wind had the earlier success and solar is now catching up.[37] Nuclear power has failed to show these results because it lacks the necessary characteristics.

42. The nature of the renewable technologies involved affords the opportunity for a great deal of real-world development and demonstration work before it is deployed on a wide scale. This is the antithesis of past nuclear development. The alternatives are moving rapidly along their learning curves, which can be explained by the fact that these technologies actually possess the characteristics that stimulate innovation and allow for the capture of economies of mass production. They involve the production of large numbers of units under conditions of competition. Nuclear power, involves an extremely small number of units from a very small number of firms, with the monopoly model offered as the best approach. The monopoly in New York State is that a single corporation owns all the upstate nuclear reactors and is the sole beneficiary of the Tier 3 program.

43. If policymakers have to bet on subsidies to accelerate innovation, limit cost, and reduce carbon emissions, then the performance history of the nuclear and alternative industries gives them extremely good reason to expect a single outcome: alternatives will overcome their challenges more quickly and efficiently than nuclear technology ever has.

## AGING REACTORS ARE NOT NEEDED TO MEET THE CLEAN ENERGY GOALS [38]

[37] Badcock and Lenzen, 2010. Branker and Pearce, 2010.

[38] The nuclear power industry's last hope is to make it seem as though reactors are the only option Upstate jobs, tax revenues, or climate mitigation.... Our analysis below will show that New York has all the tools necessary to increase its energy efficiency and renewable energy targets to accommodate a rapid phase-out of nuclear power while meeting its climate goals. (Comment, p. 5). Consider interim benchmarks for other core resources: Utility-scale Solar PV, Onshore Wind, Energy Storage, Implement a binding efficiency target, Increase the RPS to 65 percent by 2030, Make a commitment to offshore wind, Augment the CES projections to include growth of rooftop solar (Responsive Comment, pp. 0-11).

44. Having shown that the cost of alternatives is much lower than aging reactors in independent analyses, a central challenge for policy makers is the question of whether the resource base will be sufficient to accomplish the goal.

**(a) Meeting short- and mid-term needs**

45. The analysis generally proceeds at two levels. First, as shown in Attachment MNC-11, we see comparisons of how other states are doing in the effort to deploy clean, low carbon alternatives. The upper graph shows the levels achieved by U.S. states. It highlights the fact that NY and Illinois, the two states that have offered nuclear bailouts, have had a mediocre performance. At least two large states with large industrial economies that have achieved much higher levels of contribution from efficiency and non-hydro renewables.

46. The lower graph focuses on non-hydro renewable generation options, showing that not only have a number of states performed better, but so too have a number of nations. States and nations have achieved eight time the contribution of non-hydro renewables to their generation needs as New York and Illinois. In New York, combining this level of non-hydro renewables with its large base of hydro would bring the state to its 2030 goal. Relying on the market in the near term should be preferred because it allows for a smoother transition, in addition to installing the overall market framework.

47. While comparisons between states and nations in non-hydro performance is suggestive, the ultimate question involves the resource base in the state. Is it adequate? Attachment MNC-12 addresses this issue. It is based on an NREL analysis of the potential for all supply-side renewable resources in the long term. The NREL estimate of potential contribution as a percentage of 2016 demand taken from an EIA estimate, which ensures uniformity in the

comparison between New York and Illinois. Using a slightly different load as the basis would not make much of difference because the potential resources are so much larger than the need, particularly for the 2030 target.

48. Attachment MNC-12 shows that the main renewable resources provide more than adequate resource to meet load and the decarbonization goal... Including efficiency, onshore wind, urban utility PV, and rooftop PV, yields well-over twice as much low carbon resources as would be needed to achieve the 2030 goal, even if existing hydro is not counted. Adding in hydro would push the total to 2.5 times the amount needed, even if no nuclear is counted. The constraint on proceeding without the ZEC program is not a lack of potential capacity. The primary obstacle a is lack of will by the PSC to move quickly in that direction.

**(b) Meeting long-term goals.**

49. Moreover, there are two important potential resources that the above analysis does not take into account. Offshore wind represents a potential that is four times the 2030 target and rural utility PV represents another 10 times the target. The potential for rural utility scale PV is most interesting since the counties where the subsidized aging reactors are located are quite rural, with population densities just over one third as high as the rest of the state.

## EFFICIENCY PLAYS A KEY ROLE IN FACILITATING THE TRANSITION TO A CLEAN ELECTRICITY SECTOR

**(a) Increasing the contribution of the least cost, lowest carbon, cleanest resource**

50. One of the primary points of contention is how much load can be served by efficiency, which is a very low carbon, low pollution resource. Attachment MNC-11 above shows that

Massachusetts and California have much high levels of efficiency. Attachment MNC-13 shows that demand in New York in 2017 was well-below the level the staff had projected using a fixed quantity of reduction due to efficiency that equals about 1.37 percent of 2017 load. On a weather adjusted basis, the trend was not reversed in 2018. The actual reduction between 2015 and 2017 is closer to 2%, the level achieved by California and well below Massachusetts. Thus, the suggestion that a higher level of annual efficiency gain is achievable seems plausible.

51. In this analysis I use a cost for efficiency of $035/KWh, escalating to $0.04/KWh, which is very cautious.[39] My finding that the contribution of efficiency to the mid-term goal of decarbonization could be twice what the staff has assume is consistent with my findings at the national level. As shown in Attachment MNC-14, the contribution of efficiency could also be double what the EPA assumed in its Clean Power plan, based on the estimates of the national experts.

**(b) The broader significance of efficiency**

52. Efficiency plays a much more important role than just helping to meet demand. Efficiency has long been the least cost resource when it comes to meeting the need for electricity, but it takes on a new prominence in the larger 21st century electricity system that is being born.

[39] See Mark Cooper, *Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California,* California Energy Commission's Energy Academy, February 20, 2014 and the underlying studies including Kenji Takahasi and David Nichols, "Sustainability and Costs of Increasing Efficiency Impact: Evidence from Experience to Date," ACEEE Summer Study on Energy Efficient Buildings (Washington, D.C., 2008), p. 8-363, McKinsey Global Energy and Material, Unlocking Energy Efficiency in the U.S. Economy (McKinsey & Company, 2009); National Research Council of the National Academies, America's Energy Future: Technology and Transformation, Summary Edition (Washington, D.C.: 2009). The NRC relies on a study by Lawrence Berkeley Laboratory for its assessment (Richard Brown, Sam Borgeson, Jon Koomey and Peter Biermayer, U.S. Building-Sector Energy Efficiency Potential (Lawrence Berkeley National Laboratory, September 2008).

