BRIGHT FUTURE

A MORE RELIABLE AND RESPONSIBLE CLIMATE PLAN FOR NEW YORK

JULY 2022

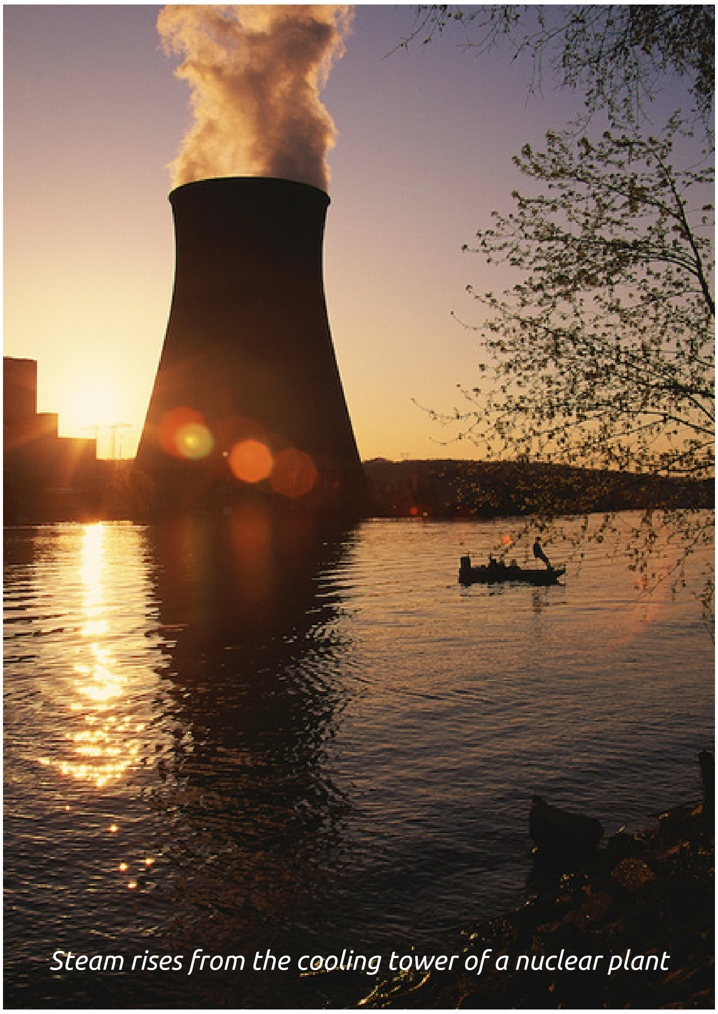
EXECUTIVE SUMMARY

Key Points

- Making nuclear energy the foundation of New York's carbon-free grid would ensure reliable, affordable, and sustainable decarbonization.
- Nuclear provides well-paying generational jobs for skilled tradesfolk to enable vibrant and healthy host communities enriched by steady tax revenues.
- A Made-In-America nuclear program offers a strong solution to the energy security challenges facing the state and country, including our reliance on foreign supply chains and intermittent energy technologies.
- Nuclear is the electricity source with lowest lifecycle greenhouse gas emissions and smallest land footprint. Nuclear is also among the least impactful with respect to mining, materials, and toxicity.
- Expansion of nuclear energy will enable a responsible buildout of solar and wind facilities, conserving nature and productive farmland from energy sprawl.
- Extending the operating licenses of New York's currently operating nuclear plants from 60 years to 80 years would save $9 billion in decarbonization costs.
- The spent fuel from today's reactors (i.e. the "waste") can be recycled to power the next generation of carbon-free nuclear plants.
- The safety record of nuclear in America is unmatched by any other energy source.

Key Recommendations

- Extend the Zero Emission Credits program to ensure timely investment in license renewals and capacity upgrades of upstate nuclear power plants.
- Work with the U.S. Nuclear Regulatory Commission, U.S. Department of Energy, U.S. Environmental Protection Agency, and other necessary state and federal agencies to authorize and expedite the siting of new nuclear technology without delay.



Steam rises from the cooling tower of a nuclear plant

GND

Clean Energy Jobs Coalition New York

Nuclear New York

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AUTHOR ORGANIZATIONS

Nuclear New York
is an independent, non-partisan advocacy organization working towards a future of aggressive climate action, well-paid meaningful work for New Yorkers, nature conservation, plus rich and vibrant communities. They conduct rigorous research, unbiased education, policy advocacy, and non-intrusive activism.

Clean Energy Jobs Coalition, New York
is a growing coalition of labor and management leaders presently representing more than 270,000 skilled energy workers across New York State with the mission to be a sensible voice advocating on key energy issues. Their focus is to foster a green energy economy that creates jobs and savings for New Yorkers, by New Yorkers.

Campaign for a Green Nuclear Deal
is a nationwide advocacy effort to articulate a new vision for nuclear growth as a way to regain American industrial capabilities and create dignified jobs in clean energy and manufacturing.

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FOREWORD

Climate change is an extremely serious problem and very difficult to solve. Switching the world economy off fossil fuel is a huge undertaking, and so far the world has failed to make real progress on the needed scale and timeline. This effort must mobilize all people and all technologies. To think that climate change can be solved by piecemeal efforts that use only certain technologies, and shun other proven ones, is a form of climate denial – denial of the scale of effort needed.

Yet this is what New York's climate plan does, trying to decarbonize the state's electricity generation with wind and solar power while dismissing the country's #1 source of carbon-free electricity – nuclear power.

The Bright Future New York report shows in detail how to correct this error of omission. By making nuclear power the backbone of New York's clean energy economy in the coming decades, the Bright Future scenario makes decarbonization practical, affordable, and achievable, none of which the state's draft scenarios can do. The grid's reliability, which is crucial to economic strength more broadly, would be assured. Natural landscapes would be preserved from energy sprawl. And instead of jobs in China, nuclear power would create good, local, union jobs.

Decarbonization is urgent. We need a proven solution, not miracle technologies that don't yet exist, like cheap grid-scale batteries. And we have a proven solution. Several countries have already decarbonized their grids quickly and affordably, eliminating coal generation and minimizing gas. All have done so by building either hydroelectric power (e.g., Norway), nuclear power (France), or both (Sweden). New York's hydroelectricity cannot expand to meet the state's growing electricity needs, as transportation and heating transition to electricity in the coming years, but nuclear power offers unlimited scalability. Decades ago, France switched from fossil-fueled electricity to primarily nuclear power in just 15 years. French electricity is cheap, its grid is reliable, and the public has never been harmed by the French nuclear industry. More recently, New York's neighbor Ontario has done the same. Toronto, like Paris, runs its grid on reliable, carbon-free nuclear power.

New York City, by contrast, still runs on fossils. In fact, New York recently closed the Indian Point nuclear plant that had cleanly provided one-quarter of the city's electricity for decades. New natural gas plants replaced it. Years are being lost as the state draws up plans to power a 24/7 grid with intermittent renewables alone, and ends up burning more and more polluting natural gas. Studies show that the most affordable and practical decarbonization combines nuclear and renewables. Time is pressing; serious decarbonization plans are needed now, and they must include the clean backbone of nuclear power that this report envisions.

Prof. Joshua S. Goldstein, *Professor Emeritus of International Relations, American University*

Dr. James E. Hansen, *Climate Scientist, Earth Institute, Columbia University*

INTRODUCTION

New York's Climate Leadership and Community Protection Act (CLCPA) is one of the most ambitious pieces of climate legislation in the world. The act requires New York to have 100% carbon-free electricity by 2040 and economy-wide decarbonization by 2050. The scale of this challenge is staggering: in 2021, 49% of New York's electricity generation was from carbon-free sources, largely due to nuclear (24% of total) and hydro (22% of total).

In December 2021, the Climate Action Council published a Draft Scoping Plan (CAC Plan)[1] as the foundation for extensive collaboration. We agree with the CAC Plan that to meet our climate goals will require "comprehensive vision and integrated approach to build new programs while significantly expanding existing efforts."

This Brief, titled 'Bright Future,' presents how New York can achieve a clean, resilient, and affordable electricity system for all New Yorkers without compromising New York's workers, communities, or natural landscapes. A *just transition* must make a low-carbon economy a benefit, not a burden, to New Yorkers.

Bright Future focuses on decarbonizing New York's electricity sector, which is foundational to deep decarbonization. The CAC Plan anticipates electricity demand to double by 2050, largely due to the electrification of the transportation and building heating sectors. While other areas of the economy are not evaluated in this study, we acknowledge that reducing economy-wide emissions will require far greater amounts of low-carbon energy.

The New York Independent System Operator (NYISO), the state's non-profit grid operator, asserts that "The path to a greener grid must remain a reliable one" in Power Trends 2022 [2]. They warn reliability margins are shrinking and raise concerns about retiring generators needed for reliability amidst delays in constructing new supply. NYISO emphasizes that, "higher than expected demand and extreme weather could threaten reliability and resilience in the future." For a successful transition "we must build and interconnect technologies that fill in reliability gaps and mimic the reliability attributes of our existing fleet of generation."

While New York is poised to embrace utility scale geothermal networks for heating and cooling, as well as innovations in hydrogen for clean fuels, the state will need abundant, carbon-free power to decarbonize. This brief will first present the case for making nuclear power the backbone of New York's decarbonization framework.

The Bright Future proposal (i) explores the realities of New York's current electricity mix, (ii) challenges the strategy of the proposed CAC Plan, and (iii) offers carbon-free nuclear energy as a strategic answer to New York's reliability needs as part of our shared pursuit of a clean energy system. Lastly, the Bright Future proposal details the beneficial impact nuclear provides to communities, skilled workers, and the natural environment. We conclude with New York's responsibility to preserve its existing nuclear capacity and recommend that the Empire State lead the deployment of advanced nuclear technology.

THE NEED

Meeting New York's ambitious climate targets will require a historic reduction in the state's emissions. The plan enacted to achieve these reductions will ultimately determine how deep and quickly decarbonization is able to happen. An abundant, affordable, reliable, and resilient electric grid is the backbone of every prosperous modern society. The energy transition will ultimately fail if it causes energy to become scarcer or more expensive. Sacrificing reliability or affordability of low-carbon energy are regressive choices that disproportionately hurt the most vulnerable and have the potential to derail decarbonization efforts.

