Critique of NYSERDA's Draft Plan, REV. 1.0

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About the Author

Herschel Specter, President of Micro-Utilities, Inc., holds a BS in Applied Mathematics from the Polytechnic Institute of Brooklyn and a MS from MIT in Nuclear Engineering. He is a Licensed Professional Engineer in the State of New York. At the Atomic Energy Commission in the 1970s he was responsible for the licensing of the Indian Point 3 nuclear power plant. In the 1980s the New York Power Authority hired Mr. Specter to defend its Indian Point 3 nuclear plant in a federal adjudicatory trial. He and his team of experts prevailed in court. Mr. Specter served at diplomat rank for 5 years at the International Atomic Energy Agency in Vienna, Austria where he led an international effort writing design safety standards for nuclear power plants.

Mr. Specter has been Chairman of two national committees on nuclear power plant emergency planning and was a guest lecturer for several years on emergency planning at Harvard's School of Public Health. He analyzed emergency responses for a hypothetical terrorist attack on the Indian Point power plants which were located in the nation's highest population density area. Mr. Specter has presented testimony at the National Academy of Sciences on the Fukushima accident and on other nuclear safety matters and has been a guest speaker at many universities on matters of energy policy.Today he is one of 14 Topic Directors in Our Energy Policy Foundation, a group of about 1500 energy professionals who seek to bring unbiased and comprehensive energy information to our political leaders and members of the public.

Mr. Specter has been active in social and environmental matters. He has been a Big Brother and in 1971 had the honor of being selected as "Big Brother of the Year" for all of the USA and Canada. While voluntarily serving as President of Big Brothers of Washington, D.C., the number of boys the agency helped was doubled. He also received a personal letter of commendation from the President of the United States for his work with the Youth Conservation Corps.

Mr. Specter was born in White Plains, NY and lives there now.

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1.0 Executive Summary

This document is a critique of the "New York State Climate Action Council's Draft Scoping Plan" prepared by NYSERDA with the assistance of E3 and Abt Associates, herein identified as the NYSERDA Plan.

In January, 2021 an event occurred in Texas that resulted in an estimated 702 fatalities and close to $200 billion dollars in damages. This was not the result of any nuclear meltdown, nor severe air pollution, nor a tornado, hurricane, or flood. Texas was exposed to a three week long period of extreme cold weather from polar vortex conditions during which time electric power was unavailable for many. Those people who could get electricity paid exorbitant prices, but they were far better off than those who lost power.

The 2003 heat wave that hit Europe caused an estimated 70,000 deaths. In the US heat waves kill more than 600 people per year on average, more than all other climate hazards.(1) The New York Independent System Operator, NYISO, recently warned that New York State, and particularly NY City, are facing major electricity shortages from high temperatures this decade.(2)Two energy margins, one in the generation of electricity and the other in the transmission of electricity, are shrinking and could fail to meet New York's reliability criteria if statewide temperatures reach the upper 90 degree F range. Because of climate change, increased frequencies and extended durations of extreme hot and extreme cold temperatures are anticipated.

The lesson learned from these tragedies is straightforward: **If there is a gap between energy demand and energy supply during times of extreme cold or extreme heat, fatalities and property damage are likely to occur.**

But there is another existential concern besides energy shortages. This concern comes from the production of energy. Fatalities and property damage are also happening from climate change. Climate change is largely attributed to the burning of fossil fuels and their release of greenhouse gases (GHG) into the atmosphere and into the oceans. Record high carbon dioxide levels in the atmosphere have been measured (3) and there has been a marked increase in the earth's heating rate.(4) In the last five years $500 billion dollars of damage in the United States has been attributed to the effects of climate change and the potential for further damage will increase as the atmospheric concentration of GHG rises. The most recent report from the United Nations shows that as the threat from COVID-19 has subsided, the release of GHG has accelerated significantly. **So the second lesson learned is that the release of carbon dioxide and other greenhouse gases must be reduced as rapidly as possible.**

So there are two energy pathways to environmental catastrophe. One pathway is the burning of fossil fuels with their release of GHG which leads to devastating climate change.The other pathway is through insufficient energy which, in the extreme, can lead to war. Both of these pathways are qualitatively shown in FIGURE A-1, first presented in 1982 (5). There are risks and benefits from energy production and there are risks from insufficient energy production.We must not trade one risk pathway for the other; both pathways must successfully be dealt with, simultaneously. Today the world, including Germany, California, and New York, is on both pathways to environmental catastrophe.

New York already is on the climate change catastrophe pathway. It has long favored building fracked gas infrastructure over both renewable energy and nuclear energy. (See Appendix C). More recently the closure of the two Indian Point nuclear units and their replacement with natural gas, raised carbon dioxide emission levels in the electricity generation sector. New York is also on the insufficiency pathway. Gas shortages, caused by both local actions and world events have caused energy bills to rise sharply in the Hudson Valley and NY City areas. Further, energy related actions taken by the former Governor have led to new security issues. Because of increased usage of gas in space heating, in hot water production, and in electricity generation, gas supply utilities have sought to build new gas pipelines. This led to a conflict with the former Governor. He resolved this issue by allowing the delivery of some gas by truck instead of the much safer and less expensive pipeline method. This created a new class of terrorist targets: "truck bombs" filled with natural gas that now travel our neighborhood streets.

Renewable Energy (RE), wind and solar energy, are safe ways to produce electricity which do not directly add GHG to the environment. However, today they are backed up by fossil fuels to assure energy sufficiency and reliability, thereby compromising their environmental benefits. Low carbon futures would eliminate using fossil fuels to back up RE. When this is done RE would no longer be on the climate change pathway to catastrophe. **However, 100% Renewable Energy (RE) scenarios can have serious energy gaps which would place them on the insufficient energy pathway to catastrophe. This critique describes a number of potential energy gaps that appear to be overlooked in the NYSERDA Plan or are the result of miscalculations.**

The NYSERDA Plan itself recognized the potential for energy gaps in its analysis of projected year 2050 normal weather patterns. This critique argues that satisfying future energy needs for projected normal conditions is not good enough. A low carbon future should be designed to deal with extreme hot and cold conditions with a margin for unanticipated failures in electricity generation and transmission and for the evolving effects of climate change itself. Among the evolving climate change effects are the creation of widespread and long lasting wind lulls, like the one that recently took place over all of northern England.(6) **However, RE energy gaps are only risk significant if we elect to make them so by choosing an extreme RE scenario like the plan NYSERDA has put forward.**

The NYSEDA Plan offered two remedies for the 2050 normal conditions energy gap it recognized; one dependent on a massive overbuild of offshore wind combined with more solar energy capacity and energy storage in the form of hydrogen. The other remedy would use a combination of RE and 25 gigawatts of firm (dispatchable) energy. This firm energy would be comprised of nuclear energy and/or fossil fuels with carbon capture and sequestration (CCS). This critique shows that the 100% renewable energy with hydrogen storage option is not likely to succeed. The NYSERDA alternative firm energy option is much better, but still needs to be significantly improved.

The NYSERDA Plan also contains serious data errors. It appears that the capacity factors NYSERDA used for solar energy and for onshore wind power are far too large and are inconsistent with the NY capacity factor data NYISO and the NREL have gathered. These capacity factor errors lead to overestimates of the amount of electricity these RE systems would generate. To correct these NYSERDA errors would require expanding RE by an amount of additional capacity that is close to the total capacity in today's NY electricity system.

NYSERDA and the CAC have to do more than present graphs and tables of analyses. NYSERDA has an obligation to the citizens of New York and their elected officials to explain its avoidance of nuclear energy when the United Nations' Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency, the Clean Air Task Force, and many others, have called for much greater use of nuclear energy for cost-effective decarbonization. The NYSERDA Plan should clearly state what it recommends for the future of upstate nuclear plants.

After years of failed energy policies in New York, NYSERDA and the CAC have to restore the public's confidence. The people of New York have to be convinced that their best interests are being served. NYSERDA and the CAC have to explain why such emphasis was put on renewable energy when many other studies show that a mix of variable energy sources and firm energy sources is superior to an all-RE energy future. Is there a technical basis that justifies this narrow choice or is this NYSERDA Plan just a residue of the former Governor's failed energy policies? With a world facing increasing impacts from climate change, why emphasize the use of renewable energy, the energy source least resilient to the effects of climate change? In a highly competitive world, why emphasize renewable energy with its inherently low capacity factors? With all kinds of uncertainties tied to climate change, why pick an energy source that is not inherently dispatchable to respond to unforeseen events? Why pick an energy source, which because of its low capacity factors and variability, is more land, materials, and transmission line intensive than mixes of RE plus firm energy? Even if all these barriers were overcome, studies show that high deployment RE scenarios are considerably more expensive than scenarios which include RE plus firm energy resources. How well do higher prices and lower reliability serve the people of New York or implement the goals of the Climate Leadership and Community Protection Act CLCPA?

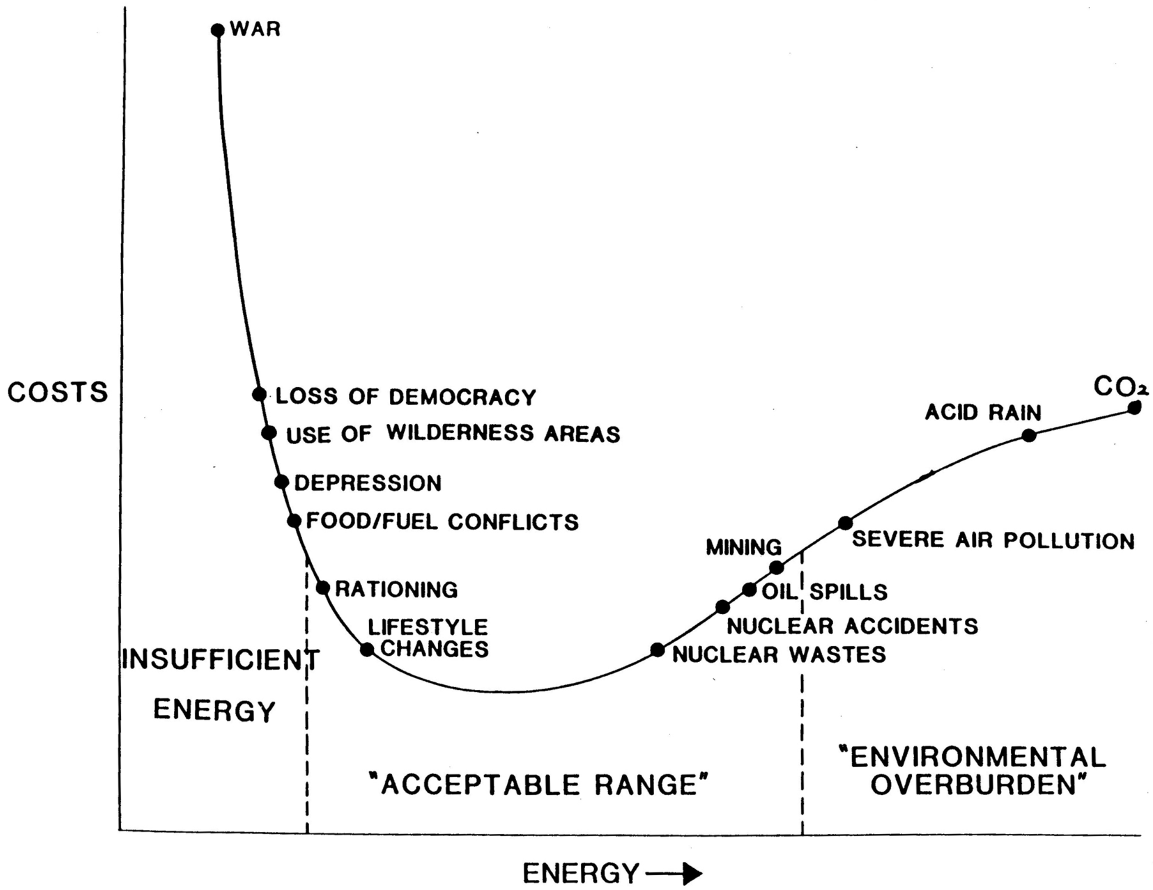
Renewable energy definitely has a place in NY's energy future, which should be determined by what mix of variable and firm energy sources best meets the needs of the people of New York. This critique provides three sets of goals to help decision-makers select the best overall mix of energy sources. Should the CAC conclude that a mix of variable and dispatchable energy sources serves New Yorkers best, it should take two immediate actions: (1) Recommend that the CLCPA be rewritten so that the words "100% renewable energy" are replaced by "100% clean energy" where clean energy includes RE, nuclear energy, and fossil fuels with no net carbon dioxide addition to the atmosphere and oceans, and (2) Call for a replacement report that uses an optimized mix of variable and dispatchable energy sources.

The NYSERDA Plan, as it stands now, does not implement the goals of the CLCPA and does not provide Governor Hochul with the fresh start on energy policy that she and New Yorkers deserve.

2.0 Two Pathways to Environmental Catastrophe

FIGURE A-1 displays two pathways to environmental catastrophe, one from burning fossil fuels that add GHG to our atmosphere and oceans and the other from having insufficient energy.

FIGURE A-1 Two Pathways to Environmental Catastrophe



3.0 RE Insufficiency Examples

As discussed in the Executive Summary, insufficient electricity, especially under extreme temperature conditions, can lead to fatalities and property damage. This section offers a guide to examples of where more detailed discussions on specific electricity shortfalls/gaps can be found in this critique.

FIGURE A-2, first published by the National Renewable Energy Laboratory, is a qualitative description of technical uncertainties.(7) This figure shows that as the deployment of renewable energy increases, so does its difficulty and costs. At high deployment levels an unresolved seasonal technical problem emerges. This unresolved seasonal problem is a large energy gap that occurs when solar plus wind energy are insufficient to meet demand. Neither NREL on a national level, nor the Brattle Group (8), nor the Analysis Group (9), nor the NYSERDA Plan on a NY State level, has presented a plausible solution to this gap issue. Further, the gap issue appears to be getting worse, driven by climate change. In recent years very large wind lulls have formed which diminish, if not eliminate, wind farm contributions for extended periods of time.(7) Being subjected to the risks from wind lulls is a matter of choice. If we choose an extreme scenario, like 100% renewable energy, we are electing to put ourselves at an avoidable risk.

A. The NYSERDA Plan used solar panel capacity factors that are far higher than those presented by the New York Independent System Operator and by the National Renewable Energy Laboratory. Even if one assumes that NYSERDA used tracking solar systems, the NYSERDA selected solar capacity factors are still too high. Correcting this error in order to produce the requisite number of GWh to meet year 2050 requirements would require a very large expansion in the number of solar panels, land use, MW-miles of transmission lines, and costs. This would likely trigger even more public resistance. The NYSERDA Plan apparently also overstated the capacity factor for land based wind power. Together, these two data errors add up to an electricity capacity shortfall of 36,717 MW, almost the size of NY's 2019 electricity capacity of 39,295 MW. If no corrective action were taken, this energy shortfall would result in insufficient hydrogen being produced by excess solar energy. This would create an energy gap the following winter with the potential of causing fatalities and property damage.(Section 8 and slide 42.)

B. The NYSERDA Plan analysis only examined energy storage needs for one week in January. There may be other weeks where there are energy shortfalls, albeit smaller than the week NYSERDA chose. They too would have to be dealt with. NYSERDA should have calculated energy storage needs for the whole year, not just one week, in order to estimate how much total stored hydrogen would be needed.(Slides 43 and 45).