53. Efficiency is a better strategy for buying time for non-hydro renewables than nuclear for several reasons, in addition to the fact that it is much lower in cost. It buys time for the deployment of non-hydro renewables to meet need and lower emissions. The ICT revolution on which the 21st century electricity system relies makes it possible to manage and rely on the demand-side for a larger role in the operation of the system. It fits comfortably into the new system. And, it reduces the scale of needed increments of power, thereby favoring the small scale, decentralized alternatives.

54. Attachment MNC-15 highlights this effect of efficiency. First, it is important to note that the alternative approach, but shrinking demand and integrating it with supply, while shedding huge central station facilities reduces the size of the required system. The transformation to a system that dynamically matches supply and demand has a "transformation dividend" in the reduction of load of 10-20%. The Regulatory Analysis Project puts the number at 17%. It turns out NYSERDA arrived at exactly the same conclusion.

55. Using a slightly higher level of achieved efficiency (2% instead of 1.37%), enables the state to easily achieve its goals without subsidizing nuclear, per Attachment MNC-15. The table below. The combination of efficiency and the transformation dividend accounts or one-sixth of the total low carbon resources in 2030 and over one-quarter in 2040. Efficiency provides the margin that ensures the renewables will meet the need.

## EMPLOYMENT AND THE LOCAL ECONOMY[40]

[40] The Commission, the Governor, or the NYS Legislature could implement a community and worker protection program to ensure a responsible and effective economic transition for communities and workers impacted by power plant closures. Multiple pieces of New York State energy policy are designed to supplant the state's current dirty energy resources with new, renewable, and/or distributed resources. The state should recognize this fact and approach it proactively and with a commitment to ensure that workers and communities land on their feet. (Responsive Comments, p. 10).

**(a) Subsidizing reactors does not increase employment**

56. The 2015 Brattle Group Report, entitled "New York 's Upstate Nuclear Power Plants' Contribution to the State Economy Brattle Group" ("Brattle Report")[41] assumes that

- every kilowatt hour of electricity produced by a retired reactor is replaced with a kilowatt hour generated by natural gas,
- there will be no increase in production by wind, solar or efficiency, at the end of the subsidy period,
- the elasticity of price with respect to supply implicit in the analysis is just under one, while the elasticity of demand with respect to price is zero,
- the macroeconomic multiplier on the use of natural gas to generate electricity is assumed to be equal to that of nuclear, so the reduction of direct and indirect jobs and economic activity resulting from the price increase is a total loss.

57. Based on the Brattle Report's assumption at the end of the Tier 3 nuclear subsidy program, New York will find itself in exactly the same position it is in today, having less electricity produced from new renewable technologies and more electricity still being produced aged, 60+ year, outdated nuclear reactor technology.

58. All of these assumptions are incorrect, which means the self-serving analysis should not be taken seriously. Put another way, the analysis should be seen as so seriously flawed that it

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41 xx

should not provide the basis for making policy choices. The key flaws in the Brattle Report's assumptions are:

- The "dash to gas" is not an unavoidable or inevitable outcome. If the PSC does not put its thumb on the scale of competition, but allows all low carbon resources to compete to meet increasing levels of carbon reduction set by mandates on utilities, the lower cost alternatives would expand rapidly. In this analysis I assume it expands incrementally to replace nuclear (i.e. it fills 1/12 of the retiring capacity per year). Initially there is reliance on gas, but that is eliminated over time.

- Due to the lower cost of alternatives, the market clearing price rises initially, as gas increases but declines rapidly. This is a very cautious approach to the transition. A more aggressive policy could deliver benefits much more rapidly.

- As alternatives replace nuclear and back out transitory gas, there is a macroeconomic impact. Construction for the alternatives is much more labor intensive than operating nuclear reactors.

59. Because the cost of the alternatives is lower, they have a larger long-term impact on indirect economic activity because they leave more money in the consumers pocketbook to buy other things. The literature overwhelmingly supports the proposition that the economy is better off relying on the alternatives.

60. For the purposes of this analysis, I assume that the approach that relies on alternatives has a multiplier that is twice that of nuclear. Attachment MNC-16 summarizes the basis for this assumption. It combines the results of three studies that apply a very common approach. Using macroeconomic models, the study estimates the direct and indirect effect of investing in a

technology to produce or conserve energy. One such model was used in the effort to defend the continued operation of aging reactors. Some activities have larger multipliers because the results (savings or spending) circulated faster through the economy. This is true both across sectors, as shown in the right-side graph of Attachment MNC-16 and within the electricity sector, as shown in the left side graph of Attachment MNC-16.

61. I have rendered the results of these studies comparable by indexing energy across studies and expressing the outcome as a ratio. The PERI study gives estimates for the impact of investment in nuclear and oil and gas. I equate the energy category from ACEEE to the oil and gas category from PERI. Setting nuclear equal to one as the base, I can then calculate the relative job intensive of broad economic sectors (to the right) and electricity resources (to the left). Wei et al., calculated the number of jobs for each of the resources directly. While the correlation is not perfect, it is substantial and the directionality is clear. The nuclear multiplier is the smallest of all sources of electricity and economics sectors. In light of this data, my assumption that the alternatives would have a multiplier twice the size of nuclear is extremely cautious.

62. Attachment MNC-17 shows the impact of the alternative scenarios. The upper graph shows the projected market clearing price. The impact study prepared to defend keeping the reactors online assume complete replacement with gas, which drive up the market clearing price by almost 16%. In the alternative scenario, efficiency and non-hydro renewables replace the retired reactors incrementally at a steady pace (1/12 per year). I bring these increments in at a cost of $45/MWh, consistent with the earlier analysis. Since this is almost 20% below the market clearing price, it incrementally lowers the market clearing prices. The market clearing price increases initially but by year six, it is below the base case. The cost in the early years is

offset by savings in the later years, so that consumers break even shortly after the reactors are fully retired.

**(b) More Jobs Created from Renewable Energy Sector Than by Continued Operations of Aging Nuclear Reactors**

63. In the lower graph, I plot the macroeconomic impacts of this alternative scenario. Since "indirect" jobs represent over 90% of total jobs, the multiplier is far and away the most important factor. In this analysis I do not include decommissioning jobs, since those will be captured whenever the reactors are required. In this orderly transition, there is no net loss of jobs even from the beginning. Direct jobs added by replacing the reactors exceeds the number lost in early retirement.

64. The Illinois Department of Commerce analysis presents a more balanced view and raises the question of the impact on the local and state economy. As shown Attachment MNC-18, the loss of nuclear reactor-related jobs (direct and indirect) is offset in the early years by construction of alternatives. This calculation does not include decommission activities at the reactors. Ironically, while the Department of Commerce does not include decommissioning jobs, it then criticizes the Nuclear Energy Institute analysis that failed to do so.[42] In long term, the lower cost of the alternatives and high multipliers far outweigh the small difference in direct jobs, yielding much higher levels of employment and economic activity. There is no reason to delay capturing these benefits, or put them at risk by extending the life of reactors.

