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Efficiency and Nuclear Energy: Complements, not Competitors, for a Low-Carbon Future

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Submitted to *The Electricity Journal* in response to Amory Lovins, "Do Coal and Nuclear Generation Deserve Above-Market Prices?," *The Electricity Journal*, July 2017, Vol. 30, Issue 6, Pages 22-30.

Abstract

Amory Lovins claims that rather than supporting distressed nuclear plants, greater overall carbon savings could be had by allowing them to close and funding low-cost efficiency improvements instead ("Do Coal and Nuclear Generation Deserve Above-Market Prices?," *The Electricity Journal*, July 2017). He errs in presenting the issue as a dichotomous choice in which we can either support nuclear plants or support efficiency, but not both. The magnitude of the decarbonization challenge means that many resource types, including both nuclear and efficiency, will be needed. Replacing nuclear plants with efficiency would require very large additional efficiency improvements on top of the significant progress that will occur in any case, pushing into a realm where the marginal efficiency opportunities are likely to have decreasing availability and increasing cost. Since any replacement could not be immediate, carbon emissions would increase substantially in the near term.

Keywords

Nuclear, carbon, efficiency

Nuclear power is the largest source of carbon-free electricity in the U.S., providing about 20% of our total electricity, but 60% of our carbon-free power. This means it is and should remain a key component of the transition to a decarbonized power sector, alongside energy efficiency and renewable generation. Amory Lovins, in his article "Do Coal and Nuclear Generation Deserve Above-Market Prices?" (*The Electricity Journal*, July 2017) criticizes a variety of arguments that are put forth in support of "baseload" power plants, especially nuclear. His primary point is that distressed nuclear plants should not receive financial support to preserve their zero-emissions output, because that would lead to higher carbon emissions. This argument is incorrect and misleading.[1]

[1] There is merit to another of Mr. Lovins' points, that putting a material price on carbon would be a more efficient way to reduce emissions.

Based on nuclear's dominant share of our carbon-free power, and contrary to Mr. Lovins' assertion, it is clear that retaining this large source of carbon-free generation will keep carbon emissions lower, not increase them. In fact, Mr. Lovins implicitly acknowledges that supporting nuclear plants would lower carbon emissions relative to letting them retire and be replaced by fossil generation. He suggests, however, that it should be possible to achieve *even larger* carbon reductions by allowing nuclear plants to retire early and "reinvesting their saved operating cost into severalfold-cheaper efficiency." In other words, he argues that supporting nuclear plants will displace energy efficiency investments that would yield even greater carbon emissions reductions for the same cost. This argument relies on the implicit assumption that there are energy efficiency opportunities that are cheaper per unit of avoided carbon than supporting nuclear plants, and that enough of these opportunities could and would be implemented immediately to offset the loss of the nuclear output (more on this below). More importantly, Mr. Lovins errs by presenting the issue as a choice in which we can either support nuclear plants or support efficiency, but not both. Because of the magnitude of changes that will ultimately be needed to decarbonize the economy, many types of resources will be needed, including both efficiency and nuclear.

Mr. Lovins' Unnecessary Choice

Even if efficiency opportunities are as inexpensive as Mr. Lovins maintains, he unnecessarily limits the question to a dichotomous choice between supporting nuclear plants versus supporting efficiency to keep carbon emissions down. Rather than forcing an either/or choice, both of these opportunities can and should be evaluated and pursued on their own merits in the context of long-run goals. Preserving a nuclear plant does not prevent investing in efficiency, nor does improving efficiency mean we cannot keep zero-emission nuclear plants operating. By characterizing the challenge of reducing carbon dioxide (CO_2) as a competition in which a single approach must dominate, Mr. Lovins disregards the magnitude of the emissions reductions that are ultimately needed and the importance of reducing or avoiding CO_2 emissions as early as possible. The magnitude of the necessary change means that it will take a broad portfolio of options to attain such reductions at a reasonable cost. Both efficiency and nuclear resources can play a role in the large portfolio of options that will be necessary to achieve decarbonization.