The CAC Plan requires New Yorkers' per-capita energy demand to decline by over 50% in 2050. While we encourage energy efficiency as means to do more with less, this cannot mask a regressive call to do less — including, for example, shunning energy-intensive industries that may otherwise benefit New York.

Additionally, the CAC Plan models New Yorker's per-capita Gross State Product (GSP) to grow at 0.8% per annum, less than half the historic growth rate of 1.9%. There are serious concerns as to whether this reduction in economic growth would be desirable or viable. Were New York to prosper as it has in the past, our energy needs will be larger (Figure 1).

Even with these assumptions of aggressive conservation and degrowth, the CAC Plan projects electricity demand must double by 2050. As such, New York will need to deploy massive amounts of carbon-free power. According to the latest scientific and technical understanding of energy systems, the CAC Plan represents a high-risk pathway for decarbonization.

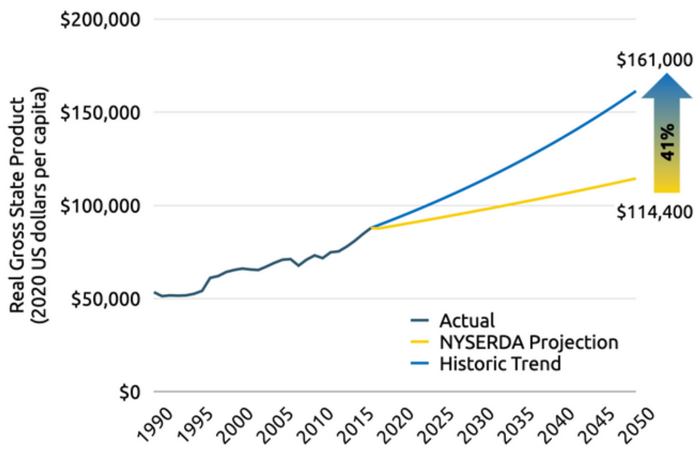


Figure 1. NYSERDA GSP projection vs. historic trend

An 'Integration Analysis' conducted by the New York State Energy Research & Development Authority (NYSERDA), incorporated into the CAC Plan as Appendix G, concluded a 100% carbon-free electricity system "cannot currently be met by the deployment [of] existing renewable energy and energy storage technologies... to meet demand and maintain reliability." The study outlines the need for 'Firm Clean' resources — generators able to provide power on-demand regardless of the time of day or weather — to ensure grid reliability.

For example, periods of peak electricity demand during the winter often coincide with extended periods of low solar and wind output. NYISO shows that during such a winter wind lull scenario, the electric system will need to rely primarily on such dispatchable, carbon-free resources to prevent outages.[3]

CAC S3 requires Firm Clean generation capacity of 24 gigawatts (GW), nearly as big as the entire fossil generation capacity presently available in-state (26 GW).

Clearly this would be a tremendous financial undertaking. Yet NYSERDA models this Firm Clean energy source to operate only 2.9% of the time on average, or merely 10.5 full days per year.

The majority of New York electricity demand is 24x7 (Figure 2). An efficient system optimized for the best use of its installed capacity would operate a baseload source to meet this constant demand.

What if instead of building Firm Clean capacity only to use it when the sun is not shining and the wind is not blowing, these sources formed the foundation of New York's grid? That's where nuclear comes in.

Nuclear power is the largest source of clean power in the U.S., and nearly matched hydro in New York, despite the premature closure of Indian Point in April 2021 (Figure 3). The upstate nuclear plants contribute much of New York's carbon-free power. Like fossil fuels, nuclear plants can reliably deliver power as-needed, regardless of time of day, season, or weather. Unlike fossil fuels, nuclear can do so without combustion; hence no carbon emissions or harmful air pollutants. In fact, a comprehensive analysis conducted by the United Nations found nuclear also has the lowest lifecycle greenhouse gas emissions of any type of electricity generation, solar and wind included (Figure 4).[4]

Despite all four of the Intergovernmental Panel on Climate Change (IPCC) illustrative pathways that limit global warming to 1.5°C calling for 2050 nuclear generation to be 2x to 6x the 2010 level [5], the CAC Plan has nuclear power playing a smaller role in New York's future. Nuclear energy is available, scalable, and deployable today. By expanding the suite of carbon-free technologies beyond wind and solar, New York can lead the transformational change for

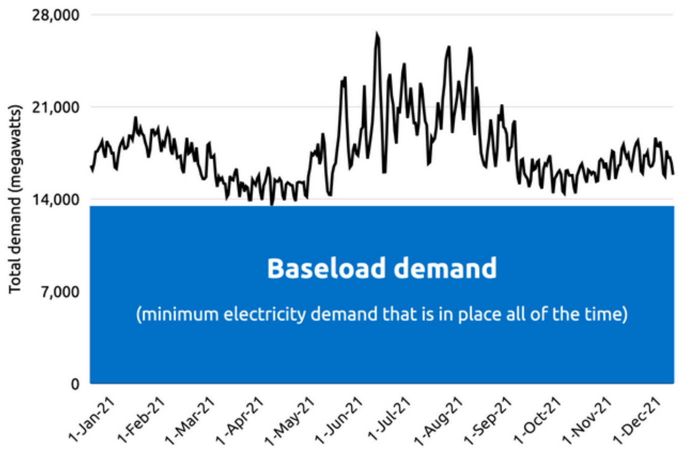


Figure 2. New York state daily average electricity demand

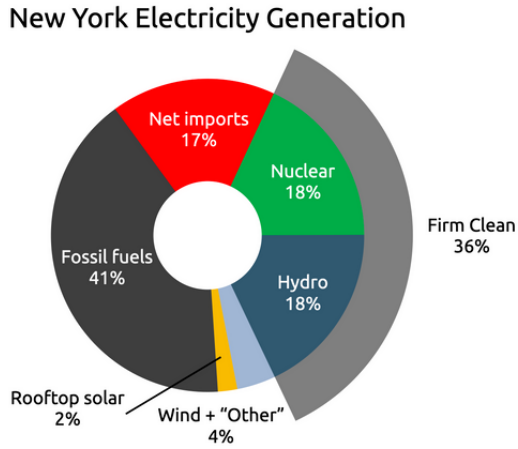


Figure 3. Electricity by source from May 2021 to April 2022

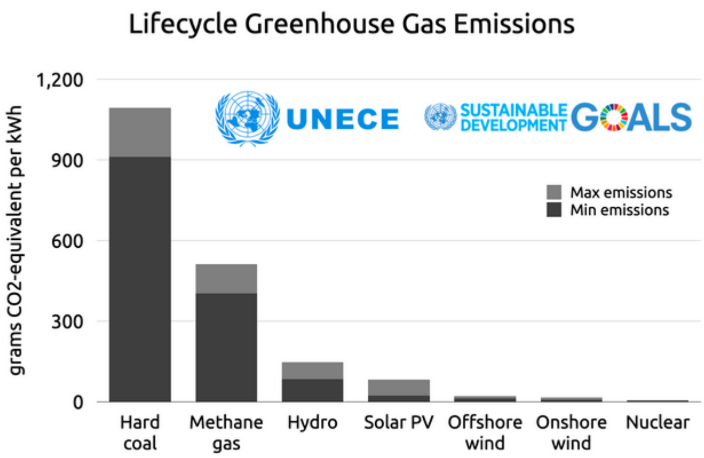


Figure 4. UNECE's calculated lifecycle emissions

effective climate mitigation.

Despite serious issues identified with the CAC Plan and NYSERDA's Integration Analysis, our proposal retains certain assumptions and targets in order to more easily compare these pathways. In this brief, we compare Bright Future mainly against CAC Plan's Scenario 3 (CAC S3), although the comments here are applicable to all CAC scenarios. Addressing key knowledge gaps identified in Appendix 2 will help refine this proposal further.

The scope of Bright Future is effectively generating electricity via carbon-free sources. However, beyond the electric sector, civilian nuclear technology can efficiently provide direct heat for industrial processes, produce low-carbon liquid fuels to decarbonize transportation, to power negative emissions technologies, and to generate life-saving isotopes for modern medicine.

While the Empire State Building has a contract for wind electricity, downstate New York is over 92% fossil fueled

BRIGHT FUTURE

"By making reliable, always-on nuclear the foundation of the state's carbon-free grid, New York will be able to generate abundant, more affordable electricity while protecting more land from industrial development."

Bright Future is a proposal to grow the share of New York's electricity from nuclear power to 50% by 2050 (Figure 5). By making reliable, always-on nuclear the foundation of the state's carbon-free grid, New York will be able to generate abundant, more affordable electricity while protecting more land from industrial development. Further, by enhancing in-state energy generation instead of relying on extensive imports, Bright Future makes New York a net energy exporter and a jobs destination, reversing opposite trends. See further detail in Appendix 1.

The CAC Plan estimates New York's electricity demand in 2050 to double from 2021. Due to its primary focus on intermittent wind and solar, Scenario 3 requires an electricity system over 3.5 times New York's generation capacity of today. By adding nuclear to the mix of low-carbon technologies, Bright Future could meet the estimated demand with just twice the current generating capacity and substantially lower transmission expenses.