[42] Illinois Commerce Commission, Illinois Power Agency, Illinois Environmental Protection Agency, and Illinois Department of Commerce and Economic Opportunity. *Response To The !/linois General Assembly Concerning House Resolution I I46.* January 5, 2015, p. 1 50.

65. Above I showed that if policy makers conclude that subsidies are necessary to accelerate and ensure the transition to a low carbon sector, they should target those subsidies at the alternatives. I reach the same conclusion with respect to employment and macroeconomic impacts. If policy makers conclude that the transformation of the electricity sector requires support for local labor and the local economy are necessary, they should focus on moving toward the alternative electricity system, not move toward a dead end by extending the life of existing reactors.

**MNC-1**

**RESEARCH AND TESTIMONY ON NUCLEAR POWER AND THE EMERGENCE OF THE 21ST CENTURY ELECTRICITY SYSTEM**

**Articles/Papers**

"Governing the Global Climate Commons: The Political Economy of State and Local Action, After the U.S. Flip-Flop on the Paris Agreement," *Energy Policy,* 2018.

*The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Power Sector* (Santa Barbara, Praeger, 2017).

"Energy Justice in Theory and Practice, Building a Progressive Road Map," in Thijs Van de Graaf, et al. (eds.) *The Palgrave Handbook of the International Political Economy of Energy* (Palgrave, Macmillan, 2016)

"Renewable and distributed resources in a post-Paris low carbon future: The key role and political economy of sustainable electricity," *Energy Research & Social Science,* 2016.

"Small modular reactors and the future of nuclear power in the United States," *Energy Research & Social Science,* 2014.

*Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California,* California Energy Commission's Energy Academy, February 20, 2014

"Multi-Criteria Portfolio Analysis of Electricity Resources: An Empirical Framework for Valuing Resource in an Increasingly Complex Decision-Making Environment", *Expert Workshop: System Approach to Assessing the Value of Wind Energy to Society, European Commission Joint Research Centre, Institute for Energy and Transport*, Petten, The Netherlands, November 13-14, 2013

"Nuclear Aging: Not so gracefully," *Bulletin of the Atomic Scientists,* 69, 2013

"Nuclear Safety and Affordable Reactors: Can We Have Both?," *Bulletin of the Atomic Scientists,* 68, 2012

"Nuclear Safety and Nuclear Economics, Fukushima Reignites the Never-ending Debate: Is Nuclear Power not worth the risk at any price?," *Symposium on the Future of Nuclear Power,* University of Pittsburgh, March 27-28, 2012

"Nuclear liability: the post-Fukushima case for ending Price-Anderson," *Bulletin of the Atomic Scientists,* October, 5, 2011

"Prudent Resource Acquisition in a Complex Decision-Making Environment: Multidimensional Analysis Highlights the Superiority of Efficiency," *Current Approaches to Integrated Resource Planning, 2011 ACEEE National Conference on Energy Efficiency as a Resource*, Denver, September 26, 2011

The Implications of Fukushima: The US perspective," *Bulletin of the Atomic Scientists*, July/August 2011 67: 8-13

*Least Cost Planning for 21st Century Electricity Supply: Meeting the Challenges of Complexity and Ambiguity in Decision Making,* MACRUC Annual Conference, June 5, 2011

"Risk, Uncertainty and Ignorance: Analytic Tools for Least-Cost Strategies to Meet Electricity Needs in a Complex Age," *Variable Renewable Energy and Natural Gas: Two Great Things that Go Together, or Best Not to Mix Them.* NARUC Winter Committee Meetings, Energy Resources, Environment and Gas Committee, February 15, 2011

**Testimony**

"The Economic Feasibility, Impact on Public Welfare and Financial Prospects for New Nuclear Construction, For Utah Heal," July 2013.

"Comments of Dr. Mark Cooper." In the Matter of Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Environmental Protection Agency, RIN 2060-AR33, November 24, 2015.

*Nuclear Power Is an Expensive, Inferior Resource That Has No Place in a Least-Cost, Low-Carbon Portfolio.* Submission to the Electricity Generation from Nuclear Fuels, Nuclear Fuel Cycle Royal Commission, August 3, 2015.

Testimony and Surrebuttal Testimony on Behalf of the Sierra Club, 33*Before The South Carolina Public Service Commission*, Docket No. 2012-203-E, October 2012

Statement of Mark Cooper, *Nuclear Economics after Fukushima,* Before the Standing Committee on Natural Resources House of Commons, Ottawa Canada, March 24, 2011

"Testimony of Dr. Mark Cooper on House File 9," *Minnesota House of Representatives Committee on Commerce and Regulatory Reform*, February 9, 2011

Testimony of Dr. Mark Cooper, Senior Fellow for Economic Analysis Institute for Energy and the Environment, Vermont Law School, on 'Economic Advisability of Increasing Loan Guarantees for the Construction of Nuclear Power Plants," *Domestic Policy Subcommittee, Committee on Oversight and Government Reform, U.S. House of Representatives,* April 20, 2010

"Testimony of Dr. Mark Cooper on House File 9," *Minnesota House of Representatives Committee on Commerce and Regulatory Reform*, February 9, 2011

"Direct Testimony of Dr. Mark N Cooper in Re: Nuclear Plant Cost Recovery for the Southern Alliance for Clean Energy," Before the *Florida Public Service Commission*, FPSC Docket No. 100009-EI, August 2010

"Direct Testimony of Dr. Mark N Cooper in Re: Nuclear Plant Cost Recovery for the Southern Alliance for Clean Energy," Before the *Florida Public Service Commission*, FPSC Docket No. 090009-EI, July 15, 2009

**Research Reports**

*A Clean Slate for Vogtle, Clean Energy for Georgia: The Case for Ending Construction at the Vogtle Nuclear Power Plant and Reorienting Policy to Least-Cost, Clean Alternatives,* for the Sierra Club of Georgia, February 2018

*Trump's $2 Trillion Mistake, The "War On Energy Efficiency: The "command-but-not-control" approach to energy efficiency performance standards for appliance and vehicles corrects market failures and delivers consumer pocketbook savings, macroeconomic and public health benefits* (Consumer Federation of America, December 1, 2017)

*The Failure of The Nuclear Gamble In South Carolina: Regulators can Save Consumers Billions by Pulling the Plug on Summer 2 & 3 Already Years behind Schedule and Billions Over Budget Things are Likely to Get Much Worse if the Project Continues*, for the Sierra Club of South Carolina, July 2017

*Power Shift, The Nuclear War Against the Future: How Nuclear Advocates Are Thwarting the Deployment of a 21st Century Electricity Sector*. Institute for Energy and the Environment, Vermont Law School, May, 2015.

