CONCORD CITY COUNCIL

CONCORD ENERGY AND ENVIRONMENT COMMITTEE

ADVISORY REPORT IN SUPPORT OF THE GOAL OF 100% RENEWABLE ENERGY FOR CONCORD

January 31, 2018

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EXECUTIVE SUMMARY

The Concord Energy and Environment Committee (the "CEEC") recommends that the City Council adopt the following goal: 100% renewable energy for Concord, across the electricity, thermal energy and transportation sectors, for the entire Concord community not just municipal government operations, by 2030 for electricity and by 2050 for thermal and transportation.

The CEEC makes this recommendation because ambitious and far-reaching actions are needed to meet the challenge of climate change triggered by human-caused greenhouse gas emissions, and specifically by the use of fossil fuels. The effects of climate change are already being felt around the world and here in New Hampshire and will only get more severe if we do not take bold action right away. In order to avoid the worst effects of climate change, we need to get off fossil fuels entirely and transition to renewable energy and clean transportation by the middle of this century. The time to begin is now.

Moving to renewable energy and clean transportation is not a matter of self-sacrifice. This transition will bring benefits to Concord, including reduced and stable energy and transportation costs, new jobs, greater local control of our energy supply, reduced health impacts and health costs associated with fossil fuel emissions, and reduced costs of climate change mitigation.

Recent developments in the energy and vehicle marketplace have only strengthened the momentum toward renewable energy. The cost of solar and wind power and the cost of energy storage have decreased dramatically over the last several years and are expected to decrease much further. Large-scale onshore wind and solar power is price-competitive with fossil fuel power in parts of the U.S. right now. The same will be true for other renewable energy projects across the U.S. in the coming years. Cost reductions and technological advances are already enabling the combination of intermittent renewables like wind and solar with storage to offer firm sources of renewable power. The electric grid itself is changing and will incorporate microgrids and other new approaches that will facilitate more renewable energy and storage. Electric vehicles (EVs) have declined significantly in cost and will continue to do so thanks to improvements in battery technology. EV performance is improving, consumer choices are widening and charging stations to support the use of EVs are proliferating.

A movement toward 100% renewable energy is growing. Nations have committed to get entirely off coal and ban combustion vehicles by future target dates. U.S. states are moving toward 100% renewable energy, and major corporations have committed to make the transition on aggressive timeframes. But this movement is being driven mainly by cities. Over 50 cities across the U.S. have committed to 100% renewable energy, and some have already achieved 100% renewable electricity. Experts have found that a transition to 100% renewable energy is technologically feasible, the economics of doing so are becoming irresistible, and the main barriers to achieving the goal are political. A large-scale transition to renewable energy is underway. Concord should anticipate that transition and get ahead of it. Indeed, as the capital of the first-in-the-nation primary state, Concord should be a leader in this movement.

The CEEC believes that adopting a 100% renewable energy goal will benefit Concord environmentally, economically and enhance Concord's image in the region and the wider world. We believe that this commitment will attract green businesses and other businesses to Concord, and will make a positive statement that Concord is a city that believes in itself, is moving forward and is a great place to live. It is a commitment that our children and grandchildren will be proud of.

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PART 1 - INTRODUCTION

Communities across the nation are embracing a renewable energy future, choosing to embark on an ambitious path to achieve 100% renewable energy by 2050. The City of Concord has an opportunity to join this movement, building upon the progress that the City has achieved to date in energy efficiency and the use of renewable energy.

The Concord Energy and Environment Committee (the "CEEC") recommends that the City Council adopt the following goal:

- 100% Renewable Energy in the City of Concord
- Across the Electricity, Thermal Energy and Transportation Sectors
- Community-wide not just Municipal Operations
- Achieve 100% renewable electricity by 2030, 100% renewable thermal energy and transportation by 2050

This Paper discusses the 100% renewable energy goal, and is organized as follows. Part 2 summarizes the City's current energy situation and recent energy actions. Part 3 discusses the threat posed by global climate change, the role of fossil fuels in creating the threat and the potential solution offered by renewable energy. Part 4 examines the policy and market context for the transition to renewable energy. Part 5 explains the movement to 100% renewable energy (see Appendix A for a list of cities committed to 100% renewable energy). Part 6 lays out the CEEC's recommendations and a vision for Concord's energy future in 2050.

The benefits of committing to 100% renewable energy include enhanced economic development and job creation through the deployment of clean energy sources, a greater ability to predict and control energy costs, and improvements in public health due to reduced air emissions. As the capital of New Hampshire, Concord has a unique opportunity to exercise leadership in the fight against climate change, control its energy destiny and inspire others to act.

PART 2 – CONCORD'S ENERGY PRESENT

A. Current Community-Wide Energy Consumption

Concord's estimated community-wide energy usage is as follows:

Sector	Approximate Annual Usage
Electric	Approximately 474 million kilowatt-hours (KWH) (2011)[1]
Natural Gas	20.9 million therms[2]

Approximately 17% of the city-wide electric supply comes from renewable energy sources, reflecting Unitil's percentage requirement under the State renewable portfolio standard (RPS) program. As of 2012, the U.S. Census Bureau's American Community Survey estimated that 49% of Concord households used natural gas for heating while 25% used fuel oil.[3] At this time, we are not aware of any reliable estimate of the City's community-wide carbon footprint.

B. Current Municipal Government Energy Consumption

Concord's current estimated (2017-18) municipal government energy usage is as follows:

Sector	Approximate Annual Usage
Electric	9.5 million kilowatt-hours (KWH), at a cost of about $1.6 million per year.[4]
Natural Gas	225,737 therms of natural gas per year, at a cost of $1.095 per therm, or $247,182 per year.[5]
Transportation (includes Concord School District and Merrimack Valley School District)	• 143,240 gallons of gasoline per year, at $1.9172 per gallon, or $274,619 per year • 186,590 gallons of ultra-low sulfur diesel at $2.1553 per gallon, or $402,157

At this time, we are not aware of any reliable estimate of the City's municipal government carbon footprint.

C. Existing Non-Fossil Fueled Energy Generation in Concord

Existing non-fossil fueled energy generation facilities in Concord include the following:

- Four hydroelectric projects are located wholly or partially in Concord.[6] Briar Hydro Associates owns three projects with a combined generating capacity of 11.2 megawatts MW on the Contoocook River in Penacook.[7] The Garvins Falls project is owned by PSNH/Eversource but will be sold to Hull Street Energy in the coming weeks, has a capacity of 12.3 MW and operates on the Merrimack River between Concord and Bow.[8]

- Solar photovoltaic (PV) projects operating in Concord include a 60 kilowatt (KW) project at the Unitarian Universalist Church on Pleasant Street, and a 57 KW project on the DMV building on Hazen Drive. NextEra has proposed a 10 MW solar project to be sited on Portsmouth Street.
- Wheelabrator Concord Company operates a waste-to-energy facility on Whitney Road in Penacook. The facility can accept up to 500 tons of solid waste per day, and has a generating capacity of approximately 14 MW.[9]
- Apart from the numerous residential wood stoves, at least four wood biomass-fired heating facilities operate in Concord, at Merrimack Valley School District's campus in Penacook, the New Hampshire Audubon McLane Center, the Society for the Protection of New Hampshire Forest and the State's Hazen Drive campus.

Concord Steam Company's biomass-fired steam heat plant supplied steam heat to much of downtown Concord, but ceased operation for economic reasons on May 31, 2017.[10]

D. Concord's Recent Energy-Related Initiatives

In the last ten years, the City of Concord has undertaken a number of significant energy-related initiatives, including the following:

- Formed the Concord Energy and Environment Committee in 2008.
- Incorporated an Energy Chapter written by the CEEC into the Master Plan in 2012.
- Conducted an inventory of energy use by municipal operations.
- Implemented a variety of energy efficiency improvements, including updated thermostats and temperature control systems at several municipal buildings, LED lighting and chiller replacement at Everett Arena,[11] LED lighting at pedestrian crossings and other locations, solar thermal hot water heating systems at several municipal buildings, anti-idling devices on municipal vehicles.
- Issued an RFP for a solar project to be sited at the wastewater treatment plant (WWTP) on Hall Street in 2016, and selected a solar developer to build the project, which would have supplied the WWTP with solar power. Unfortunately, negotiations with the developer failed.
- Currently buys green power (with RECs from midwestern wind farms) from a competitive electric supplier under contract expiring in December.
- Bike lanes were added to Main Street as part of the "Complete Streets" project.
- Adopted a solar property tax exemption in June 2017, assuring property owners that installing solar facilities on their properties would not raise their property tax assessments. The exemption takes effect for tax year beginning April 1, 2018.
- Mayor Jim Bouley joined the U.S. Climate Mayors group in the summer of 2017.

Concord has a good track record in terms of sustainability and environmental stewardship, but more ambitious and far-reaching actions are needed to meet the challenge of climate change.

PART 3 -- THE THREAT OF CLIMATE CHANGE AND THE RENEWABLE ENERGY SOLUTION

A. Global and National Impacts

The effects of global climate change caused by human emission of greenhouse gases ("GHGs")[12] are being increasingly seen and experienced around the world in the form of record heat, stronger storms, reduced ice packs in the Arctic, Antarctic and Greenland, rising sea levels and much more. Nations have recognized the threat of climate change for at least three decades, and over time reached a consensus that to avoid the worst effects of climate change we need to hold global temperature rise to 3.6°F (2°C) over preindustrial levels by the end of the 21st century.[13] At the Paris Climate Conference in 2015, nations set a more ambitious target of 1.5°C of temperature rise, reflecting the latest science on the amount of warming that would still avoid catastrophic consequences.[14]

In November 2017, the U.S. Global Climate Change Research Program issued its Fourth National Climate Assessment reporting on the continent-wide effects in the United States, and made the following findings:[15]

- Global average surface air temperature has increased by about 1.8°F (1.0°C) from 1901 to 2016, making this the warmest period in the history of modern civilization. The years 2014-16 were the warmest years on record for the globe.[16]
- It is extremely likely that human activities, especially GHG emissions, are the dominant cause of observed warming since the mid-20th century. There is no convincing alternative explanation.
- In addition to warming, including changes in surface, atmospheric and oceanic temperatures, melting glaciers, diminishing snow cover, shrinking sea ice, rising sea levels, ocean acidification, and increasing atmospheric water vapor.
- Global average sea level has risen by about 7-8 inches since 1900, almost half occurring since 1993. This rate of rise greater than during any preceding century in at least 2,800 years. Global sea level rise has already affected the U.S. in the form of accelerating daily tidal flooding along the Atlantic and Gulf coasts.
- Global average sea levels are expected to continue to rise by at least several inches in the next 15 years and 1-4 feet by 2100. A rise of as much as 8 feet by 2100 cannot be ruled out. Sea level rise on the Atlantic and Gulf coasts will be higher than the global average.
- Changes in the characteristics of extreme events will affect human safety, infrastructure, agriculture, water quality and quantity, and natural ecosystems. Heavy rainfall is increasing in intensity and frequency across the U.S., especially in the Northeast, and will continue to increase.
- Recent record-setting hot years will become more common as average temperatures continue to rise. By 2050, average annual temperatures in the U.S. are expected to rise by about 2.5°F relative to the recent past under all plausible future climate scenarios.
- The magnitude of climate change after the next few decades will depend primarily on the amount of GHGs emitted globally. Without major emission reductions, annual average

global temperature could rise 9°F (5°C) or more relative to preindustrial times could reach by the end of this century. With major emission reductions, global temperature rise could be limited to 3.6°F (2°C) or less.

- CO_2 concentrations have now passed 400 parts per million,[17] a level last reached 3 million years ago, when global temperature and sea level were significantly higher than today. Continued growth in CO_2 emissions would lead to the highest atmospheric CO_2 concentration in tens to hundreds of millions of years.
- In 2014 and 2015, GHG emission growth rates slowed as economic growth became less carbon-intensive. Even if this slowing trend continues, it is not yet at a rate that would limit global average temperature change to well below 3.6°F (2°C) above preindustrial levels.

Severe weather events in 2017, including some of the largest wildfires on record in the West, a series of record-setting hurricanes in the Caribbean and U.S. and extreme heat in many parts of the country, only underscore the fact that human-caused climate change is not a hypothetical future risk but a present-day reality. Even the cold snap experienced in the eastern U.S. in early January 2018 may be linked to disruptions to the jet stream attributable to climate change. While our region was freezing, Alaska and the Arctic were experiencing unusually warm weather.[18]

Climate change imposes profound ecological costs,[19] human costs and economic costs. In October 2017, the U.S. Government Accountability Office estimated that climate change cost U.S. taxpayers $350 billion in disaster assistance programs, losses from flood and crop insurance and similar costs over the preceding decade.[20] This figure does not include the cost of responding to last year's wildfires and hurricanes (which occurred after the report was prepared) nor does it include private sector losses. Costs stemming from health care impacts of air pollution and climate change could amount to hundreds of billions of dollars per year by mid-century. Failing to respond to climate change could prove to be very costly.[21]

B. State and Local Impacts

Climate change is also causing serious and profound changes here in our own state. In a 2014 report,[22] the Sustainability Institute at the University of New Hampshire found that since 1970 the climate of southern New Hampshire has changed as follows:

- Average annual maximum temperatures have warmed 1.1 to 2.6°F with the greatest warming occurring in winter.
- The number of days with minimum temperatures less than 32°F has decreased and the coldest winter nights are warming.
- The length of the growing season is two to four weeks longer.
- Annual precipitation has increased 12 to 20%.
- Extreme precipitation events have increased across the region.
- The number of snow-covered days has decreased by 27 days in Durham and 12 days in Hanover.
- More than a century of observations show spring lake ice-out dates on Lake Winnipesaukee and Lake Sunapee are occurring 10 to 20 days earlier today than in the past.

The UNH report evaluated future GHG emissions scenarios and found that in a higher emission (business as usual) annual average temperatures in southern New Hampshire will rise between 3 to 5°F by mid-century and by 4 to 8°F by the end of the century. Summer temperatures may increase by as much as 11°F compared to the historical average from 1980 to 2009.[23] We will experience more extreme heat days and the hottest days will be hotter, which will have profound and wide-ranging impacts.

Specific potential impacts of climate change in New Hampshire include the following:[24]

- Loss of winter recreation (skiing, snowmobiling) opportunities and related economic activity
- Maple trees shift to higher elevations and latitudes and yield less maple sugar.
- Characteristics of our seasons may change as we experience weather more like currently experienced in the South.
- Autumn foliage may be dulled, potentially reducing tourist visits.
- Cold water fishing may be lost.
- Loss of plant and animal species and increased pressure from invasive species
- Increased incidence of Lyme disease
- Higher tides and increased flooding and erosion in coastal areas
- Crop failure resulting from temperature stress and extreme precipitation events.