It is widely agreed that to avoid the worst impacts of climate change, deep decarbonization is necessary, with developed economies eliminating the majority of their carbon emissions by mid-century, and the steepest reductions in the power sector. Deep decarbonization cannot be achieved with efficiency alone (i.e., efficiency cannot serve all our electricity needs), even if some efficiency opportunities are available at relatively low cost. In fact, the need for carbon-free electricity may increase substantially; electrification appears to be one of the more promising ways to decarbonize other sectors like transportation and heating. Limiting the available carbon abatement alternatives by allowing existing nuclear plants to be pushed into premature retirement will make it more difficult and costly to meet the long-run challenges. Existing nuclear plants are a particularly important piece of the puzzle in the U.S., given their large size and the immediacy with which carbon emissions will rise if they retire. As noted above, nuclear plants provide a very substantial share of U.S. generation – 20% of the total but about 60% of current zero-emissions generation. Wind and solar together provide only 7% of total generation;

hydro, the other major emissions-free power source, yields a similar amount. Achieving the large emissions cuts that will be necessary over the next several decades will require a broad portfolio of carbon-mitigating strategies and resources, including some that will likely be considerably more costly than any of the alternatives currently being discussed. To allow the premature closure of our largest sources of carbon-free power would foreclose a cost-effective and viable component of the solution, making the long-run problem much more difficult and perhaps intractable. Nuclear closures most certainly increase emissions in the near-term. And because retirement is irreversible, once these resources are lost, they cannot be regained.

Comparing Efficiency Cost with Nuclear Operating Costs

Mr. Lovins may be overly optimistic about the cost advantages of energy efficiency over nuclear operating costs.[2] Most important in this regard, and closely related to the magnitude of carbon-free resources ultimately required, the relevant measure is the availability and cost of additional, incremental efficiency improvements – beyond those that would be implemented in any case. Like any resource, the next unit of available supply tends to be more costly, since cheaper opportunities are generally exploited first. State and utility programs to encourage clean energy already support significant energy efficiency, and efficiency efforts at many levels have been pursued for decades, so some of the least costly opportunities have already been exploited. Mr. Lovins claims efficiency is available at 2-3¢/kWh, but this estimate reflects the average cost of utility efficiency programs undertaken in the recent past. To replace a lost nuclear plant with efficiency will require substantial incremental new efficiency activities far into the future, well beyond the future improvements that will be undertaken in any event. The more efficiency improvements we make, especially on an accelerated schedule, the more costly it becomes to do still more. Even in the absence of nuclear plant closures, energy efficiency improvements will be necessary on a scale that dwarfs historical levels. It is unrealistic to assume that future efficiency opportunities on this scale will be available at the same low cost as historical programs, and even less credible to claim that the further incremental gains that would be necessary to replace retiring nuclear plants would also have similarly low cost.

Additionally, it is not clear that the historical energy efficiency program cost estimates cited by Mr. Lovins fully capture the costs of efficiency. These cost estimates are based on calculated estimates of gross energy savings, ignoring the so-called rebound effect whereby making energy services cheaper can encourage additional consumption and reduce the net energy savings.[3] Perhaps more importantly, by

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2 In addition to potentially underestimating the cost of efficiency, Mr. Lovins may in some cases be overestimating the nuclear operating costs to which he compares it, by focusing on only the most costly nuclear plants. Not all the threatened nuclear plants have high costs; some have relatively lower costs, but operate in markets with very depressed prices.

3 See Billingsley, M., et al., The Program Administrator Cost of Saved Energy for Utility Customer-Funded Energy Efficiency Programs, Lawrence Berkeley National Laboratory, March 2014. Also, Gillingham, K., et

citing measures that only consider program administrator costs, Mr. Lovins ignores the costs that must be paid by program participants and may thus substantially understate the total cost of efficiency.[4] For a more balanced comparison between the costs of efficiency and nuclear power, the total costs of nuclear power should be compared with the total cost of efficiency, including participant costs. By looking only at program administrator costs, Mr. Lovins effectively considers just the "out-of-market" costs of efficiency – the additional costs paid to procure more efficiency resources than would be provided by the market itself. Thus Mr. Lovins' efficiency cost metric may be more comparable to the Zero Emissions Credit (ZEC) payments in New York that compensate the distressed Upstate nuclear plants for their zero carbon output. The ZEC price is set initially at 1.7¢/kWh, far below Mr. Lovins' estimate of total nuclear operating costs, and below the 2-3¢/kWh program administrator costs that he cites for efficiency.[5]