C. Very large and long lasting wind lulls have occurred, significantly decreasing wind power output. This does not appear to be examined in the NYSERDA Plan.(Section 6.3).

D. The NYSERDA Plan's scope is too narrow. It did not consider the cost and energy requirements to draw down and sequester carbon dioxide removed from the atmosphere or the cost and energy requirements to return the oceans to an acceptable pH level. Dealing with climate change is much more than bringing greenhouse gas releases to zero.(Section 7.0).

E. The NYSERDA Plan did not discuss the importance of establishing a well integrated energy continuum so that the point of no net GHG additions would occur as soon as possible. Energy sources, distribution networks, and the replacement of fossil fueled end uses must proceed in a co-ordinated way, not piecemeal.(Section 7.1).

F. Electricity needs and energy storage requirements are not based on the demands presented during extreme hot or cold temperatures, yet these are the times when people are at most risk. The NYSERDA Plan, instead of basing its analysis on extreme weather conditions, based its generation and storage capacities on typical, normal weather conditions. This is inadequate.(Section 9).

G. Extreme temperatures affect both energy demands and energy supplies. One must not assume that any imported electricity will be available. Air source heat pumps, batteries, electric vehicles, and even solar panels are all less efficient in cold temperatures. It does not appear that the NYSERDA Plan accounted for this. In the 2014 NY polar vortex there were a number of equipment failures and other issues, like ice formation in NY's hydropower supply. NYC avoided a Texas-like tragedy because the two nuclear units at Indian Point continued to reliably supply large amounts of CO_2-free electricity. NYSERDA needs to explain how it will maintain high reliability during extreme events now that NY State has allowed the Indian Point units to be demolished.(Section 6.3).

H. The NYSERDA Plan did not explain how NY's industrial base must change in order to manufacture, deliver, and install all the solar panels, onshore wind turbines and offshore wind turbines at a rate consistent with its schedules. How will New York erect very large numbers of huge offshore wind turbines if it does not have a single jack ship to do this? Similarly, what is process by which millions of end use devices like electric vehicles, heat pumps, charging stations, can be manufactured and delivered in a timely manner? Many people live check-to-check and others depend on welfare. How will all these clean end use devices be paid for? (Section 6.4).

I. What is NYSERDA's plan to overcome growing public resistance to renewable energy projects? If the wishes of the public, the limits of our manufacturing base, and the limits of our installation capacity are not properly addressed, the whole energy transition effort could stall out with no time left for a Plan B.(Section 6.5).

J. The NYSERDA Plan did not explain how, and at what cost, its hydrogen storage system would overcome leakage and steel embrittlement problems or how it would handle required pressures in the 10,000 to 15,000 psi range or extremely cold hydrogen around minus 253 degrees C. How does NYSERDA justify using a solar energy -> to hydrogen production -> to hydrogen storage -> to burning hydrogen, thereby making about 50% of the electricity input from the solar energy in the first place? With a round trip efficiency of 50% combined with solar panels having a 14% capacity factor, the overall efficiency of the solar/hydrogen system selected by NYSERDA would be around (.14)(.50) =0.07. Why should New Yorkers pay for a system that is only 7% efficient when much more efficient systems are available? (Section 9).

4.0 Structure of This Critique

The driving force behind the enactment of the Climate Leadership and Community Protection Act is the belief that climate change represents an existential threat to life on this planet. As such, the probability of failure to properly deal with climate change must be made as close to zero as possible. Our best science and engineering tell us that an extreme scenario, like the virtually 100% renewable energy approach in the NYSERDA Plan, does not represent a least risk pathway.

The people and their elected officials need to receive energy analyses that are agnostic, i.e., no energy source is given special preference and no energy source is excluded for political reasons. The first principal of Climate Leadership is to tell the truth, even if it means that NY State would have to rewrite some of its energy mandates.With so much emphasis on renewable energy, it is important to re-evaluate its strengths and limitations.

It cannot be overemphasized that the goal of this critique is not to attack renewable energy by identifying its limitations. Renewable energy must be part of our energy future. One goal of this critique is to prevent renewable energy development from stalling out because of growing technical problems and increasing public opposition. The path to further expansion of renewable energy is as a member of an energy family that also includes energy conservation, nuclear energy, and hydrocarbon fuels that have a zero net addition of greenhouse gasses to the atmosphere or to the oceans. This more inclusive approach leads to new opportunities with renewable energy/nuclear combinations that are not possible with either technology alone. Such energy combinations could be the basis for new industries and new jobs in NY State. An example of such a combination is provided in this critique.

In order to deal with these two energy pathways to catastrophe, three sets of energy goals are presented in this critique. These three sets of goals are a more comprehensive description of what must be done to implement the CLCPA. The first set of goals focuses on reducing the risks from climate change. The second set of goals deals with reducing the risks from insufficient energy. The third set of goals is sensitive to the needs of people, especially those who live in Environmental Justice areas. All proposed low carbon future scenarios should be evaluated using these three sets of goals. No energy scenario can get “a perfect score” on both sets of goals. However, having more “tools in the tool box” as in the Energy Family Plan (EFP), described below, gives decision-makers more flexibility to reach the best overall compromise.

Three different energy scenarios are reviewed in this critique. The first scenario is business-as-usual by continuing to burn vast amounts of fossil fuels. This scenario has the benefit of meeting sufficiency objectives. Because the business-as-usual scenario failed to protect the environment, it was rejected. Hydrocarbons, like fossil fuels, have an important place in our energy future, but only if they are made to be zero net carbon dioxide sources.

The second scenario is a 100% Renewable Energy (RE) scenario, as typified by the NYSERDA Plan. The NYSERDA Plan depends highly on variable energy sources like wind and solar energy.

The third scenario is called the Energy Family Plan (EFP). The EFP is more expansive than the 100% RE scenario because it not only includes RE, but also includes contributions from nuclear power and fossil fuels with carbon capture and sequestration (CCS). The EFP is a mix of variable energy and firm (dispatchable) energy sources. Both the 100% RE and the EFP scenarios emphasize energy efficiency and conservation (E&C), although there are some unique E&C opportunities in the EFP scenario.

This critique is divided into three main sections. First, there is a general discussion of the two pathways to climate catastrophe. This two pathways discussion is supplemented by three sets of energy goals. One set of goals deals with climate change and the other set deals with energy sufficiency. Second, the benefits and limitations of renewable energy are discussed. Third, there is a specific discussion of defects in the NYSERDA Plan. This third section also includes a discussion of hydrogen and how a new approach uses a beneficial combination of nuclear energy and renewable energy. Supplemental information can be found in the Appendices and in the References section.

5.0 Establish Three Sets of Goals

5.1 Environmental Goals

Environmental goals must have the highest priority. Three different environmental goals are listed below with goal A being most important:

A. Stop adding greenhouse gases (GHG) to the environment as rapidly as possible,

B. By 2050 or sooner, draw down the concentration of GHG in the atmosphere to levels that existed around year 1900, and

C. Restore acceptable pH levels in the oceans.

Reducing the GHG concentration in the atmosphere, Goal B, will not occur unless Goal A is achieved. It will take time and money to achieve Goal A. But as it has been pointed out in the NY Times, "The single most important fact about climate change: warming is proportional to the cumulative emissions over the industrial era." By the time we have reached the point where no more GHG is being added to the environment, the cumulative emissions would be greater than they are today and the impacts of climate change will be even more severe. This implies that we have to do two things simultaneously: stop adding GHG and remove GHG from the atmosphere as rapidly as possible. However, even this is not enough. The atmosphere and the oceans are in equilibrium with regard to carbon dioxide, CO_2. About 39% of the CO_2 released into the atmosphere has ended up in the oceans causing significant damage to many life forms and to coral reefs, etc.(10) If the CO_2 in the atmosphere were significantly reduced, the flow of CO_2 could reverse directions and CO_2 could evolve from the oceans back into the atmosphere until a new equilibrium was achieved between the atmosphere and the oceans. Such a reversal could cause the rate by which CO_2 was being depleted from the atmosphere to slow down. Consequently, in order to achieve Goal B, a net reduction of the CO_2 in the oceans must also be done simultaneously. Such a net reduction of dissolved CO_2 in the oceans would eventually lead to achieving Goal C. Implementation of these three goals would overlap each other, but their time frames differ. Achieving environmental goal C is expected to take the longest time.

5.2 Reliability Goals

A. Reliability and sufficiency. The supply of energy must be highly reliable. For example, the electric power system in New York State is designed so that the probability of a total loss of load for an hour or more during a single day is less than once every ten years. This reliability requirement should be met in all energy future scenarios.The energy system must be sufficient to meet all the energy demands of the all end use sectors during all weather conditions, with a reserve margin.

B. Cost effectiveness. Energy should be as inexpensive as possible for two major reasons. In a competitive world, countries with a low of cost energy have an advantage, leading to more jobs and greater financial security. Secondly, the cost of energy, especially electricity, is regressive. Lower income communities pay disproportionately more for electricity than more affluent communities.

C. Flexibility. Climate change introduces many new energy uncertainties in both energy supply and demand, as does population growth and decline, as do technological advances. To deal with uncertainties the energy system must be flexible enough to evolve over time.

D. Security. The energy system must be designed to survive cyber attacks and other threats like those from climate change.

5.3 Societal Goals

A. Many societal goals, like the equitable distribution of risks and benefits, would be met by a balanced implementation of Sections 5.1 and 5.2. Beyond these goals there is public consent. Every form of change produces some impact. Energy decisions should garner public consent as much as possible. Government officials must provide accurate and comprehensive information to the public on energy actions that affect them.

5.4 Overview

No one energy plan can fully meet all the above goals at the same time, so balanced compromises must be made. The best overall compromises by government leaders are expected to come when there is a diverse number of tools in the tool box, i.e., the inclusive Energy Family approach described in this report, and when analyses based on Probabilistic Risk Assessments are provided.

6.0 Will Further Growth of Renewable Energy Stall Out?

6.1 Introduction

Renewable energy has made great progress in the past decade, especially in cost reduction. However, it is widely recognized that as the deployment of renewable energy increases, so do the technical challenges and public resistance to further expansion. There appears to be a growing wall of public resistance to deploying increasing percentages of renewable energy, be it because of land use, expansion of transmission lines, use of materials, cost, reliability, health issues, impacts on wildlife, aesthetic reasons and a growing opposition to an authoritarian form of government that imposes a particular energy source structure against the will of many local people. If the NYSERDA report's 100% renewable energy approach was attempted and stalled out, critical time and resources would have been lost and this could lead to enormous damage.

Costs can be an issue. The only operating offshore wind farm in the United States is Rhode Island's 30 MW Block Island Wind Farm. The economics of that wind farm have been subject to a great deal of criticism. The existing Block Island Power Purchase Agreement (PPA) specified that utilities pay $245/MWh for its electricity. With its 3.5%/year price escalation agreement, the cost will rise to $470/MWh by 2035, the last year of this PPA. The average wholesale price for electricity in New England in 2019 was $30.67/ MWh. **Reports, like the NYSERDA report, must be totally transparent and comprehensive in reporting the costs to achieve the scenarios it favors.**

Land use can be an issue.

In one report (11) it was claimed that a high renewable energy deployment future for the U.S.would need 590,000 square kilometers, an area roughly equal to the size of Connecticut, Illinois, Indiana, Kentucky, Massachusetts, Ohio, Rhode Island, and Tennessee put together. This figure did not include the land area that additional transmission lines would occupy.

Others claim that the needed land area for the solar portion of high deployment RE future would only occupy about 0.5 percent of the USA land area.(12) Can both of these statements be true? Land use for onshore wind power was extensively analyzed in a recent National Renewable Energy Laboratory report (13) which concluded that siting wind power is significantly dependent on local attitudes and regulations. National projections of 2050 onshore wind power capacity varied from + 7% (49 GW) under the least restrictive siting regime to a decrease of 37% (270 GW) in the most restrictive siting regime. NREL has calculated that those areas that have the most restrictive land use regulations may still achieve high onshore wind power capacities by greater generation. If this greater generation is achieved by using much larger onshore wind machines, this may stir up further public resistance. Such social uncertainties are not reflected in the NYSERDA report's analysis. **The lesson for New York is, use a local consent-based approach to siting renewable energy sources or run the risk of a backlash that could cause further growth of renewable energy to stall out.**

Using New York State (NYS) as an example, to install large upstate wind and solar farms, some forests will be cut down and some food producing farms bought out. There already is considerable local resistance to this. For example, in White Plains, NY local citizens fought against installing solar panels in a cemetery because to do so would require cutting down an old stand of trees. If increasing the renewable energy contribution requires State and/or the Federal governments to become too authoritarian, people rebel. Such rejection of the States' energy plans has already begun. As reported in the Oneonta, New York Daily Star *"But a process for turbo-charging reviews of green energy projects is now under legal attack, with an assortment of rural towns, bird conservation clubs and citizen groups arguing the state government has stripped localities of sufficient time to evaluate the plans"*.(14)

6.2 **The Importance of High Energy Density**

Many of these growing technical and social challenges of all-renewable energy futures can be traced back a single inherent renewable energy property: low energy density.

Three areas where low energy density is important to renewable energy are:

- Ability to withstand the effects of climate change,
- Manufacturing and installation capacity, and
- Social acceptance

6.3 Ability to Withstand the Effects of Climate Change

In general, solar, wind, and biomass have low energy densities. Because of these low energy densities large collection areas are necessary and this precipitates a number of other problems. Per kilowatt-hour of clean electricity, renewable energy is materials intensive, land intensive, and needs more miles of transmission lines, all of which have been opposed by the public.

Large collection areas also make renewable energy much more vulnerable to climate change than nuclear power. Each U.S nuclear plant today has its reactor surrounded by a strong containment building. These robust structures have safely withstood direct hits by category 5 hurricanes, tornadoes, huge earthquakes, and local floods. Their basic designs make them "hardened" structures. The areas used by solar and wind farms cannot be hardened and not just because of the high costs to do so. To cover them over to protect them from the detriments of nature would end their ability to enjoy the benefits of nature, such as collecting low energy density wind and sunshine. As an example of this vulnerability to nature, just a small snowfall, frost covering. or saltwater spray on proposed offshore solar panels reduces or eliminates their electricity output.

In addition to renewable energy being less resilient to climate change than nuclear power, nature interferes with renewable energy in other ways. For example, in winter in New York and elsewhere, the sun sets before the evening peak demand for electricity occurs.Unless very large energy storage capacity is available, solar energy alone can not reduce peak winter demands. As space heating and hot water production become more electrified, the winter peak demand will be much higher, making the inability of solar energy to reduce peak winter electric loads a more important drawback.

Not only are there seasonal variations in solar output, but there also are geographical ones. A solar panel in New York would produce 41% less electricity per year than the identical panel in Los

Angeles. In New York fixed solar energy panels have a capacity factor of 14%. This is like having a car that only operates one day a week. The optimum mix of energy sources would be location dependent. One cannot extrapolate the role of solar energy in southern California to New York. Similarly, onshore wind power in NY State can never match the capacity factors of wind turbines sited in the Great Plains.

Large offshore wind turbines are only built to withstand category 3 hurricanes. Stronger storms, like hurricane Maria, have torn the blades off of wind turbines. Wind turbines with category 5 hurricane protection would cost more. Ice storms have collapsed electricity transmission towers and renewable energy needs more miles of transmission lines per KW-hr than firm energy sources.(Appendix B)

While extreme windstorms would have the largest impact, small variations in wind speed are important too. For example, the New York Independent Systems Operator reported *"In 2019 there were 64 instances when wind resources supplied less than 100 MW to the grid for periods of more than 8 consecutive hours. 100 MW represented about 5% of the installed wind capacity in 2019"*. (15) That was during 2019. In 2020 there were 74 such instances.

