Comment on the Draft State Energy Plan:

Analyzing the Electric Grid's Need for Firm Dispatchable Resources, the Role of Nuclear, and the Balanced Technology Plan as a Practical Way to Meet this Need

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The Need for an Improved Analytical Tool

The electric components of the draft State Energy Plan are already obsolete. The Pathways Analysis (Chap. 16) was performed before the Governor determined, correctly, that the state cannot achieve its climate goals without including a major role for nuclear power in its energy portfolio.

Chapter 16 was clearly prepared before the Governor's move, but the need for this action was clearly observed there. The Pathway Analysis of most scenarios still requires the substantial burning of fossil fuels (labeled "Gas + FO" in the graphs and tables) in every scenario through 2040, when all GHG emissions are, by the CLCPA, to be eliminated. (Some scenarios shown in the Pathways Analysis output reveal the presence of "Zero-emission Firm" resources, but these resources do not appear in the input data; they have been added in some ad hoc fashion.)

However, a more serious analytic problem is that the RESOLVE modeling tool used by NYSERDA is not capable of accurately assessing the need for these clean dispatchable resources, even though they're essential to the desired reliability. Several years ago, a study using RESOLVE noted its serious limitations: "*It is worth noting that RESOLVE is not designed to answer detailed reliability questions in systems without sufficient firm capacity. The RESOLVE modeling framework is limited to a set of 37 representative sample days, which does not have enough data points to make robust conclusions on reliability events that happen infrequently, potentially less than once per year. In addition, the sample days are independent (not connected) and therefore do not capture the potential need for multi-day or seasonal storage.*"

A very different model is needed to properly simulate the situation in which a grid has a large component of intermittent resources which must be supplemented, or replaced, by a firm dispatchable source that will maintain continuing reliability. We have used such a model, initially developed by the Center for Academic Collaborative Initiatives (CACI) but adapted by us in the Hourly Electric Grid Analysis, or HELGA, model. RESOLVE ignores the time dependence of renewables, using only a fractional capacity factor to take account of their intermittency. HELGA, instead, performs an hour-by-hour analysis so that daytime differs from night and windy periods are distinguished from the doldrums. We have previously described the HELGA model and shown the scale of the *gap* between demand and supply in the renewable-focused Climate Action Council's Scoping Plan.

Quantifying the Need for a Firm, Dispatchable, Zero-emission Source

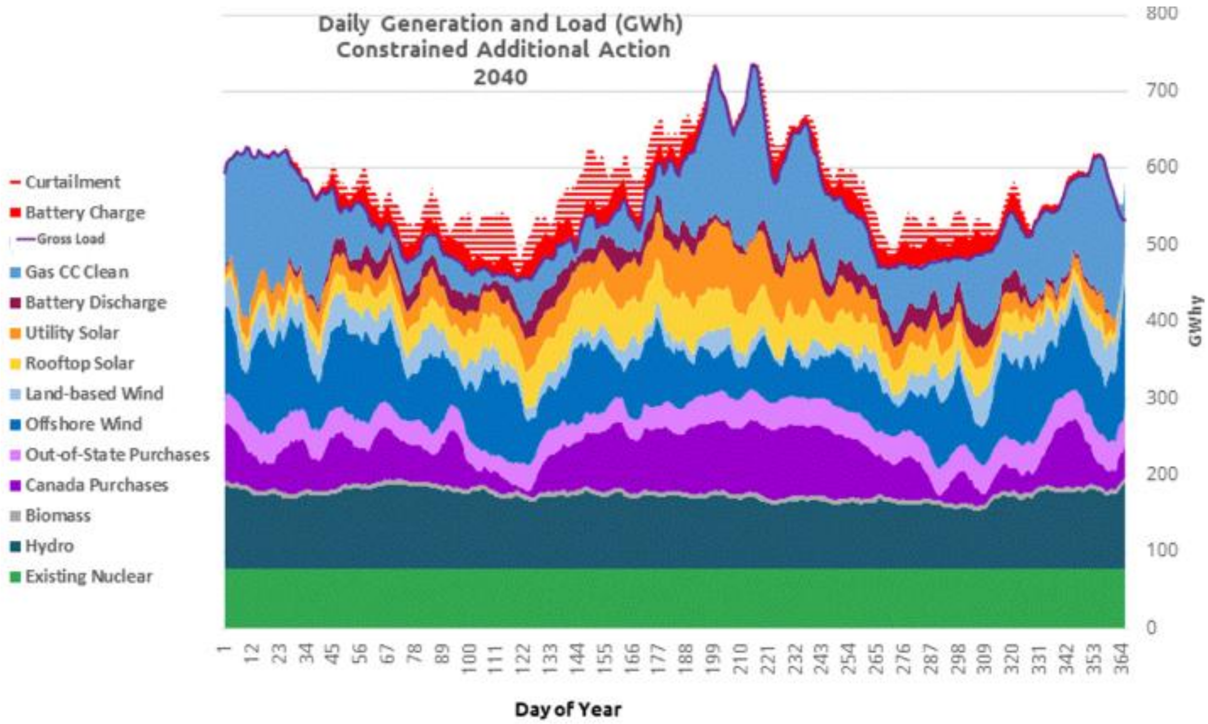
In the current context, we have modeled five scenarios proposed in NYSERDA's Pathway Analysis to determine how much energy the Zero-emission Firm resources have to generate over a typical year.

