A 100% Renewable Energy Strategy for New Hampshire's Future

- A White Paper (Oct. 2018 V.3) –

Foreword

This paper was motivated by the release of New Hampshire's 10-Year State Energy Strategy plan in April 2018. That document emphasized the need for continued support of coal and nuclear energy generation for NH's future, perhaps even with additional subsidies. It greatly understated, however, the importance of the Granite State's in-state renewable and clean energy resources, the national and international trends favoring the rapid deployment of new emerging energy technologies and the power of energy efficiency measures. While energy efficiency is the lowest hanging fruit available (a "negawatt" = 1 Watt energy saved, is the cheapest Watt) to reduce energy demand, the emerging new technologies provide an opportunity to improve energy independence and grow more new and good paying jobs, which also would attract desperately needed younger workers.

To highlight the undervalued areas of the 10-Year plan, a group of individuals, knowledgeable in the specific energy areas was recruited to provide their views. They were asked to address the current state of their technology or energy area, point out possible obstacles that currently prevent maximizing those energy resources, and also to attempt to project into the future, to 2040 and 2050, how they expect those resources to evolve over time. Given the resources available and the time constraints, this paper does not claim to be all inclusive, or the final word. It also does not represent a consensus view of all the topics discussed. That is why the author of each contributed section is clearly identified, and is only representing their own view. When a specific author is not listed, that section was contributed by the editor, using the various sources referenced. Despite these short-comings, we believe the paper represents a complementary resource that policy-makers and lawmakers should use to provide a more comprehensive view and an exciting new vision of our shared energy future.

Executive Summary

Our state needs to chart its own renewable energy course for the future and become less dependent solely on out-of-state energy resources. We have the opportunity to generate all of NH needed electricity using 100% renewable energy sources by 2040. There are different pathways to achieve this but the technical opportunity is available, now all that is needed is political will and leadership.

New Hampshire should find the right combination of renewable energy resources and set challenging but achievable Renewable Portfolio Standard (RPS) timelines and

goals. Having fuel diversity and building up our state's energy dominance, both of which will result in more economic activity and jobs for NH residents, are benefits that must be considered in addition to the quantity of energy that they produce. It should be important to all NH residents where our energy comes from, and where our energy dollars go, whether it stays in our state or leaves our state. We must make maximum use of our state's assets as well as accommodating partnerships with neighboring states that have assets of mutual interest.

Table 1 in the Summary & Conclusions-section provides information on the impact of energy efficiency measures and the resulting savings. Reducing our energy use, with more energy efficiency, should be the first step and it is the cheapest one as well. More efficient use of energy is always a good strategy. Such a strategy will improve the air quality in NH and reduce harm to our environment including reducing Greenhouse Gas (GHG) emissions which contribute to worldwide climate change. We can also expect to benefit from numerous technological innovations that are becoming more viable and affordable.

This paper outlines a number of pathways for NH to use 100% renewable energy resources to replace our current total electricity consumption of approx. 11,000 [GWh] and opportunities to include other energy uses such as heating and transportation. For the purposes of this paper, however, we are focused on electrical consumption of which 59%, or 6448 GWh, was used by Commercial and Industrial(C&T) users, while 41% or 4438 [GWh] was consumed by Residential(R) users.

In addition, it is assumed that another 45,113 [GWh] of energy is consumed by both C&T and R- users for heating needs with the ratio of 56% (23156 [GWh]) C&T to 41% (21951 [GWh] for Residential users. Included in the NH energy use calculations is 13,045 [GWh], which is considered to be energy losses due to production, transmission and distribution. And finally, an amount of 29,307 [GWh] is assumed to be used for transportation needs.

These pathways to 100% renewable energy use for both electricity and heating should include partnerships with our neighbors to develop and enhance currently underutilized regional renewable energy sources. The significant potential of offshore wind (promised fast-track licensing by the Interior Department) is one such opportunity, which would require a partnership between the states of Maine and New Hampshire. Canadian onshore wind power and hydro power present another such opportunity. Within the borders of our state, solar, hydro, wind and biomass installations offer the opportunity to develop and maximize in-state renewable energy resources, adding substantial business investment and employment and enhancing the energy dominance of our state.

Tables 2-7 in the Summary & Conclusion-section deal with the various types of in-state renewable energy resources as well as the potential of offshore wind energy emerging in the near future, up to 2050.

Table 8 provides an overview of all NH in-state electricity generation, including the possible offshore wind energy that would be accessible for NH as a source of electricity. It would appear that of all the possible NH energy choices that could be available by 2030, the top choices in order would be: offshore wind, onshore wind, large hydropower, and solar energy (because of its growth potential). Small hydropower and biomass remain more minor players. However, their other contributions to fuel diversity, economic impact and environmental impact are significant and important.

The opportunities for offshore and onshore wind are constantly in the news. An article[a] reported that 6 east coast states (MA, NY, NJ, RI, Maryland and Conn.) have all joined together to contract for 10 GW of offshore wind capacity, enough to generate 35,000 [GWh] of low-cost and clean electricity which is 3 times the current NH electricity consumption. These states plan to begin the process of creating a new heavy industry business, focusing on offshore wind and creating an estimated 160,000 new jobs.

In the meantime, our state must aggressively address the actions needed to remove the obstacles for the development of renewable energy resources in and for New Hampshire. Some of the actions needed to remove obstacles are:

- Aggressively increase the Renewable Portfolio Standard (RPS) goals both for the types of energy and the timeline involved, 25% by 2025 is too low a bar
- Drive down Demand via an aggressive energy efficiency program, which in turn reduces customers utility bills, and reduces GHG emissions. Because Transmission & Distribution cost are the reason for NH's utility bill increases, far higher than in neighboring states, we must work to reduce demand.
- Address the underfunding of low-income energy efficiency programs
- Increase funding of renewable energy projects so that they are fully funded for the entire year, instead of for only approx. 6 months as is the case currently
- Increasing or even eliminating the net-metering cap which controls the demand for more renewable energy projects, both for municipalities and private companies
- Join other Atlantic coast states on the federal board involved with the awarding of offshore wind energy leases off the coast of New Hampshire
- Investigate the opportunity to join Maine in creating a new offshore wind energy industry on the Maine/NH coast
- Raise the Alternative Compliance Payment (ACP) to be more in line with neighboring states
- Expedite grid modernization to allow access for more renewable energy generation
- Join efforts to help create a nationwide carbon pricing system that places a genuine price on producing energy with fossil fuels

[a] S.McClellan, Renewable Energy World, 9/14/2018

- Join with municipalities to encourage increased energy efficient use of municipal buildings, waste water treatment facilities, street lighting and recycling center.

  For NH to see the future as an opportunity instead of a threat, it will require strong political leadership that will set challenging goals and work together with businesses, municipalities and the public to achieve them. Other states are doing just that and NH is no less capable of rising to this opportunity.

Table of Contents

Purpose

While the 2018 NH 10-Year State Energy Strategy offered one perspective on NH's energy future, many of the up and coming technologies and opportunities were neglected in favor of traditional conventional energy resources and strategies. This paper is an attempt to provide an alternative view of NH's energy future including new and more innovative renewable energy (RE) strategies, that are already beginning to replace traditional energy resources, either due to higher efficiencies or lower prices. While levelized and unsubsidized costs are important in planning such an energy future, it is important to remember that all of our current energy resources: coal, nuclear, oil and natural gas have been and continue to be the beneficiaries of government assistance, which keeps those industries operating and ensuring employment for many of our fellow Americans. However, as new and innovative technologies emerge, it is important to allow them likewise to benefit from government assistance, as they create the jobs of the future.

Despite the modest progress our state has made in some areas, our state's approach to the future often seems to have a pattern: 1 step forward and 2 steps back, while at the same time changing the rules governing our energy issues every 2 years. This approach is not beneficial for our NH business community. They want stability and predictability for business planning. It is also not a strategy that will attract new businesses, especially the kind that are attractive to new and younger workers in our economy. This is particularly true for companies involved with renewable energy and energy efficiency sectors of our state's economy. And it is no way to build an energy strategy for the future. We need a plan with vision and forethought that is based on facts and that all Granite Staters have a realistic roadmap to reach our most efficient and cleanest shared energy future.

That is why the focus of this paper is specifically on developing new energy technologies that will fuel the growth of the NH economy. It also attempts to take both the pulse of this economic sector as well as proposing ideas to enhance and to stimulate future development of these sectors.

An attempt is made to show a path forward in the direction of a NH that is 100% self-sufficient and builds energy dominance for its energy needs, for electricity, heating and transportation. It is focused on a pragmatic approach: i.e. what is realistically achievable by the years 2030, 2040 and 2050.

The authors recognize that climate change is a fact, and adaptation to this fact is needed. But they also see adaptation as an economic opportunity, because a 100% renewable energy goal will in fact benefit and mitigate, and possibly reverse the effects of climate change.

Our state has a number of the elements that would allow us to benefit from renewable energy and an aggressive energy efficiency policy such as : A) currently NH imports roughly $3.0 billion dollars each year of fossil fuel products[b]. These could be replaced by in-state renewable (RE) resources. B) a viable biomass and small hydro industry already exists, C) a strong and growing solar and onshore wind industry sector is waiting to be unleashed, D) the huge potential for Gulf of Maine offshore wind energy has which so far been ignored, E) municipalities interested in community renewable energy projects and efficiency upgrades have been waiting for our state to facilitate more aggressive action (e.g. more net-metering, microgrids), and finally, F) a still largely untapped opportunity for energy efficiency measures have been chronically underfunded. So that, e.g. 30,000 low-income residents wait for energy audits (funded by both state and federal funds), but there is only enough funding to perform approx. 1000 such audits each year. This severe underfunding results in an unacceptable waiting period of 30 years.

This paper is focused on inventorying all of NH's in-state RE assets, e.g. solar, biomass, hydro, wind energy (both on land and in the Gulf of Maine), and biofuels as well as efficiency measures, identifying ways to generate more in-state energy and identifying the current restrictions that are blocking such efforts. Generating more in-state energy and increasing energy efficiency to push down energy demand are the most effective ways to lower energy bills for all NH residents. We also attempt to project the expected trends for RE and the increased efficiencies that new emerging technologies are expected to produce. Enhanced efficient use of various energy forms will likewise be discussed.

National and Global Trends for 100% Renewable Energy (Peter Somssich)

A summary of the global energy transformation[c] which was published in 2018 by G.P.Yeh of Fermilab provides a comprehensive global and national overview, which is described here.

Some highlights of this article include: Current worldwide energy consumption is 15 Terawatts (=15,000 [Gigawatts] = 15,000 x 1000 [Megawatts]) for the world's 7 billion people. This number is the Effective Power (EP) being provided globally by all energy producing resources. The EP is = Capacity x Cf= Capacity Factor (efficiency), with the capacity referring to the number provided by a manufacturer of energy generation, e.g. an 8 MW offshore wind turbine. Global carbon emissions are 10 billion tons a year or approx.1 million tons per hour. The world's 400 nuclear reactors, with the average age of 30 years, are providing 2.3% of the world's energy. Solar, wind and other renewable

[b] Settling Parties to NH Energy Efficiency Resource Standard, Press Release, 9/8/2016

[c] G.P. Yeh, Fermilab-Chicago, World Energy Transformation, July 2018
https://www.aps.org/units/fps/newsletters/201807/world-energy.cfm

energies and energy efficiency continue their tremendous recent progress. In 2016 globally 55 GW of wind and 75 GW of solar were installed bringing the cumulative totals to 487 GW of wind power capacity and 303 GW of solar power capacity. This is approx. 3% for wind and 2% for solar of world capacity. In 2016, cumulative solar water heating capacity was the electrical equivalent of 465 GW-thermal, while in 2016. Concentrating Solar Power (CSP) is also providing utility-scale electricity. Solar energy capacity is projected to provide a significant percentage of the total multi-Terawatt energy worldwide capacity by 2050.

Well planned water systems, including hydro power, can provide drinking water, flood control, irrigation and electricity for society. Hydro power capacity was 1096 GW in 2016 supplying 16.6% of world electricity energy generation. Small Hydro can benefit local communities. Hydro power can provide 2000 GW of world energy by 2050. Ocean tidal, wave and ocean current power are being developed and will also provide sustainable clean energy in the future.

Bio-energy can be close to carbon neutral. The main problem with CO2 emissions comes from fossil fuels[d]. That is why fossil carbon should be kept underground. Biomass, ethanol, biodiesel from recent plants, are renewable and almost “net-zero” carbon, because while trees and plants absorb carbon from the atmosphere, dead trees and plants will eventually emit carbon(in the form of CH4) if not buried underground. Bio-energy, including biomass heating, bio-power, ethanol and biodiesel provide 14.1% of worldwide energy.

To reduce the impact on food production, cellulosic ethanol from corn stalks, cobs and grasses has been in production in the last few years. Biodiesel development also includes using algae, while bio-jet fuel is already being used.

Other renewable energy resources include using geothermal heat pumps for heating and cooling. Hydrogen produced from water electrolysis with wind power or solar power would be a clean fuel with zero GHG emissions. Hydrogen could be used for energy storage and/or to replace other fossil fuels applications.