*Advanced Cost Recovery;* Institute for Energy and the Environment, Vermont Law School, September 2013

*Renaissance in Reverse: Competition Pushes Aging U.S. Nuclear Reactors to the Brink of Economic Abandonment,* July 2013

*The Economic Feasibility, Impact on Public Welfare and Financial Prospects for New Nuclear Construction, For Utah, Heal,* July 2013

*Public Risk, Private Profit, Ratepayer Cost, Utility Imprudence: Advanced Cost Recovery for Reactor Construction Creates another Nuclear Fiasco, Not a Renaissance,* March 2013

*Fundamental Flaws In SCE&G's Comparative Economic Analysis,* October 1, 2012

*Advanced Cost Recovery for Nuclear Reactors*. Institute for Energy and the Environment, Vermont Law School, March 2011

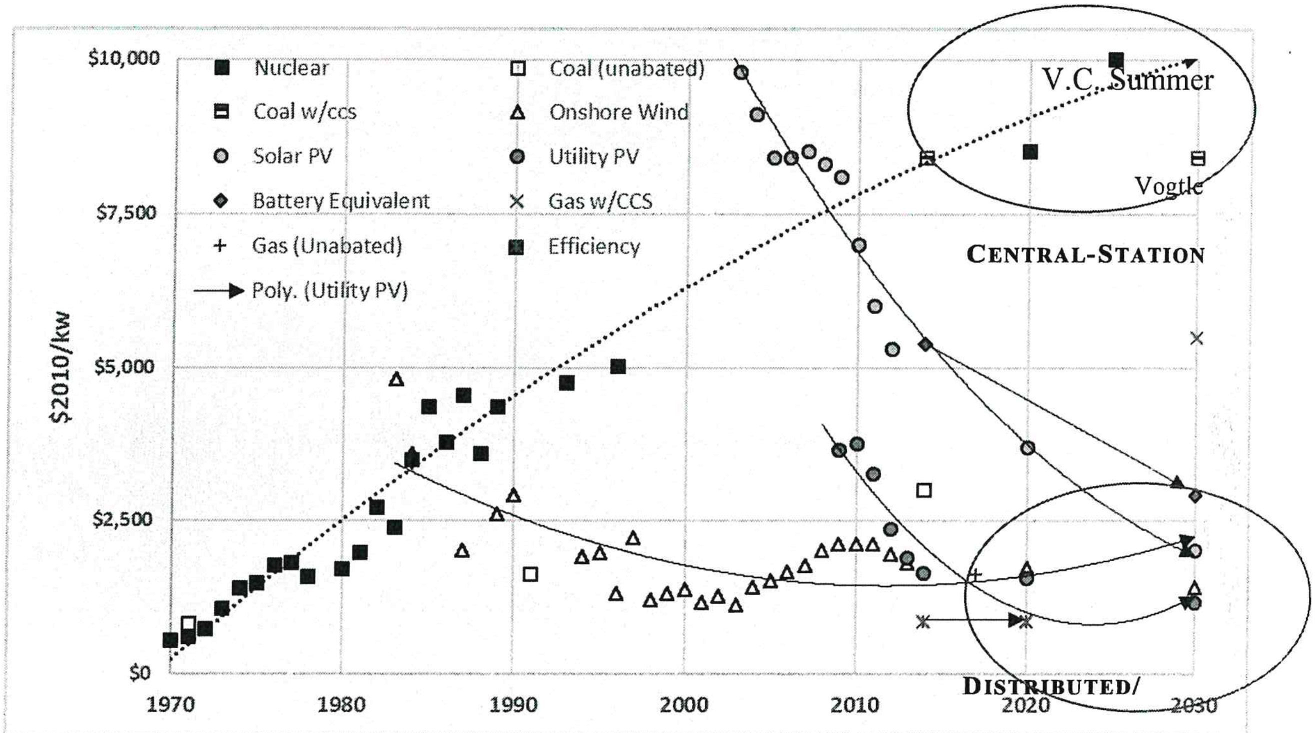
*Policy Challenges of Nuclear Reactor Construction: Cost Escalation and Crowding Out Alternatives,* Institute for Energy and the Environment, Vermont Law School, September 2010

*All Risk; No Reward,* Institute for Energy and the Environment, Vermont Law School, December 2009

*The Economics of Nuclear Reactors: Renaissance or Relapse*, Institute for Energy and the Environment, Vermont Law School, June 2009

