STATE OF NEW YORK

PUBLIC SERVICE COMMISSION

Proceeding on the Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard	Case 15-E-0302

CLOSING NEW YORK'S FIRM CLEAN ENERGY GAP

NUCLEAR NEW YORK

RESPONSE TO

ZERO EMISSIONS BY 2040 TECHNICAL CONFERENCE OF DECEMBER 2023

MARCH 2024

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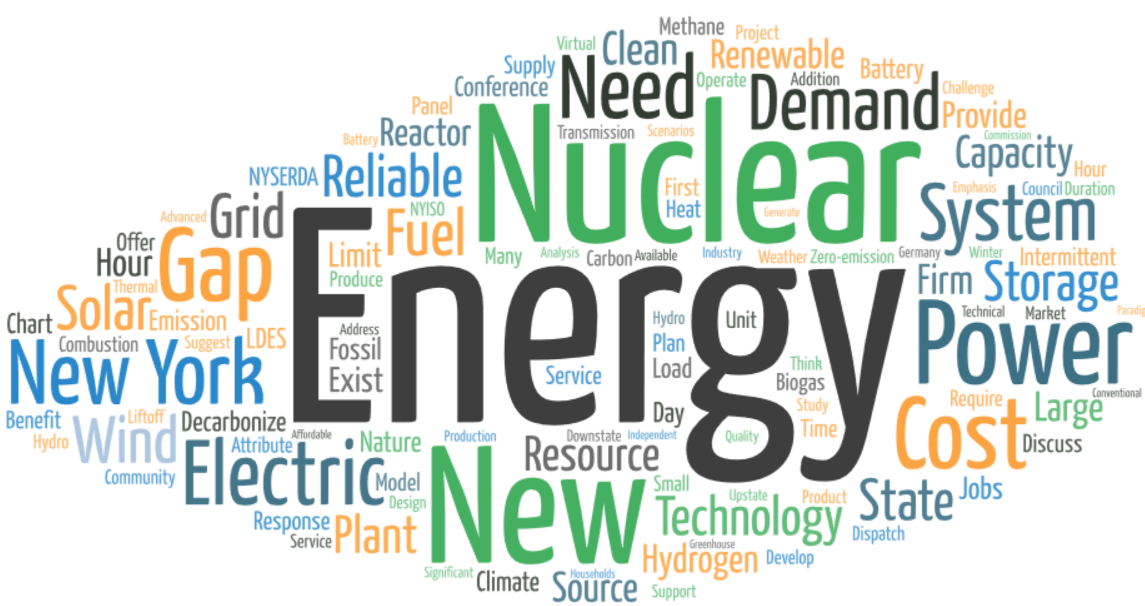

Executive Summary

By pursuing predominantly intermittent energy sources, New York persists in the same energy system paradigm that is failing California and Germany. Nuclear power can ensure the reliability that New York enjoys today, largely served by fossil combustion. Nuclear is a reliable, versatile, firm, clean energy technology that can operate in baseload or load-following configurations. Repeat deployment of the same reactor design rapidly brings costs down.

Demand shifting has climate and cost benefits but can only go so far. Supply and feasibility issues with biogas, renewable natural gas, and carbon capture & storage limit the likelihood that methane-based technologies will fill the gap. Batteries will likely remain too expensive to provide 100-hour "Long Duration Energy Storage" capable of filling the gap. Able to maximize electrolyzer capacity utilization, nuclear energy is well-suited for emissions-free hydrogen production.

We recommend establishing and pursuing technology-neutral "zero-emission" energy targets rather than sources arbitrarily deemed as "renewable." This will allow wind and solar expansion, while preserving existing nuclear capacity and deploying new nuclear technology necessary for cost-effective decarbonization and a reliable electricity system.

Introduction

Nuclear New York is an independent, non-partisan advocacy organization working towards a prosperous decarbonized future and nature conservation. We conduct rigorous research, education, policy advocacy, and non-intrusive activism. We are a 501(c)3 nonprofit organization.

We applaud the New York State Public Service Commission (NYSDPS) for hosting the Zero Emissions by 2040 Technical Conference ("Conference") in December 2023 to inform how New York can implement the zero-carbon electricity goal of the Climate Leadership and Community Protection Act (CLCPA). As a volunteer group of climate scientists, energy workers, tech investors, and community leaders advocating for climate solutions that enable human prosperity, Nuclear New York has provided extensive constructive input to the NYSDPS Clean Energy Standard Docket 15-E-0302. These include the response to the May 18, 2023 *Order Initiating Process Regarding Zero Emissions*

Target[1,2] among others. Nuclear New York members attended the Conference in-person in New York City and Albany, and have reviewed the recordings[3,4,5] and associated presentations.[6]

New York State has been incentivizing the build-out of solar photovoltaic ("solar") and wind electricity generation, but these energy sources are intermittent and are unable to fully serve moment-to-moment load by themselves. The remaining gap appears small in the four scenarios that the New York State Energy Research and Development Authority (NYSERDA) prepared for the State's Climate Action Council (CAC).[7] However, many assumptions made in these scenarios, and analyses we have conducted, suggest that the gap is actually much larger. Not surprisingly, this is also reflected in studies conducted by New York Independent System Operator (NYISO)[8], New York State Reliability Council (NYSRC)[9], and independent academic research. NYISO's 2021-2040 Outlook report predicts the need for 27 to 45 gigawatts (GW) of additional firm clean generation capacity carrying at

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[1] Nuclear New York, Inc. Comments in Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard. 16 August 2023. https://www.nuclearny.org/wp-content/uploads/2023/08/NuclearNY-Comments-PSC-Case-15-E-0302-16-Aug-2023.pdf

[2] Nuclear New York. Nuclear is a Dispatchable Electricity Source. November 2023. Submission to NYSDPS docket 15-01168/15-E-0302: https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BA0F5C88B-0000-C521-AAAD-996DCC98AF0F%7D

[3] NYSDPS. Zero by 2040 Technical Conference Day 1, Part 1. 11 December 2023 https://youtu.be/H8cDf0bRetQ?feature=shared

[4] NYSDPS. Zero by 2040 Technical Conference Day 1, Part 2. 11 December 2023 https://youtu.be/QeTG7FQ66_4?feature=shared

[5] NYSDPS. Zero by 2040 Technical Conference Day 2. 12 December 2023 https://youtu.be/rFXYWMxMfOg?feature=shared

[6] NYSDPS. December 11-12 Technical Conference Slide Presentations https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={B05B7E8C-0000-CF31-9D6B-F96B484F16CB}

[7] Climate Action Council. Scoping Plan. December 2022. https://climate.ny.gov/resources/scoping-plan/

[8] NYISO, 2023-2032 Comprehensive Reliability Plan. November 2023. https://www.nyiso.com/documents/20142/2248481/2023-2032-Comprehensive-Reliability-Plan.pdf/c62634b6-cdad-31dc-5238-ee7d5eaece04

[9] NYSRC. Off Shore Wind Data Review - NYSRC Preliminary Findings. June 2023. https://www.nysrc.org/wp-content/uploads/2023/07/NYSRC-Wind-Impacts-Final-07_18_23.pdf

least 10% of the load.[10] Further, the NYSERDA scenarios are silent on the duration of the actual gaps in generation, a crucial factor to consider when selecting technologies.

The Conference provided an opportunity for expert panelists to offer guidance in the next steps of our energy transition. It not only identified pathways to fill the gaps between generation and load, but also technologies that can preemptively limit the occurrence of such perilous gaps in the first place. As experiences from Texas to Germany have shown, electricity shortages can be both deadly and economically devastating.[11,12]

Nuclear power is indispensable for protecting nature and elevating humanity. As an electricity source, it provides reliable carbon-free energy with minimal land, ecological, and human health impacts of any energy source. Nuclear plants can produce electricity on demand, thereby substantially reducing the total amount of installed generation capacity, transmission infrastructure, and storage required for decarbonization. These system-level efficiencies significantly lower costs to consumers. Additionally, civilian nuclear technology can efficiently provide heat for industrial processes and district systems, it can be used to produce hydrogen and other carbon-neutral fuels to decarbonize transportation and industry, and it can power negative emission technologies.

The following comments discuss key take-aways from the Conference that we find relevant to achieving a reliable, zero-emission grid. Nuclear New York advances the discussion beyond the Conference's findings, building upon our 2022 submission to the Climate Action Council, *Bright Future: A More Reliable and Responsible Climate Plan for New York*[13] and other research.

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[10] NYISO, 2021-2040 System & Resource Outlook (The Outlook), September 22, 2022. https://www.nyiso.com/documents/20142/33384099/2021-2040-Outlook-Report.pdf

[11] Texas Health and Human Services. February 2021 Winter Storm-Related Deaths – Texas. December 2021. https://www.dshs.texas.gov/sites/default/files/news/updates/SMOC_FebWinterStorm_MortalitySurvReport_12-30-21.pdf

[12] Eckl-Dorna, W., Randow, J., Look, C. and Sorge, P. Germany's Days as an Industrial Superpower Are Coming to an End. *Bloomberg*. February 2024. https://www.bloomberg.com/news/features/2024-02-10/why-germany-s-days-as-an-industrial-superpower-are-coming-to-an-end

[13] Nuclear New York, Clean Energy Jobs Coalition-NY, and Campaign for a Green Nuclear Deal. Bright Future: A More Reliable and Responsible Climate Plan for New York. July 2022. https://www.nuclearny.org/bright-future/

Energy System Paradigm

By pursuing predominantly intermittent energy sources, New York persists in the same energy system paradigm that is failing California and Germany. Setting technology-neutral "zero emission" targets will allow wind and solar to expand while encouraging existing and new nuclear, essential to cost-effective decarbonization and system reliability.

To date, discussions of the "gap" appear to have been focused largely on four scenarios developed for the Climate Action Council by energy consultant Energy and Environmental Economics, Inc (E3) and NYSERDA. All are nearly identical scenarios which model 90% of 2040 electricity demand being served by energy sources deemed "renewable" and exclude new nuclear power. Yet, as we discuss in these comments, nuclear technology has the smallest physical footprint, lowest material requirements, and lowest per-unit lifecycle ecosystem impacts, per UN studies (UNECE).[14] CAC discussions were focused on the "70% renewables by 2030" target of the CLCPA, apparently based on the assumption that a grid largely dominated by intermittent sources will become difficult to maintain only at the latter stages of decarbonization. However, real-world experience in California[15] and Germany[16] reveal the perils of relying so heavily on intermittent generation sources. Both are struggling to achieve deep decarbonization, despite many billions of dollars spent by ratepayers and

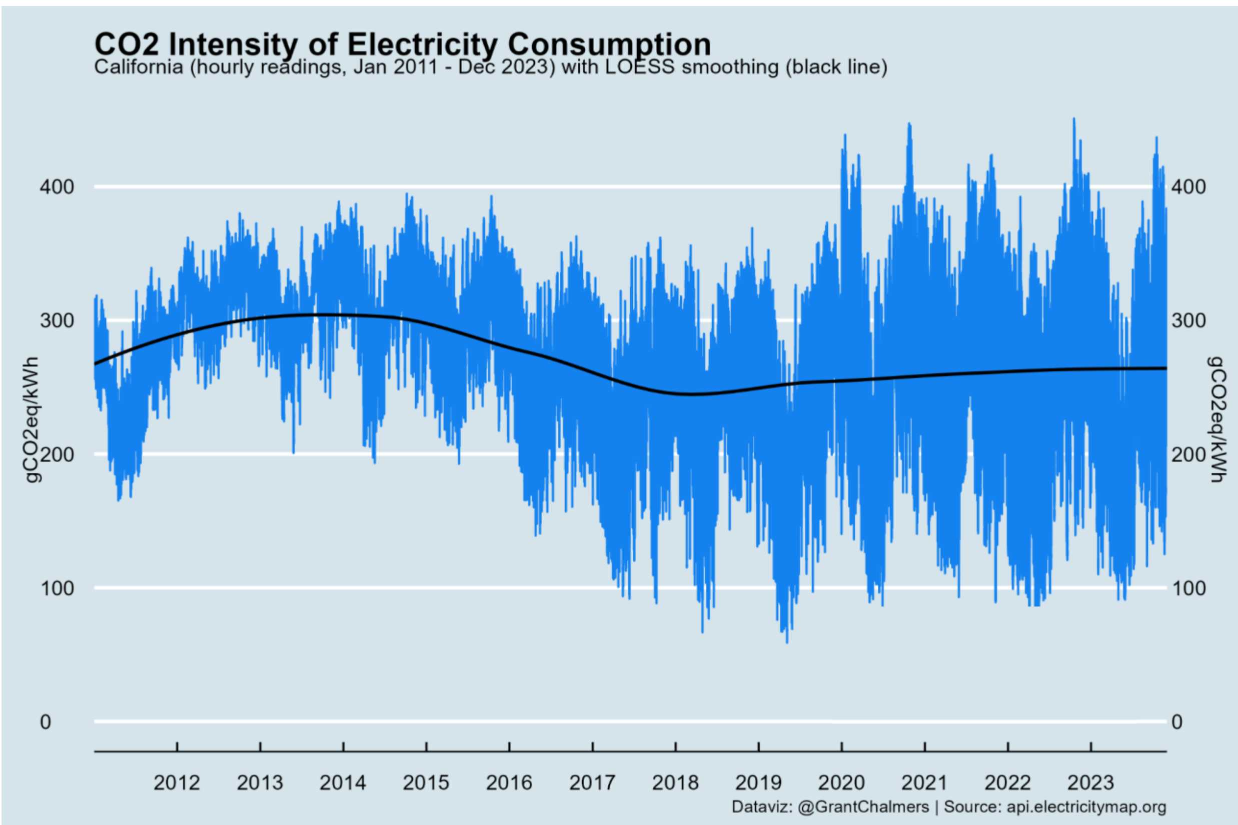
[14] UNECE. Life Cycle Assessment of Electricity Generation Options. May 2022. https://unece.org/sed/documents/2021/10/reports/life-cycle-assessment-electricity-generation-options

