Too Big to Bail Out

The Economic Costs of a National Nuclear Power Subsidy

by Tim Judson **November 2016**

Since 2014, nuclear power companies and supportive policymakers have begun promoting new forms of subsidies to benefit existing nuclear power stations in the United States. Thus far, such proposals have only been adopted in one state (New York), and legal and regulatory challenges have resulted in only one nuclear reactor receiving temporary financial support to date: the R.E. Ginna Nuclear Power Plant in New York, from April 2015-March 2017.

A new long-term, statewide subsidy policy recently adopted in New York, to be implemented beginning in April 2017, is now being touted as a national model. The total cost of the 12-year subsidy New York is offering to Ginna and three other reactors is substantial: an estimated $7.6 billion--more than three times as much as the subsidies for new renewable energy sources ($2.44 billion by 2030) under the state's new 50%-by-2030 renewable energy standard.

A recent draft report by the U.S. Department of Energy recommends providing new and increased subsidies and incentives to promote the longevity of existing reactors and deployment of new reactors; the DOE report recommends subsidies amounting to $27/MWh, very close to those under the New York model.[1] According to this analysis, **a national subsidy program based on New York's would carry a significant cost to consumers and/or taxpayers: over $280 billion by 2030.** According to a recent report by *Bloomberg*, over half of existing nuclear power in the U.S. (56% of total generation) is projected to be unprofitable by 2020. If only unprofitable reactors were subsidized through such a program, the cost would still be quite large: **$160 billion by 2030.**

We provide these estimates to inform discussion of nuclear energy policy proposals in the coming months, as state and federal policymakers consider how to respond to the declining economics of nuclear power. The energy status quo is changing rapidly, between aging energy infrastructure, dramatic advances in renewable energy and new technologies, the need to rapidly reduce greenhouse gas emissions, and problems of energy affordability and consumer cost burdens. Decisions about how to deal with nuclear power must be made in context of these broader changes, as well as in consideration of the economic and environmental impacts of subsidizing aging reactors and other legacy energy infrastructure.

Reactor Closures and Operating Cost Trends

Proposals to subsidize existing nuclear power plants are being driven by the declining economic viability of the U.S.'s aging nuclear fleet. From 2002-2012, average operating costs for nuclear power plants rose by 50%, or about 4.5% per year, on average.[2] At the end of that period, the closure of five reactors were announced in a 10-month period--the first reactor closures in the U.S. in nearly fifteen years.[3] That period spanned the "deregulation" of electricity markets, during which the industry's economics improved significantly due to several factors:

- Approximately $130 billion (2016 dollars) in bailouts of nuclear utilities' bad debts for building reactors.[4]
- Improved economies of scale, due to consolidation of reactor ownership through utility mergers and sales of reactors.
- Surging electricity prices up through 2008, delivering high profit margins.
- Lightened safety regulations, requiring fewer shutdowns for maintenance and reduced or postponed costs.
- Operating practices and upgrades resulting in higher electricity output.

However, the advancing age of the reactor fleet also caught up with the industry during this time. The U.S. has the oldest reactor fleet in the world, now averaging 35.6 years, with 37% older than their original licensed lifespan of 40 years; another 37% are between 31 and 40 years old.[5] The capital cost of maintaining aging reactors has risen dramatically, due to the high cost and specialized nature of materials and components.

Since 2014, six more closures have been announced, and several more reactors have been named as potential closure candidates. A July 2016 Bloomberg report found that 56% of the U.S. reactor fleet may be uneconomical to operate by 2020.[6] Policymakers have not adequately understood the cost factor driving the reactor closure trend, and a prevailing wisdom still lingers among regulators and policymakers that nuclear power is cheap—which only ever appeared to be true because of the bailout of nuclear stranded costs in the 1990s shift to competitive power markets.

Announced and Potential Reactor Closures (2013-2016)

Nuclear Reactor/s	State	Capacity (MW)	Closure Date	Reason
Crystal River 3	FL	860	Feb. 2013	Maintenance Error
Kewaunee	WI	556	May 2013	Uneconomical
San Onofre 2&3	CA	2,350	June 2013	Maintenance Error
Vermont Yankee	VT	610	Dec. 2014	Uneconomical
Fort Calhoun	NE	480	Oct. 2016	Uneconomical
Clinton	IL	1,080	June 2017	Uneconomical
Quad Cities 1&2	IL	1,824	June 2018	Uneconomical
Pilgrim	MA	688	June 2019	Uneconomical
Oyster Creek	NJ	637	Aug. 2019	Legal Settlement
Diablo Canyon 1&2	CA	2,240	2024 & 2025	Energy Planning
FitzPatrick	NY	838	Possible	Uneconomical
Ginna	NY	581	Possible	Uneconomical
Three Mile Island 1	PA	829	Possible	Uneconomical
Davis-Besse	OH	889	Possible	Uneconomical
Palisades	MI	811	Possible	Uneconomical

The blame for nuclear's economic problems has been misplaced on lower electricity prices resulting from declining demand and the growth of lower-cost energy sources. However, had nuclear operating costs not increased so dramatically over the last 15 years, reactors would not be unprofitable nor would their owners require such large subsidies to ensure their continued operation. The industry is focused on new revenue sources because operating costs are rising and there is not much potential for further cost reductions: most of the reactors now closing are in competitive markets and their owners have operated under strict cost-discipline for well over a decade, with reduced staffing levels, higher operational performance, negotiated property taxes deals, etc.

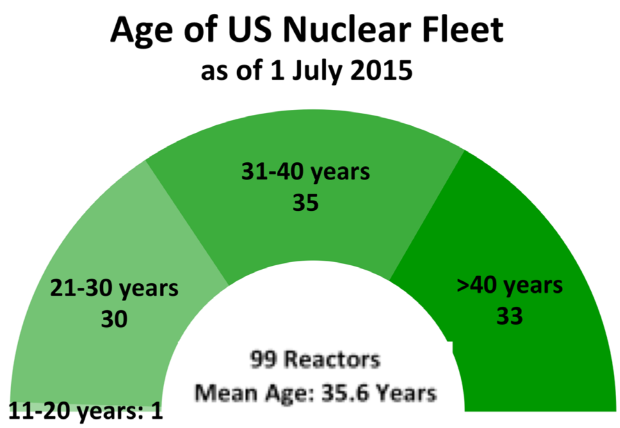
Nuclear Subsidies and Bailouts

Since 2014, the industry has advanced several talking points to support its pleas for new subsidies. Two of these have provided a basis for considered policymaking: grid reliability, that is, sufficient electricity supply and/or voltage support to avoid power shortages or blackouts; carbon dioxide emissions levels, through the assumption that the electricity provided by nuclear power plants that close down would be replaced by electricity from fossil fuel power plants. These claims about the roles nuclear can or must play are often inaccurate, and experience has shown that both reliability and emissions targets can be met in different ways.

The industry has also proffered political talking points, claiming that nuclear is being disadvantaged by a lack of government support, particularly relative to renewable energy sources. These considerations are worth addressing, to put the plea for new subsidies in the proper context. One the one hand, it is untrue that existing nuclear power stations are unsubsidized. Nearly all reactors were heavily subsidized by state and federal policies, from research and development, to favorable cost-recovery treatment by state utility commissions, to the aforementioned $130 billion bailout of stranded nuclear construction debts in the 1990s.[7] The new proposed subsidies are for these same reactors, nearly half of which were sold or transferred effectively debt-free to merchant power generators between 1998 and 2004.

On the other hand, the industry benefits from several major federal and state policies that reduce or eliminate reactor owners' liability for environmental impacts, including nuclear accident insurance, nuclear waste management and disposal, reactor decommissioning and site cleanup, uranium mine and processing waste, and water consumption. A comprehensive study of nuclear power subsidies in 2011 concluded that the cost of financial supports to the industry has frequently exceeded the value of the electricity nuclear power plants produce.[8]

In addition, the claim that renewable energy sources enjoy subsidies not offered to nuclear power is simply unfounded. The federal production tax credit (PTC) and investment tax credit (ITC) that support new wind, solar, and other generation sources have also been available to new nuclear reactors since 2005. Most existing reactors also benefitted from similar ITCs available at the time they were built. However, while the economics and performance of wind and solar have been favorable and improved dramatically over the last ten years, the opposite has been true of new nuclear reactors. As a result, not a single new reactor has been brought online in the eleven years since the nuclear PTC was created, so the industry has thus far failed to cash in on a subsidy very much on the same scale as that offered to new renewable energy sources ($18/MWh, or up to $750 million/year for the first 6,000 MW of new reactors).