## MNC-2

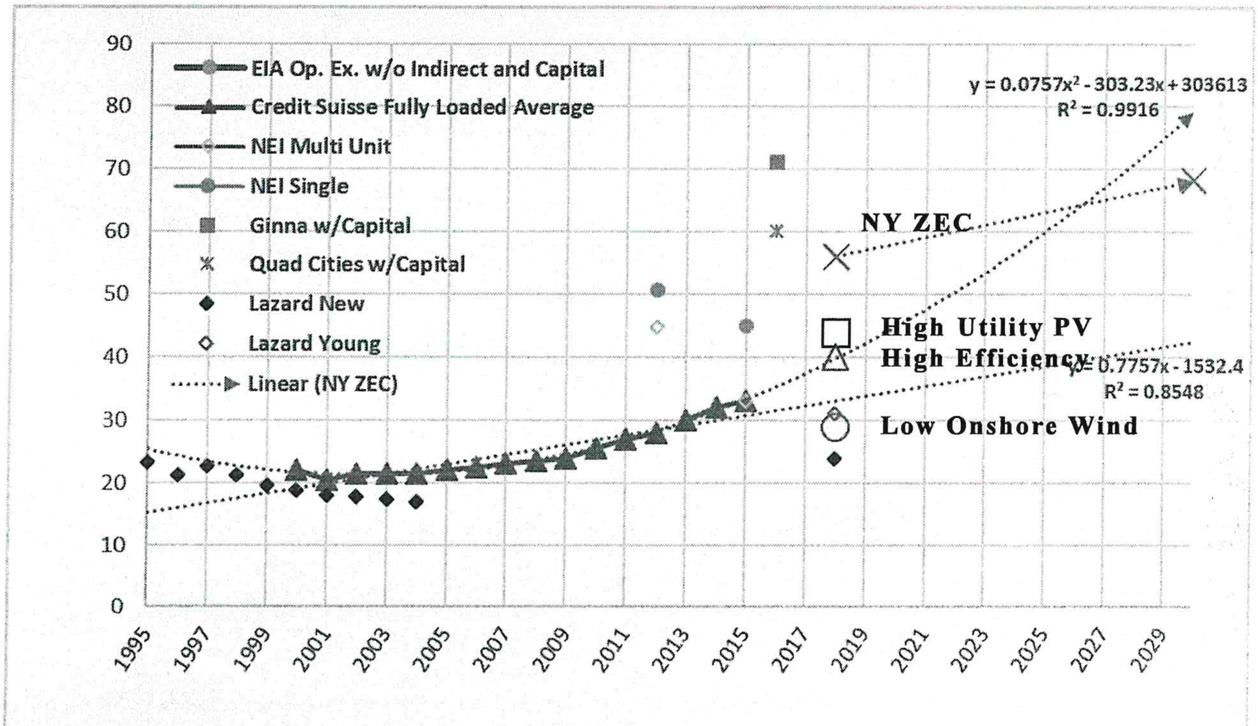
### PAST, PRESENT AND FUTURE COST OF NUCLEAR POWER V. ALTERNATIVES




Source: Updated and adapted from Mark Cooper, *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Sector* (Santa Barbara, Praeger, 2017), Figure 2.1 and accompanying text. (overnight cost for capital-intensive technologies, fuel-intensive technologies based on relative cost per kWh). Underlying data from the following: Mark Cooper, "Nuclear Safety and Nuclear Economics, Fukushima Reignites the Never-ending Debate: Is Nuclear Power not worth the risk at any price?" *Symposium on the Future of Nuclear Power*, University of Pittsburgh, March 27-28, 2012, "Small Modular Reactors and the Future of Nuclear Power in the United States," *Energy Research & Social Science*, 3, 2014;; Charles Komanoff, *Power Plant Cost Escalation, Nuclear and Coal Capital Costs, Regulation and Economics* (1981); James McNerney, J. Doyne Farmer, and Jessika E. Trancik, "Historical costs of coal-fired electricity and implications for the future," *Energy Policy*, 39 (6), 2011; Lazard, *Lazard's Levelized Cost of Energy Analysis – Version 12.0*, November 2018; Galen Barbose, Naïm Darghouth, Samantha Weaver, and Ryan Wiser, *Tracking the Sun VI: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012*, Lawrence Berkeley National Laboratory, July 2013; Ryan Wiser and Mark Bolinger, *2012 Wind Technologies Market Report,* U.S. Department of Energy, August 2013; Greenpeace International, Global Wind Energy Council, and Solar Power Europe, *energy [r]evolution: A Sustainable World Energy Outlook, A 100% Renewable Option for All*, September 2015; Jaffe, S. and Adamson, K.A., *Advanced Batteries for Utility-Scale Energy Storage*, Navigant Consulting, Boulder, CO, 2014, *Australian Power Generation Technology Report,* November 2015. Bjorn Nykvist and Mans Nilsson, "Rapidly falling costs of battery packs for electric vehicles," *Nature Climate Change*, 2015 (5).]

