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NEW YORK'S CLEAN ENERGY PROGRAMS

The High Cost of Symbolic Environmentalism

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About the Author

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Executive Summary

New York State continues to pursue aggressive goals for renewable energy and reduced emissions. In 2016, the New York Public Service Commission (NYPSC) enacted the Clean Energy Standard (CES).[1] Under the CES, by 2030, 50% of all electricity sold by the state's utilities must come from renewable generating resources. At the same time, emissions of greenhouse gases (GHG)—principally carbon dioxide (CO_2) but also such gases as methane and chlorofluorocarbons—must be reduced by 40%. The CES also incorporates New York's previous GHG emissions reduction mandate, established by Executive Order in 2009,[2] which requires that the state's GHG emissions be reduced 80% below 1990 levels by 2050 (the "80 by 50" mandate). More recently, as part of the CES, Governor Andrew Cuomo issued an executive order requiring 2,400 megawatts (MW) of offshore wind to be installed by 2030.

Also in 2016, NYPSC established the New York State Clean Energy Fund (CEF),[3] which imposes surcharges on electric ratepayers to fund programs to reduce energy use in residential, commercial, and industrial buildings by about 25% below current levels, or about 600 trillion BTUs (TBTUs), by 2030.[4]

According to a 2016 report prepared by the New York Department of Public Service (NYDPS), the interim CES goal will increase New Yorkers' electric costs by $3.6 billion. But the NYDPS analysis also claims that the CES will provide about $8 billion in CO_2 reduction benefits, and thus the CES will provide net benefits of $4.4 billion.[5] The report also claims separate significant economic benefits in the form of increased gross state product (GSP) and job creation.

Although proponents of renewable energy policies like the CES tout such overall benefits, the analytical basis for these claims is flimsy. A thorough literature review found that not a single state in the country has ever done a rigorous cost-benefit analysis of its renewable energy policies.[6] Nor has any state followed up to measure the efficacy of those policies after they were enacted. Furthermore, the technical studies that a few states have prepared, including the report issued by NYDPS and NYPSC's "Benefit-Cost Analysis Framework," contain fundamental economic flaws.[7]

The lack of valid cost-benefit studies belies their importance for evaluating energy policies like the CES, which will increase electricity costs and therefore have real and measurable adverse impacts on consumer well-being, as well as adverse impacts on the broader economy. Instead, New York policymakers and regulators have justified the CES on the basis of flawed estimates tied to: (i) the creation of new green industries and jobs paid for by subsidies and mandates; (ii) the artificial suppression of wholesale electricity prices; and (iii) an inflated projection of climate benefits.

Key Findings

- Given existing technology, the Clean Energy Standard's 80 by 50 mandate is unrealistic, unobtainable, and unaffordable. Attempting to meet the mandate could easily cost New York consumers and businesses more than **$1 trillion** by 2050, while providing scant, if any, measurable benefits.

- Meeting the CES mandate will require substituting electric-powered equipment for most existing equipment that burns fossil fuels (vehicles, furnaces, etc.), adding many billions of dollars in costs in both the private and public sectors. It will, in short, mean electrification of the New York economy, including most of the transportation, commercial, and industrial sectors.

- Even with enormous gains in energy efficiency, the mandate would require installing at least 100,000 megawatts (MW) of offshore wind generation, or 150,000 MW of onshore wind generation, or 300,000 MW of solar photovoltaic (PV) capacity by 2050. By comparison, in 2015, about 11,300 MW of new solar PV capacity was installed in the entire United States. Moreover, meeting the CES mandate likely would require installing at least 200,000 MW of battery storage to compensate for wind and solar's inherent intermittency.

- Just meeting the interim goals of the CES of building 2,400 MW of offshore wind capacity and 7,300 MW of solar PV capacity by 2030 could result in New Yorkers paying more than **$18 billion** in above-market costs for their electricity between now and then. By 2050, the above-market costs associated with meeting those interim goals could increase to **$93 billion**. It will also require building at least 1,000 miles of new high-voltage transmission facilities to move electricity from upstate wind and solar projects to downstate consumers. But none of the state agencies—NYDPS, the New York State Department of Environmental Conservation (NYDEC), and the New York State Energy Research and Development Authority (NYSERDA)—has estimated the environmental and economic costs of this new infrastructure. Such a large buildout of renewable infrastructure will surely have significant effects on agriculture, offshore fisheries, property values, human health, and biodiversity.

- As noted, the Clean Energy Fund's 2030 energy-efficiency mandate calls for 600 TBTUs of savings in buildings. This mandate lacks economic justification and appears to be technically unreachable: the savings mandate is double the most optimistic projection of energy-efficiency potential in the state.

- NYDPS and NYSERDA have both claimed that renewable energy and the CES will provide billions of dollars of benefits associated with CO_2 reductions. Not so. Regardless of one's views on the accuracy of climate models and social-cost-of-carbon estimates, the CES will have no measurable impact on world climate. Therefore, the value of the proposed CO_2 reductions required under the CES will be effectively **zero**. Moreover, even if there were benefits, virtually none of those benefits would accrue to New Yorkers themselves.

- Lower-income New Yorkers will bear relatively more of the above-market costs necessary to achieve even the interim CES goal. For example, absent significant changes to how retail electric rates are developed, affluent consumers who install solar PV will be able to "free-ride" on their local electric utilities, relying on those utilities to provide backup power when their solar systems are not providing electricity, while forcing other customers to pay for that electricity.

NEW YORK'S CLEAN ENERGY PROGRAMS

The High Cost of Symbolic Environmentalism

Introduction

Many of New York's energy policies today, including the Clean Energy Standard (CES), can trace their origin back to the first OPEC oil embargo in 1973. That embargo led the United States to enact wave after wave of legislation designed to "solve" various energy issues. Peter Grossman, an economics professor at Butler University, has called these efforts "the pursuit of failure" because almost all these policies have failed. Nevertheless, as the U.S. lurched from one "crisis" to another, the various energy policy moves either changed or, having previously failed because they ignored basic economics, were tried yet again, with the same failed outcomes.

For example, the Public Utilities Regulatory Policy Act of 1978 (PURPA) instituted a requirement that electric utilities purchase alternative sources of non-fossil-fuel electricity from so-called Qualifying Facilities (QFs). The goal was to reduce U.S. dependence on foreign supplies of crude oil by encouraging development of renewable energy from small hydroelectric plants, wind turbines, and solar photovoltaics (PV), as well as industrial cogeneration.

Although PURPA was a federal mandate, its implementation was the responsibility of state utility regulators, who set contractual prices for electricity supplied by QFs. The prices were based on forecasts of the utilities' "avoided" costs, that is, the cost of generating supplies that the utilities would otherwise have to produce themselves. Unfortunately, most of these forecasts were wildly exaggerated, which forced utilities and their customers to pay hefty prices for electricity that, in many cases, the utilities did not even need.

In addition to administering federal energy policy mandates, many states also began implementing their own policies to address energy and, later, environmental issues. But because crude oil and natural gas pipeline systems were nationwide and subject to Interstate Commerce Clause requirements, states could not impose specific rules that interfered with interstate commerce, or otherwise skew markets toward in-state suppliers.[8] Consequently, states focused almost exclusively on how their respective electric utilities provided electricity to retail customers because electric utilities were, and remain, primarily controlled by state regulators.[9]

The first catalyst for extensive state involvement in electricity policy appeared in the late 1970s, with the sudden decrease in what had been fairly steady historical growth for electricity. The reduction in demand growth was the result of two factors: (i) the economic recessions caused by the OPEC oil embargoes; and (ii) the huge cost overruns that electric utilities were incurring as they built more nuclear power plants. Not only did the reduction in electricity demand growth mean that some of those plants were not needed; the cost overruns caused electricity rates to skyrocket, reducing demand even more.

To combat cost overruns and unneeded generating plants, by the early 1980s many state regulators were imposing new "least-cost" (now called "integrated resource") planning requirements on electric utilities. The idea was to force the utilities to develop comprehensive, long-term plans that would match forecast growth in electricity demand with new generation supplies and thus avoid overbuilding. But activists and environmentalists convinced regulators that what was really needed was a policy to force utilities to focus on (and subsidize) energy conservation programs. Thus, utilities ended up having to compare the costs of new generating resources with the values of energy conservation measures—values based on many of those same flawed cost forecasts, as well as a variety of "economic" tests that, in some cases, excluded costs and tended to overstate benefits, especially through the use of inaccurate estimates of the environmental costs of electricity.[10]

Ironically, the second catalyst for greater state involvement was electricity deregulation efforts that began in the mid-1990s. Many states became concerned about losing control of the electric-utility industry, especially over the types of generating resources that were being built. In addition, many states had growing fears about greenhouse gas (GHG) emissions—principally carbon dioxide (CO_2) but also such gases as methane and chlorofluorocarbons—and about the impacts of climate change. The combination of those concerns led various states, including New York, to enact laws mandating acquisition of increasing quantities of renewable energy, primarily wind energy but also solar PV, waste-to-energy plants, and plants that burn wood.

Today, 29 states, plus the District of Columbia, have renewable portfolio standards (RPS) mandating that electricity demand for consumers be met with increasing shares of renewable energy resources. The participants include New York and all of New England.[11]

Subsequently, because there was no federal legislation requiring GHG reductions, many individual states, including New York, began to impose mandates to reduce those emissions, again focusing on the electricity sector because it was far more controllable than other energy sectors. Today, 20 of the states with RPS mandates also have committed to GHG reductions of 75%–80% below historical emissions levels by 2050, including 40%–50% reductions by 2030. New York's Clean Energy Standard is one of those mandates.[12]

Finally, 26 states have imposed energy-efficiency resource standards (EERS).[13] These require electric utilities to reduce retail energy consumption and/or peak electricity demand each year, typically by requiring those utilities to acquire cost-effective energy-efficiency measures.[14] Typically, such mandates require these utilities to reduce overall electricity consumption 1%–2% annually, up to a specified overall reduction below a chosen base year.

Do the Benefits of Clean Energy Policies Exceed Their Costs?

The justifications for state clean energy policies vary. In some states, the primary goal has been environmental improvement. In others, including New York, such programs have been justified as providing both environmental improvement and economic development, with advocates promising that these policies will create jobs, new industries, and greater economic growth.[15]

One might imagine that comprehensive analyses of the benefits and costs of clean energy policies—especially those focused on the electric industry—would be commonplace. Yet a review of the existing literature found only a handful of studies that have assessed the benefits and costs of state clean energy policies, and none have done so in a manner consistent with the fundamental economic principles underlying cost-benefit analysis.

A 2015 report by the Lawrence Berkeley National Laboratory spells out the stated purposes and goals of this kind of analysis:

> With the proliferation of RPS programs has come renewed interest in understanding their costs and benefits.... [U]tilities or regulators are often required to estimate RPS compliance costs annually in order to fulfill statutory reporting requirements, to develop surcharges used to recover RPS-related costs, or to ensure that utilities do not exceed statutory cost caps. Occasionally, states have also undertaken more expansive cost-benefit analyses, either on a prospective basis to inform the development of new RPS policies or, less frequently, on a retrospective basis to evaluate existing programs and inform possible revisions.[16]

The reality, however, is that many studies simply focused on the direct costs to implement policy mandates, devoting little attention to estimating the actual benefits of these programs. In other words, most studies have focused only on the cost side of the cost-benefit ledger, arguing that the costs are relatively low. For example, a widely cited 2015 article coauthored by Mark Jacobson of Stanford University[17] purported to demonstrate that, by the year 2055, the entire U.S. could meet its electric needs solely with wind, solar, and hydroelectric generation at a relatively low cost. But the article's findings were recently debunked as the product of invalid models and numerous modeling errors, as well as invalid and unsupported assumptions.[18]

In other cases where benefits have been estimated, those projections have suffered from fundamental economic flaws. For example, a study prepared by the New York State Energy Research and Development Authority (NYSERDA) examining the costs and benefits of the state's RPS mandate, which I discuss later in this report, treats wholesale price suppression—in effect, forcing the market price of electricity down by increasing the supply of subsidized renewable energy—as an economic benefit. Yet such price suppression is only a transfer of wealth from electricity producers to consumers—and a temporary transfer at that: when unsubsidized suppliers that are unable to compete leave the market, supply decreases and prices rise again.[19] In fact, such subsidies, by increasing uncertainty and reducing the incentive for new entry by unsubsidized suppliers, can lead to higher long-term market prices.

Other cost-benefit studies appear almost to have been designed to justify a preordained conclusion: that green energy policies, especially RPS mandates, provide significant benefits to electricity consumers at little or no cost. For example, a 2012 guide prepared by the Clean Energy States Alliance, a group that works to advance clean energy markets, states: "When an RPS causes a renewable energy facility to be built in a state, the jobs associated with that facility need to be counted as a benefit of the RPS, as do multiplier effects created when the workers at that facility spend money in the state."[20] In fact, in the context of a valid cost-benefit analysis, job creation is never treated as an economic benefit. Rather, job creation is a transfer of wealth from one set of parties (ratepayers) to others (subsidized employees).

Advocates of green energy typically report the additional costs of these policies disingenuously. Rather than report total additional costs, they couch those costs in terms of a small change in a typical residential customer's bill. Such "pennies per day" assessments are designed to make costs *appear* more manageable to consumers; a cost impact described as "one dollar per month for an average residential ratepayer" will be perceived as more manageable than if the impact is reported as a total cost for 10 million ratepayers of $120 million a year.[21]

This paper presents a critical assessment of New York's clean energy programs, including the assumptions and analysis behind the official estimates of the programs' costs and benefits.

- ***Section I*** provides a brief description of the New York Clean Energy Standard, the focus of this report.
- ***Section II*** offers a review of key concepts that provide the framework for evaluating the costs and benefits of the CES, identifying specific categories of costs and benefits relevant to the evaluation.
- ***Section III*** assesses the costs and benefits of the CES, as well as related components, such as solar PV programs and Governor Andrew Cuomo's January 2017 mandate to install 2,400 megawatts (MW) of offshore wind generation off Long Island by 2030.
- ***Section IV*** offers conclusions.

I. The New York Clean Energy Standard

The New York Clean Energy Standard (CES) was adopted in August 2016[22] and contains two mandates. First, it mandates that 50% of New York electricity consumption be from renewable energy resources—including hydroelectric, wind, and solar power—by 2030. Second, it mandates a 40% reduction in GHG emissions below 1990 levels by 2030 and an 80% reduction below 1990 levels by 2050. The latter is called the "80 by 50" goal.

The CES establishes three "tiers" of carbon-free resources:[23]

- ***Tier 1:*** New renewable generating resources, including customer-owned ("behind-the-meter," or BTM) solar PV through a program called "NY-Sun";[24] utility-scale solar PV, from which utilities and other electric suppliers will purchase renewable energy credits (RECs) each year; and a commitment to develop 2,400 MW of offshore wind generation by 2030[25]
- ***Tier 2:*** Existing renewable resources that require subsidies to continue operation or that could otherwise export power outside New York after their existing subsidized contracts with New York utilities expire
- ***Tier 3:*** Upstate nuclear power plants, which will be subsidized using "zero emissions credits" (ZECs) to prevent these plants from otherwise shutting down because they are uneconomical to operate[26]

More recently, in March 2017, Governor Cuomo announced another new program, "Drive Green," which will subsidize the purchase of electric vehicles as part of the CES. Under this program, New Yorkers who purchase electric vehicles will be eligible for up to a

$2,000 rebate paid by the state, depending on the type of vehicle purchased.

The governor has allocated $70 million for this effort. Of that amount, $55 million will be used for the subsidies—enough for rebates on 27,500 battery-powered vehicles—with the remaining $15 million earmarked for advertising and promotional activities, as well as building charging stations.[27] The objective of Drive Green is to have 700,000 electric vehicles, including plug-in hybrids, on New York roads by 2025.[28]

That is an ambitious goal. In 2016, a total of 8,874 electric vehicles were registered in the state.[29] Of that total, 6,106 were registered in the New York City metropolitan area, where vehicles are likely to be driven less per year because of greater availability of public transit than in the more rural upstate regions.

The RPS programs are also supposed to enhance economic growth through direct investment in renewable generation, including renewable resource manufacturing and installation. For example, the state committed $1 billion of taxpayer money to revitalize the economy around Buffalo,[30] including $750 million to construct a solar PV manufacturing plant for SolarCity, a solar manufacturer that was purchased by Tesla in 2016. The Buffalo facility, which has been mired in scandal,[31] is expected to begin manufacturing rooftop solar materials, such as glass roof tiles, later this year.

Calculating the Required GHG Emissions Reductions

Before assessing the costs and benefits of the CES and the required GHG emissions reductions, one is confronted with a basic measurement question: What were total GHG emissions in 1990? Because CO_2 emissions are not directly measured, an assessment of usage is based on fossil-fuel consumption, along with assumptions about emissions of other GHGs. Thus, the amount of GHG emissions in 1990 depends on various assumptions and on which GHGs are included in the overall total.

According to a recent NYSERDA report, total GHG emissions in 1990 were about 236 million metric tons of CO_2-equivalent ($MMtCO_2e$).[32] The "CO_2-equivalent" moniker arises because CO_2 is not the only greenhouse gas. Other gases, such as methane, also have a greenhouse effect, in that they trap heat in the atmosphere. To determine equivalence—e.g., the CO_2 equivalent of one ton of methane or one ton of chlorofluorocar-

FIGURE 1.

New York State GHG Emissions Levels and Sources

		1990		2014		2030 Reqt	2050 Reqt
		$MMtCO_2e$	Pct of Total	$MMtCO_2e$	Pct of Total	40% Decrease	80% Decrease
GHG Emissions by Sector	Transportation	60.40	25.6%	74.01	34.0%		
	In-State Electric Generation	62.99	26.7%	30.41	14.0%		
	Electricity Imports	1.63	0.7%	7.99	3.7%		
	Residential	34.22	14.5%	35.50	16.3%		
	Commercial	26.53	11.2%	22.03	10.1%		
	Industrial	19.99	8.5%	11.04	5.1%		
	SUBTOTAL, FUEL COMBUSTION	205.76	87.2%	180.98	83.1%	123.46	41.15
Other GHGs	Methane	23.52	10.0%	20.15	9.3%		
	Fluorocarbons	0.02	0.0%	10.03	4.6%		
	Nitrous Oxide	5.93	2.5%	3.31	1.5%		
	Other	0.61	0.3%	3.26	1.5%		
	SUBTOTAL, OTHER GHGs	30.08	12.8%	36.75	16.9%		
Total GHG Emissions		235.84	100.0%	217.73	100.0%	141.50	47.17
Energy-Related GHG Emissions (1)		212.87	90.3%	186.12	85.5%	127.72	42.57
Required GHG Reductions ($MMtCO_2e$)							
Below 1990 Levels						94.34	188.67
Below 2014 Levels						76.23	170.56

(1) NYSERDA 2017, Table S-2, note a.
Source: NYSERDA 2017, Table S-2

FIGURE 2.

Primary Energy Use by End-Use Sector, 2014

	Residential (TBTUs)	Commercial (TBTUs)	Industrial (TBTUs)	Transportation (TBTUs)	Electric Generation (TBTUs)	Total Energy (TBTUs)
Nonelectric Primary Energy Use (1)	644.2	399.4	141.4	1,073.0	1,475	3,733.5
Percent of Total Electric Generation	34%	52%	12%	2%		100%
Primary Electric Energy Generation Use by Sector (2)	500.3	766.5	180.2	28.5		1,475.4
Total Primary Energy Consumption by Sector (3)	**1,144.5**	**1,165.9**	**321.6**			
Total Residential, Commercial, and Industrial Primary Energy Consumption						2,632
Energy-Efficiency Reduction Mandate						600
Net R+C+I Primary Energy Consumption (TBTUs), Relative to 2014						2,032

(1) NYSERDA Patterns and Trends: New York State Energy Profiles: 2000–2014, Oct. 2016, Table 3-3 (excludes end-use electricity).
(2) Equals total electric generation primary energy use (1,475 TBTUs) multiplied by the percentage of electric generation consumed in the given end-use sector.
(3) Equals (1) + (2).

bons—researchers have developed values for "CO_2 potential."[33] For example, NYSERDA assumes that a single ton of methane has the same warming potential as 25 tons of CO_2 in terms of its heat-trapping characteristics.[34]

NYSERDA's estimates of total GHG emissions by sector, as well as the overall reduction in GHGs needed to meet the CES interim 2030 goal and ultimate 2050 goal, are shown in **Figure 1**. NYSERDA estimates that GHG emissions from fuel combustion in 1990 were 213 $MMtCO_2e$, of which electricity generation (in-state plus imports) accounted for about 65 $MMtCO_2e$. The estimates are based on CO_2 production from fossil-fuel consumption, as well as estimates of other GHG emission sources, such as methane leaks from transporting, storing, and distributing natural gas.