The five Pathways scenarios are:

- Current Policies
- Additional Action
- Constrained Additional Action
- Net Zero Scenario A
- Net Zero Scenario B

We took the capacities of each fuel source from the inputs in the Pathways Analysis and used HELGA to determine the projected annual output of each source in 2040. We used the weather pattern in 2022 to provide the hourly output of the solar and wind resources. Their capacity factors were calculated from this data. The hourly import of power in 2022 was assumed to continue in 2040.

The results for each scenario are shown in the Appendix. The firm dispatchable resource, which fills the gap between the Gross Load and the output of the available, mostly renewable, resources, is labeled "Gas CC Clean". (This might be thought of as hydrogen-powered gas turbines, with the source of the hydrogen unspecified. Below we suggest an alternative using nuclear power as well as hydrogen produced using nuclear power.) The output of this dispatchable source is needed for more than 350 days during the year. Graphically, the daily output over the course of the year appears as shown in Figure 1 for the Constrained Additional Action scenario. Clearly, this resource is essential and meets a substantial portion of the load.



Here are summary results for the required output from the Zero-emission Firm Resource in each of these scenarios:

Scenario	2045 Load (GWH/yr)	Zero-emission Firm Resource (GWh/yr)	Share of Load (%)
Current Policies	196,130	24,040	12.3%
Additional Action	201,240	26,680	13.3%
Constrained Additional Action	201,240	31,103	15.5%
Net Zero Scenario A	254,325	43,707	17.2%
Net Zero Scenario B	254,325	42,993	16.9%

Approximately one-seventh of the load must be supported by the zero-emission firm resource. *This is more than an order of magnitude (factor of ten) greater than is projected in the* *Pathway Analysis*. Powering the necessary resource with hydrogen produced by solar power would require *tripling* the number of solar installations in the already-expansive net zero scenarios. The state needs another way to provide this essential service to the grid.

A Balanced Technology Plan

Trying to use hydrogen-driven turbines with solar-produced hydrogen is impractical. The only realistic way to produce that amount of clean, zero-emission energy is with nuclear power. (We assume this is the motivation behind the Governor's recent call for beginning to build nuclear.) We suggest a Balanced Technology plan which draws on the scenarios in the draft State Energy Plan, beginning with the Constrained Additional Action plan.

