A critique of the Physicians, Scientists, and Engineers research brief
'Evaluating the potential for renewables, storage, and energy efficiency to offset retiring nuclear power generation in New York'

February 2021

Isuru Seneviratne
James E. Hansen
Dietmar Detering
Leonard Rodberg
Gary Krellenstein
Keith W. Schue
Dennis M. Higgins
Meredith Angwin
Gary Kahanak

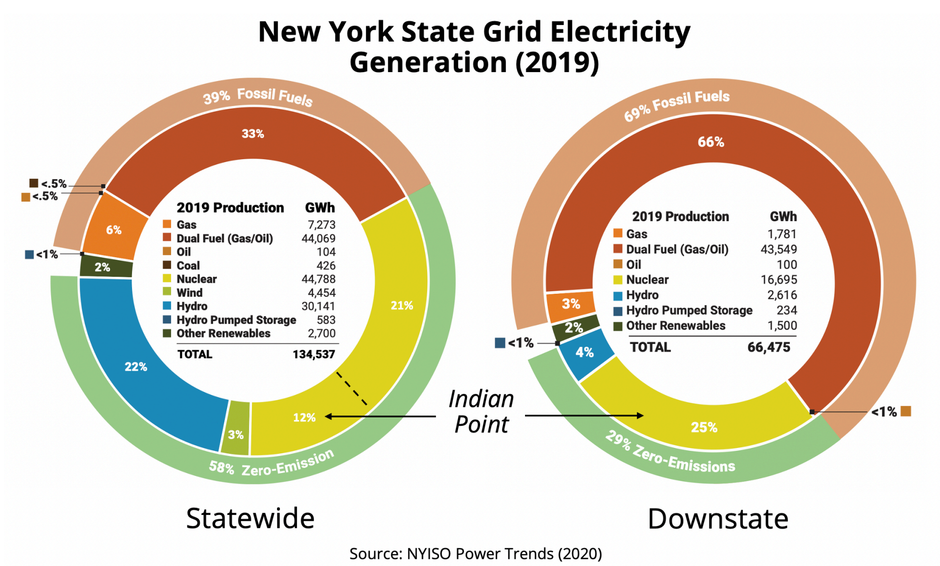
INTRODUCTION

In April 2020, the organization Physicians, Scientists, and Engineers for Healthy Energy (PSE) released a "research brief" titled *Evaluating the potential for renewables, storage, and energy efficiency to offset retiring nuclear power generation in New York.* The document actually seeks to evaluate the potential for renewables, storage, and efficiency to replace electricity from a particular nuclear facility, the two-gigawatt Indian Point power plant in Buchanan, NY. One of Indian Point's two reactors (IP2) was shut down on April 30, 2020 and the other (IP3) is scheduled to close in 2021. PSE's brief has been widely circulated by various groups as evidence that recently-built gas-fired power plants are not needed to replace electricity from Indian Point. In reality, the brief never makes this claim and in fact acknowledges that natural gas, at least in part, is providing electricity to compensate for Indian Point's closure. Nonetheless, the brief draws a number of questionable conclusions regarding the possibility that Indian Point, and by inference other nuclear reactors in the state, can be replaced realistically by renewables, storage, and energy efficiency while meeting state climate goals, including the recently enacted NYS Climate Leadership and Community Protection Act (CLCPA).

The purpose of this response is to take a more careful look at the PSE brief and its conclusions, recognizing the real-world engineering challenges and performance requirements associated with designing systems that are capable of providing reliable carbon-free energy. Our analysis relies primarily on data available from the New York Independent System Operation (NYISO), which is responsible for managing New York's electric grid.

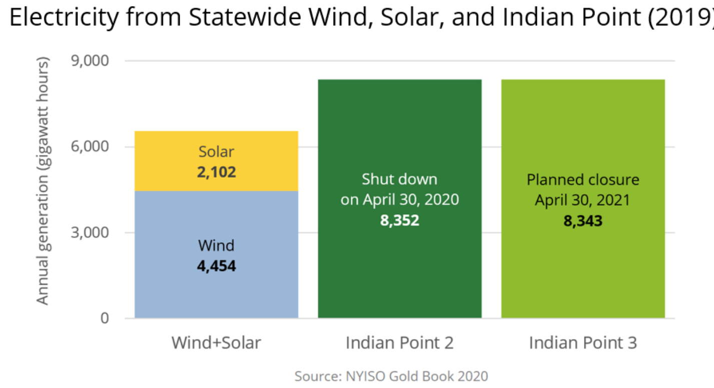
UNDERSTANDING THE IMPACT

Discussing Indian Point requires first understanding the magnitude of impact that its closure has upon state goals. In 2019, nuclear power comprised a third of total electricity generation in New York and was responsible for over half of carbon-free electricity statewide. The two reactors at Indian Point represented a fifth of in-state nuclear capacity. Located in the lower Hudson Valley, they produced a quarter of the downstate region's electricity and nearly all of its carbon-free electricity.[1]