In 2014, NYSERDA estimated that total energy-related GHG emissions were 186.1 $MMtCO_2e$, of which electricity generation (including imports) accounted for just over 38 $MMtCO_2e$, or slightly more than GHG emissions from fossil-fuel consumption in the residential sector. As Figure 1 shows, by far the largest single source of GHG emissions is the transportation sector, with emissions of about 74 $MMtCO_2e$ in 2014.

The CES interim goal will require that total GHG emissions be no more than 141.5 $MMtCO_2e$, a reduction of about 46 $MMtCO_2e$ below total GHG emissions in 2014. By 2050, the CES requires emissions of no more than 47.2 $MMtCO_2e$, a reduction of about 171 $MMtCO_2e$ below 2014 levels.

The Energy-Efficiency Mandate

In conjunction with the CES, NYPSC also issued an order in 2016 establishing the Clean Energy Fund (CEF).[35] The CEF includes specific mandates for spending on energy efficiency and establishes a requirement that energy use in buildings be reduced by 600 trillion BTUs (TBTUs) by 2030. This is equivalent to a reduction in end-use electricity consumption of 172 terawatt-hours (TWh) and is also equivalent to about 23% of total primary energy use in the residential, commercial, and industrial sectors in 2014 (**Figure 2**).[36]

By comparison, the most recent forecast of electricity demand by the New York Independent System Operator (NYISO) envisions cumulative energy-efficiency program savings in the electric sector, including improved building standards, of just 12.5 TWh by 2027 (**Figure 3**), equivalent to about 43 TBTUs. In addition, NYISO forecasts total behind-the-meter (BTM) solar PV generation of 5.3 TWh, along with 2.5 TWh of other sources of BTM and distributed generation, both of which reduce the need for utility-scale generation to meet electricity demand.

If the NYISO forecast is extrapolated through 2030, the realized energy savings would be about 15 TWh, or just over 51 TBTUs (**Figure 4**). These savings are about one-twelfth the CEF mandate for 2030. Thus, more than 90% of the CEF-mandated energy-efficiency gains will presumably come from reductions in end-use fossil-fuel consumption.

Although these reductions will include declines in end-use fossil-fuel consumption—e.g., water heaters

FIGURE 3.

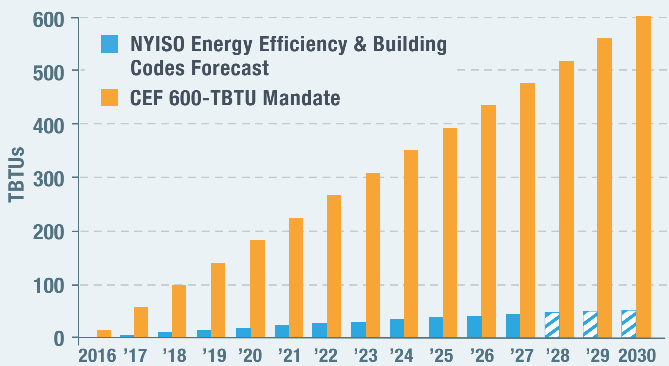
NYISO Forecast of Cumulative Reductions to Electric Energy Demand by 2027 (TWh)

2016 ACTUAL ENERGY CONSUMPTION	159.2	
	2017	2027
Baseline Energy Forecast (TWh)	163.3	175.3
Energy Efficiency and Behind-the-Meter (BTM) Generation		
Energy Efficiency	1.3	12.5
BTM Solar PV	1.8	5.3
BTM Distr. Generation	1.6	2.5
Total	4.7	20.3
Net Electricity Demand	158.6	155.0

Source: NYISO 2017 Load and Capacity Report ("Gold Book")

FIGURE 4.

CEF Cumulative Energy Savings Mandate vs. NYISO Projection



Source: NYISO 2017 Load and Capacity Report ("Gold Book")

and furnaces—the CEF mandate also includes potential savings from energy lost when fuel is burned and converted to electricity. For example, a typical coal-fired power plant burns three BTUs of fuel for every BTU of electricity produced.[37] This is why Figure 2 shows a total of 1,475 TBTUs of energy used to generate electricity but Figure 6, infra, shows only 500.3 TBTUs of end-use electricity consumption. The difference, 972 TBTUs, represents energy lost from generation, transmission, and distribution.

The 2016 CEF Order does not include specific overall energy-efficiency goals, except for 2016, for which NYPSC ordered NYSERDA to achieve 13.4 TBTUs of savings.[38] To achieve the 600-TBTU savings mandate, the cumulative savings will have to increase by an average of 30% each year. As of this writing, there is no evidence that NYSERDA achieved the required savings in 2016.

Two other fundamental issues affect the energy savings mandate. First, measuring actual, realized savings is virtually impossible, absent direct metering of specific end uses. For example, the actual savings from replacing an incandescent lightbulb with a more efficient LED bulb depend on how many hours per day the bulb is in use. Similarly, the savings from replacing an air conditioner with a more efficient unit depend on how much it is actually used. Moreover, by reducing the cost of obtaining a specific energy-related service—heat, air conditioning, and so forth—the quantity of that service used by consumers can increase, a phenomenon known as a "rebound" or "takeback" effect. The phenomenon is similar to one observed when individuals purchase more fuel-efficient vehicles: as the cost of driving decreases, some individuals drive more.

Because measuring actual energy savings is impractical, estimates are drawn from engineering models. But such models rely on numerous assumptions, including how quickly energy-efficient technology is adopted as a function of subsidies and financing costs; how much energy will be saved based on specific characteristics of a household or business; the expected lifetimes of more efficient equipment (which may be quite different from actual lifetimes); and how consumers use energy. A NYSERDA report on energy efficiency and renewable generation potential used just this approach.[39]

A number of researchers have found that the cost-effectiveness of energy-efficiency investments is significantly overstated because realized energy savings are far lower than predicted savings. Moreover, the difference is far greater than simply accounting for rebound effects.[40]

A second fundamental issue is determining the cost-effectiveness of energy savings measures. Not only are physical energy savings based almost entirely on engineering estimates; the economic value of such savings is based on forecasts of equipment costs and avoided energy costs that are often inaccurate.

For example, the NYSERDA 2014 EE Study on energy efficiency and renewable energy potential in the state assumed a market price for electricity in the New York City load zone[41] of $341 per megawatt-hour (MWh) in 2017 (in 2012$) during peak summer hours.[42] That's equivalent to about $368/MWh (2017$).[43]

By comparison, the actual peak-hour prices for the New York City zone[44] for June–July 2017, which are published by NYISO, averaged less than $35/MWh,[45] less than 10% of the price level assumed in the NYSERDA study. Although futures prices change each trading day as new information becomes available, they are the best predictor of prices in the short run because they reflect traders' expectations based on market conditions and are thus a crucial component in estimating costs and benefits accurately. For 2030, the same NYSERDA report assumed an average annual wholesale electric price in New York City of about $275/MWh (2012$), equivalent to $297/MWh (2017$). By contrast, the 2016 NYDPS CES cost-benefit study assumed an average New York City zone price of $80/MWh in 2030, just over one-fourth of the average price that was assumed in the NYSERDA report.[46]

Not surprisingly, the cost-effectiveness of energy-efficiency measures will be skewed if estimated energy savings and avoided energy costs (i.e., the costs of energy not purchased) are both too high. For example, the NYSERDA 2014 EE Study estimated achievable electric energy-efficiency savings of just over 36 TWh (123 TBTUs), almost 2.5 times the electric savings projected by NYISO. The NYSERDA study also projected natural gas savings of 108 TBTUs and petroleum savings of 43 TBTUs through 2030. In all, the study projected total savings of 274 TBTUs. Thus, despite the study's high electric-price assumptions, its total estimated energy savings by 2030 are still less than half the goal of 600 TBTUs established by NYDPS in its 2016 order.

The gulf between the 600-TBTU energy-efficiency goal and the optimistic projections by NYSERDA, to say nothing of the still-lower forecast of electric savings recently projected by NYISO, calls into question the ability of New York to realize anything close to that goal, apart from the costs of doing so.

Is the 80 by 50 Mandate Technically Feasible?

In 1990, in-state electricity generation accounted for 27% of New York's GHG emissions, and imports accounted for another 0.7%, with combined GHG emissions of about 65 $MMtCO_2e$. Moreover, whereas in-state GHG emissions declined between 1990 and 2014, emissions attributed to imported electricity increased.

As discussed previously, based on NYSERDA emissions data, total GHG emissions by 2030 could be no more than about 142 $MMtCO_2e$ and no more than 47 $MMtCO_2e$ by 2050. By way of comparison, the required interim reduction in GHG emissions by 2030 is 30% greater than total electricity-related GHG emissions were in 1990, and more than double the total electricity-sector emissions in 2014. Thus, even if New York were to become 100% reliant on renewable generation,[47] the resulting decrease in GHG emissions would not come close to meeting the interim 40% GHG reduction mandate by 2030, much less the 80% reduction mandate in 2050. Thus, to meet the CES mandate, the majority of *all* end-use fossil-fuel energy consumption in all four sectors, including transportation, will need to be electrified.

Setting aside, momentarily, the physical feasibility of a 100% renewable generation portfolio—which will require installing thousands of additional megawatts of wind turbine and solar PV capacity and addressing the reliability issues caused by the inherent intermittency of those resources—the CES's GHG reduction mandates clearly will require reducing GHG emissions from other sectors, especially the transportation sector (**Figure 5**).[48]

Figure 5 provides a breakdown of the estimated 60.4 $MMTCO_2e$ of GHG emissions from the transportation sector in 1990, which accounted for 26% of the 213 $MMtCO_2e$ of all energy-related GHG emissions, and the estimated 74.01 $MMTCO_2e$ from the transportation sector in 2014, which accounted for 40% of the 186 $MMtCO_2e$ of all energy-related GHG emissions.

Even if *all* transportation—automobiles, trucks, trains, ships, and airplanes[49]—could be powered by electricity (reducing 2014 emissions by 74 $MMtCO_2e$), which is infeasible, given existing technology, and even if all the additional electricity needed to power this electrified transportation sector were generated from renewable resources, the resulting reduction in GHG emissions below 1990 levels would still leave energy-related GHG emissions at about 112 $MMtCO_2e$, 75 $MMtCO_2e$ greater than the 47 $MMtCO_2e$ target mandated by the CES.[50] That difference is greater than the combined 2014 emissions in the residential, commercial, and industrial sectors.

FIGURE 5.

New York State GHG Emissions, Transportation Sector

	1990		2014	
TRANSPORTATION SECTOR EMISSIONS	$MMtCO_2e$	Pct of Total	$MMtCO_2e$	Pct of Total
Motor Gasoline	50.62	83.8%	54.25	73.3%
Diesel	7.07	11.7%	7.06	9.5%
Jet Fuel	1.54	2.5%	8.32	11.2%
Residual Oil	0.65	1.1%	3.60	4.9%
Other	0.52	0.9%	0.78	1.1%
TOTAL	60.40	100.0%	74.01	100.0%

Source: NYSERDA 2017, Table 3-2

FIGURE 6.

New York State End-Use Energy Consumption by Sector, 1990 and 2014

NONELECTRIC ENERGY CONSUMPTION

	1990			2014			2005–2014
End-Use Sector	TBTUs	Pct of Total	Equivalent TWh	TBTUs	Pct of Total	Equivalent TWh	Pct. Change in Consumption
Residential	570.5	24.7%	167.2	644.2	28.5%	188.8	12.9%
Commercial	433.9	18.8%	127.2	399.4	17.7%	117.1	-8.0%
Industrial	246.5	10.7%	72.2	141.4	6.3%	41.4	-42.6%
Transportation	1,061.8	45.9%	311.2	1,073.0	47.5%	314.5	1.1%
TOTAL	2,312.7	100.0%	677.8	2,258.0	100.0%	661.8	-2.4%

ELECTRIC CONSUMPTION

End-Use Sector	TBTUs	Pct of Total	TWh	TBTUs	Pct of Total	TWh	Pct. Change in Consumption
Residential	138.6	30.5%	40.6	170.5	33.9%	50.0	23.0%
Commercial	217.0	47.8%	63.6	261.2	51.9%	76.6	20.4%
Industrial	88.9	19.6%	20.0	61.4	12.2%	18.0	-30.9%
Transportation	9.9	2.2%	2.9	9.7	1.9%	2.9	-2.0%
TOTAL	454.4	100.0%	133.2	502.8	100.0%	147.4	10.7%

Note: 1 TWh = 3.412×10^{12} BTUs
Source: NYSERDA 2014 Patterns and Trends, Oct. 2016, pp. 26, 30; NYSERDA, 1994 Patterns and Trends, p.9

Because complete electrification of the transportation sector is infeasible with existing technology, meeting the CES mandate will require not only reducing residential, commercial, and industrial sector emissions but also significant investments in new renewable generating capacity, both to replace existing fossil-fuel generation and to meet the increased demand for electricity associated with electrification of the four end-use energy sectors.

How Much More Electricity Would Be Needed to Meet the 80 by 50 Goal?

We can estimate the additional amounts that will be required to meet the CES mandate (**Figure 6**). In 1990, NYSERDA reported total nonelectric energy consumption in the residential, commercial, industrial, and transportation end-use energy sectors of 2,313 TBTUs,[51] equivalent to about 678 TWh of electricity. In 2014, total energy use was 2% lower, about 662 TWh. However, total energy use in the transportation sector increased by almost 13% during that 25-year period.

In 1990, total end-use electricity sales were 133 TWh. In 2014, total end-use sales were about 10% higher, at just over 147 TWh. NYISO forecasts total end-use electricity consumption in 2017 at about 159 TWh.[52] As was shown in Figure 3, the NYISO forecast includes 4.7 TWh of reduced electricity demand from energy efficiency, BTM solar PV, and other types of BTM distributed generation. NYISO forecasts that these sources will increase to 20.3 TWh by 2027, of which 12.5 TWh will be energy-efficiency savings and 5.3 TWh will be BTM solar PV. The net effect of the forecast increases in energy-efficiency savings and BTM solar PV generation means that NYISO forecasts net electricity consumption to remain relatively constant.

However, the NYISO forecast does not appear to include increased electricity consumption that will arise if there is significant electrification of existing nonelectric, end-use energy consumption (e.g., transportation, residential heating, and industrial process energy). But if the CES 80 by 50 goal is to be achieved, such electrification will have to take place.

For example, as shown in Figure 6, total nonelectric end-use energy consumption in 2014 was 2,258 TBTUs, equivalent to about 662 TWh of electricity, more than four times the state's total electricity generation of 160 TWh, including imports, in 2014.[53] Another 503 TBTUs was consumed as end-use electricity, for total end-use energy consumption of 2,761 TBTUs. Of that total, 1,073 TBTUs, or almost 40%, was used in the transportation sector alone, equivalent to 314.5 TWh of end-use electricity. Thus, in 2014, even excluding the additional generation needed to account for electrical

Electrification and the Economics of Battery Storage

One way of providing backup energy to address the intermittency of solar PV and wind generation is battery storage. For example, on Jan. 30, 2017, Southern California Edison began operating a 20-MW battery storage facility in Ontario, California. The facility, which was built by Tesla, is located on a 1.5-acre site and consists of 198 "closet-size" battery packs.[64] The batteries can provide up to 80 MWh of electricity each day. So each MW of battery capacity can provide 4 MWh of electricity each day, assuming full recharge. Although the cost of the project has not been disclosed, Bloomberg reports that a 2-MW facility installed by Tesla for Southern California Edison in 2016 cost $2.9 million, or $1.45 million/MW.[65] That facility can provide 8 MWh of electricity each day, assuming it is fully recharged. Storage is not 100% efficient, however, with losses of 10%–20%. In other words, to store 10 kWh of electricity requires generating 11–12 kWh. Those losses also depend on how a battery is cycled; maximum efficiency requires slow recharge and discharge.

Electrification would require over 300,000 MW of solar PV capacity, even assuming 600 TBTUs of energy efficiency, to meet an annual energy use of 633 TWh. (see p.15 infra) That's equivalent to average daily electricity consumption of 1.73 TWh, or 1,730,000 MWh.

For planning purposes, NYISO assumes an availability of solar PV during summer peak hours of 46%. That is, during the summer, NYISO expects that solar PV, on average, would be providing 46% of total capacity.[66] Thus, if 1,000 MW of solar PV were installed, NYISO assumes that an average of 460 MW of capacity would be available to meet peak demand. During the winter, solar PV availability is negligible, with a capacity availability of only 2%.[67] Thus, even with all that solar PV, significant quantities of backup generation or battery storage would be required.

On a cloudy winter day, we would expect no solar generation. Thus, suppose we assume that we install enough battery storage to meet just a half day's electricity consumption, or about 800,000 MWh of electricity. To do so would require installing 200,000 MW of battery capacity. At a price of $1.45 million/MW, installing 200,000 MW of battery storage would cost $290 billion. To have this quantity of battery storage by 2050 would require installing more than 6,000 MW of facilities, at a cost of $12.6 billion, each year. Even if the cost of battery storage were to decrease by 50%, the cost would still be more than $145 billion, or $6.3 billion per year. And, at 1.5 acres for a 20-MW facility, this would entail using 150,000 acres of land, or 234 square miles, an area 10 times larger than Manhattan.

Another comparison: the Tesla Powerwall home storage system can provide up to 14 kWh of electricity, or 0.014 MWh. Thus, providing 800,000 MWh would require more than 57 million Powerwall units. According to U.S. census data, in 2015 there were 8.2 million housing units (including apartments) in the state. In other words, 800,000 MWh of storage would require each housing unit in the state to have the equivalent storage of seven Powerwall units.

What about relying on electric vehicles for backup generation? The latest Tesla battery pack provides 100 kWh of electricity, or 0.1 MWh, which Tesla CEO Elon Musk has stated is close to the theoretical limit for energy density with its current battery-pack design.[68] To provide 800,000 MWh of storage on that cloudy winter day would therefore require 8 million electric vehicles in New York State, all of which would have to be fully charged and none of which could be driven that day.

losses that occur when electricity is transmitted over power lines, as well as backup capacity to compensate for wind and solar PV intermittency, electrifying the transportation sector with renewable resources would require a doubling of total electric generation.

Consider also nonelectric residential, commercial, and industrial end-use energy consumption. In 2014, that consumption totaled 1,185 TBTUs, equivalent to 347 TWh of end-use electricity. Converting just half that energy consumption to electricity from renewable generation would require an additional 178 TWh of electricity—again, more than the total amount of electric generation in 2014.

To replace all 2,760 TBTUs of end-use energy consumption in 2014 would require 809 TWh of electricity. Even if the CES energy-efficiency mandate reduced that amount by 600 TBTUs, to 2,160 TBTUs (which, as discussed previously, does not appear technically or economically feasible), New York would still need the equivalent of more than 625 TWh of electricity,[54] before accounting for transmission and distribution losses and the need for backup generation and storage. To meet the 80 by 50 goal, that 2,160 TBTUs of end-use energy would have to be provided, while emitting less than 47 $MMtCO_2e$ GHG emissions per year, equivalent to an average emissions rate of 43 pounds per million BTUs (pounds/MMBTUs).

By way of comparison, natural gas emits about 117 pounds of CO_2/MMBTUs. Thus, to meet the 43 pounds/MMBTU emission average and assuming that all end uses were electrified, the generating mix would have to be about 63% renewables and 37% natural gas, assuming that no other higher CO_2-emitting fossil generation, e.g., coal, was used.[55] That means that by 2050, there would need to be sufficient renewable generation to provide 1,420 TBTUs of end-use energy, equivalent to about 400 TWh of electricity.