Source: World Nuclear Industry Status Report 2016.

It is important to remember that, while the merits of energy subsidies may be debated, the purpose of the federal tax subsidies is to encourage technological innovation and deployment of commercially viable energy sources, and that all of those incentives phase out over time. If new nuclear generation were commercially viable, the industry would have been able to build reactors to begin replacing older, uneconomical units with the incentives the federal government has offered. However, providing new, long-term or open-ended subsidies to existing nuclear reactors does nothing to advance innovation and technological development, nor to ensure that the U.S. meets its long-term emissions reduction obligations.

Nuclear Power in the Clean Power Plan

The Environmental Protection Agency (EPA) considered the possible role nuclear power could play in meeting carbon emissions goals in the Clean Power Plan (CPP) regulations adopted in 2015. The CPP establishes state-level carbon dioxide (CO2) emissions targets for existing power plants based on the "best system of emissions reduction" (BSER), determined through evaluating feasible and cost-effective strategies for reducing emissions in the 2030 timeframe.

In the draft regulation published in June 2014, the EPA proposed including two sources of nuclear generation in the BSER[9]:

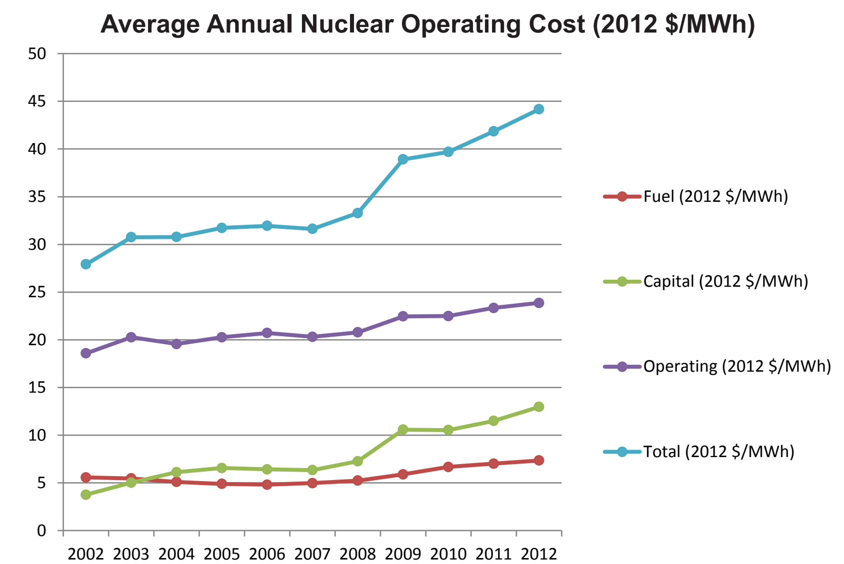
- Five new reactors already under construction in 2014, which EPA assumed were likely to be completed.
- 6% of states' existing nuclear generation, in recognition of economic pressures on the industry.

It is worth noting that the EPA also considered including existing renewable generation facilities as BSER, to encourage their continued operation.

In the final regulation published in August 2015, EPA revised its consideration of nuclear power and existing renewables, removing both from BSER and states' emission targets. With respect to existing reactors, EPA based the draft CPP on an assumption that the economic margins causing reactor closures were only around $6/MWh, much smaller than the actual conditions in the industry. In preparing the final regulation, EPA determined that both retiring nuclear power plants and renewable energy sources could be replaced with new renewable energy sources, and it was not appropriate to include them in setting the emissions goals.[10] However, in the final rule, EPA also created mass-based emissions targets as an alternative to the rate-based targets. The nuclear industry is urging states to adopt mass-based targets because it provides a rationale for subsidizing existing reactors. It is nevertheless important to remember that EPA set the targets at levels that would enable nuclear to be replaced with renewables and/or energy efficiency.

Further, the EPA had sound reasoning for basing the CPP on rate-based emissions targets. Electricity generation is only one source of CO_2 emissions, and some strategies for reducing emissions in transportation, heating, manufacturing, agriculture, etc., may involve increasing reliance on electricity. For instance, increasing use of electric vehicles and geothermal heat pumps could increase electricity demand--and place upward pressure on CO_2 emissions from power plants in the 2030 period--but still lead to significant decreases in overall emissions because of the much greater efficiency of natural gas power plants compared to combustion engines, furnaces, and boilers.

Thus, by locking themselves into mass-based emissions goals for the CPP, states might limit their flexibility in achieving the overall mass-based emissions reductions that are ultimately necessary. For instance, in 2011, New York had reduced greenhouse gas (GHG) emissions from electricity generation by over 30% from 1990 levels, while total statewide emissions only dropped by 11%.[11] If the state is to meet its goal of reducing statewide GHG emissions by 40% in 2030, reducing power plant emissions is much less important than addressing transportation and heating, which made up 60% of statewide emissions in 2011, compared to just 20% from power plants. Reducing emissions as rapidly as possible from all sectors is preferable, but states should have a comprehensive strategy that identifies low-hanging fruit, while supporting measures that will be necessary to achieve deep emissions reductions in the 2030-2050 timeframe.



Subsidy Proposals

Several ways of delivering subsidies for existing reactors have been proposed over the last 2-3 years. However, the industry has had difficulty advancing them because of both the heavy price tag and the failure to identify legally and technically sound policies to justify payments that are large enough to make reactors profitable. The American Nuclear Society published a handbook detailing a wide range of ideas to restore reactors to profitability, some of which have proved inadequate or unsound; others lack sufficient detail to be ready for widespread consideration.[12] Actual policymaking has proved a crucible for testing the soundness of various subsidy models, most of which have proved insufficient or not viable.

Illinois: Low-Carbon Energy Standard

In 2014, Exelon demanded the state begin providing subsidies for nuclear generation before addressing the state's lagging development of renewable energy. Following completion of a multi-agency review of nuclear economic conditions and impacts of reactor closures, Exelon proposed legislation to create a Low-Carbon Energy Standard (LCES) in 2015. The proposed LCES would require investor-owned utilities (IOUs) to purchase credits from qualifying sources for up to 70% of the electricity they provide to their customers.[13] The eligibility standards proposed favored nuclear power plants, and the 70% standard represents roughly the amount of electricity generated by Exelon's eleven reactors in Illinois. Together with the state's existing renewable energy standard and a standard for fossil fuel generation employing carbon capture and sequestration, the LCES added up to about 100% of the affected utilities' electricity sales.

The LCES would cost consumers about $300 million per year, producing subsidies of $27 million per reactor, on average. Lawmakers have been unwilling to support such a large subsidy, particularly with other significant budgetary problems affecting the state government and the ongoing profitability of all but three of the eleven reactors.[14, 15] In addition, despite its continued advocacy for the subsidy, Exelon has said the LCES would be insufficient, on its own, to prevent the closure of the three most unprofitable reactors (Clinton and Quad Cities 1&2), which it says have lost about $800 million over five years. Exelon is negotiating with other stakeholders over compromise legislation to support those reactors, but it remains uncertain whether lawmakers would support a subsidy large enough to reverse the company's decision to close Clinton and Quad Cities.