[15] Bryce, R. The High Cost of California Electricity Is Increasing Poverty. FREOPP. July 2020. https://freopp.org/the-high-cost-of-california-electricity-is-increasing-poverty-d7bc4021b705 Chalmers, G. September 2022. https://x.com/GrantChalmers/status/1573469075069542400?s=20

[16] Vinoski, J. German Deindustrialization Is A Wake-Up Call For U.S. Manufacturers. *Forbes.* February 2024. https://www.forbes.com/sites/jimvinoski/2024/02/29/german-deindustrialization-is-a-wake-up-call-for-us-manufacturers/?sh=310c7a287c0c https://www.bloomberg.com/news/features/2024-02-10/why-germany-s-days-as-an-industrial-superpower-are-coming-to-an-end

taxpayers on solar, on wind, and on "gap filler" technologies.[17,18] Furthermore, the problem of the gap only exists because of a lack of firm zero-emission generation. The most efficient system will be one that maximizes backbone firm generation so as to minimize the need for backup.

The below chart from decarbonization analyst Grant Chalmers visualizes the emissions intensity of California's electricity supply from 2011 to 2023, using hourly data from ElectricityMaps.[19] From 2011 to 2014, emissions increased significantly due to the premature closure of the San Onofre Nuclear Generating Station. While the emissions intensity dropped with solar and wind penetration between 2014 and 2018, it has crept up since then despite a massive investment in renewables.



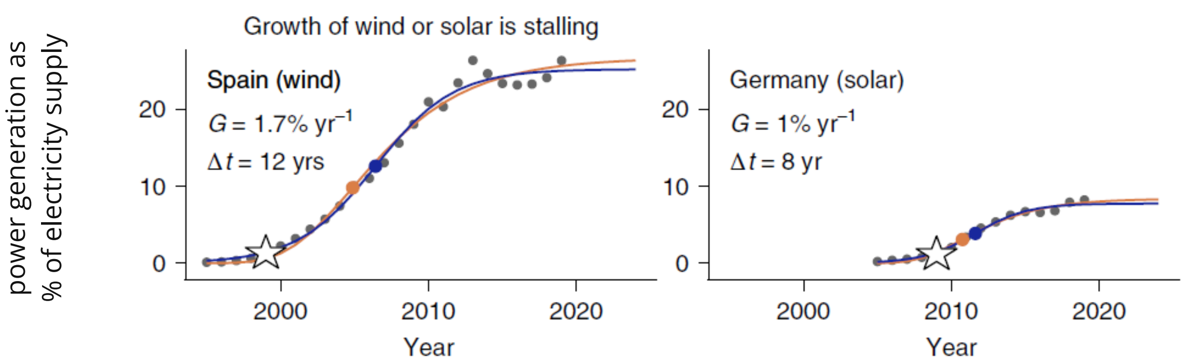
[17] Bryce, R. California's Electricity Disaster In Seven Charts. March 2024. https://robertbryce.substack.com/p/californias-electricity-disaster

[18] Amelang, S. How much does Germany's energy transition cost? *Clean Energy Wire.* June 2018. https://www.cleanenergywire.org/factsheets/how-much-does-germanys-energy-transition-cost

[19] ElectricityMaps. California Independent System Operator. https://app.electricitymaps.com/zone/US-CAL-CISO

European energy researchers Cherp et al (2021)[20] analyzed the 60 largest countries, both developed and developing, that account for over 95% of global electricity production, and published in *Nature Energy* how solar and wind growth follow an S-curve growth rate. While these resources are easily integrated into electric systems at low levels of penetration, the task becomes much more difficult as the share of total intermittent generation increases. The graph below highlights how, despite major government support, Spain's wind generation stalled when the fraction of total electricity supply reached about 25%. Similarly, solar penetration in Germany has stalled even earlier at under 10%. Their research stated:

> *Wind and solar power were first introduced in the European Union and other high-income OECD countries, in which their growth has largely stabilized after an initial acceleration... our analysis indicates that some 1.5 and 2 °C pathways pose serious feasibility concerns. This is because these pathways envision the growth of wind or solar power on continental or even global scales that lasts for decades and is faster than that historically observed for peak periods in individual countries under favourable conditions.*



Although the four scenarios modeling by E3 and NYSERDA did not consider additional nuclear energy, the Scoping Plan adopted by the CAC actually does. In November 2022 NYSERDA presented an example to the CAC showing that adding merely 4 gigawatts (GW) of new nuclear capacity would obviate the need for 12 GW of intermittent generation capacity *and* 5 GW of storage and backup

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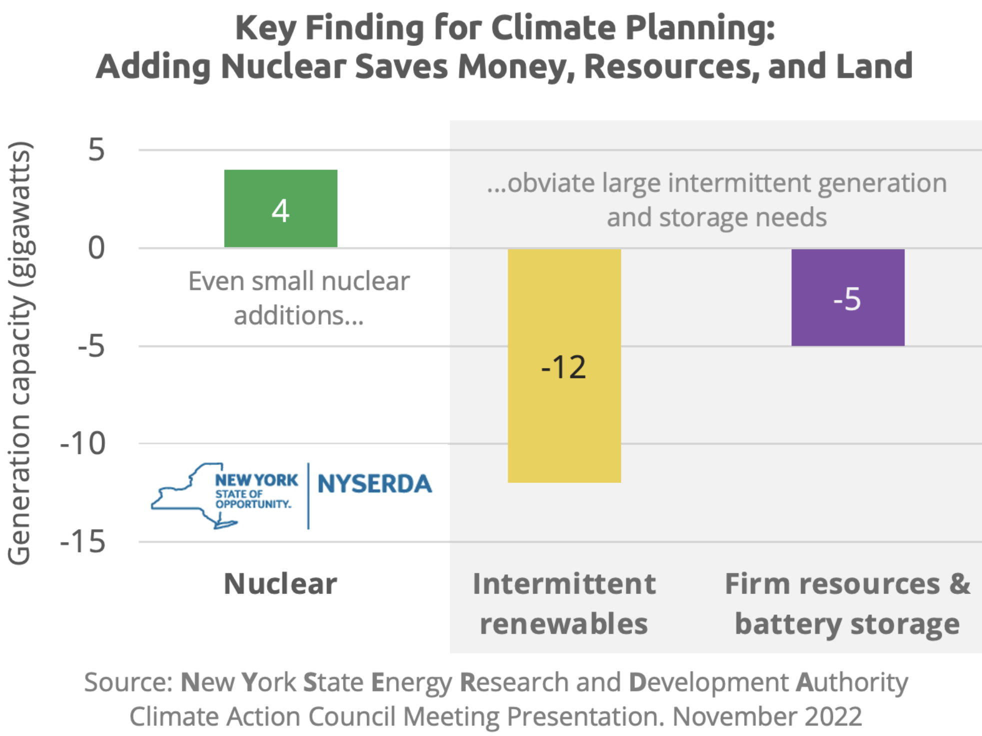
[20] Cherp, A., Vinichenko, V., Tosun, J. *et al.* National growth dynamics of wind and solar power compared to the growth required for global climate targets. *Nat Energy* 6, 742–754 (2021). https://doi.org/10.1038/s41560-021-00863-0

generation (chart below).[21] Furthermore, NYSERDA found that adding nuclear would save New Yorkers money and conserve the State's farms and forests from industrial energy sprawl. These findings are also discussed in Appendix G of the Scoping Plan.



[21] Nuclear New York. Advocates for Sound Climate and Energy Policy Praise New York for Proposing Nuclear Power. November 2022. https://www.nuclearny.org/press-release-advocates-for-sound-climate-and-energy-policy-praise-new-york-for-proposing-nuclear-power/

Gap Characterization

A system built around wind and solar is not reliable, while nuclear power can ensure the reliability largely served by fossil combustion today.

Energy Attributes

During the Conference, Zachary Smith, VP of System and Resource Planning for the New York Independent System Operator (NYISO) described the services that fossil generation currently provides to our electricity system and that would have to be replaced to achieve a decarbonized grid (emphasis added):

> *But going out through time the objective with CLCPA is to retire fossil. So what does that get replaced with? There are a lot of attributes that today's fossil generation provides that wind, solar, and batteries simply cannot provide. They cannot provide all of those attributes. There's a lot of attributes that are needed to reliably operate the grid that come today from our conventional generation. Our fossil fleet. So that has to be replaced with something.*

Mr. Smith presented a table to showcase the different performance attributes required for a reliable and gap-free energy generation system.[22] While this table partly highlighted the shortcomings of solar and wind to reliably meet demand, our revision below more comprehensively and precisely reflects the characteristics of various energy technologies:

[22] NYSDPS. December 11-12 Technical Conference Slide Presentations. Page 10. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={B05B7E8C-0000-CF31-9D6B-F96B484F16CB}

	Energy Attribute						Other Reliability Attribute			
	Carbon-Free Source	Dependable Fuel Source	Non- Energy Limited	Dispatchabl	Quick Start	Flexible	Multi-Start	Inertial Response	Dynamic Reactive Control	High Short Circuit Current
Methane Gas	No	Yes	Maybe	Yes	Maybe	Yes	Maybe	Yes	Yes	Yes
Hydro	Yes	Yes	Maybe	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pumped Storage	Maybe	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hydrogen Fuel Cell	Maybe	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No
Hydrogen Combustion	Maybe	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nuclear	Yes	Yes	Yes	Yes	Maybe	Maybe	Maybe	Yes	Yes	Yes
Battery	Maybe	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No
Solar PV	Yes	No	No	No	No	No	No	No	Yes	No
Wind	Yes	No	No	No	No	No	No	No	Yes	No
Demand Response	N/A	Yes	No	No	No	Yes	No	No	No	No
Synchronous Condenser	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes

1. Carbon Free Source (low lifecycle greenhouse gas emissions, as per studies by the IPCC[23], UNECE, etc.)
2. Dependable Fuel Sources that allow these resources to be brought online when required ("does it have a fuel?");
3. Non-Energy Limited means capable of providing energy for multiple hours and days regardless of weather, storage, or fuel constraints ("does the fuel not run out?");
4. Dispatchable to follow instructions to increase or decrease output on a minute-to-minute basis ("does it have a control dial?");
5. Quick-Start to come online within 15 minutes;
6. Flexibility to be dispatched through a wide operating range with a low minimum output ("is it a wide-ranging dial?");
7. Multiple Starts so resources can be brought online or switched off multiple times through the day as required based on changes to the generation profile and load;
8. Inertial Response and frequency control to maintain power system stability and arrest frequency decline post-fault;
9. Dynamic Reactive Control to support grid voltage; and
10. High Short Circuit Current contribution to ensure appropriate fault detection and clearance.