We can estimate how much renewable generation would be required to produce 400 TWh of electricity from wind or solar energy resources. For example, solar PV has an average annual capacity factor of about 15% in New York State, meaning that solar PV will generate electricity during 15% of the 8,760 hours in a year.[56] Thus, 1 MW of solar PV would not generate 8,760 MWh of electricity over the course of a year but instead would generate 15% of that amount on average, or 1,314 MWh. If we ignore the additional reserves and/or storage capacity that would be needed to address solar PV's inherent intermittency and unavailability at night, and if we further ignore all transmission and distribution (T&D) system energy losses, generating 400 TWh of electricity would still require installing more than 304,000 MW of solar PV capacity.[57]

A similar calculation can be performed for onshore and offshore wind energy. Offshore wind has a projected capacity factor of 47%. Thus, again ignoring intermittency and storage issues, almost 100,000 MW of offshore wind capacity would need to be installed to generate 400 TWh of electricity. Existing onshore wind in New York has a capacity factor of about 26%.[58] If new wind installations are more efficient and have a capacity factor of 30%, generating 400 TWh of electricity will require 150,000 MW of wind capacity.

Suppose, instead, that the CEF energy-efficiency savings through 2050 are only 300 TBTUs—half the 600 TBTUs mandate but more than the 274 TBTUs estimated in the NYSERDA 2014 EE Study, using optimistic assumptions. In that case, renewable generation would have to provide about an additional 90 TWh of electricity, or 490 TWh in total. This would require more than 370,000 MW of solar PV capacity, or 110,000 MW of offshore wind capacity, or over 150,000 MW of onshore wind capacity.

If New York were to meet the 80 by 50 mandate solely with new solar PV, the state would need to install 9,000–11,000 MW of solar capacity each year. By comparison, according to data published by the U.S. Energy Information Administration (EIA), about 11,270 MW of new solar PV (both small-scale and utility-scale) was installed in the entire U.S. in 2016.[59] Similarly, New York's first offshore wind plant, a 90-MW facility located off Montauk, Long Island, is not scheduled to be online until 2022. Meeting the CES thus would require installing over 3,000 MW of offshore wind capacity *each year* through 2050, or 4,500 MW of onshore wind each year. By comparison, in 2016, a total of 8,200 MW of onshore wind generation was installed in the entire country.

Installing this much wind or solar capacity also would require vast areas. The energy density of utility-scale solar PV (which typically means installations with an installed capacity of 1 MW or more) is about 8 acres/MW, depending on the size of the facility.[60] Based on this land-use value, meeting the CES mandate with in-state, utility-scale solar PV would require covering an area of between 2.4 million and 3.0 million acres with solar panels, equivalent to between about 3,800 and 4,600 square miles. By comparison, Manhattan is 22 square miles. Therefore, at a minimum, the footprint for solar energy needed to meet the CES would be roughly equal to 172 Manhattan islands. Even if solar PV became more efficient and required only 7 acres/MW, the total required land area would still be between 2.1 million and 2.6 million acres, equivalent to between 3,300 and 4,000 square miles.

We can similarly examine the land-use requirements for wind generation. According to the U.S. Department of Energy (DOE), the energy density—that is, the project footprint for both onshore and offshore wind projects—is about 3 watts per square meter.[61] A bit of math shows that this means 1,000 MW of wind capacity would require about 131 square miles of land.[62] Thus, installing 150,000 MW of onshore wind would require almost 20,000 square miles of land, or 12.8 million acres.

According to the NYDPS Final Environmental Impact Statement (EIS) for the CES, a total of 1.3 million acres—or 2,031 square miles—is suitable for wind power development in the entire state, nearly all of it located in New York's western and northern sections.[63] Even if all 2,031 square miles could be used, it would support only one-tenth of the required wind capacity, and that's without accounting for reserve or storage capacity needed to address wind intermittency.

Moreover, because there is increasing local opposition to siting onshore wind facilities upstate, the prospect of installing thousands of new onshore wind turbines seems unrealistic at present.[69] Additionally, because most of this wind capacity would be located far from southeastern New York, where electricity demand is highest, and because of existing west-to-east and north-to-south transmission constraints,[70] billions of dollars of additional costs would be incurred to build transmission capacity to deliver all that wind-generated electricity.

The Deepwater Wind South Fork Project, to be built off Montauk, Long Island, which is slated to go online in 2022, is expected to have a 47% capacity factor. Based on that capacity factor, fulfilling the CES mandate would require about 97,200 MW of offshore wind capacity, if the CEF energy-efficiency rule is met,[71] and about 110,300 MW of capacity, if only 300 TBTUs of energy-efficiency savings were realized. Again, these values exclude all reserve generating capacity and T&D losses.

As for the area required for offshore wind development, the DOE data put the total at between 12,700 and 14,400 square miles. By comparison, Long Island Sound is 1,200 square miles.[72]

If, as is more realistic, not all end uses can be electrified (e.g., jet aircraft and large ships), the amount of renewable generating capacity needed to meet the 80 by 50 goal would increase. For example, suppose fossil-fuel energy use in the transportation sector was reduced by half. This could happen by replacing gasoline-powered vehicles with battery-electric ones until transportation-related GHG emissions were reduced to the 46 $MMtCO_2e$ of allowed GHGs under the CES, a decrease of 28 $MMtCO_2e$ from 2014 emissions. In that case, another 652 TWh of electricity would be needed as the replacement. Assuming that the 600 TBTUs of energy-efficiency savings would reduce that amount by 176 TWh, the remaining 476 TWh would have to be provided solely from renewable generation.

In that case, the equivalent capacity for solar and offshore wind would be 354,900 MW of solar PV. If energy-efficiency gains were 300 TBTUs, the amount of solar PV capacity would be 420,500 MW. For offshore wind, the needed capacity would be 115,600–137,000 MW.

Even if such extensive electrification of the New York economy is technologically feasible, staggering amounts of new renewable generating capacity will be needed to meet the 80 by 50 mandate. Also needed: significant investment in new T&D infrastructure to deliver the additional electricity and huge investments in backup generation and energy storage. Even accounting for current trends of improved technology, the costs would be prohibitive.

Beyond illustrating the additional quantities of renewable generation required to electrify the New York economy and meet the CES mandate, this approach reveals a fundamental flaw in the CES cost-benefit analysis prepared by NYDPS in 2016: it did not address the additional costs associated with meeting the increased demand for electricity that must take place, even after efficiency gains, from the required electrification.[73]

Summary: The CES Numbers Do Not Add Up

Even before considering the projected costs and benefits of the CES, the numbers do not add up. Although New York State agencies have prepared several cost-benefit studies of the CES and related energy policies, the link between the findings in those studies and the CES mandate is tenuous. Instead, the 80 by 50 GHG reduction mandate appears to have been adopted simply because other states, including all those in New England, adopted similar mandates.

As was shown in **Figure 1**, meeting the CES GHG reduction goal by 2050 will require reducing GHG emissions to 47 $MMtCO_2e$, a decrease of 140 $MMtCO_2e$ below 2014 levels. Even if the energy-efficiency mandate succeeds in reducing building use by 600 TBTUs by 2030, state end-use energy consumption would still exceed 1,600 TBTUs, equivalent to almost 470 TWh of electricity, more than three times total electricity consumption in 2014. The vast majority of that consumption will need to be electrified and supplied solely by renewable generation.

Where will all that renewable energy come from? New hydroelectric development in the state is unlikely. The NYDPS cost-benefit study assumes that 600 MW of new hydroelectric generating capacity, producing less than 3 TWh per year, can be developed by 2030, based on upgrades of existing hydroelectric plants and building generating facilities at existing storage dams.[74] Whether environmentalists will oppose such development is an open question.

Similarly, for biomass generation, NYDPS projects the development of an additional 189 MW by 2030, generating just 1.3 TWh of electricity per year, because the available supply of wood to fuel such plants is limited.[75]

Increased imports of renewable electricity is another option. But if other nearby states and Canada electrify their economies to meet similar GHG reduction goals, and thus require developing far more of their own renewable generation, New York may be unable to secure significant new quantities of imports over the long run. Moreover, increasing imports requires building new high-voltage transmission lines. For example, the recently approved Champlain-Hudson line, which is scheduled to enter service in 2021, will transmit up to 1,000 MW of electricity from Hydro-Quebec. The cost of the line is estimated to be $2.3 billion. The electricity it will deliver is less than 8 TWh per year.[76]

The NYDPS 2016 analysis predicts 33 TWh of additional renewable generation, the approximate amount needed to meet the interim goal of 50% renewable generation. Of that amount, NYDPS assumes that almost half, 15 TWh, will come from almost 4,500 MW of new onshore wind, with another 9 TWh from BTM and utility-scale solar PV.

Thus, to meet the interim 50% renewable goal, far more solar PV and wind will have to be built. That, however, will result in far higher costs, as both solar PV and offshore wind generation are more costly than onshore wind.

Even updating the NYDPS estimates to include the governor's mandate for 2,400 MW of offshore wind capacity by 2030, total renewable generation would be less than 40 TWh. By comparison, the Indian Point Nuclear Facility, located 44 miles north of New York City, produces an average of 16 TWh of electricity each year. (Under an agreement reached with the governor, Entergy Corporation will be closing the plant by 2021.)[77]

Furthermore, achieving the governor's mandate for installing 2,400 MW of offshore wind capacity by 2030 seems unlikely, given that the Deepwater Wind South Fork Project is not to be online until 2022.[78]

Despite the magnitude of the required increases in renewable generating capacity to achieve even the interim goal of 50% renewable generation, the need to expand reserve capacity is not taken into account. As noted above, because wind and solar generation are intermittent, i.e., they cannot be scheduled to run like fossil-fuel and nuclear generating plants, large increases in reserve generating capacity will be needed to meet reliability standards. The New York State Reliability Council, an electric service industry group, has estimated that onshore wind will be available in only 14% of summer peak-demand hours,[79] while solar PV will be available in 45% of those hours.[80] Thus, 1,000 MW of onshore wind generation would be expected to provide only 140 MW of capacity during peak demand hours, such as an August afternoon, while 1,000 MW of solar PV would be expected to provide just 450 MW.

To compensate for this lack of availability, far more capacity, known as the installed reserve margin (IRM), will need to be built. For example, to obtain 1,000 MW of capacity from onshore wind generation during peak demand hours, an additional 860 MW would be required. Similarly, 1,000 MW of solar PV would require an additional 550 MW of solar capacity. In contrast, NYISO's overall IRM is currently 17.5%. Thus, for every 1,000 MW of generation, an additional 175 MW is required to ensure that there is sufficient capacity to meet peak demand. To meet the 50% renewable generation goal by 2030, NYISO estimated that the IRM would need to increase 40%–45%.[81] That increase will, not surprisingly, entail additional costs that will be paid by New York consumers and businesses.

Besides more than doubling the IRM, NYISO will need to increase operating reserves and frequency regulation to ensure that sudden fluctuations in wind and solar output do not cause systemwide blackouts, such as the one that took place on Sept. 28, 2016, in South Australia.[82] Operating reserves refers to generation that is on "standby" and can be brought online within a matter of minutes.[83] Frequency regulation is achieved by adjusting the output of certain generators up or down to ensure that electricity demand and supply balance at all times. Without sufficient regulation capacity, especially to compensate for sudden changes in wind and solar output, voltage and frequency levels can fluctuate to the point where an entire generating system collapses. That is what occurred in South Australia.

As was shown in Figure 1, to meet the 40% interim GHG reduction goal in 2030, New York will need to decrease GHG emissions by an additional 76 $MMtCO_2e$ below 2014 emissions. By comparison, between 1990 and 2014, energy-related GHG emissions decreased by 26 $MMtCO_2e$, about equal to total reductions associated with instate electric and imports. Total electric sector emissions in 2014 can account for just over half of the total *reduction* that will be required to meet the interim goal. Thus, meeting that goal will require significant reductions in other end-use energy sectors, especially transportation.

Given the announced shutdown of the Indian Point Nuclear Facility by 2021—and its likely replacement with a mixture of gas-fired generation and imported electricity—the observed rate of decrease in GHG emissions from electric generation is unlikely to continue, which means that a much greater proportion of future GHG reductions will have to come from the end-use sectors, especially the transportation sector. Again, this will require massive electrification of existing fossil-fuel consumption, which will increase electricity demand and require huge increases in both in-state and imported renewable generation.

Of course, predicting long-term changes in technology is a fool's errand. New, low-cost technologies for battery storage and fuel cells, as well as yet-to-be-discovered technologies, may be developed over the next 30 years and allow the CES's mandates to be achieved with ease. Then again, the history of the electric industry is replete with unfulfilled promises of low-cost, emissions-free resources, from nuclear power to room-temperature fuel cells that use water as their fuel. But given today's technology, meeting the 80 by 50 mandate appears to be technologically impossible, regardless of cost. As for the benefits of achieving the 80 by 50 mandate, that is the subject of the remainder of this report.

II. An Introduction to Cost-Benefit Analysis Concepts

Setting aside the technical feasibility of meeting the CES goals, and before evaluating the costs and benefits of the CES, it is useful to provide a brief introduction to some key concepts that underlie cost-benefit analysis.[84] These concepts provide an economically valid framework with which to evaluate the costs and benefits of the CES and, using that framework, an understanding of the fundamental flaws of the cost-benefit studies of clean energy programs prepared by New York agencies.

What Cost-Benefit Analysis Measures and Why It Matters

In effect, cost-benefit analysis compares the world as it is with the world under a proposed policy.[85] In making such comparisons, the goal is to evaluate changes in the overall economic values of market goods and services (e.g., electricity) and nonmarket goods (e.g., human health, habitat loss, reductions in GHG emissions, species diversity).[86]

The fundamental reason underlying the importance of evaluating the benefits and costs of proposed policies is scarcity; money spent on reducing GHG emissions is money not available to spend on repairing bridges and highways, improving water quality, and so forth—a concept that economists call "opportunity cost." By comparing the world under alternative policies, cost-benefit analysis can aid decision making. Even if a specific policy goal is determined, such as reducing GHG emissions, a variant of cost-benefit analysis called "cost-effectiveness analysis" can help identify the least costly ways of achieving the goal.

It's also important to evaluate how benefits and costs are allocated. For example, policies that benefit the wealthy at the expense of the poor may be viewed as inequitable, regardless of whether the benefits exceed the costs. Often, policies that purport to provide benefits are really just wealth transfers between groups: robbing Peter to pay Paul benefits Paul; but society, to say nothing of Peter, is unlikely to be better off.

Typically, measuring economic value is based on a buyer's willingness to pay (WTP) and a seller's willingness to accept (WTA). WTP is the amount that a buyer who does not currently possess a good or service would be willing to pay to obtain it. WTA is the amount that a seller who has the good or service would be willing to take in payment to give it up. These are typically measured by what economists call "consumer's surplus" (CS) and "producer's surplus" (PS). For example, if an individual consumer was willing to pay $10 for a good, but the market price was $4, the individual's CS would be $6 ($10 minus $4). Similarly, if an individual producer would be willing to sell that good for $3, that producer's PS would be $1 ($4 minus $3).

The overall value of the market for a good or service, then, is the sum of CS and PS. And that is why, when performing a cost-benefit analysis for a policy, the objective is to measure how a producer's and a consumer's surplus *change* as a result of that policy.

For example, a new cost-reducing technology will benefit consumers by lowering market prices. However, in doing so, part of the increased benefit to consumers is transferred from existing producers, who can no longer charge the previous market price. As discussed below, identifying transfers from producers to consumers is particularly important because they are frequently mistaken for benefits.

Taxes, Subsidies, and Wealth Transfers

As I discuss in Section III, the transfer of wealth is especially relevant to evaluations of the benefits and costs of the CES and other policies that subsidize energy resources.

One of the most common arguments made for subsidizing wind and solar energy, which has been made by New York policymakers, is that there are economic "benefits" from wholesale market price "suppression." The argument is that by subsidizing wind and solar energy, electricity supplies increase, causing market prices to decrease—hence the term "price suppression." Estimates of price suppression were included in the NYDPS cost-benefit analysis of the CES and have been included in other state analyses, such as evaluations of the benefits of solar PV subsidies.[87]

In contrast to technological improvements that lower market prices, the price suppression caused by subsidizing suppliers is both artificial and temporary. In fact, when price suppression results from subsidies, such as subsidies for wind and solar energy, not only is there no economic benefit; there is a net economic cost.

Because they use no fuel and have virtually no variable operations and maintenance (O&M) costs, subsidized wind and solar generators will offer electricity to the market at a zero cost. As such, they simply displace existing, unsubsidized suppliers.[88] Moreover, it turns out that the net cost to producers is greater than the net benefit to consumers. Thus, from a societal standpoint, price suppression has a net cost.

The subsidy thus causes a transfer of wealth from producers to consumers—and from a societal perspective, it is not a benefit at all. For example, in its 2013 report on the benefits and costs of the state's RPS standard, NYSERDA estimated $455 million of wholesale price suppression impacts, which is labeled a benefit.[89] But the gains to consumers are more than offset by the cost of the subsidy itself, which consumers (or taxpayers) must pay.[90]

Because this artificial price suppression forces out existing, unsubsidized competitors that were previously on the margin, the benefits are temporary. In other words, by driving out existing suppliers, supply shrinks over time and market prices increase. Moreover, subsidies will discourage new entry by unsubsidized generators that might otherwise enter the market.

Furthermore, although renewable generation subsidies can suppress wholesale electric market prices, at least in the short run, that does not mean that New York consumers will pay less for electricity. The reason is that the subsidies paid to renewable generators arise, in part, from their selling renewable energy credits. New York requires local electric utilities and competitive retail electric suppliers to purchase RECs to meet the renewable portfolio mandate. For example, the owner of a 100-MW wind farm "generates" RECs based on the output of the wind turbines, which are then sold to local utilities and other competitive electric suppliers that must have a minimum quantity of RECs to meet the renewable mandate. The costs of those RECs are incorporated into the retail price of electricity paid by customers. Thus, RECs act like a tax on retail electric suppliers. And, in fact, the primary cost identified by NYSERDA in its 2013 study of the state's renewable portfolio mandates—and by NYDPS in its 2016 study of the CES—is higher electricity costs paid by retail ratepayers.

Investment, Jobs, and Economic Growth

The other major type of transfer payment relates to impacts on the economy. One of the most commonly claimed "benefits" of green energy programs is greater investment in the economy and job creation. New York has highlighted such claims in extolling the benefits of the CES. For example, NYSERDA states: "By focusing on low carbon energy sources, the CES will bring investment, economic development, and jobs to New York State."[91]

Claims of economic benefits arising from new investment and job creation are erroneous. Using subsidies to increase investment in low carbon energy sources and to create jobs is simply a transfer of wealth from electricity consumers and unsubsidized electricity generators to renewable energy and energy-efficiency providers.

Yet, despite the fact that using subsidies to create jobs is an obvious transfer of wealth, many studies have simply ignored this. For example, a 2009 report published by the College of Natural Resources at the University of California at Berkeley recommended a comprehensive policy of aggressive energy-efficiency improvements and renewable generation, estimating that such policies would create between 900,000 and 1.9 million new jobs and would increase household income between about $500 and $1,200 per year.[92] In fact, the report concluded, "the stronger the federal climate policy, the greater the economic reward."[93]

This is a stunning example of "free-lunch" economics. The study notes that from 1972 to 2006, energy-efficiency programs in California "created 1.5 million additional jobs."[94] However, the authors failed to provide the most important component of such an assertion: Compared with what? The study never considered the impacts on businesses and households from higher electricity prices and taxes to fund those energy-efficiency programs.

Another study, released in February 2010 by Navigant Consulting, examined the economic impacts of adopting a mandatory national renewable portfolio standard of 25% of total generation by 2025. It was prepared for the RES Alliance for Jobs, a group whose members primarily include renewable generation manufacturers.[95] The report concluded that such a standard "will lead to job growth in all states, especially those currently without state-level renewable electricity standards" and that it will produce 274,000 new jobs in the renewables industry.[96]

Similarly, a September 2010 report issued by the National Renewable Energy Laboratory (NREL) concluded that building 54,000 MW of offshore wind generation would "revitalize our domestic manufacturing sector and create high-paying, stable jobs while increasing the nation's competitiveness in 21st-century energy technologies," adding that it would "create approximately 20.7 direct jobs per annual megawatt in the United States, or over one million jobs."[97]

More recently, a 2016 report suggested that New York's clean energy programs employed more than 85,000 people and that the aggressive clean energy policies being pursued in the state would bolster the economy.[98] And, in announcing the initiative to develop 2,400 MW of offshore wind in his 2017 State of the State address, Governor Cuomo claimed that it would "spur new investments in infrastructure and manufacturing, creating high-quality jobs across the state."[99] Or, as NYPSC stated in its order implementing the CES, "New York State is fortunate to have substantial potential for offshore wind production and with appropriate time, careful planning, and deliberate action, the State has the opportunity to exploit its geographic advantage to develop offshore wind and promote the beneficial attendant economic activity associated with this burgeoning industry."[100]

The fundamental flaw underlying such claims of economic benefits is that they assume that renewable energy subsidies are paid for by someone else, when the reality is that those subsidies are paid for by ratepayers and taxpayers themselves. This is why treating economic impacts of subsidized renewable generation, or subsidies of any sort, as a benefit is incorrect. Moreover, as discussed later in this report, empirical evidence for claims of benefits from subsidizing new technologies, such as by "leveling the playing field" and accelerating technological change, is scant.