C. The Role of Fossil Fuels

The rise in global GHG emissions and the corresponding rise in global temperatures is mainly caused by the combustion of fossil fuels from the 19th century to the present day.

The combustion of coal, oil and gasoline powered industrialization, first in western countries and now in developing countries. These fossil fuels were used in electric generation, industrial processes, most heating applications, and most forms of transportation including automobiles. Combustion of coal,[25] oil and gasoline all emit large amounts of GHGs, as well as a range of other toxic and environmental harmful pollutants, into the atmosphere.

In the past ten years, the use of coal in the U.S. has declined in favor of natural gas, and to a lesser extent renewable energy. Natural gas is supplanting coal and nuclear as a source of baseload electric power around the country following the discovery of vast new gas fields in the central U.S.[26] It is beating coal and nuclear on cost. Natural gas is better on combustion-related emissions than coal and oil, but when you consider CO_2 emissions from the combustion of natural gas together with methane (CH_4, a much more potent GHG than CO_2)[27] leakage from drilling sites and pipelines, natural gas is as harmful as coal or oil on GHG emissions,[28] and so it leaves us no better off from a climate change perspective For more information on natural gas, see Appendix B.

Global GHG emissions have accelerated as developing nations combust more fossil fuels and emit more GHGs while developed nations' GHG emissions have stayed relatively flat. Experts estimate that if we simply combust all fossil fuels accessible by currently operating mines and wells, we would release 1.1 trillion tons of CO_2 emissions to the atmosphere, which would cause temperatures to rise more than 2°C. If we open more mines and drill more wells than are currently operating, the goal of limiting temperature rise becomes even more difficult to achieve.[29]

D. The Need for Deep Decarbonization

Experts say that at this point a gradual decline in GHG emissions is not enough to hold global temperature rise in this century to 2°C, much less 1.5°C. Rather, we need to eliminate GHG emissions by the middle part of this century, which requires getting off fossil fuels by mid-century.[30] This transition is sometimes called "deep decarbonization." Deep decarbonization requires removing fossil fuels from all sectors of energy use, including electricity, thermal energy, and transportation.

We will still need energy in a decarbonized world. The answer lies in renewable energy. Most forms of renewable energy do not result in GHG emissions, or are carbon-neutral (e.g., biomass). Transitioning from fossil fuels to renewable energy is critical to limiting GHG reductions.

Deep decarbonization will require weaning ourselves off of natural gas. If we are serious about combating climate change, we must limit our further investments in natural gas infrastructure, lest they lock us in to natural gas and inhibit further decarbonization later.[31] Some argue that we should think of natural gas as a "bridge fuel,"[32] a fuel we may need in the short term, but one that should not be a significant part of our energy mix by mid-century.

E. The Promise of Renewable Energy and Clean Transportation

Renewable energy and clean transportation are a critical solution to the challenge of global climate change and an essential means to deep decarbonization. The benefits of renewable energy and clean transportation, further discussed in Section 4.D, include the following:

- Avoided GHG Emissions from Fossil Fuel Plants. The share of our energy that comes renewable sources is growing, and the share that comes from fossil fuels is shrinking. Generation of solar and wind power has grown exponentially since 2006.[33] For the past few years, most new electric generation capacity installed in the U.S. has been renewable energy. As renewable electricity replaces coal and oil plants, and eventually natural gas plants, it will eliminate their GHG emissions.

- Reduced Energy Costs. The cost of wind power, solar power and battery storage have dropped dramatically in recent years, and are predicted to drop much further still. Large-scale solar and wind power are already beating fossil fuels on price in some situations. Energy analysts predict that electricity from renewables will out-compete fossil-fuel energy at some point in the next decade. The day is coming soon when energy consumers will switch to renewable energy because it is less expensive, even without considering its environmental benefits.

- Stable Energy Prices. Unlike fossil fuel, renewable energy is not subject to the ups and downs of commodity market prices. You can lock in a steady price for solar and wind power over the long term because you do not pay for fuel. By contrast, fossil fuel prices are variable and cannot be locked in for a long period of time.

- Avoided GHG Emissions from Combustion Vehicles. Electric Vehicles ("EVs") are rapidly coming down in cost. Performance (e.g., mileage between charges) is improving, and more makes and models of EVs are now available. Charging stations are becoming more widespread. EVs offer an operational cost savings over combustion vehicles, offsetting the current (but rapidly disappearing) purchase price premium. EVs are powered on electricity from the grid, which is cleaner than gasoline combustion now and will become more clean as we transition to renewable electricity.

- Creates Jobs. Renewable energy and energy efficiency jobs are growing faster than the rest of the economy, and will likely continue to do so. Jobs in the solar and wind power sectors and in energy efficiency have grown substantially over the last several years, and are creating jobs at a rate much faster than the rest of the U.S. economy. Investments in renewable energy sources generate about three times more direct and indirect jobs than comparable investments in fossil fuels.[34]

- Better Health Outcomes and Reduced Health Costs. Use of renewable energy and clean transportation avoids harmful air emissions, which ultimately has a positive effect on human health and significantly reduces health care costs. A study by Lawrence Berkeley Lab found that wind and solar power in the US reduced SO_2, NO_X (smog), and particulate emissions (soot) by over a million tons, and those emission reductions helped avoid 7,000 premature deaths. Those avoided deaths, along with other public health impacts, are worth a cumulative $56 billion.[35]

- Saves Climate Change Mitigation Expenses. Greater use of renewable energy and clean transportation will help us avoid the worst effects of climate change, which will save money in climate change mitigation expenses (e.g., disaster assistance programs and flood and crop insurance).[36] Lawrence Berkeley Lab found that using wind and solar power saved $32 billion in avoided climate costs.[37]

- Local Control. Renewable energy can be generated locally. Generating and buying more renewable energy enables communities to better control their energy supply, reducing reliance on foreign and far-away energy sources and vulnerability to supply disruptions and price spikes.

The most commonly cited disadvantages of renewable energy and clean transportation are: (a) the intermittency of wind and solar power, (b) the perceived higher cost of solar and wind power and EVs, and (c) EV impracticalities such as miles per charge and availability of charge. But storage technologies are already helping to solve solar and wind power's intermittency problem. The cost of renewable energy, EVs and battery storage are approaching or in some cases have reached parity with conventional fuels and technologies and are expected to fall further. Also, EVs are rapidly improving on miles per charge and availability of charge, as further discussed in Section 4.D.

F. The Importance of Energy Efficiency

Improving energy efficiency usually means saving money that would otherwise be spent on energy costs. Higher energy usage used to be associated with higher economic output as well as higher GHG emissions, but when fuel costs rose the virtues of energy efficiency were recognized. Nations and other governmental units, as well as corporations, now pursue the goal of reduced energy usage per unit of economic output, or lower "energy intensity," either for economic (reduced costs) or environmental (reduced GHG emissions) reasons. Improved energy efficiency, or lower energy intensity, also makes easier the achievement of renewable energy goals by reducing the amount of renewable energy that must be generated to achieve the goal.

PART 4 –THE POLICY AND ENERGY MARKET CONTEXT

A. The Paris Climate Conference

In December 2015, 195 nations signed on to the Paris Climate Agreement under which each nation agreed to set targets for GHG emission reductions and submit a plan for achieving its targeted reductions. Paris followed a series of global climate conferences at which either nations did not agree on a framework for addressing climate change or agreed on a framework that proved to be ineffective. Paris was universally acknowledged to be insufficient by itself to hold temperature rise by the end of the century to 2°C or 1.5°C, but appeared to mark a turning point in the effectiveness of international efforts to reduce GHG emissions. The approach of offering nations the flexibility to set their own targets and means of compliance appeared to be a more promising avenue for worldwide cooperation on climate change, and the basis for future, more aggressive agreements and actions. At Paris, under President Obama's leadership, the U.S. pledged to reduce its GHG emissions by 26 to 28% from 2005 levels by 2025, relying mainly but not exclusively on the Clean Power Plan. Nations around the world likewise committed to meaningful and aggressive action to reduce GHG emissions and increase use of renewable energy, as detailed in Appendix C.

The momentum of Paris was threatened on June 1, 2017, when President Trump announced that the U.S. would withdraw from the Paris Climate Agreement. This announcement was met by outrage in the U.S. and around the world. Nations have reaffirmed their Paris commitments, including China and India.[38] Local, state and national leaders responded by reaffirming their own commitments to reduce GHG emissions, and by making new and bold and more specific commitments. Fourteen states and Puerto Rico formed the U.S. Climate Alliance, supporting Paris and pledging to take steps toward meeting their share of the U.S. goal set by President Obama.[39] At least 388 U.S. mayors, including Mayor Bouley, have joined the Climate Mayors group, pledging to take actions to uphold the commitments made in the Paris Climate Agreement.[40] For now, it seems that the "spirit" of Paris is alive.

B. Federal Renewable Energy Policy

There are numerous federal policies and programs in place to support the reduction of GHG emissions and increased use of renewable energy, including an investment tax credit in the amount of 30% of the qualified expenses spent installing a residential or commercial solar energy system, a production tax credit in the original amount of 2.3 cents per kilowatt-hour (KWH) of power generated from wind projects, and a tax credit for the purchase of an electric vehicle worth up to $7500 per vehicle. These and other policies and programs, discussed in more detail in Appendix D, are given partial credit for flattening U.S. GHG emissions since 2005 (state and local policies and the recession and slow recovery also played a role), as well as for the rapid growth in U.S. renewable energy generation and the steep drop in the cost of renewables, as further detailed below.

Some threats to climate action and renewable energy have materialized during the Trump Administration. The U.S. Environmental Protection Agency, under Administrator Scott Pruitt, is in the process of reversing President Obama's Clean Power Plan.[41] Congress considered repealing some or all of the above-described tax credits supporting renewable energy and clean transportation, but ultimately decided not to do so. The U.S. Department of Energy ("USDOE") has announced a series

of policies aimed at bolstering the continued operation of coal and nuclear plants.[42] The U.S. Department of the Interior recently announced a proposal to open nearly all U.S. coastal waters to offshore oil and gas drilling.[43] Most recently, in January, the Trump Administration announced the imposition of a tariff on solar cells and modules imported from China and other countries in the Suniva trade case, which will add to the cost of developing solar projects in the U.S. The tariff will apply for four years, starts at 30% in the first year, is reduced by 5% in each of three years following, then ends.[44] These developments, however, are unlikely to fundamentally alter our path toward a renewable energy future.

C. New Hampshire and New England

New Hampshire and New England are moving in the direction of reducing GHG emissions and increasing renewable energy. Policies applicable to New Hampshire include the Regional Greenhouse Gas Initiative (RGGI), the New Hampshire Renewable Portfolio Standard (RPS), net metering (including group net metering) and other policies or initiatives. Detail on policies and initiatives affecting New Hampshire are set forth in Appendix E. Information regarding renewable energy laws and policy initiatives in other states is discussed in Appendix F.

D. Where the Energy and Vehicle Markets Are Going

The energy landscape is rapidly changing and these changes will affect the sources of energy and the way energy is consumed in Concord in the future, as discussed below.

The Rise of Renewables

Renewable energy is rapidly gaining market share against conventional energy sources. In 2016, wind and solar power together represented a combined 9.9% of installed electric generation capacity and 7.2% of electricity generation across the U.S., up from 1.1% and 0.7% respectively in 2006. All renewables (including hydroelectric and other sources) represented 18.3% of generation capacity and 15.6% of electricity generation in the U.S. in 2016. Renewables are the fastest growing energy source, comprising 67% of new electric generation capacity installed in the U.S. in 2016.[45] Among renewables, solar generation has grown the fastest in the last couple of years, while wind grew fastest in prior years. The trend toward more renewable energy is more pronounced in some states (e.g., California) than in others, but energy analysts expect the share of renewables in the U.S. energy mix to more than double in the next two decades.[46]

Solar and wind's gain in market share has corresponded with a dramatic reduction in solar and wind prices. The cost of solar PV power has fallen about 75% since 2010.[47] The cost of onshore wind power fell 66% from 2009 to 2016.[48] These price declines are attributable to technological learning (solar module costs decreased by around 23% with each doubling in installed capacity),[49] efficiencies in manufacturing and supply and other factors. Multiple energy analysts using different metrics have observed that energy from on-shore wind and utility-scale solar projects is competitive on price with fossil fuel energy right now.[50] USDOE's SunShot Initiative set target prices for solar power in 2020, and awarded research and development grants to help make that happen. The targeted prices are 6 cents/KWH for utility-scale (greater than 2 MW) projects, 8 cents/KWH for commercial (10 KW to 2 MW) projects and 10 cents/KWH for residential (3 to 10 KW). In September 2017, USDOE announced that utility-scale solar had already achieved its 2020 target price. Commercial and residential solar prices have fallen significantly, but have not reached the 2020 targets yet.[51] Going

forward, prices for onshore wind and solar power are expected to continue to fall. Bloomberg New Energy Finance projects that the cost of solar power will fall another 66% by 2040, while onshore wind will fall another 47%.[52]

Results of recent utility solicitations suggest that the low-cost renewable energy future may have already arrived. At the end of December, Xcel issued a report on the results of an RFP it had issued seeking new power from all sources in Colorado to replace two coal plants that are shutting down.[53] Xcel received 430 bids, 350 of which involved renewable energy. As reported by Xcel, the median bid price from wind projects was 1.81 cents/KWH and the median bid from solar PV projects was 2.95 cents/KWH. Interestingly, the median bid price from wind plus storage (2.1 cents/KWH) and solar plus storage (3.6 cents/KWH), thus for power that is at least partially firm, were only slightly higher than the bid prices for wind and solar alone. Adding storage to solar or wind makes the power they generate "firm" (i.e., they don't need backup). The median bid price for new wind + storage energy is cheaper than the operating cost of all coal plants operating in Colorado, and new solar + storage is cheaper than most of those coal plants.[54] The bids to Xcel represent the lowest known bid prices for solar and wind projects in the U.S., following a series of new lows that had been set in 2017.[55] To be sure, conditions for wind and solar projects in Colorado are excellent, the prices offered to Xcel are for 2023 since the projects are not scheduled to come on-line until then (and so the bids might anticipate future cost reductions), and we do not know how much storage is included in the bids. But these are the median bid prices from hundreds of bids, making it less likely that outliers are skewing the numbers, and they are backed up by trends in auction results not only in the U.S. but also around the world.[56] The results of the Xcel RFP are likely a harbinger of renewable cost reductions to come.