Nuclear New York submitted substantial relevant testimony titled "Nuclear is a Dispatchable Electricity Source" (November 2023) in this proceeding regarding the actual dispatchable capabilities associated with different types of nuclear reactors.[24] See also Flexible Nuclear Energy for Clean Energy Systems by National Renewable Energy Laboratory (NREL).[25]

As discussed in our filing, the dispatchability of a nuclear power plant depends on the particular technology employed. Some, including advanced reactors like the Westinghouse AP1000, have impressive load-following and ramping capability, with the ability to function in the grid much like fossil-based thermal plants. This capability of certain nuclear facilities is reflected with "maybe"

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[23] IPCC. WG3 AR5 Annex III: Technology-specific Cost and Performance Parameters. Table A.III.1 (continued). 2014. https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf#page=5

[24] Nuclear New York. Nuclear is a Dispatchable Electricity Source. November 2023. Submission to NYSDPS docket 15-01168/15-E-0302: https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BA0F5C88B-0000-C521-AAAD-996DCC98AF0F%7D

[25] Nuclear Innovation: Clean Energy Future. Flexible Nuclear Energy for Clean Energy Systems. *National Renewable Energy Laboratory.* September 2020. https://www.nrel.gov/docs/fy20osti/77088.pdf

labels in the above chart. We also remove the distinction between modular and non-modular reactors since modularity is not deterministic of these performance attributes.

Energy storage technologies (such as pumped hydro, hydrogen, batteries) are not energy generators. The emissions profile of stored energy is a derivative of the charging source and therefore is marked as “maybe” under the “Carbon Free” dimension.

Generation sources with fuel are deemed “dependable,” but the amount of fuel reserve is tied to system characteristics, including energy density. A conventional nuclear power plant gets refueled every 12-18 months, while some advanced nuclear reactors have been designed to operate for 5 to 20 years between refueling. Hence nuclear power is not energy-limited. Methane gas, on the other hand, is a just-in-time delivered fuel. As space heating takes precedence during cold winter days, fossil power plants turn to burning oil-based liquid fuels, or curb output in response.[26]

Being weather-dependent, wind and solar resources do not provide “Flexibility,” “Quick Start,” or “Multi Start” services, contrary to such a suggestion in NYISO’s original table. In reality, these resources demand that the rest of the system be flexible and able to ramp up and down to compensate for their intermittency.

Wind and solar generators deploy power electronics such as electronic inverters, which contribute to and increase harmonic distortions on the grid.[27] The frequent connection and disconnection events of weather-dependent generation can also create additional grid “noise” in the form of voltage drops and spikes. We urge NYSDPS to pay close attention to these emergent issues and the threat of growing costs to energy consumers that could result from a decline in power quality.

The reliability services necessary for a functional electric system are broader than simply matching total electricity demand with the sum of generator nameplate capacities multiplied by capacity factor. While firm energy sources like hydro, nuclear, and fossil combustion can provide reliability services, the Conference made clear that intermittent resources such solar, wind, and batteries are incapable of doing so at the necessary scale and at an affordable cost.

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[26] Angwin. Shorting the Grid, The Hidden Fragility of Our Electric Grid. 2020. https://www.meredithangwin.com/books/

[27] ArenaWire. Bringing national harmony to harmonic distortion. January 2023. https://arena.gov.au/blog/bringing-national-harmony-to-harmonic-distortion/

Sizing up the Gap

The gap between demand and supply is large and cannot be filled with more solar, wind, and battery resources alone. It requires the expansion of firm clean generation technologies.

The “gap” has several dimensions:

- The size of the generation (or storage) *power capacity* (measured in watts) needed to fill the maximum difference between a load (demand) at any moment and available actual generation at that moment, under worst-case scenarios;
- The maximum length of time of the gap;
- The *total energy* (measured in watt-hours) over a year that must be provided by the combination of chosen technologies; and
- In the case of storage systems, their ability to be charged between the occurrence of gaps.

NYSERDA’s four scenarios do not account for geospatial constraints, and they appear to assume perfect transmission between New York Control Area (NYCA) zones. New York has a largely clean upstate grid (92% carbon free, powered largely by hydro and nuclear) and a largely fossil powered downstate grid (91% fossil-powered, even after accounting for behind-the-meter solar).[28,29] The persistence of this “Tale of Two Grids” demonstrates that the assumption of perfect transmission is unrealistic. NYISO’s geospatial models have shown that additional firm dispatchable resources will need to serve at least 10% of demand, much larger than the 1.3% that NYSERDA suggested to the CAC in its Integration Analysis. Our analysis shows that this need will likely be even greater.

Taking into account limited transmission capacities between zones and conducting multi-year analysis, the results are even worse. This is confirmed in a spatiotemporal model analyzed by researchers at Cornell University, which estimated the capacity gap to be 37 GW.[30] One of the

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[28] NYISO. Power Trends 2023. https://www.nyiso.com/power-trends

[29] Nuclear New York, New York’s Climate Plan https://www.nuclearny.org/new-yorks-climate-law/

[30] Liu V., Srikrishnan V., Doering K., Kabir E., Steinschneider S., Anderson C.L. Heterogeneous Vulnerability of Zero-Carbon Power Grids under Climate-Technological Changes. Jul 2023 (v1), last revised Sep 2023 (v2) https://arxiv.org/abs/2307.15079

authors of this study and a panelist in the Conference, Dr. C. Lindsay Anderson highlighted the compounding challenges revealed in the Cornell model which NYSERDA and E3 overlooked (emphasis added):

> *One of the important things that came out of our analysis was really that building more renewables and adding more storage is not going to solve the problem. In our analysis, we included the installation of the two new transmission lines. One from Hydro Quebec and one from upstate to downstate, both bringing a fair bit of capacity downstate. The challenge here is that… these renewables are by and large upstate, with the exception of offshore wind downstate. The problem is, that when we need the power downstate, we can't get it there.*
>
> *Even with these new transmission lines and subject to the assumptions of the analysis we are seeing that those lines are already congested more than they're not, quite a lot more than they're not. The vast majority of the time they're congested. So even if we have the renewable power upstate, we can't get it downstate. Even if we had the batteries down there to fill up, there's very limited windows when we can move that power on the projected configuration of the system.*
>
> *What that means is it's not unusual at all to see load shedding downstate and renewables curtailment upstate. So we're dumping the wind, we're dumping the solar. The batteries are full and we've got load shedding downstate. What if we add more batteries downstate? What if we add more renewables? Just adding more is not necessarily going to solve that problem.*

Dr. Leonard Rodberg submitted a study on the gap to the Case 15-E-0302 docket, showing that the gap is not only large in power (lack of capacity) magnitude, but also needs much larger amounts of energy generated by the gap-filling technology than suggested by NYSERDA and E3.[31] Rodberg and colleagues found, using a single-zone model for the State ("CACI model"), that in 2040 a zero-emission firm resource capable of delivering up to 29 GW of power would be needed, and that it

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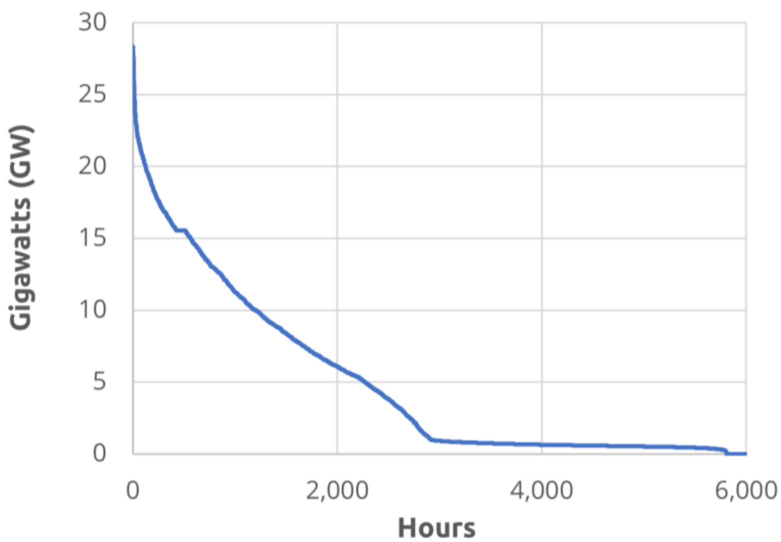
[31] Filling the Gap in New York's Decarbonization Plan: A New View of the Electric Grid. Leonard Rodberg, PhD, Reiner Kuhr, and Ahmad Nofal
https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={8085D08C-0000-C71D-B387-27BFB74FB081}

would be called upon to serve 15% of annual statewide demand. By comparison, NYSERDA and E3 predicted a need in 2040 for a zero-emission firm resource capable of delivering less than 18 GW of power, serving only 1.3% of annual statewide demand.

The CACI model calculated resource usage for every hour of the year using New York's weather (both onshore and offshore), found that for many evenings in the winter, and even some in mid-summer, there would be insufficient battery and wind capacity to meet the load.[32] The residual hourly gap between load and generation for 2040 would have the following power/duration profile. Many hours in the year show a very small gap while very few hours have a very large gap. The area below the curve is the amount of energy needed to fill the gap.

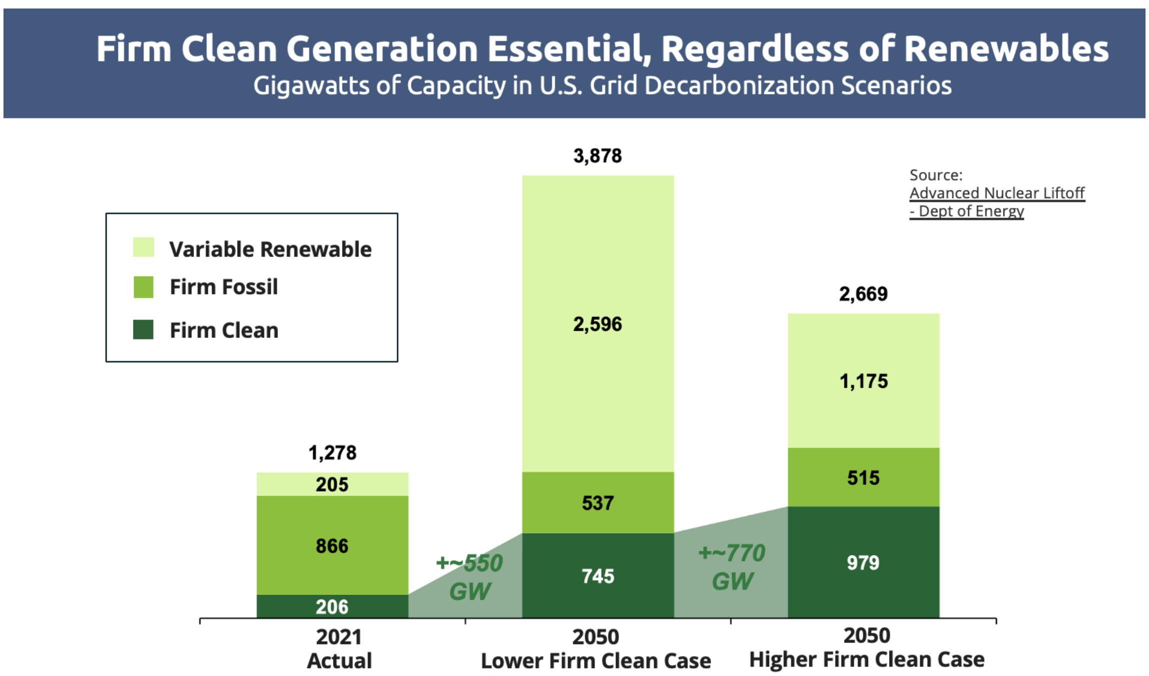


This research also found that replacing intermittent solar and wind with nuclear, even at today's prices, would substantially reduce system costs, corroborating NYSERDA's own findings from November 2022. Like in NYSERDA/E3 scenarios, the CACI model used data only from one year and relied on a copper-plate assumption for transmission. Using the sophisticated spatiotemporal model deployed by Dr. Anderson and her colleagues would make these findings even more dramatic.

[32] The illustrated iteration 1) added NYISO-projected new demand from electric vehicles and building electrification to the 2022 demand curve; 2) used NYSERDA/E3's Scenario 3 (behind-the-meter and grid-scale) solar plus (onshore and offshore) wind capacity; 3) modeled output based on historic weather and NYISO's Offshore Wind Profile (2021); and 4) augmented import availability with hydro from Quebec via the Champlain Hudson Power Express. We expect similar gap power/duration profiles with other resource mixes as well.