The CAC Plan requires Firm Clean generation as backup. Scenario 3 assumes these will be fuel

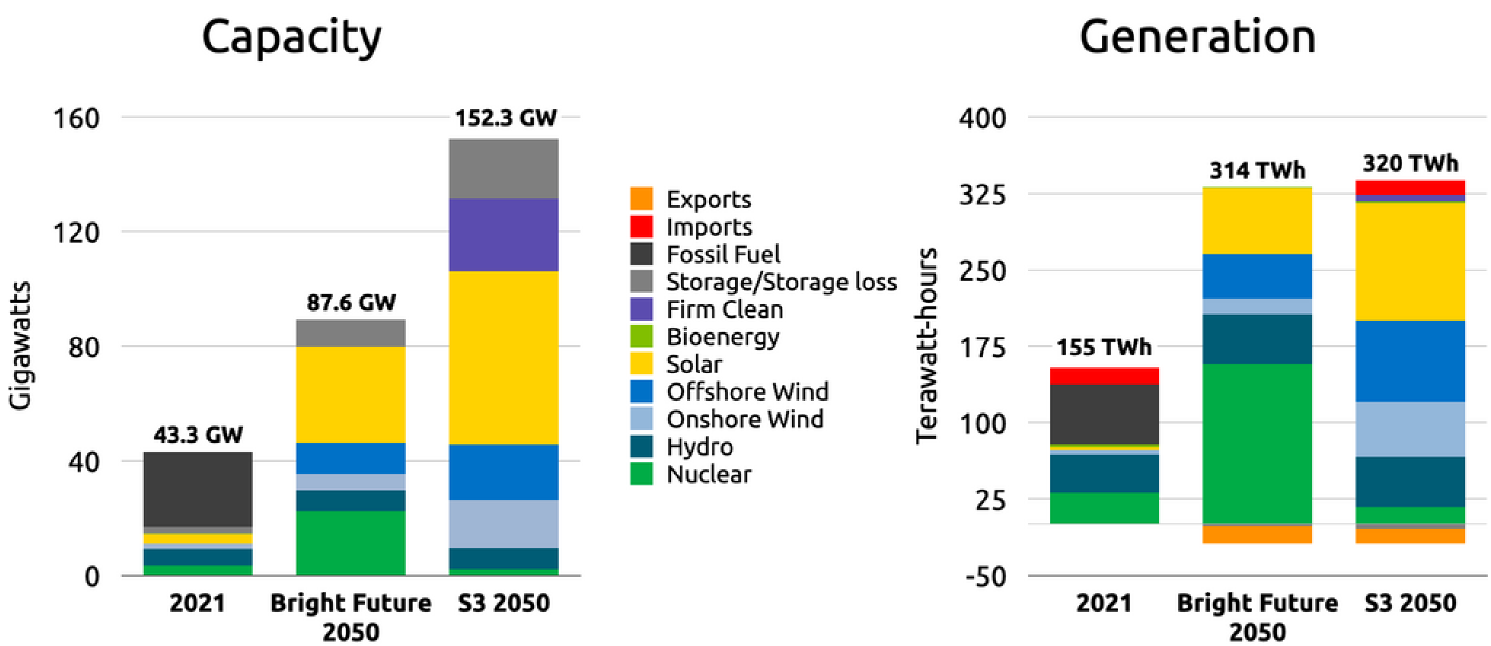
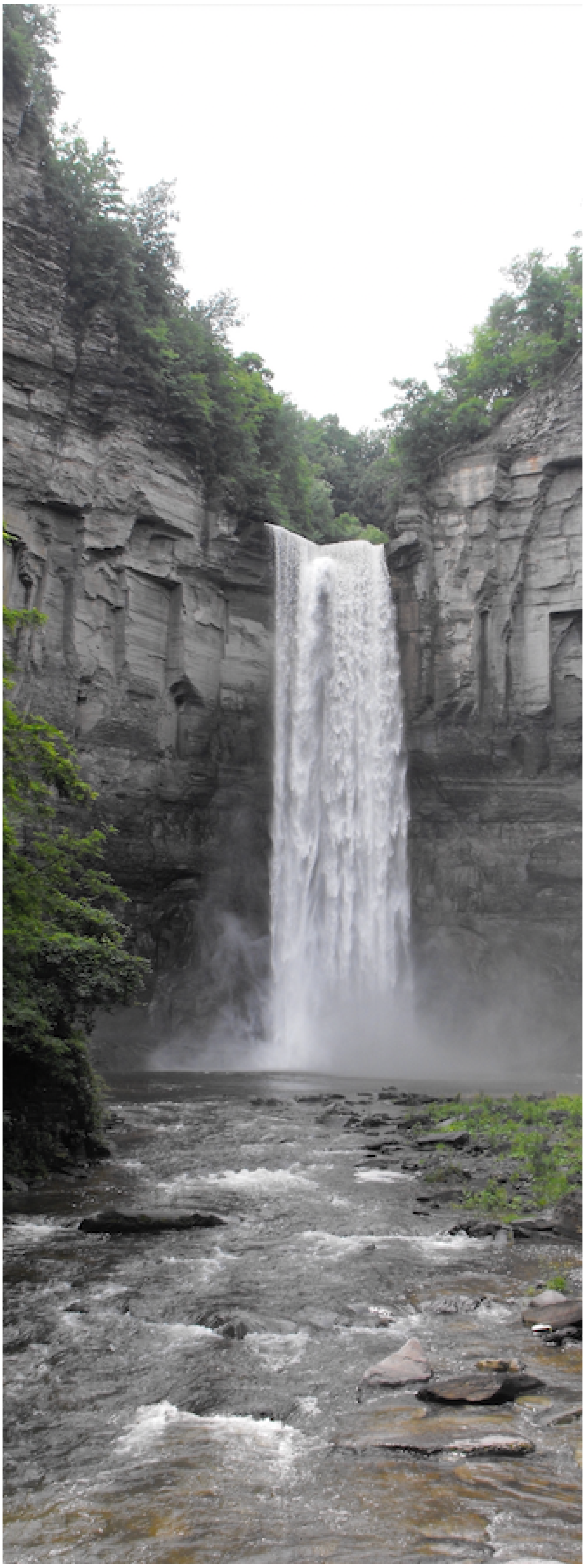


Figure 5. Capacity and electricity generation comparisons: 2021 actual plus 2050 under Bright Future and CAC Scenario 3



Taughannock Falls near Ithaca, NY

cells powered by 'green hydrogen.' However, this would require using electricity to make hydrogen to make electricity, losing half the energy in the process. On the other hand, using nuclear as baseload *and* dispatchable clean power is the most effective use of installed capacity. Any excess electricity from nuclear may be exported to other states or used to generate synthetic fuels to decarbonize other sectors.

The CAC Plan also assumes that New York's neighbors will host a large part of New York's wind capacity for electricity and provide half its hydrogen, presumably in order to avoid in-state land-use conflicts. Relying on wind imports from neighbors will make New York more dependent on the whims of surrounding state administrations, but that's not the only problem. When New York is experiencing a lack of supply due to cloudiness or low wind, it's more than likely neighboring states will also be experiencing similar weather. Bright Future eliminates that dependence on our neighbors.

Furthermore, the CAC Plan assumes that New York's neighbors will act as a 'virtual battery' for New York absorbing unneeded excess generation and bailing out New York when in-state resources cannot meet demand.

Bright Future also calls for an ambitious but realistic expansion in solar and wind. In the Bright Future scenario, the deployment of onshore wind would need to accelerate to 2.8 times the pace of growth during the last decade, whereas CAC Scenario 3 requires future deployment that is 11.0 times the historic average. For solar, Bright Future models deployment at 3.1 times the rate experienced over the last decade, while CAC Scenario 3 assumes a rate that is 5.8 times as high. New York has no offshore wind generation at present; Bright Future models deployment of offshore wind in-line with CLCPA goals.

BENEFITS OF BRIGHT FUTURE

Equitable Access to High Quality, Family-Sustaining Jobs for Vibrant and Healthy Communities

For a clean energy transition to be successful, it must be advantageous for the workers responsible for delivering it. That means quality of work and wages of current fossil fuel workers must be maintained or improved upon. New jobs should be able to build and sustain communities, with equal opportunities for all New Yorkers in diverse and desirable careers. The electricians, pipe fitters, millwrights, and boilermakers who keep our lights on and our homes comfortable have earned the right to a prosperous life.

Our ability to create a just transition is inseparable from technology choice, with each scalable power generation option having a better or worse potential to create high-quality, community-building, uplifting jobs that power domestic supply chains.

The problem with wind and solar is that they are not concentrated revenue sources for host communities as a whole, even if a few large landowners can collect rent for allowing such facilities to be constructed on their land. With commodified manufacturing largely offshored to China, more than half of the domestic jobs in solar are in installation and construction, transient and temporary jobs that provide only short-term economic benefits to local communities. After construction and installation, wind and solar installations are virtually workerless facilities with few hands-on operational requirements, generating limited value and capacity-building potential to local communities.

Meanwhile, nuclear provides well-paying jobs that enable vibrant, healthy, and prosperous host communities. New York's three operating nuclear energy plants support 25,000 jobs, contribute over $3 billion to New York's economy and generate $144 million state and local taxes annually.[6] Nuclear energy is produced with inexpensive fuel and high-skilled labor, the largest component of its costs. Nuclear plants are bustling facilities with large parking lots and abundant year-round work for skilled tradespeople, nuclear operators, STEM

Electricity generation	Unionization	Median wage	Carbon-free energy?	Firm energy?	Benefits concentrated in local community?
Nuclear	19.5%	$80,000	Yes	Yes	Yes
Methane gas	15.1%	$65,000	No	Yes	Yes
Coal	14.7%	$65,000	No	Yes	Yes
Solar	9.6%	$50,000	Yes	No	No
Wind	9.5%	$45,000	Yes	No	No
Other renewable	8.8%	$35,000	Maybe	Maybe	Maybe

Figure 6. Nuclear has the highest unionization rate and highest wages across the electricity generation sectors. Wage and unionization data from the U.S. Energy and Employment Jobs Report (USEER, Department of Energy) [7]

professionals, firefighters, healthcare professionals, and more. Multi-generational employment at nuclear power plants ensures steady tax revenues enriching local communities.

In fact, nuclear offers the highest pay of all electricity generation sectors (Figure 6). Nationally, nuclear generation sector median wages are over 20% better than fossil generation, and 60-70% better than offered by solar and wind industries. The average annual payroll of over 2,100 employees at New York's nuclear plants exceeds $113,000.[8] And like coal and natural gas, the U.S. nuclear sector is heavily unionized (Figure 6), with over a dozen unions representing tens of thousands of workers.

We cannot wish our way to high wages, union membership, and other positive concessions for social and labor justice. These arise from the ability of highly skilled workers to organize and win concessions from management in bargaining and ultimately with the threat of strikes. While these opportunities abound at nuclear power plants, they are absent at workerless facilities erected by lower-skilled construction and installation jobs.

Nuclear is the perfect community energy source from the perspectives of communities that either have to find new industries with tax revenue and employment or face decline followed by blight. According to the International Monetary Fund, nuclear energy has the largest economic multiplier effect of any clean energy technology.[9] Nearly all the money spent on nuclear energy stays in New York and the U.S. Investing in nuclear is the ultimate economic stimulus.

Protection and Restoration of New York's Natural and Working Lands

It is important that, in addressing climate change by reducing emissions, other aspects of environmental protection such as biodiversity and land conservation are considered.