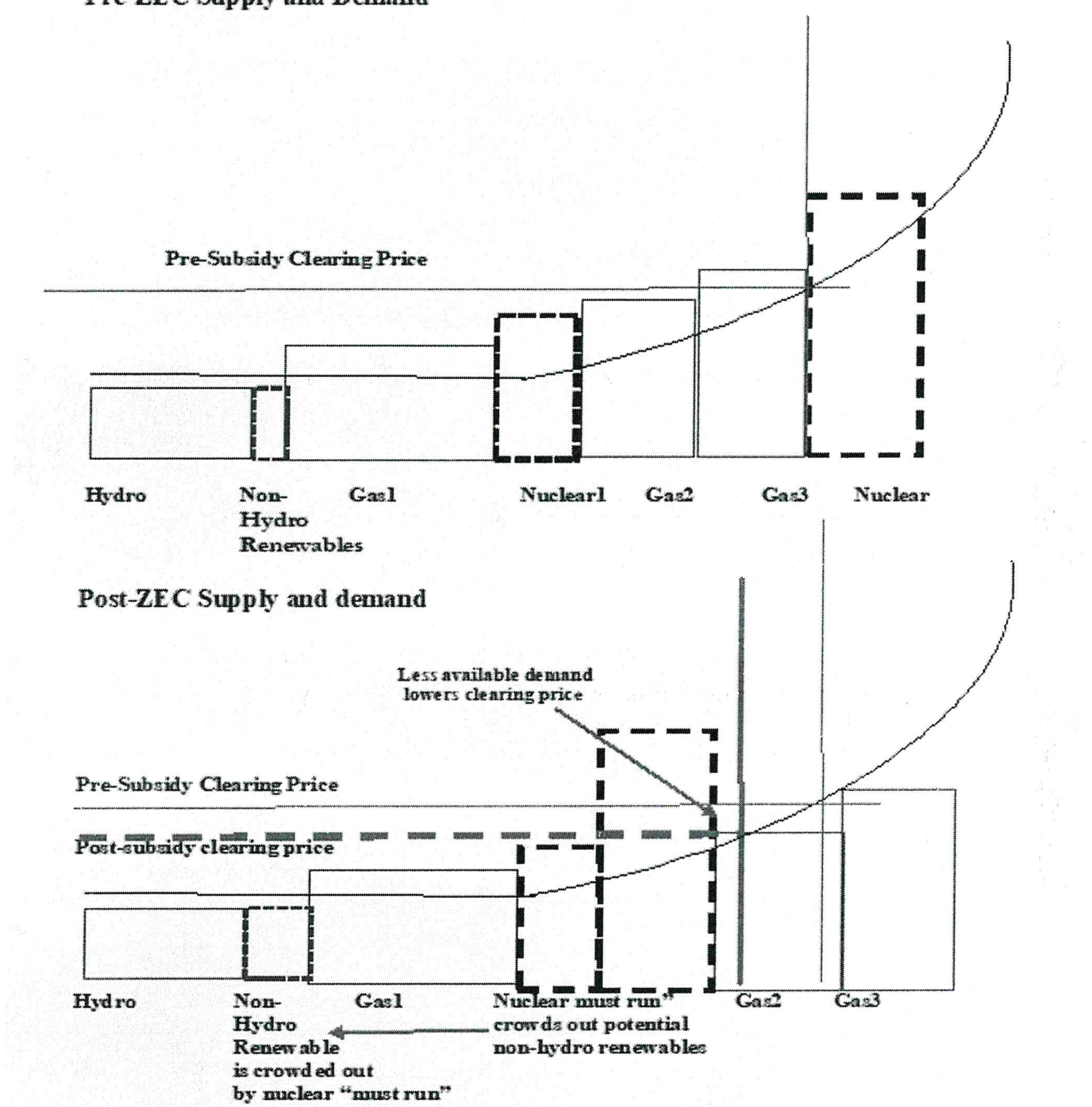
**MNC-3**

**OPERATING AND TOTAL COST OF AGING REACTORS COMPARED TO WIND & UTILITY PV**




Sources: Eggers, Dan, Kevin Cole, and Matthew Davis. *Nuclear . . . The Middle Age Dilemma? Facing Declining Performance, Higher Costs, Inevitable Mortality.* Credit Suisse, 2013; Lazard. *Lazard's Levelized Cost of Energy Analysis12.0*, November 2018, Nuclear Energy Institute, *Nuclear Costs in Context,* October, 2018; NEI Operating Cost (Nuclear Street News Team. "NEI Lays Out the State of Nuclear Power." Nuclearstreet.com. February 26, 2014); NEI Excludes Indirect (Nuclear Energy Institute, Operating Costs, http://www.nei.org/Knowledge-Center/Nuclear-Statistics/Costs-Fuel,-Operation,-Waste-Disposal-Life-Cycle/US-Electricity-Production-Costs-and-Components); Naureen S. Malik and Jim Poulson, "New York Reactors Survival Tests Pricey Nuclear," *Bloomberg,* January 5, 2015, p. 2. Quad Cities is based on a $580 million subsidy (Steve Daniels, "Exelon Puts an Opening Price Tag on Nuclear Rescue: $580 Million," *Crains Chicago Business*, September 24, 2014), converted to $25/MWH for output at risk reactors. Illinois Commerce Commission, Illinois Power Agency, Illinois Environmental Protection Agency, Illinois Department Commerce And Economic Opportunity, 2015, *Response To The Illinois General Assembly Concerning House Resolution 1146*, January 5, real price increase to break even, plus $11/MWH for capital. "Comments of Dr. Mark Cooper." In the Matter of Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Environmental Protection Agency, RIN 2060-AR33, November 24, 2015. Comments by Alliance For A Green Economy and Nuclear Information and Resource Service, Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard, Case 15-E-0302, April 22, 2016; RE: Case 15-E-0302- In the Matter of the Implementation of a Large-Scale Renewable Program and a Clean Energy Standard Re: Case 16-E-0270: Petition of Constellation Energy Nuclear Group, LLC; R.E. Ginna Nuclear Power Plant, LLC; and Nine Mile Point Nuclear Station, LLC to Initiate a Proceeding to Establish the Facility Costs for the R.E. Ginna and Nine Mile Point Nuclear Power Plants, July 22, 2016

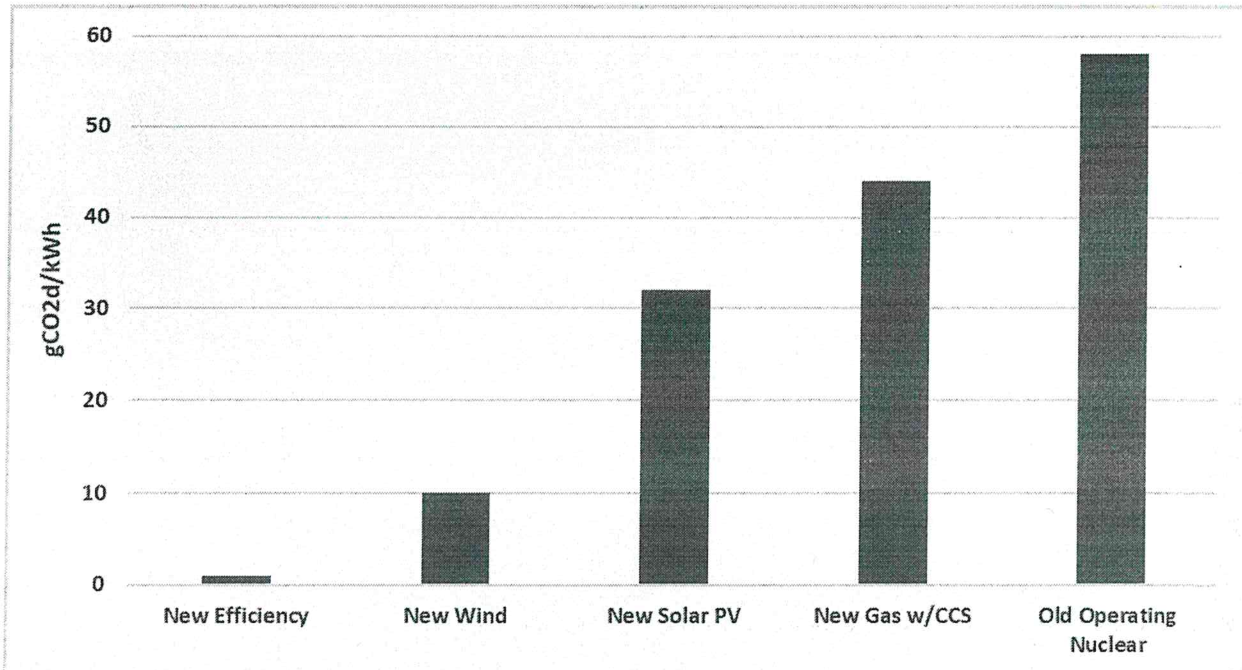
## MNC-4
### MARKET DISTORTION CAUSED BY THE ZEC SUBSIDY, CROWDING OUT NON-HYDRO-RENEWABLES




Source: The merit order effect has been widely recognized and nuclear advocates began using it to argue for "out of market" treatment shortly after initial economic retirements. See, Doug Vine and Timothy Juliant, 2014, *Climate Solutions: The Role of Nuclear Power,* Center for Climate and Energy Solutions, April, p. 6; Mark Cooper, *Power Shift, The Nuclear War Against the Future: How Nuclear Advocates Are Thwarting the Deployment of a 21st Century Electricity Sector*. Institute for Energy and the Environment, Vermont Law School, May, 2015.

## MNC-5

### PRESENT CARBON FOOTPRINT OF LOW CARBON RESOURCES




Source: Benjamin K. Sovacool, "Valuing the greenhouse gas emissions from nuclear power: A critical survey," *Energy Policy,* Volume 36, Issue 8, August 2008, Pages 2950-2963.

## MNC-6
### Lifecycle Carbon Emissions with Lost Opportunity of Delay
(Grams of $CO_2$/ **kwh**)

| | Life Cycle | | Cost of Construction delay | |
|---|---|---|---|---|
| | Low | High | Low | High |
| **Wind** | **4** | **7** | | |
| **CSP** | **9** | **11** | | |
| **Solar** | **19** | **59** | | |
| **Geothermal** | **15** | **55** | **1** | **6** |
| **Hydro** | **17** | **22** | **31** | **49** |
| **Nuclear** | **9** | **70** | **59** | **106** |

Source: Jacobson, Mark Z., "Review of solutions to global warming, air pollution, and energy security," *Energy and Environmental Science*, 2009, Table 3; Benjamin K. Sovacool and Michael Dworkin, *Global Energy Justice,* Cambridge University Press, 2014 (Non-GHG, p. 149; GHG, p. 108); Benjamin K. Sovacool, "Exposing the Paradoxes of Climate Change Governance," *International Studies Review,* 16 (2), 2014;