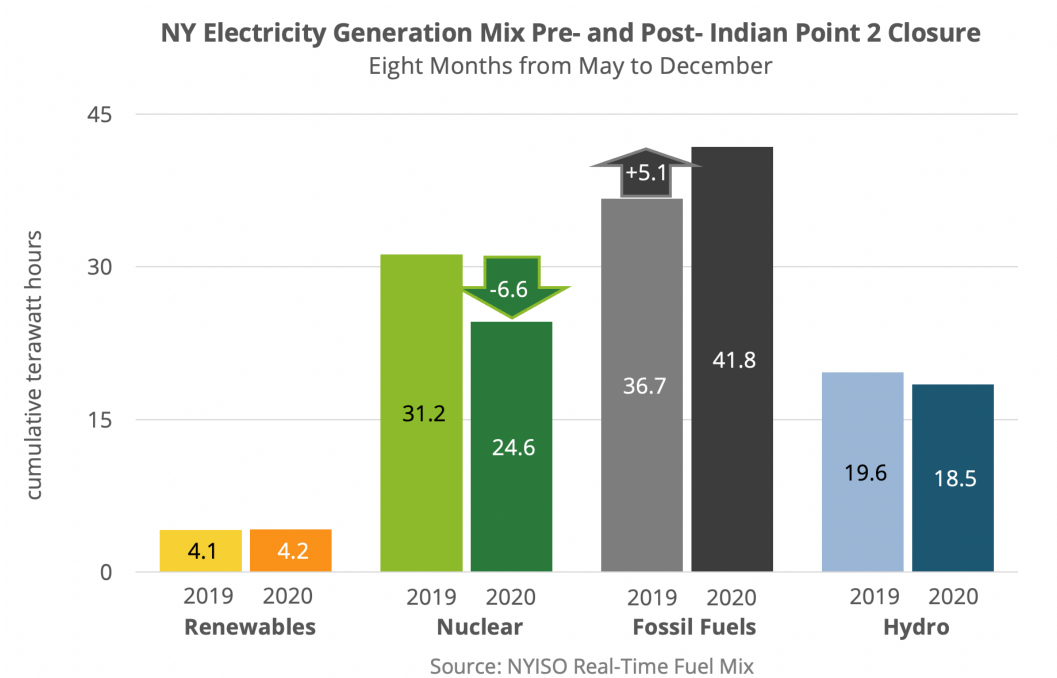


[1] NYISO 2020 Power Trends, Figure 14 and NYISO 2020 Gold Book, Tables III-2 and I-9A. The donut charts from NYISO Power Trends Figure 14 do not include behind-the-meter solar generation. However, all of the calculations in our report do. https://www.nyiso.com/documents/20142/2223020/2020-Power-Trends-Report.pdf

Operating at a capacity factor of 91%, Indian Point generated 16,695 GWh of electricity in 2019, consistent with its performance over the last decade. IP2 alone generated 8,352 GWh. Meanwhile, wind and solar (utility-scale and "behind the meter") in New York produced approximately 6,600 GWh the same year.[2] This means that from a climate standpoint**, shutting down just half of Indian Point eliminated more carbon-free electricity than is annually produced by every wind turbine and solar panel in the state.**



Since Indian Point generates reliable baseload electricity, IP2's closure created a very large, immediate, and continuous gap in real energy within the downstate region. That gap has been filled with fossil fuels, primarily methane—also known as "natural" gas. This is readily seen by comparing generation data for the eight months of May through December in 2020 following deactivation of IP2 to the same period in 2019.[3] Despite 2,753 GWh of reduced energy demand in 2020 during the COVID pandemic, New York generated significantly more electricity, 5,068 GWh, from fossil fuels in 2020 than in 2019 due to the loss of nuclear power.[4]



---

[2] NYISO 2020 Gold Book. https://www.nyiso.com/documents/20142/2226333/2020-Gold-Book-Final-Public.pdf

In 2019 wind produced 4,454 GWh (Figure III-3), utility-scale solar produced 52 GWh (Figure III-3) and there was 1,896 MW of installed behind-the-meter solar capacity in the state (Table 1-9A). Applying a capacity factor of 12.34%, this corresponds to 2050 GWh of behind-the-meter solar annually. This capacity factor is derived from NYISO projections of nameplate capacity and annual generation for statewide behind-the-meter solar in 2020 (Table 1-9A and 1-9B). If a 14% capacity factor is assumed, as PSE has in its brief, then this corresponds to 2,325 GWh. For either capacity factor, the total amount of generation from all of the wind and solar in the state is less than the annual output produced by IP2 in 2019. Generation data for IP2 and IP3 is found in Table III-2.

[3] Generation data from NYISO for May through December of 2019 and 2020. http://mis.nyiso.com/public/P-63list.htm. Actual load data from NYISO for May through December of 2019 and 2020. http://mis.nyiso.com/public/P-58Clist.htm

[4] This correlation between a reduction in nuclear power and increased gas use can also be seen, absent any change in demand, by analyzing generation data for the week following IP2 closure and a prior week with matching total generation and matching load. http://www.nuclearny.org/ip2-press-release/

Due to greater fossil fuel consumption, shutting down IP2 results in the annual production of about 4 million tonnes of avoidable carbon dioxide emissions (twice this in CO_2-equivalent greenhouse gases if lifecycle emissions are included).[5] This impact will double if IP3 closes in 2021. However, losing downstate nuclear power not only moves New York backwards on climate change; it subtracts emission-free energy from the grid in a part of the state where—except for Indian Point itself—electricity is generated almost entirely from fossil fuels. Shuttering Indian Point exacerbates poor air quality as more fossil fuels are burned in giant new gas-fired power plants within the lower Hudson Valley—680 MW CPV Valley Energy Center (CPV) and 1,020 MW Cricket Valley Energy Center (CVE). It also harms Environmental Justice communities which suffer from old, polluting oil and gas plants that will remain in operation longer, and that may need to run more, within the densely-populated New York City metropolitan area.

"REPLACING" INDIAN POINT

Although claiming to analyze the "replacement" of electricity from Indian Point, PSE's brief goes no further than its title suggests, which is to evaluate the potential for "offsetting" watts or watt-hours of electricity from Indian Point with other sources. The brief does not fully consider the *function* that Indian Point performs in the network. Instead, it redefines the task, asserting that replacement is achieved if (1) additional recent or projected gains in local renewable energy and efficiency exist to equal the nameplate capacity of Indian Point at peak times; and (2) additional recent or projected gains in renewable energy and efficiency exist statewide to equal the total annual generation of Indian Point. This approach is flawed for several reasons: It inappropriately counts existing renewable and efficiency gains that were displacing fossil fuels; it does not adequately consider the real-time impacts of intermittency; and it dismisses physical constraints of transmission and deployment at scale. We discuss each of these in the sections that follow.