In fact, renewable energy (i.e., solar and wind) is on track to become the least-cost energy option in the relatively near future. The question is when. According to the International Renewable Energy Agency (IRENA), by 2020 all renewable power generation technologies now in commercial use are expected to fall within the fossil fuel-fired cost range, with most at the lower end or undercutting fossil fuels.[57] According to Bloomberg New Energy Finance, by 2030 wind and solar PV will start to undercut existing coal plants on an operational basis in some countries.[58] The answer will vary by size of project (sooner for utility-scale solar than for commercial or, later still, residential) location (sooner in states with better wind and solar resources and more favorable state policies before other states), market conditions (sooner in states with high energy prices than low energy prices) and policy drivers (sooner in states with strong policy support for renewable energy). But it seems likely to happen in the coming decade for many renewable energy applications in many places. In the words of Vox.com energy columnist David Roberts, "renewable energy is not 'alternative' anymore. Costs are dropping so fast, it is difficult to keep track. It is the cheapest power available in more and more places, and by the time children born today enter college, it is likely to be the cheapest everywhere. That's a different world."[59]

Community/Shared Solar, Offshore Wind

Solar and wind power is becoming available in new ways that will become more prominent in our energy mix in coming years.

Solar power is becoming more accessible to business and residential consumers by way of "community" or "shared" solar projects. Shared solar takes many different forms, in part depending on the policy regimes in different states. It has taken off in states with policies friendly to shared solar – e.g., California, Colorado, Massachusetts and Minnesota. Typically, customers subscribe to a shared solar project, to a portion of the project's capacity or its output. This enables consumers that lack enough suitable rooftop space, funds or electric load to receive the benefits of renewable energy.

Shared solar has particular promise as a means to deliver solar power to low or moderate income consumers.[60] New Hampshire offers group net metering, enabling multiple electric utility customers to receive credit for the output of a single solar project.

Future development of wind projects in New England is likely to focus on offshore wind.[61] While there are many offshore wind projects off the coast of northern Europe, the first offshore wind project (5 turbines, 30 MW) in the U.S. only began operating in December 2016 off of Block Island.[62] The coast of the northeastern states from Maine to New Jersey has been identified as a major offshore wind resource (up to 233 gigawatts (GW)) that could eventually produce a significant portion of our electricity.[63] Massachusetts has required its utilities to procure 1,600 MW of offshore wind by 2027,[64] and those utilities issued an RFP seeking half of that requirement, to which three developers have responded.[65] Selection of winning bids is scheduled for April 2018, and the selected projects could be in operation by the early-to-mid 2020s. Meanwhile, other northeastern states are following the lead of Massachusetts and aggressively seeking offshore wind generation.[66] Offshore wind power is likely to be more expensive than onshore wind at least initially, but is expected to decrease in cost even more quickly than onshore wind.[67] Offshore wind is still a maturing industry, but with continued development, technological improvements (e.g., higher capacity turbines), new approaches (e.g., floating turbines) and a vast offshore wind resource to be tapped, there is every reason to believe that offshore wind will supply a significant portion of our power starting in the not-too-distant future.[68]

The Decline of Coal and Nuclear

The trend of coal and nuclear power declining in favor of natural gas-fired electric generation is the same in New England as nationally, but more pronounced. Coal-fired generating plants, once the major source of baseload electric generation in New England, are retiring at a rapid rate because they are unable to compete with newer natural gas plants. There are now only three operating coal plants left in New England – Merrimack Station (Bow), Schiller Station (Portsmouth), and Harbor Station (Bridgeport, Connecticut - expected to convert to natural gas soon). Merrimack and Schiller Station were just sold by Eversource to Granite State Power, will have to operate as merchant plants, and are considered by many to be at significant risk of closure in the future. With the shutdown of Vermont Yankee, there are now only three nuclear generating facilities operating in New England – Seabrook Station, Plymouth Station in Massachusetts and Millstone Station in Connecticut. Plymouth is scheduled to shut down in 2019. Seabrook's NRC license expires in 2030, and any attempt to extend the license will likely be vigorously opposed. Natural gas, which now supplies nearly 50% of New England's power, has replaced coal and nuclear as the major source of baseload power in New England, while also supplying much of New England with heating fuel. However, supply of natural gas into New England is limited by pipeline capacity, and it is difficult to site and build new pipeline projects. ISO-New England is worried about the region's overreliance on natural gas.[69]

While natural gas is largely responsible for the decline of coal and nuclear power to date, solar and other forms of renewable energy are likely to push coal, nuclear and natural gas out of business in the not-too-distant future.[70]

Electric Vehicles (EVs)

EVs are already viewed as the heir apparent to combustion vehicles within the transportation industry. Tesla and the major automakers are making huge investments to produce EVs in variety and volume. It will be a disruptive transition that will still take decades to complete. Electric vehicles already have a lower cost to operate and own[71] over their lifetime than combustion vehicles, and may become less expensive to purchase by 2025.[72]

In the next 10 years, over a hundred new plug-in vehicles, including a variety of trucks, will be introduced to the market, and most will be made in high volume. Volvo,[73] Mercedes Benz[74] and Toyota[75] plan to electrify their entire vehicle lines by 2019, 2022 and 2025, respectively. GM plans to phase out gasoline-powered vehicles in favor of EVs on an as-yet unannounced timeframe.[76] Ford will invest $11 billion to produce 40 electric or hybrid vehicle lines by 2022.[77] Other automakers are making significant investments in EVs.

The transition to EVs will affect the nature and amount of our electricity usage. Bloomberg New Energy Finance projects that EVs will account for 12% of electricity demand in the U.S. by 2040, and the growth of EVs will push the cost of lithium-ion batteries down by 73% by 2030. Charging EVs flexibly when renewables are generating and wholesale prices are low will help the system adapt to intermittent solar and wind.[78] It is anticipated that 80% of EV charging will be done at home at night (if electric pricing policies encourage this), and 20% will be done during the daytime. Solar PV systems may be well-suited to help serve an additional daytime EV charging load.

An even more rapid transition may be underway in the bus sector, as cities are increasing their purchases of Battery Electric Buses ("BEBs"). BEB purchase costs are declining rapidly. Factoring in typical federal funding of upfront capital costs, BEBs may be less expensive to municipalities than diesel-powered buses on a lifecycle basis right now. Ryan Popple, CEO of the electric bus company Proterra, predicted that BEBs will make up 100% of all new transit sales by 2030.[79]

Energy Storage

While the idea of energy storage is not new,[80] investors are pouring money into battery storage and storage technologies generally for applications to support the electric grid and in EVs. Storage projects facilitate the integration of intermittent renewable energy into the electric grid, and policymakers are increasingly interested in more storage for that reason.[81] They can receive power from intermittent resources when it is generated then release the power when it is most needed by the grid. Regulators[82] and utilities[83] are also interested in using storage for grid reliability, and as an alternative to expensive electric transmission projects.[84] Much of the investment money and attention has been directed to lithium-ion batteries, which is rapidly improving as a technology. For example, Tesla just built the world's largest lithium-ion battery (100 MW) in Australia.[85] But other potential storage technologies[86] are in research and development, and might be commercialized and eventually out-compete lithium-ion in the not-too-distant future. The cost of storage has fallen dramatically, and continued rapid growth of the storage market is anticipated.[87]

Microgrids.

Microgrids are self-contained areas of the larger electric grid that contain generation, storage and consumers, and that are capable of "islanding" from (operating independently of) the regional grid. There are some microgrids operating in the U.S., and it is believed that increased use of microgrids would improve overall grid reliability and resiliency. For example, they would minimize the duration and extent of outages during weather events such as ice storms in New England and hurricanes in the Caribbean or during a cyber attack. Locally-generated renewable energy and development of battery storage would enable the development of more microgrids.[88] A community microgrid project is being explored in Warner, New Hampshire.[89]

Electrification of Thermal Energy/Heat Pumps

Energy and environmental experts generally agree that the road to zero GHG emissions will involve electrification of heating applications - switching to heat pumps or other electro-technologies

(devices powered by electricity). Currently, we mainly rely on combustion of fossil fuels (oil, natural gas and propane) for heat. The technologies for generating electricity without GHG emissions are available or in sight, but we do not know how to combust fuels without GHG emissions.[90] Government policy is not driving increased electrification as of yet, but probably will as they focus on how to drive down GHG emissions from thermal energy. It should be noted that electrification will increase demand for electricity, which makes reaching 100% renewable electricity more challenging, so should be coupled with energy efficiency.

Renewable Natural Gas (Biogas) and Synthetic Natural Gas (Hydrogen)

Carbon-neutral methane gas heating could eventually be delivered using existing pipeline infrastructure by deriving natural gas equivalents from renewable sources or technologies such as biogas[91] or power-to-gas[92] rather than from fossil fuels. Such uses might result in CO2 emissions but are considered carbon-neutral because the emissions are no greater than would have occurred absent the process.

Biogas derived from sources such as landfills, wastewater treatment plants, livestock, biomass or other organic wastes can be substituted for natural gas after processing by filtering out unwanted contaminants and increasing the ratio of methane to other gases. After such processing the biogas is sometimes called renewable natural gas (RNG) [93] Many forms of biogas or RNG energy projects or applications are in operation or in development right now, including landfill gas to energy projects, RNG to gas pipeline projects, or use of compressed RNG in automobiles.

Even more promisingly in the long-term, researchers are working to develop power-to-gas technologies to allow for electricity generated by wind and solar to convert water to hydrogen, which in turn can be combined with carbon dioxide from the atmosphere to form methane as a synthetic natural gas (SNG).[94] Power-to-gas test sites are already underway the United States at the pilot scale[95] and in Europe at the industrial scale.[96] Commercialization of SNG is still years away. If and when it can be commercialized, SNG could be produced at a scale to replace natural gas in many or most of its applications.

Clean Energy Jobs Are Growing

Clean energy jobs are the fastest growing job sector in the country. Solar and wind power jobs have grown at rates of about 20% annually in recent years, and are each creating jobs at a rate 12 times faster than the rest of the U.S. economy. Energy efficiency jobs are growing at a rate nearly as fast. As of early 2017, over 3 million people were employed in clean energy in the U.S., including 2.2 million in energy efficiency, 475,000 in wind and solar power, 259,000 in clean transportation and 120,000 in other clean energy sectors.[97] According to the U.S. Bureau of Labor Statistics, the fastest growing job in the U.S. over the next decade will be solar installer. The second fastest growing job will be wind turbine technician.[98] These jobs tend to be created in places where the market and policy support for renewable energy is strong. Attracting clean energy businesses to a city means creating good local jobs in that city.

PART 5 - 100% RENEWABLE ENERGY AND THE LEADERSHIP MOMENT FOR CITIES

A. The Goal

The evidence is clear. We must get off fossil fuels and transition to 100% renewable energy by the middle of the 21st century in order to achieve deep decarbonization and avert the worst effects of climate change. This goal must encompass electricity, thermal energy and transportation because these forms of energy account for the vast majority of GHG emissions. If we don't make the transition in all of these sectors, we will not achieve deep decarbonization.[99] Making this transition will enable us to access less expensive and more secure energy, create jobs, save lives and health care costs, and avoid the costs of mitigating the effects of climate change.

B. The Movement

In the wake of the Paris Climate Agreement, and especially since President Trump's decision to withdraw the U.S. from the agreement, the movement toward 100% renewable energy and clean transportation has gained momentum in the U.S. and around the world. For example:

- As of the date of this paper, at least 50 cities and towns across the U.S. have committed to the goal of 100% renewable energy across the electricity, thermal and transportation sectors by 2050 through the Sierra Club's Ready for 100 campaign,[100] as further discussed in Section 4.D below. In addition, 186 U.S. mayors have pledged to support a community goal of 100% renewable energy.[101]
- The State of Hawaii has committed to 100% renewable energy by 2045, and may achieve this goal early.[102] Vermont has adopted a goal of 90% renewable energy by 2050.[103] The California[104] and Massachusetts[105] legislatures are considering bills that would commit those states to 100% renewable energy. Gov. Phil Murphy of New Jersey set a goal that his state reach 100% clean energy by 2050.[106]
- Here in New Hampshire, legislators have filed a bill to create a committee that would study what is needed for the State of New Hampshire to commit to 100% renewable electricity by 2040.[107]
- In 2017, bills were introduced in the U.S. Senate[108] and the House[109] to commit the entire U.S. to 100% renewable energy by 2050.
- A large and increasing number of major U.S. and global companies have made commitments to achieve 100% renewable energy at various points between now and 2050.[110] These companies include Bank of America, Citigroup, JP Morgan Chase, Morgan Stanley, IKEA Group, Johnson & Johnson, Kellogg, General Motors, Walmart, Apple, Microsoft, Google and Facebook. A more complete list of these companies is attached as Appendix G.
- Colleges and universities are also committing to 100% renewable energy and otherwise aggressively reducing their GHG emissions. Leading institutions include the University of New Hampshire,[111] Plymouth State University,[112] Boston University,[113] Dartmouth College,[114] Georgetown University,[115] Colorado State University[116] and Carnegie Mellon University.[117]

- Some utilities have expressly committed to help the cities they serve achieve 100% renewable energy – e.g., Portland General Electric is helping Portland, Oregon, Ameren Missouri is working with St. Louis, and Rocky Mountain Power is assisting Salt Lake City.
- Several countries, including Sweden[118] and Denmark,[119] have committed to the goal of 100% renewable energy across energy sectors. Other countries have committed to achieving 100% renewable electricity, including Costa Rica[120] and Scotland.[121] Major international cities committed to 100% renewable energy include Barcelona, Frankfurt, Vancouver, and Malmo.[122]
- At the Paris Climate Conference in 2015, 700 mayors from around the world whose cities are responsible for 70% of worldwide GHG emissions committed to 100% renewable energy by 2050.[123]
- France[124] and the United Kingdom[125] each plan to end the sale of gasoline and diesel-fueled vehicles by 2040. France also recently passed a law immediately banning new licenses for oil and gas exploration and stopping all gas and oil extraction by 2040.[126] Norway has a plan for all passenger cars and vans sold in 2025 to be zero emission. China has signaled that it will end production and sale of gasoline and diesel vehicles.[127]

C. The Feasibility

Is it feasible to convert to renewable energy by mid-century?

Some nations are already there, or nearly there. Costa Rica's electric grid ran on 100% renewable energy (mostly hydropower, wind and geothermal) for over 300 days in 2017.[128] Iceland receives nearly all of its energy from hydropower and geothermal, but is investing heavily in research to try to make better use of geothermal.[129] In Norway, 98% of electricity generation comes from renewable energy sources.[130].