Not only does the wind vary from year-to-year, there are moment-to-moment variations as well. The electricity produced by a wind turbine varies as the cube of the wind speed. As a hypothetical example, if a wind turbine experienced a decrease in the wind speed of 10%, going from 20 m/s to 18 m/s, there would be a potential decrease in electrical output of 27%. If there were a 10% increase in the wind speed, going from 20 m/s to 22 m/s, there would be a potential increase in electrical output of 33%. Shifts in wind speeds from - 10% to +10%, in this example, would result in a potential variation in electrical output of 60%. Published data on wind turbine output have shown large output swings in comparatively short time periods. Should wind turbines be connected to batteries with the goal of producing a steadier output, frequent charging and discharging may reduce battery lifetimes well below design specifications. This shorter battery lifetime has been observed in a Texas utility that has a large wind contribution. This Texas battery life situation needs to be explored further by NYSERDA because of the huge number of batteries the NYSERDA report is counting on.

Beyond these frequent episodes of low wind speeds there are now global events that are the opposite of violent hurricanes: huge areas covered by still air over long periods of time.The creation of long duration lulls appears to be another impact of climate change. During the summer and early autumn of 2021 Europe experienced a long period of low wind speeds. The United Kingdom power company SSE, stated that its renewable assets produced 32% less power than expected. The latest Intergovernmental Panel on Climate Change report suggests that the average wind speeds over Europe will be reduced by 8% to10% as a result of climate change.(6)

Meteorologically, wind patterns are very large, much larger than the largest wind farms.This means that increasing the number of wind turbines in a wind farm is unlikely to overcome large scale wind lulls, but it could result in having a larger number of simultaneously idle wind turbines. There are indications that the frequency of large area wind lulls may be increasing as the climate changes. Both of these climate related extremes, stronger hurricanes and widespread and long-lasting lulls, challenge the ability of wind power to reliably meet a large fraction of our future electricity needs. Who knows what the wind patterns might be by 2050? This lack of knowledge adds uncertainty to large wind farm endeavors. The commitment to build a very large number of wind turbines with a specific design would have to be made well before future wind data became available.

Long duration and widespread lulls represent a potential significant risk situation. However, it should be remembered that risk significant lulls are a matter of choice. They are only important if we choose to be heavily dependent on wind power.

Nature can interfere with solar energy in other ways beside climate change. In 1815 there was a massive eruption of Mount Tambora. Enormous amounts of material was injected into the atmosphere, 1816 being known as the "Year Without a Summer."(16) The average global temperature decreased by 0.4 to 0.7 degrees centigrade because of all the airborne particles. Reduced sunlight led to massive starvation at many locations around the world. Reduced sunlight means less electricity from solar panels. Huge volcanic eruptions are rare, but not impossible. Ongoing eruptions in Tonga remind us of the great forces of nature and the need for diverse sources of energy. We have already seen a smaller version of this. Smoke from California fires impacted people as far away as the east coast. The moon appeared to have a brown/orange color while these fires were ablaze.

FIGURE A-2 is a qualitative description of technical uncertainties.(7) This figure shows that as the deployment of renewable energy increases, so does its difficulty and costs. At high deployment levels an unresolved seasonal technical problem emerges. This unresolved seasonal problem is a large energy gap that occurs when solar plus wind energy are insufficient to meet demand. As stated before, neither NREL on a national level, nor the Brattle Group (8), nor the Analysis Group (9), nor NYSERDA analyses on a NY State level, presents a plausible solution to this gap issue. Further, the gap issue appears to be getting worse, driven by climate change. In recent years very large wind lulls have formed which diminish, if not eliminate, wind farm contributions for extended periods of time.(6) Being subjected to the risks from wind lulls is a matter of choice. If we choose an extreme scenario, like 100% renewable energy, we are electing to put ourselves at an avoidable risk.

6.4 Manufacturing and Installation Capacity

This section quantifies how low energy density forces the need for huge numbers of solar panels and wind turbines in a 100% renewable energy future. This presents a variety of infrastructure challenges such as the ability to manufacture and install such large numbers of energy sources in the years that remain between now and 2040 or 2050.

6.4.1 State Level Analyses

A. **The Brattle Group.**

Table A-1 compares Brattle Group's installed NY capacities in years 2024 and 2040.(11) To achieve this 100% renewable future by 2040, an unprecedented manufacturing rate and the installation rate would have to be achieved. Areas of exceptional growth are identified with a red color.

TABLE A-1 Brattle Groups's Installed NYS Capacities, 2024 and 2040, GW

Item	GW in 2024	GW in 2040	2040/2024
BioGen	0.1	0.0	0.0
Coal	0.0	0.0	0.0
Hydro	5.0	5.0	1.0
Kerosene	0.2	0.0	0.0
Gas CC*	11.0	12.5*	1.14
Gas CT*	3.0	12.5*	4.17
Gas ST*	8.7	8.7*	1.0
Nuclear	3.3	2.2	0.67
Oil CT	1.5	0.0	0.0
Oil ST	1.6	0.0	0.0
Pumped Storage	1.2	1.2	1.0
Solar	0.1	31.7	317
Solar BTM	4.5	6.4	1.42
Storage 2 hr	1.2	8.2	6.83
Storage 4 hr	0.0	5.9	Infinity
Wind Offshore	0.6	25.1	41.83
Wind Onshore	1.7	23.3	13.71
Capacity Imports	1.1	1.1	1.0
Demand Response	1.3	1.3	1.0
Flexible Load	0.0	3.2	Infinity
RNG Production	0.0	11.6**	Infinity
Total	46.2	159.8	3.45
* Supplied by RNG, total = 33.7 GW. ** With the energy needed to produce RNG, 45.3 GW.	N/A	N/A	N/A

The Brattle Group assumed the availability of RNG, renewable natural gas, yet undeveloped. This RNG was to be used to overcome long lull periods in wind power. Not only is there no clear path today to manufacture and install 33.7 GW of renewable natural gas, the NYS overall electric capacity would have to increase by 345%. The calculated solar contribution would need to increase by a factor of 317 to reach a capacity of 31.7 GW of installed solar energy by 2040. This is to be accomplished in just the 16 years between 2024 and 2040. This seems impossible. Add to this a projected need for an onshore wind power capacity of 23.3 GW.

B. **The Analysis Group**

Further insights on the immense infrastructure challenges that lie ahead are presented in the Analysis Group's report for NY State.(9) TABLE A-2 repeats Table ES-1 from the Analysis Group's report for the generation needs for NY State by 2040 for the CCP2-CLCPA Resource Set.

TABLE A-2 Analysis Group's Generation Capacity in MW, Year 2040

Land Based Wind	35,200
Offshore Wind	21,063
Solar (Behind the meter)	10,878
Solar (Grid connected)	39,262
Hydro Pondage	3,573
Hydro Pumped Storage	1,170
Hydro Run-of-River	913
Nuclear	3,364
Imports	2,810
Storage	15,600
Price Response Demand (Summer)	5,236
Price Response Demand (Winter)	3,412
DE Resources	32,137

The Analysis Group also provided information on the New York installation rate necessary to put the above resources in place, as adapted below in TABLE A-3. The differences between historical growth rates and those needed to meet 2040 goals are profound.

TABLE A-3 New York Required Rate of New Resource Development

	Wind, Onshore and Offshore, MW	Grid Connected Solar, MW	Required Wind Growth Rate, MW/Year	Required Solar Growth Rate, MW/Year
Existing Resources (2020)	1,985	57	N/A	N/A
1.Climate Phase II Reference Case R	39,962	34,354	1,899	1,715
2.Climate Phase II CLCPA Scenario	56,263	39,262	2,714	1,960
3.Grid in Transition Reference Case	23,522	30,043	1,077	1,499
4.Grid in Transition CLCPA Scenario	48,357	31,669	2,319	1,581
Historical Capacity Growth Rate,(2012-2020), MW/Year	N/A	N/A	**71.4**	**3.1**

The Analysis Groups' term DE stands for *dispatchable* and compliant with *emission* requirements. DE is comparable to the Brattle Group's RNG, Renewable Natural Gas. Similar to the Brattle Group, how to deliver this very large component of NY's projected 100% renewable energy future has not been identified by the Analysis Group. Some have suggested that land fills and dairy wastes might be sources of RNG. Waste energy from dairy farms is very small.(17)

Both NY State studies show that the expansion of renewable energy needed to meet State goals is enormous, as is the required and unprecedented installation rate.

6.4.2 A Historical Perspective

When former Governor Cuomo first announced New York's offshore wind program with great fanfare it was described as the "world's largest wind farm". This large undertaking had a goal of 2.4 GW to be completed by 2030. As other east coast states announced their offshore wind programs, suddenly the NY program was increased to a capacity of 9 GW to be completed by 2035. The Analysis Group analysis calls for 21.1 GW by 2040 and the Brattle Group calls for 25.1 GW by 2040. The NYSERDA Plan calls for 16-19 GW of offshore wind by 2050 as shown on slide 40. However, if firm energy is not used to deal with energy gaps, an additional 17 GW of offshore wind would be needed, as shown on slide 44, bringing the total up to 33-36 GW. This is 15 times larger than what former Governor Cuomo boasted as the "world's largest offshore wind farm". New York has never built an offshore wind turbine and does not have a single specialized jack ship, at $500 million dollars each, to install offshore wind turbines. Recently British Petroleum and Equinor, two giant oil companies, filed a request with the Federal Energy Regulatory Commission, to be allowed to delay by a year and a half its installation of its Danish made offshore wind turbine, citing difficulties in obtaining key permits and government approvals.

6.4.3 National Level Analyses

A. **The Clean Air Task Force**

In addition to the infrastructure data at the state level there are infrastructure data at the national level in a report sponsored by the Niskanen Center and the Clear Air Task Force.(18) The opening paragraph in this report summarizes the infrastructure situation: *"Though the details vary, a dominant theme in decarbonization studies is that any pathway to a net-zero carbon energy system in the United States will require a staggering build-out of electricity generation and transmission, zero-carbon fuels, and carbon sequestration".*

In the above referenced report the following infrastructure estimates were made:

- More or less completely replacing the current bulk electricity system, including existing zero-carbon sources at the end of their life, by mid-century, and increasing total generation capacity from today by a factor of four, from 1,100 GW to 4,000 GW.

- Adding wind and solar at an accelerating rate, ending the 30-year period until 2050 with annual additions five times faster than today, even as the best sites are taken early. This would be a wind and solar fleet that at peak could produce three times as much electricity as all types of power plants combined can generate today.

- Adding 500-1000 GW of mostly new, clean capacity that guarantees a steady output such as nuclear, gas with carbon capture, hydrogen-fueled turbines, and long duration energy storage, up from 875 GW today.

- In doing so, expanding the total land area requires for electric generation (apart from transmission) by a factor of 13, with wind and solar taking up 590,000 square kilometers, an area roughly equal to the size of Connecticut, Illinois, Indiana, Kentucky, Massachusetts, Ohio, Rhode Island, and Tennessee put together.

- Building 100,000 km of new CO_2 pipeline infrastructure, a twelve-fold expansion, and developing hundreds of CO_2 storage sites able to store 1.3 billion tons of CO_2 per year, handling more fluid than U.S. oil production does today.

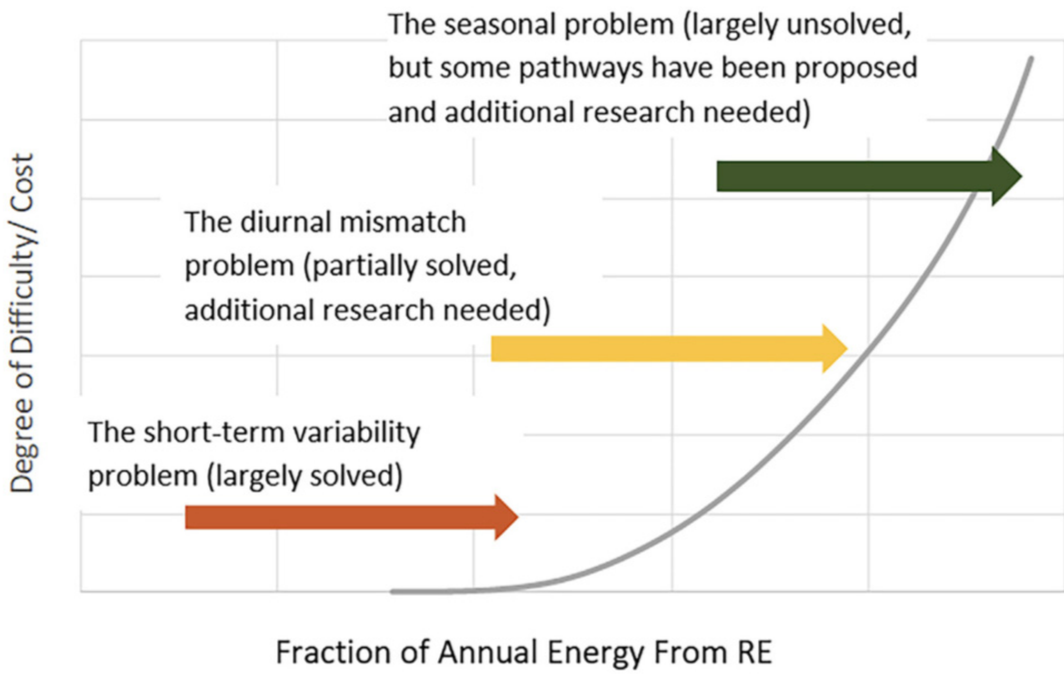
- More than tripling the capacity of the long distance U.S. transmission network, while adding tens of thousands of shorter generation ties to connect wind and solar farms to bulk transmission lines.

B. The National Renewable Energy Laboratory (NREL)

NREL's FIGURE A-2 is a qualitative description of the degree of difficulty/cost of renewable energy as a function of the fraction of deployment of RE.(7) The greater the deployment of RE, the greater the difficulty. At very high levels of deployment there are largely unresolved seasonal problems. These are the same unresolved problems identified before, such as long lasting lulls in wind energy.

FIGURE A-2 appears to be an analysis depicting increasing technical difficulty/cost with increasing deployment of renewable energy. FIGURE A-2 may be misinterpreted by some, believing that RE difficulties will not begin until around the 80% RE deployment level. However, there are other sources of difficulty besides those caused by technological issues. These additional issues relate to social values and to infrastructure issues and these issues are being raised now. Land area issues are a growing concern and the NREL has revised downward the amount of land that might be available for RE Projects in locations with public opposition and restrictive siting regulations. Net metering subsidies for homeowners with rooftop solar panel systems are now being challenged in that lower and middle income citizens who do not own a house are ending up subsidizing higher income people with houses through surcharges in their electricity bills.

FIGURE A-2 Fraction Annual RE vs. Degree of Difficulty/Cost



In 2020 renewable energy contributed 19.8% of the nation's energy of which wind was 8.4% and solar 2.3%. Hydropower, which may have already reached its maximum contribution was 7.3% and biomass was 1.4%. Many low carbon energy future studies look to solar energy and wind energy (mostly offshore) to be the main sources of additional renewable energy in the future. Together, wind + solar today add up to 10.7% of the nation's energy today. Yet, already there is increasing push back against further expansion of these two renewable energy sources. Objections to renewable energy are largely centered around significant land use, opposition to large increases in the transmission network, high costs for renewable electricity, aesthetic objections, and health concerns. Further, resistance to wind and solar energy has been expressed by people concerned about the need for massive amounts of concrete and steel and a national security issue of depending on other countries for rare metals used in wind turbines. These difficulties are already happening in the zero to ten percent deployment range in FIGURE A-2, and are likely to worsen as RE deployment increases.