REALLOCATION OF EXISTING RENEWABLES AND EFFICIENCY

In its analysis, PSE credits renewable energy and energy efficiency measures deployed for three years prior to the closure of IP2 toward the future replacement of Indian Point. However, this is inappropriate since those investments were already displacing fossil fuels. Whether installed recently or years ago, existing renewables provide electricity to the grid and thus reduce the need for generation from fossil fuel power plants. If those existing renewables are *subsequently* reallocated to the displacement of nuclear power being taken offline, they can no longer displace fossil fuels and more fossil fuels will be burned. This is precisely what occurred when IP2 closed. Likewise, existing gains in energy efficiency have already been absorbed into the broader energy system, reducing demand and avoiding generation from fossil fuel power plants. If those efficiency gains are later credited with the replacement of nuclear power, previously avoided generation from fossil fuels will occur.

This basic problem with the brief appears both in the discussion of local capacity and statewide generation. Referencing NYISO's 2017 deactivation assessment,[6] PSE attempts to compare "compensatory megawatts" identified by NYISO (200 MW in 2023 and 600 MW in 2027) with recent gains in renewables and energy efficiency that it attributes to winter and summer peak load reduction and peak generation. However, such gains are already working to reduce fossil fuel use, and thus not available to compensate for the loss of Indian Point unless fossil fuel use increases.[7] The comparison is also misleading since deficiencies identified by NYISO in 2023 and 2027 do

---

[5] Based on a global warming potential of methane that is 86 times that of CO_2 over a 20-year time horizon.

[6] Generator Deactivation Assessment Indian Point Energy Center, NYIO, December 2017. https://www.nyiso.com/documents/20142/1396324/Indian_Point_Generator_Deactivation_Assessment_2017-12-13.pdf/

[7] PSE's calculations of saving in summer and winter peak capacity are also in error because they do not reflect real-time demand. See next section on intermittency.

not represent total replacement power. NYISO's 2017 study concluded that electricity from three new gas plants (CPV, CVE, and Bayonne Uprate) would not be needed for reliability until 2023 **only because *excess capacity* to generate electricity is available from previously *existing* power plants in the region**. Utilizing "excess capacity" means burning more fossil fuels. Likewise, with respect to statewide generation, PSE inappropriately credits 6,550 GWh of annual statewide renewable energy and efficiency from 2017 through April 2020 against real gigawatt-hours of electricity from Indian Point (second column of Figure 1 in PSE brief).

When a source of electricity that serves real demand suddenly stops producing, it leaves a hole that must be filled by one or more other real sources that did not generate electricity before or that must now generate more. Intermittent generators like wind and solar produce whatever amount of electricity they can depending on conditions at the time. But without energy in reserve (fuel), they lack "excess capacity." As seen in 2020, the loss of continuous baseload electricity from IP2 was compensated by fossil fuel power plants that could be dispatched to deliver an equivalent amount of electricity into the grid during the same period of time that IP2 had before. Whether renewable energy and efficiency resources were installed before or after the 2017 announcement of Indian Point's partial closure in 2020 is irrelevant. The consequence of reassigning already deployed resources is more fossil fuels combustion.

PSE vaguely acknowledges that fossil-fuel power plants may need to run more due to Indian Point's closure. However, it seems to excuse this, stating *"…a portion of the plant's generation might temporarily be replaced with gas generation rather than renewables. A short-term demand for gas generation could likely be met by existing plants, however, without the need to build new gas infrastructure."* This latter point is rendered moot by the fact that large new gas power plants—CPV and CVE—are already operating.[8] Moreover, the brief fails to define "temporary" or quantify the impacts of additional gas-fired generation, whether from new or existing plants, on carbon emissions or air quality within affected communities. From the standpoint of Environmental Justice, a particular concern is that older facilities within the NYC metropolitan area may have to operate more.

The bottom-line is that gains in renewable energy and efficiency prior to the closure of Indian Point were not held in a lockbox waiting to replace nuclear power. They had been put to good use, reducing fossil fuel consumption. When IP2 closed, those good uses were forfeited, causing more fossil fuels, particular gas, to be burned. Gas, not renewable energy or efficiency, replaced IP2; and the same stands to happen if IP3 closes. A more honest assessment of events would admit that Indian Point is in fact being replaced by fossil fuels, and then determine what must be done to make up for that setback.

INTERMITTENCY

Although the PSE brief acknowledges the intermittency of renewables like wind and solar, it fails to seriously consider the real-world challenges that intermittency poses. The result is an apples-to-oranges comparison of dissimilar forms of generation.

In its analysis of local capacity, PSE multiplies the nameplate capacity of existing and projected solar projects by winter and summer capacity factors to calculate what the brief describes as winter and summer peaking capacities. This is then compared to the capacity of Indian Point. However, derating capacity in this manner does not determine available power. The purpose of capacity factor, whether applied annually or seasonally, is to estimate how much electricity (measured in watt-hours) a generator is likely to produce over a given period of time. Derated capacity is a mathematical construct, not a quantity corresponding to guaranteed deliverable

[8] From January to October 2020, CPV operated at an average capacity factor of 79%. CVE went into service at in March 2020, coinciding with the closure of IP2 in April. From March to October 2020, CVE operated at an average capacity factor of 58%. CPV and CVE monthly plant level data from EIA; https://www.eia.gov/

power. The amount of power that an intermittent source can produce ranges anywhere from zero up to its rated nameplate capacity, depending on particular conditions at any given time. As PSE points out in its brief, the average summer capacity factor of solar may be 37%. However, the amount of deliverable power from solar in the summer *at night* is zero.