Several studies by environmental groups such as Environment America,[131] Greenpeace[132] and the World Wildlife Fund have concluded that 100% renewable energy is feasible and will be cost-effective when factoring in health benefits, avoided health care costs and avoided climate mitigation costs.

The Renewable Energy Policy Network for the 21st Century (REN21), a global renewable energy policy multi-stakeholder network, in its 2017 report entitled "Renewables Global Future Report: Great Debates Towards 100% Renewable Energy," surveyed 114 energy experts around the world and found that 71% of them agreed that a global transition to 100% renewable energy is both feasible and realistic. The U.S. energy experts surveyed by REN21 were less optimistic about a complete transition to renewables by 2050. Interestingly, they believe the barriers to 100% renewable energy are not technical, but socio-economic and political. They cited opposition by vested interests in the conventional energy industry as the main political barrier, and noted the lack of requisite sustainability polices such as carbon pricing. Regarding technology, REN21 noted a dramatic drop in the cost of solar photovoltaic modules and lithium-ion batteries for cars (a trend that is likely to continue) and solar/storage applications, but not surprisingly, there is uncertainty about exactly which storage technologies will win over others in the marketplace.

A team of researchers led by Professor Mark Jacobson of Stanford University and the Solutions Project modeled and studied the economic effects of a transition to 100% renewable energy across the entire country and in each of the 50 states.[133] They modeled the most plausible mix of renewable

energy sources in each state, including New Hampshire, and found that 100% renewable energy across the U.S. by 2050 is technically and economically feasible, would create about 5.9 million 40-year construction and operation jobs for energy facilities alone, produce noticeable cost savings for individual households, avoid about 46,000 air-pollution related deaths per year, save $600 billion in annual health care costs, and eliminate over $3 trillion in costs needed to respond to climate change caused by U.S. emissions. Electrification of heating applications and increased use of energy storage would be critical. They found the barriers to 100% renewable energy are not technical and economic, but social and political. Some experts have challenged the Jacobson paper's findings, arguing that deep decarbonization will be technically and economically difficult to achieve without at least some use of conventional energy sources such as nuclear or natural gas, and caution against reliance on unproven technologies.[134] We think these critics are overly pessimistic and do not account for cost trend lines and the potential of new technologies.

There is ample evidence that 100% renewable energy is technologically feasible right now. We could transition to 100% renewable energy with the technologies presently available – wind and solar power coupled with battery storage, biomass and hydroelectric power, electrification of heating systems and electric vehicles. To deploy these technologies economically and in a practical way will take some time. The cost of these existing technologies is coming down rapidly and they may become fully cost-competitive with conventional technologies in as little as five to ten years. Moreover, there are new technologies in development that could improve on and eventually supplant the current renewable technologies in terms of cost and performance. Within a decade. the transition to renewable energy and clean transportation could not only be the right thing to do but also the clear economic thing to do. For these reasons, we agree with those who believe that the main barriers to 100% renewable energy are perception and politics.

D. U.S. Cities and Towns Are Leading

Cities and towns across the U.S. are also committing to 100% renewable energy. At present, nearly 50 cities (see Appendix A) have made this commitment, including the following:

- In May 2017, the Town of Hanover adopted a goal of 100% renewable electricity by 2030 and 100% renewable energy for heat and transportation by 2050,[135] becoming the first municipality in New Hampshire to adopt a 100% renewable energy goal and the first in the country to do so via popular vote. The effort was led by the Sustainable Hanover Committee. Hanover hopes to hire a Sustainability Director, and plans to develop a Community Choice Aggregation entity along with the City of Lebanon, enabling both communities to purchase cleaner and less expensive electricity on behalf of their residents. At town meeting, the Town will consider a ballot measure to amend zoning ordinance to allow installation of large-scale solar farms. Hanover is working with Dartmouth College, which has developed its own sustainability plan. The Town formally opposed Liberty Utilities' proposal to install a natural gas pipeline delivery system in Hanover and Lebanon.
- In 2016, Salt Lake City adopted a goal of 100% renewable energy by 2032, with 50% renewable energy for municipal operations by 2020 and an 80% reduction in community GHG emissions by 2040.[136] The City collaborated with its electric utility Rocky Mountain Power on a Clean Energy Implementation Plan released in March 2017, which focuses on energy efficiency, renewable energy, electric vehicles and a progressive grid. Following SLC's lead, the nearby towns of Moab and Park City also committed to 100% renewable energy in a similar timeframe.

- In March 2017, Madison, Wisconsin adopted a goal of 100% renewable energy.[137] Madison currently receives 89% of its electricity from fossil fuel sources, including 64% from coal, mainly through its local electric utility, Madison Gas & Electric (MGE). MGE has a goal of 30% renewable energy by 2030, far below the City's goal, and it is understood that MGE will have to accelerate its transition to renewable energy to keep pace with the City. The City allocated $250,000 for staff and a consultant to develop a plan with target dates, interim milestones and budget projections by January 2018. The Sustainable Madison Committee, with 18 members appointed by the mayor, will help manage implementation of the plan. Madison is utilizing grant funding to facilitate discounts and financing assistance for rooftop solar projects.

A handful of U.S. cities, including Burlington, Vermont, already procure 100% of their electricity from renewable energy sources. Burlington committed to a goal of 100% renewable electricity in 2012 and achieved it in 2014 when it purchased the 7.4 MW Winooski River hydropower facility.[138] The City once relied on coal for its power, and now relies on hydropower (50%), wood biomass (30%), and landfill methane, wind and solar (a combined 20%). Burlington was partly motivated by a desire to do right by the environment, but the move was also driven by economics. City officials considered a shift to renewables to be the "cheapest long-term financial investment…with the least amount of risk," with savings estimated at $20 million over 20 years. Meanwhile, Burlington's electric rates have not increased since 2009.[139] The City is now working on a goal to be net carbon zero in the heating and transportation sectors.[140]

Two other New Hampshire towns – Plainfield and Cornish – will vote on 100% renewable energy initiatives at town meeting in March. Discussions about 100% renewable energy are ongoing in other New Hampshire communities as well.

U.S. cities and towns, as well as cities around the world, are determined to take action to realize the specific commitments and achieve the long-term goals set forth in the Paris Climate Agreement. McKinsey, in an analysis prepared for C40 Cities (a network of the world's largest cities focused on addressing climate change), said the following about the role of cities:[141]

> *Cities have an essential role to play in encouraging the build-out of renewables. Some cities might deprioritize pushing for cleaner electricity, believing they have little influence over the grid mix, when in reality they represent a major portion of any local electric utility's customers; this influence provides significant leverage to shape the emissions profile of the electricity consumed within a city's metropolitan area. By setting clear decarbonization goals, aggregating demand for renewables, shifting more urban energy consumption to electricity (especially in transportation and heating) and improving load management, cities can help utilities navigate the path to a highly electrified renewables-powered future.*

PART 6 – RECOMMENDATION THAT CONCORD COMMIT TO 100% RENEWABLE ENERGY AND A VISION OF OUR POTENTIAL ENERGY FUTURE

A. Our Recommendation

The CEEC recommends that the City Council adopt the following goal:

- 100% Renewable Energy in the City of Concord
- Across the Electricity, Thermal and Transportation Sectors
- Community-wide not just Municipal Operations
- Achieve 100% renewable electricity by 2030, 100% renewable thermal and transportation by 2050.

B. General Approach

Combating climate change is a moral imperative. Scientists tell us that we must get off fossil fuels and transition to 100% renewable energy by the middle of the 21st century in order to avoid the worst effects of climate change. The goal that we are recommending is ambitious, but it is of the size and scope needed to achieve that end. The time to act is now. We cannot count on the federal government to lead, so it falls on cities like Concord to take the lead and drive the necessary changes forward. We will do ourselves a favor by recognizing now the size and scope of change that is necessary, giving ourselves time to make a gradual transition rather than waiting until later and reacting then.

The transition to renewable energy also presents a massive opportunity. We can re-make our community in energy terms. We will make new investments that will create new jobs. We will have energy that is affordable and more subject to our control. We will be healthier and spend less money on health care. We will avoid the costs that air pollution and climate change impose. We will get credit for our leadership and enhance Concord's image as a dynamic forward-thinking community. We believe that adopting this goal will encourage businesses to locate in Concord, and attract people to live in and visit Concord. We are also in a great position to inspire others to act. As the capital of the first-in-the-nation primary state, Concord can send a powerful signal to the country and the world by adopting these goals.

Before discussing specific ideas for how Concord should move toward 100% renewable energy, here are some principles that we believe should guide Concord's actions:

1. Put Energy Efficiency Front and Center. We need to reduce our energy intensity. The cheapest unit of energy is the one you don't use. The less energy we use, the less renewable energy we need to generate to meet our goal.
2. City Should Lead by Example. The City should move early and transition to renewable energy ahead of the rest of the community. Energy efficiency should be an early priority.
3. Low-Hanging Fruit First. Pursue projects with a quick return on investment, and defer or decline projects that are uneconomic.

4. Facilitate Private Sector Action. Take steps to encourage and enable the private sector to make the transition to renewable energy. While the City must lead, the private sector will inevitably do most of the work toward achieving the goal.
5. Generate Energy Locally. We should strive to generate as much energy as we can within Concord's borders. Inevitably, we will import some renewable energy from outside our borders as necessary, but generating the maximum amount locally ensures that we keep control over our energy supply.
6. Equal Access to Renewable Energy. Make sure the benefits of renewable energy are shared equally by all – including low and moderate income families.

The CEEC does not expect the City to invest in renewable energy against its economic interest, although we do believe that environmental considerations should be factored into the cost/benefit analysis. It will make sense to pursue some projects and not others for economic reasons. We simply ask the City to seek out, recognize and take advantage of opportunities as they arise and become economic. Over time, as the costs of renewable energy come down, we expect that the transition to renewable energy will offer clear cost savings.

C. Specific Recommendations to Begin the Drive to 100% Renewable Energy

Reconstituted Concord Energy and Environment Committee

The CEEC should be reconstituted by revising its charter to reflect the following changes. The CEEC will ultimately be responsible for moving the entire process forward and coordinating the various actors involved.

Dedicated City Staff Time

The City should dedicate City staff time to implement the energy transition, working with the reconstituted CEEC to make sure the plan is developed with Concord-specific expertise and experience. We expect that the Planning Department, the Engineering Department, Code Enforcement, General Services and Economic Development will be instrumental in the success of the program.

Stakeholder Advisory Committee

The City should form a stakeholder group representing different interests in the community, including organizations representing labor, faith, social justice, environmental justice, front line communities and those most impacted by our current energy systems, public health and the environment, economic development, utility sector, clean energy sector, academic institutions, business, housing, employment services, low income advocates, government and any other relevant groups, to advise the CEEC and city staff in the development and implementation of plans.

The stakeholder committee will meet quarterly to provide input into the drafting of the plan, and will be facilitated by the chair of the CEEC

Develop and Approve Strategic and Implementation Plans

The City should develop and adopt an initial plan within one year of making its commitment to achieve the goals of 100% renewable electricity by 2030 and 100% renewable thermal energy and transportation by 2050. City staff will primarily draft the plan, with the CEEC providing oversight

and assistance and the stakeholder group providing community input. There will also be a public input process beyond the stakeholder group, which will primarily be organized by the CEEC.

The plan might include a conceptual approach to achieving the long-term renewable energy goals, as well as more specific steps that might be achieved in short-term timeframes. The plan would be updated periodically over the course of the period until 2050.

Specific Early Action Steps

The City could take the following early action steps in conjunction with the plan:

- Update the energy chapter of the City's Master Plan (written in 2012) to reflect the goal of 100% renewable energy and the results of the initial strategic and implementation plan.
- Develop a comprehensive energy and emissions baseline for Concord, both community-wide and municipal operations, against which we can measure progress over time.
- Review municipal properties for suitability for siting ground-mounted and roof-mounted solar installations. Some installations might be City-owned and financed, while others could be private party-owned and financed, with associated leases and power purchase agreements. Solar installations should be modeled using at least 20 year financing projections and bonds.
- Streamline permitting requirements for the siting of solar projects. Consider enacting a solar ordinance or otherwise establishing a clear permitting path tailored to solar projects.
- Encourage community solar projects on available sites around the City. Community solar will enable residents and business that do not have sufficient or suitable roof space or funds to site their own solar projects.
- Bring in a community group like Energize 360 to help residents understand their clean energy options.
- Work with Unitil and Liberty on the achievement of these goals. We have had positive meetings with both companies. It is our hope and expectation that they will collaborate with Concord in meeting a 100% renewable energy objective. We believe that there are business opportunities for the utilities in this transition, and that our goal will help give them the impetus to pursue those opportunities.
- Participate in Unitil's upcoming low and moderate income pilot program, time of use rate pilot program and non-wires alternative pilot program to gather information, take advantage of funding opportunities and take initial steps in the modernization of the local electric grid.
- Work with Liberty to explore the potential for biogas-to-energy projects at the Hall Street and Penacook WWTPs and biogas projects fueled by manure from local farms.
- Engage with state agencies such as the New Hampshire Public Utilities Commission and the New Hampshire Department of Environmental Services, as well as regional organizations like the Central New Hampshire Regional Planning Commission, in the achievement of the goal.
- Mandate consideration of electric plug-in vehicles for every municipal vehicle purchase and establish guidelines for favoring such vehicles. This should include police cars, city buses, fire trucks (probably at a later point) and all other city vehicles. Vehicle evaluations should be required to include comparable EVs that are available and should be based on total cost of

ownership (TCO) over the vehicle's lifetime, rather than just upfront cost. TCO equivalency between vehicles might favor electric vehicles.

- Commence a vehicle procurement pilot project to use and evaluate Plug-in Electric/Hybrid vehicles for the city fleet. Suitable EV pilot projects should be selected from the best comparable vehicle appraisals. Selected pilot projects should be aimed at the core of the fleet not the periphery.
- Install or partner with others to install vehicle charging stations throughout the City for fleet and public use. Include Fast Charging Stations in the mix of stations.
- Require vehicle charge station cabling to be installed in every new building and housing project, and in major retrofits of existing buildings.
- Research and apply for grant money available for renewable energy and energy efficiency projects.
- Monitor other communities' successful renewable energy and energy efficiency projects and borrow ideas that make sense for Concord.
- Take into consideration the potential for renewable energy installations in any project that is brought before the City (e.g., architect's plan for new park at Terrill Park).
- Investigate and test multiple bike lane configurations for both Main Street and major arterial roadways.
- Facilitate renewable energy and energy efficiency projects for low and moderate income families so that they get the benefit of affordable, secure, clean energy. Community shared solar projects may a promising vehicle for making solar accessible. The City's role may include sponsoring projects, identifying available grants, and community education.
- Assist and encourage the owners of our buildings, shops, restaurants, and especially our box stores to utilize solar on their rooftops and/or on open land.
- Encourage and as feasible incentivize new and existing buildings to maximize energy efficiency, including building to LEED or similar standards.
- Engage the Concord School District and the State of New Hampshire as key partners in the implementation of the 100% renewable energy goal, given that they are large consumers of energy within the City of Concord. Also engage Concord Hospital, Merrimack Valley School District and St. Paul's School.
- Document the City's energy and sustainability accomplishments in an on-line dashboard, similar to that being used by Nashua.
- Review the State of New Hampshire's Energy Plan and Climate Action Plan for actions that the City could take, and encourage the State to follow through on actions that it should be taking.
- Develop a system of reporting (probably on an annual basis) to assure accountability and measure progress.