Ohio: Long-Term Power Contracts

In Ohio, FirstEnergy proposed a subsidized power contract for the Davis-Besse reactor and several coal-fired power plants, arguing that the units were unprofitable and their continued operation is needed for reliability. Through the arrangement, FirstEnergy's utility companies in Ohio would purchase electricity from the power plants at prices determined by the operating costs of the plants (plus a profit margin), estimated to average at least $70/MWh over 15 years.[16]

That proposal appears to have thoroughly run aground. Challenges in the Public Utility Commission of Ohio (PUCO) proceeding resulted in revisions that shortened the contract period to eight years, before receiving PUCO approval. However, several affected parties complained to the Federal Energy Regulatory Commission (FERC), arguing that PUCO exceeded its authority by intervening in the wholesale energy market.[17]

FERC issued an order in April 2016, enjoining PUCO from implementing the contract pending a full review, a decision widely understood as a sign that FERC would rule against PUCO. Rather than wait for FERC to decide on the case, FirstEnergy submitted a new proposal to PUCO, involving shutting some of the coal units, but it was not clear that it would fare any differently at FERC.[18] But on October 12, PUCO rejected the proposal, and issued an order providing FirstEnergy's utilities vaguely designated payments to incentivize modernizing their transmission and distribution systems.[19]

Energy Market Reforms

The industry has also argued that competitive energy markets do not recognize the full value that nuclear power plants provide to the electricity system. Exelon, FirstEnergy, PSEG and others say that nuclear power plants provide significant reliability and market price benefits that should be rewarded. Market regulators have responded with some reforms that are delivering increased revenues to many nuclear plants, as well as other resources that provide the same benefits.

For instance, PJM, the largest electricity market in the country, has adopted new "capacity performance" rules for setting capacity market prices according to more stringent requirements. The rules began being implemented in 2015, and have delivered significantly increased capacity market revenues from two years ago.[20, 21] However, several reactors were unable to clear the auction--including two of the unprofitable Illinois reactors (Quad Cities 1&2)--because the prices they required were still too high.[22, 23] The third unprofitable Illinois reactor (Clinton) is in the adjacent electricity market (MISO), where capacity market reforms are also delivering higher prices, but still too low for Clinton to benefit.

Because grid operators are not reliant on any one resource to meet reliability and supply needs, even market regulators that are sympathetic to nuclear generators cannot justify setting prices based solely on the needs of particular uneconomical reactors, nor establishing policies to favor a specific technology for its own sake. At the same time, financial losses for uneconomical reactors are so large that even a combination of proposed subsidies and market reforms might be insufficient to justify their continued operation.

Subsidies in New York: 2014-2016

The industry has turned to New York to provide a model for delivering large enough nuclear subsidies. To date, New York is the only state where subsidies to an existing reactor have been implemented thus far, but only in a limited fashion. In 2014, Exelon announced that it would close the 44-year old Ginna reactor near Rochester, New York, unless the state approved an above-market contract guaranteeing sufficient revenue to meet the plant's operating costs. Based on a reliability impact study performed by the New York Independent System Operator (NYISO), which concluded that Ginna would be needed for reliability purposes for 3.5 to 5 years, the New York Public Service Commission (NY PSC) ordered the local utility, Rochester Gas and Electric (RG&E) to negotiate a Reliability Support Services Agreement (RSSA) with Constellation Energy Nuclear Group (CENG, the Exelon joint venture that owns Ginna).

In the course of the NY PSC proceeding, RG&E identified a substation upgrade that would resolve the reliability issues, by enabling more electricity to be transmitted to the Rochester area than RG&E's grid could previously handle. The upgrade could be implemented within two years, at lower cost than subsidies to support Ginna, thus permitting the reactor to close sooner than originally projected. On that basis, RG&E and

CENG entered into negotiations with PSC, FERC, and other parties to negotiate a two-year RSSA, which is providing $165 million in above-market subsidies over the two years (or $83 million/year).[24] At the time of this writing, RG&E has confirmed the substation project will be completed and operational before the March 31, 2017 termination of the RSSA.[25]

From RSSA to the Clean Energy Standard

Subsequent to the Ginna settlement, in October 2015, Entergy announced plans to close the FitzPatrick reactor, in nearby Oswego County. Governor Andrew Cuomo expressed concern about the local economic impact of the FitzPatrick closure. Negotiations with Entergy to reverse the decision were unsuccessful, and Governor Cuomo issued an order to the NY PSC in December 2015.[26, 27] Under the banner of a Clean Energy Standard, the governor directed the PSC to establish an enforceable 50% renewable energy standard by 2030, and to provide financial support for nuclear power plants to ensure their continued operation. Because the governor remains opposed to the operation of the Indian Point nuclear power plant near New York City, nuclear subsidies were to be limited to upstate reactors deemed to be unprofitable.

Average Annual Generation, by Reactor

Reactor	Generation Capacity (MW)	Capacity Factor	Avg. Annual Generation (MWh)
FitzPatrick	838	94%	6,900,427
Ginna	581	94%	4,784,186
Nine Mile Point 1	621	94%	5,113,562
Nine Mile Point 2	1,311	94%	10,795,298

PSC commenced the proceeding in January 2016, and the Department of Public Service (DPS, the administrative agency) issued a white paper proposal on the renewable energy standard and the nuclear subsidy program.[28] The DPS's nuclear proposal was based on the subsidy mechanism in the recently approved Ginna RSSA. Reactors would become eligible for subsidies based on whether they are unprofitable, and be compensated based on the difference between their projected annual operating costs and projected market revenues.

The subsidies would be delivered through the sale of Zero Emissions Credits (ZECs), a unique instrument priced according to the projected economic losses of qualifying reactors, divided by their total annual electricity output. All load-serving entities (LSEs) in the state, including distribution utilities and electricity retailers, would be required purchase ZECs in proportion to their share of statewide electricity sales. For instance, a utility that sells 10% of the electricity in the state would have to purchase 10% of the available ZECs.

The proposal envisioned the program commencing in April 2017 (after the Ginna RSSA expires) and extending to 2030, initially including Ginna and FitzPatrick; the other two upstate reactors, Nine Mile Point 1 and 2, would phase in over the next two to three years, based on their profitability projections. Indian Point would be excluded. Based on projected market prices and reactor operating cost and performance, NIRS and the Alliance for a Green Economy estimated that the subsidy would cost between $3 billion and $5.5 billion by 2030.[29]

Various parties to the case challenged the proposal, arguing that it was anti-competitive, uneconomical, and/or unjustified. In addition, Entergy argued that the exclusion of Indian Point was discriminatory, and that the subsidies should be based on avoided CO2 emissions, rather than reactor profitability and operating costs.[30] In addition, a reliability study provided by NYISO concluded that neither Ginna nor FitzPatrick would be required for reliability purposes after their anticipated 2017 closure dates, eliminating the conventional rationale for providing economic assistance to merchant power plants.[31]

A New Subsidy Model

DPS issued a second white paper in July with a revised proposal for pricing subsidies for nuclear reactors.[32] The proposal was adopted by the PSC after a mere two-week period for public comment, along with the rest of the Clean Energy Standard.[33] The revised nuclear subsidy program declares qualifying nuclear facilities as a public necessity, and requires all LSEs to purchase proportional amounts of ZECs. No LSEs are exempted, including those offering 100% renewable energy products, as well as public power companies, which are not normally subject to PSC's ratemaking authority. The PSC adopted a set of five criteria for making public necessity determinations and concluded that the four upstate reactors would immediately qualify for the program, and Indian Point 2 and 3 would not, due to the facilities' profitability on the basis of market-based revenues. However, unlike the initial proposal, the adopted ZEC program leaves open the possibility that Indian Point could qualify at a future date.

The program is to be implemented for a twelve-year period, commencing April 1, 2017 with the CES, and concluding on March 31, 2029. PSC did not explain the reasons for terminating the ZEC program 21 months before the remainder of the CES, but the nuclear operating licenses for two of the four reactors initially covered by the program expire in 2029 (Nine Mile Point 1 and Ginna), and both would normally be scheduled for refueling outages in the spring of that year.

The New York State Energy Research and Development Authority (NYSERDA) would be required to enter into a 12-year contract with reactor owners for the purchase of ZECs, and would serve as the purveyor of ZECs to the LSEs. The PSC ruling states that the purpose of the 12-year contract is to provide a guarantee to the reactor owners on the basis of which they can make investments in the reactors. NYSERDA also serves as the administrator of the REC market.

New York Subsidy Formula and Adjustments

If the program is implemented, ZECs will be priced, not according to reactors' projected cash flow losses (though unprofitability is one of the criteria for the public necessity determination), but according to a price on CO2 emissions assumed to be avoided through reactors' continued operation. The program would be structured in six two-year periods (labeled "tranches"), with adjustments to the ZEC price before commencement of each. DPS proposed using the EPA's Social Cost of Carbon (SCC) as the basis for ZEC prices. The SCC is used in regulatory analyses to determine the environmental impact of policies and actions affecting incremental CO2 emissions.