As part of its assessment of local capacity, PSE also recites various CLCPA targets for the deployment of solar and offshore wind, which it assumes will be installed on schedule. But the capacities of intermittent renewables are not necessarily additive, nor can they be considered “replacement” for baseload generation, which is always on.

PSE performs similar calculations on efficiency to arrive at figures for winter and summer peak demand reduction. But as with its analysis of peak renewable capacity, this is not a legitimate indicator of replacement power. Furthermore, it is important to recognize that “energy efficiency” is not electricity. It is the absence of demand. Regardless of how much efficiency has been achieved in the region, each reactor at Indian Point will continue to generate electricity that meets a gigawatt of real customer demand until it is deactivated. In this sense, even on its face, the argument that efficiency can be used to “replace” Indian Point is suspect.

Creative arithmetic within PSE’s brief obfuscates basic facts that are not difficult to understand. The very nature of intermittency means that electricity may not be available when it is needed, including during peak periods. Moreover, the ability to provide power at peak times is fundamentally different from the continuous delivery of baseload electricity. NYISO makes no reference to peak loading in its 2017 deactivation assessment of Indian Point for a good reason: It does not relate to the particular *function* that Indian Point performs and which NYISO was obliged to consider in evaluating impacts to the network from its closure.

These problems are also seen in PSE’s discussion of annual generation. To claim that one source of electricity can “replace” another, it is not sufficient to demonstrate that the total amounts of electricity that each produce throughout the course of a year are equal. It must be shown that the alternative can reliably provide the same amount of power **at all of the same times** (and to all of the same places) as the source being eliminated, thus satisfying the same real-time load demands. For this reason, the total amount of electricity generated annually by wind and solar throughout the state is of little relevance in determining whether nuclear power can be removed from the downstate grid without burning more fossil fuels. In justifying its analysis, PSE asserts that *“statewide resources can replace Indian Point’s non-peak generation,”* but this is not necessarily so. Whether intermittent resources are local or statewide, their ability to replace nuclear power depends on *when* they are generating electricity, and *how much* they are generating at any given time, in addition to transmission constraints. Treating all watt-hours equally—regardless of when or where they are generated and when or where they are needed—ignores the dynamics of grid operation. Nevertheless, this is exactly what PSE does in Figure 1 of its brief by indiscriminately summing watt-hours of renewable energy and efficiency as “replacement” for Indian Point.

CONSEQUENCES OF INTERMITTENCY

Today, intermittent renewables (wind turbines and solar panels) make up a very small portion of the state’s total energy portfolio, so integrating them into the grid is relatively simple. When wind and sunshine are present, they supply electricity. When not, other generators that comprise our electricity portfolio do. However, as intermittent renewables become a larger part of that portfolio, and are expected to deliver energy needed when wind and sunshine are not present, intermittency becomes an increasingly difficult and costly problem.

Storage has a role to play in addressing intermittency, but understanding its practical limitations is important. In the power sector, advances in technology have allowed batteries, sometimes coupled with renewables, to become a viable alternative to traditional oil- or gas-fired “peaker” plants. This is because peakers tend to be small plants with low capacity factors. Their *function* is to supply the grid with electricity for short bursts of time. If a peaker plant is replaced with batteries, the amount of energy that must be stored is modest, and typically, there will be sufficient time between discharge periods for that energy to be replenished from other sources, including those that may operate intermittently. However, replacing the function of very large baseload power plants that constantly generate electricity is an entirely different scenario, requiring far more storage than currently exists or will realistically be developed in the foreseeable future.

An evaluation of actual grid-based battery systems is useful in understanding these constraints. To date, the largest battery in the world is California's Moss Landing project. Its total storage capacity is 1,200 MWh, which corresponds to only about one half-hour of the energy that Indian Point delivered reliably 24 hours a day prior to the loss of IP2. Notably, Ravenswood Development has proposed to construct and operate a 316 MW battery with eight hours of storage (2,538 MWh of energy) at its power generation facility in Queens, NY. However, this constitutes merely 15% of Indian Point's deliverable power. If configured to match the power output of Indian Point, the proposed Ravenswood battery could deliver about 80 minutes' worth of electricity that IP2 and IP3 generated all the time. These battery projects are impressive, but they do not come anywhere close to replacing the critical function served by Indian Point in delivering reliable, baseload electricity. It is also important to note that Ravenswood's proposed battery is not intended to compensate for the loss of Indian Point. It is intended to replace the function of small peaker turbines currently located at the Ravenswood plant that operate infrequently. Assuming an optimistic figure of $150/kWh for Lithium-Ion batteries, the Ravenswood storage project may cost about $380 million. Storing just one day's worth of electricity (50,000 MWh) from Indian Point would require $7 billion and require a battery nearly 20 times larger than this.

Any reliable, real-world system must account for a wide range of operating conditions, whether they are frequent or rare. This makes the analysis of storage required to achieve grid reliability for different levels of renewable penetration a complex statistical exercise. With battery technology becoming more affordable, one might expect that short-term storage could begin to mitigate hourly fluctuations in demand, for example helping to address the "duck curve" that plagues the large-scale deployment of solar panels in California. However, batteries capable of adequately mitigating longer term fluctuations in demand and supply that occur day to day and seasonally due to the widespread deployment of intermittent renewables will not be available anytime soon.

Despite recent advances in battery technology, the most practical way of storing large amounts of energy for later use continues to be traditional pumped hydro. An example of this is the Blenheim-Gilboa plant in New York's Catskill Mountains. Although a quarter of its energy is not recoverable due to efficiency losses, Blenheim-Gilboa is capable of storing 12,000 MWh and delivering a maximum 1,100 MW of power. Replacing Indian Point with renewables would require storage systems even larger than this. If New York was serious about developing a carbon-free grid that relies heavily on intermittent sources, it would be building large pumped-hydro facilities throughout the state or other systems with much higher capacity and longer-duration storage capability than chemical batteries. However, this is not happening.