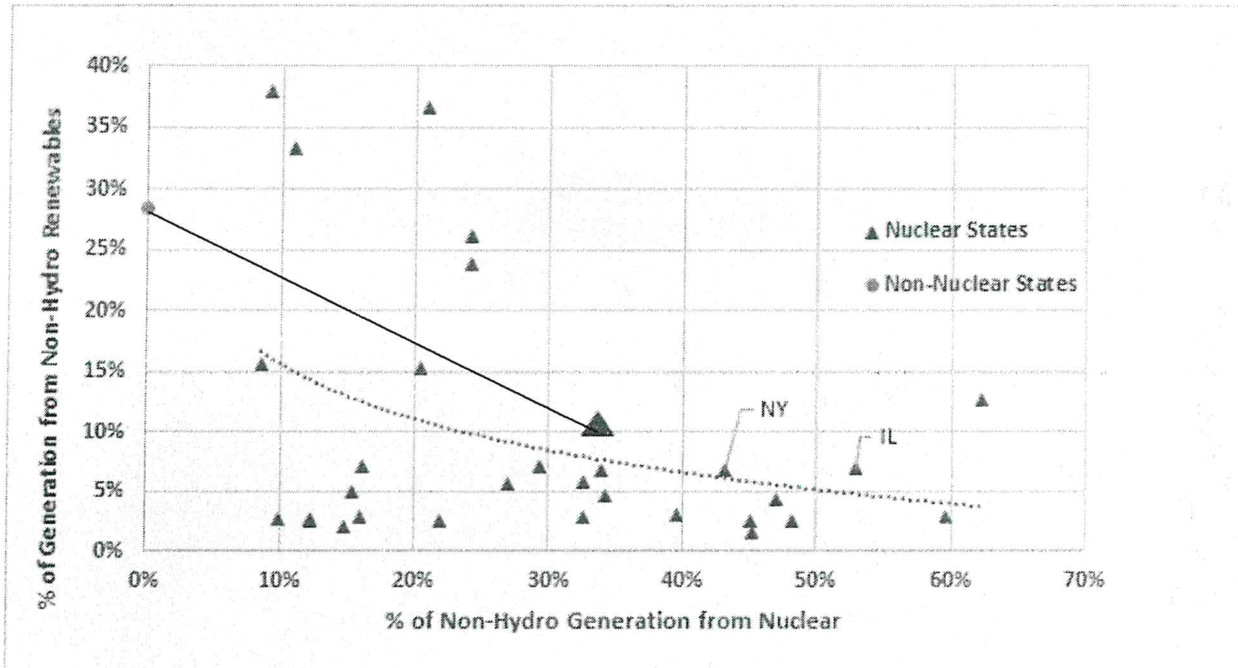
## MNC-7
## NON-CARBON ENVIRONMENTAL IMPACTS

| Resource | Pollutants Cents/MWh | Accidents Fatalities | | Water (m3/MJ) | Land (m2/GWh) | |
|---|---|---|---|---|---|---|
| Efficiency | ~0 | ~0 | | 0 | 0 | |
| Wind | 0.29 | 1 | | 0.01 | 2404 | |
| PV | 0.69 | 4 | | 0.042 | 1232 | |
| Gas w/CCS | | 14.87 | 20 | | 0.31 | 325 |
| Nuclear | 8.63 | 7 | | 0.59 | 78 | |

Source: Mark Cooper, *The Political Economy of Electricity,* Table 5.8 and 5.9 and accompanying text. Underlying data is from Benjamin K. Sovacool and Michael Dworkin, *Global Energy Justice,* Cambridge University Press, 2014 (Non-GHG, p. 149; GHG, p. 108); Benjamin K. Sovacool, "Exposing the Paradoxes of Climate Change Governance," *International Studies Review,* 16 (2), 2014; Mark Z. Jacobson, "Review of solutions to global warming, air pollution and energy security," *Energy Environ. Sci.*, 2, p. 165, 2009; Saeed Hadian and Kaveh Madani, "A system of systems approach to energy sustainability assessment: Are all renewables really green?" *Ecological Indicators* 52, 2015. Sharon J. Klein and Stephanie Whalley, "Comparing the sustainability of U.S. electricity Options through multi-criteria decision analysis," *Energy Policy,* 79 (2015). BEV=battery electric vehicle; CCS = carbon capture and storage.

**MNC-8**

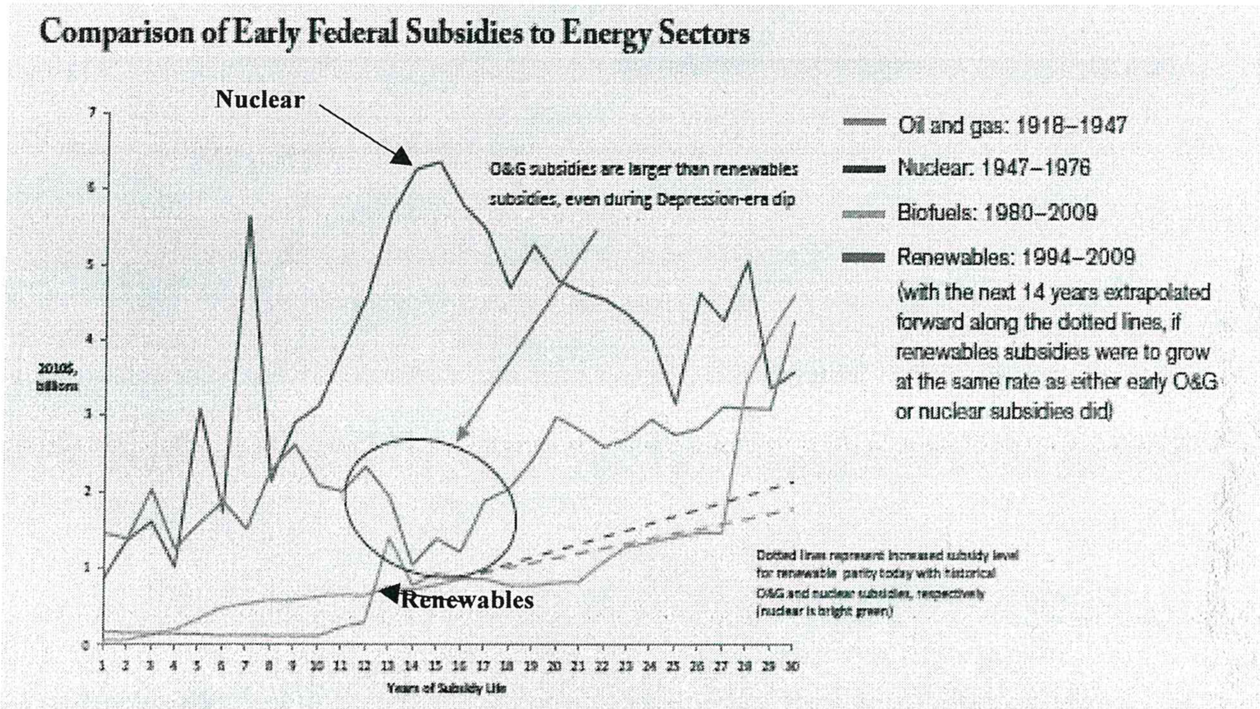
**NUCLEAR STATES HAVE MUCH LOWER LEVELS OF NON-HYDRO RENEWABLES**




Sources: EIA, Electric Power Monthly.