The aforementioned United Nations study also confirmed that nuclear energy has the smallest life-cycle land footprint of any energy source. It is also among the least impactful with respect to mining, materials, and toxicity. Compared to nuclear and conventional fossil fuels, solar and wind have very low energy densities. Because of these low energy densities, large collection areas are necessary to meet demand (and that still does not solve for seasons, wind droughts, etc.). Per unit of energy generated, wind has 2 to 19 times the ecological impact of nuclear, even excluding climate change, which dominates the overall picture (Figure 7). The impact from solar is 17 to 29 times that of nuclear.

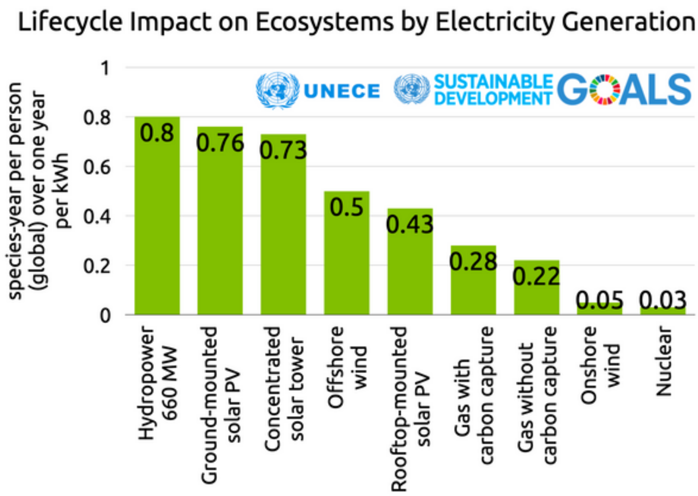


Figure 7. Nuclear has the lowest impact on ecosystems

The three nuclear power plants in upstate New York produce enough carbon-free electricity for 3.8 million homes on just 2,050 acres of land. And all of the spent fuel created over the 52 years of its operation could fit on less than half of a Walmart parking lot.

Expanding land area used for electricity generation harms the goal of conserving forests and wildlife, while taking away potential carbon sinks that reduce atmospheric greenhouse gas concentration. Without preserving existing nuclear or deploying advanced reactors, solar and wind generation would require the industrial development of far more land than necessary for decarbonization. Just replacing the energy output of New York's upstate nuclear plants would require covering between 100 and 200 square miles of land with solar panel projects.

Thankfully, by expanding nuclear capacity at existing nuclear stations and onto brownfield industrial sites, New York can conserve New York's forests and farmland. A smaller land footprint also means higher acceptance from communities who would otherwise oppose major industrial development.

Redevelopment of Industrial Communities & Decarbonization Technologies

CAC Plan's Appendix C warns "New policies that increase the cost of energy, reduce the reliability of energy, or increase the cost of emitting GHGs could cause businesses to shift their production outside of New York, or avoid the State altogether and instead invest in out-of-state locations with lower energy and/or GHG emission costs."

Jurisdictions that have invested heavily in wind and solar while ignoring or shutting down nuclear capacity have experienced significant increases in the cost of electricity. For example, Germany's electricity is twice as expensive as France's, despite French electricity being 6 times as clean (France gets 70% of its electricity from nuclear power; Germany got 29% of its electricity from coal and lignite). Here in the U.S., California has seen its retail electricity prices climb 80% higher than the average of the remaining contiguous states.[10] By pursuing a similar decarbonization strategy, the CAC Plan would make energy more scarce and expensive, chasing away industry and leading to energy poverty.

Nuclear energy promotes system reliability with minimal downtime. New York's own Indian Point Unit 3 recorded 751 days of uninterrupted operating run since its last refueling, setting a world record for commercial light

A thousand helmets on a fence, one for each clean energy job lost with the premature closure of Indian point. Seen in April 2021 at the farewell address by the village of Buchanan, host to the plant.

water reactors. Some advanced reactor designs will be able to operate for years without refueling.

By expanding New York's existing nuclear power generation, Bright Future paves the path to abundant, affordable, reliable and clean energy to support all industries. While much of the country has seen electricity prices climb as a result of the global energy crisis, Illinois consumers are actually seeing their electric bills decline. This is because the state secured the operation of its nuclear power plants as a hedge against high fossil fuel prices. Nothing attracts future-facing industries like a reliable source of affordable energy.

Development of Robust In-State Low-Carbon Energy and Manufacturing Supply Chains

The coronavirus pandemic has revealed the fragility of America's supply chains and the consequences of relying on other nation's for our most important goods and services. As such, Climate Action Council's Just Transition Working Group wants to bolster industry and retention of sustainable economic development.

Differences in materials, labor, and manufacturing requirements between nuclear, wind, and solar create dramatically differentsupply chains. With such large investments needed to transform the energy sector, we must aim to capture as much of that investment as possible in domestic supply chains, and ensure that these new power sources create permanent, high-skills, well-paying jobs with opportunities for everyone.

By relying heavily on solar and wind, the CAC Plan would be extremely dependent on offshore supply chains. Powered by low-cost coal, China is the top manufacturer of solar panels and wind turbines in the world. Eighty percent of global polysilicon and ninety-eight percent of the world's silicon wafers and ingots come from China. Seven out of the top ten wind turbine manufacturers are Chinese, and many European wind developers are moving manufacturing to China for cheaper glass fiber, blades, and steel. [11]

A U.S. Department of Commerce investigation into anticompetitive behavior is threatening two-thirds of planned solar additions in 2022, underscoring the risks of extreme import reliance.[12] Forty percent of the world's polysilicon comes from China's Xinjiang province, where the U.S. deemed that Chinese government is undertaking forced labor of – and genocide against – the minority Uyghur Muslim population.[13,14] While the U.S. could (and should) invest in domestic manufacturing for wind and solar, environmental regulations and labor standards would make panels and turbines significantly more expensive.

Much of the nuclear supply chain is already domestic. The scale of nuclear projects and the high-skilled labor and operational requirements make it extremely difficult to offshore much of this industry. However, we currently import most of our fuel and industrial forgings from abroad. Given that fuel is a small fraction of nuclear cost and is available from allied nations, there has not been a strong political urgency to invest in fuel fabrication. Still, there is no reason we cannot invest in the facilities to re-shore these capabilities. Nuclear was invented in America and had a completely independent supply chain at the advent of the industry. With proper motivation and investment, we could make our nuclear industry completely self-sufficient.

Reliable and Resilient Electrical Grid

Beyond independence from other countries for meeting our energy needs, another energy

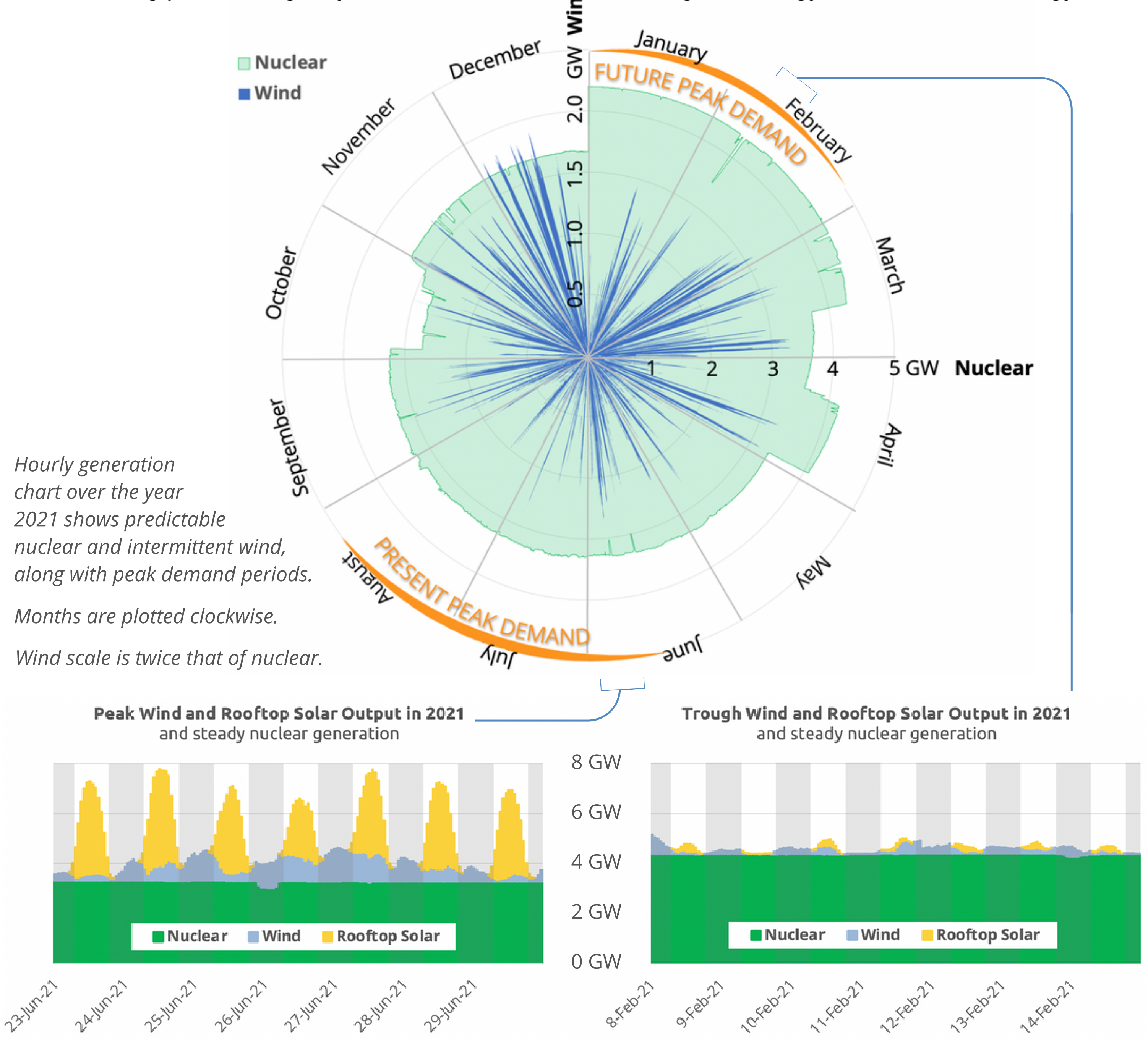


Figure 8. Annual nuclear and wind generation (top); peak and trough one-week wind and solar output (bottom)

security imperative is having a robust, resilient grid — one that can keep the lights on in the face of extreme weather events or emergencies. With electrified heating, transportation, and industrial processes, the consequences of supply shortages go from economically severe to incredibly dangerous and life threatening.