One reason for discrepancies between the NYSERDA/E3 analysis and others might be that NYSERDA and E3 assume that a certain amount of demand (about 5%) will be met by imported electricity of unspecified origin. As discussed in other filings to this proceeding, we are concerned that this might be a backdoor method of addressing the gap with electricity from conventional non-zero-emission sources.[33] However, to comply with the CLCPA, load-serving entities providing electricity to New York in 2040 must be zero-emission.

Furthermore, the amount of sunshine that New York receives at any given time is similar to that of its neighbors, and wind patterns can span large parts of the continent. Therefore, if New York's neighbors pursue similar renewable-focused energy policies, their generation will likely parallel that of New York. Weather-related drivers of electricity demand will also be similar as well. Since New York and its neighbors will often experience coincident gaps between demand and available intermittent energy, it is imprudent to assume that imports will be readily available to fill the gap.[34]



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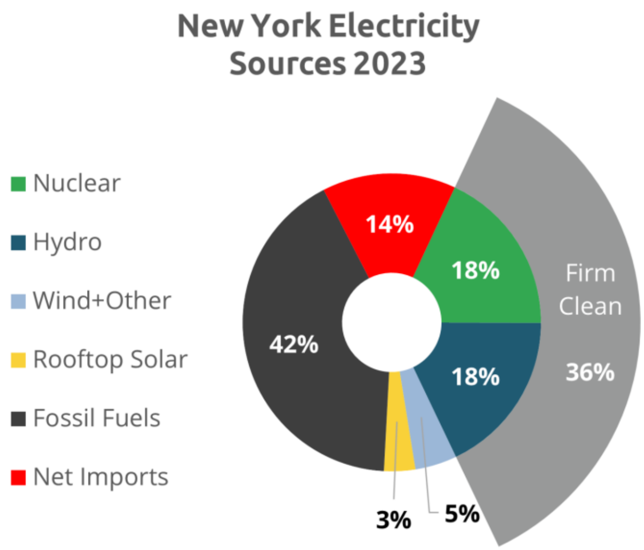
[33] See question 8 in this email to NYSERDA officials https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={9044358C-0000-CA10-8DFF-AE01BCECCB09}

[34] Energy systems thinker Meredith Angwin outlines the fatal trifecta affecting many electric grids: 1) overreliance on intermittent renewables 2) backing up intermittency with just-in-time methane gas 3) overdependence on neighboring power grids. Angwin. Shorting the Grid, The Hidden Fragility of Our Electric Grid. 2020. https://www.meredithangwin.com/books/

Many technology-neutral studies of decarbonization identify the need for a significant share of generation to be firm and clean, rather than "gap-filler" as envisioned by NYSERDA. See the above chart from the Department of Energy's Pathways to Commercial Liftoff: Advanced Nuclear ("DOE Nuclear Liftoff").[35] For a reliable carbon-free U.S. grid in 2050, firm clean generation needs remain high, regardless of intermittent generation capacity.

The below chart shows the breakdown of New York's 2023 electricity generation, highlighting firm clean sources.[36] As seen, today nearly all electricity generation in the State — and nearly all its *clean* generation — is from firm sources. This is why New York has an extremely reliable grid.



Source: New York Independent System Operator OASIS

Unfortunately, the first panel of the Conference had too little time to explore these questions with sufficient detail. We urge NYSDPS to investigate the frequency and extent of dark doldrums ("*dunkelflauten*") present vulnerabilities to New Yorkers if the State continues to pursue an energy system largely reliant on weather-dependent energy sources. Such studies must incorporate multi-year worst-case scenarios and persistent transmission and interconnection constraints.

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[35] Department of Energy. Pathways to Commercial Liftoff: Advanced Nuclear. March 2023. https://liftoff.energy.gov/advanced-nuclear/

[36] Nuclear New York. Four Years Since Passing the Climate Leadership and Community Protection Act, New York Struggles to Replace Shuttered Clean Energy. January 2024. https://www.nuclearny.org/wp-content/uploads/2024/01/New-York-Struggles-Clean-Energy-8-Jan-2024.pdf

Nuclear Energy

Nuclear is a reliable, versatile, firm, clean energy technology that can operate in baseload or load-following configurations. Repeat deployment of the same reactor design rapidly brings costs down.

We are pleased that the Conference included a panel to discuss the *only* zero-emission energy source that is not energy-limited or intermittent, and that is ready to be deployed today: nuclear. Existing and advanced nuclear systems are capable of delivering many of the services needed for a reliable and resilient electric grid.[37]

Nuclear is a firm clean energy source that can operate in baseload or load-following configurations. Beyond the demonstrated load-following capabilities of Generation II reactors in jurisdictions like France, the table below shows how new nuclear designs exist or are being developed with greatly enhanced dispatchability.[38,39,40] Instead of the conventional steam-based Rankine cycle for heat transfer from the reactor core to the electric turbine, some advanced designs use the Brayton cycle and gas as a "working fluid." This enables better thermodynamic efficiency and fast power-level changes, up to 20% per minute ramping rate.[41] The table also lists the expected timeframes for the first commercial demonstration projects per technology type.

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[37] OECD NEA. Technical and Economic Aspects of Load Following with Nuclear Power Plants. Nuclear Development. June 2021. https://www.oecd-nea.org/upload/docs/application/pdf/2021-12/technical_and_economic_aspects_of_load_following_with_nuclear_power_plants.pdf

[38] IAEA. Advances in Small Modular Reactor Technology Developments (2022 Edition). 2022. https://aris.iaea.org/Publications/SMR_booklet_2022.pdf

[39] Hill. IMSR® Commercialization before 2030. 2020. https://msrworkshop.ornl.gov/wp-content/uploads/2020/11/40_TEUSA_GAIN_MSR_Workshop_-_20_10_14_v2_hill1.pdf

[40] Heat pipe reactors are capable of ramping even faster by dumping all heat to the condenser directly.

[41] NIA. Advanced Nuclear Reactor Technology: A Primer (March 2023 Update). 2023. https://nuclearinnovationalliance.org/sites/default/files/2023-03/NIA%20Primer%20-%20March%202023_0.pdf

Reactor Technology	Power range MW (electric)	Ramp Rate (%/min)	Sample Vendor and Output Capacity	Commercialization Status/Commercial Production at First Project
Pressurized Water Reactor	20-1,650	2.5-5	Framatome's EPR (1,650 MW)	Currently operational (Finland, China)
			Westinghouse's AP1000 (1,110 MW)	Operational (U.S. and China)
			KEPCO's APR1400 (1,400 MW)	Operational (South Korea and United Arab Emirates)
Boiling Water Reactor	50-1,535	0.5	GE Hitachi's BWRX-300 (300 MW)	2029 in Darlington, ON
			GE Hitachi's ESBWR (1,535 MW)	NRC design certification in 2014
High Temperature Gas-Cooled Reactor	1-250	5-20	USNC's MMR (5 MW)	2027 in Chalk River, ON
			X-Energy's Xe-100 (80 MW)	2029 in Seadrift, TX
Liquid Metal Fast Reactor	1-1,200	5-12	Oklo's Aurora (15 MW)	2027 at Eielson Air Force Base, AK
			Terrapower's Natrium (345 MW, boostable daily to 500 MW for 5.5 hours)	2030 in Kemmerer, WY
Molten Salt Reactor	10-390	10	Terrestrial Energy's IMSR (390 MW)	2031 expected
Heat Pipe	1-5	5-20	Westinghouse's eVinci (5 MW)	2029 with Saskatchewan Research Council, SK

Conference panelist Rita Baranwall, former Assistant Secretary for the U.S. Department of Energy (DOE) Office of Nuclear Energy and current Senior Vice President and Former Chief Technology Officer of Westinghouse Electric Company, highlighted how the AP1000 can ramp up or down by 5% of total capacity per minute (nearly 60 MW) in response to demand.

After providing a technology overview, the panel made the case for deploying more nuclear energy:

Nuclear energy facilitates successful decarbonization.

- Every major industrialized jurisdiction that has successfully developed a zero or near-zero emission grid relies on firm generation: hydro, geothermal, and/or nuclear energy. Where hydro and geothermal sources are maxed out or unavailable, the only proven path to decarbonization involves a large amount of nuclear energy.
- The cheapest means of decarbonization is by keeping existing nuclear plants online.
- Nuclear power plants require very little land to generate a large amount of reliable energy.
- Real-world examples of nuclear plants being shut down, including here in New York, result in increased fossil fuel use.
- Weather-dependent renewables require large investments in often underutilized transmission, backup, and storage systems that are not needed for nuclear energy.
- By providing reliable, weather-independent, and zero-emission energy, deploying nuclear power avoids a gap from appearing in the first place.
- Both weather-dependent and nuclear power produce zero-emission electricity with near-zero variable costs. Therefore, in times of surplus supply, it is immaterial which power is being curtailed. If it is difficult or disadvantageous to throttle a nuclear reactor's output quickly, then curtailing wind or solar resources will make more sense. Nuclear can also be brought up to full output early in anticipation of a generation drop from wind or solar.

Nuclear energy is versatile, benefits communities, and supports economy-wide decarbonization.

- Nuclear power plants offer thousands of well-paying direct jobs and generate many more indirect and induced jobs.
- Nuclear reactors can not only generate reliable electricity for the grid, but also large amounts of energy important for economy-wide decarbonization: district heating services, industrial process heat, desalination, and inexpensive, emission-free hydrogen production.
- Micro reactors can power off-grid uses for the military or remote locations, replacing environmentally harmful and costly diesel generators.

Data centers and global commitments suggest strong growth in nuclear energy to come.

- Data centers appreciate the reliable and inexpensive electricity provided by nuclear power plants.[42] Co-locating data centers with nuclear power can offer combined benefits for host communities.

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[42] An example of this is Amazon's recent acquisition of the expanding Cumulus data center connected to the Susquehanna nuclear power plant in Pennsylvania.

- Data centers now contribute significantly to forecast electricity demand growth. Already, Duke and GA Power had to correct their electricity demand projections by gigawatts upwards and are exploring the addition of more nuclear reactors to their grid.
- The United States, along with 19 other nations, have committed to tripling nuclear energy generation by 2050 at the recent COP conference in Dubai.[43]

Julie Kozeracki, Senior Advisor with the DOE Loan Programs Office for nuclear energy, covered recent challenges faced by the industry, saying (emphasis added):

> *I want to explain some of the challenges that were faced at Vogtle because obviously the project came in more than twice the cost and a number of years behind, but none of these were nuclear specific challenges. All of these were general mega-project construction issues around the design, which is terrific, not being complete enough before construction; around the supply chain not yet being mature; around the workforce, not yet being trained. We now have all of those solved, actually. We now have a constructed design. We have a mature supply chain. We have a trained workforce.*
>
> *As exciting as [Small Modular Reactors] and [microreactors] are, we are likely going to need a lot more big reactors to meet our goals of tripling nuclear energy and getting to 200 gigawatts of new nuclear capacity. And I would like folks to think through the fact that most of the challenges that made the Vogtle project difficult have now been solved. And so more AP1000s. Although that was unthinkable a year ago, it is something that I've talked to a number of utilities about in the past few weeks because it's just difficult to add that much clean, firm capacity with smaller reactors. So I really hope that folks are going to start thinking through that path as they go forward.*