Enormous numbers of solar panels and wind turbines will need to be built and installed at an unprecedented rate by year 2040. Like land use issues, these infrastructure challenges are starting at deployment levels well below the 80% mark.

6.5 Social Acceptance and Clean Firm Power

Land use is a source of contention for renewable energy, but there are other social acceptance issues. A 100% renewable energy future requires a large expansion of the number of MW-miles of transmission lines. Historically, expanding transmission lines has often met with considerable public resistance. Unfortunately people often consider having adequate electricity as a civil right and then turn around and resist the additional nearby transmission lines needed to have such adequate electricity. For years NY State talked about an "Energy Highway", a high voltage direct current system meant to bring upstate renewable electricity to the NY City area. There was considerable public resistance to this idea, especially in the more densely populated areas in downstate New York, and this idea was allowed to quietly fade away.

More recently NY State has sought again to expand its transmission capacities. One can hope that these latest efforts will succeed. However, Riverkeeper already is on record in its opposition to the CHPE, the Champlain Hudson Power Express, because major portions of this transmission line would be placed along the bottom of the Hudson River.

This New York experience is far from unique. In Shasta County, California the County's Planning Board unanimously voted on June 23, 2021 to reject the Fountain Wind project citing the project's impact on the environment, the scenery, and the long-term harm it would do to the area's economy.(18)

It is noted that this resistance to wind power has occurred in New York and California, two states which claim to be leaders in renewable energy. Since 2015, according to published media stories, about 300 government entities across the nation have moved to reject or restrict wind energy projects.(19)

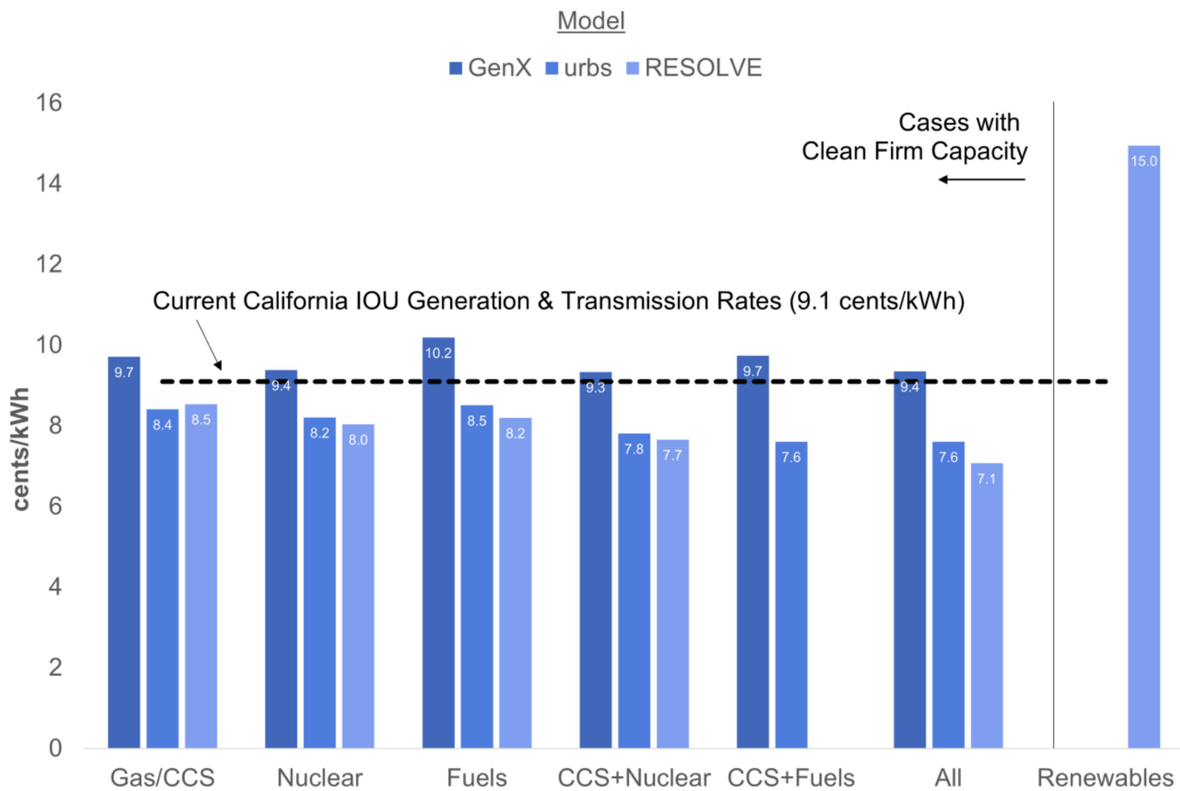
The cost of electricity, land use, and miles of transmission wires are all important social issues. All would be reduced by adding clean firm power. Clean firm power is nuclear energy, fossil fuel energy with carbon capture and sequestration or combinations of both. Once clean firm power is added the energy mix is no longer 100% renewable energy. Stated differently, the needs and wishes of the public are better served by an Energy Family approach.

A major step in analyzing the value of adding firm energy are analyses of possible California energy futures published by the Clean Air Task Force (CATF). See TABLE A-4.

TABLE A-4 Summary of Issues Related to the Need For Clean Firm Power

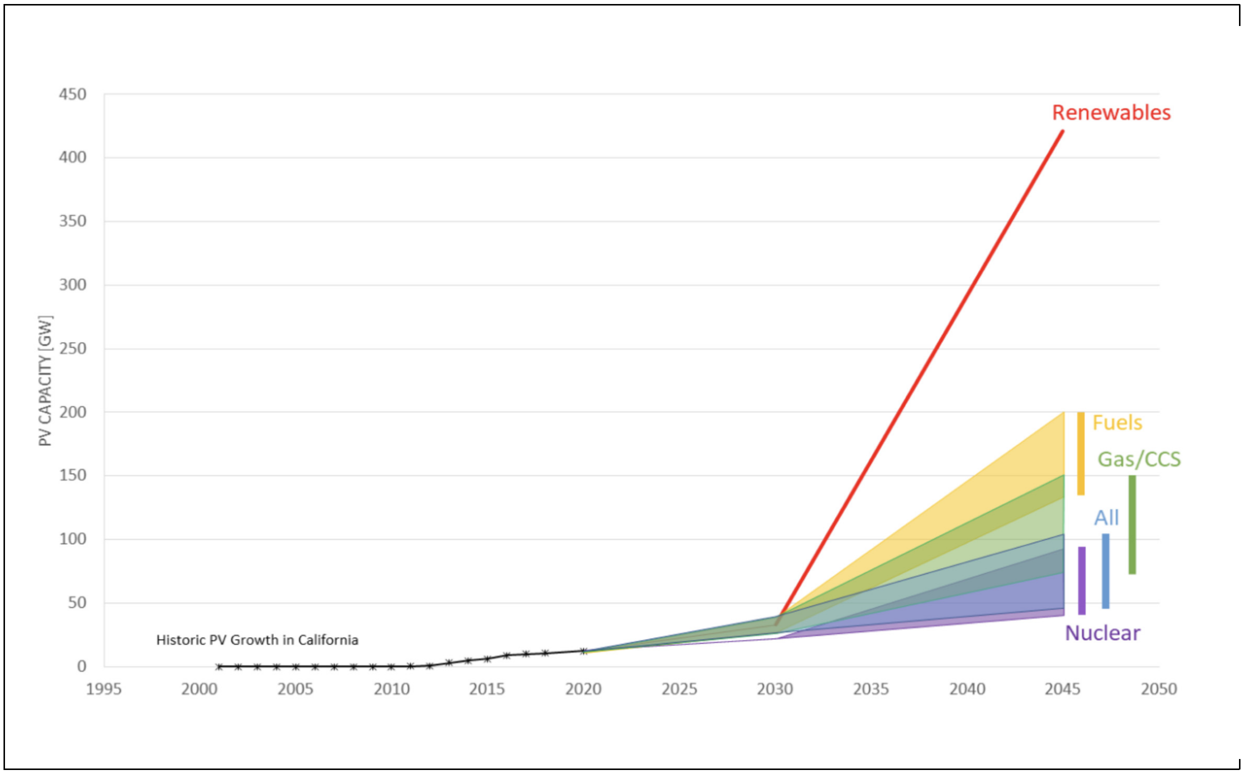
California Firm Power Issue	With Firm Power	Without Firm Power
Cost for Generation and Transmission	~9 cents/KWh	~15 cents/KWh
Solar and Wind Capacity	25-200 GW	470 GW
New Short Term Battery Capacity	20-100 GW	160 GW
New Energy Storage	100-800 GWh	1,000 GWh
Land Use	625-2,500 square miles	6,250 Square Miles
Transmission	2-3 Million MW-miles	~ 9 Million MW-miles

FIGURE A-3 California Generation and Transmission Rate



The Clean Air Task Force produced FIGURE A-3. It showed many scenarios which are not 100% renewable energy are far more economical than the 100% renewable energy scenario.FIGURE A-4 also was produced by the Clean Air Task Force. Its message is similar to that in NREL's FIGURE A-2 in that both show rising difficulties as the deployment of RE increases.

FIGURE A-4 Growth of Photovoltaics



The addition of clean firm energy in the CATF scenario marked an important improvement, but it did not go far enough.

6.5.1 Further Improvements in the CATF Analysis

A. Nuclear power and fossil fuels with CCS are treated as "corrective actions" to make significant improvements over a 100% renewable Energy future. However, the value of nuclear power and net zero fossil fuels is far greater than this role. In the CATF report nuclear power is treated much like today's gas peaker plants: only operating at times of peak demand. The CATF report assumes that these nuclear plants would only operate 2% of the time. Because of their high capital costs and low fuel costs, nuclear plants are run in a base load configuration, often achieving capacity factors larger than 90%. While better than the 100% renewable energy scenario, using nuclear power in a peaker plant mode is in poor economics. A simple improvement might be to expand the use of these nuclear plants to make hydrogen in exactly the same manner that the NYSERDA report assumes can be done by using excess solar energy to generate and store hydrogen. This approach would reduce the number of GW of nuclear needed, but would entail the construction of a hydrogen storage system similar to what NYSERDA has proposed. An economic analysis would be made to determine the lowest cost configuration of fewer nuclear plants but with increasing the volume of the hydrogen storage system, plus additional hydrogen to electricity turbines. If the nuclear plants and hydrogen gas turbines were co-located near salt caverns now used by the natural gas industry and sufficient water was available to make hydrogen by the electrolysis of water, hydrogen distribution issues would be simplified.

B. The CATF report suggests about 30 GW of nuclear power and/or net zero fossil fuels be built to be available when the renewable energy deployment reaches such high levels that the cost increases non-linearly. A 30 GW addition of nuclear power is a very large undertaking, just for one State, California. If this 30 GW were to be comprised of a series of one GW nuclear plants, then, on average, about 3 new, one GW, nuclear plants would have to become operational every two years until 2040. There is no nuclear program in place today to accomplish this for California, let alone the rest of the country. It appears that the CATF report is implying that in order to make renewable energy more attractive to the public at the higher deployment levels, a major and rapid increase in nuclear power would be needed. Similar comments apply to fossil fuels with CCS.

C. If California were to build 30 GW of nuclear power plants, it should operate them as soon as possible. The sooner these nuclear plants start operating, the greater the decrease in GHG releases as the nuclear plants replace gas electric power plants. Rapid development of nuclear power minimizes the number of millions of tons of CO_2 equivalent now being released by California’s gas plants and the methane leakage from this fossil fueled system that was replaced by the nuclear plants.

D. The CATF report ignores the importance of preserving the Diablo Canyon nuclear facility. It is inconsistent to talk about a large expansion of nuclear power in California and be silent about the loss of California’s present largest source of carbon-free electricity. Rapid development of nuclear power and renewable energy sources enhances the creation of combinations of these energy sources which can be superior to renewable energy sources acting alone.

An interesting observation appears on page 7 of this CATF California analysis report: “*An ambitious but achievable investment in clean firm power with a capacity on the order of California’s gas fleet could, on the upside, eliminate the need for* ***10 times that amount of renewable energy***”. (Emphasis added). Reducing the need for new infrastructure is consistent with meeting the goals of the CLCPA. Even though the data in TABLE A-4 do not represent an optimized use of firm power, it supports the conclusion that a broader, more inclusive, approach is superior to any extreme scenario like 100% renewable energy.

As supported by FIGURE A-3 and TABLE A-4 of this critique, there are RE plus firm energy scenarios which have much lower costs, require far less land, fewer megawatt-miles of transmission lines, and lower short term battery costs than a 100% RE scenario. Clearly these scenarios are superior to the 100% RE scenario and they are much more in line with the goals of the CLCPA.

7.0 Narrow Scope

7.1 The Need for an Energy Continuum

The scope of the NYSERDA Plan is too narrow. In order to reduce GHG releases as rapidly as possible, the NYSERDA Plan has to consider strategies that support a well integrated clean energy continuum. An energy continuum starts at the sources of energy, proceeds through the various distribution networks and connects to a myriad of end use devices. For optimum results, all the segments of this energy continuum have to proceed in harmony with each other. For example, there is no value for a utility to offer clean electricity to a homeowner who does not have the financial means to replace his fossil fueled space heating system. Department of Energy studies show that many people already have difficulty paying their energy bills. It is insufficient to concentrate on clean sources of electricity when, in NY, over 80% of the GHG are emitted by the end use devices. Returning to the heat pump example, if there are financial and/or physical barriers to installing all the heat pumps the NYSERDA Plan relies on, then this NYSERDA report needs to identify such barriers and offer strategies to overcome such impediments. Otherwise, the pace at which GHG releases can be reduced will be slowed down. NYSERDA has to identify all the installation barriers, such as not having jack ships to install offshore wind turbines.

7.2 PRAs

The analytical methods used in the NYSERDA Plan are outdated. It is commonplace now when analyzing high consequence, low probability events to use Probabilistic Risk Assessments (PRAs). PRAs examine many different scenarios and display outcomes with an expected mean value and with an uncertainty band. The consequences of failing to prevent the worst impacts of climate change are immeasurably large. Therefore it is imperative to select scenarios whose probability of failure is as close to zero as possible. Even those scenarios with very low failure probabilities have uncertainty bands. It is important to know which scenarios have the greatest uncertainties and what factors drive these uncertainties. Decision-makers are far better informed with this level of information. The NYSERDA Plan does not provide an assessment of its probability of failure or the range of uncertainties in its analysis. Consequently the NYSERDA Plan does not provide decision-makers with as much information as more modern analysis technologies would.

100% RE scenarios face multiple types of uncertainties. This critique discusses technical uncertainties in manufacturing and installing enormous numbers of RE systems, uncertainties introduced by climate change itself, and social acceptance uncertainties. These uncertainties might be incorporated into a PRA analysis and they certainly were not included in the NYSERDA analysis.

7.3 Beneficial Combinations Ignored

The 100% RE approach foregoes valuable RE + firm energy combinations. As an example, this critique provides readers with a section on how present hydrogen deployment obstacles can be overcome with a beneficial combination of RE and nuclear energy. Such a combination would not be possible using RE or nuclear energy alone.