When businesses and consumers pay more for electricity, they have less money to spend on everything else. Consumers have less money to spend on other goods and services; businesses have less money for investments that increase economic output. Goods and services whose production requires electricity also increase in cost, leaving less money to spend on goods and services, which cost more to produce. Thus, subsidizing electric generation—of any kind—effectively imposes two separate taxes on businesses and consumers: the first is a direct tax associated with higher electric bills; the second is an indirect tax in the form of higher costs for purchased goods and services that require electricity as an input.[101]

Measuring the Costs and Benefits of Nonmarket Goods

The primary rationale for the CES is to address global climate change. Thus, much is made of the projected monetary benefits of reductions in GHG emissions, as well as air pollution. But because GHGs and air pollution are not "market" goods—although the U.S. has a system for trading sulfur dioxide (SO_2) and oxides of nitrogen (NO_x) emissions, and New York participates in the Regional Greenhouse Gas Initiative (RGGI)—valuation of emissions reduction benefits must be done indirectly.[102] Similarly, the potential environmental costs of the CES (e.g., visual impairment from wind turbines, damages to fisheries associated with construction of offshore wind facilities, loss of migratory birds and bats from wind turbine collisions) must be valued indirectly. In other words, because none of us can venture to the local hardware store and purchase "cleaner air" or "reduced species loss," the values of such nonmarket goods cannot be estimated based on changes in market prices and quantities.

Economists have developed a variety of techniques to address these nonmarket costs. For example, visual impairment can be measured based on observed reductions in property values near wind turbines, compared with similar properties not so impaired.[103] Commercial damage to fisheries can be estimated by the loss of income, while valuation of species losses can be measured based on survey data and the willingness of individuals to pay for species preservation.

Although the claimed benefits of the CES focus on the value of reductions in GHG emissions and the value of reduced air pollution (in the form of reduced health impacts), little or no attention has been given to estimating the nonmarket costs. For example, in a 2016 NYPSC order establishing the analytical framework to use to estimate the costs and benefits of Governor Cuomo's Reforming the Energy Vision (REV) program,[104] which the CES has effectively supplanted, there is no discussion whatsoever of potential nonmarket costs.[105]

Critics of nonmarket valuation techniques can, and do, argue that placing monetary values on clean air and water, species habitats, and so forth is imperfect, or even immoral. Imperfect though such values are, as are all estimates based on models, economics is about using scarce resources to select among alternatives. Unless there are compelling moral or legal prohibitions against using monetary estimates of costs and benefits, such estimates provide the most reasonable way of selecting among different policy options.

Measuring Benefits and Costs over Time—Why the Discount Rate Matters

When benefits and costs accrue over time, there must be a way to evaluate them on an equivalent basis. The standard approach for doing so is to estimate the equivalent costs and benefits occurring in the future and convert them into present-day dollars. This enables costs and benefits to be compared on an equivalent basis.

Doing so, however, first requires selecting an appropriate discount rate. The discount rate represents the time value of money. For example, individuals will prefer receiving $1,000 today rather than 10 years from now—in other words, they value $1,000 today more than $1,000 10 years from now. How *much* more depends on their discount rates. The greater an individual's discount rate, the lower he will value a future payment relative to a payment today.

The choice of discount rate can affect the relative values of benefits and costs. For example, comparing the benefits and costs of a policy that requires an investment today, in exchange for benefits decades from now, depends on how those future benefits are discounted. The higher the discount rate, the lower the present value of those benefits, and the less likely the benefits of the policy will exceed its costs.[106]

From the standpoint of investments today that provide returns in the future, discounting is a matter of overall economic efficiency and the opportunity cost of capital (i.e., investments today that provide a return on capital). For example, a business contemplating investing in a new machine today will do so if the expected returns provided by that machine are greater than other alternative investments.

In the context of clean energy policy recommendations, especially long-term issues like climate change, economic-efficiency arguments about the opportunity cost of capital become enmeshed in arguments about intergenerational equity and fairness, as well as how averse to risk society ought to be.

There is a huge literature on the appropriate discount rate to use when evaluating potential societal investments, as well as the appropriate rate to use when evaluating policies that address climate change.[107] Some argue that it is unethical to discount the welfare of future generations relative to the current generation's welfare, and thus the appropriate discount rate is zero.[108]

From an economic-efficiency standpoint, the appropriate discount rate with which to evaluate societal clean energy programs such as the CES is the social opportunity cost of capital (SOC). The SOC can be thought of as a weighted average return on capital investment from all sources of capital.[109] When capital is invested in a specific societal project (such as subsidized renewable generation), it is unavailable to be invested elsewhere, whether in other societal projects (water treatment facilities, education, etc.) or private projects.

Suppose a project designed to reduce CO_2 emissions will cost $100 million to construct this year. The project has an expected life of 50 years. Suppose the emission reduction benefits are estimated to be $3 million per year. If the project benefits are discounted at a 3% rate that reflects the SOC, then the project's net present value will be –$22 million. That is, the project's costs will exceed its benefits. But if the benefits are not discounted at all, owing to concerns about intergenerational equity, then the present value benefits are +$50 million. This simple example shows that the choice of discount rate can determine whether a project's present value benefits exceed its costs, or vice versa.

III. Evaluating the Benefits and Costs of New York's Clean Energy Programs

Developing an overall framework to evaluate the costs and benefits of the CES and the CEF is complicated by the need to predict how the future would evolve without those programs. For example, if there were no mandate to increase renewable generation to 50% of total generation by 2050, what would the percentage of renewable generation be? Would there be additional development of wind, solar PV, biomass, and so forth, if not for the mandate? Could technological changes, such as low-cost battery storage, room-temperature fuel cells, and new technologies that may not even exist today, lead to an 80 by 50 future regardless of the CES?

The simple answer is that nobody knows—just as 50 years ago, few would have predicted the existence of smartphones and the Internet, much less our reliance on them. Even the fictional *Star Trek* communicators of the 22nd century, for example, were basically high-powered walkie-talkies. Although generating technology clearly has not advanced at anywhere near the rate of telecommunications technology, that does not mean that new, low-cost, and emissions-free generation technologies will not be developed in the next few decades.

FIGURE 7.

Cataloging CES Benefits and Costs

COSTS	BENEFITS
Direct Market Costs	**Direct Market Benefits**
• Additional generating costs of electricity (substitution of higher-cost renewable generation for lower-cost fossil generation, especially natural gas–fired generation) • Additional costs of electric end-use technologies to replace existing fossil-fuel technologies (e.g., electric vehicles, electric furnaces) • Additional reserve generating capacity to address intermittency of wind/solar resources and meet peak electric demand • Additional ancillary services costs (spinning and non-spinning reserves, voltage and frequency regulation, etc.) to meet system reliability standards • Additional transmission system infrastructure needed to import renewable resources from upstate or from out of state • Additional transmission system losses from increased renewable generation • Additional administrative costs of energy-efficiency programs, electric vehicle programs, etc.	• Reduced transmission system infrastructure needed to import renewable resources from upstate or from out of state because of local BTM (behind the meter) solar PV • Reduced distribution system investment because of BTM solar PV • Reduced transmission system losses from siting BTM solar PV and local siting of utility-scale solar PV • Reduced spending on end-use fossil-fuel technologies (gasoline- and diesel-powered vehicles, oil furnaces for heating, etc.)
Indirect and Nonmarket Costs	**Indirect and Nonmarket Benefits**
• Reduced value of agricultural land due to wind and solar facilities siting, loss of agricultural production • Reduced values for properties due to adverse impacts on views • Adverse human health impacts from onshore wind generators (e.g., low-frequency noise) • Adverse impacts on raptors and bats, including species endangerment, from deaths caused by onshore wind turbines • Economic losses to commercial fisheries from habitat destruction, inability to use existing fishing techniques (e.g., trawling) • Losses due to habitat destruction of offshore areas where wind facilities are constructed/operated • Adverse human health impacts from reduced indoor air quality due to "tightening" of indoor areas • Cost associated with reduced power system reliability if reliability standards are not met	• Reductions in air pollution (e.g., SO_2, NO_X, mercury, and particulates) that harm human health • Reductions in water pollution (e.g., accidents that dump fuel into waterways) • Reductions in GHG emissions • Increased fuel diversity (e.g., reduced reliance on natural gas)

Source: Author analysis

Instead, any cost-benefit analysis of policies such as the CES must be based solely on the generation and energy-efficiency technologies that exist today, including their observed cost trends. This is similar to the frameworks developed by NYSERDA and NYDPS. In effect, these agencies' cost-benefit analyses compared two alternative futures: (i) a business-as-usual future, based on existing programs and projected costs of generating technologies; and (ii) the mandates of the CES and CEF, which require investment in more costly renewable resources and additional investment in energy efficiency that would not otherwise occur.

In a 2015 white paper associated with the REV program, the NYDPS proposed a comprehensive cost-benefit analysis framework.[110] That framework included reductions in direct costs, including reduced electric losses associated with locally sited renewable generation, avoided T&D infrastructure investments, reduced ancillary services costs (operating reserves, frequency, and voltage regulation, etc.), and reductions in outage and system restoration costs. The framework also included nonmarket benefits associated with reductions in CO_2 emissions and air pollution, as well as avoided land and water impacts.[111]

On the cost side, NYDPS included additional program administrative expenses, such as rebates for energy-efficiency measures; additional ancillary service costs; additional T&D infrastructure investment; and some non-energy-related costs (e.g., noise and reductions in indoor air quality from increased "tightening" of buildings).

But NYDPS ignored most other nonmarket costs associated with renewable generation. For example, it failed to consider the need for increased reserve-generating capacity to ensure sufficient capacity to meet electricity demand during peak hours, as discussed in Section I. It also failed to assign any monetary values to adverse health and visual impacts, species loss (including raptors and bats), and loss of agricultural land and productivity associated with onshore wind generation.[112] Similarly, NYDPS ignored the potential environmental impacts of wind development off the coast of Long Island on fisheries from construction and operation on the sea floor, as well as interference with weather and national defense radar.[113]

One item of note is that the NYDPS framework includes items, such as ancillary services and T&D infrastructure investment, that appear as both benefits and costs. The reason is that different investment alternatives can affect both costs and benefits. For example, the NY-Sun program, which was announced by Governor Cuomo in 2012, established a goal of an additional 3,000 MW of BTM solar PV by 2023, much of which would be located in southeast New York.[114] Although building BTM solar PV could avoid adding new transmission lines from upstate into the southeast region, it could also require additional investment in local distribution systems. Moreover, reliability issues constrain the quantity of BTM solar PV that can be installed along any distribution circuit. A study by NREL noted that typical guidelines limit BTM solar quantities up to 15% of a circuit's peak capacity in order not to jeopardize reliability. According to that study, that amount could double to 30%, depending on where solar PV is located along a circuit.[115]

Figure 7 summarizes the costs and benefits that might reasonably be included in an analysis of the CES. Direct costs include: additional expenses of installing and operating new renewable generating capacity rather than lower-cost generation; costs of new T&D infrastructure to deliver power to demand centers, especially southeast New York (e.g., the $2 billion Champlain-Hudson high-voltage transmission line that will extend from the Canadian border to the lower Hudson Valley); costs of meeting higher reserve capacity requirements owing to wind and solar intermittency; costs of replacing existing fossil-fuel-consuming technologies with electric technologies in the residential, commercial, industrial, and, especially, transportation sectors (e.g., with electric vehicles); and the additional costs of installing new renewable generation technologies to meet the CES mandates.

Some of these costs and benefits can be estimated directly. Indeed, several studies have done so for specific aspects, such as a 2016 NYISO study on the costs of integrating up to 9,000 MW of solar PV with the bulk-power electric system.[116] However, large increases in the demand for wind and solar generating capacity may affect the prices of that capacity and increase the costs of labor to build and maintain that capacity.

Similarly, NYISO prices ancillary services, such as spinning and non-spinning reserve and regulation service. (Spinning reserves can be brought online within five minutes; non-spinning reserves generally take 30 minutes to go online.) Whether the CES results in a net increase or decrease in the need for ancillary services to maintain electric system reliability will depend, in part, on where new renewable generating resources are installed and how those resources interact with the overall T&D system. Moreover, it will depend on the mix of other generating resources over time. Thus, the additional costs associated with the anticipated closure in 2021 of the Indian Point Nuclear Facility will depend on the actual resources that replace Indian Point's output and the costs of additional investments in energy efficiency to reduce electricity demand.

Additional administrative costs associated with specific state-run programs can be estimated as well. As noted, the recently announced Drive Green electric vehicle subsidy program includes $15 million for advertisements and other program expenses.

It is also possible to estimate some indirect market costs, such as the lost value of agricultural production from siting of onshore wind and utility-scale solar capacity, as well as reduced property values of homes near such facilities. Similarly, offshore wind may severely damage the fisheries habitat and, thus, impose economic losses on commercial fisheries. Nonmarket costs, such as species loss associated with wind turbines killing birds and bats, as well as adverse health impacts associated with human exposure to wind turbines' low-frequency noise, are more difficult to estimate.

Just to evaluate the impacts on the electric system requires the use of complex power-flow models. But given the many permutations, it is impossible to develop a definitive estimate of additional market costs. Moreover, because the CES will require electrification of most nonelectric, end-use energy consumption, models that can estimate the likely changes in those secondary markets would need to be developed.

For example, if millions of electric vehicles are purchased and driven by New Yorkers, the demand for gasoline will decrease, which will lead to a decrease in gasoline prices. A decrease in gasoline prices will, in turn, increase the net cost of purchasing and owning an electric vehicle relative to an internal-combustion one. Similarly, to meet the CES, fossil-fuel consuming equipment in the residential, commercial, and industrial sectors (furnaces, water heaters, process heat, etc.) will need to be replaced with equivalent electric technologies, which will affect the relative prices of equipment and fuel. In effect, the CES will require the entire reengineering of the New York State economy to run almost entirely on electricity. Perhaps ironically, as the demand for electricity increases because of that required electrification, wholesale and retail electric prices will increase, while fossil-fuel prices will decrease, thus raising the relative cost of electrification.

Similarly, direct benefits, such as avoided T&D infrastructure spending made possible by BTM solar PV installation, also could be estimated, as could reductions in expenditures on end-use consumption of fossil fuels.

Finally, indirect and nonmarket benefits, such as reductions in air and water pollution, could be estimated, although estimating reductions in end-use emissions from reduced fossil-fuel consumption would be extremely complex and would depend on the sources of electricity used to replace that consumption.

Review of NYSERDA and NYDPS Cost-Benefit Studies

With these caveats, I turn to examining studies by NYSERDA and NYDPS. Although the framework prepared by NYDPS in 2015 was comprehensive, actual estimates of benefits and costs associated with the state's RPS goals and the CES have proved to be far narrower. Moreover, all the analyses have wrongly equated transfer payments as benefits.

FIGURE 8.

NYSERDA Solar Study—Benefits and Costs

	NPV (Millions of 2011$)
COSTS	
Total Cost of Solar PV	$(11,779)
BENEFITS	
Market Revenues	$4,611
Price Suppression	$3,282
Avoided Electric Losses	$332
Avoided Distribution Costs	$811
Avoided RPS Compliance Costs	$106
Avoided CO_2	$455
Total Benefits	**$9,597**
Net Benefit (Cost)	**$(2,182)**

Source: NYSERDA 2012, p. 5-13, Table 33

Three cost-benefit studies have been prepared by NYSERDA and NYDPS. Two of these—the 2012 NYSERDA Solar Study and the 2013 NYSERDA study of the then-current RPS mandate—address components contained within the CES. The third, the 2016 NYDPS study, directly addresses a portion of the CES mandate.

1 | 2012 NYSERDA Solar Study

The 2012 NYSERDA Solar Study analyzed the benefits and costs of installing 5,000 MW of solar PV by 2025, including a mix of customer-owned, BTM, and utility-scale solar PV. The study examined the net present value (NPV) of the benefits and costs over 2011–49.[117] The study ignored any possible impacts of increasing demand for solar PV on the costs of that capacity, as well as on installation costs because of limited supplies of labor.

The estimated benefits and costs for the study's base case are shown in **Figure 8**.

The NYSERDA cost-benefit calculations suffer from several fundamental flaws. First, the cost estimate reflects the subsidy provided by the federal investment tax credit (ITC). The ITC provides a direct dollar-for-dollar reduction in the installed cost of solar PV facilities. The current ITC credit is 30%. Thus, if a commercial firm spends $100,000 to install a BTM solar PV system, it could claim a $30,000 tax credit, meaning that its net cost would be just $70,000. Thus, the ITC is a transfer payment from taxpayers to solar PV owners; it is not an economic benefit.

The NYSERDA study assumed that the ITC credit would remain at 30% through 2016, and then drop to 15% thereafter. The 30% rate was extended, however, through 2019, after which it decreases.[118]

Second, as discussed previously, the price suppression impact is a temporary transfer from existing generators to consumers and therefore is not a benefit.

Of the $9.6 billion in estimated benefits, $3.3 billion is associated with wholesale price suppression, which takes the form of a transfer payment to solar PV owners from weaker producers (who are assumed to be driven out of the market) and from stronger producers to consumers through lower wholesale prices.

FIGURE 9.

NYSERDA 2012 Solar Study—Revised Benefits and Costs

	NPV (Millions of 2011$)
COSTS	
Above-Market Cost of Solar PV	$(10,814)
BENEFITS	
Avoided Electric Losses	$332
Avoided Distribution Costs	$0
Avoided RPS Compliance Costs	$106
Avoided CO_2	$0
Total Benefits	**$438**
Net Benefit (Cost)	**$(10,376)**

Source: NYSERDA 2012, p. 5-13, Table 33, and author calculations

Another $4.6 billion in estimated benefits is associated with revenues from sales of solar PV into the wholesale energy and capacity markets. But those revenues are also transfers from buyers, such as utilities and retail electric sellers, to solar PV owners. Moreover, a portion of the market revenues is based on avoided retail costs associated with BTM solar installations. However, retail electric rates for many New York ratepayers, such as customers of Consolidated Edison, include per-kWh charges for local distribution service. Although customers with BTM solar PV avoid consuming electricity generated elsewhere, they are effectively provided with subsidized backup service from their local utility whenever their solar PV is not generating power (e.g., at night). This subsidized service is paid for by the utility's other retail customers.

Thus, the actual benefits are limited to the final four categories (avoided losses, avoided distribution costs, avoided RPS compliance costs, and avoided CO_2 emissions).

NYSERDA also claimed as a benefit an estimated $811 million of deferred or avoided distribution system investment.[119] However, because local electric distribution utilities must still provide backup for all customers with BTM solar, reductions in distribution system investment may be minimal, depending on whether solar PV reduces the need to expand distribution feeders to meet peak demand.[120] Moreover, as BTM solar PV increases, distribution costs can increase because the utility must address increasing voltage fluctuations caused by sudden changes in solar production (e.g., when clouds pass over a neighborhood).[121] In the longer term, as BTM solar PV is increasingly relied on to meet the 80 by 50 mandate and its requirement for increasing electrification of end-use energy consumption, the additional backup generation and storage needed to compensate for intermittent solar will also add to overall distribution system costs. Thus, a more realistic value, reflecting potentially higher costs to ensure reliable operations, is no net benefit whatsoever.

Finally, although NYSERDA estimated $455 million in present value benefits associated with avoided CO_2, based on an estimate of the "social cost of carbon" (SCC), these benefits are effectively zero, as will be discussed below.