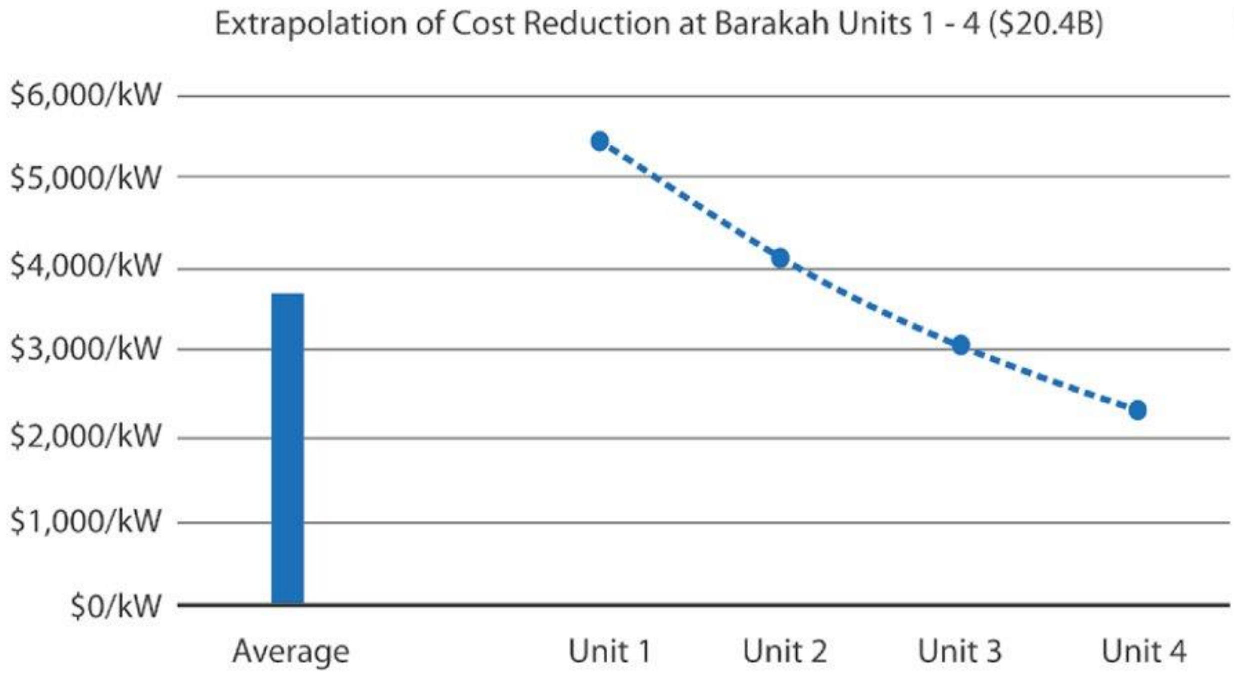
Kozeracki also pointed to South Korea as a nation that was successful in minimizing construction costs (and time) by repeatedly building the same design.[44] At the Barakah nuclear plant in the United

Mann. Amazon goes nuclear, acquires Cumulus Data's atomic datacenters for $650M. *The Register*. March 2024. https://www.theregister.com/2024/03/04/amazon_acquires_cumulus_nuclear_datacenter/

[43] Department of Energy. At COP28, Countries Launch Declaration to Triple Nuclear Energy Capacity by 2050, Recognizing the Key Role of Nuclear Energy in Reaching Net Zero. December 1, 2023. https://www.energy.gov/articles/cop28-countries-launch-declaration-triple-nuclear-energy-capacity-2050-recognizing-key

[44] Currently, Korea Electric Power Corporation is offering the APR-1400 reactor in the U.S., with NRC design certification.

Arab Emirates, the fourth reactor unit was built at 57% lower cost than the first one, the foremost nuclear reactor built in the Middle East. See below Barakah's cost decline curve, from technology and economic analysts LucidCatalyst.[45] Similarly, major cost improvements were realized at Vogtle unit 4 over unit 3, the first U.S. nuclear build in a generation (see DOE Nuclear Liftoff).



Vertically integrated utilities in regulated markets (like the Tennessee Valley Authority, Ontario Power Generation, and Southern Company) recognize that adding nuclear energy to their grids reduces system cost and include nuclear in their system planning.[46,47,48] These utilities will deliver long-term benefits of reliable, clean, affordable energy to their customers, which is attracting investments and jobs to their states. Georgia, which invested in two new nuclear reactors at Vogtle, has attracted 19 major clean energy projects between August 2022 and August 2023, which are expected to create almost 39,000 jobs, generate tens of billions of dollars in new wages, tax

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[45] LucidCatalyst. The ETI Nuclear Cost Drivers Project: Full Technical Report. September 2020. https://www.lucidcatalyst.com/the-eti-nuclear-cost-drivers

[46] Tennessee Valley Authority. Advanced Nuclear Solutions. Small Modular Reactors | Darlington SMR - OPG. https://www.tva.com/energy/technology-innovation/advanced-nuclear-solutions

[47] Ontario Power Generation. https://www.opg.com/projects-services/projects/nuclear/smr/darlington-smr/

[48] Yoganathan. Southern Co. talks plans for more nuclear energy. *Atlanta Business Chronicle.* March 2024. https://www.bizjournals.com/atlanta/news/2024/03/12/southern-company-nuclear-energy-chris-womack.html

revenue, and deliver economic growth.[49] A February 2024 study, funded by a grant from the U.S. Commerce Department's Economic Development Administration and led by energy trade association E4 Carolinas, found that while providing 37% electricity in Georgia, North Carolina, South Carolina, Tennessee, and Virginia, nuclear energy generates a total annual economic impact of $42.9 billion.[50] This impact corresponds to 152,598 jobs and $13.7 billion in labor income that otherwise wouldn't exist.

Unfortunately, today's restructured electricity markets, such the one overseen by NYISO, do not compensate for the many benefits nuclear energy would bring to our grid. In 2017, New York led the nation by recognizing the zero-emission benefits of its existing upstate reactors[51], and it should continue to offer Zero-Emission-Credits to those reactors. However, investors are not presently rewarded for the other, system-level benefits of nuclear energy such as efficient use of the existing transmission grid, avoided storage and backup power, and high power quality. This is worsened by a looming decay of market-derived revenue streams for energy and capacity as policy actions drive more subsidized intermittent generation into the market.

The panel suggested several ways of encouraging investors to consider adding new beneficial nuclear capacity to the NYISO grid:

- New York could offer guaranteed strike prices for nuclear energy via firm offtake contracts like it does for wind power or energy brought to New York City via Tier IV contracts, or, like the U.K. has done, offer Regulated Asset Base or "contracts for difference" payments.
- The federal Inflation Reduction Act offers an investment tax credit of up to 50%, which is even payable in cash to a public tax-exempt investor such as New York Power Authority (NYPA).
- The DOE has a $250 billion federal loan program to reduce financing costs for nuclear investments.

We observe that NYSERDA has already solicited offshore wind and hydro power from Quebec with

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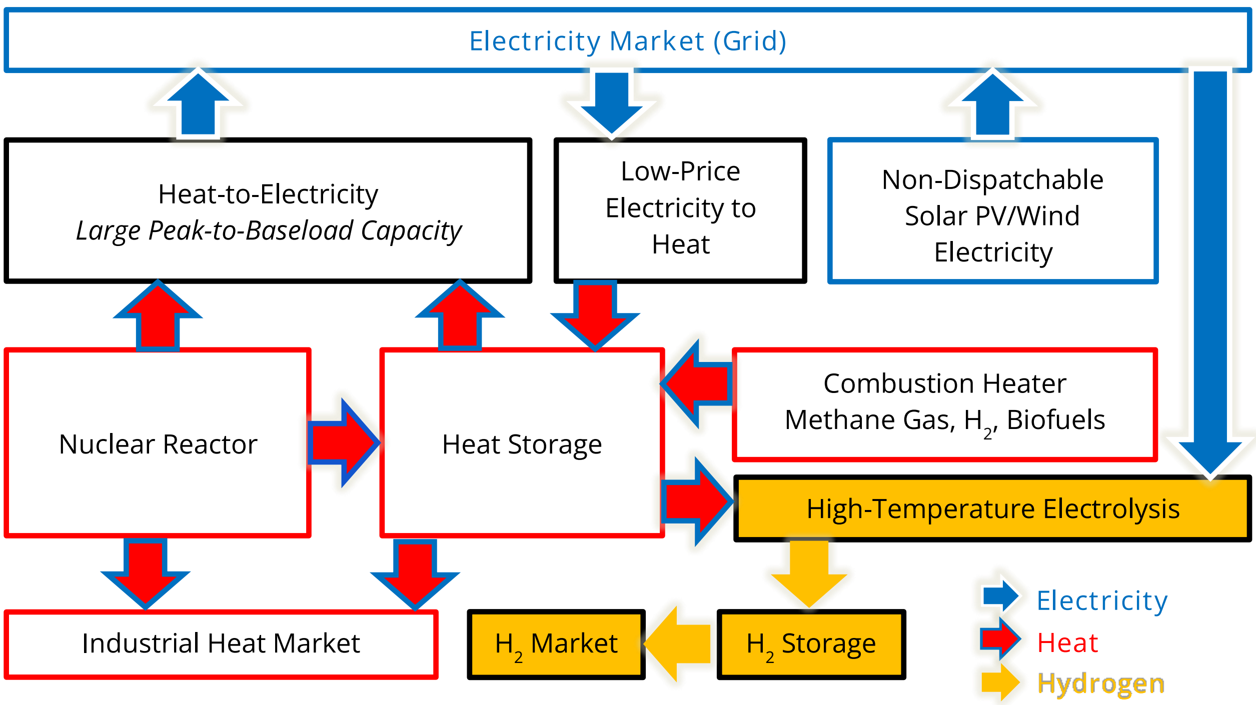
[49] E2. Georgia Clean Economy Works | An Economic Impact Analysis of Major Clean Energy, Vehicle Projects. February 2024 https://e2.org/reports/georgia-clean-economy-works-economic-impact-reports-2024/

[50] E4 Carolinas. The Economic Impact of the Nuclear Industry In the Southeast United States: A Regional and State-Level Analysis. February 2024. https://d1aettbyeyfilo.cloudfront.net/senuclear/113083672585E4_Carolinas_Economic_Impact_Report_Final.pdf

[51] McDermott. NY Creates New Emissions Credit for Nuclear Plants. September 2016. *Energy Business Law.* https://www.energybusinesslaw.com/2016/09/articles/environmental/ny-creates-new-emissions-credit-for-nuclear-plants/

long-term contracts that are far above the wholesale electricity price.[52,53] NYSDPS should encourage future clean energy solicitations to be technology neutral, thereby enabling all zero-emission sources to play a meaningful role.

Although not discussed during the Conference, nuclear can also be integrated into other strategies for economy-wide decarbonization as visualized in the below chart, adapted from NREL's NICE Future report.[54] We note that heat storage can be integrated into thermal energy networks, envisioned in the Utility Thermal Energy Network and Jobs Act, which was championed by labor and environmental leaders in New York.[55]



[52] Ludt, B. New York approves 2 offshore wind projects totaling 1.7 GW. *Windpower Engineering & Development.* February 2024. https://www.windpowerengineering.com/new-york-approves-2-offshore-wind-projects/

[53] NYSERDA. Tier 4 Renewable Energy Certificate Purchase and Sale Agreement between the New York. State Energy Research and Development Authority and H.Q. Energy Services (U.S.) Inc. November 2021. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Clean-Energy-Standard/CHPE-contract.pdf

[54] Nuclear Innovation: Clean Energy Future. Flexible Nuclear Energy for Clean Energy Systems. *National Renewable Energy Laboratory.* September 2020. https://www.nrel.gov/docs/fy20osti/77088.pdf

[55] New York State Governor's Office. Governor Hochul Announces Progress toward Implementing Utility Thermal Energy Network and Jobs Act to Reduce Greenhouse Gas Emissions. September 2022 https://www.governor.ny.gov/news/governor-hochul-announces-progress-toward-implementing-utility-thermal-energy-network-and-jobs

Demand-side Resources and Virtual Power Plants

The climate & cost benefits of shifting demand are real but limited.

Nuclear New York welcomes emerging demand management tools, in addition to demand response solicited from large energy consumers, to reduce energy price spikes and transmission distribution system stress. The result should be lower system costs and lower emissions welcomed by all New Yorkers, provided that participation is voluntary and consensual. However, our enthusiasm about these methods is tempered by issues that received too little attention during the Conference.

The size of demand response has three components: the amount of suppressed demand, how long demand can be suppressed, and the extent to which suppressed demand bounces back. People expect reliable electricity, and nobody wants to be inconvenienced. This is why willingness to participate in demand management drops off the more it is called upon and the longer it is exercised. Demand response participants gladly accept enrollment incentives but may have regrets when their use of electricity is curtailed. As expressed by Ernest Orlando of the Lawrence Berkeley National Laboratory, "First, customers tend to become frustrated with the effects of the service interruptions and oftentimes will leave the program if they are called too frequently."[56]

Reliance on demand management could reduce the need for additional generation capacity and transmission/distribution upgrades. However, it could also lead to more frequent energy emergency situations, requiring more demand response to prevent blackouts. Eventually this will find an equilibrium, which may look much less exciting than some Conference participants suggested.

Furthermore, the durational benefit of demand response is limited. Demand response is merely a shift in load service and, in the manufacturing sector, costs accrue the longer demand is curbed. In reality, "virtual power plants" are not power plants at all. "Virtual power plants" are a collection of resources and response techniques that can fill short gaps and help moderate demand but will be unable to fill extended gaps in supply or address extreme situations. For the purposes of the Conference, demand response and virtual power plants appear to be of limited relevancy.

