desert, California

Maybe a solar farm would work better. Pictured above is one of the U.S.'s largest solar farms, in the Mohave Desert in California. This location works well for a solar farm because the Mohave is sunny 279 days out of the year. It's also flat. It has a capacity of 550 MW and covers 16 sq. km. To supply 18,253 MW of power, we'd need some 33 farms, covering an area of 531 sq. km. which is about half the area of Middlesex County.



In other words, to make room for this huge solar farm, we'd have to completely flatten half of Middlesex County, removing every building, road, river, and rock and flatten every hill and smooth over every valley.

Conclusion

While desirable in theory, an all-electric economy cannot be achieved in practice. The amount of land or sea area that solar or wind farms would consume would be too great. The materials such farms require are very carbon-intensive to produce, and the huge volume of solar panels and wind farm blades will result in a massive waste disposal problem. Connecticut would also be at a severe disadvantage at competing with the rest of the country, and the world, for electric vehicles to achieve the goal of an all-electric transportation sector, as such EVs will be in short supply due to the limitation on rare minerals and elements they require. And even when these are secured, the disposal of used EV batteries poses a hazardous waste risk.

Accordingly, we oppose passage of Bill 354.