D. A Vision of Concord's Energy Future in 2050

A message from Jane Boulanger, Mayor of Concord in the year 2050:

> *We did it! In 2018, the Concord City Council set a goal of 100% renewable energy for the City of Concord, and now, 32 years later, we have achieved that goal, securing a better energy future for our children and grandchildren. I want to review with my fellow Concord residents how we achieved a goal that once seemed unreachable, both to celebrate what we accomplished and to remind ourselves that we are capable of meeting any challenges that we might face in the second half of the 21st century.*
>
> *About half of our electricity comes from sources within the City, including local solar PV projects and local hydroelectric projects that have operated since the 20th century. The rest of our electricity is comes from offshore wind, onshore wind, biomass plants and newer renewable sources such as tidal and wave power, and is generated in the region. We streamlined our local siting regulations to make the solar permitting process predictable, which encouraged many businesses and individuals to put solar panels on their roofs or on their property. The City sited solar panels on suitable municipal buildings and other City-controlled spaces such as the old landfill on Turnpike Road and parking garages. We also have larger solar projects, on rooftops of big box stores and other large buildings, on canopies in parking lots and some on open land.*
>
> *We use electricity in more ways than we used to, including charging our EVs and heating many of our buildings, but we do not consume much more electricity than we did in 2018 on a per capita basis. That is because we use electricity much more efficiently. Devices run on less electricity than before. We are charged for electricity on "time of use" rates (higher rates at peak usage times and lower rates at non-peak times), and every home has smart devices that defer electric consumption to times of low rates where possible. Our electricity is no more expensive than it was in 2018, adjusting for inflation. Even better, our energy prices are stable because we are no longer subject to commodity price swings. Businesses can predict their energy costs, which helps to foster a strong business climate.*
>
> *Our electric grid is set up differently than it was in 2018. We have much more distributed generation, locally generated, so a lower percentage of our electricity is delivered to us over transmission lines. We have energy storage facilities, both customer-sited and grid-connected, that collect power from the grid when it is available and release power when it is needed. Energy storage makes our consumption of electricity more even over the day, which reduces our overall cost of electricity. In addition, our local electric grid is more resilient than before because it is composed of many microgrids, within each of which electricity is generated and stored. The microgrids can be operated independently of the regional grid during ice storms and other energy emergencies.*
>
> *Much of the City receives thermal energy from electro-technologies, which run on 100% renewable energy. Downtown Concord and other areas formerly served by natural gas now use renewable gas (a blend of RNG and SNG), delivered by the pipelines that used to deliver natural gas. Some institutional and commercial*

customers receive heat from on-site biomass plants or solar thermal equipment, while some residences have solar thermal or wood stoves/furnaces .

Our existing buildings are more energy-efficient. New buildings are designed, built and operated to more stringent energy efficiency standards. They are also designed to be energy self-sufficient - they do not rely on the grid except as backup. All new buildings are equipped with EV charging stations. While our electricity consumption is higher than in 2018, our overall energy consumption is lower.

Practically all cars and trucks in Concord are EVs. We occasionally see gasoline-fueled cars, and we view them as curiosities. The City led the way by transitioning over to an all-electric city fleet (e.g., police cars, fire engines, CAT buses) and by installing EV charging stations around the City in the late 2010s and 2020s, which encouraged more residents to make EV purchases and attracted EV-driving visitors to Concord. By the early 2030s, all of the major automakers had stopped manufacturing combustion vehicles, so over time individuals came to own EVs. The transition to EVs was followed and overshadowed by an even more radical transition to self-driving cars. Young adults in 2050 find it hard to believe that we all used to drive combustion vehicles. Soon, we will not remember when people drove cars.

Concord set an example, other communities followed, New Hampshire and other states followed, and now the nation and the world have mostly converted to renewable energy. Climate change is still occurring, because we did not get off fossil fuels soon enough to avoid it, and it was already baked into the cake by 2018. But we avoided the worst effects and it now appears that we can hold temperature rise to 2°C or even 1.5°C if we successfully deploy technology to remove CO_2 from the atmosphere over the next several decades. Because we got off fossil fuels, we are healthier as a community, with fewer pollution-related health impacts, and we spend less money on health care than we would have otherwise.

In 2018, city leaders set an ambitious goal and wisely gave us enough time to achieve it. Setting the goal focused the community's attention on the changes that needed to occur, while enabling businesses, institutions and residents to make their own transitions to renewable energy in their own time and in their own way. It was a big transition, but it unfolded in a predictable and gradual way. And even though we achieved our goal, we are not standing still. Our energy supply and usage continue to evolve. We keep getting cleaner and more efficient in our use of energy.

Thanks to its early and comprehensive commitment to renewable energy, which we marketed by calling ourselves the "Renewable Energy Capital," Concord justifiably gained a reputation as a confident, proactive, innovative community committed to sustainability and willing to invest in itself, building on the earlier success of the Main Street redevelopment project in 2015-16. This reputation, and the stable energy costs that accompanied the transition to renewable energy, attracted businesses and individuals to locate to Concord. As a result, Concord enjoyed a strong economy in the 2020s, 2030s and 2040s as compared to communities that were slower to transition to 100% renewable energy.

PART 7 –CONCLUSION

The Concord Energy and Environment Committee offers this report with humility, in the sense that we do not know exactly what our energy future will look like. We do not intend to proscribe the specific manner in which Concord will achieve 100% renewable energy. Much of what we write is aspirational. Meeting our 100% renewable energy goal will depend on a continued decline in the cost of solar and wind power, energy storage and electric vehicles, which we are confident will happen. Success also depends on the broader world also making the transition to renewable energy. By taking action, Concord will be helping to give the broader world a push to make this necessary transition.

Thank you for your consideration of our recommendation.

APPENDIX A - U.S. Cities Committed To 100% Renewable Energy

U.S. Cities And Towns Committed To 100% Renewable Energy (as of 1/31/18)

1. Abita Springs, Louisiana
2. Amherst, Massachusetts
3. Angel Fire, New Mexico
4. Atlanta, Georgia
5. Boulder, Colorado.
6. Breckenridge, Colorado
7. Cambridge, Massachusetts
8. Chula Vista, California
9. Columbia, South Carolina
10. Del Mar, California
11. Downingtown Borough, Pennsylvania
12. Eagle Nest, New Mexico
13. East Hampton, New York
14. Edmonds, Washington
15. Encinitas, California
16. Fayetteville, Arkansas
17. Georgetown, Texas
18. Goleta, California
19. Hanover, New Hampshire
20. Hillsborough, North Carolina
21. Lafayette, Colorado
22. Longmont, Colorado
23. Madison, Wisconsin
24. Menlo Park, California.
25. Moab, Utah
26. Monterey, California
27. Nederland, Colorado
28. Nevada City, California
29. Orlando, Florida
30. Palo Alto, California
31. Park City, Utah
32. Phoenixville, Pennsylvania
33. Portland, Oregon
34. Pueblo, Colorado
35. Questa, New Mexico
36. Red River, New Mexico
37. Salt Lake City, Utah
38. San Diego, California
39. San Francisco, California
40. San Jose, California
41. Santa Barbara, California
42. Sarasota, Florida
43. Solana Beach, California
44. South Lake Tahoe, California
45. Southampton, New York
46. St. Louis, Missouri
47. St. Petersburg, Florida
48. Taos, New Mexico
49. Taos Ski Valley, New Mexico
50. Truckee, California
51. West Chester Borough, Pennsylvania

U.S. Cities and Towns Currently Powered by 100% Renewable Electricity (as of 1/31/18)

1. Aspen, Colorado
2. Burlington, Vermont
3. Greensburg, Kansas
4. Kodiak Island, Alaska
5. Rock Port, Missouri

[Source: Sierra Club Ready for 100]

APPENDIX B - Natural Gas: A Bridge Fuel To The Future?

In the last decade in the U.S., at least a third of all coal-fired electric generating plants have been retired and mostly replaced by natural gas-fired generating plants. A combination of cheap and plentiful natural gas from hydraulic fracking and new federal and state environmental policies have caused coal-fired generation to shift dramatically. In the decade prior to 2016, coal-fired generation in the U.S. dropped from 50% to 30%, while natural gas-fired generation has increased from 18% to 34%.[142] These trends are expected to continue.

GHG (carbon) emissions from natural gas-fired generation plants are as much as 66% less than a typical coal-fired plant primarily due to the differing carbon intensity of the two fuels, with gas emitting about 40% less carbon than coal per unit of heat produced. In addition, natural gas-fired plants are also more energy-efficient that coal-fired plants, resulting in less carbon emitted per unit of heat produced.

Although natural gas combustion emits much less carbon at the smokestack than coal does, it does have some characteristics that complicate the emissions comparison. Studies indicate between 1.5% and 4% of natural gas is lost in production, transmission and storage. Methane is a powerful GHG, about 120 times more powerful than carbon dioxide when released, but it degrades into carbon dioxide over time through chemical reactions and only about 20% of methane leaked to the atmosphere is still in the atmosphere as methane after 20 years. In comparison, carbon dioxide is a long-lived GHG with about 50% and 15% of emitted carbon dioxide still in the atmosphere after 100 years and 10,000 years, respectively. Methane is emitted to the atmosphere in much smaller amounts than carbon dioxide, but will have an outsized shorter-term impact on warming and climate change.

In an ideal world, we would replace retiring coal-fired plants with renewable energy sources, skipping natural gas-fired generation and eliminating all of the complicating issues of natural gas. But we do not live in an ideal world. We have already invested a considerable amount in natural gas, and for now we need natural gas generation for base-load power and as backup for intermittent renewable power. Until renewable projects are more widespread and are coupled with or backed up by storage, natural gas generation will be needed. However, there is a downside to continued investment in natural gas. The more that we invest in natural gas-fired electric generation and natural gas pipeline distribution, the more sunk costs we will have in natural gas infrastructure when renewables are ready for wide-scale deployment with storage. This will in turn delay the full-scale implementation of renewables and storage unless society is willing to write off these costs before the end of the life cycle of these investments.

Overreliance on natural gas poses another problem. Supply of natural gas into New England is limited by transmission pipeline capacity. Natural gas is used for heating and increasingly for electric generation. During peak energy usage periods, extreme cold weather in the winter or extreme hot weather in the summer, we need more gas than the pipelines can deliver and gas prices spike. New gas transmission lines are difficult to build and site, and so price spikes may become more frequent as overall gas consumption increases. As a result, ISO-New England is concerned about the region's dependence on natural gas.[143]

APPENDIX C - International Efforts

Commitments

- In addition to signaling that it would end production and sale of gasoline and diesel vehicles, China pledged in the context of the Paris Climate Agreement to peak its GHG emissions, lower the carbon intensity of its GDP by 60-65% below 2005 levels, and receive 20% of its energy from renewable energy sources, all by 2030.[144] Subsequent to that rating, China announced that it would create the world's largest carbon trading system.[145]

- India has committed to lower the emissions intensity of its GDP by 33-35% below 2005 levels by 2030, increase the share of non-fossil based generation to 40% (equivalent to 26-30% of generation), and create an additional carbon sink of 2.5-3 gigatons of CO_2 equivalent.[146]

- The European Union committed to reduce GHG emissions by 40% from 1990 levels by 2030, and 80-95% below 1990 levels by 2050. Austria, Denmark, France, Finland, Italy, Portugal, the Netherlands, Sweden, the United Kingdom have committed to phase out coal generation, but the two largest coal emitters in the EU, Germany and Poland, have not.[147]

- Canada has committed to reducing its GHG emissions by 30% below 2005 levels by 2030.[148] policies has announced a proposed new climate policy framework. Canada is moving to retire all of its coal and oil fired power plants by 2030 as part of its commitment under the Powering Past Coal Alliance.

Networks and Alliances

- Most of the world's largest cities have formed a climate network, C40, that is helping to coordinate climate actions by those cities. Two important reports – Deadline 2020, McKinsey – Focused Acceleration – have been published by or on behalf of C40.[149]

- More than 20 countries have joined the Powering Past Coal Alliance, with a goal of phasing out coal generation.[150]

APPENDIX D - Additional Federal Policy Information

There are numerous federal policies and programs in place to support the reduction of GHG emissions and increased use of renewable energy, including the following:

- Investment Tax Credit (ITC). The ITC is currently worth 30% of the qualified expenses spent installing a residential or commercial solar energy system. The ITC is due to step down from 30% to 26% in 2020 and to 22% in 2021. Starting in 2022, the ITC will drop to zero for residential systems and to a permanent 10% for commercial systems.
- Production Tax Credit (PTC). The PTC was worth 2.3 cents per kwh of power generated from wind projects for projects that began construction in 2016 and earlier, stepped down to 80% of that amount in 2017 and 60% in 2018, and is due to step down to 40% in 2019. All projects must be completed by 2021 in order to qualify for the PTC.
- Electric Vehicle (EV) Tax Credit. A tax credit of up to $7500 (value of credit depends on size of vehicle and battery capacity) is available for the purchase of an electric vehicle. The EV tax credit starts to phase out when a manufacturer sells 200,000 plug-in vehicles.
- SunShot Initiative. The U.S. Department of Energy's (the "USDOE") SunShot Initiative (a nod to the "Moonshot" of the 1960s) dedicates funding via competitive grants to research and development projects aimed at reducing the cost of installing solar projects. The USDOE set the following targets for the average installed cost of solar by 2020 - $0.06 utility-scale, $0.08 commercial and $0.10 residential. This fall, the USDOE announced that the 2020 target for utility-scale solar has already been achieved, and also set new targets for 2030 - $0.03 utility-scale, $0.04 commercial and $0.05 residential.
- CAFE Standards. Under current law, automakers are required to achieve an average fuel efficiency of 54.5 MPG for new cars and trucks by 2025. The Trump Administration has opened a review of the CAFE standards, but as of this writing they remain in effect. California has authority under the Clean Air Act to adopt vehicle emission standards that are more strict than federal standards. Other states may also adopt California standards at their own discretion, but may not adopt their own standards.
- Renewable Fuel Standard (RFS). The RFS is a federal program that requires transportation fuel sold in the U.S. to contain a minimum volume of renewable fuels.