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[56] Shen B., Ghatikar G., Ni C., and Dudley J. Addressing Energy Demand through Demand Response: International Experiences and Practices. *Lawrence Berkeley National Laboratory.* June 2012. https://www.osti.gov/servlets/purl/1212423

Just Transition / Climate Justice

1) Nuclear provides multi-generational, community-building, high-quality jobs, powered by domestic supply chains.

2) Relying predominantly on land-intensive technologies causes unnecessary habitat destruction, biodiversity loss, and rural farming community encroachment.

3) Rising energy costs from an ill-conceived, cumbersome climate plan causes injustice to the most vulnerable New Yorkers.

Nuclear New York supports environmental justice and a just transition. We have also fought to limit local air pollution from fossil fuel combustion.[57] However, in working to mitigate climate change, the State should be mindful to not harm new constituent groups. Although the CLCPA was passed ostensibly to fight climate change and protect environmental justice (EJ) communities, when Indian Point closed, a thousand highly skilled permanent jobs were lost, and the amount of fossil fuels burned for electricity downstate rose dramatically. In fact, this was pointed out by panelist John Murphy, international representative of the United Association of Journeymen & Apprentices of the Plumbing and Pipefitting Industry. Further, Murphy stated (emphasis added):

> *… Developing new dispatchable zero-emission resources will be critical in helping New York meet its climate goals. While the State has created an extensive program to support renewable sources, it has not developed a similar system for alternative clean energy projects. Like other forms of energy, zero-emission sources require public*

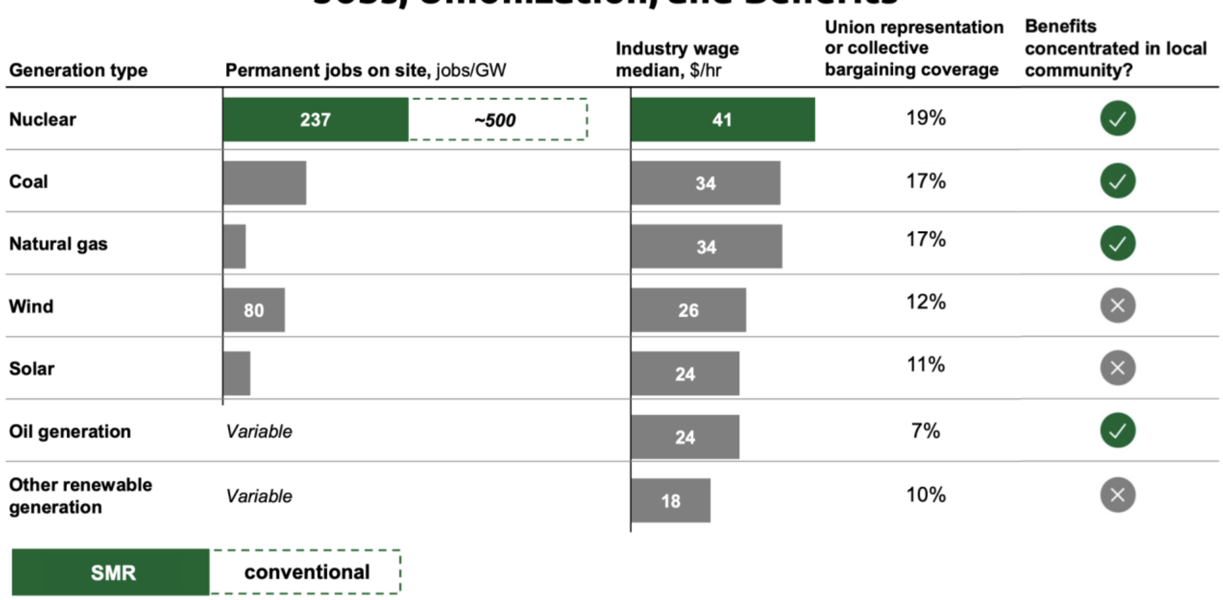
[57] Open Letter to Elected Representatives: Prevent the Fossil Fuel Takeover (Sept-Nov 2020) https://www.nuclearny.org/open-letter-prevent-nyc-fossil-takeover/

subsidies, especially in the early stages to become feasible. Investment advisors will always suggest diversifying retirement savings to mitigate risks—Don't put all of your eggs in one basket. Diverting billions in subsidies to primarily renewable sources is putting New Yorkers at risk.

Nuclear energy notably has the highest average wages and highest union membership of any electric utility sector. Murphy punctuated his support by stating, "Any future clean energy programs, policies, and initiatives need to include new and existing nuclear generation."

For a clean energy transition to be successful, it must be advantageous for the workers delivering it. That means that the quality of work and wages of existing fossil fuel workers must be maintained or improved upon. New jobs must build and sustain communities, with equal opportunities for all New Yorkers in diverse and desirable careers. The ability to create a just transition is impacted by our choice of technology, with some having a better potential to create high-quality jobs, strengthen communities, and support domestic supply chains than others. The following chart combines research from DOE's Nuclear Liftoff and US Energy Employment and Jobs Report.[58]

Jobs, Unionization, and Benefits

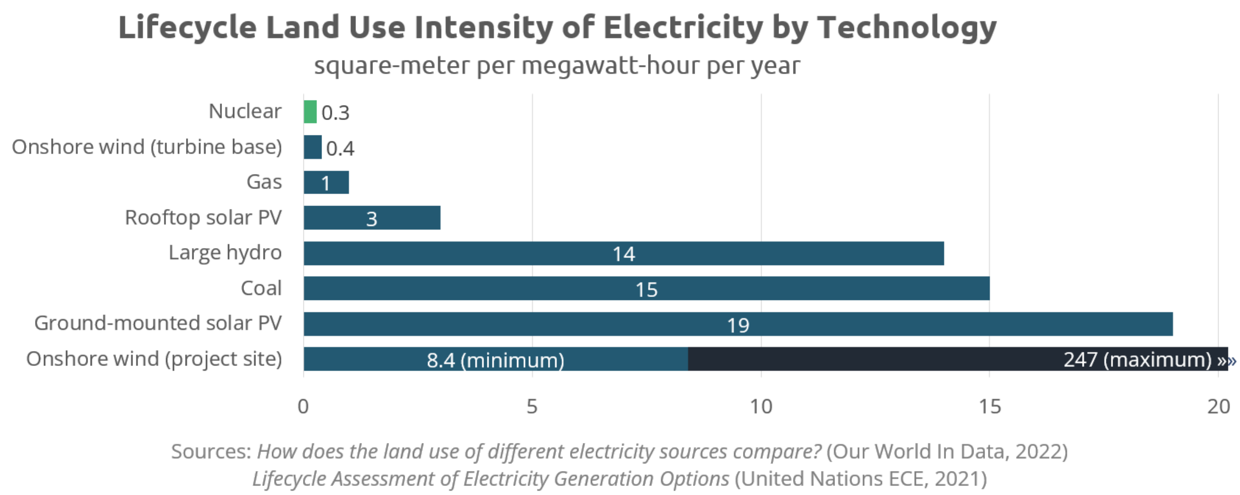


We cannot wish our way to high wages, union membership, and other positive concessions for social

[58] US Energy Employment and Jobs Report. 2023 National Report. June 2023. https://www.energy.gov/media/299601

and labor justice.[59] These arise from the ability of highly skilled workers to organize and win concessions from management in bargaining. While these opportunities abound at nuclear power plants, they are absent at workerless facilities that are erected by temporary, lower-skilled, and often out-of-state labor.[60]

The lifecycle land use and material intensities of different decarbonization technologies must also be carefully considered in any climate plan that professes to protect the environment (see chart below from UNECE). Given the high population density of downstate New York, the ability to install land-intensive solar and wind is limited, as acknowledged in NYSERDA/E3 scenarios.[61]



The cradle-to-grave land and material footprint of energy[62,63] is proportional to habitat destruction and biodiversity loss. See charts on the following page.

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[59] Nuclear New York, Clean Energy Jobs Coalition-NY, and Campaign for a Green Nuclear Deal. Bright Future: A More Reliable and Responsible Climate Plan for New York. July 2022. https://www.nuclearny.org/bright-future/

[60] Gurley, L. Building Solar Farms May Not Build the Middle Class. *New York Times.* July 2021. https://www.nytimes.com/2021/07/16/business/economy/green-energy-jobs-economy.html

[61] Seneviratne. Electric Evolution: New York's Electricity System, Prices, and Climate Plans. *Harvard Center for Geographic Analysis.* November 2022. https://storymaps.arcgis.com/stories/75ae570ed31844629721ef87d37a9b02

[62] Wang, S., Hausfather, Z., Davis, S., Lloyd, J., Olson, E. B., Liebermann, L., Núñez-Mujica, G., & McBride, J. Future demand for electricity generation materials under different climate mitigation scenarios. *Joule*, 7(2), 309–332. January 2023. https://doi.org/10.1016/j.joule.2023.01.001

[63] Touran, N. How much coal/gas/oil matches the energy of a single nuclear fuel pellet? *What Is Nuclear?* April 2023. https://whatisnuclear.com/calcs/energy-equivalents-of-one-fuel-pellet.html

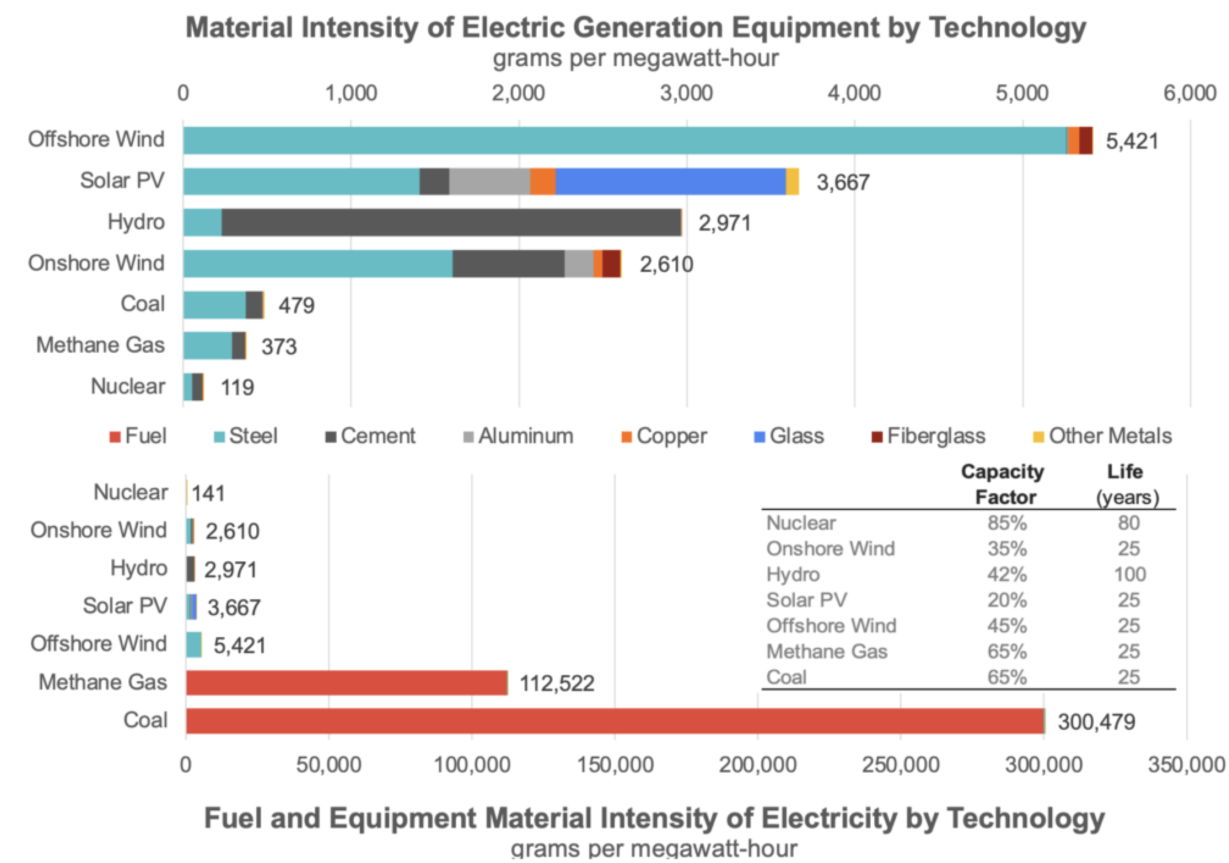
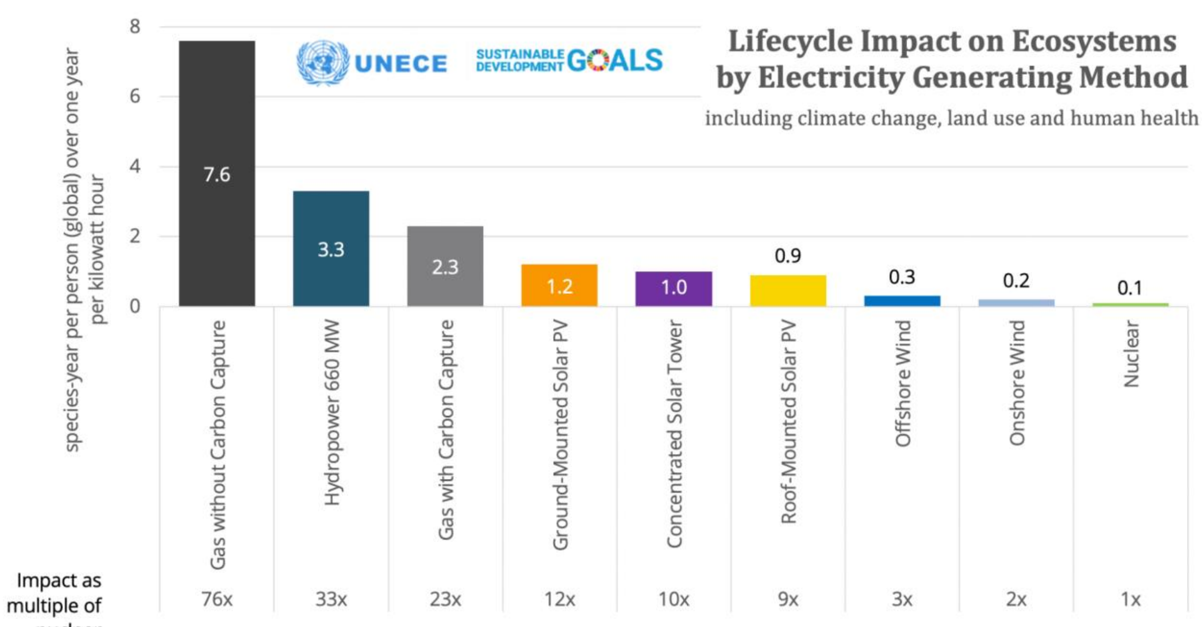