The CAC Plan relies heavily on the importing and exporting electricity from and to neighboring power grids. The issue, however, is that many of these states will be experiencing the same weather as New York.[15] Meteorologically, wind patterns are very large, sometimes spanning entire continents. This means that reliance on neighboring grids is unlikely to overcome large-scale wind lulls, as that may just result in a larger number of simultaneously idle wind turbines. Similarly, large storms will result in similar weather conditions across large geographical areas.

Intermittency of solar and wind generation is not a trivial matter. The electric grid requires absolute moment-to-moment continuity in power supply in-line with demand. During 2021, peak one-week wind and solar generation in New York was nearly 10 times the trough output (Figure 8). No energy storage option has the necessary technological maturity, affordability, or scalability to back up a grid for any extended period of time (see Appendix 3). Expanding battery storage to power the entire state for hours at a time would be incredibly resource-intensive and environmentally damaging. Believing that unproven technologies will overcome seasonal energy storage will ensure that New York remains hooked on fossil fuels.

Despite major investments in renewables, California has been unable to retire fossil fuel capacity and suffers from an unreliable grid. To keep the lights on, the state has had to seek exemptions from federal air pollution rules so that it can burn more gas.[16]

With bipartisan federal support, the U.S. is deploying new nuclear technology that can rapidly ramp their output up or down to help the power grid cope with load spikes and interruptions in intermittent energy sources.[17]

The CAC Plan makes New York reliant on her neighbors for 47% of onshore wind and 39% of hydro for electricity (Figure 9). This plan also expects New York's neighbors to provide half the hydrogen to power our hard-to-decarbonize sectors, and supply grid-balancing electricity when New York cannot provide for herself. Bright Future eliminates the need for all dedicated wind and electricity imports, freeing our neighbors to use their valuable resources. It also does not need to import hydrogen to keep New York's lights on.

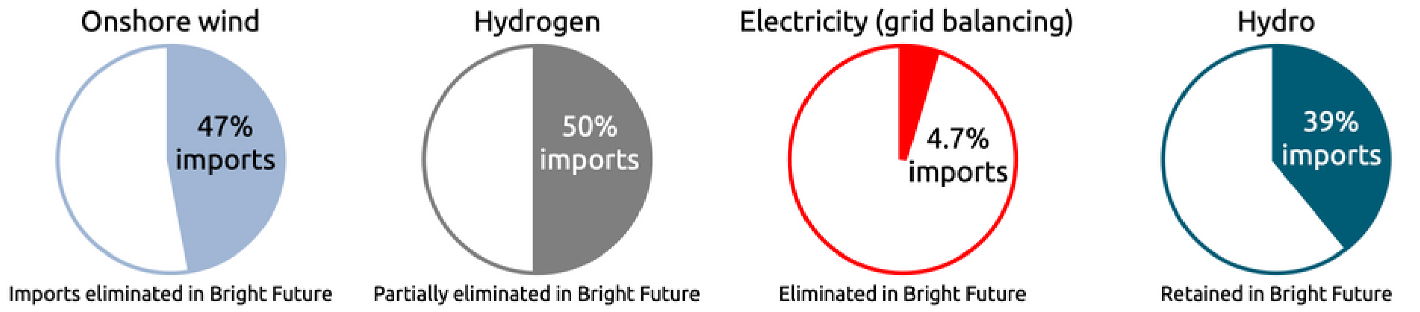


Figure 9. Climate Action Council Scenario 3's import dependence in 2050

COMMUNITY CONSIDERATIONS

Much as there are growing concerns about the large-scale deployment of solar and wind, everyone may not be in favor of developing nuclear energy. The potential concerns specific to nuclear plants are broadly about waste and power plant emergencies.

Nuclear waste concerns are overwhelmingly focused on "high-level waste," byproducts of atomic fission that will release their energy sometime between now and thousands of years in the future. Nuclear fuel is made up of cylindrical metal tubes containing small ceramic pellets of uranium. These metal tubes are gathered into bundles for loading and unloading into the reactor. After nuclear fuel has spent about five years in a reactor making energy, it is placed into a pool of water to cool off for another five-to-eight years. Unlike other hazardous waste, the extremely small amount of nuclear residue becomes less toxic with time.

After cooling in the spent fuel pools, spent nuclear fuel is either recycled (France) or moved into large concrete canisters called dry casks (most other places). These casks hold several spent fuel assemblies each. In the history of civilian nuclear energy, no one has been injured or killed by commercial nuclear waste. Nuclear is the only energy industry to fully account for all waste streams and disposal is already paid for in the U.S.

The second major concern is nuclear plant emergencies. In over nearly seventy years of commercial nuclear generation, the U.S. has had one voluntary evacuation, Three Mile Island, PA in 1979. About half of the local population declined to evacuate and those that did returned

Dry cask storage at the Palo Verde nuclear power station
Credit: Paris Ortiz-Wines

Three Mile Island Nuclear Power Plant, Pennsylvania
Credit: Exelon

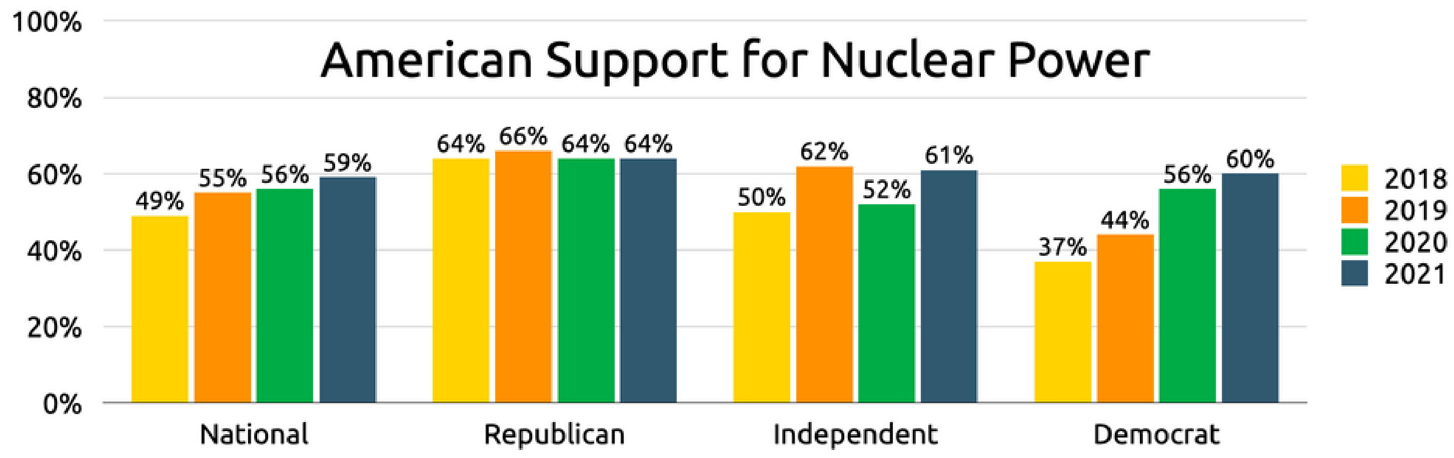


Figure 10. A survey conducted by ecoAmerica found that American support for nuclear is growing

within three weeks. There were no injuries and no discernible health impacts on the population. [18] Evacuations due to non-nuclear industrial plant accidents like wildfires and floods are far more likely to occur than nuclear evacuations.

After comprehensive analysis of sustainable energy choices, the EU's highest scientific body deemed "There is no science-based evidence that nuclear energy does more harm to human health or to the environment than other... climate change mitigation [technologies]."[19] The report goes on to state "The fatality rates characterizing state-of-the art Gen III Nuclear Power Plants are the lowest of all the electricity generation technologies."

Most new reactors are intentionally designed to all but eliminate the need for temporary evacuations even in the event of severe accidents. Passive safety features – like using gravity and natural flow of coolant – allow these plants to shut down even with the complete loss of power to the facility (from blackouts, earthquakes, or major storms) or any breakage of equipment in the plant. New reactors are designed to avoid the need for evacuations.

The people who best understand the high rewards of nuclear and the low risks are its neighbors. Surveys demonstrate that the strongest support for nuclear energy comes from those who live closest to nuclear plants. [20] Reasons cited for support are environmental protection, the plant's contribution to jobs and the economy, favorable perception of safety, and good public outreach. Nearly 70% of people surveyed responded that adding a new reactor to their nearby plant would be an acceptable way to meet new electricity demand.

A 2021 survey by ecoAmerica, an independent non-profit building climate leadership, found that American support for nuclear power has grown from 49% in 2018 to 59% by 2021, with Democrats' support fast catching up with that of Republicans (Figure 10).[21]

NEW YORK'S RESPONSIBILITY

Maintaining Existing Nuclear Plants

Keeping existing nuclear plants operational is the simplest, cheapest, and most immediate action to protect the global climate and New York communities harmed by air pollution.[22] Preserving New York's nuclear plants will reduce the herculean burden to build redundant generation, extra transmission lines, and energy storage infrastructure that would span millions of acres and cost billions of dollars. The CAC Plan itself found that extending the operating licenses of New York's upstate nuclear plants from 60 years to 80 years would save $9 billion in decarbonization costs.