8.0 NYSERDA Data Errors

8.1 Wrong Capacity Factors

Fundamental to the determination of how many solar panels and how many onshore wind turbines will be needed for a low carbon future in NY State is the measured capacity factors of these renewable energy systems. These data can be obtained from NYISO's Power Trends reports. The table below compares NYISO's capacity factors for solar energy and onshore wind to NYSERDA's capacity factors and computes the shortfall in capacity due to the NYSERDA errors.

TABLE A-5 Comparison of the NYSERDA and NYISO Capacity Factors

	NYSERDA Report	NYISO	Capacity Shortfall, MW	Revised NYSERDA Slide 40, Scenario 3, MW
Solar	0.219	0.140	34,175	94,738
Onshore Wind	0.325	0.260	2,542	12,728
Total Shortfall	N/A	N/A	36,717	107,466

To put this in perspective, this total shortfall of 36,717 MW can be compared to the total installed NY capacity of 39,295 MW in 2019. These basic errors are almost as large as the whole generating capacity of New York State in 2019. This also means that the NYSERDA slides 42,43, and 45 are incorrect. If the incorrect solar and onshore wind capacities listed in NYSERDA slide 40 were installed, large shortfalls in electricity production would happen. On the other hand, to prevent a dangerous shortfall, 34,175 MW of additional solar panels would have to be installed as well as 2,542 MW more of onshore wind. Costs, land use, MW-miles of transmission lines, and public opposition would similarly rise.

Supporting Analysis:

1. NYSERDA slide 40, installed capacity in 2050, Scenario 3: Solar 60,563 MW, onshore wind 10,166 MW. NYSERDA slide 41, Energy Production in 2050, Scenario 3: Solar 115,982 MWh, onshore wind 28,971 MWh.
2. NYSERDA solar capacity factor, (115,982 GWh)/[(60,563 MW)(8,760 hours)] = 0.219,

By comparison, NYISO's measured solar capacity factor for NY = 0.140

3. NYSERDA's onshore wind capacity factor,(28,971GWh)/[(10,186 MW)(8760 hours)] = 0.325,

By comparison, NYISO's measured onshore capacity factor for NY = 0.260 and the average capacity factor for the past 11 years is somewhat less at 0.25.

4. The NYISO capacity factors derived from NYISO Power Trends 2019, page 26.

8.2 Comparison of the NYSERDA and NREL Solar Panel Capacity Factors

In addition to comparing NYSERDA solar capacity factors to NYISO, it is possible to compare NYSERDA to data presented by the National Renewable Energy Laboratory (NREL) by using their PVWATTS online calculation tool. This NREL tool provides capacity factors for different locations across the county and for five different types of solar arrays. The solar array is NREL's standard 4 KW design which has an area of 25 square meters (269 square feet). To represent all of NY State, three locations were investigated: Rochester, Ithaca, and New York City. Results are presented in TABLE A-6.

TABLE A-6 NREL Solar Capacity Factors Across New York, Percent

City	Fixed, Open Rack	Fixed, Roof Mounted	One Axis, Tracking	One Axis, Backtracking	Two Axis, Tracking	KWh per Year, Fixed Rack	Dollars Saved
Rochester	13.7	13.3	15.7	15.7	18.9	4,812	$516
Ithaca	13.6	13.4	15.4	15.4	18.5	4,762	$439
NYC	13.6	13.3	15.4	15.4	18.5	5,251	$1,219

None of the NREL solar panel capacity factors at any of the above locations in New York is as large as the capacity factor used by NYSERDA. Further, solar systems with tracking cost more, and because of their moving parts which are exposed to the weather year after year, are likely to have higher maintenance costs than fixed systems.

The two-axis tracking design produces more electricity than the open fixed rack system, but usually is impractical. As pointed out by Solar Reviews, it would be more cost effective to purchase more fixed ground mounted capacity than to invest in a double axis tracking system. (20)

TABLE A-7 compares recent prices for different solar system types.

TABLE A-7 Representative Cost Comparison

Solar System Type	System Cost	Annual Energy Savings	Estimated Payback Period, Years
Fixed Ground Mounted System	$14,625	$1,100	13.3
Ground Mounted System With Single Axis Tracker	$22,125	$1,430	15.5
Ground Mounted System With Double Axis Tracker	$29,625	$1,540	19.2

The estimated payback period was calculated by dividing the system cost by the annual energy savings. If a present worth analysis were used, assuming a constant cost per KWh for electricity, the estimated payback period would be longer. With greater maintenance costs, the payback period for the double axis system may exceed its design lifetime. **On this basis, NYSERDA should have used the NYISO solar system capacity factor of 0.14.**

8.3 Conclusions

The solar capacity factor used by NYSERDA is about 50% larger than what both NYISO and NREL have used for New York. This is a very large difference. The difference between the NYSERDA Plan solar and onshore wind capacity actors is close to the total electricity production in NY State today, from all sources.

Using a capacity factor of 0.14 to achieve the GWh of solar energy presented in NYSERDA's slide 41 (115,982-125,295 GWh) would increase the needed land area, the number of required solar panels, the MW-miles of transmission lines, and the cost of electricity. Public opposition would also likely increase.

Another impact of these capacity factor errors shows up in NYSERDA's slide 42. Keeping the total solar capacity as originally presented by NYSERDA, far less electricity would be produced at the 0.14 capacity factor level. This would reduce/eliminate any summertime excess solar energy production. This, in turn, would reduce the amount of hydrogen generated, putting NY into an energy gap situation the following winter. As warned before, the combination of insufficient energy and extreme temperatures, hot or cold, could cause fatalities and property damage.

These capacity factor errors invalidate all of the NYSERDA report's analyses and conclusions.

9.0 NYSERDA Modeling Errors

9.1 Introduction

The NYSERDA's method of determining the adequacy of New York's electrical grid is a departure from decades of careful analysis by NYISO and others. NYISO projects what the peak electricity demand in the future might be and continuously updates this analysis as additional data become available. NYISO then adds a reserve margin of capacity to offset unforeseen losses in electricity generation and/or transmission and unanticipated increases in demand. NYISO then takes a further step to protect New Yorkers by establishing a quantitative reliability criterion, the LOLE, or Loss-of-Load-Expectation. For years NYISO has set LOLE at 0.1/year. This means that a blackout condition should not occur more frequently than a one day loss-of-load every ten years. A loss-of-load for even one hour is considered an event day when estimating LOLE. The NYISO practices have served New Yorkers very well and the NY grid, so far, is one of the most reliable grids in the nation.

At this time New York State is a summer peaking area. With the growth of air conditioning over the past few decades, the highest electricity demands occur on the hottest days. NYISO has continuously prepared for this by providing adequate generation and transmission capacities, with a reserve margin. However, all this is in the process of changing because New York is projected to become a winter peaking area. This shift to a winter peaking area is a consequence of trying to deal with climate change. In order to deal with climate change, the emissions of man-made (anthroprogenic) greenhouse gases (GHG) must be reduced to low or even zero values by mid-century. This is to be accomplished by eliminating or offsetting the burning of fossil fuels in the generation of electricity and in all the end uses in the transportation, residential, commercial, industrial, and agricultural sectors.

Replacing our electricity sources and all of our end use devices to be carbon-free is a huge task. However, even this task does not fully address climate change, as described below.

9.2 The NYSERDA Grid Design is Inadequate for Extreme Events

The NYISO approach to establishing the adequacy of the electricity system has been to estimate what the peak demand might be, add a reserve to that figure, and monitor it against a conservative reliability criterion. However, the impact of climate change requires a re-examination of what constitutes a peak demand situation. Extreme temperatures, both hot and cold, are happening more frequently and for longer durations. This situation is reflected in NYISO's recent 2021-2030 Comprehensive Reliability Plan (3) where the effects of extreme heat were analyzed. This NYISO report showed that within this decade statewide temperatures in the mid-to-upper level 90s could cause the electrical grid in New York to be unable to deliver enough electricity in a reliable manner. At the other temperature extreme, is the tragic event in Texas in January, 2021 where a polar vortex led to an estimated 702 fatalities and close to $200 billion dollars worth of damage.

There are many uncertainties in predicting future energy systems, but one thing is certain: if there is an electricity shortfall during a time of extreme heat or cold, some people will likely die.

The NYSERDA grid design is based on using low or no CO_2 emitting end uses, like electrified transportation and space heating, to meet electricity demands during the coldest week in January for a typical winter. However, the energy demand for a week in a typical winter is not the same as the peak demand that could occur during a polar vortex event. To match the well proven NYISO approach, **the NYSERDA report should estimate the peak demand during polar vortices and during extreme heat for the year 2050 when many of our end use devices would be electrified, add a reserve margin, and utilize the LOLE criterion.**

As part of this analysis of designing for extreme events, NYSERDA should not assume any imported electricity during either hot or cold extreme temperature events. For polar vortex events. NYSERDA should account for the decrease in the coefficient of performance in air sourced heat pumps; the decrease in battery output; the increase in demand from electric vehicles so that their driving ranges were not reduced by lower battery efficiency and use of electricity from the battery to heat the passenger cabin; and a decrease in solar panel output of about 0.26% per degree F relative to standard temperatures. NYSERDA also needs to examine the impact of extreme hot temperatures on the efficiency of air conditioners, thermal power plants, and transmission lines. Extreme temperatures can cause equipment failures, such as stuck valves as was observed in a previous polar vortex in New York. Extreme temperatures cause increases in demand for electricity and decreases in the supply of electricity.

In addition to extreme heat and cold made more frequent and longer lasting by climate change, there is a third emerging climate caused event. NYSERDA needs to account for widespread, long duration lulls in wind power, as recently occurred over all of England. In the NYSERDA 100% RE system a widespread, long duration lull like what happened over England would be devastating if it happened in the winter when the solar contribution is very limited and poorly timed to meet peak winter demand which occurs after sunset.(9) Such a winter lull could eliminate both offshore and onshore wind power at the same time because of the huge size of such lull patterns. **NYSERDA meeds to account for widespread, long duration lulls.**

However, widespread, long duration wind lulls in warmer times of the year could also present problems, even though a smaller contribution from wind power in warmer weather is expected compared to wind's winter contribution. In the NYSERDA analysis it is postulated that during warmer time periods excess energy from solar panels would use electrolysis to generate hydrogen. This hydrogen would be stored until converted back into electricity during times when wind + solar fell short of meeting energy demands. NYSERDA assigned a 50% round trip efficiency for this solar energy -> into hydrogen and then -> back into electricity process. It appears that NYSERDA is counting on 21% efficiency out of its solar panels but relying on tracking solar systems. With tracking solar energy panels the overall efficiency of this hydrogen storage system would be (0.50)(0.21) = 0.105 or 10.5 percent, which is inefficient. If having a huge number of tracking solar panels is not feasible and fixed position solar panels with their 14% capacity factors, in New York are used, this hydrogen storage system would have a meager overall efficiency, just 7%.

Slide 42 of the NYSERDA report shows a Typical Spring Week in 2050 (as if anyone today knows what a typical spring week in 2050 might look like). This slide shows excess generation of solar energy and has an insert stating "Excess renewable energy can be used to produce hydrogen or charge another long duration solution". **This other long duration solution in the NYSERDA report is undefined.** In slide 42 there is energy contribution from both onshore and offshore wind power. However, if there was a long duration and widespread wind lull during this warmer time period, both onshore and offshore wind contributions likely would not be available. In such a case the excess solar energy normally used to make hydrogen for later use would, instead, have to be used to meet ongoing demands for electricity. This, in turn means that there could be insufficient long term hydrogen storage for the following winter months. So a widespread, long duration wind lull in the summer could lead to energy shortfalls the following winter. **Therefore long term lulls in wind power, be they in winter or summer, could create an energy tragedy similar to what happened in Texas. Overall, the NYSERDA analysis does not appear that to have analyzed the adequacy of its grid design to meet extreme events.**

9.3 Hydrogen

The physical and chemical properties of hydrogen produce significant engineering challenges. The energy density of hydrogen is very low. In order to have an attractive energy density, either hydrogen has to be compressed to very high pressures in the 10,000 to 15,000 psi range or cooled to extremely low temperatures, like minus 253 degrees C.(FIGURE A-5). As shown in TABLE A-8, hydrogen compared to various hydrocarbon gases, represents a much greater fire/explosion risk because of its much wider ignition range and higher flame speed. Hydrogen embrittles steel and hydrogen would be more likely to leak out of piping and storage systems than hydrocarbon gases because its molecular size is much smaller.

There are multiple ways to make hydrogen. Today, almost all hydrogen is produced by a steam methane reforming process. However, this process releases CO_2 and therefore is unacceptable in a low carbon future. Hydrogen also can be manufactured by the electrolysis of water using electricity from RE and/or nuclear power. High temperature methods, under development, may also produce hydrogen from water. This appears to be an opportunity for high temperature liquid metal cooled or helium gas cooled nuclear power designs. So nuclear power potentially has two basic methodologies to generate hydrogen from water.

So the central challenge for hydrogen systems is not in the generation of hydrogen, and the cost for electrolyzers is expected to decrease. The larger hydrogen problems lie in the storage and distribution of hydrogen.

The number of miles of hydrogen pipe systems is very small compared to the natural gas piping network. A number of proposed hydrogen piping distribution systems try to replicate the natural gas distribution system, i.e., generate hydrogen in one or more locations and then distribute this hydrogen to end users spread out over many locations. This ended up, in one design, with 1.61 inch diameter pipes with thick steel walls so that high pressures could be maintained. This creates a variety of problems. Storage would be necessary, as it is in natural gas systems, to deal with varying loads and varying supplies. In natural gas systems large diameter pipes, up to 48 inches in diameter, connect to their storage systems. To match the 48 inch pipe flow area with small diameter hydrogen fill pipes, 1.6 inches in diameter, would require close to 900 such small pipes.

This approach is the opposite of the successful designs that have been used in refineries where co-location of hydrogen production and hydrogen use have minimized the need for piping systems.

Further, if the hydrogen can be used directly, then there is no need to use the hydrogen to generate electricity. Then there is no need to buy hydrogen burning turbines to generate electricity.The need for hydrogen storage is minimized if the hydrogen production and hydrogen consumption have similar time distributions.