Nuclear operates most efficiently in continuous, baseload mode, so we suggest a substantial amount of always-on nuclear power. To reduce the cost and environmental destruction of an extensive renewable buildup, we cut the plan solar and wind targets by 50% and add 5 GW of baseload nuclear, the most that can be introduced without having to curtail some of its output. (For comparison, the now-shuttered Indian Point plant produced about 2 GW.) We then need clean dispatchable power to meet the daily and seasonal variations in demand upon the grid. To meet this requirement, we suggest adding roughly 7 GW each of flexible nuclear power (as in Terrapower's Natrium combined reactor-plus-molten salt thermal storage) and hydrogen-powered turbines. The resulting system capacity and output in 2040 are as follows:

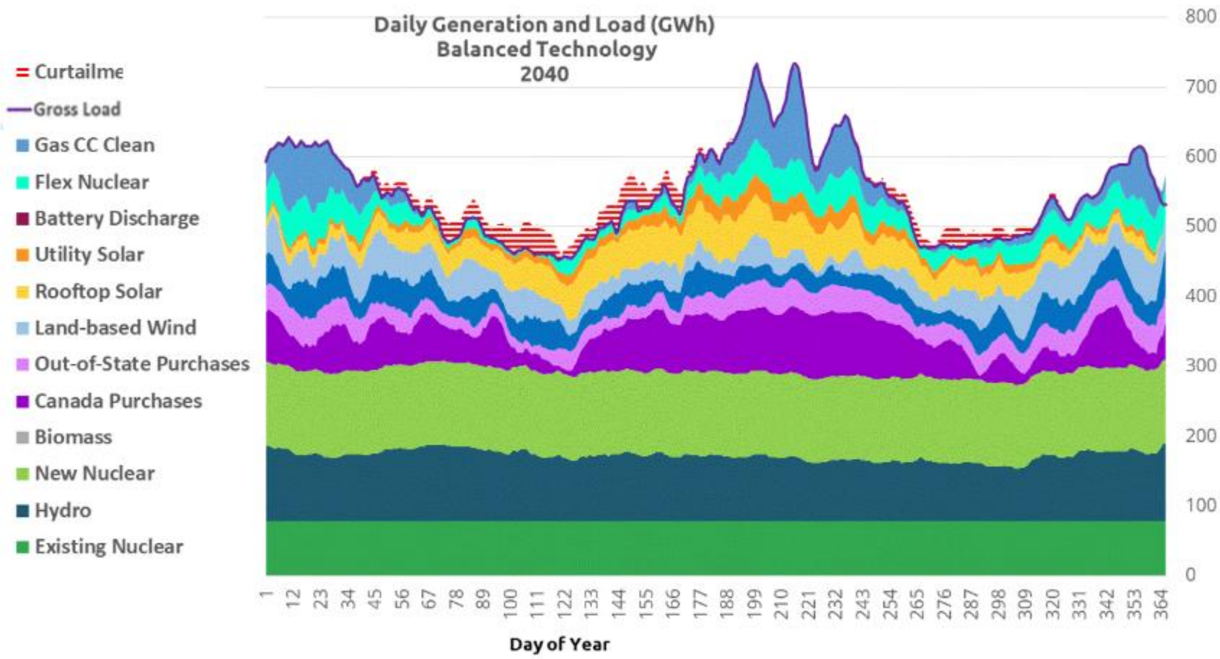
Electricity Generation
Balanced Technology
2040

Energy Source	Capacity (MW)	Output (GWh/yr)	Capacity Factor (%)	% Load
Existing Nuclear	3,305	28,972	100.1%	14.4%
New Nuclear	5,000	42,060	96.0%	20.9%
Hydro	5,485	34,154	71.1%	17.0%
Biomass	258	0	0.0%	0.0%
PV BTM	11,195	12,981	13.2%	6.5%
PV Grid	6,000	5,160	9.8%	2.6%
Wind ON	9,250	12,869	15.9%	6.4%
Wind OFF	3,450	11,644	38.5%	5.8%
Flex Nuclear	6,500	10,462	18.4%	5.2%
Gas CC CLean	11,000	10,667	11.1%	5.3%
NE and PJM Purchases		10,713		5.3%
Canada Purchases		21,080		10.5%
Load		201,240		100.0%

* Battery charging load is part of solar and wind output.