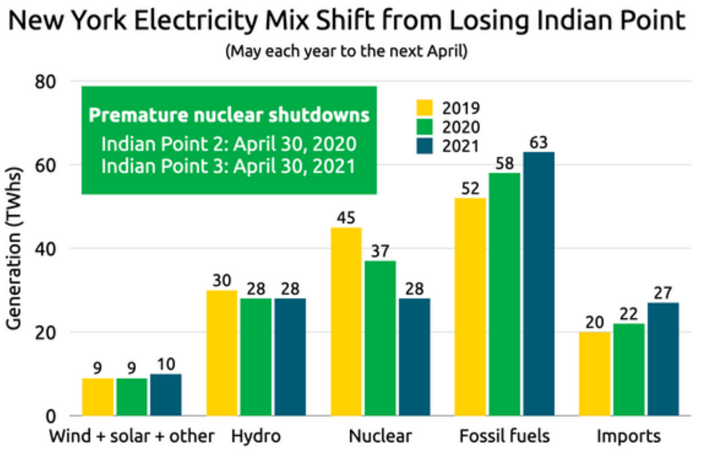


Figure 11. Electricity generation from May to April of each year

When nuclear plants close, they are invariably replaced by fossil generation, not energy efficiency or renewables, as New York is demonstrating (both in-state and through an increase in net imports, Figure 11). Notes NYISO in the recent Power Trends report "Stemming from the deactivation of Indian Point, production from nuclear generation fell... That supply was primarily replaced by [fossil] fuel units…" and "Recent increases in the CO_2 emission rate coincide with [this] phased closure."[2]

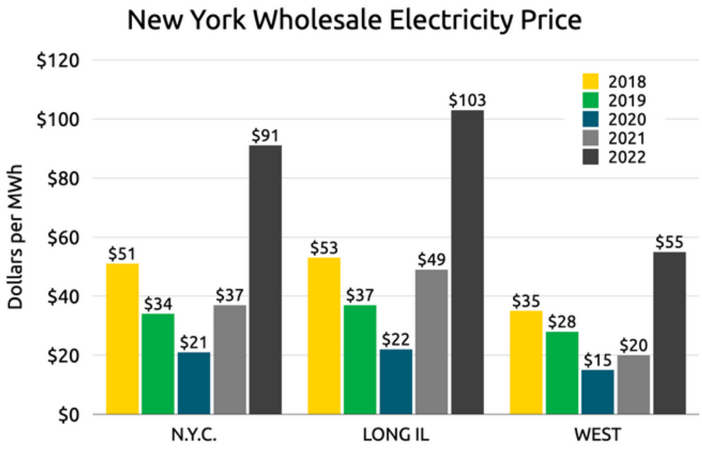


Figure 12. Wholesale price from January to April each year

Furthermore, as long as gas-fired generation is needed to make up for intermittency of wind and solar, replacing nuclear generation with a combination of intermittent wind or solar and fossil gas leads to far greater emissions than simply maintaining existing nuclear generation, as seen in Germany.[23,24]

In rate-deregulated merchant electricity markets, prices have been driven down by low-cost fracked gas and to a lesser extent, by market distortions due to subsidized renewable generation.[23] As the era of historically-cheap fossil gas appears to be over (Figure 12), NYISO's notes that wholesale electricity prices "generally increased as a result of the retirement of Indian Point. As eastern New York has become more reliant on natural gas-fired generation, spikes in congestion because of tight gas market conditions on cold winter days have become more frequent."[2] Operating nuclear plants are a strong hedge against fossil fuel price volatility.

Long-term operation of existing nuclear plants is the least-cost means to prevent greenhouse gas emissions.[25] Recognizing the value of existing nuclear sources, New York introduced the ground-breaking policy of Zero-Emissions Credits in 2016, which has thus far enabled the upstate plants to compete with shale gas-powered low electricity prices.[26]

As the 2029 expiration of this program draws close, in the absence of comprehensive carbon pricing, New York needs to extend this program to ensure timely investment in upgrades and license renewals. Permitting and upgrading major energy infrastructure takes years, especially for large projects.

America's nuclear plants are among the best in the world. The Nuclear Regulatory Commission, responsible for the safe operation of the U.S. nuclear fleet, has permitted water-cooled reactors to operate for 80 years. With proper maintenance and replacement of reactor system components, there is no technical reason these plants couldn't continue to operate even further into the future.

Deploying New Nuclear

Advanced nuclear technologies exist or are under development that could support a significant, rapid expansion of U.S. nuclear energy capacity. With appropriate industrial policies and economic conditions, New York could be a leader in this keystone clean energy technology. Nuclear power has a long history in New York, with the establishment of Knolls Atomic Power Lab (a premier nuclear propulsion laboratory) at Niskayuna in 1946. Not long after, the first nuclear reactor for naval propulsion research was built in New York.[27] Thereafter, New York built the powerful nuclear plants that continue to provide firm clean power to this day.

New York has also played a central role in nuclear innovation. The first naval prototype reactor built in New York is closely related to modern waste recycling designs. The first civilian power plant in New York (Indian Point 1) used thorium, a potential future nuclear fuel.[28] New York also has a leadership position in the field of nuclear fusion, with the Laboratory for Laser Energetics in Brighton possessing some of the largest lasers in the world for fusion energy research.[29] To ignore advanced nuclear technology in New York energy planning is to ignore our rich history as leaders in the field and the incredible expertise and facilities already present in the state.

New nuclear technologies are being designed and tested to offer a number of advantages that will be crucial to reducing emissions, especially of the hard-to-decarbonize parts of the economy. These advantages include obtaining even higher levels of efficiency by increasing the time before refueling; creating smaller reactors that can be tailored to various energy needs and budgets; operating at high temperatures to supply heat to service industrial facilities; and recycling the used fuel from today's nuclear plants to make even more clean electricity.

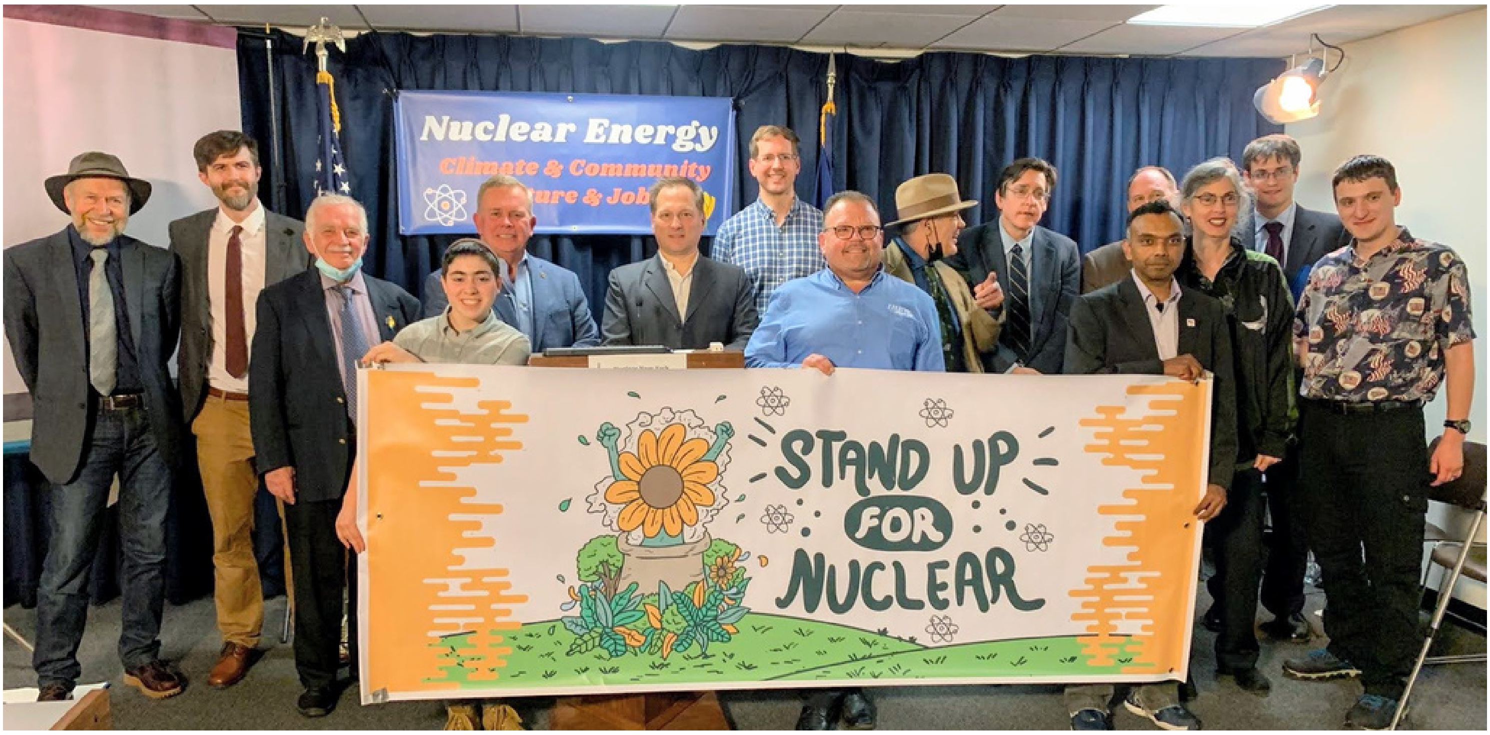
New York has a responsibility to protect its forests and farmland from industrial energy sprawl.

CONCLUSION

New York's carbon-free future is bright, but only if we steward the existing clean energy we have and usher in a new era of reliable, resilient, and clean power. Bright Future brings a data-driven approach rooted in real-world case studies to improve upon the CAC Plan. Nuclear is an evidence-based pathway of deep decarbonization, one that New York has walked before. Thanks to nuclear and hydro, upstate New York already has a world-leading 90% carbon-free electric grid.

New York should authorize and expedite the siting of new nuclear technology without delay. The state should partner with the U.S. Nuclear Regulatory Commission, U.S. Department of Energy, U.S. Environmental Protection Agency, as well as other interested state and federal agencies to install new nuclear facilities to achieve affordability, secure reliability, and seize our shared climate goals.

New York has the necessary expertise, nation leading apprenticeship programs, and financial sophistication to capture the economic rewards of carbon-free nuclear power. With the right technological choices and policies, New York can deploy our most scalable tool in the fight against climate change while ensuring a prosperous future.