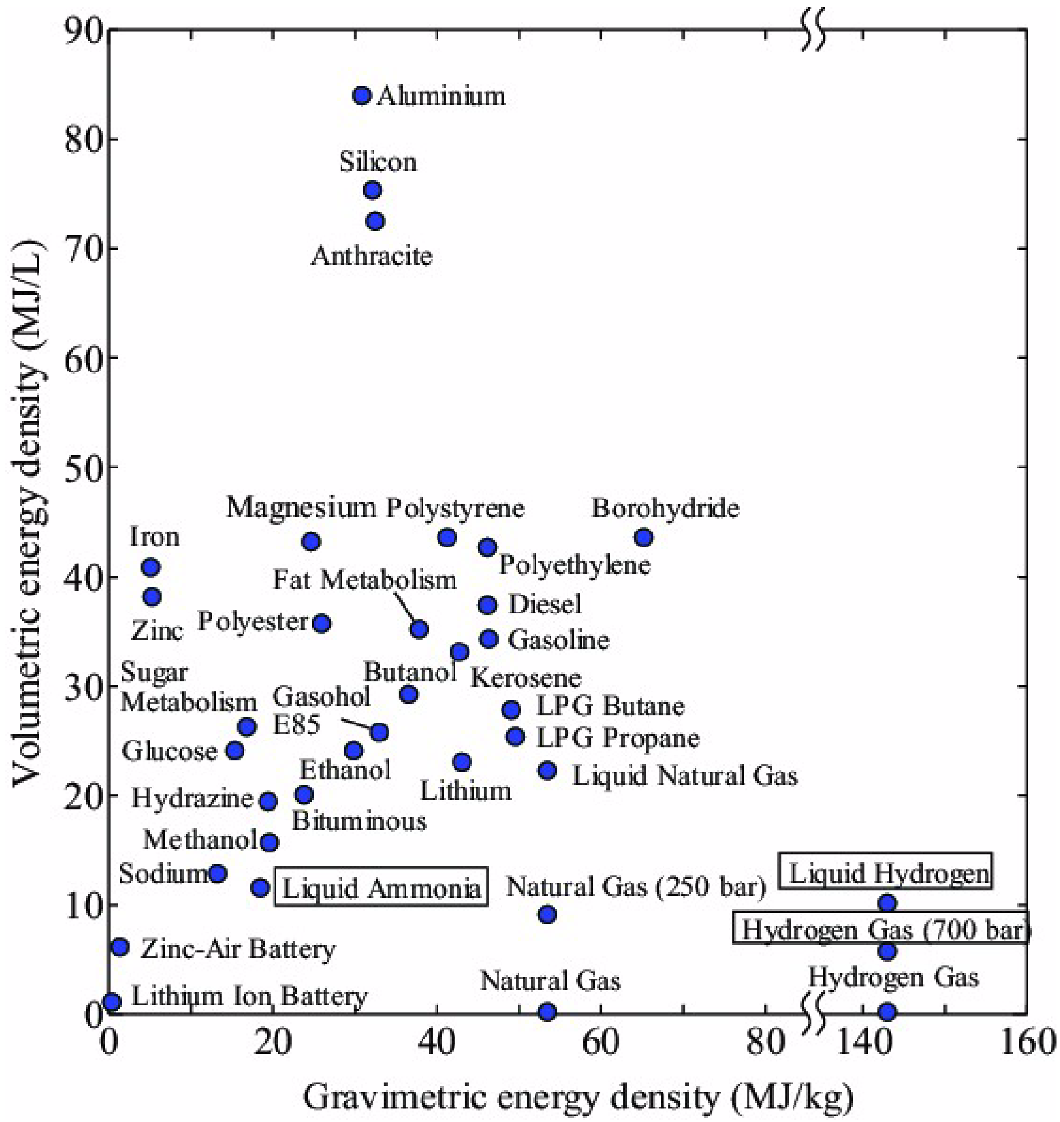
The NYSRDA plan does not provide details on the hydrogen system it relies on. To be credible, the NYSERDA report needs to explain how it would overcome all these hydrogen challenges as well as the very unattractive low overall efficiency of solar electricity -> to hydrogen ->and back again -> to electricity it is promoting. How does NYSERDA plan to store hydrogen for long periods of time? What would be the leakage during this period of time? If cooled to very low temperatures, how much energy would be required to maintain such low temperatures? How might the system be affected by embrittlement?

Solar and wind farms in the NYSERDA Plan would be spread out across NY State. This eliminates efficient arrangements where the source of hydrogen and the end user of this hydrogen would be co-located. Instead, these solar and wind farms would need to transmit their electricity to a centralized hydrogen production facility where the hydrogen would have to be stored for an extended period of time and then converted back to electricity. This hydrogen-generated electricity would then have to be transmitted to the end user. This RE/hydrogen system may require even more transmission lines. This arrangement appears to be opposite to the hydrogen applications that have been successful.

TABLE A-8 Physical Properties of Hydrogen

Property	Hydrogen	Comparison
Density (Gaseous)	0.089 kg./ Cubic Meter @Zero Degrees C, 1 Bar	1/10 of Natural Gas
Density (Liquid)	70.79/Cubic Meter @ -minus 253 Degrees C, 1 Bar	1/6 of Natural Gas
Boiling Point	-252.76 Degrees C, I Bar	90 Degrees C Below, LNG
Energy per Unit of Mass	120.1 MJ/kg	3x That of Gasoline
Energy Density (Ambient Conditions)	0.01 MJ/L	1/3 of Natural Gas
Specific Energy (Liquefied)	8.5 ML/liter	1/3 of LNG
Flame Speed, cm/sec, At Stoichmetric Conditions	170	38.3 Methane 40.6 Ethane 42.3 Propane 58.8 Carbon Monoxide,
Ignition Range	4-77% in air, by volume	6x wider Than Methane
Autoignition Temperature	585 Degrees C	220 Degees C for Gasoline
Ignition Energy	0.02 MJ	1/10 of Methane

FIGURE A-5 Volumetric and Gravimetric Energy Densities



9.4 The NYSERDA Grid Design is Inadequate for Projected 2050 Normal Events

Even though the NYSERDA analysis apparently did not address extreme events, it did attempt to deal with an energy gap that might manifest itself during a typical peak winter week in January, 2050. This analysis of typical situations as projected for 2050, also may be inadequate. Slide 43 displays NYSERDA's calculation model on how much energy storage is needed, with a reserve margin, to get through a week long period of low solar and wind production. However, there can be other weeks in the winter which also have shortfalls in their electricity production relative to that week's demand for electricity. Even if the shortfalls in these additional weeks are not as severe as the single week selected in slide 43, they would still need to able to draw upon long term storage. **The amount of energy needed to for long term storage requires a full year's analysis, not just one week's worth.**

NYSERDA recognizes there can be seasonal energy shortfalls. Various consulting groups have also come across this energy gap issue in their 100% renewable energy analyses and none have specific technologies to solve it at this time.The Brattle Group, in its analysis of New York's low carbon future used a term called RNG, Renewable Natural Gas. The Analysis Group used a term called DE, standing for dispatchable, emissions-free energy, and the NREL, in its Joule report(15), acknowledged that it did not yet know how to solve seasonal energy problems in 100% renewable energy scenarios.

NYSERDA provided two possible responses to possible seasonal electricity shortfalls, as shown in slide 44.

One response would use 25 GW of zero-carbon firm capacity. The other, all renewable energy, response would use 17 GW of offshore wind power +9 GW of solar + 31 GW of 100-hour long duration energy storage. This long duration storage, LDS, would be in the form of hydrogen.

The ability to add 17 more GW of offshore wind power is discussed in Section 6.4.2. It seems implausible. This all renewable energy option also relied on using hydrogen, as discussed in Section 10.3.

9.5 NYSERDA's Alternative Approach to Dealing With RE Shortfalls

The NYSERDA report's alternative to dealing with RE Shortfalls is to have 25 GW of zero-carbon firm capacity. Yet this major source of clean energy is only scheduled to operate 1-2% of the time, i.e., to act as clean energy peaker plants.(See slide 41). If one assumes that new nuclear power cost $6 billion dollars per GW, then 25 GW of zero-carbon firm capacity would cost $150 billion dollars which would be paid for by the public. How can one justify having a $150 billion dollar investment be inactive except for brief periods of time? Other studies presented in this critique show that significant savings can be achieved when firm energy displaces RE. **Such a wasteful, inefficient arrangement would raise the cost of electricity for everyone and would be particularly harmful to low and middle income citizens and inconsistent with the goals of the CLCPA.**

Once it is recognized that the NYSERDA 100% RE scenario is inferior to a mix of RE plus firm energy, two immediate actions that should be taken: (1) NY State's 100% renewable energy mandate should be replaced. This mandate should be rewritten to read "100% Clean Energy", where "clean energy" includes renewable energy, nuclear power, and fossil fuels with CCS, and (2) The eventual mix of variable energy sources with firm energy sources should be determined by finding the best overall compromise among the three sets of goals presented in Section 5.

9.6 Additional Issues With the NYSERDA Report

1. Even if all the graphs and tables in the NYSERDA report were correct, this report is significantly incomplete. There is no analysis to determine if NY's industrial base can produce all these solar panels and wind turbines rapidly enough or if they can be installed rapidly enough to meet CLCPA goals. As one example of how important this is, consider the installation of

offshore wind turbines; a task NY State has never accomplished. Unless NY State decided to only use floating offshore wind turbines it will need large, specialized vessels called jack ships. There are no jack ships in the United States at this time, but two are under construction. One, a 472 foot long vessel, costs about $500 million dollars and has an estimated construction time of three years. This is a very large ship and not all shipyards might be capable of building ships of this size. Smaller jack ships may not be able to install the super large offshore wind turbines that have higher capacity factors. One of the largest jack ships to go into service off of England's east coast was built in China. China also has one of the world's largest facilities for constructing the very large cranes needed to lift the heavy nacelle and turbine blades into place. So, even if New York could manage to build large offshore wind turbines, these wind turbines might sit idle on a wharf waiting years for a jack ship to install them. Unless it is repealed, New York would have to be compliant with the Jones Act which controls certain activities of merchant ships. Meeting this law could greatly slow down the installation of offshore wind power. The construction of a second smaller jack ship, 260 feet long, the Eco Edison, was just announced. This second vessel is to be delivered by 2024 and would be built in the United States. It is not clear if this smaller jack ship can handle very large offshore wind turbines. The huge 15 MW wind turbine to be built by Empire Offshore Wind, a joint venture of British Petroleum and Equinor, two oil giants, will use the Vestas design. Vestas is a Danish company and Equinor, formerly Statoil, comes from Norway.

2. There are significant differences between the Phase 2 Climate Impact and Resilience Study performed by NYISO and the NYSERDA report. These differences need to be justified.

3. Slide 40 of the NYSERDA report calls for 61 to 65 GW of solar energy. Assuming tight packing of 4 acres per MW the area needed is acres or about 406 square miles. The five boroughs of New York City is 302 square miles. Even under a tightly packed configuration an area somewhat larger than twice the size of New York City would be required. A more realistic analysis would account access roads and support infrastructure one would need 6-7 acres per MW. This translates into an area of 609 to 711 square miles, over twice the size of the City of New York. Additional land area would be needed for the 2,542 MW of onshore wind. More land area would be needed for all the additional transmission lines.

4. As shown on slide 40, there is a significant amount of battery capacity in the NYSERDA report, in the range of 16 GW to 19 GW. At 4 hours to 8 hours of battery storage, this results in 64 GW-hours to 152 GW-hours. The largest battery in the world today is the 1.2 GW-hour battery at Moss Landing in California. What is being proposed here is a battery system 127 times larger than the world's largest battery system. If battery costs as low as $100 per KW-hour could be achieved, battery costs would amount to $6.4 to $15.2 billion dollars. If a 1000 MW electric nuclear plant cost $6 billion dollars and had a 0.90 capacity factor it would produce 7,884 GW-hours per year. This would be about 500 times the output of 19 GW of battery storage with an 8 hour capacity at a fraction of the cost. The nuclear plant would not have a limited lifetime due to charging and discharging cycles as is the case for batteries, nor would its electricity output decrease at low temperatures. It would seem that the NYSERDA report has made a very uneconomical choice by assuming such a large amount of battery storage.

5. If large land based wind turbines, at 5 MW each, were used to meet the 12,728 MW of capacity, some 2,546 such wind turbines would be needed to be built and installed by 2040. That averages out at about 141 per year for the next 18 years. Based on the recent request sent to

FERC by BP and Equinor, both giants in the petroleum industry, to delay New York's first off-shore wind turbines by a year and one-half, such build and install rates appear to be very optimistic, if not impossible.

6. The NYSERDA report does not present reliable cost figures. It shows a total cost of $3 trillion dollars, but a net cost, compared to the Reference Case, of less than $500 billion. However, it does not show what the Reference Case will cost, or even exactly what its contents are.
7. The NYSERDA report is incomplete in that there is no discussion of how it is responsive to the Community Protection portion of the CLCPA. Perhaps the worst offense is in upstate NY which occurred when Home Rule has been stripped away from rural communities and replaced by a process that makes public participation difficult. There are 1,694 onshore renewable energy projects, at 1 MW AC or larger, already planned for New York and the NYSERDA plan would greatly increase this.(Appendix C) Some call this the industrialization of rural New York and strongly object to it. Local areas are taking NY State to court. These heavy handed actions by NY State are clearly inconsistent with the Community Protection part of the CLCPA. The NYSERDA report makes no mention of these ongoing law suits even though law suits like these could derail the whole RE effort.
8. People are angry about the CPV plant in Orange County and its impact on surrounding environmental justice areas. This plant has operated without obtaining all of its environmental permits. In another NY area, fishermen off of Long Island have complained about offshore wind farms that could diminish their ability to earn a living.
9. Perhaps the most insightful land use discussion is presented in the Clean Air Task Force (CATF) report on California's need for clean firm power. (14) The CATF report calculated that a 100% renewable energy future in California would require 6,250 square miles, bigger than the combined size of Connecticut and Rhode Island. This land use estimate may not include the additional land needed for the approximately 6 million more MW-miles for transmission lines dedicated to the solar and wind farms. California has an area of about 164,000 square miles. The required land area for 100% renewable energy in California would be 6,250/ 164,000 = 0.038 or 3.8%,which is a considerably larger percentage than the 0.5% figure others have claimed for the solar portion of a high RE deployment scenario.(11) With firm power from nuclear energy and/or fossil fuels with carbon capture the required land according to the CATF report is reduced to 625 to 2,500 square miles. The CATF report goes on to say *"Recent reports of the solar resource in California indicate that 2,500 square miles may actually exceed the amount of land fit for utility-scale solar but not subject to restrictions (such as conservation easements or national park status). Moreover, the estimates of available land for utility-scale do not account for other restrictions, such as excessive slope, ownership problems, and access to transmission lines. New estimates currently underway will account for these and will probably decrease estimates of land availability"*. Again, the NYSERDA report is incomplete in that there is no analysis of land use issues.

9.7 Conclusions

The NYSERDA plan has departed from NYISO's approach to maintaining the electrical system's reliability. No justification was offered that justified this departure from NYISO's practices that have served New Yorkers very well for many decades. The NYSERDA report does not address extreme weather conditions such as very high and very low temperatures and widespread wind lulls. When sizing the amount of hydrogen to be placed into long term storage it did not determine if energy gaps might occur for 51 other weeks in the year. Instead of just analyzing one week in January, a full year's analysis is needed. Long duration storage relies upon unproven hydrogen technology. The NYSERDA report's suggestion as an alternative to using zero-carbon firm capacity would require the addition of 17 GW of offshore wind farms on top of the planned 19 GW of offshore wind in Scenario 3, for a total of 36 GW. To put these numbers into perspective, when former Governor Cuomo first announced that the 2.4 GW of offshore wind power to be built by 2030 would be the "world's largest offshore wind farm". Later, as other east coast states began to announce their plans for offshore wind farms, New York suddenly announced a new offshore wind farm project of 9 GW by 2035. If 2.4 GW would have been the world's largest wind farm, then 9 GW would have to be the largest wind farm in the whole solar system. NYSERDA's 36 GW of offshore wind farm(s) must therefore be the largest wind farm in the whole galaxy.

The grid model used in the NYSERDA report is incorrect and inadequate. Most important is the observation that a 100% renewable energy future is an extreme scenario and that a mix of energy sources comes much closer to meeting the cost, reliability, social justice, and climate change goals that gave rise to the CLCPA in the first place.

10.0 Nuclear/Renewable Energy Combinations

A major benefit of an Energy Family approach to building a low carbon future is that beneficial combinations of different technologies can be formed that would not be possible within these technologies alone. There are numerous examples of such beneficial combinations, but for the purposes of this critique a nuclear energy/renewable energy combination that could expand the use of hydrogen was selected.