Although the title of PSE's brief claims to evaluate the potential for storage to make up for the loss of Indian Point, the document does not actually do this. Instead, PSE merely states that *"Hourly grid modeling will be necessary to determine the optimal siting and operation of storage to allow renewable resources to replace the consistent power provided by Indian Point and other nuclear facilities."* Rather than analyzing storage needs and limitations, PSE simply recites goals of the CLCPA: 1,500 MW of storage *capacity* by 2025 and 3,000 MW by 2030. Later, the brief asserts that the downstate region would require 730 MW of storage to achieve a "proportional contribution to statewide 2025 targets". However, none of these numbers address the question of how much storage is actually needed to mitigate the loss of Indian Point. Deliverable power (1500 MW, 3000 MW, or 730 MW) without a time dimension does not represent a unit of energy. Moreover, a battery system capable of producing 730 MW of power (ignoring storage duration completely) would only be able to serve a third of Indian Point's customer load.

Even a rudimentary assessment would reveal that the scale, cost, and physical impact of building storage to convert intermittent generation into two gigawatts of constant power is prohibitive (not to mention what it would take to do the same for "other nuclear facilities" in the state).

In the absence of unrealistic amounts of storage, a dispatchable source of energy—typically gas—becomes necessary when intermittent sources are unavailable. Indeed, the pairing of renewables with natural gas, described by the fossil fuel industry as a "perfect partner", is common practice where large amounts of wind or solar are deployed, including California. However, that partnering creates a dependency on gas that thwarts the goals of carbon-free electricity. It also leads to inefficient gas-fired generation as dispatchable sources are forced to react in real-time to systemic intermittency. This can result in frequent startup and shutdown which degrades performance, the use of simple-cycle gas plants that respond quickly but consume more gas per watt-hour, or running plants in "hot standby" (meaning that fuel is burned even when not producing electricity). Operating a network this way may help to prop up arbitrary renewable energy targets, but it undermines the fundamental goal of greenhouse gas reduction.

Another consequence of adding intermittent renewables to the grid without considering the dimension of time is the production of electricity when it is not needed. This is a common occurrence in California which has deployed significant amounts of photovoltaic solar. If excess energy cannot be used or stored, it must be curtailed (i.e. "dumped"). This results in a lower effective capacity factor, systemwide inefficiency, and increased cost associated with deploying and maintaining underutilized resources. Continuing to add renewable capacity into the system, known as "overbuild," may help meet demand during periods of marginal generation (cloudy days and winter for solar, or during periods of low wind). However, the benefit of this must be weighed against overproduction at other times, which leads to a scenario of diminishing return as more intermittent capacity is added to the grid.

The difficulties of matching supply and demand grow exponentially as intermittent sources comprise larger and larger portions of total generation. However, PSE neglects this, suggesting that its assessment is also applicable to the retirement of other nuclear plants in New York. In the real world, a certain amount of "firm" generation capacity is essential to any scenario capable of ensuring system reliability.[9]

These inconvenient truths are ignored by advocates for 100% renewable energy. Realistically, if the state plans for an electricity network largely dependent on intermittent renewables and simultaneously eliminates nuclear power, fossil fuel generation will become indispensable. Unfortunately, the practical limitations of intermittency and storage will likely mean that there is nothing "temporary" about the replacement of Indian Point with gas.

TRANSMISSION CONSTRAINTS AND ENERGY DENSITY

Related to intermittency is the issue of transmission. Because solar and wind are intermittent sources with low capacity factors, the transmission infrastructure to carry the electricity they produce is often underutilized. Regardless of whether a generator with a given nameplate capacity produces electricity almost all the time (like nuclear power with a capacity factor of over 90%) or infrequently (like solar with a capacity factor in New York of 15%), the conduits for transporting that power in watts must be sized the same. This is compounded by the inherently low energy density and distributed nature of intermittent renewables. Contrary to common belief, there would be very little "local" about a grid dominated by intermittent renewables. For such a network to function, robust and flexible paths must exist for electricity to flow, potentially very long distances, from wherever

[9] Dr. Jesse Jenkins of Princeton's Arlington Center for Energy and the Environment has conducting useful research and modeling of these dynamics. https://mae.princeton.edu/people/faculty/jenkins
In particular, see his May 15, 2020 presentation to the Clean Energy State Alliance: *Decarbonizing Electricity: The Critical Role of Firm Low-Carbon Resources*; https://vimeo.com/419053746

electricity happens to be generated—which can change dynamically depending on weather—to wherever it is needed. Power lines and transformers cannot move in response to dynamically changing pathways, so this requires the large-scale expansion of transmission infrastructure.

While the PSE brief mentions transmission, it largely dismisses such concerns as if they are already being solved. For example, the brief references 1,250 MW of new transmission capacity to come online in December 2023 as if this is entirely available to replace Indian Point without regard to other needs for congestion relief (which had been a problem prior to IP2's closure) or the far more substantial transmission improvements which would be needed to completely replace fossil fuels (which dominated downstate New York's energy mix even before closure of IP2). Regarding this particular reference, PSE is also in error—two projects that it claims will collectively contribute 1,250 MW of new transmission capacity for moving electricity downstate (a 350 MW 'Segment A' and a 900 MW 'Segment B') would physically operate in series with one another, so their transmission capacities are not additive.

Similarly, PSE dismisses constraints that impact electricity transmission within local distribution networks. The brief predicts significant amounts of new renewable generation statewide between 2020 and 2025. However, it is not valid to credit electricity produced from rooftop solar panels in Buffalo (which in all likelihood does not leave Buffalo) against electricity continuously produced by Indian Point to serve the downstate metropolitan area. Similarly, PSE misapplies statewide gains in energy efficiency to overstate its relevance to Indian Point. Replacing incandescent lightbulbs in Rochester with LED lighting does not reduce the demand for electricity in New York City or the need for transmission capacity to deliver that electricity from sources outside the region.