A more straightforward method of estimating the costs and benefits of solar PV is to look at the latest long-term wholesale energy price forecast published by EIA in its 2017 *Annual Energy Outlook*.[122] This forecast, along with actual historical average wholesale electric prices, can be used to estimate the above-market cost of NYSERDA's assumed solar PV installations between 2011 and 2015. The projection can be based on the levelized costs of solar PV estimated by NYSERDA and the levelized costs of wholesale electricity estimated by EIA.[123]

NYSERDA assumed that BTM solar PV will operate for 25 years and estimated levelized 25-year costs for solar PV between 2011 and 2025. To compare these levelized costs with average wholesale prices, I calculated 25-year levelized wholesale costs, based on EIA estimates published in the agency's 2017 *Annual Energy Outlook*.[124]

Table 122 of the NYSERDA report provides levelized cost estimates for solar PV in five regions of the state (e.g., upstate and New York City) and four sizes of installation—Residential, Small Commercial, Large Commercial, and "MW-Scale"—the last referring to installations that are not BTM. In 2017, in its base-case analysis,[125] the NYSERDA study assumed a 25-year levelized cost for residential solar PV in New York City of 41.95 cents per kWh, including the benefit of the solar ITC. By comparison, using the same 7.0% discount rate assumed by NYSERDA, the 25-year levelized wholesale cost forecast price of electricity is 6.53 cents per kWh.

However, the NYSERDA levelized costs include the cost reductions provided by the ITC. Because, as discussed above, the ITC is a transfer payment from taxpayers to solar PV owners, I removed the tax credit, increasing the levelized cost of solar PV.[126] The results of the revised cost-benefit analysis show a net cost of almost $10.4 billion, or almost five times the net cost estimated by NYSERDA (**Figure 9**).

FIGURE 10.

NYSERDA Estimated Benefits and Costs of State RPS Programs, 2002–37

	NPV (Millions of 2012$)	
	Base SCC ($15/ton)	High SCC ($85/ton)
COSTS		
Above-Market Cost of Solar PV	$(431)	$(431)
Investments Not Made	$(80)	$(80)
Total Costs	**$(511)**	**$(511)**
BENEFITS		
Wholesale Price Reduction	$455	$455
Avoided CO2	$312	$2,196
Health Benefits of Reduced Pollution	$58	$58
Direct RPS Investments	$1,252	$1,252
Total Benefits	**$2,077**	**$3,961**
Net Benefits/Costs	$1,566	$3,450
Benefit/Cost Ratio[130]	4.6	9.0

Source: NYSERDA 2013, p. 27, Table 11

FIGURE 11.

NYSERDA Estimated Benefits and Costs of State RPS Programs, 2002–37, Revised to Exclude Transfer Payments

	NPV (Millions of 2012$)	
	Base SCC ($15/ton)	High SCC ($85/ton)
COSTS		
RPS Program Cost	$(431)	$(431)
Total Costs	**$(431)**	**$(431)**
BENEFITS		
Avoided CO2	$312	$2,196
Health Benefits of Reduced SO_2 and NO_X	$48	$48
Health Benefits of Reduced Mercury	$10	$10
Total Benefits	**$370**	**$2,254**
Net Benefits/Costs	$(61)	$1,823
Benefit/Cost Ratio	0.9	4.2

Source: NYSERDA 2013, p. 27, Table 11, and author calculations

2 | 2013 NYSERDA RPS Study

The 2013 cost-benefit analysis of New York's RPS programs prepared by NYSERDA included as benefits: (i) the value of reductions in CO_2 emissions under two alternative forecasts of the SCC;[127] (ii) reductions in air pollution emissions—sulfur dioxide (SO_2), oxides of nitrogen (NO_x), and mercury—that are associated with adverse health impacts; (iii) lower wholesale electric prices; and (iv) economic development benefits from additional in-state investment (**Figure 10**).[128] Unlike the Solar Study, this study did not incorporate savings associated with avoided distribution system investments and electric losses. (Because the study focused on the actual RPS mandate, RPS program costs were not avoided.)

NYSERDA's estimate of the costs was limited to the direct programmatic costs of the RPS mandate. Thus, NYSERDA did not include additional costs associated with: (i) the need for additional generating reserve capacity because of the inherent intermittency of wind and solar generation;[129] and (ii) ancillary operating reserves and frequency control to ensure system reliability.

The two largest categories of benefits in the NYSERDA report are "Direct RPS Investments," which NYSERDA estimates to have a present value benefit of $1.25 billion; and avoided CO_2, which NYSERDA estimates to have a present value benefit between $312 million and $2.2 billion, based on a range of SCC values. Together, these two categories account for 75% of total estimated benefits under the base SCC value case and 87% under the high SCC value case.

As discussed previously, both direct RPS investments and "Investments Not Made" are neither benefits nor costs but rather transfer payments. Thus, neither should be included. Similarly, the $455 million of benefits that NYSERDA associates with wholesale price reductions is a transfer payment and should also be eliminated (**Figure 11**). Excluding these transfer payments, the revised NPV cost is $431 million under both SCC cases. The NPV benefit under the base SCC case is $370 million and $2.3 billion under the high SCC case. Thus, the RPS program has a net economic cost under the base SCC case of $61 million but a net benefit of $1.8 billion under the high SCC scenario.

3 | 2016 NYDPS Study

The 2016 NYDPS cost-benefit analysis of the CES itself was more restricted. Costs were limited to the direct program costs, i.e., the ZEC payments and subsidies provided to upstate nuclear plants (Tier 3), and benefits were limited solely to the value of reduced CO_2 emissions. NYDPS estimated present value costs of $3.6 billion and present value benefits of reduced CO_2 emissions of just over $8 billion, for an overall NPV benefit of $4.4 billion through 2030 (**Figure 12**).[131]

Absent from the NYDPS analysis are the additional costs associated with increases in electricity demand that will result from the necessary electrification of existing end-use energy demand, especially transportation. In other words, nowhere did NYDPS consider that reducing GHG emissions 80% below 1990 levels by 2050 would require extensive electrification, as discussed in Section I. Such electrification is likely to increase demand threefold over current projections.

The Economic Fallacy of Avoided CO_2 Benefits

The vast majority of benefits in both the NYSERDA 2013 and NYDPS cost-benefit analyses are associated with the value of reduced CO_2 emissions, which are, in turn, based on the SCC. A key question is whether these CO_2 emissions reductions benefits are reasonable.

In fact, they are not; the appropriate value for these CO_2 emissions reductions is effectively zero. The reason for this is not that climate change is a hoax or that CO_2 emissions do not affect the climate. The reason is simple economics: the marginal benefit of reduced CO_2 emissions caused by the CES cannot be valued at the SCC because the latter reflects an average value of reducing many billions of tons of CO_2. Moreover, because climate change is, by definition, a global phenomenon, the benefits to New Yorkers themselves from reduced CO_2 emissions will necessarily approach zero, as virtually all the putative benefits will be captured outside New York.

FIGURE 12.

NYDPS 2016—Estimated Benefits and Costs of the CES, Through 2030

	NPV (Millions of 2012$)			
PROGRAM	Gross Program Costs	Gross Benefits	Net Benefits Through 2030	Benefit/ Cost Ratio
Tier 1	$2,440	$4,320	$1,880	1.8
Tier 2	$907	$622	$(285)	0.7
Tier 3	$270	$3,070	$2,800	11.4
TOTAL	**$3,617**	**$8,012**	**$4,395**	**2.2**

Source: NYDPS 2016, p. 283, and author calculations of gross benefits and B/C ratios. The NYDPS analysis included separate estimates for sub-tiers of existing renewables; NYPSC later rejected that classification. Thus, the sub-tier data from the NYDPS study have been combined.

NYSERDA and NYDPS based their estimates of CO_2 emissions reductions benefits on the average SCC value, which equals the total economic damage divided by total additional CO_2 emissions. This is shown as the straight dashed line in **Figure 13**. (The total SCC at any level of CO_2 emissions equals the area under the marginal SCC curve. The average SCC equals the total social cost divided by the quantity of CO_2 emitted.) Because the marginal SCC is increasing, the average SCC curve always lies below the former, as shown.

NYSERDA and NYDPS calculate annual benefits of forecast reduction in CO_2 emissions simply by multiplying projected CO_2 reductions each year by the estimated SCC value. For its analysis, NYSERDA used two separate values: $15/ton and $85/ton. NYDPS used annual estimates of the SCC that were calculated by the White House Interagency Working Group (IWG)—a group of 12 agencies, including the Environmental Protection Agency (EPA), formed under the Obama administration.[132]

The SCC values estimated by IWG are not based on marginal CO_2 emissions changes. Instead, the SCC estimates are average values, equal to the estimated impact of a large change in CO_2 emissions in a given year, divided by the present value of lost economic output, as measured by a decrease in world GDP. In Figure 13, the amount of CO_2 reduced, $CO_{2\ IWG}$, is associated with an estimated per-ton benefit of SCC_{IWG}.

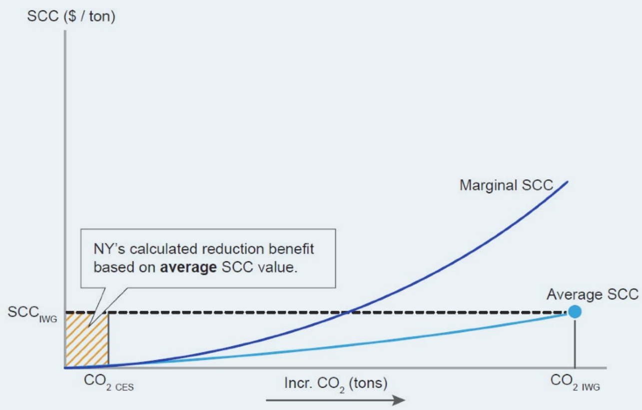
However, when the increase in CO_2 emissions is small, the marginal damage is not even measurable. Equivalently, the marginal benefit of a small reduction in worldwide CO_2 emissions is also small. This will be the case with the CES. Temperature changes that are too small to physically measure[133] and impossible to separate from natural climate variability cannot be associated with changes in climate and economic output. Thus, the benefits of equivalent CO_2 reductions are effectively zero.

In Figure 13, this is shown as the shaded rectangle, which equals the product of the estimated reduction in CO_2 emissions, $CO_{2\ CES}$, and the average SCC value, SCC_{IWG}. But because the magnitude of CO_2 reductions under the CES will be far below a threshold level (assumed to be the level where there are measurable climate impacts), the CES's actual GHG reduction benefits will be effectively zero.[134]

The issue of marginal vs. average benefits, on which the NYSERDA and NYDPS

FIGURE 13.

Average and Marginal SCC Value



Source: Author illustration

CO_2 reduction benefits are estimated, may be better understood with a health-related analogy. It's generally recognized that regular exercise improves one's health. Suppose a study were performed comparing the health of individuals who walked three miles daily with those who did not exercise at all and that the study estimated each walker's health benefit at about $11,000 per year. Thus, the average benefit per mile walked is $11,000 / (three miles/day • 365 days) = $10/mile. But this does not mean that, if a couch potato walks 15 feet per day (roughly one mile each year), he will derive a $10 annual benefit, because the average benefit from walking is not the same as the marginal benefit.

Yet this is exactly the type of error implicit in the NYSERDA and NYDPS benefits estimates. To calculate SCC values, modelers assumed different scenarios in which CO_2 emissions would be reduced worldwide by multiple billions of tons per year.[135] But the CES will not reduce CO_2 emissions by billions of tons; the goal of the CES is to reduce emissions by about 189 million tons by 2050 below 1990 levels.

As with the couch potato, NYSERDA and NYDPS wrongly equate the average SCC values with marginal ones.

As shown in Figure 13, the marginal SCC is the economic impact of each additional ton of CO_2 emitted. So assume that the marginal damage caused by increasing CO_2 emissions itself increases, as illustrated by the curved line, labeled "Marginal SCC." Thus, the benefit of a given reduction in CO_2 emissions equals the area under the Marginal SCC curve.

Correcting the economic error made by the NYSERDA and NYDPS studies effectively eliminates the estimated benefits attributed to reduced CO_2 emissions. The present value benefits of the NYSERDA study are just the $58 million value of reduced air pollution and the related health improvements. Compared with the estimated program costs of $431 million, this is a B/C ratio of just 0.13—i.e., 13 cents in benefits for every dollar spent. In the case of NYDPS, its study would show no benefits whatsoever associated with a $3.6 billion program cost.

Furthermore, the NYDPS Final EIS on the CES estimated CO_2 reductions of about 8.2 million tons by 2030.[136] In comparison, the NYDPS cost-benefit analysis published one month earlier estimated avoided CO_2 of about 15 million tons in 2030.[137] But as Figure 1 showed, meeting the interim GHG reduction goal of the CES requires reducing emissions by about 94 million tons below 1990 levels and about 76 million tons below 2014 levels. Thus, at best, by 2030, the anticipated new renewable generating capacity achieves only one-third of the CES GHG reduction mandate, even if the 50% renewable generation mandate is met.

Avoided Air Pollution Benefits

Replacing fossil-fuel generation with renewable generation and electrifying end-use energy consumption will reduce local air pollution, thus providing health benefits to New Yorkers. NYSERDA estimated the emissions reductions arising from the RPS program, based on replacement of fossil-fuel generation in New York with renewables. Specifically, NYSERDA estimated reductions over the 2002–37 period of about 15,000 tons each of SO_2 and NO_X, as well as 278 pounds of mercury.[138] NYSERDA then applied dollar/ton health values to these reductions to derive an overall present value benefit of $58 million (Figure 11). Of that total, $48 million in benefits result from reduced SO_2 and NO_X emissions and $10 million from reductions in mercury emissions.

NYSERDA used an estimate of $198.5 million per ton to value mercury emissions reductions. That value appears to be unreasonably high, especially in comparison with the EPA's estimates of reduced mercury emissions from its 2011 Mercury and Air Toxics Standards (MATS) rule.

In its analysis, the EPA estimated present value benefits from reduced mercury emissions for the entire U.S. of about $6 million, which was associated with an overall reduction in mercury emissions of about 20 tons, or about $300,000/ton on a present value basis.[139] Thus, NYSERDA's assumed benefit-per-ton value is almost 700 times larger than the value used by the EPA.

Renewable Generation and the Collapse of the Wholesale Electric Market

One important issue rarely raised when discussing the 80 by 50 mandate or the interim 50% renewable generation requirement by 2030 is the likelihood that these mandates will cause the entire wholesale energy market to collapse.

Both NYSERDA and NYDPS have estimated the benefits of wholesale price suppression to New York consumers. But in addition to price suppression being a transfer from existing producers to consumers—and a temporary one, at that—increased quantities of renewable generation could simply collapse the entire wholesale market.

The reason is that the price offers that wind and solar generators submit into the wholesale energy market should be zero because they have zero marginal cost.[160] As more wind and solar are added to the generating system, more energy is offered into the market at a zero price and price suppression increases, driving out fossil-fuel generators.

This is already taking place in Europe. In Germany, subsidies paid to renewable generators have driven retail electric rates to the highest levels in Europe, about 30 cents/kWh. At the same time, average wholesale electric prices have decreased by two-thirds, falling from more than 60 euros in 2011 to about 20 euros today.[161] The price decreases are forcing fossil-fuel generators out of the market and threatening the viability of nuclear plants, which has jeopardized reliability. A similar state of events has taken place in Great Britain, where wholesale prices are too low to encourage new generation development and provide sufficient returns for some existing generators.[162]

The same is likely to occur in the New York wholesale energy market as renewable generation increases to the 50% mandated percentage by 2030 and, especially, as more renewable generation is added to meet the 80 by 50 CES mandate. Wholesale prices will be further suppressed, which will drive out marginal generators. Moreover, as more wind and solar PV enter the market, the ability of even those facilities to recover their capital costs will decrease until, ultimately, the market becomes unsustainable for all generators and collapses.

The value for reduced mercury emissions used by NYSERDA in its solar PV study was even higher. In that report, NYSERDA cites a present value benefit of $11 million (2011$) from reducing mercury emissions by just 120 pounds over 2013–47. In other words, the NYSERDA Solar Study assumes a mercury value more than double the value that it assumed for its RPS study.[140]

There are no available estimates of health benefits associated with large-scale electrification needed to meet the CES goals, such as from reduced vehicle emissions. To develop such estimates would require detailed modeling about the type of fossil-fuel equipment replaced, especially in the residential, commercial, and industrial sectors, and associated emissions. However, additional reductions in air pollution from gasoline-powered vehicles, primarily NO_x, carbon monoxide, and particulates, are likely to be small, for the simple reason that emissions from new vehicles are 99% lower than 1970 models.[141] Quite simply, there is little remaining pollution to be removed, and the benefits of further state air pollution reductions are thus likely to be minimal.

The largest potential air pollution reduction benefits from vehicle electrification would be commercial vehicles, especially diesel-powered trucks, as diesel engines can emit high levels of particulates. Yet the likelihood of electrifying these vehicles is far lower than electrifying the majority of New York's 11 million private vehicles.[142] Commercial vehicles often haul heavy loads, which would necessarily require additional battery capacity. But the weight of those batteries would reduce the remaining load-carrying ability, much as payloads on rockets launched into space are limited because almost all the launch weight is fuel.

Other Indirect CES Benefits

Renewable energy proponents often cite fuel diversity as an additional economic benefit of such generation. Specifically, proponents argue that, by reducing reliance on fossil fuels, especially natural gas, greater reliance on renewable generation reduces the potential cost impacts of higher fossil-fuel prices. In other words, the disruptive impacts of much higher natural gas prices will be reduced if the demand for natural gas is reduced. Thus, renewable generation acts as an insurance policy, or hedge, against volatile fuel prices.[143]

While the argument is true—reducing, or eliminating, natural gas consumption reduces the impact of potential future price increases—it is also disingenuous, for at least three reasons.

First, if fuel diversity is a benefit, the issue should be identifying the least-cost approach to achieve it. But markets already offer numerous mechanisms to hedge fossil-fuel prices. Even if renewable generation offers a fuel diversity benefit, there is no empirical evidence that such benefits exceed the cost of renewable subsidies.

Second, hedging is a form of insurance. But insurance always has a net expected cost. Because insurance is designed to address aversion to risk, a fundamental issue is whether society as a whole should be risk-averse (e.g., willing to purchase insurance) and, if so, how risk-averse? If society is indifferent to risk, hedging is not a benefit but rather a cost.

Third, while renewable generation advocates often point out that market-based hedging mechanisms are imperfect (e.g., they cannot address gas pipeline constraints and are limited in time), those same advocates ignore the implicit costs of locking in specific renewable technologies that may prove more costly to operate, or that may have shorter economic lifetimes than anticipated. As reliance on renewables increases, the same lack of diversity concerns can arise.

Subsidies, Mandates, and Innovation

Another oft-advanced argument of a benefit of renewable energy subsidies—including RPS mandates, which are themselves a form of subsidy—is that such subsidies accelerate technological innovations and thereby reduce costs. For example, in subsidizing wind generation with the federal production tax credit and in imposing state RPS mandates, wind generators are less costly and more efficient than they would be but for such subsidies. Thus, by increasing the quantity of renewable generation, subsidies lead to learning-by-doing that will drive down the cost and price of the technology more quickly than absent subsidies. The empirical evidence for such impacts is scant, and it is difficult to separate out the effects of subsidies from other factors, such as economies of scale.[144] The argument in favor of subsidies as accelerating technological innovation and reducing costs conflicts with a standard economic result: subsidies promote inefficiency and higher costs by reducing the incentive to innovate. Just as a monopoly supplier has little incentive to innovate and reduce his costs, owners of subsidized generation have less incentive to reduce costs because the subsidies they receive provide a monetary cushion allowing otherwise inefficient suppliers to remain in the market. As discussed previously, such subsidies drive out unsubsidized suppliers, something I have termed "Gresham's Law of Green Energy."[145]

Direct Costs

The direct costs of the CES are the additional costs that will be incurred to meet the mandate through renewable generation and electrification, as well as the costs of the required 600 TBTUs of new energy efficiency relative to the cost of replacement electricity.