Examples: New York and Illinois

Much attention around this question has focused on New York and Illinois, two states that have recently taken notable actions to decarbonize their power sectors. Both have implemented support mechanisms for their financially troubled nuclear plants, as part of broader strategies that also include aggressive policies to add renewables and increase efficiency. Their approaches shed light on the magnitude of the transformation needed, the pace at which it can happen, and the role that existing nuclear plants can play in limiting carbon emissions.

As we have shown previously, the nuclear component of New York's ambitious Clean Energy Standard (CES) accounts for the majority of the program's near-term carbon avoidance. Figure 1a below shows the new carbon-free resources that are projected under the CES, showing the incremental efficiency (illustrated here as if it were generation) and renewable resources that the CES will induce. This depiction shows no change in nuclear generation since the Upstate New York nuclear plants continue to operate, supported by the ZEC component of the CES. The bold red line at the top shows the aggregate increase in carbon-free resources in New York over time; as a result of the CES, emissions would be

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al., The Rebound Effect and Energy Efficiency Policy, *Review of Environmental Economics and Policy*, volume 10, issue 1, Winter 2016, pp. 68–88.

4 In fact, one of the primary sources cited by Mr. Lovins, a 2014 ACEEE study on the cost of efficiency programs, finds that while participant cost information can be difficult to come by, the available data suggests that participant costs are generally greater than the utility program costs. This implies that the full cost of efficiency may be more like 5.4¢/kWh, over twice the program costs that Mr. Lovins cites. See M. Molina, "The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs." American Council for an Energy-Efficient Economy, March 2014, pp. 22-23.

5 While the ZEC cap rises slowly over time with the social cost of carbon, the actual ZEC cost may be below this cap.

lower by about this amount multiplied by the marginal system emissions rate (in New York, this is the emission rate of a gas plant).

Figure 1b shows what the situation would look like with the same CES programs for new efficiency and renewable resources, but without the ZEC component, which would cause the Upstate nuclear plants to close, losing over 25 million MWh of carbon-free generation each year. To understand the scale, this is 16% of total New York load. Clearly, this would mean a substantial and immediate drop in New York's carbon-free generation, with a corresponding increase in emissions. The growth over time of renewables and efficiency planned under the CES would not offset the lost nuclear output, since these new resources will be implemented in any case. The shortfall in carbon-free generation would persist over time at more than 25 million MWh annually (illustrated as the dark blue area between the solid red line in Figure 1b and the dashed red line carried over from Figure 1a), continuing to add this amount each year to New York's cumulative carbon emissions.

Figure 1a
Change in New York CO_2-Free Resources with Upstate Nuclear

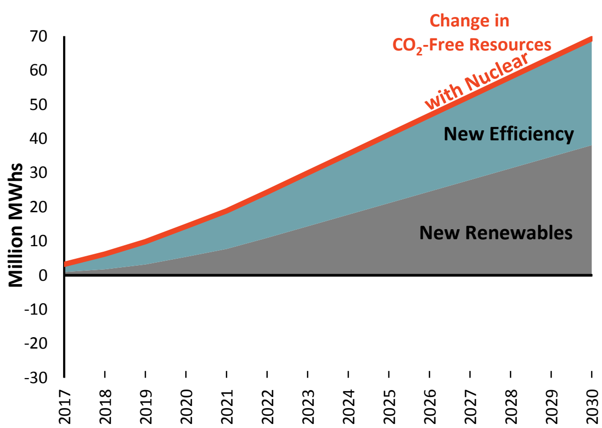
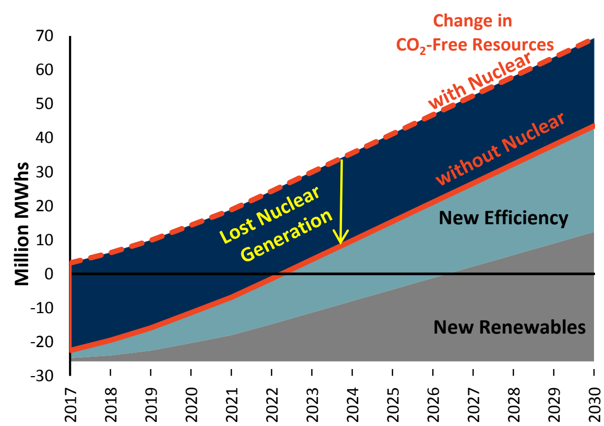