Renewable energies, including wind and solar power, now have competitive prices compared to fossil fuels and nuclear power.

Improving energy efficiencies is the most cost-effective component energy solution. LEDs, with 80-90% efficiencies, 10 times more efficient than incandescent light bulbs, can save most of the energy used for lighting. More energy efficient appliances, buildings, power plants, factories, vehicles, public transportation, and recycling will also reduce energy consumption by multi-Terawatts.

[d] G.P. Yeh, Private Communications, 9/2018

Wind power in 2016 provided 4% of the world's electricity or 1% of the world's energy. Solar power provided 1.5% of the world's electricity. The annual increase of electricity generation from wind, solar, hydro and other renewables is now, in today's dollars of capital investment, equivalent to the electricity that would be generated by adding ~50 nuclear reactors per year. Research and development continue to advance efficiencies, reduce costs, and improve utilization of renewable energies. Solar, wind, hydro and biofuels, will each will provide a significant percentage of total world TeraWatts by 2050.

The United Nations and the World Bank are currently partnering on a "Sustainable Energy for All by 2030" initiative.

The trend among developed countries as well as many emerging countries is away from fossil fuel energy and towards 100% renewable energy goals. Countries as diverse as the European Union countries, Kazakhstan, China, Brazil and Peru have announced RE goals, both to mitigate climate change effects and because the economics of RE sources is becoming more favorable every year.

In the USA, a number of states have already passed into law or are about to commit to RE goals. Hawaii, with its unique situation as an island, has now passed laws mandating 100% RE for electricity by 2045 and 100% RE for all energy sectors, including transportation by 2050.

California appears to be suffering from too much installed solar capacity since the investor-owned utilities are now well ahead of the state's target for 25% renewables by 2020. However, a resolution is in sight: a new higher target. The mandate to generate 50% of the state's electricity from renewable sources by 2030 is now easily within reach (renewables accounted for 27% of total electricity generation in 2017), so that the state senate has proposed legislation to require 100% RE for electricity by 2045. It is another indicator, that setting ambitious RE goals and having both government and business work to achieve those goals, is a winning formula for everyone involved. This could be a lesson for NH as well; if you raise the bar for RE the market place will respond.

Even though solar energy currently has slowed a bit, residential solar capacity in the U.S. has been increasing dramatically in recent years, and analysts expect such expansion to continue in emerging state markets such as Utah, Texas, South Carolina and Florida. Other neighboring New England states are not only talking about ambitious RE targets, but are very close to finalizing 50% renewable electricity goals. These states include[e] New York, Rhode Island, Massachusetts, Connecticut and Vermont.

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[e] Maritime Executor, NY State 50% Renewable Energy by 2030, Maritime Executor, 9/2/2018

If NH is planning to compete with other New England states for affordable and clean energy resources, and for the workforce willing to take on such challenging goals, we must begin soon. As a small player in the New England region, if we do not act soon, surrounding states will start implementing their plans, and we will lose control over our own future.

Energy Status Quo in New Hampshire (Peter Somssich)

Our state does not have any useful fossil fuel energy resources of its own, which also means that we are not financially obligated to any particular in-state fossil fuel commercial interest. As of 2016 our state's total energy consumption was 88,000 GWh, with the following allocation: 26,400 [GWh] for Residential Use, 20,500 [GWh] for Commercial Use, 12,000 [GWh] for Industrial Use and 29,300 [GWh] for transportation. Currently, the major supplier of NH in-state generated electricity[f] is the Seabrook nuclear power plant. The next largest energy resource for in-state electricity generation is natural gas. These two resources together account for 80% of NH's in-state generated electricity, which in 2016 totaled 19,284 [GWh]. However, our state is a net exporter of electricity, with only 10,905 [GWh] electricity retail sales (2016) in New Hampshire while the remaining 8,377 [thousands MWh] is sold (2016) into the New England electricity market. In 2016 the Seabrook power plant alone generated 10,761 [GWh], approx. an amount enough to power the entire state, while in the same year 8523 [GWh] of non-nuclear electricity was generated, which included natural gas and coal. The state's in-state energy resources include biomass, hydro-power (large and small), wind and solar energy. Both biomass and hydro had been neglected in our recent past, but have now been revived to produce clean and renewable energy, along with the more modern technologies of solar and wind power generation. Both the biomass and the hydro industry also provide the state with numerous other services (improving our state's forest resources, and removing debris form our waterways), as well as significant tax and salary payments to towns and employees. In the period from 2011 to 2016, electricity generated from biomass, hydro, wind and solar increased from 2,696 to 3,318 [thousands MWh], accounting for 17% of electricity generation. In fact, for the first time in 2016, NH obtained more of its electricity from wind power than from coal-fired power plants (8.1% wood/biomass, 5.9% hydro, 2.2% coal, 2.2% wind and 0.5% solar), and this trend is continuing. The increase in total energy generated from the in-state renewables occurred despite minimal assistance from the state.

Since New Hampshire adopted a RPS which sets targets for electricity generation by different renewable energy resources, our in-state renewable resources have benefited from selling the renewable energy that they generate to our utilities, and also from the revenue they receive from Renewable Energy Credit (REC) they earn if the quality of their power qualifies under PUC rules. A REC is earned when a generator creates

[f] NH Office of Strategic Initiative, NH 10-Year State Energy Strategy, April 2018

1 MWh of electricity, while abiding by clean emission requirements. RECs are an attempt to attach a price to the benefits provided by renewable energy that are currently not priced into the cost (e.g. the health and environmental impacts of fossil fuels). Utilities are required to either purchase a number of RECs based on the targets set each year by the RPS, or they must make an ACP instead. However, because the ACP price is set by the legislature, and indirectly funded by ratepayers to promote renewable energy and energy efficiency, the ACP amount in New Hampshire has been very low, resulting in many in-state renewable energy generators struggling financially to stay in business. These businesses need a base revenue from both the RECs and the price in the marketplace for their electricity to stay in business.

Their situation has been worsened due to the low-cost of out-of-state fossil fuel natural gas which has flooded the market, making price competition difficult for other energy generators including coal and nuclear. Between 2004 and 2016 as the result of natural gas prices, wholesale electricity prices have dropped by approx. 50%. This would seem like good news for ratepayers. However, NH ratepayers, expecting a drop in their electricity bills, where surprised to see them continue to rise at a faster rate than surrounding New England states. As the NH 2018 Strategy plan[f] explains, this increase is the result of a 374% increase for transmission costs (T) along with an increase of 73% for distribution costs (D). It is important to know that these T&D costs are apportioned among the New England states based on electricity demand. While neighboring states have been dramatically containing or reducing their demand, New Hampshire has been less aggressive. That is why demand reduction, by way of more in-state energy production and energy efficiency measures (pushing down demand), is the best way to reduce ratepayer utility bills.

The displacement of coal energy by natural gas energy has resulted in a decrease in GHG emissions in New England, a goal of the Regional Greenhouse Gas Initiative (RGGI) of which NH is a member. This process replaced one fossil fuel with another, that generates less CO2 emissions. But the RGGI process in fact helped to facilitate and encourage this process, while at the same time introducing more renewable clean energy into the region, resulting in an approx. 24%decrease in New England of the GHG emissions levels. While this step should be seen as a positive one, to make significant progress for both NH energy dominance and GHG emissions reductions, more renewable energy needs to be installed. Many of the contributors to this paper offer ideas for doing just that.

In addition to energy needed for electricity, approx. 89% of NH's total energy use is for home heating and transportation. For example, in 2013, NH spent $5.9 billion on energy of which approx. $3 billion per year was spent for 2 million gallons of fuel/day. Almost all of that revenue is lost to NH every year in business taxes and jobs. Ideas to address energy use in NH for transportation are also offered in a later section.

Renewable & Sustainable Energy

1. **Energy Efficiency (Robert Backus and John Mann)**

   Ever since energy expert Amory Lovins (of Rocky Mountain Institute, Colorado) coined the word "negawatts" to help people understand that a kilowatt hour of energy saved is just as good as, and more valuable than, a kilowatt generated, the always sound case to make energy efficiency the top priority of energy policy has become even more compelling.

   There was a time when energy efficiency was called "energy conservation," a phrase that seemed to imply reading with dimmer lights, or turning down the thermostat. No more. Today we know that energy efficiency means getting the same quality of service but using fewer kilowatts to do so. In fact, energy efficiency – especially when it relates to heating of residences or municipal buildings – often provides much better service for a fraction of the cost.

   As the 2014 NH Energy Strategy stated:
   Energy efficiency is widely understood to be the cheapest, cleanest, most plentiful energy resource. Investments in efficiency reduces the state's reliance on imported fuels, provides a boost to the state's economy by creating in-state jobs, and lowers energy costs for consumers and businesses. Efficiency improvements also raise the quality of New Hampshire's building stock and have environmental benefits. Action in this area is necessary to reduce the widening gap between New Hampshire and surrounding states, which have realized the cost savings and economic benefits of efficiency and are out-pacing New Hampshire in investing in this area. A 2013 study found that if all buildings in the state were improved to the highest level of cost-effective energy efficiency, consumers would save $195 million each year and an additional $160 million would be added annually to the New Hampshire Gross Domestic Product (GDP).*

   * Increasing Energy Efficiency In New Hampshire: Realizing Our Potential ("2013 EERS Report"), available at:
   http://www.nh.gov/oep/resource-library/energy/documents/nh_eers_study2013-11-13.pdf.

   Although energy efficiency is the lowest cost energy resource we have, it has cost. It costs money to insulate and air-seal a house, although the energy savings over the life of the structure will be multiples of that up-front cost (an electric bill likewise includes a share of the costs of building the energy generating plants).

   One way to implement the goal of maximizing all cost-effective energy efficiency is to adopt an Energy Efficiency Resource Standard (EERS) which sets targets for both electricity and natural gas savings. That has now been achieved, although funding constraints were imposed by the legislature soon after EERS was established.

In the meantime, New Hampshire has funded energy efficiency investments through revenues gained through participation in the Regional Greenhouse Gas Initiative, or RGGI. NH, along with 9 other northeastern states, operates this market-based cap and trade program whose goal is to reduce the rate of CO2 emissions. Revenue gained through RGGI participation is allocated to member states to further address climate change. New Hampshire initially dedicated all of it to energy efficiency, although legislation in 2012 caused most of it to be simply rebated to ratepayers. Legislation to allocate more or all of it for energy efficiency would help lower future electric bills, by reducing demand which determines each state's share of regional grid transmission cost.

A study by the Vermont Energy Investment Corporation (2013) found that energy efficiency would create 2,300 jobs and add $160 million to the New Hampshire GDP. Estimated impacts on energy ranged from 29 million KWH to 49 KWH per year. It also found that there was plenty of "low-hanging fruit" in the form of projects in NH with good returns on investment.

To be fair, the 2018 update of the Energy Strategy included the sentence "Energy Efficiency is the cheapest and cleanest energy resource." However, unlike the 2014 Strategy, it did not recommend any policy steps to maximize this resource, except to say that we should "continue to coordinate and develop energy efficiency programs.... " It then went on to disparage any government action, particularly if it involves any ratepayer support or otherwise involves a "subsidy" (which, in fact, is an investment). (It should be noted that no form of energy supply exists without subsidy, including fossil fuels and nuclear power.)

New Hampshire's failure to vigorously support steps to achieve all cost-effective energy efficiency has a big cost. For example, according to the EIA, NH sends hundreds of millions of dollars out of state annually to buy 130 million gallons of heating oil, just for residences; this money is never seen again. According to ACEEE, New Hampshire ranks only 21st in our energy efficiency gains, while 4 neighboring states are ranked 1, 3, 4 and 5.

An interesting feature of a steady energy efficiency program is the way the savings accelerate. Because each years' work keeps producing savings in all later years, annual savings follow an upward trajectory. Failing to aggressively drive energy efficiency amounts to "nipping in the bud" what citizens would otherwise come to appreciate and demand.

Energy efficiency isn't the only or the whole solution, but it is a vital part of a strategic effort toward a better energy future. It can help us all get much more for our energy dollar, and be implemented with essentially no adverse environmental effects.