The PSC determined that this pricing method rewards nuclear for an environmental attribute (i.e., avoided CO2 emissions), and believes it is consistent with the Supreme Court's *Hughes v. Talen* decision, which preserves states' authority to subsidize power sources on such bases. However, legal challenges to the NY PSC ruling are expected, for instance, due to the uncompetitive nature of the ZEC program, and the CES's uneven application of the SCC to one energy source (nuclear) and not others providing similar CO2 benefits. (RECs will still be priced according to the type of competitive market model that is quite well-established.)

ZEC Pricing Formula

Social Cost of Carbon	MINUS	RGGI Baseline Effect	MINUS	Market Price Threshold	EQUALS	ZEC Price

Projected ZEC Prices

Tranche	SCC ($/ton)	RGGI Effect ($/ton)	Adjusted SCC ($/ton)	Conversion Factor (tons/MWh)	ZEC Base Price ($/MWh)	Market Price Threshold ($/MWh)	ZEC Price ($/MWh)
1	$42.87	$10.41	$32.46	0.53846	$17.48	$0	$17.48
2	$46.79	$10.41	$36.38	0.53846	$19.59	unknown	≤ $19.59
3	$50.11	$10.41	$39.70	0.53846	$21.38	unknown	≤ $21.38
4	$54.66	$10.41	$44.25	0.53846	$23.83	unknown	≤ $23.83
5	$59.54	$10.41	$49.13	0.53846	$26.45	unknown	≤ $26.45
6	$64.54	$10.41	$54.13	0.53846	$29.15	unknown	≤ $29.15

The ZEC pricing formula includes the following:

- Two-year average SCC price for each period.
- Market price effect of the Regional Greenhouse Gas Initiative (RGGI) cap-and-trade program (weighted average for the first two-year period, April 1, 2017-March 31, 2019).
- NYISO Zone A market and capacity prices in excess of $39/MWh.

The SCC and RGGI factors are converted to an electricity price figure ($/MWh) using a factor for the CO2 emissions rate of fossil fuel generation sources presumed to replace nuclear if reactors permanently cease operations. The factor NY PSC used was provided in a December 2015 report prepared for a proceeding to determine the value of distributed solar photovoltaics.[34] The report included a calculation of the incremental emissions rate for generation sources that would supplement variations in solar output, estimated at 0.538456 tons/MWh, based on a weighted average mix of emissions from coal-, natural gas-, and oil-fired generation sources.[35]

PSC also assumed that forward-going impacts of RGGI price increases would be accounted for through the baseline market price adjustment, though that would only be true if market prices exceed the $39/MWh threshold. DPS assumed in its cost analyses that market electricity prices in New York would rise significantly over the period of the CES. It is possible that prices could rise from current levels, due to fuel costs, carbon pricing, and other factors; but it is also possible that prices may not rise substantially, due to increasing renewable energy generation, energy efficiency, demand response and other peak load reducing resources, energy storage, and other distributed energy resources. The rapid growth of such non-fossil fuel energy resources--per the objectives of the CES and the development of NY's distributed energy resource market--could lead to stable or decreasing market prices in the future, both by decreasing the amount of fossil fuel generation bidding into the market, as well as fundamental changes to wholesale market dynamics. It is also true that, despite occasions of short-term market volatility, the trend since 2008 is that markets and regulators have responded to prevent sustained increases in electricity prices.

It is, therefore, possible that ZECs will end up being sold at their maximum price under the formula. On the other hand, should market prices rise from the CES's threshold level, then ZECs would instead provide a sort of guaranteed premium price for nuclear, equal to the sum of $39/MWh and the ZEC Base Price.

It is worth noting that the levelized costs of energy for other major low-carbon energy resources (wind, utility-scale solar, and energy efficiency) are all projected to be lower than the ZEC-guaranteed prices for nuclear generation under the CES, particularly as ZEC prices go up over time.[36]

ZEC-Guaranteed Nuclear Energy Prices

Tranche	Total Energy Price ($/MWh)
1	$56.48
2	$58.59
3	$60.38
4	$62.83
5	$65.45
6	$68.15

ZEC Subsidy Cost Projections

Reactor	Cost: Tranche 1	Cost: Tranche 2	Cost: Tranche 3	Cost: Tranche 4	Cost: Tranche 5	Cost: Tranche 6	TOTAL
Ginna	$167,255,157	$187,444,423	$204,571,810	$228,014,324	$253,083,461	$278,918,067	**$1,319,287,242**
FitzPatrick	$241,238,935	$270,358,738	$295,062,267	$328,874,360	$365,032,599	$402,294,906	**$1,902,861,805**
Nine Mile Point 1	$178,770,142	$200,349,375	$218,655,928	$243,712,384	$270,507,451	$298,120,688	**$1,410,115,967**
Nine Mile Point 2	$377,403,632	$422,959,791	$461,606,960	$514,503,922	$571,071,285	$629,365,897	**$2,976,911,487**
TOTAL	**$964,667,883**	**$1,081,112,347**	**$1,179,896,987**	**$1,315,105,014**	**$1,459,694,822**	**$1,608,699,587**	**$7,609,176,501**

ZEC-Guaranteed Nuclear Energy Costs

Reactor	Cost: Tranche 1	Cost: Tranche 2	Cost: Tranche 3	Cost: Tranche 4	Cost: Tranche 5	Cost: Tranche 6	TOTAL
Ginna	$540,421,696	$560,610,962	$577,738,350	$601,180,863	$626,250,000	$652,084,606	**$3,558,286,477**
FitzPatrick	$779,472,257	$808,592,059	$833,295,589	$867,107,682	$903,265,920	$940,528,227	**$5,132,261,734**
Nine Mile Point 1	$577,628,009	$599,207,242	$617,513,795	$642,570,251	$669,365,318	$696,978,555	**$3,803,263,171**
Nine Mile Point 2	$1,219,436,907	$1,264,993,067	$1,303,640,235	$1,356,537,197	$1,413,104,561	$1,471,399,172	**$8,029,111,138**
TOTAL	**$3,116,958,925**	**$3,233,403,389**	**$3,332,188,029**	**$3,467,396,056**	**$3,611,985,864**	**$3,760,990,629**	**$20,522,922,520**

New York Cost Projections

To estimate the cost of New York's nuclear subsidy program, it is necessary to apply the ZEC price to the projected annual generation output of each of the reactors participating in the program. The projected annual generation output can be determined by multiplying the rated generation capacity of each reactor by the number of hours of operation each year. The latter figure is represented by the maximum number of hours per year (8,760) multiplied by the capacity factor, representing the percentage of hours of full-time equivalent operation for the reactor. NY PSC applied a capacity factor for nuclear generation of 94%.

The total projected cost of nuclear energy subsidies through New York's program is $7.6 billion (nominal dollars) through March 31, 2029. It should be noted that this cost is more than three times DPS's projected cost of subsidies for new renewable energy sources to be deployed through the CES program ($2.44 billion, through 2030). In order to reach the 50% renewable energy goal, DPS projects sufficient renewable energy generation will be developed by 2030 to provide 33.7 million MWh/year of electricity. That is to say, renewables would generate more than 22% more electricity than the maximum amount that will be supported through nuclear subsidies, at one-third of the total subsidy cost to consumers, making renewable energy subsidies nearly four times as effective at mitigating CO2 emissions as nuclear subsidies.

In addition, because at least two of the four reactors would close in 2029 when their operating licenses expire, the nuclear subsidy program will result in at most 17.7 million MWh of generation to assist in meeting the state's 2030 emissions goal--or just over half (52.5%) as much electricity as supplied by new renewable energy sources. The state's renewable energy program is therefore projected to be nearly six times more cost-effective toward reducing emissions than subsidies for nuclear power. Despite this imbalance in funding support, the total generation from new renewable sources would be about two-thirds (64.6%) of the total amount of subsidized nuclear generation under the CES, making renewable energy twice (201%) as cost-effective at mitigating carbon emissions in the near term.

Providing above-market subsidies to nuclear power plants not only imposes additional costs on electricity consumers and/or taxpayers. It guarantees that the electricity they generate will find a market—both taking market share from competing sources, including renewables; and consuming ratepayer dollars for the commodity price of the power. Conceived another way, the anti-competitive subsidies provided to financially prop up nuclear power plants are the tip of a fiscal iceberg. They also force consumers to buy the nuclear-generated electricity, thereby directing even more money to supporting nuclear power, rather than toward purchasing power from renewables, energy efficiency, or other low-/zero-carbon resources.