Figure 1b
Change in New York CO_2-Free Resources without Upstate Nuclear



Source: The Brattle Group

To actually replace the lost nuclear generation and get back to the emissions level that would have prevailed if the Upstate plants were operating, the gap would need to be filled with <u>additional</u> new carbon-free resources, well beyond the ambitious CES targets. Particularly since it would be impossible to replace this much carbon-free generation immediately, emissions would be much higher initially, requiring even larger incremental reductions in later years to compensate. Mr. Lovins suggests that nuclear plants can be replaced by low-cost energy efficiency, but looking at the magnitudes involved shows how difficult that might actually be. The New York Public Service Commission (NYPSC) recognized the challenge in its CES Order.[6] According to the NYPSC, despite that "the Commission is working to ensure that the potential of energy efficiency is maximized in New York … it is simply unrealistic to assume that sufficient additional energy efficiency measures could be identified and implemented in time to offset the 27.6 million MWh of zero-emissions nuclear power that would need to be replaced per year." In fact, "To offset all of the cumulative zero-emissions MWh [of the nuclear plants] *the annual incremental rate of energy efficiency would have to be tripled* to 6.6 million MWh per year."[7] [Emphasis added.] If this were even possible, the sheer magnitude of the incremental resources needed would likely push the cost per avoided MWh quite high compared with past average levels. The new efficiency programs that are incorporated in the CES already embody ambitious targets; they will tend to consume the inexpensive efficiency opportunities first, turning to more costly alternatives in the future as the efficiency targets grow. Further efficiency improvements on top of these, if needed to replace lost nuclear output, would be still more costly.

Ultimately, after studying many options including expanding energy efficiency along the lines Mr. Lovins encourages, the NYPSC concluded that maintaining existing nuclear is a large and cost-effective component of the portfolio needed to achieve large emissions reductions over time. "Considering the anticipated costs of the ZEC program against the benefits related to the large amount of zero-emission power the facilities will produce, the benefits clearly outweigh the costs."[8] Comparing the cost of the ZEC program to renewable costs, and recognizing the same phenomenon of increasing cost with greater levels of resources required, it noted "The marginal cost of additional increments of renewable resources is expected to always be significantly higher than ZEC prices."[9] In a previous analysis, we reached a similar conclusion about replacing the Upstate nuclear plants with renewables. Given the magnitude of replacement renewables that would be needed, and the fact that it would be on top of already significant planned additions, additional renewables would be much more costly than preserving the nuclear plants – potentially an additional $1 billion per year.[10] Further, even if the lost nuclear generation could ultimately be replaced with additional renewables and/or efficiency, the loss of supply in wholesale markets would increase electricity prices for consumers in the intervening years. We estimated that the loss of the Upstate nuclear supply would raise wholesale power prices considerably, costing New York consumers an additional $1.7 billion annually.

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6 Order Adopting a Clean Energy Standard, New York Public Service Commission, August 1, 2016.

7 Ibid., pp. 126-127.

8 Ibid., p. 126.

9 Ibid., p. 127.

10 "Preserving Upstate Nuclear Saves New York Consumers Billions, Compared With Additional Renewables Beyond CES Goals," D. Murphy, M. Berkman, The Brattle Group, December 2016.