2. Solar Energy (Dan Weeks-Revision Energy)

Current Status in NH:

As of Q1 2018, New Hampshire was home to 76 MW of installed solar capacity across over 12,000 rooftops and hundreds of ground-mounts serving homes, businesses, nonprofits, and government buildings.[1] Although New Hampshire saw triple-digit growth in solar from 2014-16, aided by temporary incentives, installations dipped significantly in 2017 when state rebates and net metering were curtailed. Solar currently accounts for 0.5% of the state's total electricity mix compared to 8.6% in Massachusetts and 11.1% in Vermont.[2]

In spite of New Hampshire's low solar penetration, the 76 MW of installed capacity represents nearly $200 million in direct solar investments since 2013 and 1,051 direct solar industry jobs.[3] An estimated 83 solar companies are currently doing business in New Hampshire, the majority of them installers and developers of residential and commercial solar arrays.[4] In addition to the solar industry's impact on the state economy at large, independent analyses of the direct effect of distributed solar generation on ratepayers finds either a neutral or positive result. Contrary to claims by electric utilities, the NH Public Utilities Commission (PUC) concluded in 2017 there was no evidence of a "cost shift" in favor of solar. In fact, studies by the Maine PUC5 and the Acadia Center[6] for New Hampshire found the opposite is true, as solar adds substantial value to the electric grid and ratepayers in general by "reducing energy demand, providing power during peak periods, and avoiding generation and related emissions charges from conventional power plants."[7]

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[1] GTM Research's *U.S. Solar Market Insight* report
[2] U.S Energy Information Administration's (EIA) Electric Power Monthly report
[3] The Solar Foundation's State Solar Jobs Census
[4] GTM Research's *U.S. Solar Market Insight* report; Nationwide, there are approximately 250,000 solar industry jobs, nearly three times the number in 2010 and more than all domestic jobs in oil, gas, and coal combined according to a 2017 U.S. Department of Energy report

[5] *Value of Solar* study
[6] Acadia Center study
[7] Acadia Center study

Potential Maximum Level Achievable (short-term):

Based on the experience of New Hampshire's two neighboring states with similar land areas and climate conditions, Massachusetts and Vermont, NH could rapidly scale its installed solar capacity by a factor of ten from 0.52% to 5% in the next few years by applying tested and readily-available policy levers that will drive private sector investment and jobs while reducing electricity costs. To reach 5% of current statewide electricity demand, New Hampshire would need to install approximately 674 MW of solar, less than one third the 2,138 MW of currently-installed capacity in Massachusetts.[8] Given current and projected future costs of solar ($2-$3 per watt DC for small- and mid-sized installations), scaling New Hampshire's solar capacity by a factor of ten would result in a direct economic investment of approximately $1.5 billion and the addition of 4,000 solar industry jobs, the majority of them certified electricians or electrical apprentices earning a competitive living wage. Although savings projections do not exist in terms of public health, a drop of just 1% in current respiratory ailments caused by fossil fuel power generation and gas-powered automobiles would save taxpayers in excess of $10 million per year at current rates.

Obstacles or Regulations Preventing Maximization:

Several regulatory obstacles stand in the way of taking solar energy to scale in New Hampshire. They include:

- Net metering rates: The vast majority of solar-powered homes in New Hampshire were interconnected to the grid prior to September 2017, when new regulations promoted by the electric utilities reduced the total value of net metered solar electricity by approximately 20% in the form of a 75% cut in the distribution portion of the energy reimbursement. Restoring the 1:1 net metering ratio previously in effect would have a moderately positive effect; requiring solar customer-generators to be paid the full value of exported solar electricity, according to independent analysis, would rapidly accelerate the rate of adoption.
- Net metering project cap: New Hampshire's current 1 MW (AC) cap on default-rate net metered solar installations is a major impediment to utility-scale solar development. Unless the cap is lifted, municipalities and other institutions with substantial electricity load and more than 5 acres of under-utilized land (such as

[8] GTM Research/SEIA

capped landfills) will not be able to offset their existing load with solar, much less sell excess solar power to the grid to benefit ratepayers generally.

- Renewable Portfolio Standards (RPS): New Hampshire's low 0.7% solar requirement under the state RPS depresses the value of solar Renewable Energy Credits (RECs) and signals to private developers that NH is not a priority for solar investments. The low RPS also reduces the need for utilities to make alternative compliance payments (ACPs) into the Renewable Energy Fund (REF), which previously provided a reliable source of state solar rebates to enable especially municipal and nonprofit solar projects.
- Grid-modernization: Flexible market-based electricity pricing, whereby the value of electricity is determined by real-time supply and demand, would encourage the rapid expansion of distributed solar generation (which coincides with peak system demand on sunny summer afternoons) as well as energy efficiency and intelligent storage technologies. Over time, it would reduce the need for expensive and polluting peaker power plants and inefficient long-distance electricity transmission.
- Price on carbon/reduction of energy subsidies: Although solar achieved grid parity with fossil fuel-based electricity generation in 2017 and is now less expensive to build at scale, it continues to be hampered by generous direct and indirect subsidies that flow to fossil fuels. Only a hard price on carbon which incorporates the real price of burning fossil fuels on human and environmental health (in combination with an across-the-board reduction in market-manipulating energy subsidies) will achieve accurate energy pricing and enable rapid acceleration of clean, low-cost options.

Projected Level of Solar Supply by 2050, Assuming Obstacles are Removed:

According to a detailed state-by-state analysis of current and future energy consumption and clean energy potential, New Hampshire's total end-use energy load for all sectors would be 7.1 gigawatt-hours in 2050 under a business-as-usual (BAU) scenario.[9] Canceling fossil fuel combustion and converting all energy demand in NH to electricity would reduce total energy consumption by approximately 40% to 3.9 GWh on account of inherent efficiencies gained through "beneficial electrification." The analysis finds that approximately one-third of that all-purpose end-use electricity load could be met by solar, including 24.2%

[9] Royal Society of Chemistry

from utility-scale solar farms, 4.5% from small-scale residential solar installations, and 3.3% from mid-sized commercial/institutional and governmental (C&I) installations. The projections assume that half of the approximately 9 square miles of roof space in NH that was suitable for solar in 2012 is utilized for the purpose in 2050, for a total capacity of 2,133 MW (DC); additional ground-mounted solar generation would require a fraction of 1% of NH lands.

The projected cost of new solar, wind, and hydroelectricity in 2050 under the 100% clean energy scenario is 10.8 cents per kWh (in 2013 dollars) compared to 12.5 cents per kWh from non-renewable sources in 2013. More significantly, the projected air quality damage reduction completing the clean energy conversion by 2050 amounts to nearly $1,000 per person or $1.56 billion per year or 1% of state GDP. Beyond the local health/environmental benefits, the average climate cost savings to the world at large on an annual basis from transitioning to 100% clean energy $5,621 per person per year.

Critics of this analysis point out that high penetrations of solar and other intermittent renewables like wind will reduce their economic value to the grid (and therefore their adoption rates) unless high-capacity storage and demand management tools are implemented, and breakthrough technologies like efficient thin-film solar, concentrated solar power plants, and solar-powered hydrogen generation for transportation deliver continued steep reductions in price. Nevertheless, a variety of energy experts have concluded that solar can (and must) achieve 33% or greater penetration this century as the leading energy source if Planet Earth is to stabilize rapid temperate and sea level increases and avert more catastrophic climate change.

Impacts of Solar on Transportation

Transportation is the single largest sector in terms of energy consumption in New Hampshire, with approximately 100 trillion BTUs of annual energy or one-third of total state consumption.[10] Virtually all of the energy consumed in transportation today is from fossil fuel combustion, which directly contributes to local and regional air pollution and the premature deaths of an estimated 123 Granite Staters every year due respiratory ailments; those ailments also cost state

[10] USEIA 2013

taxpayers approximately $1 billion annually in public health costs, according to the latest available data from 2004.[11]

Using available hybrid/battery electric vehicle (EV) technology, Granite Staters could rapidly reduce vehicle emissions, save money, and increase fuel efficiency even without transitioning electricity sources to clean energy like solar or wind. According to DES, New Hampshire's relatively low-polluting energy sources for electricity generation (especially nuclear and hydro) give electric vehicles an emissions advantage of similar gas- or diesel-powered vehicles, even when emissions associated with fuel recovery, refining, and electricity production are taken into account. When EV adoption and other forms of "beneficial electrification" (e.g. thermal) are combined with the rapid scaling up of clean electricity sources on the grid like solar, the benefits in terms of cost and emissions are compounded.

3. Wind Energy

Onshore Wind Power (Peter Somssich)

Based on a recent DOE study[g] there are numerous benefits provided by wind power nationwide. In contrast to coal and nuclear power which do not help regulate power system frequency, wind power is considered more reliable and can better weather grid disturbances. That is why grid operators in Texas and Colorado dispatch wind power, with its more sophisticated electronics, routinely to regulate power system frequency. That is why the DOE has called for "creating fuel-neutral markets" that compensate grid partners for services to support grid reliability (e.g. as do solar and wind power).

Renewable energy builds resilience. The cold snap events in Texas in 2011 and the Polar Vortex of 2014 showcased wind's resilience. While coal deliveries were impacted by weather conditions, wind power output continued. In fact, of the total of forced outages, 40% were coal related, while only 1% were connected to wind power. Energy resources that some label "fuel on-site"[h] such as nuclear and coal, in fact are very susceptible to whether conditions. In the case of coal, frozen coal piles, and transportation delays were mainly due to cold temperatures, while in the case of nuclear, hot temperatures have caused power

[11] NHDES "Air Pollution Transport" report; The NH Department of Environmental Services (DES) reports that "almost half of the air pollution in the state - ozone, volatile organic compounds, oxides of nitrogen and sulfur - is produced by transportation sources, most of it by on-road light duty vehicles," citing US Environmental Protection Agency data.

reductions because the cooling water needed was not cold enough for full operations. This is why some power operators now consider wind and solar power as the “new baseload”.

When it comes to federal incentives, the DOE study recognizes that all energy sources have been the recipients of financial incentives. In fact, while wind power has only received 3% of federal incentives, fossil fuels and nuclear were the recipients of 86% of those incentives.

A study by AWEA[i] attempts to look forward to the year 2025 to estimate the near-term demand for wind power. Since during the past 5 years, wind power has consistently been the number one choice when additional resources were needed to increase a state’s RPS, it is likely that as states nationwide increase their % of renewable energy compared to their total energy needs, wind power will continue to play a significant role. Many states already have specific renewable energy goals, while others are close to finalizing them. Hawaii is already committed to 100% renewable energy for electricity by 2045, while Vermont has a 75% goal by 2032 and California, DC, New York and Oregon are finalizing 50% goals.

Nationwide demand through 2025 calls for 105 TWh of renewable energy to meet wind-eligible RPS requirements, which is the equivalent of 34.6 GW of wind capacity. AWEA estimates that policies will drive the development of 15.5 GW of new capacity through 2025. This amount of capacity would generate 46.5 TWh of electricity. Many of these predications do not factor in the technology boosts to productivity of wind power. For example, while the Annual Capacity Factor (ACF), a measure for the efficiency of a turbine, from 2007 to 2014 was still under 30%, since 2014 the ACF has risen to over 40%, and if technology trends continue, could reach 50% by 2025. In addition, while previously each turbine represented about 2 MW per unit of capacity, newer turbines are now rated close to 4 MW resulting in fewer turbines needed for the same electricity output. Finally, while turbines are becoming more efficient at producing energy, even the ACF of 50% will be less significant if battery storage becomes more readily available and prices drop. This could result in both wind and solar energy

[g] Michael Goggin, DOE Study Markets and Infrastructure, AWEA, 8/24/2017

[h] Amory Lovins-RMI, Does “Fuel of Hand” Make Coal and Nuclear Power More Valuable?, Forbes Energy Beltway Brief, 5/1/2017

[i] American Wind Energy Assocation(AWEA)-Data Service, AWEA State 2017 RPS Mandates, AWEA, 9/26/2017

providing a supply of 24hr./7days/wk. and 365 days of reliable power supply.

It is worth noting that wind power also contributes benefits to our environment and our natural resources. According to AWEA[g] operating wind projects nationwide avoided 189 million metric tons of CO2 in 2017 and helped avoid the use of 95 billion gallons of water. That is equivalent to 40 million cars worth of emissions and a saving 292 gallons of water per person.

In New Hampshire at present there is 185 MW of onshore wind power capacity and with approximately 405 GWh in annual generation from five wind farms[j].

One additional project, with 29 MW capacity to be sited in Antrim, is in the “pipeline”. New Hampshire is rated 32nd in wind capacity, 34th in the number of turbines and 27th for the share of total electricity generated by wind. The 405 GWh of generation represents 2.1% of New Hampshire’s in-state electricity production with a total electricity need in 2016 of ~ 11,000 [GWh].

This wind energy power currently provides electricity to 38,500 homes. In 2017 wind power projects supported between 100 to 500 direct and indirect jobs, represent total capital investment of $375 million and were providing $500k to $1million in annual land lease payments.

There is an estimated additional capacity of between 990 MW and 12,528 MW[j] of technical potential for terrestrial (onshore) wind power in the state. The wide range in the numbers for the wind capacity results are dependent on the hub height of the turbines. This additional capacity could provide electricity to between 300,000 and as many as 2 million homes.

New Hampshire also has benefited environmentally from the installed wind turbines. In 2017, e.g. the state saved 88 million gallons of water, and a reduction of 206,000 metric tons of CO2 emissions, which is the equivalent of 44,000 cars’ worth of emissions that were avoided.

[j] AWEA WindIQ, Wind Energy in New Hampshire, AWEA WindIQ, 2018

Offshore Wind Power (Doug Bogen-SAPL)

Current Status of in NH

There are no offshore wind farms along the NH coast or anywhere in the Gulf of Maine at present, despite several projects initiated off the Maine coast in previous years. The reasons for delays or outright “sinking” of these proposed projects have been primarily political, specifically due to opposition from the current governor and his administration. The one project that is still under consideration is the UMO-led AquaVentus 12 MW 2-turbine pilot project to be sited off Monhegan Island, financing of which is now under reconsideration by the Maine PUC.