Chart by Isuru Seneviratne based on *How much coal/gas/oil matches the energy of a single nuclear fuel pellet?* (Touran, 2023), *Future demand for electricity generation materials under different climate mitigation scenarios* (Wang et al., 2023), capacity factors, lifetimes, and a uranium enrichment multiplier



Source: U.N. Economic Council for Europe (2022)

The EJ panel could have tried harder to understand and address the concerns raised by someone speaking on behalf of groups that fight energy sprawl in upstate New York (emphasis added):

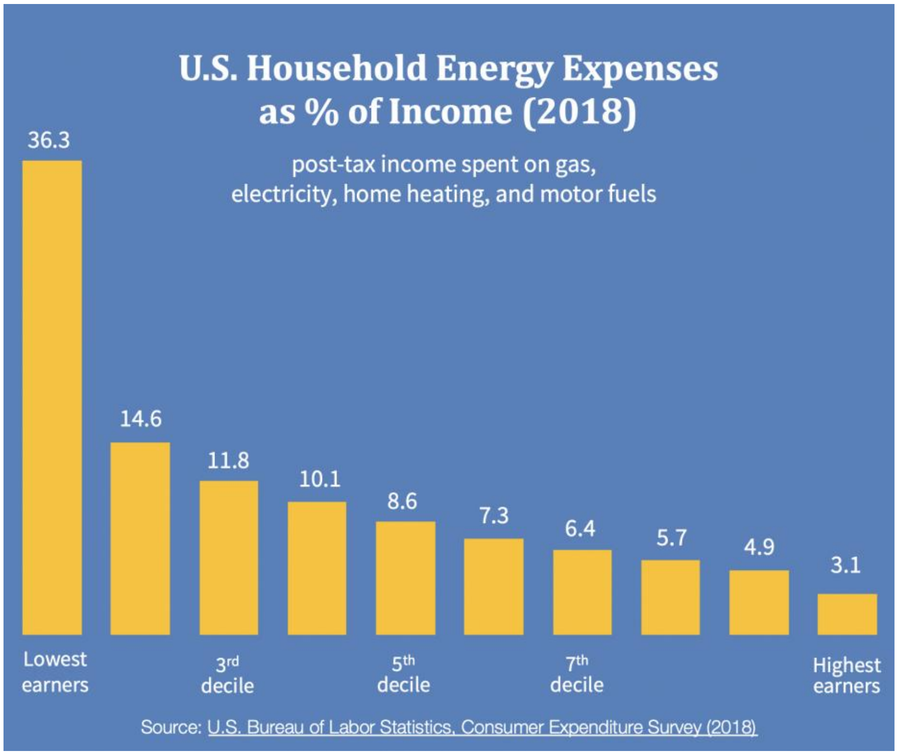
> *My name is Steve Helmin. I'm the co-chair of the GlenFARMLand (Glen Families Allied for Responsible Management of Land) and also an officer of Stop Energy Sprawl. We should be careful to not create new justice issues. How will the build-out of large-scale solar electric plants in small upstate EJ communities like mine be prevented from upending the local ag-based economies, ending farm jobs, ruining farm-support businesses, disrupting tourism? For the 650 megawatts of large-scale glass and steel solar plants [proposed in my community], the footprint for these plants could be as large as 10,000 acres or 2/3 the land mass of Manhattan Island.*

The State itself is denying Home Rule in the permitting of large-scale solar and wind projects, irrespective of harms to the involuntary host communities. The resistance mounting in upstate communities against industrial wind and solar projects is growing, and not recognizing it as legitimate will hinder the energy transition. The State must develop strategies to work with host communities of energy projects, not against them.

Another justice issue we believe has been routinely overlooked, including by this Conference, is who suffers most from rising energy costs. In 2018, the lowest-earning 10% of all U.S. households spent 36.3% of their income on energy, per U.S. Bureau of Labor Statistics' Consumer Expenditure Survey (chart below).[64] Transitioning to intermittent resources will increase total system costs, leading to an even larger burden placed on the poorest households. In fact, rising energy costs, as seen for more than a decade in California, are an inescapable burden upon the poor.[65]

[64] U.S. Bureau of Labor Statistics. Consumer Expenditures in 2018. May 2020. https://www.bls.gov/opub/reports/consumer-expenditures/2018/home.htm

[65] Bryce, R. The High Cost of California Electricity Is Increasing Poverty. *The Foundation for Research on Equal Opportunity.* July 2020. https://freopp.org/the-high-cost-of-california-electricity-is-increasing-poverty-d7bc4021b705



How will New York address this injustice? On the Demand-Side Resources and Virtual Power Plants panel, Curtis Tongue of Ohm Connect suggested that demand response management will be an opportunity for consumers to save money. However, energy costs amount to a small fraction of total expenses in high-income households (3.1% for the highest decile). Many are likely to select the benefits of uninterrupted power regardless of demand response incentives. On the other hand, energy costs are a major burden on poor households. Presenting demand management as an opportunity to save some money masks the exacerbation of inequity driven by an excessive build-out of intermittent generation, a primary driver of both higher delivered energy costs *and* the need for demand management to avoid blackouts.

No matter how much poor households participate in demand response, an expensive energy system will not become a cheap one just by having consumers accept inconveniences heretofore not expected of them. New York should do better than California and focus on providing affordable, reliable power for everyone, while attracting investments and good jobs in support of long-term prosperity for all.

Long-Duration Energy Storage (LDES)

The panel discussed the need for LDES to be 100 hours, an order of magnitude larger than NYSDPS' current definition of 10 hours. LDES needs to have capacity costs far below $20 per kilowatt-hour to compete with emission-free dispatchable resources.

The gap is the difference at any time between available generation and load which exceeds that available generation. Anything attempting to address that gap on the supply side has to rely on some form of energy storage. Panelist Ramesh Koripella, Principal Member of Technical Staff, Sandia National Laboratories laid the foundation for the discussion (emphasis added):

> *As several speakers this morning pointed out, as you put more and more renewable resources on the grid, you need flexible resources. Resources such as either gas back-up plants or energy storage to match the grid supply and demand. So, as the percentage of renewables [rises], we need more energy storage and more flexible resources.*

Koripella referred to the following chart from Department of Energy's Long Duration Energy Storage Liftoff study[66]:

	Short duration	Inter-day LDES	Multi-day / week LDES	Seasonal Shifting
Duration of dispatch	0-4 hours	10–36 hours	36–160 hours	160+ hours
Storage technologies	• Batteries • Flywheels • Some mechanical technologies	• Most mechanical technologies • Some electrochemical technologies	• Many thermal technologies • Many electrochemical technologies	• Chemical storage (e.g., hydrogen)
Primary end-use	• Intra-day energy shifting (e.g., day to night) • Frequency regulation	• Inter-day energy shifting (e.g., one point in a day to another point the next day)	• Resilience for extended shortfall of power	• Shifting energy over months (e.g., summer to winter)

[66] Department of Energy. Pathways to Commercial Liftoff: Long Duration Energy Storage. March 2023. https://liftoff.energy.gov/long-duration-energy-storage/

Lithium-Ion batteries have high capital costs for power and energy capacity and a limited lifetime, but they can endure many cycles and have relatively small storage and conversion losses. This already lends them to successful applications such as ancillary grid services and diurnal storage of solar-generated electricity. The cost is recovered by frequent cycling.

However, for long duration storage the number of annual cycles would be much lower. Addressing some of these challenges, Koripella said (emphasis added):

> *If you look at all the ISO/RTO requirements, they are 4 hours only. Only PJM is asking for 10 hours. So there is no market mechanism really for long duration energy storage. That product needs to be developed.*
>
> *… Cost needs to be less than $20 per kilowatt-hour (kWh). Most of the technologies are much more expensive. Lithium [ion] right now is the most dominant technology, with almost 95% of all the energy storage [deployment]. Costs are reducing. Right now, cell-level cost is about $150/kWh, but installation cost is more than $200/kWh. So $200-300/kWh range after installation.*[67] *It is difficult to imagine that it will scale down to $20/kWh-level for a very large-scale deployment. That's why you need to look into other technologies like iron-air, zinc-bromine batteries, zinc-air batteries, and thermal storage.*

Scott Burger, Senior Manager of Analytics, Form Energy, pointed out that about 98% of payments in today's energy markets are for energy (kWh) and capacity (kW), with the remainder being spent on ancillary services. Asserting that both grid inertia and energy sufficiency deserve more attention in the markets, he said (emphasis added):

> *I think that is a very legitimate concern… We really don't have great mechanisms for valuing reliability. Today we procure capacity and capacity markets, which are really designed around a kind of historical structure where you essentially had unlimited fuel. We're starting*

[67] Crimson Storage in California is the world's largest (lithium-ion) battery built in one go (2021-2022). The 350 megawatt (MW), 1,400 megawatt-hour (MWh) project cost $550 million ($393/kWh). Colthorpe, B. Crimson Energy Storage 350MW/1,400MWh battery storage plant comes online in California. *Energy Storage News.* October 2022 https://www.energy-storage.news/crimson-energy-storage-350mw-1400mwh-battery-storage-plant-comes-online-in-california/

to see some cracks. If you look at NERC reports of the reserve margins in markets like PJM and ERCOT. On paper, we have really huge reserve margins, but we are seeing reliability challenges during these multi-day low renewable energy periods like winter storm period. [A]n area that I think we need to spend a lot of time thinking about is how to reform capacity markets to better capture the incremental reliability benefits that dispatchable resources bring to the market.

… I don't think we need to completely reinvent the wheel on ELCC [effective load-carrying capacity], but I think we need to realize and recognize that ELCC does not solve all our problems and start to procure for something that is much more tailored for energy sufficiency, not just capacity sufficiency.

At the outset of the LDES panel, Schyler Matteson, Clean Energy Planning Lead of NYSDPS stated that the State defines LDES as 10+ hour storage.[68] Yet panel consensus was that LDES needs to be 100 hours or greater. Such a 100-hour storage system would be rarely cycled. When a storage system is rarely dispatched, its system cost becomes prohibitively expensive. Form Energy, Burger's firm, has a target price of $17-$24/kWh for LDES.[69] But during the panel's discussion, Burger cited a study that instead suggests LDES needs to be $1-10/kWh for system cost reduction.[70] A clean grid can depend on the high capacity of a firm clean resource. Utilizing such a resource for additional hours, even if it uses an expensive fuel, can be cheaper than investing in additional LDES capacity.