In that light, New York's nuclear subsidies involve a large opportunity cost in the leveraging of capital for long-term emissions reduction strategies. The total cost of nuclear-generated electricity supported by the New York ZEC program can be determined by multiplying the ZEC-guaranteed energy cost by the average annual generation of each reactor. Under the CES, consumers will purchase electricity from subsidized nuclear power plants for a total cost of up to $20.5 billion by 2029 (nominal dollars).

Nuclear Subsidy Proposals

Status, Features, Costs and Impacts - side A [61, 62, 63]

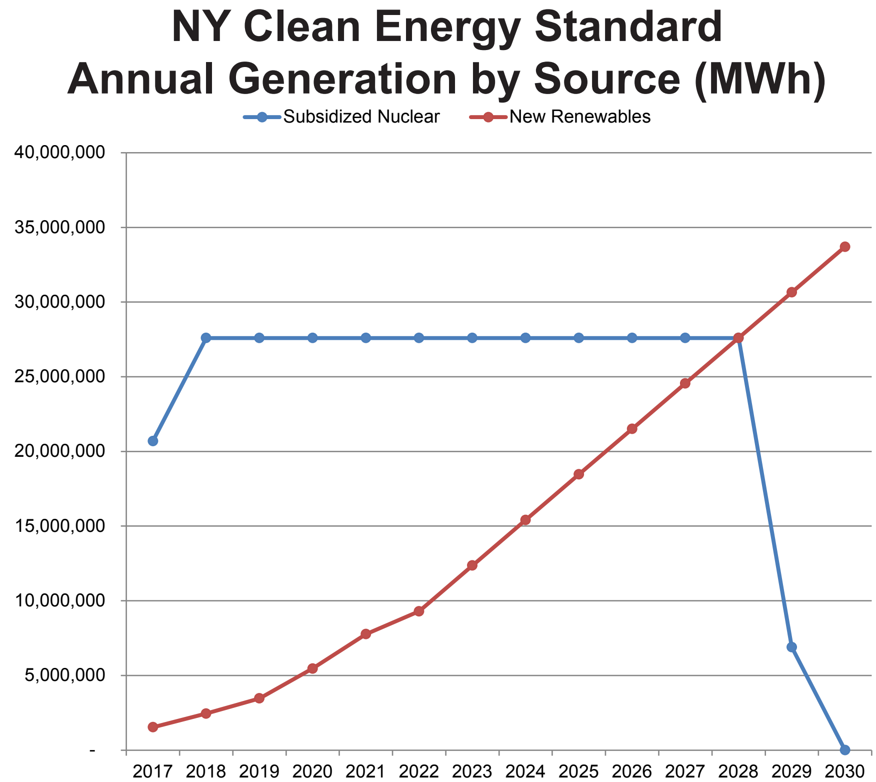
Subsidy Model	Nuclear Zero Emissions Credit	Low-Carbon Portfolio Standard	Cost+ PPA
Places Proposed	New York	Illinois	Ohio, Connecticut
Places Adopted	New York	none	none
Places Implemented	none	none	none
Policymaking Venue	Utility Commission Rule	Legislation	OH: Utility Commission Review CT: Legislation
Administrator	Utility Commission	Utility Commission	Utility Commission
Policy Basis/ Rationale	GHG Emissions	GHG Emissions, Reliability, Economic Impacts	OH: Reliability. CT: GHG Emissions, Reliability, Economic Impacts.
Eligible Resources	Nuclear	Nuclear, Renewables, Coal Gasification w ≥90% Sequestration	OH: Coal, Nuclear. CT: Nuclear, Hydro, Renewables, Trash Incineration
Alternatives to Nuclear Evaluated	No	Yes, but restricted	No
Qualifications	Public necessity determination by state utility commission.	Merchant generation; PPA ≤ 5 years. Revised: Unprofitable.	OH: Specific PPs. CT: Public interest and cost-benefit determination based on generator proposals.
Mechanism	12-year ZEC purchase contract. Prices set in 2-year periods. Price formula based on Social Cost of Carbon.	Low-Carbon Energy Credits; Utilities purchase LCECs for 70% of retail electricity sales	Long-term PPAs. OH: Price = PP operating costs + 11.5% return on investment. Utility purchases power, resells on market. CT: Utilities enter PPAs based on state-approved proposals.
Caps/Limits	ZECs capped at 27.618 TWh. Decreases by one-third with each reactor closure. ZEC price adjusted if market revenues exceed $39/MWh.	Cost Cap: 2.015% of annual retail consumer costs as of May 31, 2009	OH: None. CT: ≤ 8.4 TWh of resources, including ≤ 1.26 GWh of trash incineration
Facilities Covered	Initially: Ginna, FitzPatrick, Nine Mile Point units 1&2. Possible: Indian Point units 2&3.	All Illinois nuclear PP (11 reactors @ 5 PPs). Revised: Clinton and Quad Cities (units 1&2) nuclear PPs	OH: Davis-Bessie Nuclear PP; Sammis Coal PP; two OVEC coal PPs. CT: Millstone nuclear PP, units 2&3.
Duration	12 years (2017-2029)	5 years, 5 months	OH: 8-15 years CT: ≤ 10 years (≤ 20 years for new PPs)
Amount	$965 million in first two years. Up to $7.6 billion over 12 years.	≤ $300 million/year	OH: $400 million over first 3 years. $3 billion over 15 years. CT: unspecified
Market Impact	Distortion (long-term): uneconomic generators insulated from market under exclusive contract.	Distortion: subsidy effectively uncompetitive; guaranteed market for uneconomic generators	Distortion (long-term): uneconomic generators insulated from market under exclusive contract
Collateral Impact	Limits renewables, not allowed to compete. Maintains reactors longer than needed. Rising subsidy price runs counter to trend in competing sectors. High cost to cancel contract.	Windfall for profitable reactors. Uneconomic reactors may close. Restricts eligibility, growth of renewables.	OH: High consumer costs. Maintains uneconomic PPs longer than needed. Blocks renewables. CT: Limits access to renewables. Maintains uneconomic reactor/s longer than needed.

Nuclear Subsidy Proposals
Status, Features, Costs and Impacts - side B

Subsidy Model	Reliability Must-Run PPA	Capacity Performance ICAP	Phase-Out Plan
Places Proposed	New York	PJM	California
Places Adopted	New York	PJM	none
Places Implemented	New York	PJM	none
Policymaking Venue	Utility Commission and/or FERC Review	Regional Transmission Organization (RTO) Rule	Utility Commission Review
Administrator	Utility Commission	RTO	Utility Commission
Policy Basis/ Rationale	Reliability	Reliability	GHG Emissions, Reliability
Eligible Resources	Designated facilty(s)	Not specified.	Nuclear
Alternatives to Nuclear Evaluated	No	Yes	Yes
Qualifications	Verified reliability need	Must be capable of sustained, predictable operation; available to provide energy and reserves during year-round performance assessment hours.	n/a
Mechanism	Contract w Local Utility; Monthly base subsidy + market revenue-sharing offset	Annual capacity market auction (3 years ahead of delivery year)	Settlement among utility and stakeholders proposed to Utility Commission for approval. Reactors operate to end of operating licenses. Utility implements 55% RPS by 2030 and 2-4 TWh/year of additional efficiency.
Caps/Limits	Subsidy price based on review of operating cost & market price projections	n/a	n/a
Facilities Covered	R.E. Ginna Nuclear PP	Facilities that clear annual auction, based on 3-years-ahead capacity need	Diablo Canyon units 1&2
Duration	2 years (2015-2017)	Annual (3 years ahead)	9 years (2016-2025)
Amount	$83 million/year	Determined by auction	Estimated savings of up to $9 billion in avoided nuclear costs
Market Impact	Distortion (temporary). Transmission upgrades enhance competition, market performance long-term.	Favors thermal PPs (coal, nuclear, gas). Demand response, renewables not eligible.	None identified. Diablo Canyon is a utility-owned PP w cost recovery. Plan sets a date certain for market planning.
Collateral Impact	Reliability maintained (short-term). Consumer impacts. Local economy, tax base impacts.	Consumer impacts (residential ~$2-3/month)	Ensures attainment of emissions reduction goals. Predictably increases renewable energy market share.