Despite growing public support and pressure, New Hampshire has yet to take any concrete steps toward siting offshore wind, despite a 2014 legislative study report that recommended gubernatorial action. New Hampshire is almost alone among US coastal states in neglecting to pursue offshore wind. For federal waters (3 miles or more offshore), the first step required is a governor's request for institution of a federally-sponsored, intergovernmental task force and stakeholder process, which neither the current governor nor his predecessor has agreed to make.

Obstacles or Regulations Preventing Wind Power Maximization

As mentioned above, current obstacles to wind power development in our region have been primarily political, rather than technical, environmental or regulatory in nature, though of course expected cost and future availability of government subsidies will likely play a key role in the near term. For its part, the federal government – with the key agency being the Dept. of Interior's Bureau of Ocean Energy Management (BOEM) – has been very accommodating to offshore wind proposals. Following the debacle of Cape Wind, they have worked closely with state officials, stakeholders and NGOs to smooth the way through the maze of permits and planning required for such ventures, even naming their process "Smart from the Start." Possible environmental concerns have likewise been minimized by careful research and planning prior to site leasing, with state and national green organizations consistently in support of all recent project proposals and offshore wind in general.

The process as it has played out south of us is also certainly helped out by being conducted in federal waters, further from shore and from possible "NIMBY" attention (the Vineyard Wind project referred to below is sited 15 miles at minimum offshore, and MA and Maine have both set a minimum requirement of 10 miles off for wind farm siting). The possibility of state-level challenges will likely surface in planning for onshore connection of the required undersea power line from any offshore wind farm. In addition to possible competing uses and aesthetic concerns, environmental impact – though relatively minor – will likely need to be addressed. The difficulty of completing Eversource's "Seacoast Reliability Project" power line across Great Bay is a case in point, though coastal grid connections in our state will no doubt benefit from the existing grid infrastructure in Portsmouth/Newington and/or Seabrook. Meeting the needs of commercial fishing interests and other competing ocean users will likely be the biggest challenge, though recent experience with the Block Island wind farm off Rhode Island as well as the stakeholder process prior to the Vineyard projects siting is encouraging.

Potential in Future Decades

The potential from offshore wind in the Gulf of Maine – state boundaries being almost irrelevant once federal waters are entered – is practically unlimited. A 2010 US Dept. of Energy (DOE) study, further refined in 2016, determined that there is about 200 GW in theoretical offshore wind power potential within 50 miles of the Gulf of Maine coast, with over 3 GW in NH “waters” alone (which only extend to about 20 miles out). A 2017 DOE economic study determined that there is 2000 MW of wind power with “economic potential” immediately off New Hampshire's coast over the next decade, as well as about 85 GW total available in neighboring Gulf of Maine waters. While “closer is better” is preferable with regard to power line transmission issues, it should be noted that New York, Connecticut and Rhode Island have already committed to obtain hundreds of megawatts of offshore wind power from federal waters off neighboring states due to siting limitations off their shores.

There are several other trends that bode well for offshore wind development in the next decade. Due to technological improvements as well as up-scaling, the “standard” power capacity of offshore turbines has tripled in less than a decade and larger designs (12 MW or more per turbine) are expected to be realized in the next few years. Additionally, since most waters in the Gulf of Maine are deeper than is practical to exploit using pier-based turbines, floating platform designs will be key to establishing wind farms any farther than immediately off our shores. Fortunately, various floating system designs have been proven in waters off Portugal, Norway, Maine and Scotland – with the latter consisting of a 5-turbine grid-tied permanent wind farm up and running for almost a year now. Floating systems also have the potential for more efficient and cost-effective mass-production, since they can be assembled at shore or a drydock and then towed to the wind farm site. Wind farm developers are also teaming up with utility-scale battery producers to build offshore wind farms with short-term storage capacity.

Lastly, offshore wind farm construction costs have decreased dramatically in recent years, with “shocking” low contracted costs (said Bloomberg analysts) announced for the Vineyard Wind farm south of Cape Cod – about half the cost as previously estimated for US offshore wind in the mid-2020s. This 800 MW project is expected to save MA ratepayers $1.4 billion over other power sources in the 20-year life of the project. An additional 1400 MW of offshore wind projects are expected to be contracted at the same federally-approved site in the next few years, making southern New England the offshore wind capital of the country by the mid-2020s.

Given these trends, coupled with expected additional economic efficiencies from regional supply line development and other infrastructure, New Hampshire could technically expect to be able to provide for 100 percent of its energy needs by 2040 with offshore wind alone. Of course, combined with onshore wind, solar power and other existing and expected renewable development, a fully sustainable energy future for the Granite State could be expected to come even sooner. A Maine state-sponsored study found as much almost a decade ago (including electric transportation and space heating – and projected for a decade earlier), though subsequent actions (or in-action) by government officials since then have challenged that timeline. With enough governmental direction, we could learn from these and other regional missteps to expedite our own renewable energy future and become sustainable within a couple decades if not sooner.

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4. Hydro Power Energy (Bob King-Granite State Hydropower Assoc.)

When the industrial revolution reached New Hampshire, it was hydro power that provided the energy. By 1979, many mills and power plants had fallen into disrepair when the federal PURPA legislation triggered a small hydro power renaissance. Today, there are about 100 operating hydroelectric power plants in the state, many of these located at the sites of centuries old mills. Manchester, Claremont, Dover- all of these cities exist because of the water power that has always flowed through them.

According to the EIA, hydro power generated 1,145,000 MWh in 2016 in New Hampshire. Annually, small scale hydropower (5 MW and under) provides about 80 MW of installed capacity and 320,000 MWh of energy statewide. In addition, small hydro plants pay $5 million in property taxes and user fees as well as providing jobs, removing trash from rivers, and maintaining dams that would otherwise fall to the state and towns.

Hydropower in the Granite State faces the following challenges merely to stay in business at its current level of production:

1) low energy price. While consumers are paying more on their electric bills, energy producers are being paid less. Wholesale rates for energy have been falling for ten years. But prices for transmission and distribution (T&D) of that energy are rising, with no end in sight. To be clear, T&D are the drivers of increasing electric rates.

2) volatility of Renewable Portfolio Standard and Net Metering. Taken together, these laws help small hydro to get paid a rate better than the spot market rate (about 3 c/kwh) though less than the default energy rate (typically 9 c/kwh). But lawmakers regularly target RPS and net metering, incorrectly asserting these programs are driving rates higher. It is difficult to ‘bank’ on laws that are being assaulted every year or two.

3) regulatory burden. Hydropower is regulated by the Federal Energy Regulatory Commission, which receives regulatory input from at least a dozen state and local agencies. While FERC is generally a fair-minded regulator, their process is extremely cumbersome and inefficient. Mandatory licensing of the smallest hydro projects can take five years. Re-licensing, which is now occurring at several operating plants around the state, can cost over $1 million even for small plants.

4) lack of sites and dam removal pressures. Suitable project sites have always been limited. The rebirth of small hydro in the 1980’s happened almost exclusively at existing dams- those with the least environmental impact. But today there is new pressure to remove some of the existing dams that have not been redeveloped.

5) Building hydro plants is a capital-intensive process. Smaller projects are not usually able to attract financing as they require more investment than the typical small business. Once built, it is an ongoing challenge to operate these plants especially with the increasing frequency of flood events. A healthy dose of Yankee ingenuity and frugality is a must for these plants to be successful.

This author believes the best energy future for people and the planet is to reduce our energy usage through conservation and efficiency- so called “negawatts”.

The next most important resources are the renewable generating plants that are already built. These are carbon free and distributed throughout the system where they help reduce T&D losses and costs. This perfectly describes small scale hydropower. So, what must be done to keep hydro operating, and possibly to expand it?

1) pay a fair price for small hydro energy, higher than spot market, not exceeding the default price

2) enshrine RPS and Net Metering in law such that they cannot be threatened with every new legislative session. While the growing constituency for these laws is helping to protect them, there is still enough uncertainty that new projects cannot get off the ground. Also, the utilities should be compelled to account for net metered energy as a load reducer instead of a wholesale purchase. This would improve the economics and benefit ratepayers.

3) The state cannot control FERC, but state agencies can give clear, simple feedback to FERC on any given project, including declarations of support for small hydro as a carbon free, local energy resource.

4) we cannot change the scarcity of good project sites. And removal of certain abandoned dams makes sense if there is a direct benefit to threatened fish species. But debates over dam removal need to acknowledge the potential carbon-free generation that is lost when a dam is removed.

Small hydro development will never be easy. But the state could certainly do more to encourage continued operation of existing plants and even build new facilities by addressing the obstacles listed above. There is the potential for another wave of small hydro development, not as large as that which occurred in the 1980's, but still significant. The National Hydropower Association lists additional hydropower potential in New Hampshire of 30 MW (though it's not all 'small' hydro). DOE performed a study that showed up to 116 MW of hydropower potential at both existing dams and undeveloped sites. A later UNH study deflated this figure with more site-specific analysis. Perhaps the greatest untapped resources are the flood control dams owned by the U.S. Army Corp of Engineers, where new technology has made hydro power development technically feasible. Generally, experts in the small hydro industry believe it will be difficult to add substantial capacity in the current pricing and regulatory climate, though changes can be made to revive new development.

The best way to increase small hydro's percentage of the New Hampshire energy pie is to reduce the overall size of the pie. Then hydro becomes a larger slice. This is accomplished through aggressive energy efficiency and deep conservation. A countervailing, though positive, force is the adoption of electric vehicles, which will drive up electricity consumption. Recognizing the importance of EV's to a clean energy future, our small hydro plants already include charging stations. More EV's charging directly from hydro and solar means fewer T&D losses and heightened awareness of where one's electricity comes from. Once the software is in place, these same EV's will help shave system peaks and enhance the value of renewables of all kinds.

5. <u>Large Scale Hydro Power (Peter Somssich)</u>

Currently the state of NH only has 2 facilities[k] that are categorized as large hydro power generators (with capacity of at least 100MW), the Comerford facility with a 166 MW capacity rating and a second facility in Moore rated at 189 MW capacity. Both dams are located on the Connecticut river and neither are included in the state's RPS, since they are deemed to be commercially viable and sustainable without state support. With a capacity factor of 0.5 (50% utilization) during the course of a year, it can be expected that these facilities would annually generate approx.1555 [GWh] of electricity. Medium size hydro generators (between 5 and 100 MW of capacity) are estimated[o] to contribute another 100 MW of total capacity.

In addition, it is worth considering the proximity to a huge amount of large hydro power from Canada, which could be considered for import if NH needs this energy to reach a 100% renewable energy goal. However, we recognize there are large social and environmental costs associated with both generating Canadian hydropower and transmitting it to New England.

[k] NH Department of Environmental Services, Staff of Technical Services Bureau, Private Communications 9/2018

[o] Bob King, Private Communications, Sept. 2018

6. Biomass Energy (Jasen Stock- New Hampshire Timberland Owners Ass.)

Background and Energy Sources

According to the Governor's Office of Strategic Initiatives (OSI) data, biomass accounts for 8.76 percent of New Hampshire's total electricity generation. "Biomass" includes electricity generation from wood combustion or the combustion of methane (e.g. landfill gas). Almost all of New Hampshire's biomass (wood combustion) electricity generation comes from 8 power plants situated across the state. They are;

1. Bridgewater Power, Bridgewater, NH
2. Burgess BioPower, Berlin, NH
3. DG Whitefield (formerly Whitefield P&L), Whitefield, NH
4. Indeck-Alexandria, Alexandria, NH
5. Pinetree Power, Bethlehem, NH
6. Pinetree Power, Tamworth, NH
7. Schiller Station, Portsmouth, NH
8. Springfield Power (formerly Hemphill P&L), Springfield, NH

Collectively, these power plants produce approximately 225 megawatts of electricity using 2,571,020 tons of wood chips according to the NH Department of Environmental Services' 2015 fuel consumption data.

In addition to producing electricity, New Hampshire's low-grade biomass is also an energy source for heat (heat for buildings and heat for manufacturing processes). Firewood has always been used for home heating and according to the U.S. Energy Information Administration as much as one in twelve New Hampshire homes depends on wood products as their primary source of heat. As wood pellets make home heating easier and more attractive we anticipate this number will grow. New Hampshire is also seeing an increase in using wood products for heat in institutional facilities (e.g, school, municipal offices, etc.) and commercial buildings . These facilities use wood chips and wood pellets. According to the N.H. Wood Energy Council there are currently 121 such facilities in New Hampshire using wood products (wood chips, pellets) to produce hot water, steam, or hot air. Although these facilities provide additional markets for renewable energy (heat) generation they are a seasonal market and relatively small market compared to biomass consumption for electricity generation.

Moreover, it must be remembered that all of this wood used for energy consumption is critical to New Hampshire's broader forest products industry (a $1.4 billion industry) and sustainable forest management. These energy markets provide a home for low-grade timber removed as part of a forestry project (enabling land managers/owners to enhance forest health while adding value to the state’s forests), and they provide a critical market for sawmill wastes (e.g. sawdust, chipped slabs).