The above-listed policies and programs and others are given partial credit for flattening U.S. GHG emissions since 2007 (state and local policies and the recession and slow recovery also played a role), as well as for the rapid growth in U.S. renewable energy generation and the steep drop in the cost of renewables.

APPENDIX E - Additional New Hampshire Policy Information

Concord's push to 100% renewable energy would occur in the following state and regional context.

Regional Greenhouse Gas Initiative (RGGI). New Hampshire and eight other northeastern states participate in the Regional Greenhouse Gas Initiative (RGGI),[151] a regional cap-and-trade program under which large fossil-fuel power plants are required to reduce their GHG emissions by purchasing emissions allowances. RGGI helps reduce GHG emissions and increase renewable energy generation by making fossil fuel plants more expensive to operate and by helping to fund energy efficiency programs. New Hampshire's participation in RGGI has been threatened in recent years as some legislators have attempted (unsuccessfully) to repeal New Hampshire's participation in RGGI, or failing that, to limit the use of RGGI auction proceeds for energy efficiency programs.[152] Despite the political challenges in our state, RGGI is growing stronger. This summer, the RGGI states agreed to reduce the overall emissions cap by 30% between 2020 and 2030.[153] A vote to affirm New Hampshire's participation in the lower emissions cap will likely be taken up by the new legislature in 2019.

Renewable Portfolio Standard (RPS). Since 2008, New Hampshire's renewable portfolio standard has required electric utilities to procure a minimum (increasing) percentage of their annual customer load from renewable energy sources.[154] New Hampshire's RPS program is less ambitious than other states' programs, particularly regarding solar energy. A list of the annual requirements for percentage of renewable energy under the New Hampshire RPS is set forth below:

Renewable Portfolio Standard Obligations							
Calendar Year	**Total RPS Requirement**	**Class I Non-Thermal**	**Class I Thermal**	**Total Class I**	**Class II New Solar**	**Class III Existing Biomass**	**Class IV Existing Hydro**
2008	4.00%	0.00%	0.00%	0.00%	0.00%	3.50%	0.50%
2009	6.00%	0.50%	0.00%	0.50%	0.00%	4.50%	1.00%
2010	7.54%	1.00%	0.00%	1.00%	0.04%	5.50%	1.00%
2011	9.58%	2.00%	0.00%	2.00%	0.08%	6.50%	1.00%
2012	5.55%	3.00%	0.00%	3.00%	0.15%	1.40%	1.00%
2013	5.80%	3.80%	0.00%	3.80%	0.20%	0.50%	1.30%
2014	7.20%	4.60%	0.40%	5.00%	0.30%	0.50%	1.40%
2015	8.30%	5.40%	0.60%	6.00%	0.30%	0.50%	1.50%
2016	8.50%	5.60%	0.80%	6.20%	0.30%	0.50%	1.50%
2017	17.60%	6.80%	1.00%	7.80%	0.30%	8.00%	1.50%
2018	18.70%	7.50%	1.20%	8.70%	0.50%	8.00%	1.50%
2019	19.70%	8.20%	1.40%	9.60%	0.60%	8.00%	1.50%
2020	20.70%	8.90%	1.60%	10.50%	0.70%	8.00%	1.50%
2021	21.60%	9.60%	1.80%	11.40%	0.70%	8.00%	1.50%
2022	22.50%	10.30%	2.00%	12.30%	0.70%	8.00%	1.50%

2023	23.40%	11.00%	2.20%	13.20%	0.70%	8.00%	1.50%
2024	24.30%	11.90%	2.20%	14.10%	0.70%	8.00%	1.50%
2025 and thereafter	25.20%	12.80%	2.20%	15.00%	0.70%	8.00%	1.50%

If a utility fails to meet its percentage requirement in a given year, it makes alternative compliance payments ("ACPs") at a rate of specified dollars per MWH of shortfall. These payments are directed by the New Hampshire Public Utilities Commission (the "NHPUC") to the Renewable Energy Fund, which is used to fund solar rebates (discussed below) among other things. Thus, the RPS has a triple benefit - forcing renewables into the utility mix, providing a revenue stream to support renewable projects, and funding new projects with money raised when utilities do not procure enough renewable energy.

Solar Rebates. The NHPUC recently resumed its residential renewable rebate program after a pause in the second half of 2017. Rebates are funded out of the Renewable Energy Fund. Funding varies from year to year based on the aggregate amount of ACP payments. Currently, the value of the rebate is $0.20/watt up to $1,000, or 30% of system costs, whichever is lower.[155] The NHPUC has closed its commercial and industrial solar rebate program until further notice due to lack of funds.[156]

Net Metering. Under New Hampshire's net metering program, customers hosting solar and other customer-sited renewable generation with a capacity of 1 MW or less can receive payment from the utility for power delivered to the grid. The NHPUC recently issued an order[157] revising the program, including reducing the net metering rate for smaller facilities but lifting the statewide cap on aggregate net metering capacity. Projects that enter into the net metering program will have their rate structures grandfathered to December 31, 2040. The NHPUC ordered the initiation of a "Value of Distributed Energy Resources" study, which will inform the next iteration of net metering in a few years.

Group Net Metering. In New Hampshire, utility customers can participate in group net metering arrangements under which multiple parties can receive credit for the output of one solar project. Groups can be formed by registering with the NHPUC. Each group must have a group host. The host receives payment from the utility for excess power delivered to the grid, and is responsible for distributing those payments among the members of the group.

Grid Modernization. The NHPUC ordered Unitil and other utilities to conduct pilot programs that fall under the general category of grid modernization. Over the next few years, Unitil will undertake a low and moderate income pilot program (looking at the use of monetary bill credits to make solar benefits available to low and moderate income customers), a non-wires alternative pilot program (looking at the integration of distributed generation and distributed energy resources) and a time of use rates pilot program (looking at how time-varying rates affect customer behavior and utility costs). In addition, a NHPUC consultant has recommended that Unitil and other utilities be required to submit a Grid Modernization Plan to the NHPUC for review and approval.

Legal Options Available to Municipalities. New Hampshire law gives municipalities a few legal options to encourage renewable energy or otherwise assert control over their energy supply.

- Solar Property Tax Exemption. Under RSA 72:62, New Hampshire municipalities to adopt a property tax exemption for solar energy systems located within their borders.[158]

- PILOT Agreements. Under RSA 72:74, municipalities may enter into a payment in lieu of taxes (PILOT) agreement with the owner of a renewable energy facility, but upon request must enter into agreements on similar terms with owners of any other renewable facilities located within their borders.[159]
- Municipal Aggregation of Electric Demand. Under RSA 53-E, municipalities and counties may develop programs to aggregate retail electric customers so that customers may access lower-priced and more secure power sources.[160] No New Hampshire municipalities have elected to pursue an aggregation program to date, but Hanover and Lebanon have announced that they will pursue an aggregation program to bring low-cost renewable power to their residents.
- Municipal Electric Plants. Under RSA 38, municipalities may establish municipal electric plants to provide retail electric service.[161] Five towns[162] in New Hampshire currently operate municipal electric plants.

Energy Efficiency. The utilities administer certain core energy efficiency programs under the oversight of the NHPUC. In addition, the NHPUC has established an Energy Efficiency Resource Standard program requiring electric and gas utilities to meet certain savings goals as a percentage of 2014 statewide sales in 2018, 2019 and 2020, totaling 3.1% of electric sales and 2.25% of gas sales by the end of 2020.[163]

Volkswagen Settlement. In 2016, the U.S. government and Volkswagen agreed on a multi-billion dollar settlement of a lawsuit brought by the U.S. alleging deception by Volkswagen in skirting U.S. vehicle air emission limits. About $31 million of the settlement amount is allocated to New Hampshire. According to the settlement, up to 15% of the monies for up to 10 years can be used to build out EV charging station infrastructure. The NHOSI is in charge of developing a plan for what to do with the State's allocation and has not yet announced that plan but is expected to allocated the full 15% to charging stations. New Hampshire substantially lags neighboring states in the development of EV charging infrastructure per capita, and this new investment will lend a much needed boost to our charging station network.[164]

Sale of Eversource Generating Assets. Eversource recently sold its fossil fuel generating assets (including Merrimack Station in Bow) to Granite Shore Power pursuant to an NHPUC. Eversource's hydroelectric assets will be sold to Hull Street Energy, though the closing has not yet occurred. Some believe that the fossil fuel assets will not survive for long as merchant assets in the competitive electric market, and some groups are calling for the plants to be shut down for environmental reasons.

Proposed Transmission Projects. Two major electric transmission projects are proposed in New Hampshire. The Northern Pass project being developed by Eversource would bring hydroelectric power from Quebec through the North Country and down the Merrimack Valley and ending in Deerfield.[165] It would run from north to south in Concord on the east side of the river. Northern Pass's application for a Certificate of Site and Facility is pending before the New Hampshire Site Evaluation Committee (the "NHSEC"), with a decision expected in early 2018. Northern Pass has generated considerable public opposition, including the opposition of the Concord City Council. The Granite State Power Link project being developed by National Grid would bring wind power from Canada along a route from northeastern Vermont into New Hampshire at Monroe then along an existing utility corridor ending in Londonderry, crossing western edge of Concord for a mile or

two.[166] Granite State Power Link has not yet filed an application for a certificate from the NHSEC. Both of these projects expect to deliver power to Massachusetts utilities. Six other major transmission projects are proposed to be sited elsewhere in New England.

On-Shore Wind in New Hampshire. There are at least four on-shore wind farms totaling about 185 MW in capacity operating in New Hampshire.[167] The proposed Antrim Wind project, with a total capacity of about 28 MW,[168] received approval from the NHSEC in early 2017. That approval is under appeal at the Supreme Court.

Solar in New Hampshire. The total amount of solar generating capacity operating in New Hampshire was about 60 MW in 2016. The largest operating solar project in the state is a 1 MW project in Peterborough, though a 2 MW project is nearing completion in Moultonborough.[169] At least nine large utility-scale solar projects with a total capacity of 210 MW are currently proposed in the state. NextEra has proposed a 50 MW project in Hinsdale, a 30 MW project in Fitzwilliam and a 10 MW project on West Portsmouth Street in Concord. SunEast Development has proposed six projects in northern and western New Hampshire. Most of these large solar projects are expected to sell their power to Massachusetts utilities.

Updated State Energy Strategy. In 2017, Governor Sununu's administration undertook a process to update the 10-Year State Energy Strategy, released in September 2014. The New Hampshire Office of Strategic Initiatives ("NHOSI") collected public comments at sessions held across the state. NHOSI is expected to issue proposed updates in early 2018. The 2014 Energy Strategy included 20 specific recommendations.[170]

N.H. Climate Action Plan. In 2009, the New Hampshire Climate Change Task Force delivered a Climate Action Plan for New Hampshire to then Governor John Lynch. The plan included a series of recommendations under the heading of "overarching strategies."[171]

Building Energy Efficiency. New York recently joined six other states in adopting the latest national energy code (2015), which requires buildings to be much more insulated and have a much tighter envelope. New Hampshire still follows the 2009 code, which is better than prior versions but not nearly as up-to-date as the 2015 version. Some builders voluntarily build to the standards of the LEED certification program.

Climate Mayors. Five New Hampshire towns have joined the Climate Mayors movement – Nashua, Portsmouth, Concord, Keene and Lebanon.

APPENDIX F - Other States Policy Information

Other U.S. states have taken significant steps to address climate change and transition to renewable energy, including the following:

- California has had a cap-and-trade program for several years.[172] This program has evolved into the Western Climate Initiative, a carbon trading market that now includes the Canadian provinces of Quebec and Ontario.[173]

- At least 29 states (including all six New England states) and the District of Columbia have renewable portfolio standards (RPS), requiring electric utilities to procure an increasing percentage of their load each year from renewable energy sources. California, representing over one-eighth of the U.S. economy, has repeatedly set and achieved aggressive renewable energy goals over the last 15 years. California currently receives about 30% of its electricity from renewable sources, and has a deadline of 33% renewable electricity by 2020 and 50% renewable electricity by 2050.[174] Under New York's clean energy standard, 50% of its electricity must come from renewable sources, up from 23% currently.[175] The Vermont RPS program requires Vermont utilities to procure at least 75% renewable energy by 2032, separate from the statewide goal of 90% renewable energy by 2050.[176]

- States have enacted specific incentives for solar and community solar projects, sometimes in conjunction with their RPS programs. Massachusetts is beginning to implement its Solar Massachusetts Renewable Target (SMART) program, a successor to its earlier SREC-I and SREC-II programs.[177] New Jersey has a target of 4.1% of its electricity from solar to be achieved by 2028, is expected to reach that mark 10 years early, and will consider bills to raise the target to a higher percentage.[178] States with robust community solar programs include California, Colorado, Massachusetts and Minnesota.

- At least 38 states and the District of Columbia offer net metering.[179] The nature of the programs vary widely, but in general they allow eligible projects to deliver excess power to the grid and receive credit or payment at the retail electric rate or at a discount thereof, depending on the program. They have the effect of encouraging self-generation of electricity since the energy generated has value even if it is not needed by the host. One pending issue in several states' net metering programs is the eligibility of solar + storage projects for net metering benefits.

- Massachusetts,[180] Connecticut[181] and Rhode Island[182] each offer long-term power purchase agreements (PPAs) pursuant to requests for proposals or under a tariff. Long-term PPAs enhance the financial viability of larger renewable energy projects by making them creditworthy to lenders and investors.

- Massachusetts required its utilities to procure at least 1600 MW of power from offshore wind projects by 2027.[183] Three bidders – Deepwater Wind (project: Revolution Wind), Orsted and Eversource Energy (project: Bay State Wind) and CIP/Avangrid (project: Vineyard Wind) responded to the initial RFP seeking 800 MW of power. On January 31, the

Connecticut Department of Energy and Environmental Protection (DEEP) is expected to issue an RFP for power from offshore wind and other projects. New York committed to develop up to 2.4 GW of offshore wind power by 2030. Rhode Island announced a goal of 1000 MW of clean energy by 2020, and this procurement could include offshore wind. New Jersey, which stopped pursuing offshore wind during Governor Chris Christie's administration, is poised to pursue up to 3.5 GW of offshore wind under current Governor Phil Murphy.