National Nuclear Subsidy Proposals

Soon after the NY PSC adopted the CES, Exelon and other nuclear generators began promoting it as a model for other states to adopt,[37, 38] including Pennsylvania,[39, 40] Illinois,[41, 42] and New Jersey.[43] Industry supporters have also acknowledged the problems that have prevented other nuclear subsidy proposals from advancing, and the virtues of basing the subsidies on avoided carbon emissions impacts, as NY PSC has. However, it is not clear whether the subsidy in NY will be more successful in withstanding legal challenges, which have only just begun[44, 45, 46, 47]; nor whether the NY subsidy model would be any more successful in other states,[48, 49] given its high price tag, the state's climate action-oriented policies (still controversial in many states), and the particular political and regulatory circumstances that facilitated its adoption.



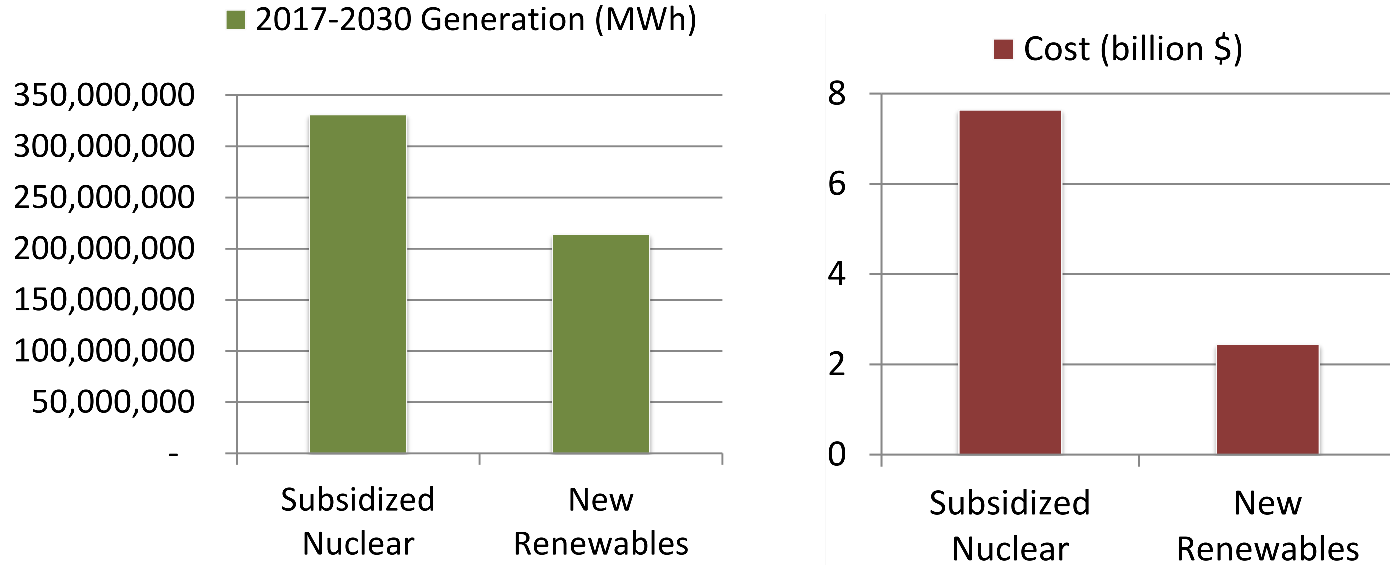
Uneven support for the industry at the state level may, in fact, undermine the case for nuclear subsidies, particularly if states are successful in achieving reliable, cost-effective electricity and reducing emissions, either without subsidizing nuclear power or by increasing renewable energy and energy efficiency. For instance, less than three months before NY PSC adopted the ZEC program, utilities in two other states announced plans to close reactors and replace them with other, lower-cost energy sources. In Nebraska, the Omaha Public Power District closed the Fort Calhoun reactor in October 2016, and plans to replace it primarily with wind generation.[50]

In June, Pacific Gas & Electric reached an agreement in California with environmentalists and other stakeholders to phase out the state's last nuclear power plant and replace it with renewable generation and energy efficiency over a nine-year period.[51] In explaining its decision, PG&E says it found that continuing to operate the Diablo Canyon reactors (total 2,200 MW) would be impractical, in light of the state's 50% renewable energy goal. The combination of solar and nuclear generation would frequently exceed electricity demand, creating economic inefficiencies and congestion on the transmission system. Under the plan, PG&E will increase renewable energy targets to a 55% renewable energy standard, adding over 30 million MWh of renewables by 2030 (compared to Diablo Canyon's 18 million MWh), increasing energy efficiency by 4 million MWh per year over previous targets, and reducing carbon emissions by 35%-60% from 2014 levels.

Therefore, industry and its supporters have begun pressing for a federal subsidy program. The incoming chief executive officer of the Nuclear Energy Institute (NEI) announced the trade association's intent to pursue a national subsidy program, acknowledging that state-level supports will likely be "bridge strategies."[52] The U.S. Department of Energy (DOE),[53] some federal lawmakers, and at least one presidential candidate have expressed an interest in preventing the closures of more reactors.[54, 55] It appears that DOE is taking a keener interest in advancing a national plan to subsidize existing reactors, through a program the agency initiated in 2015 to promote the long-term rejuvenation of the commercial nuclear power industry. In May 2016, DOE held a Summit on Improving the Economics of America's Nuclear Power Plants with NEI. Also, DOE Secretary Moniz added the issue to an Advisory Board's Task Force on the Future of Nuclear Power.

In September, a report was published from the DOE-NEI summit[56] and a draft report was produced by the task force.[57] Neither report makes specific recommendations for the price of a federal nuclear subsidy, though a second report from the DOE-NEI summit notes that revenue shortfalls for 1,000-MW reactors could range

NY Clean Energy Standard (2017-2030) - Total Generation (MWh) and Costs ($)



from $5-$15/MWh. However, as proposals to prevent reactor closures at the state level have demonstrated over the last two years, it is smaller, older, and single-unit reactors--those with the least favorable economic characteristics--that are driving policy development. In addition, regional differences in electricity prices may amplify the amount of subsidies needed to prevent reactor closures. Simply put, a subsidy of $5-$15/MWh might keep a plant with two large, 30-years-old reactors in the black, but it is not enough to support smaller, older, and/or less economical ones.

In order to achieve the objective--preventing reactor closures--subsidies must be large enough to support the least economical reactors, or there will be significant attrition in the reactor fleet. If this were not the case, the emissions attributes of small reactors (e.g., Ginna, at 581 MW) would have to be valued at a higher price than those of the largest reactors/plants (e.g., Nine Mile Point 2, at 1,311 MW), even though small reactors generate less power and could most readily be replaced with renewables or efficiency. It is likely that the New York subsidy is being so widely celebrated by the industry because of its unprecedented subsidy prices, which start at a level close to the Renewable Energy Production Tax Credit ($22.48/MWh compared to $23/MWh), and increase to $34.15/MWh in ten years. It therefore seems possible that a national subsidy price could approximate New York's, as suggested by the DOE task force's recommendation of a $27/MWh production tax credit.

The Cost of a National Nuclear Subsidy

Should a national nuclear subsidy program be adopted according to the New York model, it is possible to estimate the costs, by making some minor adjustments.

- Variations in carbon policies. Only ten states in the US have adopted carbon-pricing programs: the nine states in RGGI and California. Of the nine RGGI member states, only four (CT, MD, NH, and NY) are likely to have operating nuclear power plants by the time a national subsidy program could be implemented. For states that do not have an equivalent carbon price program, there would be no RGGI adjustment to the subsidy, resulting in prices about $5/MWh greater than in RGGI states and California.
- Emissions rate factor. We assume the emissions rate factor would be based on natural gas-fired generation (0.51621 tons/MWh) rather than the mix of peak generation sources used in NY (0.53846 tons/MWh), for two reasons: the preference under the Clean Power Plan for supplanting coal-fired generation with natural gas; and the prevalence of combined cycle natural gas plants in providing the type of baseload generation that nuclear provides.
- Market price adjustment. It is entirely possible that a national nuclear subsidy program would not incorporate an adjustment for local market prices, given the implications for wholesale market interference, the logic of pricing an environmental attribute, and the potential for uneven levels of support throughout the country.