Forest Resource

The timber resource for these facilities (electricity and heat) comes from across the entire state as evidenced by data from the N.H. Department of Revenue Administration showing countywide biomass (wood chip) production.

New Hampshire Timber Sales			
Source: timber tax records, N.H. DRA, tax year April 1, 2014- March 31, 2015			
County	**municipalities with timber sales**	**timber sales for tax year 2014-2015**	**timber sales with biomass**
Belknap	11	206	113
Carroll	17	345	107
Cheshire	23	279	47
Coos	29	311	108
Grafton	36	451	184
Hillsborough	30	319	142
Merrimack	27	448	223
Rockingham	31	233	131
Strafford	12	123	82
Sullivan	15	231	61
Total	**231**	**2946**	**1198**

Despite timber consumption for energy, lumber, firewood, and pulpwood New Hampshire’s inventory of forested acres remains relatively stable at 4,638,230 acres with a loss of 9,387 acres to non-forest use for the period between 2001 and 2006 according to National Land Cover data generated by the US Geological Survey. And, in terms of volume and value, New Hampshire’s forest inventory is increasing according to the US Forest Service Forest Inventory Analysis data (FIA). According to FIA between 2007 and 2012 New Hampshire’s forest saw a net annual growth (tree growth less mortality) of 200.4 million cubic feet per year. At the same time, approximately 134.8 million cubic feet of timber was harvested annually. The difference between net growth and harvests is 65.6 million cubic feet – this is the annual extra growth that accounts for the increasing inventory of trees.

What this data suggests is New Hampshire's forest resource is a resilient, renewable source of forest products and fiber for electricity and heat and there are still some opportunities for growth.

Current obstacles/opportunities

The electricity market is highly regulated at the state, regional, and federal levels. These regulations create obstacles and can create opportunities. A common refrain from many New Hampshire Timberland Owner Association members is the need for regulation to foster innovation, private investment, and remove barriers to entry.

Specific examples often cited are;

- Removal or relaxation of regulatory barriers to net metering,
- Recognizing the value of and providing incentives for greater distributed generation,
- Recognizing the value or and providing incentives for businesses able and willing to provide interruptible load, and
- Recognizing the value of and providing incentives for greater fuel diversity.

The failure of Senate Bill 446 during the 2018 N.H. legislative session is an illustration of an opportunity to accomplish three of these four goals that was missed.

In addition to reforming New Hampshire's net-metering policies, evaluation of the barriers (regulatory, and market/financial) to the establishment of micro-grids direct power sales, and other options for biomass electric generators to achieve a sustainable future should be undertaken.

Many large energy consumers (e.g. sawmill, wood processor) are frustrated with current utility law and utility market structures when they consider direct power purchases from a local power source (e.g. biomass power plant) . These frustrations also arise when these businesses consider aggregation of their load for purchase.

7. Other Emerging Energy Sources (Peter Somssich)

A number of new possibly promising energy sources may be coming on-line in the near future. Many customers are already making use of geothermal energy systems to provide heating and cooling services. Utilities are now looking into the possibilities of mining methane (CH_4) from landfills (34-86 times more potent as a GHG emission than CO2, according Joseph Romm –"What Everyone Needs to Know", Oxford Univ. Press 2018). Burning the methane rather than allowing it to escape into the atmosphere can both produce electricity and transform CH4 into CO2, a far less potent greenhouse gas, particularly over the short term. Since most landfills now are either releasing the CH4 into the atmosphere or flaring that gas, such a process could be more beneficial to the environment and could produce some additional revenue for the municipality. Landfills and brownfields are also being considered for solar installations.

Several municipalities have discovered the benefits of switching to far more efficient LED street lights. Additional cost savings can be achieved by buying out utility ownership and having the town either operate and maintain the street lights, or contract out those operations. In the near future, municipalities may also want to consider investing in "Smart City" technologies. These include installing electronic sensors and devices on the street lights, e.g. dimming electronics, either by time or a motion detector, traffic monitoring devices, wifi connections or sensors to assist law enforcement.

Other systems currently being evaluated for future energy generation include tidal power, wave power and generating hydrogen for fuel-cell applications, either for heating or for transportation needs.

[12]Enhanced Energy Use (Lee Oxenham)

As we look ahead and attempt to chart our course over the next ten years, it is inarguable that the imperatives of both economic growth and climate disruption will place energy use at the center of the policy agenda – in NH, the US, and the world. Keeping the global atmosphere from climbing another 2 degrees centigrade requires that we become more efficient, more cost-effective, and more innovative in our energy usage as we move off of fossil fuels and transition into a clean energy economy.

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3 Jones, Kevin B., Benjamin B. Jervey, Matthew Roche, and Sara Barnowski. The Electric Battery: Charging Forward to a Low-Carbon Future. Praeger: 2017.

4 IEEE Report. "Short term cloud coverage prediction using ground based all sky imager." Published in: 2014 IEEE International Conference on Smart Grid Communications (SmartGridComm) https://ieeexplore.ieee.org/document/7007633/.

5 Jones et al. op cit.

As a first step we will have to eliminate the subsidies provided for over a century to carbon-based fuels. All of carbon's life-cycle costs, including its so-called "externalities," must be incorporated into its price structure; from cradle to grave.[1] These include air and water pollution, greenhouse gas emissions, increased health care costs, and premature mortality. Prices that accurately reflect costs will level the playing field, allowing the manifest benefits of renewable energy sources and enhanced energy technologies to be recognized, and directing increased investment to both. Increased investment will lead to greater innovation and development, economies of scale, and lower costs.[2] A truly virtuous circle.

Just as LED lights produce better lighting at a fraction of the cost of incandescent light bulbs, electric cars powered by ever more energy dense batteries will lower the costs of moving goods and people, transforming the transportation sector, at the same time that the widespread deployment of battery storage effectively removes concerns over renewables intermittency.[3] Similarly the use of big data, analytics and artificial intelligence are already improving weather predictions to the point where anomalous factors like changing cloud cover can be accurately anticipated and appropriately balanced at grid levels.[4] The widespread adoption and diffusion of battery storage technologies, possibly augmented by safer and more cost-effective fuel cells, can be no less transformative.[5]

New R&D, capital-intensive infrastructure, and the investment dollars that support them, must be directed to the carbon-free energy sources that will make the clean energy transition possible. That means an end to investments in expensive and soon-to-be-superseded fossil-fuel projects, from pipelines to LNG port upgrades. We cannot predict all the energy sources we will be able to tap over the next 10 years, or further out, but we can certainly see the direction that leads to innovation and new technologies, a revitalized manufacturing sector, and greater energy security.[6] First we must make our energy sector local, and stop sending our energy dollars out of state. We must invest in our educational institutions, particularly our quality post-secondary institutions, to attract the teaching talent and inquiring minds that can make NH a leader in the coming, research-based, high tech, clean energy economy. Solar and onshore wind offer ample opportunities for technological innovation; while early investments in NH's exceptional offshore wind resources, and still untapped wave and tidal resources, offer additional pathways forward.[7]

It is vital that NH shed its short-term outlook and blinkered mindset, along with its obsession with tax-avoidance, and invest in its future – in its educational resources, in research and development, and in technological innovation. No business ever succeeded by buying cheap components, or wasting its resources on inefficient processes or outdated technologies. In October 2014, the

International Energy Agency (IEA) released a seminal article titled “Capturing the Benefits of Energy Efficiency.” Among its most salient conclusions was this: “the uptake of economically viable energy efficiency investments has the potential to boost cumulative economic output through 2035 by USD 18 trillion.”[8] That is a sum which is almost as large as the current size of the entire US economy. NH has all the technological means it needs and is well-placed to utilize the gains from greater efficiencies and reliance on renewables to help drive the future energy transition, but it needs to take positive, concerted action. First and foremost, by investing in its future.

We stand at the brink of transformative times, and the key to NH’s future growth and prosperity lies ready to hand. We have the resources; all we lack is purposeful policy direction. We must be bold, seize the moment, and take the initiative. By altering course and investing in NH, its population, and its resources, we can leverage the coming enhanced energy transformation and position NH at the forefront of the clean energy transition.

Transportation

The Future of Transportation Energy (P. Somssich)

Transforming the energy supply for the transportation sector from the current fossil fuel-based gasoline and diesel fuels to zero-emission fuels will be both complex and time-consuming. However, many car manufacturers and countries have already declared their intentions to do just that. For example, here in the USA, California has issued a RFP[l] to purchase zero-emission trucks for the fleet of 17,000 trucks that daily enter and leave the Port of Long Beach (our nation’s 2nd largest port). They currently seem to have two competing bidders; Tesla with a zero-emission all-electric truck and Toyota with a zero-emission H2 fuel-cell truck. Depending on the outcome, other ports and municipalities may follow suit. In addition, since 2017 Toyota[m] has already been marketing their Mirai passenger fuel-cell vehicle in California. This car is powered by a zero-emission H2 fuel-cell motor, which fuels up in minutes and provides a range of 275 miles. These vehicles foreshadow the competition to come in the marketplace between two already available and already proven technologies: electric battery operations and fuel-cell powered vehicles.

[l] Port of Long Beach, Long Beach CA, Private Communications Feb.2018

[m] Consumer Report, Oct. 2017

In addition to all-electric vehicles and H2 fuel-cell vehicles, among the fuels being considered to replace the current fossil fuel-based gasoline or diesel fuels are biodiesel and cellulosic-ethanol. These fuels would open up new markets for the agricultural sector in the US. However, while they can be produced in a renewable fashion, both also produce high levels of GHG emissions. In addition, biogas and liquified gas are also being considered, but handling both gas and liquified gas will require very different systems of storage and containment. For larger transportation vehicles such as trains, airplanes, ships and long-haul trucks, high density fuels and an infrastructure to support distribution will be a key requirement. But a number of airlines are already operating with bio-jetfuel and some countries in Europe already have plans to operate their train and bus systems using only zero-emission generated electricity.

Just as with energy efficiency programs for electricity, improving energy efficiency for transportation by reducing gross weight and improving the mpg-fleet averages will also be key contributors. In addition, standardization of and improvements in battery storage technology will have significant impacts. Minimizing transportation energy use per passenger and per mile traveled, is a similar challenge to be solved, as is demand reduction for electricity use. Perhaps, such a challenge will encourage a closer and more thorough evaluation of nationwide railroad systems and transportation networks of all types.

Transportation Energy and Fuels (Huck Montgomery)

Overview: The transportation fleet is the largest source of greenhouse gas emissions in NH.[i] In 2015, NH's transportation fleet emitted 6.7 million metric tons of CO2, or 44% of all CO2 emissions in the state. The electric power generation sector, by contrast, emitted 3.5 million metric tons of CO2, or 23% of NH's 2015 total. The residential home heating sector is the next largest source of carbon emissions, accounting for 2.7 million metric tons of CO2, or 17% of the total, with 82% of that coming from residential homeowners burning oil for heat. The commercial and industrial sectors combined emitted 2.3 million metric tons of CO2, or 15% of the 2015 total.

Virtually all of NH's transportation energy needs are currently being met by fossil fuels.[ii] 98.8% of NH's transportation energy comes from petroleum (mostly gasoline and diesel fuel), with 0.2% coming from natural gas. Electric vehicles and other alternatives make up too little of our transportation energy usage to show up in the Energy Information Administration (EIA) data.

Achieving major reductions in transportation greenhouse gas emissions in NH is possible, but will be challenging. Policy-driven transitions in this space will be hampered by structural factors like supply constraints, cost, and scaling.

Ultimately, solutions to the transportation emissions problem in NH will be achieved through regional collaboration around energy supply capacity, in much the same way as solutions for electric power and thermal energy.

Potential Solutions

Electric Vehicles: One option would be to convert the entire transportation fleet to run on electricity from the grid. Doing so would result in a reduction in transportation sector greenhouse gas emissions of approximately 86%[iii]. However, in order to achieve true reductions in greenhouse gas emissions and not simply shift the emissions between sectors, massive investment in low-carbon sources of electrical generation is required. This challenge is amplified by the fact that during times of high demand today, much of the existing demand for electricity is met by highly carbon intensive fuels (coal and oil.) As electric vehicles usage increases, so too will the demand for electricity. In 2015, NH used approximately 37.5 trillion BTUs worth of electricity, and 100.2 trillion BTUs worth of energy in the transportation sector[iv]. Electrifying NH's transportation fleet would require more than 3,000 megawatts of new electricity generation.

While electric vehicles (EVs) and charging stations are commercially viable technologies currently, without proper planning it would strain our electric grid to make significant greenhouse gas emissions reductions through electrification. ISO-New England already expects trends toward increased adoption of electric vehicles and greater use of electric heating to increase demand for power.[v] ISO's Operational Fuel Security Analysis predicts power generators will have inadequate fuel supplies, requiring emergency actions to keep power flowing, by the winter of 2024/2025.[vi] Increased policy-driven electrification of the transportation fleet will exacerbate these challenges, unless electric generation challenges are addressed first. Improving fuel security, increasing renewable generation, more energy efficiency, and new technologies like smart-grids and battery storage are necessary for greater electric vehicle deployment in NH.