The NYDPS CES cost-benefit analysis estimated the direct programmatic costs of meeting the 50% RPS mandate by 2030. These costs are defined as the net above-market capacity and energy revenues required for the projects to be financially viable.[146] Subtracting the estimated $270 million present value cost for Tier 3 upstate nuclear plant subsidies (shown in Figure 12), NYDPS estimated an overall NPV of $3.35 billion through 2030.[147]

But the NYDPS present value cost almost surely underestimates the present value cost of the CES. The NYDPS analysis assumes only 1,000 MW of offshore wind capacity by 2030. However, as discussed previously, Governor Cuomo has called for development of 2,400 MW of offshore wind by 2030. Offshore wind is far more costly than onshore wind.[148]

One way to estimate the above-market cost impact of this recent component of the CES is to use the 20-year power purchase agreement (PPA) between Deepwater Wind (DW) and the Long Island Power Authority (LIPA) that was approved by the LIPA board of directors in January 2017. Under the PPA, DW will sell all the generation of 90 MW from its South Fork wind project to LIPA. The total reported cost of the contract is $1.625 billion.[149] According to DW, the project will generate just over 357 GWh of electricity each year, which translates into an overall average cost of $220/MWh over the project's lifetime. Assuming that the contract price escalates at EIA's forecast rate of inflation of 2.0% per year over the 20-year contract life, the first-year contract price will be just over $180/MWh.[150]

The DW project is expected to come online in 2022. No other offshore wind projects are as far along in the permitting process, so we can reasonably assume that there will be no offshore wind capacity online before 2022. Thus, to reach the goal of 2,400 MW of installed offshore wind in 2030, an average of 288 MW would need to be installed each year thereafter.

According to a report prepared by NREL, over the period 2002–14 in Europe, capital costs for offshore wind facilities tripled, from about $2,000/kW to almost $6,000/kW.[151] Although the authors of the NREL report offer a number of reasons for those cost increases, they nevertheless predict a slight decrease in capital costs through 2020. The NREL report also notes that O&M expenses for offshore wind can be significant: 20%–30% of total life-cycle costs. However, little information is available on actual O&M costs because such data have not been made public by offshore wind

FIGURE 14.

Present Value of Above-Market Costs for the Offshore Wind Mandate, 2022–50 (Millions of 2015$ in 2015)

Reduction in Offshore Wind Contract Costs, 2022–30 (Percent per Year)	Cumulative Decrease in Real Costs, 2022–30 (Percent)	PV Above-Market Cost
0.0%	0.0%	$6,623
0.5%	–3.9%	$6,219
1.0%	–7.7%	$5,828
1.5%	–11.4%	$5,450
2.0%	–14.9%	$5,083

Source: Based on real discount rate = 5.5%, per NYDPS 2016

owners. Thus, predictions that offshore wind costs will decrease significantly are speculative, at best. To the extent that offshore wind facilities have shorter than predicted lives, owing to the detrimental effects of wave action and corrosion, the overall costs of such facilities may well be higher than anticipated.

There is only one operating offshore wind project in the U.S.: the 30-MW, five-turbine Block Island project off Rhode Island. Thus, it is not possible to identify offshore wind cost trends in this country. Nevertheless, we can make some assumptions about overall offshore wind costs and how they will change to estimate the above-market costs of meeting the 2,400-MW goal by 2030.

To do this, assume that the $180/MWh first-year price represents the average contractual price for all offshore wind that comes online in 2022. Using EIA inflation projections, this is equivalent to an inflation-adjusted cost of just over $156/MWh (in 2015$).[152]

Once again, we can use EIA's forecast of the average U.S. wholesale price for electricity that is published in the 2017 *Annual Energy Outlook*.[153] In 2022, EIA's forecast price is $61.74/MWh (in 2015$). EIA expects that price to increase over time by an average of 0.5% per year. The EIA forecast wholesale market price in 2030, for example, is $96/MWh. That price is about the same as the forecast electric price for the Long Island zone used by NYDPS in its CES cost-benefit analysis.[154] The forecast wholesale prices in 2030 for all other zones, including New York City, are $80/MWh or less. For 2050, EIA forecasts an average wholesale price of $146/MWh, about the same as the NYDPS forecast for the New York City and Westchester County zones, and NYDPS forecasts a Long Island zone price of just under $180/MWh.[155]

Using the DW contract price and EIA's forecast of the wholesale market price and applying the context of various assumed offshore wind cost trends, we can calculate the annual and present value above-market costs in each year as the full 2,400 MW of offshore wind generation is installed during the 2022–30 time frame (**Figure 14**).[156]

As Figure 14 illustrates, even if contractual costs decrease by 15% over 2022–30, owing to scale economies and technology improvements, the present value above-market cost borne by New York electricity consumers from meeting Governor Cuomo's 2,400-MW offshore wind mandate during 2022–50 would still be about $5.1 billion.

If there is no decrease in inflation-adjusted costs—say, because of increased demand for offshore wind turbines, increased labor costs, higher O&M costs, shorter than expected turbine lifetimes, and so forth—the present value cost paid by New Yorkers over 2022–50 would be over $6.6 billion. The nominal, above-market cost would be in excess of $35 billion. In other words, on an actual cash basis, during that 28-year period, the offshore wind mandate alone would likely cause New Yorkers to pay over $35 billion more for their electricity. Between 2022 and 2030, they could pay almost $6 billion more.

Consider next the above-market cost of reaching the 2030 goals of 2,700 MW of BTM solar PV and 3,855 MW of utility-scale solar PV, as assumed by NYDPS in its CES cost-benefit study.

As discussed, the NYSERDA Solar Study projected decreasing levelized costs for BTM and utility-scale solar PV, owing to better technology. In 2025, NYSERDA's base case, which assumed an end to the existing solar PV ITC but also assumed continued technological progress to reduce solar PV costs, estimated a real (2011$) levelized cost for utility-scale solar PV of between $209/MWh and $224/MWh, depending on location.[157] Those values are equivalent to between $219/MWh and $234/MWh in 2015$, respectively, and are 25%–30% below NYSERDA's reported levelized costs for solar PV installed in 2015.

Similarly, for BTM solar PV, NYSERDA estimated real (2011$) levelized costs between $221/MWh and $263/MWh,[158] equivalent to between $232/MWh

FIGURE 15.

Present Value of Above-Market Costs for Solar PV, 2017–50 (Millions of 2015$ in 2015)

	Utility-Scale Solar	Behind-the-Meter Solar	Above-Market Cost
2025 Base Case	$7,080	$9,786	$11,974
5% Lower LC	$6,726	$9,297	$11,130
10% Lower LC	$6,372	$8,807	$10,287
20% Lower LC	$5,664	$7,829	$8,600
40% Lower LC	$4,248	$5,872	$5,227

Source: Author calculations

and $276/MWh (2015$), respectively. Residential systems were the most costly, while larger commercial and industrial applications were the least costly.

To gauge an estimate of the above-market costs of BTM, we can perform a similar calculation as was done to estimate the above-market costs associated with the NYSERDA Solar Study and for offshore wind by estimating the above-market costs in each year, for 2017–50.

During that period, the levelized cost for wholesale market electricity, as forecast by EIA (using the same 5.5% real discount rate assumption as the NYSERDA study), is just under $66/MWh (2015$).

Using the base-case cost estimates for BTM solar PV and utility-scale solar PV for 2025, and assuming that the reductions in levelized costs in 2025 levels were achieved in 2017, the present value above-market cost in 2015 still would be $12.8 billion (**Figure 15**). The nominal above-market costs during the entire 33-year period would total more than $57 billion.

Even if technological improvements resulted in levelized costs that were 40% lower in 2025, implying cost reductions below 2015 levels of 60%, the present value above-market cost still would be $5.6 billion, and the total nominal above-market cost paid by New Yorkers during the 2017–50 period would total $25 billion.

The results in Figures 14 and 15 show that meeting the 2030 goals for offshore wind and solar PV together could result in present value above-market costs of $18.5 billion through 2050. Through 2050, New Yorkers could pay $93 billion more for their electricity as a result of solar PV goals. Even if the costs of both technologies were to decrease significantly below base-case projections—15% for offshore wind and 40% for solar PV—the total present value above-market costs still would be $10.7 billion, and the total nominal additional costs paid by New Yorkers would exceed $60 billion.

A few caveats. These present value cost estimates for offshore wind and solar PV do not take account of several other factors—some of which could reduce the above-market costs and others that could increase them. These estimates exclude all costs for reserve generating capacity and/or storage, such as the battery storage discussed previously, to address the inherent intermittency of wind and solar PV generation. As noted, that intermittency requires much more backup than traditional fossil-fuel and nuclear plants.

On the other hand, BTM solar PV may avoid the need for T&D system investments. The exact amount would depend on where the generating facilities are built and other characteristics of the T&D system. For example, if millions of battery-powered vehicles are purchased by New Yorkers, distribution systems may have to be expanded to allow for greater peak demand when residents and businesses need to recharge those vehicles, and there may be additional costs to address sudden voltage fluctuations.

Cost Implications of Mass Electrification of the New York Economy

As the above-market cost values in Figures 14 and 15 show, merely reaching the projected 2,400 MW of offshore wind and 6,500 MW of solar PV by 2030 could force New Yorkers to spend $18.5 billion more for their electricity on a present value basis, and almost $93 billion more through 2050 in nominal terms, than they would otherwise at market prices, even if no new capacity is added thereafter.

But as discussed previously, meeting the 80 by 50 goal of the CES will require massive additional investments in renewable generation to electrify most of the New York state economy, such as more than 300,000 MW of solar PV or 100,000 MW of offshore wind. If building 6,500 MW of solar PV requires New Yorkers to pay $25 billion in additional costs above market prices between 2022 and 2050, a 50-fold increase in the quantity of installed solar capacity by 2050, even if it were physically possible to achieve, could increase the above-market price tag to more than **$1 trillion**. Put another way, the 80 by 50 mandate could require New Yorkers to spend more than $30 billion extra each and every year for electricity between now and 2050. And that doesn't include the direct costs to replace the existing infrastructure for using fossil fuels with millions of electric vehicles, electrified industrial processes, and so forth.

The same cost impact holds true for a 50-fold increase in offshore wind capacity. Thus, absent unprecedented technological breakthroughs in clean generation and energy storage technologies, the additional costs alone are likely to make the CES 80 by 50 goal unachievable.[159] Additionally, New Yorkers would have to pay for an almost entirely new, electric-powered infrastructure.

Moreover, as previously discussed, the marginal benefits from reduced GHGs would be virtually zero because emissions reductions achieved in New York would have no measurable impact on world climate. (Even if there were a measurable impact, virtually all the benefits would, by definition, accrue outside the state.) Similarly, the benefits from reductions in air pollution, while real, would likely be dwarfed by the additional costs, such as shown by the NYSERDA Solar Study.

Indirect and Nonmarket Costs

Up to this point, we have not discussed the indirect and nonmarket costs of additional renewable generation identified in Figure 7. Although the NYDPS Final EIS examined some of the potential environmental benefits associated with the CES, it did not provide any monetary estimates of these potential indirect and environmental costs.

Estimating nonmarket costs, such as species and habitat loss, is both difficult and controversial. One must ask what the economic values of avoiding them are; one way to answer such questions is by asking individuals about their willingness to pay to avoid those outcomes, using what is called the "contingent valuation methodology."[163] Another approach has been to develop marginal cost curves for biodiversity,[164] although such cost curves help inform decisions only about an appropriate level of biodiversity to achieve.

In terms of species loss and agricultural value, previous research has estimated the economic value of pollination provided by bees[165] and the overall economic value, including pollination, of bats.[166] But estimating actual economic costs associated with onshore and offshore wind energy development in New York would depend on the number and locations of the installed turbines.

Although there are studies of the adverse impacts on human health and quality of life from living near wind turbines,[167] there appear to be no empirical cost estimates of health impacts in the published literature.

There have been studies of the effects of wind turbines on property values. Some of these have found no statistically significant impacts, including on property in upstate New York.[168] Others have found statistically significant adverse impacts on such values,[169] including upstate property.[170] Still another study found adverse property value impacts but concluded that they were far outweighed by the benefits of CO_2 reductions, based on the EPA's SCC estimates.[171] However, that study failed to acknowledge the distributional impacts: whereas the affected local property owners absorb 100% of the lost property values, they realize none of the benefits from CO_2 reduction.

For onshore wind and, especially, utility-scale solar PV, indirect costs are likely to include the value of lost agricultural production. These losses will be location-specific and depend on the amount of capacity installed.

Using data published by the U.S. Department of Agriculture (USDA) on agricultural production in New York State, we can develop some preliminary estimates.[172] The USDA publishes statistics on total agricultural acreage, both crops and livestock, and the value of production. The most valuable agricultural commodity produced in the state was hay, with a market value of more than $430 million in 2016.[173] The USDA reports that in 2016, New York had about 5.4 million acres under cultivation, of which 1.36 million acres were planted with hay. The average yield was 1.68 tons/acre. Based on the reported average price of $185/ton, the average value of hay production was $311/acre in 2016.

Using the acres/MW land requirement for onshore wind, as estimated by the American Wind Energy Association, 1,000 MW of onshore wind capacity would require 40,000–89,000 acres. Thus, the installation of 15,000 MW of onshore wind could occupy virtually all the land in the state currently used for hay production. (As discussed previously, the NYDPS Final EIS determined that there are only 1.3 million acres of land in the state that are suitable for onshore wind development.)

The NYDPS Final EIS reports that, for hay and alfalfa, the direct impact would average 0.6 acres/MW, because it presumes that most of the land around the wind turbines themselves would be unaffected.[174] In that case, the lost value of hay production associated with 15,000 MW of wind capacity sited on agricultural land would be $2.8 million/year. Although farming could continue to take place around wind turbines, wind farms can affect soil and crop conditions, which can lead to reduced agricultural production.[175] Thus, the lost economic value could be significantly greater than what the NYDPS EIS assumed.

Whereas agricultural production in the presence of wind turbines may be uncertain, siting solar PV on agricultural land eliminates agricultural production because crops cannot be grown underneath solar panels. Thus, in the above example, whereas the land-use requirement for 1,000 MW of solar PV would be only 8,000 acres, based on an average of 8 acres/MW,[176] virtually all agricultural production would be lost. Using the example of hay, the lost production value would be over $2.4 million/year. If 100,000 MW of solar PV were installed on 800,000 acres of hay-producing acreage in the state, the loss in value would be $240 million/year.

The next most valuable crop produced in the state is grain corn. The USDA reports a total market value in 2016 of $286.8 million, based on 570,000 acres planted, an average yield of 129 bushels/acre, and an average price of $3.90/bushel. These data imply an average value of $503/acre. Using the same 1,000 MW of installed solar PV, the lost market value of corn would be over $4 million/year, or $400 million/year for 100,000 MW.

However, lost market value is not the same thing as lost economic welfare, which, as discussed in Section II, is based on the change in producer's and consumer's surplus. If farmers are pure price takers for an agricultural commodity like hay or corn, there would be no change in consumer's surplus because there would be no change in the market price. Thus, the change in welfare would equal the change in producer's surplus.

The difficulty is that the lost producer's surplus will depend on which producers' acreage is forgone because of, say, solar PV development. If the solar PV eliminates production from marginal agricultural producers, the loss in producer's surplus will be small. But if the solar PV is sited where it eliminates efficient, low-cost producers, the loss in producer's surplus will be much larger.

A similar analysis holds for commercial fisheries that likely would be affected by offshore wind generation, such as the DW South Fork Project, especially if the 2,400-MW capacity goal is to be met by 2030. In that case, continuous construction over many years, as well as the resulting habitat degradation, could permanently disrupt the Long Island and New England coastal fisheries. Siting far higher quantities of offshore wind, such as would be needed to meet the 80 by 50 mandate, would likely have far more devastating environmental and economic impacts on the fisheries.

A 2015 NYSERDA study evaluated the potential environmental impacts of offshore wind generation, along with the views of various stakeholders.[177] Conspicuously absent were the views of those representing commercial fishermen. A 2013 study prepared by the New York Department of State estimated the overall economic contribution of the commercial and recreational fisheries industry to the state at over $11 billion/year but did not break down the specific value for commercial fisheries off Long Island.[178] The direct economic value of the commercial fishing industry is about $60 million/year.[179] However, merely reflecting the commercial value of fisheries that would be damaged by offshore wind development does not encompass the overall indirect and nonmarket costs. These may include deaths of migratory birds and bats caused by the turbines, permanent damage to the habitat,[180] and disruption of radar, including radar used by the Department of Defense.[181] There appear to be no studies estimating the monetary value of these impacts.

IV. Conclusion

Given Existing Technology, the 80 by 50 Goal of the CES Is Unrealistic, Unobtainable, and Unaffordable

In 2014, electricity generation, including imports, accounted for less than 20% of all energy-related GHG emissions in New York. Fossil-fuel energy use was four times larger than end-use electricity consumption. Therefore, to achieve the CES goal will require the almost complete electrification of New York's infrastructure—including residential and commercial heating, industrial processes, and, most important, transportation, encompassing more than 11 million vehicles registered in the state—replacing technologies that burn fossil fuels with those that use electricity. But none of the studies published by the New York agencies has addressed that issue. Instead, the focus of the CES has been on meeting the interim goal of 50% renewable generation and a 40% reduction in GHG emissions below 1990 levels by 2030.

Even this interim goal appears unrealistic. It will require huge investments in solar PV, as well as onshore and offshore wind capacity. Because of the intermittent nature of those resources, large increases in reserve generating capacity will be needed to ensure sufficient resources to meet electricity demand in peak hours.

Even if the interim 2030 CES goal can be achieved, it will be hugely expensive. Meeting the governor's January 2017 mandate for 2,400 MW of offshore wind generation by 2030 is estimated to have a present value above-market cost of over $5 billion, even if improvements in offshore wind technology can reduce costs by 15%. At current costs, based on the recently signed contract between DW and LIPA, the present value above-market cost is likely to be $6.6 billion.

The above-market cost of installing thousands of MW of solar PV will be even greater. Using NYSERDA's base-case projections of solar PV cost reductions by 2025, the present value above-market cost would be about $12 billion. Even if solar PV costs are reduced an additional 40% below projected costs, or almost two-thirds below today's costs, the present value above-market cost would be $5.2 billion.

The interim CES goal will require thousands of megawatts of new onshore wind, all of it located upstate. However, local opposition to siting industrial-scale wind facilities is increasing. Unless state regulators and policymakers simply override local opposition, the prospect for installing thousands of MW of onshore wind generation appears unrealistic.

As for energy efficiency, the CES objective of 600 TBTUs of additional efficiency savings in the residential, commercial, and industrial sectors by 2030 far exceeds all other energy savings estimates. A 2013 study prepared for NYSERDA used optimistic assumptions to estimate 300 TBTUs of savings by 2030. The most recent NYISO forecast of energy-efficiency gains to reduce electricity consumption, including improved building codes, forecasts only about 50 TBTUs of additional savings by 2030.

The most likely scenario for meeting the 2030 interim goal will be through increased imports of renewable generation, primarily from Quebec. But significantly increasing imports will require constructing significant new transmission capacity. The Champlain-Hudson transmission line, for example, which has an estimated cost of $2.3 billion, will allow for the import of about 1,000 MW of electricity from Quebec. But the electricity from Quebec will be used to replace about half the output of the Indian Point Nuclear Facility, which is scheduled to be closed by 2021. If imports of electricity are to increase by thousands of MW to meet the interim goal, billions of dollars will need to be spent for new transmission lines, the siting of which has been met with strenuous local opposition in the past.

Although energy technology can, and doubtless will, improve between now and 2050, the massive electrification of the New York economy, including most fossil-fuel end-use energy consumption, does not appear to be feasible with the current technology. In 2014, fossil-fuel energy used for transportation was twice as large as all end-use electricity consumption combined. Meeting the 80 by 50 goal will require replacement of virtually the entire vehicle stock with electric models. Although battery technology has improved, electric vehicles are still not cost-competitive with internal-combustion vehicles. The governor's March 2017 announcement of the "Drive Green" program, which will provide $70 million to subsidize electric vehicle purchases, with rebates up to $2,000 for battery-powered vehicles, seems unlikely to achieve the overall goal of 700,000 electric vehicles by 2025, given that there were fewer than 9,000 such vehicles registered in the state at the end of 2016.