- States are starting to reimagine their electric grids. New York is pursuing a comprehensive energy strategy called Reforming the Energy Vision (REV) that not only looks at the design of the electric grid and the role of utilities, but also sets statewide goals for 2030 - the 50% renewable energy goal described above, a 40% reduction in GHG emissions from 1990 levels, and a 23% reduction in energy consumption of buildings from 2012 levels.[184]

- In Washington state, Governor Jay Inslee has proposed a carbon tax, which the legislature will consider in the current legislative session.[185]

- The Minnesota Public Utilities Commission just ordered utilities to develop carbon cost estimates that the utilities must use when planning new infrastructure projects.[186]

- California required its utilities to procure a total of 1300 MW of energy storage capacity by 2020 and an additional amount thereafter,[187] and the CPUC just approved new market rules for energy storage that should enable storage to realize its full economic potential. Massachusetts has set a target of 200 MWH of energy storage by 2020.[188] Governor Andrew Cuomo recently pledged that New York would build 1500 MW of energy storage by 2025.[189] Other states are considering ambitious energy storage targets.

- States have policies supporting energy efficiency including utility programs, transportation, building energy codes, support for combined heat and power projects, state government policies, and appliance standards. Leading states in energy efficiency policy include Massachusetts, California, Rhode Island, Vermont and Oregon.[190]

- California's Zero Emission Vehicle (ZEV) program imposes a percentage requirement of EVs and other zero emission vehicles (plug-in hybrid, battery electric, hydrogen fuel cell) in California. Nine additional states - Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont - have also adopted the program. The California ZEV program has helped to drive forward the transition to EVs across the country. [191] California's Low Emission Vehicle (LEV) program imposes emission requirements that are more strict than federal standards on certain combustion vehicles sold by automakers. The above states have also adopted the California LEV program. Three states – Washington, Delaware, and Pennsylvania – have adopted the California LEV program but not the ZEV program.

- States offer a variety of incentives for the purchase and use of electric vehicles, including rebates (e.g., Connecticut, Massachusetts, New York), income tax credits (Colorado, Louisiana), sales tax exemption (New Jersey, Washington DC) and carpool lane access (Arizona, Hawaii, Nevada).[192]

- New York plans to accommodate more than 30,000 plug-in electric vehicles by 2018 and 1 million by 2025, including the installation of 3,000 EV charging stations to support an expected 30,000-40,000 EVs on the road by 2018.[193] Massachusetts has a goal of 300,000 plug-in EVs by 2025.[194]

- The U.S. Climate Alliance[195] is a bipartisan coalition of 15 U.S. states and Puerto Rico committed to advancing the goals of the Paris Climate Agreement. Each member state commits to reduce GHG emissions by at least 26-28 percent below 2005 levels by 2025.

- America's Pledge[196] is an initiative to collect data on climate action by non-national actors to quantify and report on progress made towards the U.S. pledge at Paris, communicate the findings and results of this research and data and catalyze further climate action in the near term by providing detailed roadmaps for similar business-level, city, and state action in the US and, potentially, in other countries around the world.

Policies in neighboring states affect New Hampshire to some degree, and New Hampshire might pursue some of these policies in the coming years.

APPENDIX G - Major Global Companies Committed To 100% Renewable Energy[197]

1. IKEA Group
2. Swiss Re Group
3. Anheuser-Busch InBev
4. Adobe
5. AkzoNobel
6. Alstria
7. Amalgamated Bank
8. Apple
9. Askul Corporation
10. AstraZenica
11. Autodesk
12. Aviva
13. AXA
14. Bank of America
15. Bankia
16. Biogen
17. Bloomberg
18. BMW Group
19. British Land
20. Broad Group
21. BT
22. Burberry
23. CaixaBank
24. Califia Farms
25. Canary Wharf Group
26. Carlsberg Group
27. Citi
28. Clif Bar & Company
29. Coca-Cola European Partners
30. Colruyt Group
31. Commerzbank
32. Corbion
33. Credit Agricole
34. Dalmia Cement
35. Dannon
36. Danske Bank
37. DBS Bank Ltd
38. Dentsu Aegis Network
39. Diagio
40. DNB
41. eBay
42. Elion
43. Elopak
44. Equinix
45. Estee LAUDER
46. Facebook
47. FIA Formula E
48. Gatwick Airport Limited
49. General Motors
50. Givaudan
51. Goldman Sachs
52. Google
53. H&M
54. Hatsun Agro Products, Ltd
55. Heathrow Airport
56. Helvetia Group
57. Hewlett Packard Enterprise
58. HP Inc.
59. HSBC
60. IFF
61. IHS Markit
62. Infosys
63. ING
64. Interface
65. J. Safra Sarasin
66. Johnson & Johnson
67. JP Morgan Chase & Co.
68. Jupiter Asset Management
69. Kellogg
70. Kingspan
71. KPN
72. L'Occitane Group
73. La Poste
74. Landsec
75. The Lego Group
76. Mace
77. Marks & Spencer
78. Mars
79. Microsoft
80. Morgan Stanley
81. Nestle
82. Nike, Inc.
83. Nordea
84. Pearson
85. Philips Lighting
86. P&G
87. Novo Nordisk
88. Organic Valley
89. Proximus
90. Rackspace, Inc.
91. RB
92. RELX Group
93. Royal DSM
94. Royal Philips
95. RICOH Company, Ltd.
96. Salesforce
97. SAP
98. SAVE S.p.A. Group
99. Schneider Electric
100. Sekisui House
101. SGS
102. Sky
103. Starbucks
104. Steelcase
105. Tata Motors Limited
106. TD Bank Group
107. Telefonica S.A.
108. Tesco
109. Tetra Pak
110. UBS
111. Unilever
112. Vail Resorts
113. Vaisala
114. Vestas
115. VF Corporation
116. VMware, Inc.
117. Voya Financial
118. Walmart Stores, Inc.
119. Wells Fargo & Co.
120. Workday, Inc.
121. Yoox Net-a-Porter Group

ENDNOTES

[1] According to the Energy Chapter of the Master Plan, in 2011 Unitil had 25,444 customers within Concord, including 21,859 residential accounts, 3,292 commercial accounts, 275 state/municipal accounts and 18 industrial accounts. Only one residence in Concord was served by PSNH. http://www.concordnh.gov/DocumentCenter/View/1420. Based on trends in statewide electricity consumption, it is likely that Concord's 2017 electric consumption is little changed from its 2011 consumption.

[2] According to the Energy Chapter of the Master Plan, in 2011 Liberty provided natural gas service to approximately 40% of the total land area within the City and served 11,903 meters in the City

[3] As reported in the Energy Chapter of the Master Plan.

[4] This figure reflects both approximate actual expenditures for the fiscal year ending June 30, 2017, and the budgeted amount for the current fiscal year.

[5] These numbers include estimated usage, and do not include the Penacook Library which is not on natural gas.

[6] This represents about twenty percent (20%) of Concord's present community-wide electric consumption.

[7] These projects (Penacook Upper Falls, Penacook Lower Falls and Rolfe Canal) operate under separate FERC licenses that expire in 2022 and 2024 respectively. Assuming a 40-50% capacity factor, the Briar Hydro projects probably generate between 39 to 49 gigawatt-hours (GWh) of electricity per year.

[8] Garvins Falls operates under a FERC license issued in 2007, expiring in 2047. Assuming a 40-50% capacity factor, the Garvins Falls project probably generates between 43 to 53 GWh of electricity per year.

[9] https://www.wtienergy.com/plant-locations/energy-from-waste/wheelabrator-concord.

[10] http://www.concordmonitor.com/concord-steam-history-9673675.

[11] http://unitil.com/media-center/local-news-releases/douglas-n-everett-arena-completes-energy-efficiency-upgrades.

[12] GHGs include carbon dioxide, methane, nitrous oxide, chloroflourocarbon-12, hydroflourocarbon-23, sulfur hexafluoride and nitrogen triflouride. https://www.c2es.org/content/main-greenhouse-gases/.

[13] This target has been reflected in reports issued by the Intergovernmental Panel on Climate Change (the "IPCC"), the leading global body dedicated to the study of climate change, most recently in its Fifth Assessment issued in 2014.

[14] https://www.vox.com/energy-and-environment/2018/1/19/16908402/global-warming-2-degrees-climate-change. At Paris, nations invited the IPCC to study and prepare a report on actions needed to hold temperature change to 1.5° C. The IPCC is currently working on Sixth Assessment, to be issued in a series of reports starting in September 2018.

[15] https://science2017.globalchange.gov/.

[16] Early assessments indicate that 2017 was the second or third hottest year on record, according to NASA or NOAA respectively. If the effects of the recent El Nino and La Nina patterns were statistically removed from the record. 2017 would have been the hottest year on record. NASA: https://www.nasa.gov/press-release/long-term-warming-trend-continued-in-2017-nasa-noaa. NOAA: https://www.ncei.noaa.gov/news/global-climate-201712.

[17] For comparison, preindustrial CO_2 levels were 280 parts per million (ppm), and limiting the increase in CO_2 levels to 350 ppm was considered necessary to "safely" avoid the worst effects of climate change.

[18] https://www.npr.org/2018/01/05/575905776/while-the-eastern-us-freezes-its-too-warm-in-alaska. For an explanation of how warming in the Arctic can cause cold snaps in the eastern U.S., see the video linked here: https://www.yaleclimateconnections.org/2018/01/understanding-bomb-cyclone-weather-in-a-climate-context/.

[19] The ecological effects of climate change are vast. https://nca2014.globalchange.gov/report/sectors/ecosystems.

[20] https://www.gao.gov/products/GAO-17-720.

[21] http://beta.latimes.com/politics/la-na-pol-climate-gao-20171024-story.html, https://www.vox.com/energy-and-environment/2017/12/28/16795490/natural-disasters-2017-hurricanes-wildfires-heat-climate-change-cost-deaths.

[22] The Sustainability Institute at the University of New Hampshire, Climate Change in Southern New Hampshire (2014) ("UNH Study") (https://sustainableunh.unh.edu/sites/sustainableunh.unh.edu/files/images/southernnhclimateassessment2014.pdf).

[23] According to a report by the Union of Concerned Scientists on the effects of climate change in the northeast, by late century, New Hampshire's summers could resemble current summers in Virginia (in a lower-emission scenario) or North Carolina (in a higher-emission scenario). https://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/confronting-climate-change-in-the-u-s-northeast.pdf.

[24] UNH Study (https://sustainableunh.unh.edu/sites/sustainableunh.unh.edu/files/images/southernnhclimateassessment2014.pdf), a study conducted by researchers at Dartmouth College's Thayer School of Engineering and published in the journal Global Change Biology (https://news.dartmouth.edu/news/2017/04/study-climate-change-affecting-nh-seasons), USEPA, "What Climate Change Means for New Hampshire" (https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-nh.pdf).

[25] Combustion of coal produces the following emissions: CO_2, sulfur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (soot), mercury and other toxic pollutants. https://www.ucsusa.org/clean-energy/all-about-coal/how-coal-works#.WnIMha6nEdU.

[26] Coal provided over 50% of the U.S. electricity mix during much of the 20th century, but began to decline after 2008 and sunk to 30% by 2016. Natural gas provided 22% of the U.S. electricity mix in 2008, but rose to 34% by 2016. https://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states.

[27] https://www.scientificamerican.com/article/how-bad-of-a-greenhouse-gas-is-methane/.

[28] https://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states.

[29] https://www.vox.com/energy-and-environment/2016/10/17/13190036/global-climate-change-facts-effects-cartoon.

[30] http://www.climatecentral.org/news/major-greenhouse-gas-reductions-needed-to-curtail-climate-change-ipcc-.

[31] As Vox.com energy columnist David Roberts put it, "[t]he easy, default path for the next several years will be to continue to lean on natural gas to drive down [other air] emissions and balance [variable renewable energy] ... But leaning too hard on natural gas will leave us with a ton of fossil fuel capacity that we end up having to shut down (or leave mostly idle) before the end of its useful life. That will be an economically unfortunate and politically difficult situation. We need to start thinking about alternatives to natural gas, today." https://www.vox.com/energy-and-environment/2017/4/7/15159034/100-renewable-energy-studies.

[32] https://www.yaleclimateconnections.org/2016/08/is-natural-gas-a-bridge-fuel/.

[33] U.S. renewable electricity capacity grew by 10% in 2016, up from 8% growth in 2015. U.S. Department of Energy Office of Energy Efficiency and Renewable Energy and National Renewable Energy Laboratory, 2016 Renewable Energy Data Book (https://www.nrel.gov/docs/fy18osti/70231.pdf).

[34] EDF Clean Energy Jobs Report, citing UMass Amherst study (http://edfclimatecorps.org/sites/edfclimatecorps.org/files/casestudy/the_growth_of_americas_clean_energy_and_sustainability_jobs.pdf).

[35] https://www.vox.com/energy-and-environment/2017/8/18/16160456/wind-solar-power-saving-money.

[36] https://www.gao.gov/products/GAO-17-720, http://beta.latimes.com/politics/la-na-pol-climate-gao-20171024-story.html.

[37] https://www.vox.com/energy-and-environment/2017/8/18/16160456/wind-solar-power-saving-money.

[38] https://www.wsj.com/articles/china-affirms-commitment-to-climate-agreement-ahead-of-trump-decision-1496308759, http://www.climatechangenews.com/2017/05/11/indian-energy-minister-reaffirms-paris-climate-commitments/. For its part, China appears to view the U.S. withdrawal as an opportunity to lead the global fight against climate change, and seize the trade and economic opportunities that come with a transition to renewable energy. https://www.nytimes.com/2017/06/01/us/politics/climate-accord-trump-china-global-leadership.html.

[39] https://www.usclimatealliance.org/. As of December 2017, the member states are California, Colorado, Connecticut, Delaware, Hawaii, Massachusetts, Minnesota, New York, North Carolina, Oregon, Rhode Island, Vermont, Virginia and Washington. Alliance members represent 36% of the U.S. population and $7 trillion in annual GDP.

[40] http://climatemayors.org/. The number of mayors in the group is current as of December 2017.

[41] https://www.nytimes.com/2017/10/09/climate/clean-power-plan.html.

[42] https://www.cnbc.com/2017/09/29/energy-dept-proposes-power-pricing-that-may-boost-coal-nuclear-plants.html.

[43] https://www.reuters.com/article/us-usa-drilling-florida/trump-administration-bars-oil-drilling-off-florida-after-governors-plea-idUSKBN1EZ001.

[44] https://www.vox.com/energy-and-environment/2018/1/22/16921244/solar-tariff-white-house-itc-trump. South Korea has already appealed the decision to the World Trade Organization. https://www.ft.com/content/1c1927ae-01eb-11e8-9650-9c0ad2d7c5b5.