Natural Gas Vehicles: Natural gas is a proven alternative transportation fuel that has a carbon emissions profile of between 40% and 11% less than gasoline or diesel fuel[vii]. But there are numerous structural barriers to the wide-scale implementation of natural gas as transportation fuel in NH. First, natural gas fueling stations are not widely accessible. Second, the purchase cost of vehicles configured to run on CNG runs 20-25% higher than conventional vehicles, and vehicle acquisition lead times are longer. Finally, the supply of natural gas in NH, and New England more broadly, is severely constrained, especially in the winter when homes and businesses rely on natural gas for heat. Significant expansion of the use of natural gas for transportation will require expanding the available supply of natural gas in NH.

Another option for expanding the supply of natural gas is the development of local Renewable Natural Gas (RNG) resources, including methane produced from landfill gas, anaerobic digester technology, and woodchip gasification. Significant RNG production capacity exists in NH’s landfills, sewage treatment facilities, and from the forest-products industry.

Hydrogen Fuel Cells: Hydrogen fuel cells are a virtually zero-emissions technology, and Bloomberg reports auto executives believe the technology will eventually win out over other transportation fuel options.[viii] California is leading the way on hydrogen fuel cell vehicles, and several affordable vehicles are commercially available there.[ix] Hydrogen infrastructure is in the early stages of deployment around the country, and efforts to build out this infrastructure are underway.[x]

While hydrogen fuel cells are a compelling path to a near-zero emissions transportation fleet, the challenges of getting the infrastructure up and running are substantial. Underlying this challenge is the difficulty of accessing hydrogen itself. Hydrogen is the simplest element on the periodic table, but it does not readily occur by itself in nature. Hydrogen can be produced using a variety of methods, and the US Department of Energy (DOE) says existing technologies for reforming methane into hydrogen can generate hydrogen that is cost-competitive with gasoline. The most cost-effective method at this time is to covert natural gas into hydrogen at the fueling station site, which would require increased deployment of natural gas transmission and distribution systems in NH.[xi]

Further research and development is needed to develop a cost-effective method to “crack” water to generate hydrogen, but in order for this process to be economically viable the cost of the electricity needed to perform the electrolysis process needs to be at least “half the current average grid price of electricity,” according to DOE.[xii] One way around this challenge over the long run is “wind/solar-to-hydrogen” technology, which links clean power plants to electrolyzer stacks, which would split water into hydrogen. This system would allow renewable power generators essentially store power produced during low demand times for later use.[xiii]

Adopting hydrogen fuel cell vehicles at scale in NH will be limited by the same factors affecting electric vehicles, natural gas vehicles, as well as the rest of our energy system. The most significant of these factors is a lack of access to supplies of natural gas, which is the only currently available method of producing hydrogen that is cost-effective. Natural gas is at the core of our power generation system, our thermal energy system, and would be the single most critical input for hydrogen fuel cells as well.

Existing Initiatives in NH

NH's Granite State Clean Cities Coalition, which is supported by the US Department of Energy, "seeks to reduce petroleum use in transportation through the use of domestically produced, cleaner burning alternative fuels and other fuel reduction strategies."[xiv] Since 2014 the Coalition has hosted three workshops for businesses and state government agencies on electric vehicle (EV) and alternative fueled vehicles.

18 electric vehicle charging stations are currently operational in NH. NH has designated $4.5 million from the VW settlement to improve and increase EV charging infrastructure.[xv] Two important bills were signed into law in 2018 in NH to expand electric vehicle charging stations[xvi]. Senate Bills 575 and 517 were signed into law this year. SB575 gives the NH Public Utilities Commission (PUC) the authority to set rates for EV charging stations. SB517 sets up a commission to consider ways to expand charging station infrastructure.

In 2016 the NHPUC approved a change to Liberty Utilities' electric distribution tariff to allow EV charging stations to sell electricity by the kilowatt hour.[xvii] Previously, charging stations were not allowed to charge by the kilowatt hour, and instead had to charge a flat hourly fee. Since different electric vehicles charge at different rates depending on their batteries, this resulted in inequitable charging costs for the owners of different vehicles and made it more difficult for charging stations to set fair prices. Liberty Utilities is currently the only NH electric utility with this enhanced tariff language for EV charging stations.

A small amount of NH's transportation energy needs (0.2%) are currently being met with natural gas. Some companies in NH are already working to convert their fleets to run on natural gas. For example, Liberty Utilities began a "Green Fleet" initiative in 2013. 30% of Liberty Utilities' existing fleet of vehicles in NH (57 vehicles) is currently configured to use Compressed Natural Gas (CNG), and Liberty operates CNG fueling stations in Manchester and Tilton. So far in 2018 Liberty Utilities' fleet has used 14,864 gasoline-equivalent gallons (GEG) of CNG.

Conclusion

Ultimately, the challenges facing any effort to eliminate NH's greenhouse gas emissions from the transportation sector are the same as our broader energy challenges. That is, we need more generation, transmission, and storage capacity to meet our needs. Increasing renewable energy development, improving the efficiency of the NH's residential and commercial buildings, improving access to natural gas, and increasing storage capacity – whether for electricity, natural gas, or hydrogen – will be the core challenges that must be overcome.

[i] https://www.eia.gov/environment/emissions/state/
[ii] https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_sum/html/sum_btu_tra.html&sid=US
[iii] This number is derived from:
ISO-NE's Net Energy and Peak Load report: https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/net-ener-peak-load
The most efficient existing electric car, according to the EPA, the 2017 Hyundai Ioniq, which gets 4.4 miles per kwh: https://electrek.co/2016/11/21/hyundai-ioniq-electric-efficient-electric-car-epa/
The EPA's number for carbon emissions for the average passenger car: https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle

[iv] https://www.eia.gov/state/seds/seds-data-complete.php?sid=NH#Consumption
[v] https://www.iso-ne.com/static-assets/documents/2018/02/02272018_pr_presentation_state-of-the-grid_2018.pdf
[vi] https://iso-ne.com/static-assets/documents/2018/01/20180117_operational_fuel-security_analysis.pdf
[vii] https://www.afdc.energy.gov/vehicles/natural_gas_emissions.html
[viii] https://www.bloomberg.com/news/articles/2018-03-23/the-hydrogen-powered-car-s-big-setback
[ix] https://www.granitestatecleancities.nh.gov/happening/documents/20180601-hydrogen-mhc.pdf
[x] https://www.afdc.energy.gov/vehicles/fuel_cell.html
[xi] https://www.energy.gov/sites/prod/files/2015/06/f23/fcto_myrdd_production.pdf
[xii] Ibid
[xiii] https://www.nrel.gov/hydrogen/wind-to-hydrogen.html
[xiv] https://www.granitestatecleancities.nh.gov/index.htm
[xv] https://www.granitestatecleancities.nh.gov/happening/documents/20180601-keynote.pdf
[xvi] http://www.nhbr.com/March-16-2018/NH-Senate-OKs-electric-vehicle-charging-bills/
[xvii] http://www.puc.state.nh.us/Regulatory/Docketbk/2015/15-489.html

Heating Energy (Peter Somssich)

The prospect of replacing heating oil and natural gas for heating NH homes and businesses has to be looked at long term. In 2016 approx. 56% of all energy used in NH was for the purpose of heating. By comparison, 11% of our energy was used for electricity, while 33% was used for transportation. There are no obvious short-term opportunities to replace all heating fuels with 100% renewable energy statewide. Since 11,000 [GWh] of electricity energy was used in NH in 2016, representing just 11% of total energy used, it can be assumed that more than 100,000 [GWh] of energy would be needed to replace 100% of our 2016 energy needs. While this would require a significant effort, if successful, there are some long-term opportunities to reach such a lofty goal. Geothermal heat sources for homes and businesses are already replacing the Btu's of heat energy otherwise generated by fossil fuels. Geothermal is ultimately very expandable and, if incentivized by the state, would be able to offset much of NH's heating energy needs.

This paper does not discuss the opportunities in the agriculture sector. However, biofuels are already available to homeowners today. A 20% biofuel mix (containing a vegetable oil component), which still contains 80% heating oil is not being fully utilized to the extent possible, even though it burns cleaner emitting much lower levels of pollutants and could, with more demand drive more in-state vegetable oil production. Many other states have already included such biofuels along with cellulosic ethanol (not a food producing version) as part of their agricultural policies.

The use of electricity for heating purposes was tried in the past and proved to be too expensive for most NH residents. However, new technologies may be changing our attitude about heating homes with electricity. These include heat pumps, geothermal systems and fuel-cells in combination with traditional renewable energy, which make electricity use more viable from both a cost point of view and because of the favorable environmental impact.

Also, our state's existing pipeline network could one day be used to provide other gaseous fuels, such as H2, to provide for heating needs. When hydrogen is generated from non-fossil fuel sources, such as splitting H2O molecules using split solar or wind energy, the resulting H2 fuel is a reliable and zero-emission energy source that could be used for home heating and transportation.

Finally, looking at Table 8 in the Summary & Conclusion-section, it is conceivable that by 2040, when battery storage technology is the norm, our state could in fact generate more than 100,000 [GWh] of electricity and be able to consider replacing many of the out-of-state energy resources with in-state resources. Of course, we are not immune to outside economic forces, but those trends nationwide and even globally are also moving in a more renewable energy direction.

Carbon Pricing (Marge Shepardson)

Climate change has drastically changed how we look at energy. Fossil fuels add greenhouse gases to the atmosphere and are artificially warming our planet. This is proven fact and is accepted by 97% of climate scientists. We have been slow to respond and now we need to act forcefully to reverse the damage. The most important thing we can do is stop using fossil fuels so we stop putting large amounts of CO2 and methane into the air. That is why more and more states are moving aggressively to change their fuel mix.
What steps should we be taking in New Hampshire?

1. Don't build new fossil fuel infrastructure like gas pipelines.

2. Energy Efficiency - Do more to help low income houses and businesses become more energy efficient. This can be done by using more of the RGGI (Regional Greenhouse Gas Initiative) money instead of rebating it to ratepayers. Rather than getting a few cents on their monthly bill, customers could apply for efficiency work that would lower their bills forever.

3. Encourage the development of more renewable energy.

a. Increase our current state goal of 25% renewables by 2025. Aim for 100% by 2030 for electricity generation, and 100% renewables for heating and transportation by 2050.
b. Appoint a task force to study our offshore wind potential.
c. Continue to work with the PUC to make net metering work for everyone who wants it.
d. Continue to work on modernizing the electric grid with tools like Time Of Use pricing and accounting for battery storage.

4. Work for Carbon Pricing. This would put a true price on fossil fuels instead of making us all pay for the health costs and environmental costs that they create. The IMF (International Monetary Fund) reports that world-wide, taxpayers subsidize the fossil fuel industry to the tune of $5.3 trillion a year!

We can transition to clean energy by putting a steadily increasing price on fossil fuels. The money collected through a carbon fee and dividend plan would be given back to each individual in equal amounts, a monthly check or dividend that would offset increasing fuel prices for 70% of us. This is a simple, transparent, market-based approach that is gaining support among conservatives as well as liberals, big businesses as well as environmental groups. It is clear and businesses can plan their expenses for the future. They can make reasonable decisions about which big energy projects to invest in.

Over forty countries are already doing carbon pricing and their economies have been doing well. A recent report by IRENA (International Renewable Energy Agency) states that by 2020 renewable energy will be as cheap as fossil fuels. It makes sense to quickly move away from the dirty fuels of the last century and develop a new system of clean fuels for the future.

Economic Development Impacts from Renewable Energy Goals (Suzanne Harvey)

Renewable energy has been on the radar of the New Hampshire legislature for at least over a decade. Preceded by the successful bi-partisan passage of the Renewable Portfolio Standard (RPS) and the Regional Greenhouse Gas Initiative (RGGI), the NH Department of Environmental Services published a report, The New Hampshire Climate Action Plan, in 2009 based on the findings of the Climate Change Policy Task Force convened by Gov. John Lynch.

The governor's goal published in 2006 was to have 25 percent of our state's energy derived from renewable sources by 2025. The Task Force recommended that NH reduce its greenhouse gas emissions to 80 percent below 1990 levels by 2050, with a mid-term goal of 20 percent by 2025. Where are we today?

With the passage of RPS, older resources, such as hydroelectric dams (some of which had been abandoned), had new financial incentives to meet RPS eligibility criteria. Owners invested in upgrades and sent clean power to the electric grid. Managers of natural resources, such as our dense forests, were at the ready to supply wood to biomass plants to power the grid. Newer technologies, like photovoltaics, were primed to grow at breakneck speed and create a budding industry in our state. All of this new business and job creation primed the pump, especially as the demand for solar energy decreased the price of installations, and more families and businesses determined that the savings in electric bills over the years, especially with a rebate, would more than pay for the initial investment.

In almost a decade since the publication of the Task Force report, renewable energy, RPS, and RGGI have been played in the legislature as political footballs, with their benefits taking a back seat to minor program costs to ratepayers. The concept of fuel diversity has also been lost in the noise. Unexpectedly low natural gas prices also have dampened some legislators' enthusiasm for renewable energy initiatives.