Since this response focuses on PSE's brief and is not intended to comprehensively compare nuclear power with other forms of energy, we do not discuss the environmental impacts associated with large-scale manufacturing, deployment, and disposal of wind, solar, and storage technologies here. Nevertheless, the very low energy density of intermittent renewables will also clearly affect the ability of New York to realistically meet its energy goals. As discussed in the next section, the state's proposal for 9,000 MW of offshore wind—which itself could require about a thousand wind turbines—will only be able to contribute a relatively small fraction of total carbon-free electricity needed by New York in 2040 and 2050.[10] This means that unless New York imports much of the electricity it consumes in the future from out-of-state renewable sources, a tremendous amount of wind and solar will still have to be deployed throughout the state in an extremely short amount of time (9 years).[11] This in turn will require the very rapid siting, permitting, and construction of intermittent resources over large areas, along with transmission infrastructure (and storage that has not been seriously contemplated)—all of which have environmental impacts that must also be considered. Even in politically progressive states and western Europe where renewable energy is generally supported, the tolerance level for such expansion diminishes as renewables and related infrastructure consume an increasingly large amount of the landscape, and as the cost of implementation puts an ever-growing burden on ratepayers. Germany, which has invested heavily in renewable energy, still receives more than half of its electricity from non-renewable sources and is now encountering major

[10] Applying an optimistic capacity factor of 45% for offshore wind, 9000 MW of offshore wind corresponds to about 35,000 GWh of annual generation. Significantly, New York also delayed solicitation of 2020's 2.5 GW offshore wind due to the COVID-19 pandemic. https://www.utilitydive.com/news/new-york-hits-the-brakes-on-25-gw-solicitation-of-offshore-wind-due-to-cov/576712/

Heightened federal review has materially delayed the deployment of offshore wind projects. https://www.eenews.net/stories/1060921573

[11] With respect to imported electricity, one must also recognize that unless a state or country supplying electricity to New York has already achieved carbon-free electricity itself and has renewable energy to spare, importing electricity long distances from out-of-state renewables sources will do little or nothing to reduce global emissions (i.e. "robbing Peter to pay Paul"). Importing significantly more electricity from distant out-of-state renewables sources would also require the development of additional transmission infrastructure and incur transmission losses that further reduce efficiency.

public backlash to continued renewable deployment.[12] Prudent consideration of these factors would dictate preserving energy dense, carbon-free assets that already exist, rather than eliminating them.

THE BIGGER PICTURE

By comparing existing and projected gains in renewable energy and efficiency with the singular objective of replacing Indian Point, PSE overlooks perhaps the most compelling reason for *not* closing Indian Point—which is how far New York must go to meet its energy and climate goals.

Achieving greenhouse gas reduction goals will require the widespread beneficial electrification of sectors that presently rely on combustion, including transportation, heating, and industry. This in turn will increase electricity demand. A recent climate change impact study prepared for NYISO estimates that with beneficial electrification necessary to meet CPCPA goals, New York will require 221,479 GWh of electricity in 2040—a 40% *increase* over levels that it forecast for 2020.[13] Furthermore, by 2040, the CLCPA requires that all electricity consumed in New York be carbon free.[14] Notably, this also optimistically assumes that the state successfully implements aggressive energy efficiency improvements to reduce demand by 50,636 GWh relative to forecasts. If those efficiency targets are not reached, demand could be even higher. Moreover, the same study estimates that New York will require 258,011 GWh of electricity in 2050, a 63% increase over 2020, all of which must be carbon free. This corresponds to about 185,000 GWh more electricity annually in 2040 than produced by all renewables, including hydropower, in the state today, and about 221,000 GWh more in 2050 than today.[15] These are sobering numbers that should make any credible planner think twice before shutting down a significant reliable source of carbon-free energy.

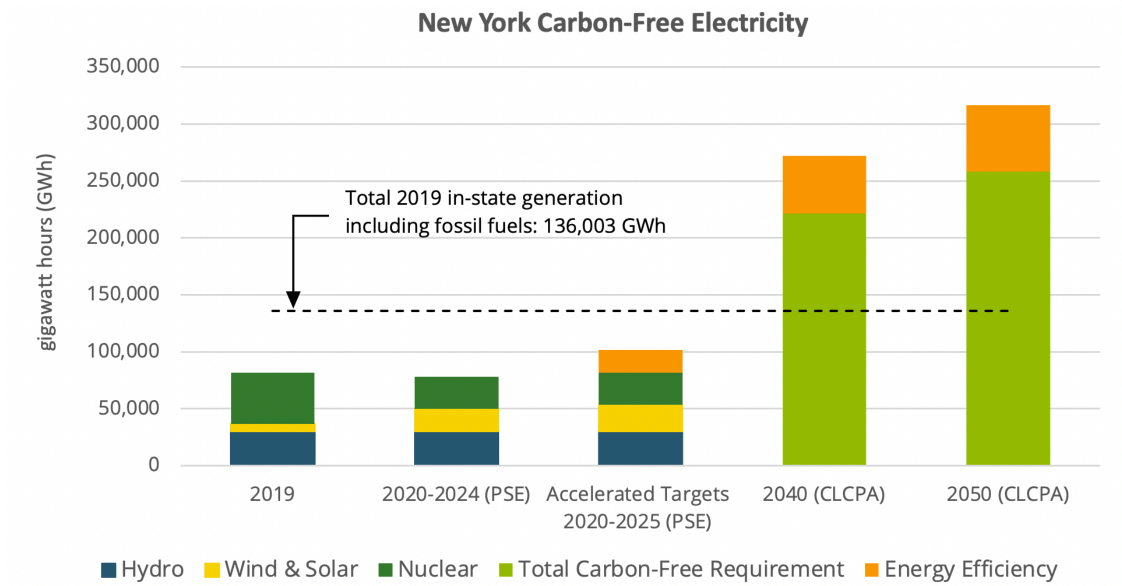
The following graph helps to put the advances cited by PSE into perspective relative to New York's climate goals. The first column depicts 2019 annual generation from carbon-free sources in the state. The second and third columns depict statewide renewable energy and efficiency with anticipated incremental gains estimated by PSE over the 2020-2024 and 2020-2025 times (corresponding to data in the third and fourth columns of Figure 1 in the PSE brief). Note that these also include reductions in statewide nuclear power resulting from the closure of Indian Point (IP2 and IP3), and resulting reduction in carbon-free electricity. The last two columns depict the total estimated demand for electricity by NYISO, which must be entirely carbon-free by 2040. In these two columns, NYISO projections additionally serve to illustrate what total demand will be if gains in energy efficiency after 2020 are not achieved.