It is worth noting that estimates of natural gas generation's emissions are very likely too low, by not accounting sufficiently for methane leakage rates in the extraction, processing, and transmission of natural gas; as well as the relative warming effects of methane in

National Nuclear Subsidy Prices, based on New York Clean Energy Standard

Tranche	Subsidy – States with Carbon Price ($/MWh)	Subsidy – States w/o Carbon Price ($/MWh)
2017-2019	$17.48	$22.48
2019-2021	$19.59	$24.59
2021-2023	$21.38	$26.38
2023-2025	$23.83	$28.83
2025-2027	$26.45	$31.45
2027-2029	$29.15	$34.15
2029-2030	$32.29	$37.29

the critical near-term timeframes for emissions reductions. Taking these factors into account, some recent studies conclude that natural gas generation may have an equivalent or worse climate impact than coal-fired power plants. If this turns out to be the case, and federal policies are adjusted accordingly, the conversion factor could result in substantial increases to the nuclear subsidy price--potentially as much as doubling the cost.

National Cost Projection

For the purposes of this estimate, we assume that a national program would be implemented in 2019, congruent with the second period of New York's nuclear subsidy. This is because the industry is demanding urgent action to prevent or reverse recent or prospective closure decisions, and some changes to federal statutes or regulations may be necessary (e.g., the Clean Power Plan and/or the Federal Power Act). In addition, implementing a costly subsidy program in 2020 could be difficult due to the election year, and states will have to be well on their way to implementing the Clean Power Plan, with compliance starting in 2022.

If the federal government implemented a national program, we project that 97 reactors would receive subsidies at the beginning, and 96 in 2030, with a maximum of 101 receiving support at any given time.

- Three current closure decisions are likely to go forward before the program is implemented: Fort Calhoun in Nebraska (2016); Oyster Creek in New Jersey (2019); and Pilgrim in Massachusetts (2019).
- Should a national program be implemented, New York PSC's decision to exclude Indian Point 2 and 3 from the state-based program would be irrelevant.
- Four new reactors are projected to come online before 2030: Vogtle 3 and 4 in Georgia (2020-2021); and Summer 2 and 3 in South Carolina (2020-2021).
- With large subsidies, reactors that have not already pursued federal relicensing will likely do so, ensuring they are permitted to operate through 2030.
- Operating licenses for five reactors will expire before 2030: Diablo Canyon 1 and 2 in 2024 and 2025; and Dresden 2 (Illinois), Nine Mile Point 1 and Ginna (New York) in 2029.

For consistency with New York's projections, we assume a 94% average annual capacity factor, while noting that sustaining such levels of performance may not be possible as the reactor fleet continues to age.

See opposite for a table summarizing the costs of nuclear subsidies, by state, for the period April 1, 2019 to December 31, 2030 (with the exception of New York beginning in 2017). A table showing reactor-specific subsidy projections is available on NIRS's website. A national nuclear subsidy program, based on the Social Cost of Carbon (SCC), would rise in cost from $20 billion per year to $27 billion as the SCC rises, and total over $280 billion by the end of 2030. Alternatively, at the fixed $27/MWh price suggested by the DOE task force, the cost would be $270 billion.[58] If the program were targeted only to the 56% of nuclear generation Bloomberg reports will be unprofitable by 2020, it would cost in the neighborhood of $160 billion by the end of 2030.

Application of the Social Cost of Carbon

There would be a concerning precedent in applying the EPA's Social Cost of Carbon to price subsidies for mitigation. EPA developed the SCC as a way to evaluate the impact of CO2 emissions in regulatory proceedings, not to measure the cost or price of emissions abatement:[59] that is, it is a measure of the global societal and environmental impacts of fossil fuel combustion as it contributes to global warming and climate disruption. EPA did not intend the SCC to be used as a way to price incentives for mitigating CO2 emissions.

There would likely be significant policy implications for doing so, particularly on the type of non-competitive basis adopted in New York. On the one hand, New York is only applying the SCC to subsidize one energy source (nuclear), and no other energy source is permitted to compete for ZECs, even though the value of the

State-by-State and Total Costs of a National Nuclear Subsidy Program, through 2030

State	Reactors	Capacity (MW)	Maximum Annual Generation (MWh)	2017-2021	2021-2023	2023-2025	2025-2027	2027-2029	2029-2030	Total (2019-2030)
Alabama	5	5,050	41,583,720	$1,960,604,791	$2,103,324,701	$2,298,667,594	$2,507,564,892	$2,722,840,733	$2,601,592,250	$14,418,641,299
Arizona	3	4,005	32,978,772	$1,554,895,483	$1,668,082,263	$1,823,002,715	$1,988,672,751	$2,159,401,413	$2,063,242,963	$11,434,981,862
Arkansas	2	1,823	15,011,311	$707,758,918	$759,279,392	$829,796,242	$905,206,098	$982,918,546	$939,149,044	$5,204,986,750
California	2	2,240	18,445,056	$692,823,495	$756,128,960	$807,723,140	$156,184,320	$0	$0	$2,490,135,022
Connecticut	2	2,080	17,127,552	$643,336,103	$702,119,748	$782,577,811	$868,618,679	$957,286,748	$927,871,795	$4,953,566,340
Florida	4	3,910	32,196,504	$1,518,012,819	$1,628,514,768	$1,779,760,454	$1,941,500,738	$2,108,179,656	$2,014,302,119	$11,163,740,095
Georgia	6	6,512	53,622,413	$2,094,547,099	$2,712,247,614	$2,964,143,242	$3,233,517,341	$3,511,116,604	$3,354,766,086	$18,060,134,073
Illinois	11	11,596	95,486,102	$4,502,014,487	$4,829,733,313	$5,278,287,013	$5,757,964,848	$6,252,289,334	$5,718,056,902	$32,852,809,529
Iowa	1	615	5,064,156	$238,766,722	$256,147,464	$279,936,747	$305,376,715	$331,593,475	$290,144,291	$1,729,250,264
Kansas	1	1,250	10,293,000	$485,298,216	$520,624,926	$568,977,127	$620,684,379	$673,970,478	$589,724,169	$3,514,736,309
Louisiana	2	2,154	17,736,898	$836,265,885	$897,140,872	$980,461,386	$1,069,563,322	$1,161,385,928	$1,109,669,249	$6,150,050,170
Maryland	2	1,750	14,410,200	$541,268,356	$590,725,750	$658,418,832	$730,808,984	$805,409,523	$780,661,366	$4,167,663,988
Michigan	4	4,088	33,662,227	$1,587,119,284	$1,702,651,758	$1,860,782,797	$2,029,886,193	$2,204,153,053	$2,106,001,806	$11,671,961,511
Minnesota	3	1,700	13,998,480	$660,005,573	$708,049,899	$773,808,893	$844,130,756	$916,599,851	$831,626,377	$4,809,642,888
Mississippi	1	1,478	12,170,443	$573,816,610	$615,586,912	$672,758,555	$733,897,210	$796,902,694	$761,416,504	$4,219,950,859
Missouri	1	1,279	10,531,798	$496,557,134	$532,703,424	$582,177,397	$635,084,257	$689,606,594	$603,405,769	$3,596,278,192
Nebraska	1	810	6,669,864	$314,473,244	$337,364,952	$368,697,178	$402,203,478	$436,732,870	$382,141,261	$2,277,549,128
New Hampshire	1	1,244	10,243,594	$384,764,477	$419,921,619	$468,041,729	$519,500,787	$572,531,113	$554,938,708	$2,962,613,715
New Jersey	3	3,573	29,421,511	$1,387,176,420	$1,488,154,288	$1,626,364,220	$1,774,164,229	$1,926,477,215	$1,840,690,913	$10,201,545,616
New York	6	5,420	44,630,448	$2,713,288,891	$1,908,397,999	$2,127,087,199	$2,360,950,752	$2,601,955,177	$2,122,498,211	$13,834,178,229
North Carolina	5	5,028	41,402,563	$1,952,063,543	$2,094,161,702	$2,288,653,596	$2,496,640,846	$2,710,978,852	$2,590,258,581	$14,355,827,416
Ohio	2	2,120	17,456,928	$823,065,774	$882,979,874	$964,985,208	$1,052,680,707	$1,143,053,931	$1,092,153,578	$6,052,974,169
Pennsylvania	9	9,934	81,800,530	$3,856,761,979	$4,137,510,411	$4,521,775,025	$4,932,702,898	$5,356,178,186	$5,117,666,815	$28,363,323,300
South Carolina	9	8,720	71,803,968	$2,951,777,867	$3,631,879,483	$3,969,184,439	$4,329,894,229	$4,701,618,057	$4,403,449,401	$24,275,558,833
Tennessee	4	4,575	37,672,380	$1,753,285,393	$1,880,913,732	$2,055,600,565	$2,242,408,525	$2,434,920,544	$2,326,493,189	$12,893,977,051
Texas	4	4,708	38,767,555	$1,827,827,199	$1,960,881,721	$2,142,995,452	$2,337,745,645	$2,538,442,410	$2,425,405,211	$13,442,170,938
Virginia	4	3,404	28,029,898	$1,321,564,101	$1,417,765,798	$1,549,438,513	$1,690,247,701	$1,835,356,407	$1,753,627,727	$9,719,020,788
Washington	1	1,170	9,634,248	$454,239,130	$487,304,931	$532,562,591	$580,960,579	$630,836,368	$602,745,135	$3,340,556,499
Wisconsin	2	1,240	10,210,656	$481,415,830	$516,459,927	$564,425,310	$615,718,904	$668,578,715	$593,177,752	$3,494,789,796
TOTAL	101	103,476	852,062,774	$39,314,794,821	$42,146,758,203	$46,121,090,970	$49,664,480,761	$53,831,314,476	$50,496,877,173	$281,575,316,403