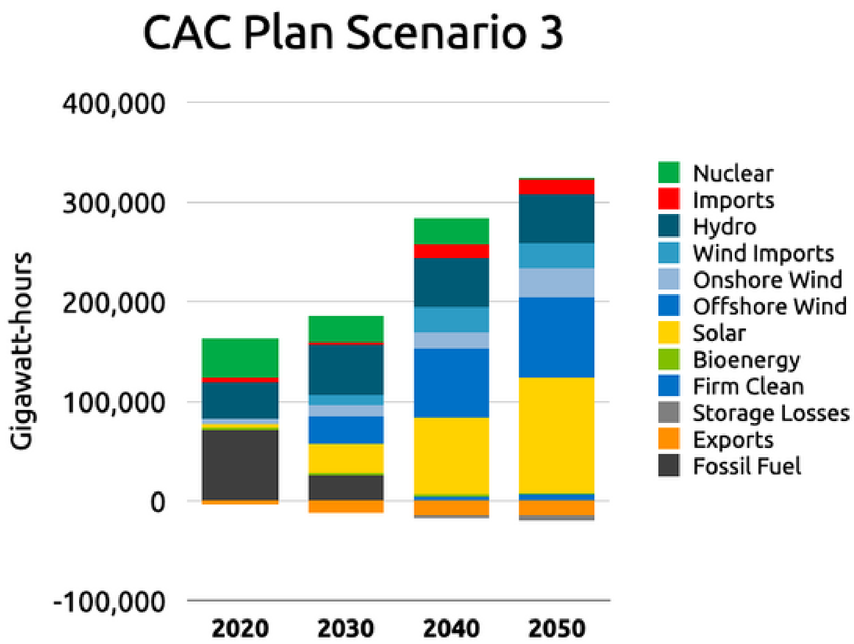


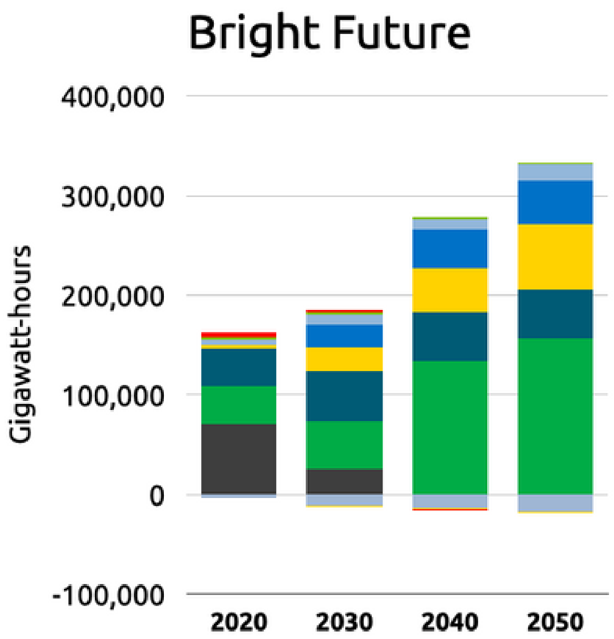
Climate Hawks and Union Leaders call for Nuclear Power in New York
Press Conference in Albany before Climate Action Council Hearing, 14 April 2022 [30]

ENDNOTES

1. Climate Action Council. Draft Scoping Plan. December 2021.
2. New York Independent System Operator. Power Trends 2022: The Path to a Reliable, Greener Grid for New York. June 2022.
3. Analysis Group. Climate Change Impact Phase II for New York Independent System Operator. September 2020.
4. UN Economic Commission for Europe. Life Cycle Assessment of Electricity Generation Options. March 2022.
5. UN Intergovernmental Panel on Climate Change. Global Warming of 1.5 °C, Figure SPM.3b. October 2018.
6. Upstate Energy Jobs, The Benefits of Upstate Nuclear Energy
7. US Energy & Employment Jobs Report (USEER)
8. The Nuclear Decommissioning Collaborative
9. Batini, et al. Building Back Better: How Big Are Green Spending Multipliers? *International Monetary Fund*, 2021.
10. U.S. Energy Information Administration. State Electricity Profiles
11. Tachev, V. What the 2021 China Wind Power Boom Means for the World. *Energy Tracker Asia*, February 2022.
12. Rystad Energy. US probe into solar imports threatens almost two-thirds of planned capacity additions in 2022. May 2022.
13. Pompeo, M. Determination of the Secretary of State on Atrocities in Xinjiang. U.S. Department of State. January 2021.
14. Murphy & Nyrola. In Broad Daylight: Uyghur Forced Labour and Global Solar Supply Chains. *Sheffield Hallam University*, 2021.
15. Anguin, M. Shorting the Grid: The Hidden Fragility of Our Electric Grid. *Carnot Communications*, 2020.
16. Groom. California asks Biden administration to allow gas plants to run at maximum. *Reuters*, September 2021.
17. Wald, M. With Natrium, Nuclear Can Pair Perfectly with Energy Storage and Renewables. *Nuclear Energy Institute*, November 2020.
18. American Nuclear Society. Health Studies Find No Cancer Link to TMI.
19. European Commission, Joint Research Centre. EU taxonomy for sustainable activities. March 2021.
20. Bisconti. Factors Affecting Public Opinion of Nuclear Energy in the United States. *Elsevier*, 2021.
21. ecoAmerica. Energy Attitudes: Americans Support Clean Energy. *American Climate Perspectives* Vol. V 2021, 2021.
22. National Academies of Sciences, Engineering, and Medicine. Accelerating Decarbonization of the U.S. Energy System. February 2021.
23. Repka & Smith. Deep Decarbonization and Nuclear Energy. *Environmental Law Reporter*, 2018.
24. Reed. Germany's Shift to Green Power Stalls, Despite Huge Investments. *New York Times*, October 2017.
25. International Energy Agency and the OECD Nuclear Energy Agency. Projected Costs of Generating Electricity 2020. 2020.
26. McDermott Will & Emery. NY Creates New Emissions Credit for Nuclear Plants. September 2016.
27. Touran. Nuclear Reactor Development History. What is Nuclear, 2020.
28. U.S. Department of Energy Office of Scientific and Technical Information. Indian Point, Consolidated Edison's Thorium Converter. October 1961.
29. Laboratory for Laser Energetics, University of Rochester.
30. Nuclear New York. New York's Climate Plan. April 2022.

APPENDIX 1: BRIGHT FUTURE





Scenario Limitations

This brief does not discuss all the shortcomings of the CAC Plan nor attempt to correct them. Some of the identified issues and how they are addressed in Bright Future is tabulated below.

	CAC Scenario 3 shortcoming	Treatment in Bright Future
Onshore NY wind capacity factor	32.5% in 2050, when the average capacity factor for the last 3 years per NYISO is 24.4%	Curb projected NY wind generation by two-thirds by 2050
Imported wind capacity factor	44.2% in 2050, when New York's neighbors have similar wind conditions to NY	Eliminate wind imports
Energy import dependence	47% of onshore wind, 50% of hydrogen, 39% hydro coming from New York's neighbors	Eliminate importation of wind and hydrogen needed for Firm Clean generation

	CAC Scenario 3 shortcoming	Treatment in Bright Future
Technology import dependence: solar	36% of 2050 electricity from solar, when 80% of global polysilicon plus 98% of the world's wafers and ingots come from China	50% of 2050 electricity from nuclear, with Made-in-America, Made-in-New York supply chain, creating the largest economic multiplier of any clean energy technology
Technology import dependence: wind	42% of 2050 electricity from wind, when 7/10 top wind turbine manufacturers are Chinese, with Europeans also moving manufacturing to China	See above
Degrowth	Assume New York's per-capita real Gross State Product to grow at 43% the historic rate	Unchanged for scenario comparability, but begin to envision an abundant future
System-wide efficiency	Build Firm Clean generation infrastructure that parallels today's entire fossil capacity, but use it only 2.9% of the time	Operate Firm Clean nuclear generation at high capacity factor
Curtailment (of excess generation)	Assume unchanged renewable capacity factor, even at high grid penetration, when upstate wind is already suffering curtailment. If Scenario 3 assumes electrolyzers to convert all excess generation into hydrogen, how large is the electrolyzer infrastructure? What is its cost?	Nuclear capacity factor of 80% (from the present 93%): improve reliability through *Dunkelflaute*, solar and wind lulls, and the ability to ramp up and down to accommodate intermittent renewables (e.g. solar 'duck curve')

	CAC Scenario 3 shortcoming	Treatment in Bright Future
Climate vulnerability	An energy system almost completely made of weather-dependent electricity, just as weather patterns are becoming more unpredictable	An energy system based on reliable carbon-free nuclear generation
Imports	4.7% of load provided by New York's neighbors in the form of unspecified, presumably "dirty" electricity, likely when they too need it the most	Eliminate electricity imports
Exports	4.7% of load dumped on New York's neighbors, likely when they need it the least (a la California)	5.3% of dispatchable emission-free electricity available to assist neighbors (a la low-carbon leaders Quebec and France)

APPENDIX 2: GAPS IN KNOWLEDGE

Questions submitted to NYSERDA on 27 May 2022 regarding NYSERDA's Integration Analysis (IA), heretofore unanswered.

1. For several years, academic studies [1] have pointed to the role of firm generating sources, such as hydro and nuclear, in "deep" and cost-effective decarbonisation. NYSERDA's chosen consultant for the IA, E3 themselves, conclude in their 2019 modeling study for the State of Washington: "As in past studies, E3 found that achieving deep emissions reductions from the electric sector is achievable at manageable cost, provided that firm capacity [namely nuclear] is available to avoid the infrequent but large electricity shortages that can occur on highly renewable grids." [2] Not surprisingly, even the IA shows that a retention of New York's remaining nuclear capacity provides significant savings. Passively-safe advanced nuclear technologies, including molten salt reactors and small modular reactors with enhanced load-following capability, are under development elsewhere in the country and around the world. Given its benefits as a provider of reliable carbon-free electricity, **what is the rationale for NYSERDA excluding nuclear energy from the list of "candidate resources" for this study?**

2. The IA predicts between 10,997 MW and 13,239 MW of land-based wind installed within New York by 2050, and estimates annual generation between 31,224 GWh and 37,896 GWh. This corresponds to a capacity factor of about 33%. However, NYISO estimates a capacity factor of 26% for land-based wind, and actual performance of New York's installed wind capacity in the years 2019-2021 was 25.6%, 23.9%, and 22.7% (data from NYISO Gold Book 2022). In addition to the above, the IA predicts 25,546 GWh (Scenario 3) of imported electricity from 6,593 MW of out-of-state wind resources (presumably Ontario, Quebec, and PJM), meaning that those turbines would operate at a capacity factor of 44%. **What are the bases for these assumptions?**

3. The IA assumes "indefinite" life for battery, hydrogen, wind, and solar infrastructure, when the typical lifetime expectations of such installations are 15-30 years. **How would the IA change if this assumption were corrected?** Furthermore, solar PV, wind turbines, and current-technology batteries degrade over time. (For example, solar panels can lose up to 1% of their output capacity per year.) **How would the IA change if this fact were taken into account?**

4. The IA provides estimates and predictions on LCOE and capital costs for different candidate resources. Either number can serve as input both for the cost optimization model and for calculating the total cost of the program. **Which value is used for which purpose?** While solar PV, wind turbines, and batteries typically last one or two decades, nuclear energy and transmission infrastructure are capital investments that can outlast these technologies by a factor of four or more. An analysis that tallies up capital expenses but truncates benefits after 2050 would discriminate against long-term investments. However, an analysis solely on LCOE would introduce other problems. **Do you agree that a more accurate approach would be to amortize capital expenses over**

the expected lifetimes, add financing costs and O&M to each year, and discount that to net present value?