[12] https://www.dw.com/en/german-wind-energy-stalls-amid-public-resistance-and-regulatory-hurdles/a-50280676

[13] *New York ISO Climate Change Impact Study, Phase 1: Long-Term Load Impact* https://www.nyiso.com/documents/20142/10773574/NYISO-Climate-Impact-Study-Phase1-Report.pdf

[14] PSE mentions a 2040 target of "carbon neutrality", but the CLCPA actually calls for carbon-free electricity from load serving entities.

[15] Phase 1 NYISO Climate Change Impact Study (Table A-156). Demand figures include 8885 GWh of behind-the-meter solar in 2040 and 9662 GWh of behind-the-meter solar in 2050. According to the NYISO 2020 Gold Book, New York generated 30,141 GWh from hydropower in 2019. Wind and solar produced 6551 GWh.



The above figure illustrates that without nuclear power, in the fifteen years between 2025 and 2040, New York must come up with about 25 times more renewable electricity than all of the wind and solar deployed across the state today. These additional renewable sources will have to be deployed at a sustained rate that is almost **four times faster** than the renewable generation PSE boasts will be installed between 2019 and 2025 as justification for closing Indian Point.[16] This corresponds to about 28 times more wind and solar installed within New York by 2040 compared to today, and 34 times more wind and solar in 2050, to meet demand forecasted by NYISO and goals of the CLCPA.[17] The PSE brief lauds the state's plan to install 9,000 MW of off-shore wind by 2035, which optimistically amounts to about 35,000 GWh of annual generation. However, this is only a sixth of the carbon-free electricity that NYISO predicts will be needed just five years later—deliverable statewide, summer and winter, day and night, rain or shine. Based on NYISO projections under the CLCPA, after deploying offshore wind, New York would still need an additional 150,000 GWh of carbon-free electricity in 2040. Without nuclear power, this corresponds to about 122,000 MW of additional solar panels occupying nearly a million acres, or 57,000 MW of wind equal to tens of thousands of land-based wind turbines.[18] These too should be sobering facts for anyone trying to engineer feasible solutions for the future.

Finally, not unlike PSE's analysis, it is important to recognize that the above figures only reflect a simple summation of annual watt-hours. They do not account for the previously-discussed real-world ramifications of large-scale renewable deployment, intermittency, overbuild, and curtailment as intermittent sources comprise a larger percentage of the total generation portfolio. Taking these factors into account, the amount of wind and solar resources required could be significantly higher than described above.

[16] PSE predicts 13,450 GWh of additional annual wind and solar generation between 2020 and 2024, and 3400 GWh more than this with accelerated targets, which corresponds to an average growth rate of 2808 GWh of additional annual generation per year. Excluding nuclear power and using PSE figures for growth in wind and solar through 2025, New York will have a carbon-free demand gap of 167,931 GWh in 2040. This corresponds to a need for 25 times more wind and solar to be deployed between 2024 and 2040 than deployed in all of New York in 2019 and a required growth rate in wind and solar between 2025 and 2040 of 11,195 GWh of additional annual generation per year. This is a four-fold increase over wind and solar growth predicted by PSE between 2019 and 2025.

[17] Excluding nuclear power, New York would have a carbon-free demand gap of 184,781 GWh in 2040 and 221,313 GWh in 2050. This corresponds to a need for 28 times more wind and solar by 2040 and 34 times more wind and solar by 2050 than today.

[18] National Renewable Energy Laboratory (NREL) has estimated on average 7.5 acres of total land area per megawatt of capacity for large fixed-panel photovoltaic installations (including service/access). Assuming 14% capacity factor, 150,000 GWh of annual generation therefore corresponds to 915,000 acres. https://www.nrel.gov/docs/fy13osti/56290.pdf

Assuming a typical capacity factor of 30% for land-based wind, this corresponds to 19,000 wind turbines at 3 MW each.

Except in parts of the world with abundant hydropower and volcanic geothermal resources, these are formidable obstacles that from a practical standpoint render the concept of carbon-free electricity based exclusively on '100% renewables' an unattainable goal. For example, in 2010, Germany undertook "*Energiewende,*" at one time described as the most ambitious energy revolution attempted by an industrialized country. However, the country simultaneously decided to eliminate nuclear power within its borders, wiping out a source of carbon-free electricity that once provided over a quarter of its total electricity. Despite half a trillion Euros invested in wind and solar, Germany has become increasingly dependent on foreign gas, still relies heavily on coal, and in 2020 even fired-up a new coal plant. To compensate for intermittent sources, the country depends on electricity produced by burning fossil fuels at home and in neighboring countries. Under the pretense of "renewable energy", it also burns wood from forests that had previously sequestered carbon and crops from farmland that could have fed people. It is ironic that despite its own aversion to nuclear power, Germany continues to import electricity from nuclear power plants in France to balance its grid.[19] Meanwhile France, which receives almost all of its electricity from nuclear power, has among the lowest carbon emissions and cleanest air in Europe—a success story that was achieved years ago in just over a decade.[20]

With a misplaced focus on the expansion of "renewable" energy rather than "carbon-free" energy, and now facing significant public backlash, Germany is boxing itself into a corner without a workable solution in sight. Similarly, in the United States, California has managed to increase non-hydro renewables to about a third of electricity generation. However, since it has reduced nuclear power, the state still requires gas for 40% of its electricity, which as previously discussed, counters climate benefits. This is roughly the same amount of gas California has burned for electricity over the past two decades. To make matters worse, customers suffer from soaring electricity rates and rolling blackouts that expose the fragility of a grid with impaired reliability.