Nevertheless, NH's renewable energy industries have seen remarkable growth in the last decade in actual sales or in investments, resulting from a mix of consumer demand or incentives. The US Energy Information Administration reported that in 2007 our state's generation of renewable energy was 10% of NH's total electric generation and was composed of biomass and hydroelectric power. That increased to 20% in 2017, with the addition of solar and wind energy.

In the biomass sector, according to a study from Plymouth State University, NH's six independent biomass power plants contribute to or support over $254 million to the economy and 931 jobs. These numbers were enhanced by Schiller Station and Burgess BioPower. The recent attack on this sector from the legislature and governor threatens the future of this industry in NH.

In the hydropower sector, with incentives from RPS, owners of small-scale NH plants have invested in ensuring they meet requirements. There are approximately 50 MW of clean NH hydro power sent to the grid

The solar industry in the state has seen healthy demand. With this growth, according to the Solar Foundation, the 2017 job census in the sector is over 1000 in NH. The Solar Energy Industries Association reports 72.84 MW installed in our state.

NH's 3 developed wind farms can produce 171 MW of power. While wind farms use a lot of labor and materials during their development, once built and send clean energy to our grid to power homes and businesses, they do not add perceptibly to the labor force.

Our state's RPS target for renewable energy in 2017 was 17.6%. That number was reached through various means, much of which could be credited with pumping money into our economy through jobs and purchasing of materials.

Discussing the economic impact of renewable energy is not complete without mentioning the healthcare dollars saved when fossil-fuels are replaced by clean energy sources. The Solutions Project used a 2015 analysis by Stanford University to develop individual state projections of economic impact on health. For New Hampshire, an estimated $1.6 billion in avoided illness and mortality costs is projected if our state transitioned all sectors to 100% renewable energy by 2050, with 171 air-pollution deaths avoided annually.

See infographic here: http://thesolutionsproject.org/infographic/#nh

Summary and Conclusions (Peter Somssich)

Our state needs to chart its own renewable energy course for the future and become less dependent solely on out-of-state energy resources. Because each state has unique conditions (e.g. Hawaii is an island, Texas has access to large fossil fuel reserves, but is still a leader in wind energy), New Hampshire should find the right combination of renewable energy resources and set challenging but achievable RPS timelines and goals. Having fuel diversity and building up our state's energy dominance, both of which will result in more economic activity and jobs for NH residents, are benefits that must be considered in addition to the quantity of energy that they produce. It should be important to all NH residents where our energy comes from, and where our energy dollars go, whether it stays in our state, or leaves our state. We must make maximum use of our state's assets as well as accommodating partnerships with neighboring states that have assets of mutual interest.

This paper outlines a number of pathways for NH to use renewable energy resources to replace our current total annual in-state electricity consumption of approx. 11,000 [GWh]. For the purposes of this paper we focus on electrical consumption, 59% or 6448 GWh of which was used by Commercial and Industrial(C&I) users, while 41% or 4438 [GWh] was consumed by Residential(R) users. Furthermore, it is assumed that another equivalent 45,113 [GWh] of energy is consumed by both C&I and R- users for heating needs with the ratio of 56% (23156 [GWh]) C&I to and 41%(21951 [GWh]) Residential users. Included in the NH energy use calculations is 13,045 [GWh], which is considered to be energy losses due to production, transmission and distribution. And finally, an amount of 29,307 [GWh] is assumed to be used for transportation needs.

All pathways to 100% renewable energy use should consider partnerships with our neighbors to develop and enhance currently underutilized regional renewable energy sources. The significant potential of offshore wind (a technology recently promised fast-track licensing by the Interior Department) is one such opportunity. The best approach to harnessing offshore wind would include a partnership between the states of Maine and New Hampshire. Canadian onshore wind power and hydro power present another such opportunity. Within the borders of our state, solar, hydro, wind and biomass installations offer the opportunity to develop and maximize in-state renewable energy resources, adding substantial business investment and employment, and enhancing the energy dominance of our state.

Our top priority, however, must be to first maximize our in-state energy efficiency programs, because these programs are the most cost-effective investments, helping to drive down energy demand. Driving down demand, which drives down the ever-increasing T&D costs for all NH energy customers, is the most effective way to reduce energy bills.

More efficient use of energy is always a good strategy. Such a strategy will improve the air quality in NH, reduce harm to our environment including reducing GHG emissions which contribute to worldwide climate change. We can also expect to benefit from numerous technological innovations that are becoming more viable and affordable.

Creating microgrid networks for municipalities, businesses or community developments, connected to, but separate from the primary grid is also one such idea. Improved and more affordable batteries and energy storage systems will have a significant impact, especially for intermittent energy generators such as solar and wind. Steady and consistent improvements are also occurring in the efficiency of both solar and wind energy systems. However, for NH to see the future as an opportunity instead of a threat, will require strong political leadership that will set challenging goals and work together with businesses, municipalities and the public to achieve them. Other states are doing just that, and NH is no less capable of rising to this opportunity.

Pathways for a Renewable Energy Future

Tables 1-8 provide insights into NH current renewable energy situation, as well as suggesting future scenarios. The data for the tables was provided from the respective sections of this paper dealing with that topic, as well as making some reasonable assumptions. The percentage values in the tables are calculated based on NH's in-state 2016 electricity use of 11,000 [GWh] and a total in-state electricity generation of 19,284 [GWh].

The power of energy efficiency is shown in Table 1. The latest energy consumption numbers from 2016 are shown for both Residential and Commercial/Industrial customers. That total number in 2016 was 56,107 [GWh]. The top of the 1st column displays the year and any % increase or decrease in useage based on reasonable assumptions. Columns 2, 3, 4 display the energy usage in [GWh] of Residential(R) and Commercial & Industrial(C/I) users for electricity, for thermal energy as well as the total of both electricity and heating needs respectively. Column 1 also displays future years, so that the impact on energy usage, of a 1% increase per year for energy usage, or a 2% decrease of usage as the result of energy efficiency (EE) or demand reduction can be measured. Columns 5-6 display the effects of cumulative energy efficiency savings by the end user and the effective savings on fuel energy saved including fuel losses. Finally, Column 7 shows the total savings due to energy efficiency measures and demand reduction for both electricity usage and thermal energy use, taking energy losses into consideration.

Table 1 shows the impact on the energy use from 2016 to 2050, if we assume a 1%/yr. increase in energy use as well as a 2%/yr. energy efficiency (EE) savings. Also, because the conversion from initial fuel energy to actual electricity or heat involves the loss of approx. 60% of that energy, the end user effectively is delivered only 40% of the initial fuel energy. So, if the usage cycle is reversed, and an end-user saves 1 unit of energy consumption, this intern results in a fuel saving of 2.5 units of fuel energy (100%/40%= 2.5). Therefore, a savings by the customer of 1 unit of energy through energy efficiency or energy reduction actually results in a reduction at the energy source of 2.5 units of fuel energy. That is why the 6th column in Table 1 is labelled Effective EE savings, which includes the losses using the 2.5 factor.

For example, Table 1 shows that for 2040 if usage of both electricity and heating energy increased by 1% annually from the 2016 level, NH customers would be using 13,848 [GWh] of electricity, 56,788 [GWh] of heating energy for a total of 70,636 [GWh]. If during the same period of 2016 to 2040 energy use is being reduced by 2% a year since 2016, those end-user savings would have totaled 42,436 [GWh] as shown in Column 5. However, because fuel energy losses are approx. 2.5 times the end user energy, Column 6 shows that end-user savings in fact created 106,090 [GWh] of fuel energy savings. As Column 7 indicates, this means that even considering a 1% increase every year in energy use, a 2% decrease utilizing energy efficiency measures would generate more total energy savings in 2040 than NH would need.

Of course, it is possible that energy use could grow faster than 1% a year, and energy reduction proceed at less than 2% a year. However, given the dramatic technological advances in energy savings (an LED light bulbs is ~ 10 time more efficient than an incandescent one), it may not be such a leap to assume energy efficiency improvement both for electricity use and home heating (consider the impact of heat pumps). The tables below provide a snapshot of our state's current electricity generation, along with some predictions from the previous chapters that dealt with the specific area of energy.

Tables 2-7 display the various sources of renewable energy available in NH. Since no energy sources convert a fuel into 100% useable energy, e.g. electricity, each source has a conversion factor, Cf, (or efficiency) assigned to it. This factor, Cf, is provided in each table for the respective energy source.

Since it is assumed that by 2030 battery storage technology will have progressed to a level where most energy generators will be using battery storage to ensure 24/7 energy delivery, the respective Cf factor will be very close to 1. Of course in reality, every system will have some downtime required for maintenance and repairs, it is assumed that the Cf factor will not be 1, but close to 1.

Tables 2-7 deal with the various types of in-state energy sources as well as the potential of offshore wind energy emerging in the near future. The first 4 columns identify the type of energy source, the Cf factor, the capacity in [MW] and the annual total electricity generation. The last 2 columns in these tables give the % of the energy compared to the actual in-state NH electricity use as well as relating it to the electricity generation. Since approx. 50% of our electricity is exported out of the state, to reach a goal of 100% renewable energy for electricity, it is only required that we can generate our in-state demand using renewable energy. As the tables demonstrate, in 2030 the following % of our needs can be generated by various sources: 5% from solar, 96% from onshore wind, 159% from offshore wind, 6.4% from small hydro, 28.3% for large hydro and 8% for biomass. This numbers assume that by 2030 all power generators will be using battery storage to improve their availability.

Finally, Table 8 provides an overview of all NH in-state electricity generation, including the possible offshore wind energy that would be accessible for NH as a source of electricity. It would appear that of all the possible NH energy choices that could be available by 2030, the top choices in order would be: offshore Wind, onshore Wind large hydropower and solar power(solar is included because of its growth potential). Small hydropower and biomass remain more minor players, however, their other contributions to fuel diversity, economic impact and environmental impact are significant.

By 2050, however, solar energy could overtake large hydro for the 3rd most important contributor to NH's electricity needs. However, it is also important to point out that Table 8 shows that already in the year 2030, NH could be producing more that 300% of its electricity needs.

Table 1: Predications for Future RE-Energy Efficiency (EE)

Energy Efficiency / Year	Total R+C/I Electriciy Use [GWh]	Total R+C/I Thermal Use [GWh]	Total Energy Elec+Ther Consumption [GWh]	Cum EE Savings [GWh]	Effective EE Savings incl.losses with x 2.5 [GWh]	Total Energy Use incl.Loss after Savings (based on 2016 Use) [GW]
2016 Data	11,000	45,107	56,107			
2025 with 1% /yr. increase	11,990	49,167	61,157			
2%/yr.EE saving				9,328	23,320	37,837
2030 with 1%/yr. increase	12,590	51,625	64,215			
2%/yr.EE saving				21,930	54,825	9,390
2040 with 1%/yr. increase	13,848	56,788	70,636			
2%/yr.EE saving				42,436	106,090	-35,454
2050 with 1%/yr. increase	15,233	62,466	77,699			
2%/yr.EE saving				54,651	136,628	-58,929

Table 2: Predications for Future RE-Energy Solar

Energy by Type Solar	Year Considered	Capacity [MW]	Total Energy [GWh]	Total Energy % of 2016 Use	Energy % of 2016 Generation
	2018 / CF=0.12	76.0	80.0	0.7	0.4
	CF=1		666.0	6.1	3.5
	2030 / CF=0.5	133.0	583.0	5.0	3.0
	2040 / CF=1	210.0	1836.0	15.0	9.5
	2050 / CF=1	365.0	3200.0	25.0	16.6

Table 3: Predications for Future RE-Energy Onshore Wind

Energy by Type Onshore Wind	Year Considered	Capacity [MW]	Total Energy [GWh]	Total Energy % of 2016 Use	Energy % of 2016 Generation
	2018 / CF=0.25	185.0	405.0	3.7	2.1
	CF=1		1620.0	14.7	8.4
		+29.0			
	2030 / CF=1	1204.0	10,547	96.0	55.0
	2040 / CF=1	10,000	87,600	796.0	454.0
	2050 / CF=1	13,547	118,672	1079.0	615.00

Table 4: Predications for Future RE-Energy Offshore Wind

Energy by Type Offshore Wind	Year Considered	Capacity [MW]	Total Energy [GWh]	Total Energy % of 2016 Use	Energy % of 2016 Generation
	2018 / CF=0.40	0	0	0	0
	CF=1				
	2030 / CF=1	2000.0	17,520.	159.0	91.0
	2040 / CF=1	2500.0	21,900	199.0	114.0
	2050 / CF=1	3000.0	26,280	239.0	136.0

Table 5: Predications for Future RE-Energy Small Hydro

Energy by Type Small Hydro	Year Considered	Capacity [MW]	Total Energy [GWh]	Total Energy % of 2016 Use	Energy % of 2016 Generation
	2018 / CF=0.46	80	320.0	2.9	1.7
	CF=1		701.0	6.4	3.6
	2030 / CF=1	80			
	2040 / CF=1	80			
	2050 / CF=1	80	701.0	6.4	3.6

Table 6: Predications for Future RE-Energy Large Hydro

Energy by Type Large Hydro	Year Considered	Capacity [MW]	Total Energy [GWh]	Total Energy % of 2016 Use	Energy % of 2016 Generation
	2018 / CF=0.50	355.0	1555.0	14.0	8.1
	CF=1		3110.0	28.3	16.1
	2030 / CF=1	355.0			
	2040 / CF=1	355.0			
	2050 / CF=1	355.0	3110.0	28.3	16.1

Table 7: Predications for Future RE-Energy Biomass

Energy by Type Biomass	Year Considered	Capacity [MW]	Total Energy [GWh]	Total Energy % of 2016 Use	Energy % of 2016 Generation
	2018 / CF=0.70	100.0	613.0	5.6	3.2
	CF=1		876.0	8.0	4.5
	2030 / CF=1	100.0			
	2040 / CF=1	100.0			
	2050 / CF=1	100.0	876.0	8.0	4.5

Table 8: Predications for RE-Energy Type and % of Total Energy (based on 2016)

Energy Type / Year	Solar [GWh]	Onshore Wind [GWh]	Offshore Wind [GWh]	Small Hydro [GWh]	Large Hydro [GWh]	Biomass [GWh]	Total Energy All Types [GWh]	Total Energy % of 2016 Use
2030	583.	10,547.	17,520	320.	3110.	876.	32,953.	300.
CF=1								
2040	1836.	87,600.	21,900.	701.	3110.	876.	116,023.	1054.
2050	3200.	118,672.	26,280.	701.	3110.	876.	152,839.	1389.