5. **Are transmission upgrade costs calculated and included in the cost model?** The "Resource Costs - Mid" tab offers ""Mid" case resource costs, including LCOE by resource with and without transmission upgrade costs; overnight capital costs; fixed operating and maintenance costs; interconnection costs, and transmission upgrade costs for renewable deliverability. The Mid case costs are utilized in all core scenarios." These transmission costs are only provided in the LCOE numbers per resource (wind, solar) and zone. Does this therefore include only the intra-zone costs of resource integration and exclude long-range transmission upgrades to, e.g., move upstate solar and wind generation downstate?

6. The "GSP" tab in the Annex-2-Key-Drivers-Outputs spreadsheet shows that New York's per capita GSP compounds at 0.8% annually (in 2020 dollars), 43% the historic growth rate of 1.9%, for your projections through 2050. To most New Yorkers, this reads like bad news. **What are the reasons for this assumption, or is this not an assumption but rather the model's output due to the proposed changes to the State's energy mix?**

7. Has the IA or NYSERDA analyzed the impact of this scoping plan on electric ratepayers and New York taxpayers (businesses and consumers)? **Could you please share it publicly?**

8. In all scenarios, the IA assumes that about 5% of electric demand will be served by "Imports", balanced out by "Exports" of the same magnitude. In so doing, it appears that NYSERDA essentially allows "clean" electricity from renewables produced when it is not needed to be traded for dispatchable (likely "dirty") electricity from out-of-state to serve actual real-time demand–essentially a "battery on paper." **How does NYSERDA reconcile this reliance on neighboring states maintaining dispatchable fossil fuels with the CLCPA requirement that load-serving entities serving New York customers be carbon-free by 2040?** We note that this amount of annually imported/exported electricity represents roughly three times the volume of energy that NYSERDA predicts will be drawn from batteries and pumped storage. Has there been a sensitivity analysis to determine the cost impacts of not counting on this "paper battery"? How much actual storage–whether in the form of batteries or hydrogen– would New York need to avoid relying on imported fossil fuels, and how would this change the amount of required in-state carbon-free resources? **What would the consequences be if neighboring grids cannot or don't want to provide electricity when New York needs it? Finally, If New York were to receive imported electricity only from renewables (regardless of how much it exports), then how does NYSERDA believe reliability problems can be avoided, when a surplus or dearth in electricity from weather-dependent wind and solar sources in New York is likely to coincide with similar conditions in neighboring states?** (NYISO warns of these very conditions within its own Phase II analysis.)

9. Curtailment of output from wind and solar resources will rise with increasing penetration on the grid due to transmission constraints and increasing mismatches between generation and demand. However, neither the IA nor the Scoping Plan discuss

this. **Has any analysis of curtailment been performed and how does NYSERDA propose to address this a) technically and b) financially given the renewable investors' expectations for compensation via market and out-of-market payments?** If the Scoping Plan assumes that all excess renewable electricity which might otherwise be curtailed will be directed to the operation of electrolyzers for the production of green hydrogen, then **how much electrolyzer equipment must be deployed to support this consumption of excess electricity during periods of peak wind and solar production in each IA scenario?** What would the capacity utilization rate of those electrolyzers be? What volume of hydrogen storage would be necessary in Scenario 3 and what would be the cost of that hydrogen?

10. The large-scale buildout of solar, wind, battery storage, transmission, and zero-carbon "firm" generation infrastructure proposed would encompass a significant amount of previously undeveloped land. What are the state's estimates on the amount of land conversion to implement the Scoping Plan? **Has NYSERDA, DEC, or any other agency performed an analysis of these cumulative, large-scale environmental impacts, and the potential economic impacts upon agricultural production within New York?** If not, when will such an analysis be conducted?

Appendix 2 Endnotes

1. Jenkins, J. Getting to Zero Carbon Emissions in the Electric Power Sector. *Joule*, December 2018
2. Energy and Environmental Economics, Inc. E3 Examines Role of Nuclear Power in a Deeply Decarbonized Pacific Northwest. 2020

APPENDIX 3: SYSTEM COSTS

Low-Carbon Energy System Costs

Some economic calculations suggest that deploying new nuclear energy is expensive, while wind and solar are becoming cheaper. Yet, cost-optimization studies consistently show that nuclear energy should have a significant role for deep system-wide decarbonization. Real-life examples, such as Ontario, France, and Sweden demonstrate how regions without abundant hydro and geothermal can also have stable, low-carbon and affordable electricity, while wind-and-solar dominant systems see costs rise with decreasing grid stability.[1] Bright Future urges New York to learn from these lessons.

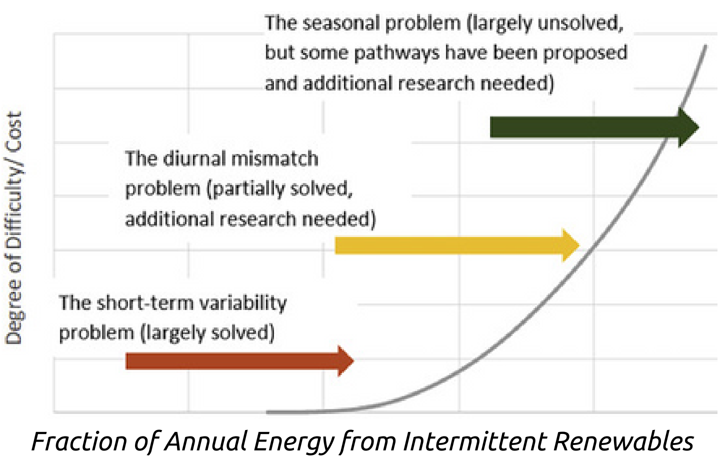


Figure A1: Integration difficulty. Source: Denholm, et al [2]

In high-emission grids, adding solar and wind capacity has significant value: (i) summer peak demand can be shaved by distributed solar; (ii) both wind and solar energy, when generated, curb high-emitting fossil generation, saving fuel and reducing emissions. At fairly low penetration, Levelized Cost of Electricity (LCOE) offers good guidance for investment decisions.

However, as a grid becomes increasingly decarbonized, whether due to a saturation by hydropower, nuclear, wind, or solar at many times during the year, adding more wind and solar increasingly provides no value because more and more of the incremental generation occurs when there is no need for it: No fossil generation is left to cycle down while demand is already being served by zero-carbon sources. The closer the electricity system is to deep decarbonization, more curtailment of solar and wind result from adding intermittent generation capacity. Worse, fossil back-up capacity is called into service in order to keep the lights on when intermittent sources fail to generate any power.

Copious transmission and energy storage is needed to displace fossil back-up systems and achieve deep decarbonization using intermittent generation (Figure A1). The four scenarios of the CAC plan, while lacking specificity on necessary transmission upgrades, include about 45 GW capacity of battery- and hydrogen-based storage systems. These systems do not generate electricity but merely time-shift electricity from generation to use and add losses and costs that are not reflected in LCOE numbers.

The difference between LCOE and full system costs exists because electricity is a service, requiring just-in-time generation, ideally in close physical proximity to demand. LCOE, however, implies that electricity is a commodity that can be stored and transported at no cost. Were this possible then the intermittency of wind and solar power would be no problem, but in real-life, system costs balloon the more the grid relies on them and battery storage and backup power plants have to be added. While nuclear energy is not free of system costs, it is able to schedule downtime to match periods of low demand.

Real-Life Examples

Actual decisions in energy policy also show that LCOE is all but ignored:

- New Jersey has been subsidizing rooftop solar with over $200 per megawatt hour (MWh) in addition to net metering benefits and federal support.[3]
- New York mandated, in the CLCPA, the contracting of 9,000 MW of offshore wind capacity by 2035 even though NYSERDA estimated its pre-subsidy LCOE to be $140/MWh [4]
- In early 2022, the New York approved two "Tier 4" projects to bring renewable energy to New York City at average prices of $130-$155/MWh (nominal dollars).[5, 6]

Common to all these projects is the remaining need for back-up capacity. Meanwhile, the federal Energy Information Agency projects the 2040 LCOE of back-up free advanced nuclear to be $85/MWh (2021 dollars, Annual Energy Outlook 2022).

Scenario Analysis

We have tested the Bright Future scenario against CAC's Scenario 3 using past NYISO generation and demand data, combined with the projected electricity demand for 2050. Some insights from this exercise are:

1. Bright Future benefits from storage technologies as well, reducing the need for generation capacity, whether intermittent or nuclear, to cover peak demand or dark doldrums, but only needs about half the storage capacity.

2. While the total storage capacity given in Scenario 3 appears on target, the suggested solar and wind power capacity appears very much undersized by a factor of 2 and more. We suspect this to be caused by the Integration Analysis not addressing curtailment and erroneously assuming that every unit of generation will find use. We also do not know how the CAC scenarios model undefined “imports” and have not included them in our tests.

3. Bright Future would be cheaper even before accounting for the value of conserved farmland and nature.

Appendix 3 Endnotes

1. Sepulveda, E. Profiles in Decarbonization
2. Denholm, P. et al. The challenges of achieving a 100% renewable electricity system in the United States. *Joule*, June 2021
3. PSEG Services Corporation. SOLAR LOAN II – THIRD QUARTER REPORT 2021
4. NYSERDA. Offshore Wind Policy Options Paper January 2018
5. Contract with Clean Path New York, approved 14 April 2022
6. Contract with Champlain Hudson Power Express, approved 14 April 2022