After reviewing where hydrogen processes have been successfully used, it was recognized that there were significant benefits to co-locating the source of hydrogen and the end users of hydrogen. A logical candidate for using hydrogen is heavy duty trucks and buses, equipped with fuel cells to convert hydrogen into electricity for motive power. There are multiple benefits for using fuel cells in heavy duty vehicles compared to using batteries. Among these benefits is the charging time. Commercial vehicles, like the large 18 wheelers, have to keep moving to be economical. The time to refuel a hydrogen storage vessel in an 18 wheeler should be approximately be the same as it takes to refill such a vehicle with diesel fuel, and certainly less time that it takes to recharge a large lithium-ion battery system on an 18 wheeler. As can be seen from FIGURE A-5, the volumetric energy density of hydrogen at 700 bar (~ 10,000 psi) is greater than the volumetric energy density of lithium ion batteries. The fuel storage tank that contains compressed hydrogen should take up less space than the space taken up by batteries for equal amounts of stored energy.The feedstock for hydrogen is water and there is no concern about sufficiency or foreign domination of supply chains. So one possible solution to decarbonizing large heavy duty vehicles is through use of fuel cells supplied with hydrogen.

The next step would be to build industrial centers styled like much larger versions of today's truck stops, in low population areas with an adequate supply of water. A Small Modular Reactor, perhaps placed underground, with storage tank/cylinder with a capacity in the range of 12-24 hours worth of normal consumption of hydrogen from 18 wheel trucks.The SMR would provide reliability for this process and could produce hydrogen year round (and electricity and perhaps district heating.) Other industries could also set up businesses here to, taking advantage of the highly secure source of electricity. This industrial center could be quite large, but its design would be such as to maximize roof space for solar panels. The use of this solar system in conjunction with the SMR would be very beneficial. The dominant cost in generating hydrogen using electrolyzers is the cost of electricity. The electricity cost for the solar system would be near zero. In today's rooftop solar systems the PV module only represents about 20% of the overall cost. The other 80% goes into actions and items that convert PV's direct current output to AC, other electronic equipment to match the solar output to the voltage, phase, etc. compatible with the electricity on the grid. Since the solar panels would not be connected to the grid but would just supply electrons to the electrolyzer significant cost reductions in the solar piece of this combination of technologies could be achieved. So the use of solar energy in this combination would lower the overall cost of electricity. With the SMR also making hydrogen the solar panel system would not have to be overbuilt to assure reliability and sufficiency.It would not matter that the solar panel output varies in that the SMR output could also vary to match the load. If the SMR was in a co-generation configuration, the SMR could become load following while running at constant power. In summary This nuclear energy/solar energy mix minimizes the solar energy capital costs, does not have to be concerned about solar energy's variability, the electrons from the solar module would be used as they are produced. No backup battery would be needed for storage for the solar panel system and the combination of the two technologies would provide diversity.

Without significant hydrogen storage or overbuilding, a 100% solar system could not meet the demands for year round hydrogen. Consequently an all solar system would likely not be selected as the way to make hydrogen for these difficult-to-decarbonize heavy duty vehicles. Low solar output in the winter time becomes a non-issue with an SMR/ solar system because year round reliability is provided by the SMR. On the other hand the near zero cost for electricity from the solar panels would lower a major cost component in making clean hydrogen by electrolysis of water. Thus each technology enhances the prospects of the other technology and the environment benefits from both.

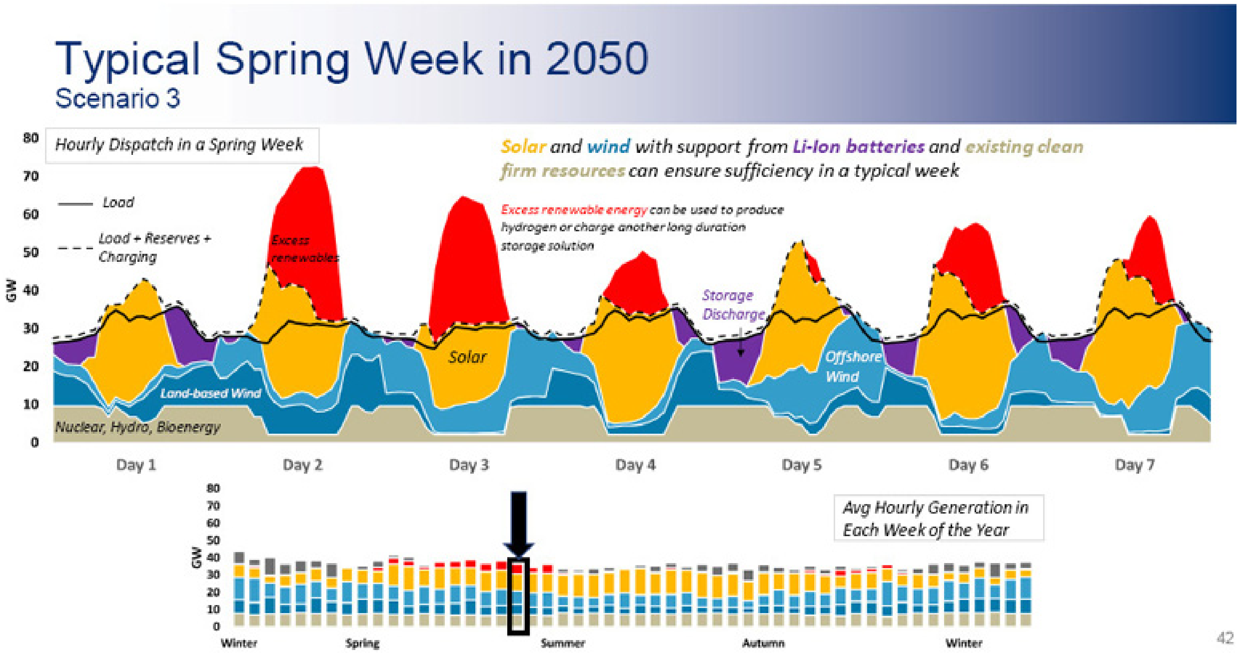
Once the public has grown comfortable with this arrangement it might be expanded to urban locations to provide hydrogen to medium heavy vehicles such as delivery trucks, like those used by FEDEX and the US Mail.

New York State could be a national leader by constructing and operating a highly efficient and carbon free prototype of this nuclear/solar combination. This would be consistent with the Climate Leadership portion of the CLCPA. Such combinations means jobs and tax revenue and would add to America's industrial base.

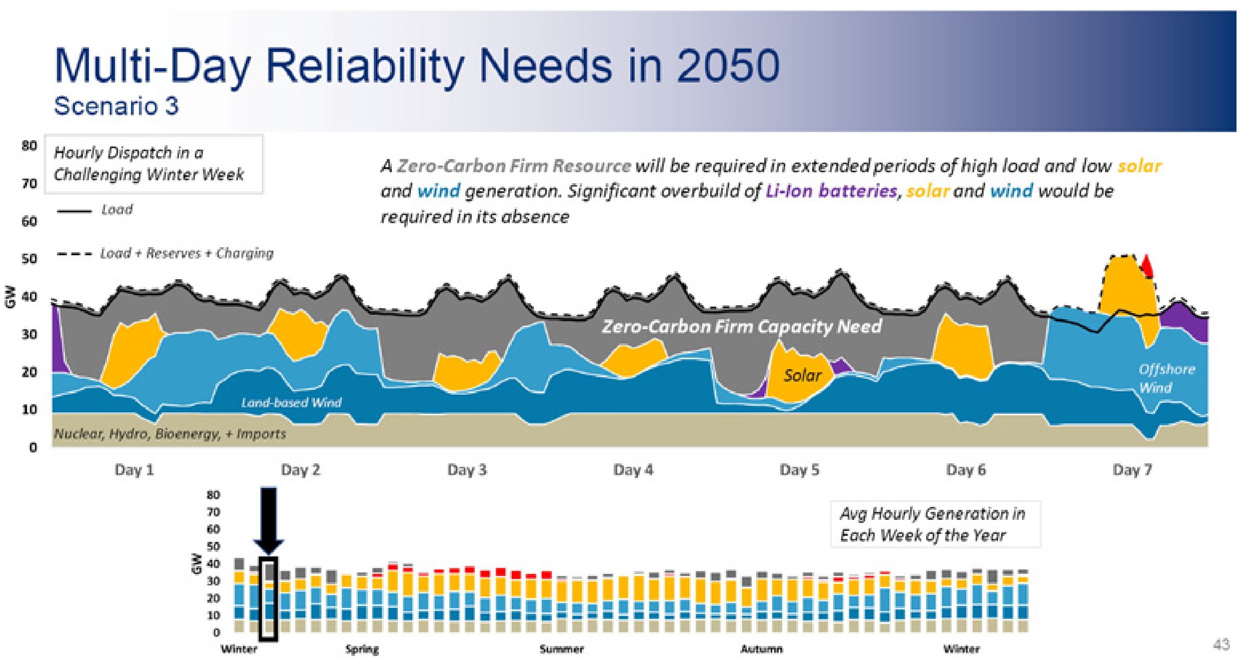
11.0 Appendices

11.1 Appendix A - Several Slides From the NYSERDA Report

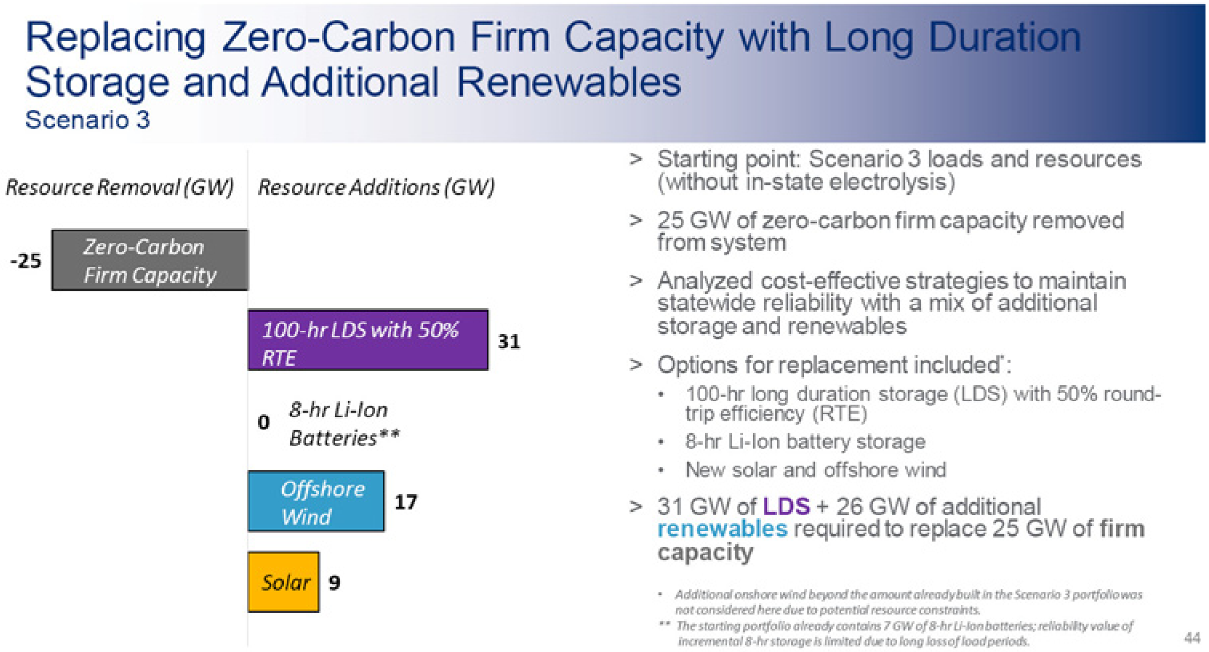
11.1.1 SLIDE 42



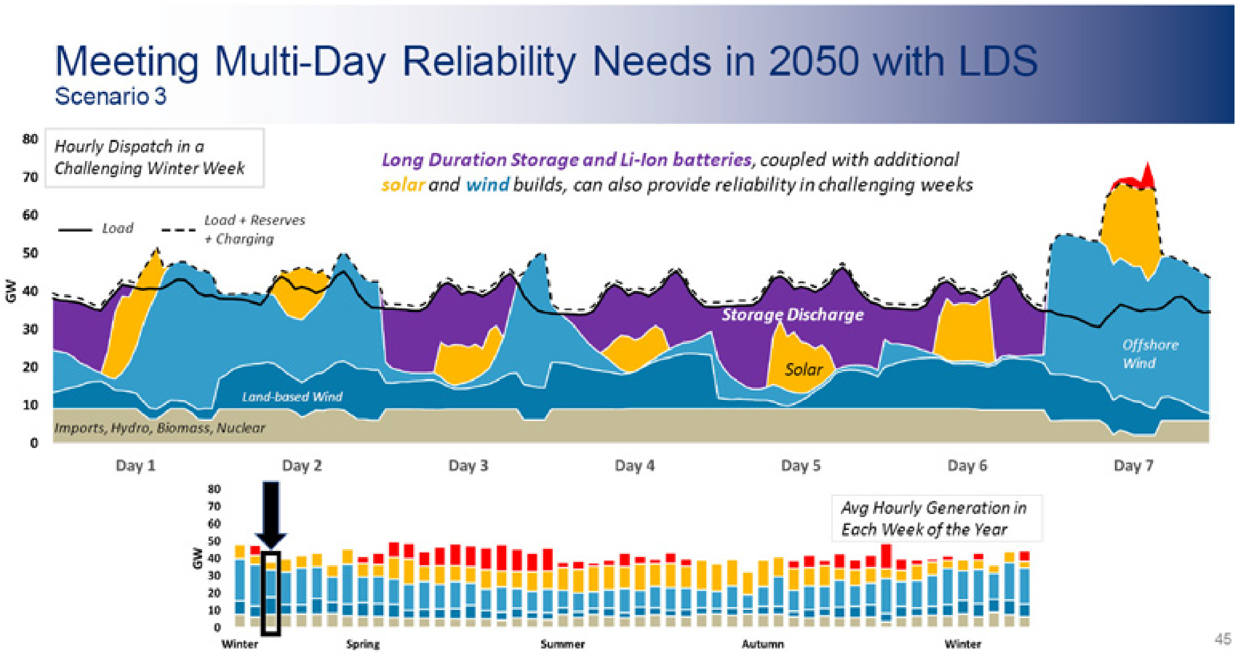
11.1.2 SLIDE 43



11.1.3 SLIDE 44



11.1.4 SLIDE 45



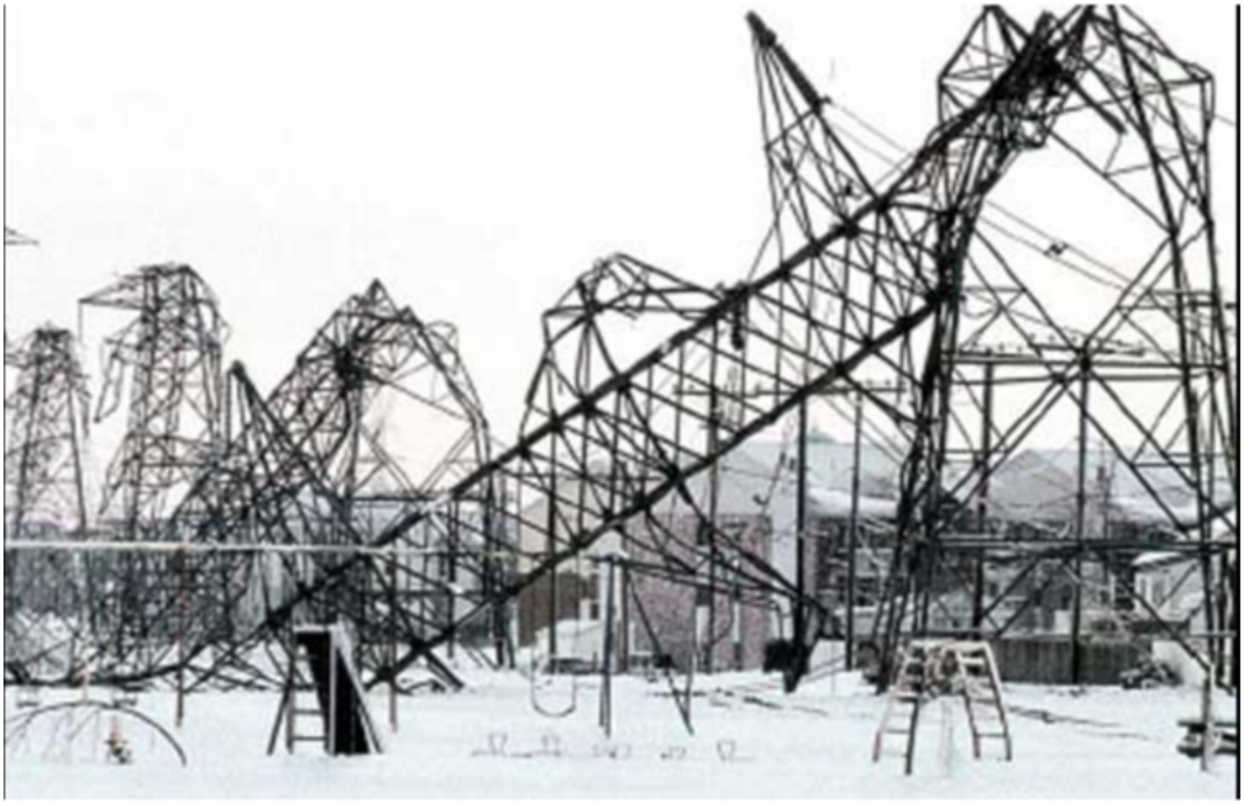
11.2 Appendix B - Impacts of Extreme Weather