Curtailment 3,820

The hydrogen required by the Balanced Technology scenario could be produced by the flex nuclear plant at times when it is not producing electricity. This would make the hydrogen essentially free. Note that, because of the steady reliability of the baseload nuclear source, the need for variable, dispatchable power is reduced to less than 10% of the overall load. The daily output of the system then appears like this:



The Balanced Technology scenario includes the firm, dispatchable power that a reliable grid requires. It also replaces a portion of the land-intensive renewables with compact baseload nuclear plants that permit preservation of much of the rural upstate environment.

Appendix

Draft State Energy Plan Scenarios

Electricity Generation
Current Policies
2040

Energy Source	Capacity (MW)	Output (GWh/yr)	Capacity Factor (%)	% Load
Existing Nuclear	3,305	28,972	100.1%	14.8%
Hydro	5,485	34,154	71.1%	17.4%
Biomass	258	2,262	100.1%	1.2%
PV BTM	11,195	12,981	13.2%	6.6%
PV Grid	23,605	19,152	9.3%	9.8%
Wind ON	8,300	11,358	15.6%	5.8%
Wind OFF	9,000	30,011	38.1%	15.3%
Battery Discharge*	9,300	7878	9.7%	4.0%
Gas CC CLean	16,100	24,040	17.0%	12.3%
NE and PJM Purchases		11,611		5.9%
Canada Purchases		21,080		10.7%
Load		196,130		100.0%

* Battery charging load is part of solar and wind output.

Curtailment **12,208**

Electricity Generation
Additional Action
2040

Energy Source	Capacity (MW)	Output (GWh/yr)	Capacity Factor (%)	% Load
Existing Nuclear	3,305	28,972	100.1%	14.4%
Hydro	5,485	34,154	71.1%	17.0%
Biomass	258	2,262	100.1%	1.1%
PV BTM	11,195	12,981	13.2%	6.5%
PV Grid	24,205	20,246	9.5%	10.1%
Wind ON	8,900	12,275	15.7%	6.1%
Wind OFF	9,000	30,207	38.3%	15.0%
Battery Discharge*	9,100	7773	9.8%	3.9%
Gas CC CLean	17,200	26,680	17.7%	13.3%
NE and PJM Purchases		11,871		5.9%
Canada Purchases		21,080		10.5%
Load		201,240		100.0%

* Battery charging load is part of solar and wind output.

Curtailment 11,601

Electricity Generation
Net Zero Scenario A
2040

Energy Source	Capacity (MW)	Output (GWh/yr)	Capacity Factor (%)	% Load
Existing Nuclear	3,305	28,972	100.1%	11.4%
Hydro	5,485	34,154	71.1%	13.4%
Biomass	258	0	0.0%	0.0%
PV BTM	11,195	12,981	13.2%	5.1%
PV Grid	33,805	29,259	9.9%	11.5%
Wind ON	15,700	21,635	15.7%	8.5%
Wind OFF	14,400	48,398	38.4%	19.0%
Battery Discharge*	11,400	9,664	9.7%	3.8%
Gas CC CLean	23,400	45,237	22.1%	17.8%
NE and PJM Purchases		11,948		4.7%
Canada Purchases		21,080		8.3%
Load		254,325		100.0%

* Battery charging load is part of solar and wind output.

Curtailment	16,122

Electricity Generation
Net Zero Scenario B
2040

Energy Source	Capacity (MW)	Output (GWh/yr)	Capacity Factor (%)	% Load
Existing Nuclear	3,305	28,972	100.1%	11.4%
Hydro	5,485	34,154	71.1%	13.4%
Biomass	258	2,262	100.1%	0.9%
PV BTM	11,195	12,981	13.2%	5.1%
PV Grid	33,505	28,707	9.8%	11.3%
Wind ON	15,700	21,566	15.7%	8.5%
Wind OFF	14,400	48,272	38.3%	19.0%
Battery Discharge*	11,100	9430	9.7%	3.7%
Gas CC CLean	18,100	42,993	27.1%	16.9%
NE and PJM Purchases		11,834		4.7%
Canada Purchases		21,080		8.3%
Load		254,325		100.0%

* Battery charging load is part of solar and wind output.

Curtailment	**16,522**