New York would be wise to learn from experiments elsewhere. In the absence of firm carbon-free generation, which nuclear power provides, fossil fuels will almost certainly remain an inextricable part of New York's grid. By contrast, if nuclear power is retained, then only about four times more wind, solar, and nuclear power would be needed than today (assuming beneficial electrification and efficiency improvement pursuant to the CLCPA), and this could be achieved without monumental investments in new transmission capacity or unrealistic amounts of storage. Looking at the future with an eye to actually achieving the state's aggressive energy and climate goals, it should be abundantly clear that New York cannot afford to lose any carbon-free source of energy, especially one that produces reliable baseload electricity. Any credible strategy for achieving CLCPA goals and meeting New York's demand for electricity without fossil fuels will require that nuclear power be retained or expanded.

MISGUIDED PRIORITIES

Perhaps of greatest consequence, the PSE brief fails to address fundamental questions: Even if it were possible to replace Indian Point with renewable energy and energy efficiency, how is that an appropriate decision when the widespread consensus of scientists across the globe is that climate change is the greatest existential crisis of our time—and that time to respond is running out. Why should New Yorkers squander gains in renewables and efficiency to eliminate a carbon-free source of electricity, instead of applying those investments to the reduction of fossil fuels? Further, why should eliminating an emission-free source of electricity take priority over shutting down polluting fossil fuel power plants that threaten public health?

---

[19] https://asiatimes.com/2020/01/germanys-overdose-of-renewable-energy/

[20] Residents of France also enjoy low electricity rates, compared to those in Germany which are the highest in Europe. https://strom-report.de/electricity-prices-europe/

Regardless of whether some, or even all, of the electricity from Indian Point might be "replaced" by renewable energy and efficiency, closing Indian Point at this time will result in the continued reliance on fossil fuel power plants that could have been shut down instead. In 2019, the recently constructed CPV power plant in Wawayanda, NY added 1.4 million tonnes of CO_2 to the atmosphere. Counting lifecycle methane emissions, CPV was responsible for about 3 million tonnes of CO_2-equivalent emissions. CVE, in Dover, NY, will likely produce more than that if Indian Point is completely shuttered. Furthermore, oil and gas-fired generators in the New York City metropolitan area continue to pollute the air within environmental justice communities. By closing Indian Point, it is very likely that those older plants will have to run more and remain in existence longer (even if a few small peakers at Ravenswood are replaced with batteries).

From both a climate and public health standpoint, closing any one of the large fossil fuel plants in New York City, or avoiding construction of CPV or CVE, would have been a more responsible and scientifically sound decision than removing from service a facility that has consistently produced over 16,700 GWh of emission-free electricity for years and could have continued to do so. According to NYISO, New York generated 51,870 GWh of electricity from fossil fuels in 2019. Whatever that number turns out to be in 2021 when Indian Point is scheduled to close completely, the fact is that it could have been 16,700 GWh ***less*** energy from fossil fuels if Indian Point had remained open. This would have prevented millions of tonnes of greenhouse gases from entering the atmosphere every year and reduced air pollution that threatens public health.

By admitting that the closure of Indian Point may result in more gas use "temporarily", PSE seems to imply that we have time to spare on climate change. In suggesting that Indian Point's closure could have been accomplished by relying more on "existing" gas plants, PSE neglects the impact that doing so has on affected communities.

Solving the climate crisis while meeting energy needs is a complex equation—and as with any equation, the order-of-operations matter. The only possible rationale for supporting the elimination of nuclear power plants *before* or *instead of* eliminating fossil fuel power plants is if one believes—contrary to the science—that climate change is less of a threat than nuclear power, or that fossil fuels are less harmful to human health than nuclear power. If that is indeed PSE's position, then PSE should say so and provide supporting evidence.

CONCLUSION

Sadly, two large gas-fired power plants built to compensate for the loss of Indian Point are now in operation. It is also likely that older fossil-fuel plants within vulnerable communities of the New York City metropolitan area will need to run more, or run longer, because of Indian Point's premature closure. Despite this, PSE's brief seems to congratulate New York for eliminating this major source of reliable carbon-free energy and suggests that the state is well on its way to meeting its energy and climate goals. This is not so. As we have shown, without nuclear power, it will become essentially impossible to realize emission reduction targets and carbon-free electricity mandates laid out in the CLCPA.

The climate crisis is upon us. Anything less than an accurate and disciplined analysis of our current circumstances and prospects for addressing them is a disservice to future generations. Moreover, responsible technical advocacy would dictate lending support to strategies with the greatest potential for success rather than those that put an exceptionally difficult task further out of reach. Although perhaps not PSE's intention, the consequence of its brief has been to bolster the unrealistic notion that New York can achieve its greenhouse gas reduction goals and satisfy the state's growing demand for electricity with only renewable energy in less than nineteen years. The fact is that in the CLCPA's first year, the state has already lurched backwards. Making up lost ground and delivering on New York's climate goals will require that state planners, and others engaged in energy policy, recognize the important role nuclear power must continue to play in the future.