11.2.1 Wind Turbines

FIGURE A-6 Impact of Hurricane Maria on Wind Turbines in Puerto Rico

11.2.2 Transmission Lines

FIGURE A-7 Impact of a Severe Ice Storm on Transmission Towers in Quebec, New York



11.3 Appendix C - Impact of NY State Energy Policies

11.3.1 Land Use

FIGURE A-8 New York’s Planned Sites for Renewable Energy and Battery Storage

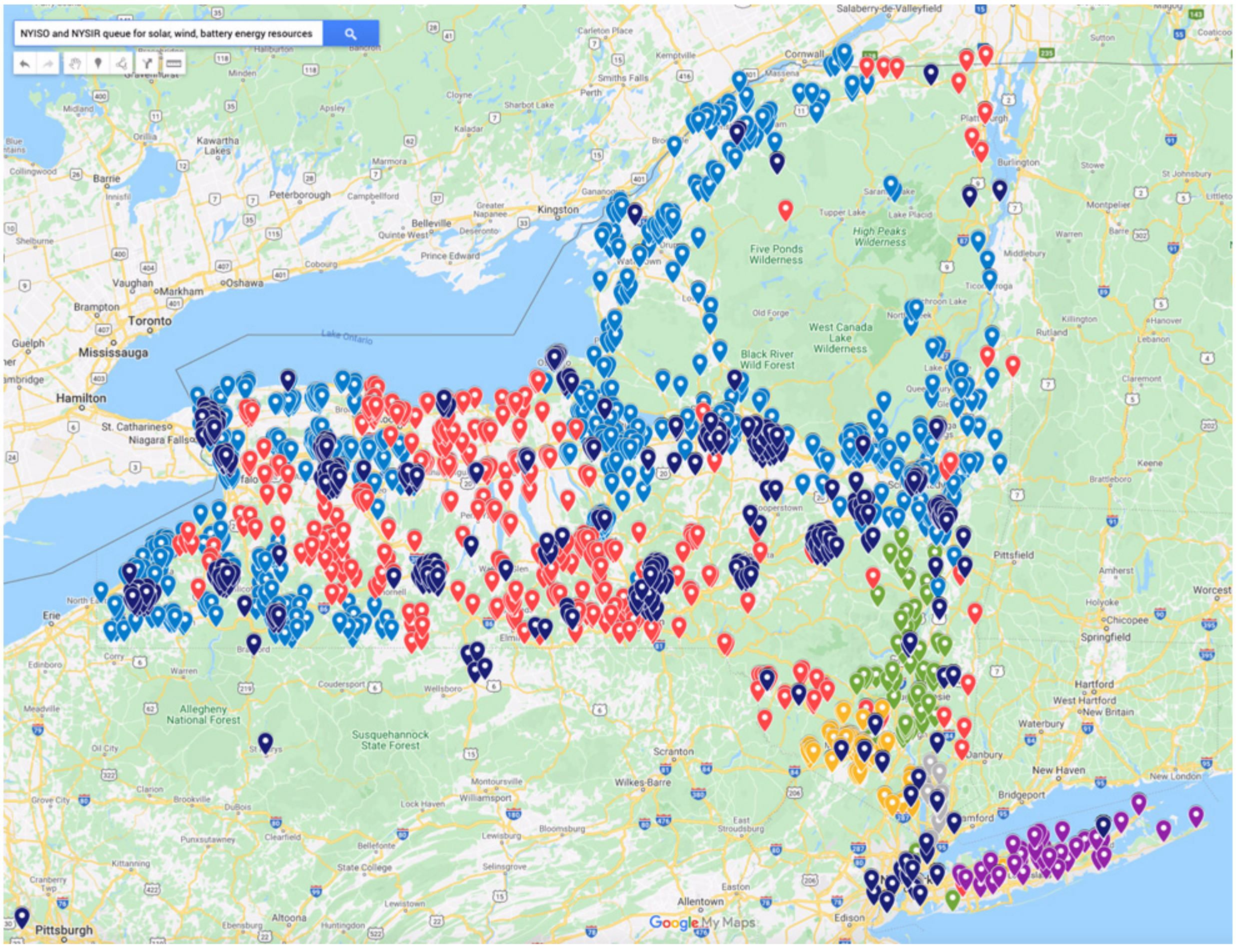


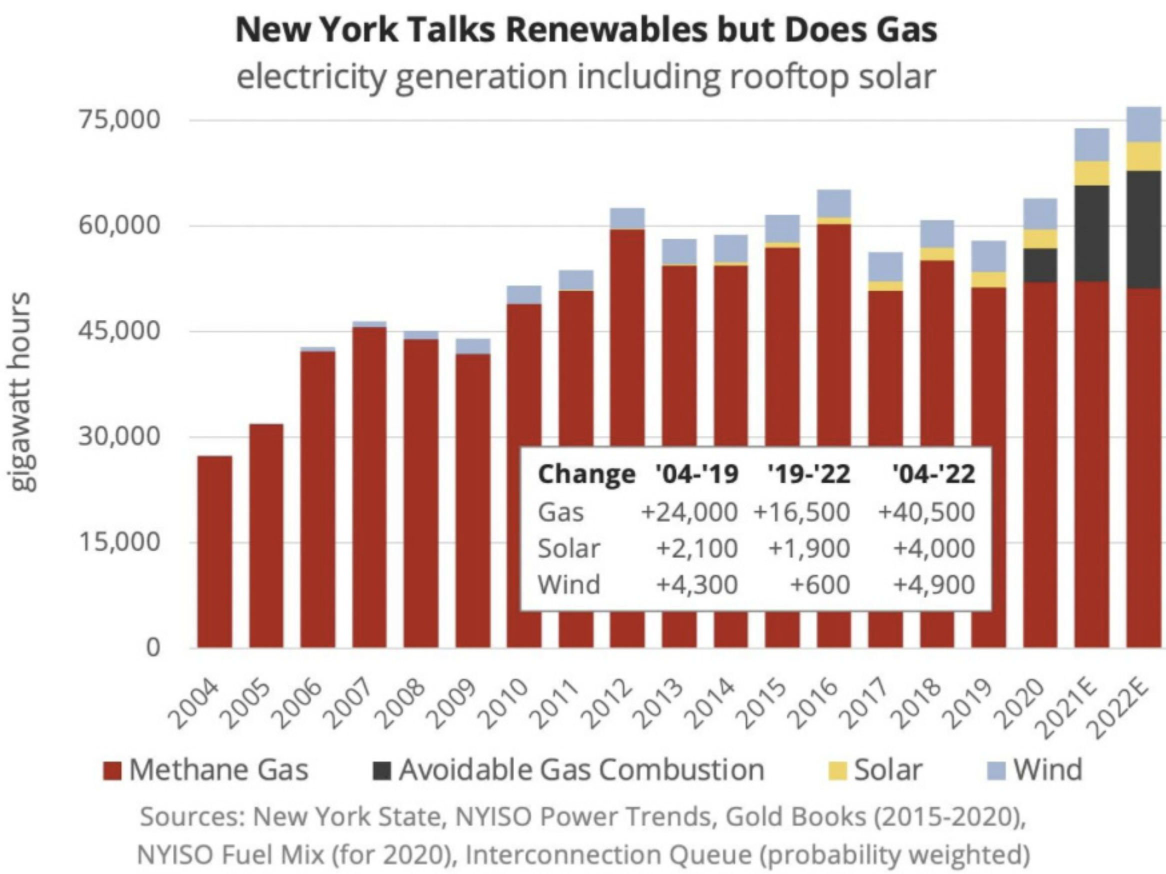
FIGURE A-8 represents what is planned for NY State at this time with 1,694 projects. A much greater impact that would occur if the NYSERDA report were implemented. Implementing the NYSERDA report would require 2,546 large, 5 MW, wind turbines.

NYSERDA slide 40 calls for 115,982 GWh. Using NREL solar data from Ithaca, New York, (TABLE A-6) in order to produce the 115,982 GWh some 24.4 million solar panels would be needed. Just these panels alone, packed as closely together as possible, would have a surface area of 235 square miles. These panels are the standard sized, 4 KW panels with an area of 25 square meters each.

FIGURE A-8 does not take into account areas occupied by transmission lines, service roads, set backs, etc.

11.3.2 Natural Gas Versus Renewable Energy

FIGURE A-9 New York Talks Renewables but Does Gas



In spite of claims of being a "Climate Change" leader, NY State's actual history is one of increased use of fracked gas. All the benefits of renewable energy in terms of reducing greenhouse gas emissions are wiped out by the use of natural gas. As shown in the above figure the sum of the wind and solar energy in GW-hours for year 2022 is still far smaller than the GW-hours for methane (i.e., fracked natural gas) was back in 2004.

For many years the number of tons of carbon dioxide equivalent released from the electricity generation sector declined, even though gas use increased. This decline was due to the phasing out of coal which is more GHG intensive per KWh than natural gas.Today, there is virtually no coal burned in NY to produce electricity.The minimum GHG per KWh in NY likely happened around 2018 to 2019. GHG releases have since risen due to replacing Indian Point with gas.

11.3.3 NY State Risked Blackouts From 2014 to 2016

During the time period from 2014 to 2016, Entergy, then owner of the Indian Point power plants, went before an Atomic Safety and Licensing Board (ASLB), an independent arm of the Nuclear Regulatory Commission, seeking to extend the licenses of Indian Point 2 and Indian Point 3. Also appearing before this ASLB was NY State and Riverkeeper who sought to prevent these license extensions.

During this time period NYISO produced annual Reliability Needs Assessments (RNAs). Conclusions reached by NYISO are summarized in TABLE A-9. If the Indian Point nuclear units continued to operate, New York's electrical grid's reliability would be adequate, that is LOLE $\leq$ 0.10. However, if Indian Point were closed, immediate reliability issues would occur.

Neither NY State nor Riverkeeper knew what actions the ASLB might take. If the ASLB ruled in their favor, the Indian Point 2 and 3 licenses would expire and NY State could have immediately been thrust into an unreliable grid condition. NY State and Riverkeeper were gambling with the health and safety of NY State citizens and the whole NY State economy, in spite of the serious warnings by NYISO. The multiple years spent by NY State and Riverkeeper before the ASLB were ideal for them. They gave the appearance of protecting New Yorkers from the (grossly exaggerated) risks from Indian Point while enjoying the benefits of a reliable grid.

All this ended when Entergy decided to stop pursuing these Indian Point license extensions. With much fanfare, former Governor Cuomo announced, on January 9, 2017, that these dangerous nuclear plants were to be shut down and would be replaced by non-carbon energy sources. To prevent an immediate reliability crisis, Entergy, NY State, and Riverkeeper agreed to keep Indian Point 2 operational until April 30, 2020 and Indian Point 3 operational a year longer until April 30, 2021. In spite of sounding the alarm for years about the dangers of these two nuclear plants, NY State and Riverkeeper signed a Closure Agreement which allowed Indian Point to operate several more years and they also withdrew permit objections they had imposed on Entergy.

In February, 2017 there was a joint meeting of the energy committees of the NY Senate and the NY Assembly to discuss the impact of the Indian Point closures. One of the legislators asked the lead NY State witness to explain what was the basis of establishing these very specific closure dates, years into the future.The reply from this State witness was that, unlike other states which give local areas very little time to prepare for the closure of a nuclear plant, NY State was being very generous in its treatment of these local areas. This generosity did not extend to these local areas and school districts, or even to the Westchester County Executive, who were blindsided by these secret meetings to close these nuclear plants. The lead NY State witness did not inform the State legislators that these additional years were needed to build gas replacement plants, leaving these legislators with the impression that the Indian Point units would be replaced by non-carbon sources of electricity as the then Governor had promised during his first public closure announcement and again during his State-of-the State.

In its December 13, 2017 Generator Deactivation Report, NYISO described a three step replacement process to deal with the IP closures. Three gas plants would be constructed and used to replace Indian Point. Even though this NYISO report directly contradicted the commitment the former Governor had made to the people of New York, he remained silent. Riverkeeper went through the motions of being outraged even though they were one of just three parties that established closure dates long enough into the future giving time to build these gas replacement plants. Indian Point 3 closed down on April 30, 2021. On its very last run, Indian Point 3 broke the world's record in the length of time it ran at full power. The price for gas to heat homes, to make hot water, and to run gas powered electric plants has recently skyrocketed. A Hudson valley utility blames this, in part, on the closure of Indian Point 3 which immediately caused an increase in the demand for natural gas.

TABLE A-9 NYISO RNA Results for the 2014 to 2016 Time Period

Year	With IP Operating	Without IP Operating
2014	LOLE ≤ 0.10	***"Significant violations of transmission security and resource adequacy would occur in 2016 if the Indian Point plant would retire as of that time."*** Without IP a LOLE of 0.31 was calculated for 2016 in this RNA, equivalent to a possible one day blackout every 3.2 years.
2015	LOLE ≤ 0.10	***"Substantial uncertainties exist in the next ten years that will impact system resources...Depending on the units affected, the NYISO may need to take swift actions to maintain reliability."***
2016	LOLE ≤ 0.10	***"This scenario simulates the retirement of the Indian Point Energy Center by removing about 2600 MW of capacity from Zone H and finds that significant violations of resource adequacy criteria would occur immediately in 2017."***

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