[45] https://www.nrel.gov/docs/fy18osti/70231.pdf. Wind power generation increased from 26,589 GWH in 2006 to 226,485 GWH in 2016, an increase of 750%. Solar power generation in the U.S. increased from 1,312 GWH in 2006 to 67,959 GWH in 2016, an increase of 5,000%. Wind is expected to overtake hydro as the leading renewable energy resource shortly. https://www.utilitydive.com/news/eia-wind-to-beat-hydro-as-leading-us-renewable-resource-in-next-2-years/515505/.

[46] Bloomberg New Energy Finance expects renewable energy to reach 38% penetration in the U.S. by 2040, with rooftop solar PV alone accounting for as much as 5% of U.S. clectricity output. https://about.bnef.com/new-energy-outlook/.

[47] https://e360.yale.edu/digest/cost-of-u-s-solar-drops-75-percent-in-six-years-ahead-of-federal-goal.

[48] http://awea.files.cms-plus.com/FileDownloads/pdfs/Top%20Facts.pdf.

[49] https://www.carbonbrief.org/guest-post-why-solar-keeps-being-underestimated.

[50] https://www.lazard.com/perspective/levelized-cost-of-energy-2017/, https://www.utilitydive.com/news/renewables-challenge-natural-gas-plants-on-price-in-latest-lazard-analysis/432700/, McKinsey Global Energy Perspective: Reference Case 2018, available at https://gep.mckinseyenergyinsights.com/, https://cleantechnica.com/2016/07/12/solar-already-beating-gas-price-natural-gas-next-fossil-fuel-go/.

[51] https://energy.gov/eere/solar/sunshot-initiative. According to USDOE, the average cost of generating solar power fell from $0.28/KWH in 2010 to $0.06/KWH in 2017 for utility-scale projects, from $0.40/KWH in 2010 to $0.11/KWH in 2017 for commercial-scale projects, and from $0.52/KWH in 2010 to $0.16/KWH in 2017 for residential-scale projects.

[52] https://about.bnef.com/new-energy-outlook/. In 2017, the USDOE SunShot Initiative set new targeted prices for solar in 2030 - $0.03 utility-scale, $0.04 commercial and $0.05 residential. https://energy.gov/eere/solar/sunshot-2030.

[53] https://www.documentcloud.org/documents/4340162-Xcel-Solicitation-Report.html, https://www.carbontracker.org/colorados-renewables-revolution/, https://www.utilitydive.com/news/renewable-plus-storage-bids-in-xcel-colorado-solicitation-could-set-low-pri/514566/, https://www.vox.com/energy-and-environment/2018/1/16/16895594/colorado-renewable-energy-future.

[54] https://www.carbontracker.org/colorados-renewables-revolution/.

[55] https://www.utilitydive.com/news/updated-tucson-electric-signs-solar-storage-ppa-for-less-than-45kwh/443293/, https://www.utilitydive.com/news/austin-energy-solar-ppa-could-be-lowest-priced-in-us-analysts-say/513453/.

[56] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_2017_Power_Costs_2018_summary.pdf?la=en&hash=6A74B8D3F7931DEF00AB88BD3B339CAE180D11C3.

[57] http://irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017.

[58] https://about.bnef.com/new-energy-outlook/.

[59] https://www.vox.com/energy-and-environment/2018/1/16/16895594/colorado-renewable-energy-future, https://www.carbontracker.org/colorados-renewables-revolution/.

[60] https://www.vox.com/2016/3/24/11297054/shared-solar.

[61] The Cape Wind project off the coast of Nantucket never went forward, but its legal travails resulted in resolution of issues of legal jurisdiction, offshore zoning, leasing and permitting that offer newer projects a clearer development path. https://www.greentechmedia.com/articles/read/in-cape-winds-demise-lessons-for-resurgent-u-s-offshore-wind#gs.viZ=hoo. The sites being pursued are out of the viewsheds of coastal residents, so these projects should not run into the same degree of opposition that Cape Wind did.

[62] http://dwwind.com/project/block-island-wind-farm/.

[63] https://www.northeastwindcenter.org/wp-content/uploads/Northeast-Offshore-Wind-Regional-Market-Characterization.pdf. Leasing of ocean areas for wind projects is run by the U.S. Bureau of Ocean Management. https://www.boem.gov/Commercial-Leasing-Process-Fact-Sheet/.

[64] The target is 1600 MW of offshore wind power by 2027. https://www.utilitydive.com/news/3-offshore-wind-developers-submit-proposals-for-massachusetts-target/513708/.

[65] Those developers are Deepwater Wind, Bay State Wind and Vineyard Wind. . https://www.utilitydive.com/news/3-offshore-wind-developers-submit-proposals-for-massachusetts-target/513708/.

[66] https://www.bostonglobe.com/opinion/2017/11/16/massachusetts-might-leading-offshore-wind-for-now-but-other-states-are-closing/27tuP3ED2P3iiPOVjGcpXN/story.html.

[67] In 2017, Bloomberg New Energy Finance projected that offshore wind will fall another 71%. https://about.bnef.com/new-energy-outlook/.

[68] https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/winds-of-change-why-offshore-wind-might-be-the-next-big-thing.

[69] https://www.iso-ne.com/static-assets/documents/2018/01/20180117_operational_fuel-security_analysis.pdf, http://www.concordmonitor.com/isone-14996311.

[70] https://www.bloomberg.com/news/articles/2017-06-15/solar-power-will-kill-coal-sooner-than-you-think.

[71] https://www.forbes.com/sites/constancedouris/2017/10/24/the-bottom-line-on-electric-cars-theyre-cheaper-to-own/#1267842510b6.

[72] https://www.bloomberg.com/news/articles/2017-05-26/electric-cars-seen-cheaper-than-gasoline-models-within-a-decade.

[73] https://www.npr.org/sections/thetwo-way/2017/07/05/535596277/all-new-volvo-models-will-be-electric-or-hybrid-starting-in-2019.

[74] https://www.reuters.com/article/us-daimler-strategy-investors/mercedes-benz-to-offer-electric-option-for-every-car-by-2022-idUSKCN1BM0TL.

[75] https://www.theverge.com/2017/12/18/16791376/toyota-1-million-electric-cars-2030-ev.

[76] https://www.usatoday.com/story/money/cars/2017/10/02/gm-electric-vehicles/722896001/.

[77] https://www.reuters.com/article/us-autoshow-detroit-ford-motor/ford-plans-11-billion-investment-40-electrified-vehicles-by-2022-idUSKBN1F30YZ.

[78] https://about.bnef.com/new-energy-outlook/.

[79] https://www.vox.com/energy-and-environment/2017/10/24/16519364/electric-buses.

[80] Pumped hydro storage has been used for decades.

[81] In California, the IOUs are collectively require to purchase 1.3 GW of storage capacity by 2020 pursuant to a 2010 law, and each IOU is required to purchase an additional 166 MW pursuant to a 2016 law. The Massachusetts Department of Energy Resources (DOER) has set a target of 200 megawatt-hours (MWh) of energy storage by January 1, 2020. https://www.mass.gov/service-details/energy-storage-target. DOER has indicated that it may expand the target to 600 MWh of storage by 2025.

[82] https://pv-magazine-usa.com/2018/01/15/california-regulators-choose-clean-energy-and-storage-over-existing-gas-plants/.

[83] https://www.utilitydive.com/news/utilities-see-benefits-in-energy-storage-even-without-mandates/504587/.

[84] https://www.utilitydive.com/news/national-grid-plans-to-install-a-48-mwh-battery-storage-system-on-nantucket/510444/. For more information on National Grid's decision to choose battery storage and a new diesel generator on Nantucket over a new transmission line to the island, see https://www.utilitydive.com/news/there-once-was-an-energy-storage-system-on-nantucket/513650/.

[85] https://futurism.com/tesla-building-bigger-battery-australia/.

[86] E.g., solid state magnesium electrolyte (https://www.utilitydive.com/news/chasing-the-holy-grail-of-battery-storage-scientists-test-solid-state-magn/513183/), hydrogen (http://www.digitaljournal.com/business/hydrogen-power-storage-development-gaining-impetus/article/501697) and polymer chains (https://solarindustrymag.com/polymer-chains-resembling-christmas-lights-help-solar-storage).

[87] https://www.utilitydive.com/news/energy-storage-sees-significant-growth-as-more-utilities-include-it-in-long/512684/.

[88] https://www.vox.com/energy-and-environment/2017/12/15/16714146/greener-more-reliable-more-resilient-grid-microgrids.

[89] https://cleantechnica.com/2018/01/24/community-microgrid-virtual-power-plant/.

[90] https://www.vox.com/2016/9/19/12938086/electrify-everything, http://www.sciencedirect.com/science/article/pii/S1040619016301075.

[91] U.S. Department of Energy. "Renewable Natural Gas (Biomethane) Production." Alternative Fuels Data Center. https://www.afdc.energy.gov/fuels/natural_gas_renewable.html (accessed 18 January 2018).

[92] Götz, Manuel, Jonathan Lefebvre, Friedemann Mörs, Amy McDaniel Koch, Frank Graf, Siegfried Bajohr, Rainer Reimert, and Thomas Kolb. "Renewable Power-to-Gas: A Technological and Economic Review." *Renewable Energy* 85 (January 1, 2016): 1371–90. https://doi.org/10.1016/j.renene.2015.07.066.

[93] Hicks, Wayne. "Undersea Microbes Provide Path to Energy Storage." U.S. Department of Energy National Renewable Energy Laboratory. https://www.nrel.gov/news/features/2017/undersea-microbes-provide-path-to-energy-storage.html (accessed 18 January 2018).

[94] Audi USA. "Audi e-gas plant helps stabilize German public power grid." AudiUSA.com https://www.audiusa.com/newsroom/news/press-releases/2015/07/audi-e-gas-plant-helps-stabilize-german-public-power-grid (accessed 18 January 2018).

[95] Hicks, Wayne. "Undersea Microbes Provide Path to Energy Storage." U.S. Department of Energy National Renewable Energy Laboratory. https://www.nrel.gov/news/features/2017/undersea-microbes-provide-path-to-energy-storage.html (accessed 18 January 2018).

[96] Audi USA. "Audi e-gas plant helps stabilize German public power grid." AudiUSA.com https://www.audiusa.com/newsroom/news/press-releases/2015/07/audi-e-gas-plant-helps-stabilize-german-public-power-grid (accessed 18 January 2018).

[97] https://www.e2.org/wp-content/uploads/2017/02/E2_CleanEnergyJobs_National.pdf.

[98] https://www.bls.gov/ooh/fastest-growing.htm.

[99] Energy use accounts for 84% of U.S. GHG emissions. http://www.wri.org/blog/2017/08/6-charts-understand-us-state-greenhouse-gas-emissions. We use energy in three major ways – electricity, thermal (heating and cooling) and transportation – each of which account for a significant percentage of our GHG emissions. http://rhg.com/notes/preliminary-2017-us-emissions.

[100] https://www.sierraclub.org/ready-for-100.

[101] The Sierra Club collected these pledges through its Mayors for 100% Clean Energy campaign. https://www.sierraclub.org/ready-for-100/mayors-for-clean-energy.

[102] https://www.greentechmedia.com/articles/read/hawaiian-electric-100-renewable-energy-plan-green-light#gs.TpDilwQ.

[103] https://legislature.vermont.gov/assets/Legislative-Reports/Executive-summary-for-web.pdf. The goal includes interim targets of 25% renewable energy by 2025 and 40% renewable energy by 2035.

[104] http://www.desertsun.com/story/news/politics/2017/09/16/landmark-california-bill-100-clean-energy-unexpectedly-put-hold-until-next-year/670434001/

[105] https://malegislature.gov/Bills/190/SD1932, https://malegislature.gov/Bills/190/H3395.

[106] http://nj.gov/governor/news/reports/docs/Environment%20and%20Energy%20Transition%20Report.pdf.

[107] The bill is HB 1544, sponsored by Representatives Peter Somssich and Howard Moffett and Senator Martha Fuller Clark. http://www.gencourt.state.nh.us/bill_status/bill_docket.aspx?lsr=2092&sy=2018&sortoption=&txtsessionyear=2018&txtbillnumber=hb1544&q=1.

[108] https://www.ecowatch.com/clean-energy-bill-merkley-sanders-markey-2381516585.html.

[109] https://www.congress.gov/bill/115th-congress/house-bill/3671/text.

[110] As of April 2017, 63 percent of Fortune 100 companies have set one or more clean energy targets, and 48 percent of Fortune 500 companies have at least one climate or clean energy target, up five percent from an earlier 2014 report. Among these, a significant number of companies have set 100 percent renewable energy goals. https://www.ceres.org/news-center/press-releases/report-fortune-500-companies-accelerating-renewable-energy-energy

[111] UNH receives 100% of its electricity and 85% of its campus energy from renewable energy sources (wind power, landfill gas), earning the school a Platinum STARS rating for sustainability from the Association for the Advancement of Sustainability in Higher Education. https://www.unh.edu/unhtoday/news/release/2017/09/27/unh-earns-highest-national-rating-sustainability

[112] In 2016, Plymouth State became the first university in the country to commit to 100% renewable energy, pledging to use 100% renewable electricity by 2030. http://www.laconiadailysun.com/community/community-announcements/99910-111816psu-renewableenergy.

[113] In December 2017, Boston University announced its commitment to purchase 100% renewable electricity by the end of 2018. https://environmentamerica.org/news/ame/boston-university-commits-100-renewable-electricity.

[114] In April 2017, Dartmouth committed to reduce GHG emissions by 50% by 2025 and 80% by 2050, including transitioning from No. 6 fuel oil to renewable sources by 2025 and becoming 20% more energy efficient. https://news.dartmouth.edu/news/2017/04/president-hanlon-big-green-will-go-more-green.

[115] https://sustainability.georgetown.edu/renewables.

[116] http://www.coloradoan.com/story/news/local/csu/2017/02/15/csu-pledges-100-percent-renewable-electricity-2030/97954126/.

[117] https://www.cmu.edu/environment/energy-water/energy-mix/index.html.

[118] http://www.independent.co.uk/news/world/europe/sweden-phases-out-fossil-fuels-in-attempt-to-run-completely-off-renewable-energy-a7047306.html.

[119] http://denmark.dk/en/green-living/wind-energy/.

[120] http://www.iflscience.com/environment/costa-rica-300-days-renewable-electricity/.

[121] https://www.irishtimes.com/news/ireland/irish-news/scotland-on-target-for-100-renewable-energy-by-2020-1.3280498.

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