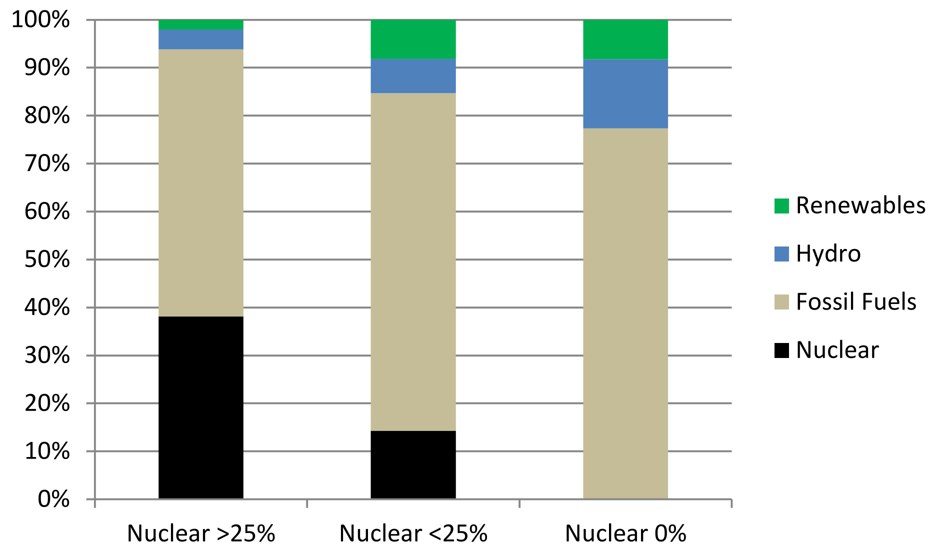
credits will become far greater with time, as reactors are aging and approaching their retirement dates. On the other hand, however, there is a perverse principle at play which could act as a disincentive to renewable energy or even nuclear sources: that the cost of mitigating GHG emissions must be the same as the impact of actually emitting GHG. In such an environment there would be no economic advantage to mitigating emissions compared to producing emissions, on either a policy or commercial basis.

This application of the SCC runs counter to the “polluter pays” principle of a carbon tax, through which the entities that create pollution economically internalize the impacts of their business activities. Instead, applied in the way proposed, nuclear power plants would simply be rewarded for contributing less to global warming than do fossil fuel generators. But there would be no way to distinguish the economic impact of selecting a nuclear power plant (or renewable energy source, if applied to them) from the impact of a fossil fuel generation source.

There is, on the other hand, a significant real-world and policy advantage to mitigation alternatives carrying a lower economic cost than GHG emissions from fossil fuel sources. When emissions-free alternatives are cheaper than the cost impact of fossil fuels, it creates a strong economic and policy preference for mitigation. However, simply awarding nuclear power plants a subsidy that makes them equivalent to fossil fuels creates a zero-sum basis for policymaking and economic decision-making--particularly when the principle is applied unevenly and the environmental impacts of nuclear are not internalized, as well (radioactive waste, accident risks and liability insurance, environmental justice, water consumption, wildlife impacts, etc.).

The cost advantages demonstrated by renewables and energy efficiency, which are increasingly cheaper than natural gas generation on a levelized, unsubsidized basis, make a strong argument for eliminating subsidies for established generation sources, with or without imposing fees on GHG emissions. If it is cheaper and more profitable to provide energy from renewables and efficiency, and polluters are subject to appropriate limits and penalties, regulators, consumers, and markets will share strong incentives to reduce emissions. Aligning policies to achieve emissions reduction and integration of renewables, while eliminating direct and indirect subsidies for fossil fuels and nuclear power, would create a significant incentive for emissions reduction through adoption of renewables, energy efficiency, and other low-impact resources.

Average State Electricity Supplies by Nuclear Share



Data Source: U.S. Energy Information Administration

Conclusion

Nuclear subsidy costs would be incurred without, on their own, reducing carbon emissions.[60] Maintaining existing reactors’ operation, in itself, does not reduce GHG emissions, as EPA determined in promulgating the Clean Power Plan. It would only hedge against possible increases in emissions, if fossil fuel generation were to increase due to reactor closures. There is, however, an opportunity cost to subsidizing aging nuclear power plants: diverting scarce consumer energy dollars from possible investment in new, zero-carbon energy resources; and making utilities and regulators support legacy infrastructure, rather than modernize the grid.

The New York projections show conventional renewable energy subsidies are at least four times as effective at mitigating CO_2 emissions in the medium-term as nuclear subsidies based on the Social Cost of Carbon, and twice as cost-effective in the short-term. This suggests that renewable energy could be developed to replace or phase-out nuclear generation at much lower cost than nuclear could be subsidized based on the SCC. This is consistent with the EPA’s determination in issuing the Clean Power Plan regulation, which concluded that incentives for existing reactors were unwarranted to meet CO2 reduction goals.

Instead of creating a national program that locks energy policies, planning and investment into supporting aging nuclear infrastructure, state and federal governments should take a flexible and adaptive approach that is focused, on the one hand, on reducing GHG emissions as quickly as possible; and, on the other hand, driving modernization and innovation in our energy system through expanding clean energy industries. Within that context, regulators should be empowered to address reactor closures through proactive planning:

- Evaluate known and potential reactor closure dates to determine their impact on GHG reduction goals.
- Monitor industry trends and plant-specific developments to anticipate economic and operational contingencies that may lead to previously unanticipated reactor closures.
- Study alternatives to subsidizing reactors for meeting GHG goals, such as incremental investments in renewables, efficiency, and/or related infrastructure to keep emissions reductions on target when reactors close.
- If enough nuclear capacity could be lost to compromise emissions reductions or would require the development of fossil fuel infrastructure to meet near-term energy supply and reliability needs, determine how much nuclear generation is needed in order to stay on track, for how long, and at what cost relative to zero-carbon alternatives.
- Create proactive plans to replace or phase out nuclear, in concert with emissions reduction and renewable energy goals, and grid modernization initiatives.

In this way, reactor closures may be treated similarly to reliability impacts of generator retirements, which involve a similar process:

- Independent evaluation of the likelihood and scale of grid impacts resulting from the plant closure.
- Evaluation of the availability, cost-effectiveness, and timeframe for alternatives, through resource planning, market-based processes, or procurement through open, competitive bidding.
- Time-limited economic support for the incumbent generator only until more cost-effective alternatives can be identified and implemented.

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