Electrifying the New York economy to achieve the 80 by 50 goal will require massive investments in solar PV, onshore wind, and offshore wind capacity. Even assuming that 600 TBTUs of energy-efficiency gains by 2030 are achieved (an ambitious assumption), New York would have to construct more than 300,000 MW of new solar PV or 100,000 MW of onshore and offshore wind to meet the 80 by 50 goal.

What About the Benefits to New Yorkers?

The main justification for the CES—and the basis for the 2016 NYDPS CES cost-benefit analysis concluding that the CES will provide billions of dollars in benefits—is reduced CO_2 emissions. But those estimates are based on a fundamentally flawed economic assumption: confusing minuscule marginal benefits with much larger average benefits that are represented by the SCC. Consequently, the actual benefits from achieving the reduced CO_2 emissions will be virtually zero. Even if we ignore this fundamental economic error, the benefits accruing to New Yorkers will still be virtually zero because almost all the benefits will be felt outside the state. Thus, the 80 by 50 mandate effectively forces New Yorkers to pay for benefits that they will not themselves receive.

The CES Imposes Inequitable Burdens on Lower-Income New Yorkers

By raising electricity costs, the CES will have an adverse impact on all residents and businesses. But lower-income New Yorkers are likely to bear a disproportionate burden. These individuals cannot afford solar PV installations, regardless of federal tax credits and state incentives. Moreover, as wealthier New Yorkers install solar PV systems, more of the fixed costs of providing electricity—essentially, utilities providing backup service—will be borne by lower-income residents, further increasing retail electric rates.

Nor will lower-income residents be likely to purchase electric vehicles under the Drive Green program, or any other rebate program. Again, the benefits of federal tax credits and rebates accrue primarily to wealthier individuals.

Wealthy New Yorkers are unlikely to be affected by the siting of utility-scale onshore wind and solar PV installations, which will be primarily located in upstate regions, where the economy remains largely moribund. Such installations will also adversely affect agriculture in the region.

Finally, the installation of 2,400 MW of offshore wind by 2030, to say nothing of the thousands of MW of additional offshore wind that will be needed to meet the 80 by 50 goal, will likely wreck the Long Island fisheries industry because of the constant construction activity needed to meet the goals.

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The CES may provide bragging rights about New York's green bona fides. It is not a plan based on a careful analysis of actual costs and benefits.

The primary reason for the CES, to reduce GHG emissions, will not lead to any measurable impacts on climate and thus no climate-related benefits. However, the CES will significantly raise electricity costs. It is doubtful that the ultimate 80 by 50 goal is even achievable with current technology, given that it will require the almost complete electrification of the New York economy, which will entail constructing vast quantities of additional renewable generation.

The published cost-benefit studies of the CES, as well as specific components, such as the solar PV program, all suffer from fundamental flaws: they identify as "benefits" economic development arising from subsidized renewable generation, through creation of green jobs and new green industries. Such analyses are exercises in free-lunch economics and wishful thinking because they fail to address the adverse economic impacts caused by lost tax revenue and higher electric prices.

The bottom line is that New York's Clean Energy Standard appears to be an exercise in symbolic environmentalism. It will provide almost no measurable benefits, while imposing huge costs, including disproportionate costs on lower-income residents.

Endnotes

1 *Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard*, Case 15-E-0302, Order Adopting the Clean Energy Standard, Aug. 1, 2016.

2 Executive Order No. 24 (2009) [9 N.Y.C.R.R. (New York Codes, Rules and Regulations) 7.24; continued, Executive Order No. 2 (2011) 9 N.Y.C.R.R. 8.2].

3 NYPSC, *Proceeding on Motion of the Commission to Consider a Clean Energy Fund*, Case 14-M-0094, et al., Order, Jan. 21, 2016 (2016 CEF Order), p. 40.

4 This value is based on data published by the New York State Energy Research and Development Authority (NYSERDA). See "Patterns and Trends: New York State Energy Profiles: 2000–2014," Oct. 2016. In 2012, total residential, commercial, and industrial primary energy consumption, which includes thermal efficiency losses from fuel combustion to generate electricity, was about 2,533 TBTUs. Twenty-three percent of that value is 583 TBTUs.

5 New York Department of Public Service (NYDPS), "Clean Energy Standard White Paper: Cost Study," Apr. 8, 2016 (NYDPS 2016), p. 5.

6 Galen Barbose et al., "Costs and Benefits of Renewables Portfolio Standards in the United States," *Renewable and Sustainable Energy Reviews* 52 (Dec. 2015): 523–33. See also Jenny Heeter et al., "A Survey of State-Level Cost and Benefit Estimates of Renewable Portfolio Standards," National Renewable Energy Laboratory, Report NREL/TP-6A20-61042, May 2014, pp. vii–viii.

7 NYPSC, *Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision*, Case 14-M-0101, Order Establishing the Benefit-Cost Analysis Framework, Jan. 21, 2016.

8 E.g., the Illinois Coal Act promoted a policy in which electric utilities would subsidize in-state coal suppliers. The act was found to violate the Interstate Commerce Clause. *Alliance for Clean Coal v. Miller*, et al., 44 F.3d 591 (7th Circ., 1995). Similarly, the U.S. Supreme Court overturned an Oklahoma law requiring coal-fired power plants in that state to burn a mix of coal that contained at least 10% of in-state sourced coal, finding that the law was protectionist and discriminatory. *State of Wyoming v. State of Oklahoma*, 502 U.S. 437 (1992).

9 Wholesale electricity markets are regulated by the Federal Energy Regulatory Commission because they cross state lines. The sole exception is Texas, which has its own wholesale power grid that is not interconnected with the rest of the country.

10 See, e.g., Richard Ottinger et al., *The Environmental Costs of Electricity* (New York: Oceana Press, 1990). The book was based on research for NYSERDA. That research, as well as the conclusions in the book, suffered from a fundamental economic flaw: equating the costs of controlling air pollution emissions with the benefits of doing so.

11 National Conference of State Legislatures, State Renewable Energy Standards and Goals, July 29, 2016.

12 All New England states have similar GHG emissions reduction goals.

13 American Council for an Energy-Efficient Economy, Policy Brief, Jan. 2017.

14 How states define "cost-effective" is, perhaps not surprisingly, open to interpretation.

15 See Jonathan A. Lesser, "Renewable Energy and the Fallacy of 'Green' Jobs," *The Electricity Journal* 23, no. 7 (Aug./Sept. 2010): 45–53.

16 Galen Barbose et al., "Costs and Benefits of Renewables Portfolio Standards in the United States," Lawrence Berkeley National Laboratory, LBNL-187516, July 2015, pp. 2–3. This is This is a pre-print of the article accepted for publication in *Renewable and Sustainable Energy Review*s (n. 6 above).

17 Mark Z. Jacobson et al., "Low-Cost Solution to the Grid Reliability Problem with 100% Penetration of Intermittent Wind, Water, and Solar for All Purposes," *Proceedings of the National Academy of Sciences* 112, no. 49 (Dec. 8, 2015): 15060–65.

18 Christopher T. M. Clack et al., "Evaluation of a Proposal for Reliable Low-Cost Grid Power with 100% Wind, Water, and Solar," *Proceedings of the National Academy of Sciences* 114, no. 26 (June 27, 2017): 6722–27.

19 NYSERDA, "Renewable Portfolio Standard Main Tier 2013 Program Review Volume 1—Main Tier Current Portfolio Analysis," Sept. 5, 2013, p. 30.

20 Warren Leon, "Evaluating the Benefits and Costs of an RPS," Clean Energy States Alliance, May 2012, p. 2.

21 For a discussion, see Richard Thaler, "Mental Accounting Matters," *Journal of Behavioral Decision Making* 12, no. 3 (1999): 183–206.

22 *Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard*, Case 15-E-0302, Order Adopting the Clean Energy Standard, Aug. 1, 2016.

23 Ibid., pp. 14–20.

24 See NYSERDA, "About NY-Sun."

25 The 2016 CES Order did not specify a specific offshore wind energy capacity target. In his State of the State address on Jan. 10, 2017, Governor Cuomo established the 2,400-MW offshore wind capacity goal.

26 This provision of the CES is controversial and the subject of a current court challenge by other wholesale generators. Although their initial challenge was rejected by a federal district court in New York, the generators are expected to appeal. More important, it is not clear that New York can maintain a reliable electric system without baseload nuclear power, especially given the state's apparent hostility to siting new gas pipelines needed for new gas-fired generating plants. An evaluation of the Tier 3 nuclear plant subsidies, as well as reliability issues associated with the shutdown of those nuclear plants, is beyond the scope of this report.

27 New York State, "Governor Cuomo Launches $70 Million Electric Car Rebate and Outreach Initiative," Mar. 21, 2017.

28 Ibid. Electric vehicles eligible for subsidies under Drive Green include battery-powered vehicles and plug-in hybrids. Rebates also will be available for hydrogen-powered fuel cell vehicles. However, given that this technology is still in its infancy and only a few vehicles are even commercially available, these vehicles are unlikely to receive any significant portion of the rebate funds, absent a technological breakthrough.

29 New York State, Transportation Vehicle and Boat Registrations by Fuel Type.

30 Western New York Regional Economic Development Council, "A Path to Renewal: The Buffalo Billion Investment Development Plan," Feb. 2013.

31 E. J. McMahon, "Cuomo's SolarCity Disaster Could Become a Monument to Corruption," *New York Post*, Sept. 22, 2016.

32 NYSERDA, "New York State Greenhouse Gas Inventory: 1990–2014" (NYSERDA 2017); rev. Feb. 2017.

33 For an introduction, see U.S. Environmental Protection Agency, "Understanding Global Warming Potentials." The UN Framework on Climate Change publishes a list of CO_2-equivalent values for numerous GHGs. Different researchers have estimated different warming-potential values.

34 A list of CO_2 equivalents for other GHGs can be found in the UN Framework on Climate Change, Appendix A.1.

35 2016 CEF Order.

36 Ibid., p. 2.

37 The efficiency of an electric generating plant is measured by its heat rate. The greater the heat rate, the less energy-efficient the plant. E.g., a coal-fired power plant with a heat rate of 10,000 BTUs per kilowatt-hour (kWh) burns 10,000 BTUs of coal to produce one kWh (3,412 BTUs) of electricity.

38 2016 CEF Order, p. 47.

39 NYSERDA, "Energy Efficiency and Renewable Energy Potential Study of New York State," Apr. 2014 (NYSERDA 2014 EE Study), vol. 1: Study Overview.

40 See, e.g., Meredith Fowlie, Michael Greenstone, and Catherine Wolfram, "Do Energy-Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program," SSRN.com, June 2015. The authors found that the costs of home weatherization programs were double the benefits and, even including benefits of reduced air pollution, were still not cost-effective. Perhaps unsurprisingly, their findings have generated much controversy for going against the conventional wisdom. See also Hunt Allcott and Michael Greenstone, "Measuring the Welfare Effects of Residential Energy-Efficiency Programs," Becker Friedman Institute for Research in Economics Working Paper No. 2017-05, Apr. 29, 2017. The authors found that residential energy-efficiency programs yielded actual energy savings that were just 58% of predicted savings.

41 The New York electric grid is divided into 11 load zones, A–K, which reflect high-voltage transmission constraints between different regions of the state. Thus, New York City, which faces constrained transmission capacity that limits the ability to import power to the city, tends to have higher wholesale market prices than upstate regions that do not face transmission constraints.

42 See NYSERDA 2014 EE Study, vol. 4: Energy-Efficiency Technical Appendices, Final Report, Appendix A, p. A-5. The NYSERDA study defined summer peak as the three-month period June–Aug., between noon and 6 p.m.

43 The calculation is based on the 8% increase in the gross domestic product, implicit price deflator (GDPIPD) between 2012 and 2017. The GDPIPD is published by the U.S. Federal Reserve.

44 The New York City area is NYISO Zone J.

45 NYISO Market and Operations Data.

46 NYDPS 2016, p. 215.

47 Although new nuclear capacity could be constructed, building new nuclear plants in the state is likely a nonstarter. Lower-cost, modular nuclear generating plant technologies are advancing, but the regulatory process remains onerous.

48 According to data published by the U.S. Energy Information Administration (EIA), 80% of renewable generation produced in New York in 2015 came from hydroelectric power. But it is unlikely that any significant new hydroelectric capacity could be developed in the state, owing to environmental opposition.

49 NYSERDA's transportation emissions include emissions from jet fuel.

50 Total energy-related GHG emissions in 2014 were 186.1 $MMtCO_2e$. Thus, 186.1 – 74.0 = 112.1 $MMtCO_2e$, compared with a required reduction to just 46.78 $MMtCO_2e$ of energy-related GHG emissions by 2050.

51 NYSERDA, "Patterns and Trends: New York State Energy Profiles: 2000–2014," Oct. 2016 (NYSERDA 2016), p. 2. NYSERDA does not have published energy consumption data prior to 2000. 2005 was selected as a reasonable alternative

52 NYISO 2017 Load and Capacity Data Report (NYISO 2017 Gold Book), Apr. 2017, p. 12.

53 NYSERDA 2016.

54 600 TBTUs is equivalent to 176 TWh of end-use electricity (600 / 3.412 = 176).

55 The calculation of the renewable generation percentage is: 1 – 43/117 = 0.63 = 63%. This calculation ignores all transmission and distribution (T&D) system losses.

56 See NYSERDA, "New York Solar Study: An Analysis of the Benefits and Costs of Increasing Generation from Photovoltaic Devices in New York," Jan. 2012 (NYSERDA 2012), pp. 3–16, Table 25.

57 The calculation is: 1 MW of solar PV generates, on average, 15% x 8,760 = 1,314 MWh = 0.001314 TWh. Thus, to generate 400 TWh requires 400 / 0.001314 MW = 304,414 MW of installed solar PV.

58 Generation data from U.S. EIA, *Electric Power Annual*. Installed capacity from EIA Form-860.

59 It is likely that a significant component of U.S. solar PV development is being driven by the 30% federal investment tax credit (ITC), along with state and local subsidies for solar PV. An article in Greentech Media concluded that extending the ITC through 2020 would increase solar PV installations by 54%. See Mike Munsell, "Investment Tax Credit Extension Would Increase US Solar Installations 54% Through 2020," Greentech Media, Dec. 16, 2015.

60 Sean Ong et al., "Land-Use Requirements for Solar Power Plants in the United States," National Renewable Energy Laboratory (NREL), Report NREL/TP-6A20-56290, June 2013 (NREL 2013), p. v, Table ES-1.

61 In 2016, the DOE released its National Offshore Wind Strategy, which puts offshore wind's capacity density at 3 MW per square kilometer (or 3 million watts per 1 million square meters). In 2015, the agency issued its Wind Vision Report, which found that "the average plant boundary for a land-based wind plant is 0.34 square kilometers per megawatt" (p. 9). The footnote on the density calculation says that it was based on "161 specific projects totaling 15,871 turbines and 25,438 MW of installed capacity." The same document puts offshore capacity density in a similar range, saying that proposed offshore wind projects on the Eastern Seaboard have a range of values, from 49.4 acres/MW to 148.2 acres/MW. Let's assume 100 acres/MW as an average. Thus, 1 million watts on 404,700 square meters = 2.47 watts per square meter (W/m2). The NREL issued a report that found that the "average area requirements" for wind energy were 34.5 hectares per megawatt, or 2.89 watts per square meter. See Paul Denholm et al., "Land-Use Requirements of Modern Wind Power Plants in the United States," NREL, Technical Report NREL/TP-6A2-45834, Aug. 2009, p. 22.

62 There are 2.59 million square meters per mile. Thus, 2.94 watts/square meter is equivalent to 340 million square meters per 1,000 MW, or 1 gigawatt (GW). Dividing that value by 2.59 million yields a total land area of 131 square miles.

63 *Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard*, Case 15-E-0302, et al., NYDPS Final Environmental Impact Statement, May 2016 (NYDPS Final EIS), p. 5–83.

64 Megan Guess, "A Look at the New Battery Storage Facility in California Built with Tesla Powerpacks," ArsTechnica, Jan. 31, 2017.

65 Tom Randall, "Tesla Wins Massive Contract to Help Power the California Grid," Bloomberg, Sept. 15, 2016.

66 NYISO, Installed Capacity Manual, Mar. 2017, pp. 4–25.

67 Ibid. Similarly, for land-based wind, NYISO assumes capacity availabilities of 10% in summer and 30% in winter.

68 Katie Fehrenbacher, "Why Tesla's New Battery Pack Is Important," *Fortune*, Aug. 24, 2016.

69 See Robert Bryce, "Where the Bully Winds Blow," *City Journal*, Dec. 1, 2016. And note that in an Apr. 19, 2017, editorial in the *Daily News*, Councilman John Riggi of Yates, NY, stated that his town would emphatically oppose the proposed 200-MW Lighthouse Wind project.

70 For a discussion, see NYISO, "Power Trends 2017: New York's Evolving Electricity Grid," May 2017, pp. 45–47.

71 The calculation is: 1 MW of offshore wind generates, on average, 47% x 8,760 = 4,117 MWh = 0.004117 TWh. Thus, to generate 400 TWh requires 400 / 0.004117 MW = 97,158 MW of installed offshore wind.

72 Connecticut Department of Environmental Protection, Coastal Access Guide, Long Island Sound Facts.

73 This point also was raised in a report last year: Ken Girardin and Annette Brocks, "Green Overload: New York State's Ratepayer-Zapping Renewable Energy Mandate," Empire Center for Public Policy, Sept. 2016.

74 NYDPS 2016, pp. 179, 279, 281.

75 Ibid., pp. 186–88, 279, 281.

76 U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability, "Champlain Hudson Transmission Project, Final Environmental Impact Statement," Aug. 2014, p. S-4.

77 See Robert Bryce, "After Indian Point: Lights Out for New York City?" Manhattan Institute, Aug. 2017.

78 In late 2016, Statoil, the Norwegian government-owned oil company, paid $42 million to lease an 80,000-acre offshore parcel south of Long Island, and will explore the feasibility of developing 900 MW of generating capacity.

79 New York State Reliability Council, "New York Control Area, Installed Capacity Requirement for the Period May 2017 to April 2018," Dec. 2, 2016, p. 12.

80 *Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard*, Case E-15-0302, Supplemental Comments of the New York Independent System Operator, Inc., July 8, 2016 (NYISO 2016a), p. 11, Table 1.

81 Ibid.

82 For a detailed discussion, see Australia Energy Market Operator, "Black System South Australia: Final Report," Mar. 2017.

83 There are two types of operating reserves: (i) spinning reserves, which refer to capacity that can be brought online within five minutes; and (ii) non-spinning reserves, which can be brought online generally within 30 minutes.

84 There are numerous textbooks on cost-benefit analysis, each offering a different balance between theory and practice. For a short introduction, see Jonathan A. Lesser and Richard O. Zerbe, "A Practitioner's Guide to Benefit-Cost Analysis," in Fred Thompson and Mark T. Green, eds., *Handbook of Public Finance* (New York: Marcel Decker, 1998).

85 This description comes from Talbot Page, "Environmental Existentialism," in Robert Costanza et al., eds., *Ecosystem Health: New Goals for Environmental Management* (Washington, DC: Island Press, 1992).

86 Various philosophical arguments have been made that cost-benefit analysis cannot be applied to nonmarket goods such as environmental quality and to policies that affect future generations. For an example, see Gregory Crespi, "Cost-Benefit Analysis: Not a Suitable Approach for Evaluating Climate Regulation Policies," *Washington & Lee Journal of Energy, Climate, & Environment* 2 (2011): 227–59. The author of this report finds such arguments unpersuasive, as they substitute the individual's beliefs for any rational analysis. More important, the principal objective of the CES is to improve environmental quality, especially from reductions in CO_2, and the monetary value of those improvements has been estimated by the State of New York.

87 NYSERDA, "Renewable Portfolio Standard Main Tier 2013 Program Review Volume 1—Main Tier Current Portfolio Analysis," Sept. 5, 2013 (NYISO 2013a), p. 28, Table 5.

88 What's more, production tax credits for wind energy producers allow them to offer electricity to the market at negative prices and still profit. Such preferential treatment raises a broader issue concerning the CES, which I discuss in Section III: if the vast majority of electricity is to be supplied by zero marginal cost resources, the entire wholesale electric market collapses because prices fall to zero. (I am ignoring the issue of "must-run" facilities, such as nuclear plants, which offer into wholesale energy markets at a zero price because such plants cannot be stopped and started at will.)