The opportunities for offshore and onshore wind are constantly in the news. A recent report[a] reported that 6 east coast states (MA, NY, NJ, RI, Maryland and Conn. have all joined together to contract for 10 GW of offshore wind capacity, enough to generate 35,000 [GWh] of low-cost and clean electricity which is 3 times the current NH electricity consumption. These states plan to begin the process of creating a new heavy industry business, focusing on offshore wind and planning to create an estimated 160,000 new jobs.

In the meantime, our state refuses to take action needed to remove those obstacles for the development of renewable energy resources in and for New Hampshire. Some of the actions needed include:

- Aggressively increase the Renewable Portfolio Standard (RPS) goals both for the types of energy and the timeline involved, 25% by 2025 is too low a bar
- Push down demand (energy use), which in turn reduces customers utility bills, and reduces GHG emissions. Because Transmission & Distribution cost are the reason for NH's utility bill increases, far higher than in neighboring states, we must work to reduce demand.
- Address the underfunding of low-income energy efficiency audits
- Address the underfunding of renewable energy projects beyond 6 months each year
- Increasing or even eliminating the net-metering cap which controls the demand for more renewable energy projects, both for municipalities and private companies
- Encourage the development of microgrids in collaboration with our state's utilities
- Recognize the value of and provide incentives for greater fuel diversity
- Join other Atlantic coast state on the federal board involved with the awarding of offshore wind energy leases off the coast of New Hampshire
- Investigate the opportunity to join Maine in creating a new offshore wind energy industry on the Maine/NH coast

- Protect current small hydro plants and discourage the elimination of dams that have the potential to generate clean hydropower for our state, while at the same time accommodating the environmental concerns
- Raise the ACP to be more in line with neighboring states
- Encourage NH businesses to transition to more energy efficient processes and allow them to fully participate in net-metering as partners with other organizations
- Expedite grid modernization to allow access for more renewable energy generators
- Work with in-state utilities to allow them to be partners in the effort to install more renewable energy in our state
- Join efforts to help create a nationwide carbon pricing system that places a genuine price on producing energy with fossil fuels
- Join with municipalities to encourage increased energy efficient use of municipal buildings, waste water treatment facilities, street lighting and recycling center

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Acronyms

The 2018 New Hampshire 10-Year State Energy Strategy includes a list of acronyms which we should also use. It is included in Appendix 1 of this document. In addition, some definitions used in the Climate Change Action Plan are included in Appendix 2

Appendix 1: Acronyms from 2018 NH 10-Year State Energy Strategy

Acronyms

Alternative Compliance Payments	ACP
Competitive Auctions with Subsidized Policy Resources	CASPR
Distributed Energy Resources	DERs
Distributed Generation	DG
Demand Response	DR
Energy Efficiency	EE
Energy Efficiency Resource Standard	EERS
Energy Efficiency and Sustainable Energy	EESE
Energy Information Administration	EIA
Electric Reliability Council of Texas	ERCOT
Electric Vehicles	EV
Federal Energy Regulatory Commission	FERC
Gigawatt hours	GWh
Independent System operator New England	ISO-NE
Kilowatt	kW
Levelized cost of electricity	LCOE
Minimum Offer Price Rule	MOPR
Megawatt	MW
Megawatt hour	MWh
National Association of State Energy Officials	NASEO
Office of Strategic Initiatives	OSI
Public Utilities Commission	PUC
Photovoltaics	PV
Renewable Energy Credits	RECs
Renewable Energy Portfolio	RPS
Revised Statue Annotated	RSA
Regional Transmission Organization	RTO
Site Evaluation Committee	SEC

Appendix 2: Climate Action Plan- Part 1 of 4

Climate Action Plan Glossary

AFW: The Agriculture, Forestry and Waste working group.

Biomass: When referring to fuel, means plant-derived fuel including clean and untreated wood such as brush, stumps, lumber ends and trimmings, wood pallets, bark, wood chips or pellets, shavings, sawdust and slash, agricultural crops, biogas, or liquid biofuels, but shall exclude any materials derived in whole or in part from construction and demolition debris.

CAFE: The federal Corporate Average Fuel Economy program, which sets minimum fuel economy for cars and light trucks, including sport utility vehicles.

Capacity: The maximum power capability of a system.

Carbon Dioxide (CO_2): The major heat-trapping gas whose concentration is being increased by human activities. It also serves as the yardstick for all other greenhouse gases. The major source of CO_2 emissions is fossil fuel combustion. Carbon dioxide emissions also result from clearing forests and burning biomass. Atmospheric concentrations of CO_2 have been increasing at a rate of about 0.5 percent a year, and are now more than 30 percent above pre-industrial levels.

Carbon Sequestration: The uptake and storage of carbon. Trees and other plants, for example, absorb CO_2 then release the oxygen while storing the carbon.

Carbon Sinks: The processes or ecological systems that take in and store more carbon than they release. This process is called carbon sequestration. Forests and oceans are large carbon sinks.

CCPTF: Climate Change Policy Task Force.

Climate Change: A significant change from one climatic condition to another, often used in reference to climate changes caused by increase in heat-trapping gases since the end of the 19th century.

Climate: The average state of the atmosphere, including typical weather patterns for a particular region and time period (usually 30 years). Climate is not the same as weather, but rather the average pattern of weather for a particular region. Weather describes the short-term state of the atmosphere; climate is longer-term. Climatic elements include average precipitation, temperature, wind, and seasonal phenomena such as length of the growing season among others.

CO_2e: Carbon dioxide equivalent, a measure that is used to express the concentration of all heat-trapping gases in terms of CO_2.

Combined Heat and Power: Also referred to as cogeneration is the process by which two different and useful forms of energy are produced at the same time. For example, water may be boiled to generate electricity in a turbine, with the leftover steam used to drive industrial processes or captured for space heating.

CSNE: Carbon Solutions New England.

DES: New Hampshire Department of Environmental Services; the state agency with primary responsibility for environmental permitting and enforcement.

DOT: New Hampshire Department of Transportation; the state agency with the responsibility to construct and maintain the transportation system and facilities in the state.

DSM: Demand-side management includes end-use measures that conserve electricity. They include energy efficient products and design, and load management strategies.

EGU: The electric generation working group.

EIA: United States Energy Information Administration, a division of the United States Department of Energy that focuses on data collection and analysis.

Embodied Energy: The total expenditure of energy involved in the creation of the building and its constituent materials. In terms of a full lifecycle of a product, it can also refer to the energy that is required to extract, process, package, transport, install, and recycle or dispose of materials and products.

EPA: United States Environmental Protection Agency.

Appendix 2: Climate Action Plan- Part 2 of 4

Executive Order 2007-3: Order signed in 2007 by Governor John Lynch establishing the Climate Change Action Plan and charging that body to develop climate change goals and a plan for the state.

FHWA: The Federal Highway Administration is a major agency of the United States Department of Transportation and is charged with the broad responsibility of ensuring that America's roads and highways continue to be the safest and most technologically up-to-date.

FIA: The Forest Inventory and Analysis Program of the United States Forest Service provides the information needed to assess America's forests.

Fossil Fuel: A general term for combustible geologic deposits of carbon in reduced (organic) form. Fossil fuels are of biological origin, and include coal, oil, natural gas, oil shales and tar sands. A major concern is that they emit CO_2 when burned, significantly contributing to the enhanced greenhouse effect.

Generation: The process of making electricity. The term may also refer to energy supply.

Greenhouse Effect: The thermal effect that results from heat-trapping gases allowing incoming solar radiation to pass through the Earth's atmosphere, but preventing most of the outgoing infrared radiation from the surface and lower atmosphere from escaping into outer space.

Greenhouse Gas: Any gas that absorbs infrared radiation (traps heat) in the atmosphere. Greenhouse gases include nations have helped the IPCC prepare periodic assessments of the scientific underpinnings of global climate change and its consequences.

KWh: Kilowatt-hour.

LEED: The Leadership in Energy and Environmental Design program of the United States Green Building Council.

Methane (CH_4): A hydrocarbon that is a heat-trapping gas carrying a global warming potential recently estimated at 24.5. Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and oil, coal production and incomplete fossil fuel combustion.

MMtCO$_2$e: Million metric tons of CO_2 equivalent.

Mt: A metric ton equivalent to 1.102 short tons (2000 lbs.)

MW: Megawatt, A measure of electricity capacity. One MW is sufficient to provide power to 700 to 1,000 homes.

MWh: Megawatt-hours (1 thousand kilowatt-hours).

NEG/ECP: New England Governors/Eastern Canadian Premiers, the regional inter-governmental organization responsible for releasing the NEG/ECP Climate Change Action Plan in 2001.

NESCAUM: Northeast States for Coordinated Air Use Management, a nonprofit regional air quality policy organization whose directors are the top air pollution control officials in all six New England states, New York and New Jersey.

Appendix 2: Climate Action Plan- Part 3 of 4

Greenhouse Gas: Any gas that absorbs infrared radiation (traps heat) in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide, (N_2O), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs).

GWh: Gigawatt-hours (1 million kilowatt-hours).

HFC: Hydrofluorocarbon compounds; a man-made greenhouse gas generated by industrial processes.

ICLEI: International Council for Local Environmental Initiatives, a nonprofit organization that partners with local governments on environmental and sustainable development projects, particularly climate change.

IPCC: Intergovernmental Panel on Climate Change. Established in 1988, the IPCC assesses information in the scientific and technical literature related to all significant components of the issue of climate change. It draws on hundreds of the world's leading scientists to serve as authors, and thousands as reviewers. Key experts on climate change and the environmental, social and economic sciences from some 60

whose directors are the top air pollution control officials in all six New England states, New York and New Jersey.

Nitrous Oxide (N_2O): A powerful greenhouse gas with a global warming potential of 310. Major sources of nitrous oxide include soil cultivation – especially from use of commercial and organic fertilizers – fossil fuel combustion in vehicles, nitric acid production and the combustion of biomass.

NO_x: Oxides of nitrogen, both nitric oxide (NO) and nitrogen dioxide (NO_2). They are key in forming ground-level ozone smog, and contribute to acid rain and particulate pollution.

OEP: New Hampshire Office of Energy and Planning; this is an executive-level office that is responsible for guiding the state's future growth through public policy development, education, research, and partnership building.

PFCs: Perfluorocarbons; a man-made greenhouse gas generated by industrial processes.

PPM: Parts per million.

PUC: The Public Utilities Commission, whose mission it is to ensure that customers of regulated utilities receive safe, ad-

Appendix 2: Climate Action Plan- Part 4 of 4

equate and reliable service at just and reasonable rates.

PV: Photovoltaic; a treated semiconductor material that converts sunlight to electricity.

RCI: The residential, commercial and industrial working group.

REC: Renewable energy certificates which are marketable/ tradable entities that represents one megawatt hour (1,000 kWh) of power generation from a renewable energy source.

RPS: Renewable Portfolio Standard; a policy designed to influence the development of renewable resources and technologies by requiring electricity providers to obtain a minimum percentage of the power they supply to their customers from renewable energy resources by a certain date.

SBC: System benefit charge; a charge on a consumer's bill from an electric distribution company to pay for the costs of certain public benefits such as low-income assistance and energy efficiency.

SF_6: Sulfur hexafluoride; a man-made greenhouse gas generated by industrial processes.

Sink: Removals of carbon from the atmosphere, with the carbon stored in forests, soils, landfills, wood structures, or other biomass-related products.

SIT: USEPA State Greenhouse Gas Inventory Tool.

Source: Any process or activity that releases into the atmosphere a greenhouse gas, an aerosol or a precursor to a greenhouse gas.

SUV: Sports utility vehicle, considered under federal gas mileage standards to be a light-duty truck, and subject to a lower average mile per gallon requirement: 20.7 mpg.

TLU: Transportation and land use working group.

UNH: University of New Hampshire

VMT: Vehicle-miles traveled.