A similar situation is illustrated below for Illinois. Figure 2a shows the new renewables and efficiency improvements under its Future Energy Jobs Act (FEJA). Similar to New York's CES, FEJA supports the distressed Illinois nuclear plants, Clinton and Quad Cities, with its own version of ZECs. If it did not, Figure 2b shows that Illinois' carbon-free generation would also drop dramatically, with correspondingly higher emissions. Also similar to New York, to replace the lost nuclear generation with additional, incremental efficiency resources would require that the FEJA efficiency programs be scaled up to multiples of their original size. Even if that is possible, it would take years for the incremental efficiency resources to match the lost nuclear output, and they would need to grow well beyond this to compensate for higher emissions in the early years. As discussed above for New York, a program of this magnitude would consume available low-cost efficiency opportunities first, leaving higher cost alternatives with which to replace lost nuclear generation.

Figure 2a
Change in Illinois CO_2-Free Generation with Clinton and Quad Cities

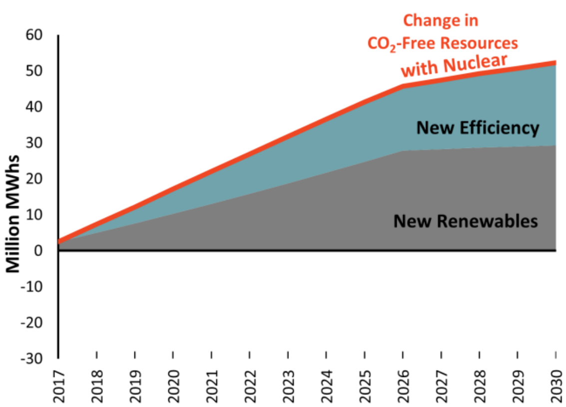
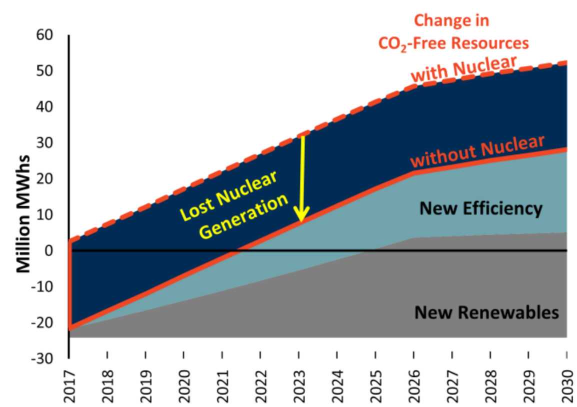


Figure 2b
Change in Illinois CO_2-Free Generation without Clinton and Quad Cities



Source: The Brattle Group

Conclusion

Ultimately, it is important to recognize that the argument about the relative merits of nuclear power versus efficiency is posing an unnecessary choice between these resource types as potential solutions to the carbon problem. A broad portfolio of resources will be needed to decarbonize the economy in the long run; both efficiency and nuclear are valid and necessary parts of that portfolio (along with other resources like renewables and storage). Allowing existing nuclear plants to retire prematurely will raise near-term carbon emissions and foreclose future carbon abatement options. Moreover, the marginal cost of sustaining nuclear as a carbon-free generation option is likely quite low compared to at least some of the other alternatives that will ultimately be needed for deep decarbonization, including incremental future efficiency opportunities. We may need even more electricity in the future, not less, regardless of potential efficiency successes, since electrification promises to be one of the best ways to decarbonize other sectors like transportation and heating. Mr. Lovins' strategy is thus short-sighted; it would "use up" efficiency opportunities to replace lost nuclear output for no net gain in decarbonization, leaving fewer remaining options with which to achieve the very large reductions needed. Since the support needed to keep existing nuclear plants operating is modest, it will make more sense to preserve them and maintain their carbon abatement for decades into the future.

In the end, Mr. Lovins' proposal to replace nuclear with efficiency can be compared to walking up the down escalator – it impairs forward progress. Progress toward deep decarbonization should consist of maintaining existing carbon-free resources like nuclear where possible, and using incremental carbon-free resource additions such as efficiency or renewables to replace fossil generation.

The views expressed in this article are strictly those of the authors and do not necessarily state or reflect the views of The Brattle Group. The authors thank Duncan O'Brien for research assistance, and several other Brattle colleagues for their helpful comments. Funding for this work was provided by Exelon Corporation.