89 NYSERDA, "Renewable Portfolio Standard Main Tier 2013 Program Review," vol. 2, Sept. 5, 2013 (NYSERDA 2013), p. 26, Table 11. The $455 million wholesale price suppression estimate is the present value for 2002–37. This issue is discussed in more detail in Section III.

90 If this were not the case, and the subsidy led to a net increase in CS + PS, the subsidy would be a "money machine"—the more the subsidies offered, the greater the benefits.

91 NYSERDA, Clean Energy Standard.

92 David Roland-Host et al., "An Economic Assessment of the American Clean Energy and Security Act and the Clean Energy Jobs and American Power Act: Executive Summary," College of Natural Resources, University of California, Berkeley, Oct. 25, 2009, p. 2. Although the report title indicates that it is an executive summary, the full report does not appear to have been published.

93 Ibid.

94 Ibid., p. 9.

[95] Navigant Consulting, "Jobs Impact of a National Renewable Electricity Standard," Feb. 2, 2010.

[96] Ibid., p. 3.

[97] NREL, "Large-Scale Offshore Wind Power in the United States: Assessment of Opportunities and Barriers," NREL/TP-500-40745, Sept. 2010, pp. 16–17.

[98] Environmental Entrepreneurs et al., "Clean Jobs New York," May 2016.

[99] New York State, "Governor Cuomo Presents 25th Proposal of 2017 State of the State: Nation's Largest Offshore Wind Energy Project Off Long Island Coast and Unprecedented Commitment to Develop Up to 2.4 Gigawatts of Offshore Wind Power by 2030," Jan. 10, 2017.

[100] 2016 CES Order, p. 18.

[101] It is not as if regulators and policymakers have not recognized these effects. E.g., in rejecting a proposed power purchase contract between Deepwater Wind and National Grid in Apr. 2010, the Rhode Island Public Utilities Commission cited as one of the reasons: "It is basic economics to know that the more money a business spends on energy, whether it is renewable or fossil based, the less Rhode Island businesses can spend or invest, and the more likely existing jobs will be lost to pay for these higher costs." *In Re: Review of New Shoreham Project Pursuant to R.I. Gen Laws § 39-26.1-7*, Docket No. 4111, Report and Order, Apr. 2, 2010, p. 82.

[102] Tradable emissions markets result in an economic value for marginal emissions reductions based on administratively determined emissions targets. But the actual economic value, measured in terms of WTP or WTA, is likely to be quite different. E.g., regulators could decree that SO_2 emissions be reduced to extremely low levels that would result in the soaring price of emissions allowances. But that is not the same as determining the actual economic value of the emissions reduction, in terms of improved health and environmental quality. Removing the last molecule of pollution is likely to have a vanishingly small economic value but an astronomical cost.

[103] This is an example of what economists call "hedonic pricing." A discussion can be found in Ronald Cummings, Louis Cox, and A. Myrick Freeman, "General Methods for Benefits Assessment," in Judith Bentkover et al., eds., *Benefits Assessment: The State of the Art* (Hingham, MA: Kluwer Academic Publishers, 1985).

[104] New York State, "Reforming the Energy Vision (REV)," Feb. 2016. The goals set forth in the CES for GHG emissions reductions and renewable generation are the same as those set forth in the REV.

[105] NYPSC, *Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision*, Case 14-M-0101, Order, Jan. 21, 2016.

[106] E.g., the social cost of carbon (SCC), which underlies the largest single component benefit of the CES, is based on a "social discount rate"; see Jonathan A. Lesser, "Missing Benefits, Hidden Costs: The Cloudy Numbers in the EPA's Proposed Clean Power Plan," Manhattan Institute, June 2016.

[107] See, e.g., David Burgess and Richard Zerbe, "Appropriate Discounting for Benefit-Cost Analysis," *Journal of Benefit-Cost Analysis* 2, no. 2 (2011): 1–18; Partha Dasgupta, "Discounting Climate Change," *Journal of Risk and Insurance* 37, nos. 2–3 (Dec. 2008): 141–69.

[108] See, e.g., Nicholas Stern, "The Economics of Climate Change," *American Economic Review* 98, no. 2 (May 2008): 1–37; Geoffrey Heal, "Climate Economics: A Metareview and Some Suggestions for Future Research," *Review of Environmental Economics and Policy* 3, no. 1 (Winter 2009): 4–21.

[109] This is discussed in Burgess and Zerbe, "Appropriate Discounting for Benefit-Cost Analysis."

[110] NYDPS, Staff White Paper on Benefit-Cost Analysis in the Reforming Energy Vision Proceeding, Case 14-M-0101, July 1, 2015 (NYDPS 2015), p. 12, Table 1.

[111] This framework also recognized that reductions in wholesale electric prices were primarily a transfer of wealth from producers to consumers, and not a societal benefit. Ibid., pp. 19–20.

[112] For a discussion of these impacts, see NYDPS Final EIS, pp. 5-22 to 5-40.

[113] U.S. Department of Energy, "Federal Interagency Wind Radar Interference Mitigation Strategy," Jan. 2016 (USDOE 2016).

[114] NYSERDA, NY-Sun.

[115] For a discussion, see Anderson Hoke et al., "Maximum Photovoltaic Penetration Levels on Typical Distribution Feeders," NREL, Report NREL/JA-5500-55094, July 2012.

[116] NYISO, "Solar Impact on Grid Operations: An Initial Assessment," June 30, 2016 (NYISO 2016b). The study examined different wind and solar penetrations on the quantities of regulation service as wind and solar capacity increased. (Regulation service is the continuous balancing of resources with demand to assist in maintaining voltage and frequency levels within operational parameters. This is done by having certain generators whose output can be continuously adjusted to meet instantaneous changes in demand. Wind and solar generation cannot do this, although advanced solar inverters—which convert direct current output of solar PV to alternating current—can.)

[117] The assumed lifetime of solar PV installations is 25 years. Therefore, installed solar in 2025 is assumed to remain operational until 2049.

[118] In late 2015, Congress extended the ITC. The credit remains at 30% of the installed cost of a solar PV system through 2019. It then decreases to 26% in 2021, 22% in 2022, and 10% thereafter. Moreover, beginning in 2022, residential BTM solar PV installations will not be eligible for the credit. See Sara Matasci, "Congress Extends Solar Tax Credit—Everything You Need to Know About the Federal ITC," Energysage.com, Mar. 12, 2017.

[119] NYSERDA 2013, p. 5-14. NYSERDA assumes values for avoided distribution system investment of $33.48/kW per year for upstate New York and $100/kW per year for New York City. Thus, if 1,000 MW of BTM solar PV were installed in New York City, the annual value of the avoided distribution system investment would be ($100/kW) x 106 kW = $100 million. An additional error with such "avoided" distribution system estimates is that they fail to recognize that distribution systems require "lumpy" investments, i.e., system capacity cannot be increased in increments of 1 kW. For a more detailed discussion, see Charles D. Feinstein and Jonathan A. Lesser, "Defining Distributed Utility Planning," *Energy Journal*, vol 18, Special Issue: Distributed Resources: Toward a New Paradigm of the Electricity Business (1997): 41–62.

[120] For an introduction, see Paul Denholm et al., "Methods for Analyzing the Benefits and Costs of Distributed Photovoltaic Generation to the U.S. Electric Utility System," NREL, NREL/TP -6A20-62447, Sept. 2014, pp. 37–43.

[121] Ibid. This issue also is discussed in NYISO 2016b.

[122] U.S. EIA, 2017 *Annual Energy Outlook*, Table 8.

[123] A levelized cost is a convenient way of comparing the costs of projects. In effect, cost levelization converts a stream of future costs, including capital costs, O&M costs, etc., into a single $/MWh value. For details of how levelized costs are calculated, see Leonardo R. Giacchino and Jonathan A. Lesser, *Principles of Utility Corporate Finance* (Reston, VA: Public Utilities Reports, 2011), pp. 41–44.

[124] U.S. EIA, 2017 *Annual Energy Outlook*, Table A8.

[125] NYSERDA estimated different cases based on the rate of solar PV cost reductions and the presence or absence of the ITC.

[126] Because the estimated levelized costs in the NYSERDA Solar Study included estimates for annual fixed O&M costs, property taxes, and insurance costs (pp. 3–11), the overall levelized cost cannot simply be increased by the ITC percentage. I estimated the percentage of the ITC to apply to the levelized cost by subtracting the present value of these annual costs from the levelized cost. Given the assumed reductions in installed costs, the ITC would apply to about 85% of costs in 2011, decreasing to about 65% by 2025. To be conservative, I used the 65% value for all years.

[127] I discuss the SCC and the fundamental economic flaw in applying SCC values to reductions in in-state CO_2 emissions below.

[128] NYSERDA 2013, p. 27, Table 11.

[129] NYISO 2016a, p. 11, provides estimates of the additional reserve capacity needed to meet the interim 50% renewable resource goal in 2030. NYISO estimated that the additional 15,000 MW of installed renewable generation, including onshore and offshore wind, utility-scale solar PV, and BTM solar PV, would require almost 8,900 MW of additional reserve capacity to ensure system reliability.

[130] The B/C ratio values calculated by NYSERDA and shown in the table are actually incorrect. Rather than treat the $80 million in "Investments Not Made" as a cost, NYSERDA treated it as a reduction in gross benefits. Thus, the B/C ratio under the "Base SCC" scenario equals ($2,077 - $80) / $431 = 4.6. Treating the $80 million as a cost would result in a B/C ratio of $2,077 / $511 = 4.1.

[131] NYDPS 2016, p. 283.

[132] The IWG is discussed in Lesser, "Missing Benefits, Hidden Costs," p. 10.

[133] Even the EPA previously admitted that its Clean Power Plan (CPP) would have no measurable impact on world climate. The plan is currently in legal limbo, having previously been stayed by the U.S. Supreme Court and, more recently, placed under review by the current EPA administrator.

[134] In an attempt to get around the basic physical fact that its CPP would have no measurable impact on climate and thus no climate benefits, the EPA argued that, because climate change is a world problem, the SCC estimates must be based on world climate impacts. This is a typical public-good argument: no single party can capture all the benefits of a public good, which means that too little of that public good will be supplied. The argument is correct, as far as it goes, but the EPA misused the argument: because the CPP itself would have no measurable climate impacts, there is no public benefit. Nor would the voluntary emissions reductions of the Dec. 2015 Paris Agreement have any measurable benefits. The same can be said for New York's 80 by 50 mandate.

[135] The SCC values have been shown to be arbitrary, based not on economics but on the preferences of the modelers who have developed SCC estimates. For a detailed discussion, see Lesser, "Missing Benefits, Hidden Costs," pp. 9–16.

[136] NYDPS Final EIS, p. 4-5, Exhibit 4-2.

[137] NYDPS 2016, p. 284. This value excludes the assumed reductions associated with subsidies for upstate nuclear plants. Moreover, as those plants' operating licenses all expire by 2030, CO_2 emissions would likely increase beginning in 2031, unless the capacity of those plants were replaced entirely with renewable generation.

[138] NYSERDA 2013, p. 21, Table 6. The NYDPS Final EIS estimated reductions of SO_2 and NO_X of 11,600 tons and 9,800 tons, respectively, over 2015–30.

[139] EPA, "Regulatory Impact Analysis for the Final Mercury and Air Toxics Standards," Dec. 2011, p. ES-6, Table ES-4.

[140] NYSERDA Solar Study, p. 8-5.

[141] Lower-income residents are likely to drive older, higher-polluting vehicles. However, these residents are least likely to be able to afford to purchase a new vehicle, much less an electric vehicle, even with tax credits and rebate programs.

[142] New York State, Vehicle and Boat Registration by Fuel Type.

[143] See, e.g., Thomas Jenkin et al., "The Use of Solar and Wind as a Physical Hedge Against Price Variability Within a Generation Portfolio," NREL, Aug. 2013.

[144] For a discussion, see Severin Borenstein, "The Private and Public Economics of Renewable Electricity Generation," *Journal of Economic Perspectives* 26, no. 1 (Winter 2012): 67–92. A specific analysis relative to solar PV is Gregory Nemet, "Beyond the Learning Curve: Factors Influencing Cost Reductions in Photovoltaics," *Energy Policy* 34, no. 17 (Nov. 2006): 3218–32.

[145] Gresham's Law is named after Sir Thomas Gresham, a 16th-century British financier who observed that "bad money drives out the good." See Jonathan A. Lesser, "Gresham's Law of Green Energy," *Regulation* (Winter 2010–11): 12–18.

[146] NYDPS 2016, p. 16.

[147] Ibid., p. 283. The NYDPS analysis uses a 5.5% real (after inflation) discount rate.

[148] 2017 SOTS Address, *supra* n. 25.

[149] Office of the State Comptroller, Deepwater Wind South Fork Project, Contract No. C00083. Although I submitted a FOIA request to LIPA for a copy of the actual contract, that request was denied because the contract is deemed to be commercially sensitive.

[150] Using an assumed 47% capacity factor, which is the capacity factor for Deepwater Wind's Block Island project off the coast of Rhode Island, and the assumed 2.0% escalation rate in the annual price, the initial price can be calculated such that the total revenues equal the $1.625 billion contract cost.

[151] Aaron Smith et al., 2014–2015 Offshore Wind Technologies Market Report, NREL, NREL/TP-5000-64283, Sept. 2015, p. 69.

[152] U.S. EIA, *Annual Energy Outlook*, May 2017, Table A20.

[153] Ibid., Table 8.

[154] NYDPS 2016, p. 281.

[155] These forecasts of market price presume that there will be a viable wholesale electric market. As discussed below, the increased penetration of renewable generation is likely to lead to a collapse of that market.

[156] The analysis assumes that all the offshore wind generation installed remains operational through 2050. The capacity factor for all offshore wind is also assumed to be the same 47% value as Deepwater Wind.

[157] NYSERDA 2012, Appendix A-4, p. A-64, Table 119. NYSERDA's "low-case" estimate includes both additional technological cost savings and continuation of the federal ITC. Because tax credits are simply subsidies paid by other taxpayers, including other New York taxpayers, the low-case levelized cost values estimated by NYSERDA are not reflective of true costs.

[158] Ibid.

[159] As discussed below, the increase in solar and wind generation required to meet the CES 80 by 50 goal would almost surely result in the entire collapse of the wholesale market (see the sidebar on p.29), making direct comparisons between the costs of renewable generation and the market cost impossible.

[160] Although biomass and hydroelectric generation have a positive marginal cost, NYDPS projects that over 80% of the increased renewable generation will be wind and solar PV. NYDPS 2016, p. 280. The wind production tax credit allows wind generators that receive the credit to submit negative price offers and still profit.

[161] Jürgen Flauger and Franz Hubik, "Electricity Prices in Free Fall," *Handelsblatt Global*, Mar. 23, 2016.

[162] Paul Deane et al., "Irish and British Historical Electricity Prices and Implications for the Future," *ESRI Research Bulletin*, Apr. 25, 2016.

[163] See A. Myrick Freeman, *The Measurement of Environmental and Resource Values: Theory and Methods* (Washington, DC: Resources for the Future, 1993).

[164] See, e.g., Claire Montgomery et al., "Pricing Biodiversity," *Journal of Environmental Economics and Management* 38, no. 1 (July 1999): 1–19.

[165] Edward Southwick and Lawrence Southwick, "Estimating the Economic Value of Honey Bees (Hymenoptera: Apidae) as Agricultural Pollinators in the United States," *Journal of Economic Entomology* 85, no. 3 (Sept. 2014): 621–33.

[166] Thomas Kunz et al., "Ecosystem Services Provided by Bats," *Annals of the New York Academy of Sciences* 1223 (2011): 1–38.

[167] See, e.g., Daniel Shepard et al., "Evaluating the Impact of Wind Turbine Noise on Health-Related Quality of Life," *Noise Health* 13, no. 54 (2011): 333–39. For a general literature review, see Loren Knopper and Christopher Ollson, "Health Effects and Wind Turbines: A Review of the Literature," *Environmental Health* 10 (2011): 78–87. See also Michael Nissenbaum, Jeffery J. Aramini, and Christopher D. Hanning, "Effects of Industrial Wind Turbine Noise on Sleep and Health," *Noise Health* 14, no. 60 (2012): 237–43. This study examined the health effects on residents living near industrial wind turbines in Maine.

[168] Ben Hoen et al., "A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States," Lawrence Berkeley National Laboratory, LBNL-6362E, Aug. 2013. These authors found no statistically significant change in property values, including properties in New York. However, their analysis does not provide a breakdown of results by state.

[169] Stephen Gibson, "Gone with the Wind: Valuing the Visual Impacts of Wind Turbines Through House Prices," London School of Economics, Apr. 2014. Gibson criticizes the specification of Hoen, "Spatial Hedonic Analysis," as including various non-wind-related variables that he believes would absorb any price differentials.

[170] Martin Heintzelman and Carrie Tuttle, "Values in the Wind: A Hedonic Analysis of Wind Power Facilities," *Land Economics* 88, no. 3 (Aug. 2012): 571–88.

[171] Corey Lang and James J. Opaluch, "The Windy City: Property Value Impacts of Wind Turbines in an Urban Setting," *Energy Economics* 44 (July 2014): 413–21.

[172] USDA, 2016 State Agriculture Overview.

[173] This includes both hay and alfalfa.

[174] NYDPS Final EIS, p. 5-28, Exhibit 5-13.

[175] See, e.g., Wei Zhang, Corey D. Markfort, and Fernando Porté-Agel, "Experimental Study of the Impact of Large-Scale Wind Farms on Land–Atmosphere Exchanges," *Environmental Research Letters* 8, no. 1 (2013): 1–8. See also Lisa Linowes, "The Incompatibility of Wind and Crop 'Farming,' " MasterResource.org, July 1, 2013.

[176] NREL 2013.

[177] NYSERDA, "Advancing the Environmentally Responsible Development of Offshore Wind Energy in New York State: A Regulatory Review and Stakeholder Perceptions," June 2015.

[178] New York Department of State, "Offshore Atlantic Ocean Study," July 2013, p. 1.

[179] New York Sea Grant Institute, "The Economic Contribution of the Sport Fishing, Commercial Fishing, and Seafood Industries to New York State," 2001.

[180] NYDPS Final EIS, p. 5-44.

[181] USDOE 2016.

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Abstract

In 2016, the New York Public Service Commission enacted the Clean Energy Standard (CES), under which 50% of all electricity sold by the state's utilities must come from renewable generating resources by 2030, and emissions of greenhouse gases (GHG) must be reduced by 40%. The CES also incorporates New York's previous emissions reduction mandate, which requires that the state's GHG emissions be reduced 80% below 1990 levels by 2050 (the "80 by 50" mandate).

Key Findings

- Given existing technology, the CES's 80 by 50 mandate is unrealistic, unobtainable, and unaffordable. Attempting to meet the mandate could easily cost New York consumers and businesses more than $1 trillion by 2050.
- The CES mandate will require electrifying most of New York's transportation, commercial, and industrial sectors. (In 2014, for example, fossil-fuel energy used for transportation was twice as large as all end-use electricity consumption combined.) Even with enormous gains in energy efficiency, the mandate would require installing at least 100,000 megawatts (MW) of offshore wind generation, or 150,000 MW of onshore wind generation, or 300,000 MW of solar photovoltaic (PV) capacity by 2050. By comparison, in 2015, about 11,300 MW of new solar PV capacity was installed in the entire U.S. Moreover, meeting the CES mandate likely would require installing at least 200,000 MW of battery storage to compensate for wind and solar's inherent intermittency.
- Meeting the CES interim goals—building 2,400 MW of offshore wind capacity and 7,300 MW of solar PV capacity by 2030—could result in New Yorkers paying more than $18 billion in above-market costs for their electricity between now and then. By 2050, the above-market costs associated with meeting those interim goals could increase to $93 billion. It will also require building at least 1,000 miles of new high-voltage transmission facilities to move electricity from upstate wind and solar projects to downstate consumers. No state agency has estimated the environmental and economic costs of this new infrastructure.
- The New York Department of Public Service and the New York State Energy Research and Development Authority claim that renewable energy and the CES will provide billions of dollars of benefits associated with CO_2 reductions. Not so. Regardless of one's views on the accuracy of climate models and social-cost-of-carbon estimates, the CES will have no measurable impact on world climate. Therefore, the value of the proposed CO_2 reductions will be effectively zero.

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