Koripella pointed out that in California, the mismatch between intermittent generation and demand is balanced by natural gas peaker plants. In the U.S., as well as New York, the dominant source of energy storage is pumped hydro.

Given the expected long-duration gaps in New York's electricity system, battery technologies appear to be a poor choice for LDES: By having to store a large amount of energy for extended periods with few opportunities for deep cycling, batteries will struggle to recoup their significant capital costs.

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[68] NYSDPS. 2022 Energy Storage Roadmap (page 7). December 2022 https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b7D4753BA-916B-483E-9E35-6749B20384A6%7d

[69] Weaver, J. F. Former US coal plant to host 100-hour iron-air battery. July 2023. *pv magazine*. https://www.pv-magazine.com/2023/07/14/former-us-coal-plant-to-host-100-hour-iron-air-battery/

[70] Jenkins, J. D., Sepulveda, N. A. Long-duration energy storage: A blueprint for research and innovation. September 2021. *Joule*. https://www.sciencedirect.com/science/article/pii/S2542435121003585

Methane

A number of issues with biogas, renewable natural gas, and carbon capture & storage limit the likelihood that methane-based technologies can fill the gap.

Biogas

Dr. Emily Grubert of Notre Dame University explained that raw biogas is a mixture of methane and CO2 with 40-60% of one or the other. CO2 tends to separate from the methane during long-term storage or during transport in pipelines, causing problems to users. She therefore supported today's general practice of burning biogas for energy generation right away on-site. While this would eliminate biogas as a resource to address the electricity gap, the loss is limited due to the very small volumes of biogas available. The combustion of biogas instead of fossil fuels for onsite industry may also be a more effective decarbonization strategy.

Renewable Natural Gas (RNG)

Although expensive to do, biogas can be refined by removing impurities and converted to "Renewable Natural Gas" (RNG), which can be transported or stored like conventional fossil-based pipeline gas. Biogas volumes can also be increased by using more fermentation feedstock, optimizing fermentation processes to maximize yield, and using non-fermentation methods to produce methane from additional biogenic feedstocks. Any one of these steps, however, increases costs and the chances of methane, a greenhouse gas much more potent than carbon dioxide, escaping.

Even if the challenges of maximizing the generation and refining of biogas and biomass-derived fuels can be solved, Grubert questioned whether it is worthwhile to maintain the extensive natural gas pipeline network for this limited purpose. She also emphasized the need for credible greenhouse gas accounting by comparing emission impacts to what would have occurred without implementing methane-enhanced production methods.

Carbon Capture and Storage (CCS)

CCS offers the appeal of potentially making combustion of renewable natural gas carbon-negative or continuing the use of fossil methane to bridge the gap. However, Dr. Grubert offered a number of warnings:

- The CCS process itself requires a significant share of the energy released by combustion, thereby requiring more fuel (fossil or RNG) and combustion capacity to generate electricity needed to fill the gap.
- CCS processes are capital intensive and would add to the significant costs of a gap-bridging system that ostensibly would have little use.
- The technologies to bridge gaps in intermittent generation will need to be quick ramping and highly responsive. While small simple-cycle gas turbines offer those attributes, large-scale CCS does not and would limit technical performance.
- CCS is not 100% effective, allowing some CO_2 escape. Further, upstream methane emissions would still occur, contributing to overall greenhouse emissions. In fact, since CCS requires more fuel, the proportion of upstream emissions per unit of electricity generated would actually increase.

Synthetic Gas

The panel dismissed the idea of producing synthetic methane for electricity generation from hydrogen and carbon feedstocks due to inefficiency, complexity, and cost. However, there might be other uses for synthetic methane or petroleum in the decarbonization of other sectors.

Hydrogen

Able to maximize electrolyzer capacity use, nuclear energy is well-suited for emissions-free hydrogen production. Due to impurities associated with underground storage, hydrogen combustion appears to be more practical than fuel cells.

Panelist Jeffrey Goldmeer of General Electric asserted that existing combustion turbines can be retrofitted to burn hydrogen. He also said that for many years, a small number of turbines have burned hydrogen produced as a byproduct of certain chemical processes. He said they are successfully keeping emission values within the legal limits, but that completely NO_x-free combustion is impossible without a nitrogen-free combustion environment.

While combustion turbines can burn hydrogen containing impurities, fuel cells require pure hydrogen. This is a serious challenge for the use of fuel cells if hydrogen is stored underground where it can mix with contaminates–a particular concern in former natural gas wells. Fuel cells require very clean storage facilities such as salt caverns and expensive refining before combustion.

Another challenge of using hydrogen is the distribution system. Existing natural gas pipelines are unsuitable to carry hydrogen, which causes embrittlement in carbon steel. Furthermore, the permeability of steel results in significant leakage of hydrogen, which itself is a very potent, indirect greenhouse gas. A new pipeline network made of hydrogen-grade steel, perhaps in the form of a hub and spoke system, would be needed. However, this could be smaller than the existing natural gas distribution network since it would only connect hydrogen producers, large hydrogen users, and storage facilities. Panelist Bryan Pivovar of the National Renewable Energy Laboratory claimed that transporting massive amounts of energy through a pipeline is more efficient and feasible than trying to do so via wires (in the form of electricity), but information quantifying this for hydrogen was not provided.

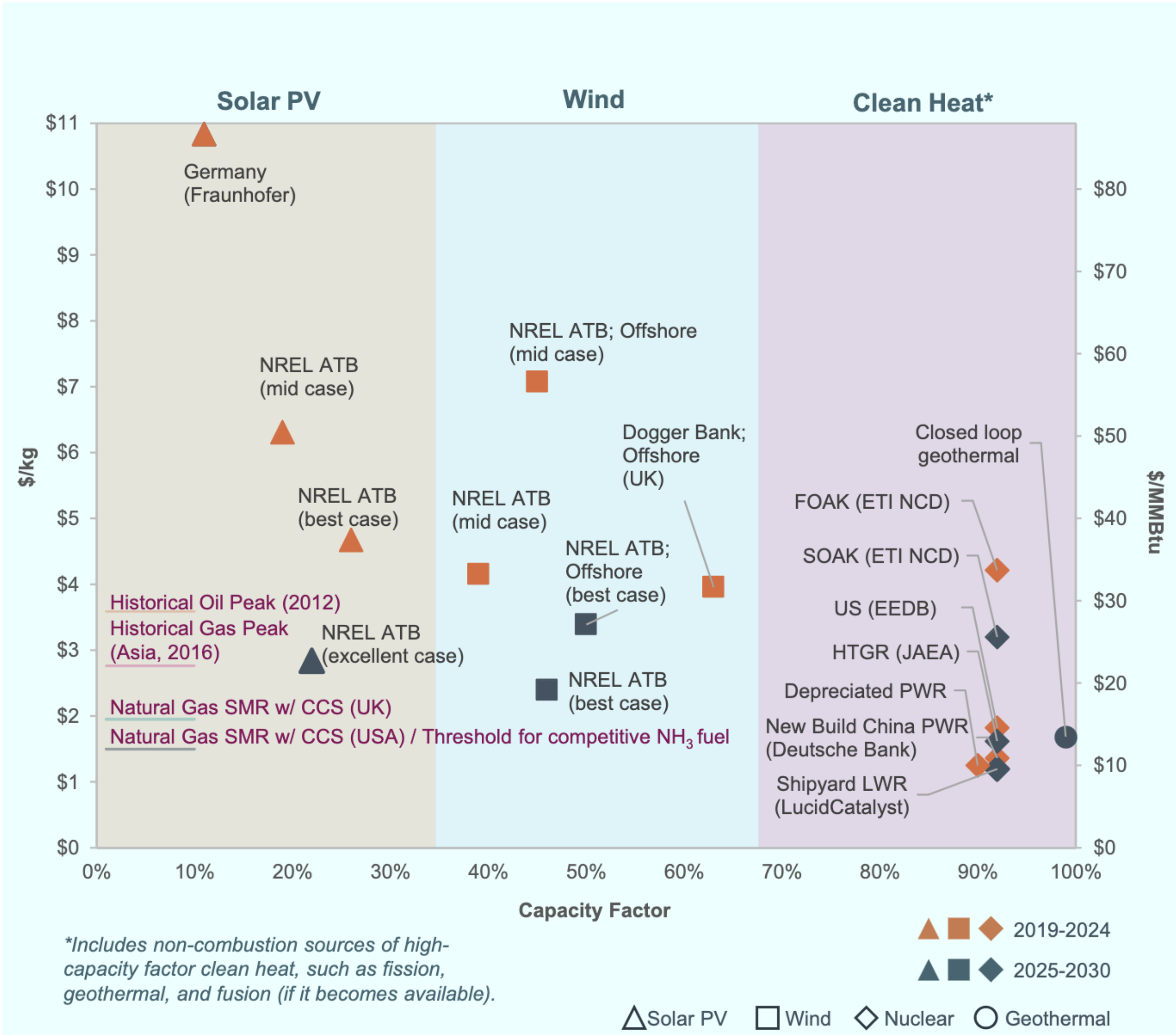
Asked about whether nuclear energy would be a good emission-free candidate to power hydrogen-producing electrolyzers, panelist David Cohn of Sargent & Lundy responded (emphasis added):

> *[I]f you have baseload generation, you can continuously produce the hydrogen at relatively low cost. Very reliable nuclear generation [can] do that and you can produce a lot of hydrogen. Then you just have to be able to either use it or store it, but it would be produced very reliably.*

Nuclear energy is well-suited for emissions-free hydrogen production,[71] as clearly demonstrated in the chart below from the technology and economic analysts LucidCatalyst.[72]

[71] Nuclear New York. Clean Hydrogen https://www.nuclearny.org/clean-hydrogen/

[72] LucidCatalyst. Missing Link to a Livable Climate. February 2021. https://www.lucidcatalyst.com/hydrogen-report



FOAK = First of a Kind
SOAK = Second of a Kind
NREL ATB = National Renewable Energy Lab's Annual Technology Baseline

Deploying a smaller number of dedicated electrolyzers producing hydrogen around-the-clock be much more efficient than building a very large number of hydrogen-producing electrolyzers that idle except when receiving surplus electricity from solar and wind. The former could also benefit from efficiency gains using nuclear-based high-temperature steam electrolysis.

Beyond potentially helping to address gaps in electricity generation in the future, hydrogen already plays an important role in petrochemical refining, food processing, and fertilizer production. It can also be used as a combustible fuel for high-temperature industries, like steel production, that are seeking ways to replace fossil fuels. Nuclear energy can help satisfy this need.

Conclusion

Nuclear New York reiterates our appreciation of NYSDPS for hosting this long overdue Technical Conference to understand the physical realities of developing a reliable, affordable, and sustainable electricity system for New York.[73] This is consistent with the NYSDPS mission, stated below:

> *The primary mission of the New York State Department of Public Service is to ensure affordable, safe, secure, and reliable access to electric, gas, steam, telecommunications, and water services for New York State's residential and business consumers, at just and reasonable rates, while protecting the natural environment.*[74]

We hope these comments will assist NYSDPS in fulfilling its mission and community protections that inspired the CLCPA.

It is abundantly clear from the analyses of NYSERDA and NYISO that New York should retain its existing firm clean nuclear generation assets. Furthermore, as we have shown here and as this Conference demonstrated, adding new nuclear capacity will provide significant benefits to New York's energy system, foster economic growth, and ensure that the State can meet its climate goals. To this end, we recommend that all future clean energy support and solicitations by New York be technology-neutral and reward the performance attributes vital to a functional and reliable electricity system.

Finally, we observe that New Yorkers still lack clarity on system-level cost implications of CLCPA implementation, as well as the economic consequences of actions being considered. We recommend follow-up analyses and conferences by NYSDPS to help build consensus on an effective path forward.

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[73] IPPNY. Case 15-E-0302 – Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard; Petition of Independent Power Producers of New York, Inc., New York State Building & Construction Trades Council and New York State AFL-CIO for the Establishment of a Zero Emissions Energy Systems Program Under the Clean Energy Standard. February 10, 2022. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={A027B9BC-F029-42F7-BC18-F8B9F91D2C28}

[74] NYSDPS. About DPS and PSC. https://dps.ny.gov/about-us