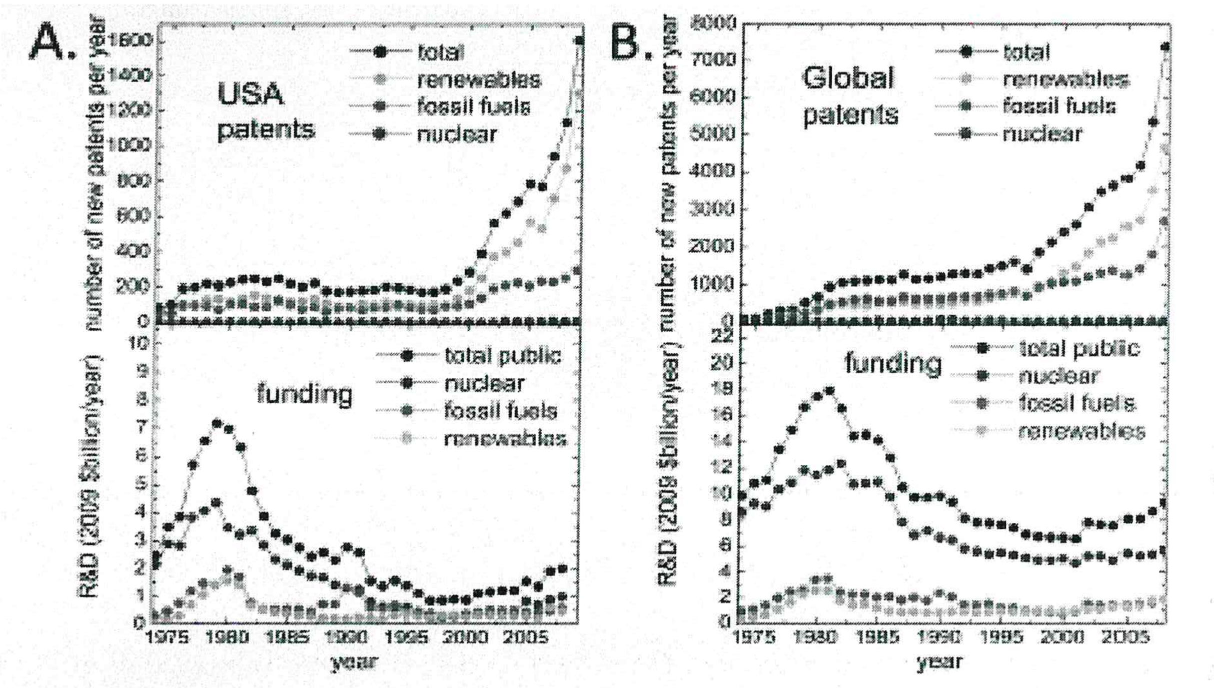
## MNC-9

**FIGURE 5.3: FEDERAL SUBSIDIES FOR INFANT ENERGY INDUSTRIES AND BEYOND**




Source: Nancy Pfund and Ben Healey, *What Would Jefferson Do? The Historical Role of Federal Subsidies in Shaping America's Energy Future*, Double Bottom Line Investors, September 2011, pp. 29–30.

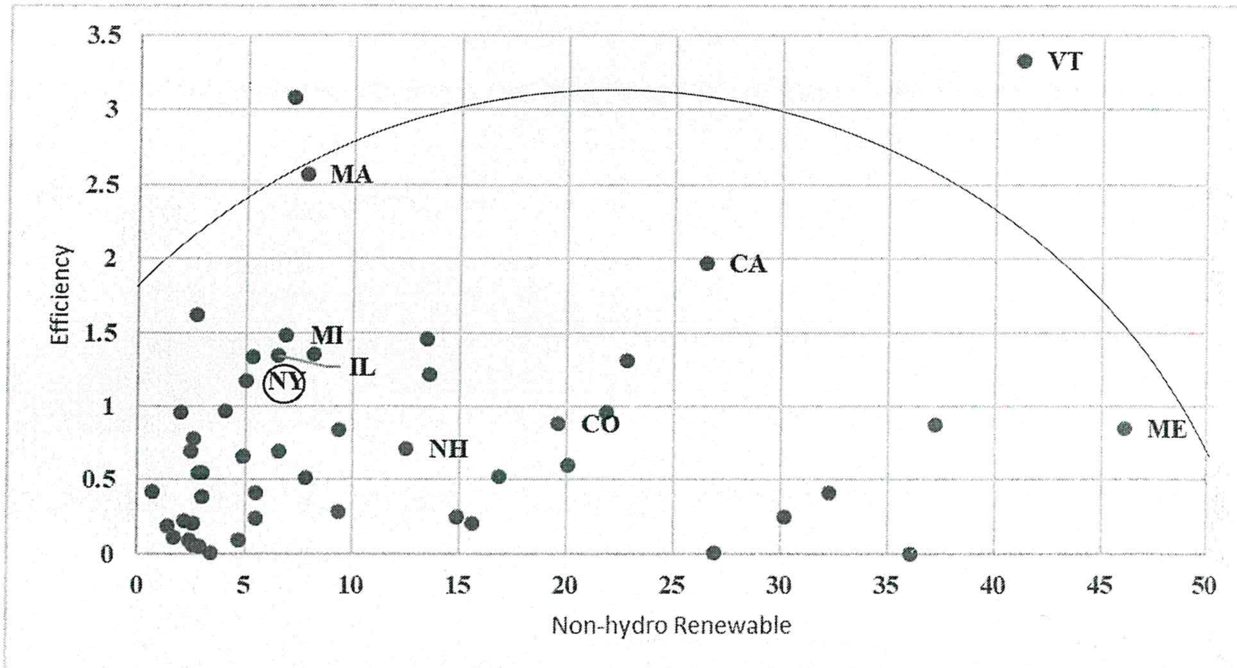
# MNC-10
## INNOVATION AND PUBLIC SUPPORT FOR R&D




Source: Bettencourt, Luı´s M.A., Jessika E. Trancik, and Jasleen Kaur, 2013, "Determinants of the pace of global innovation in energy technologies," *PLoS ONE*, October 8, p. 10.

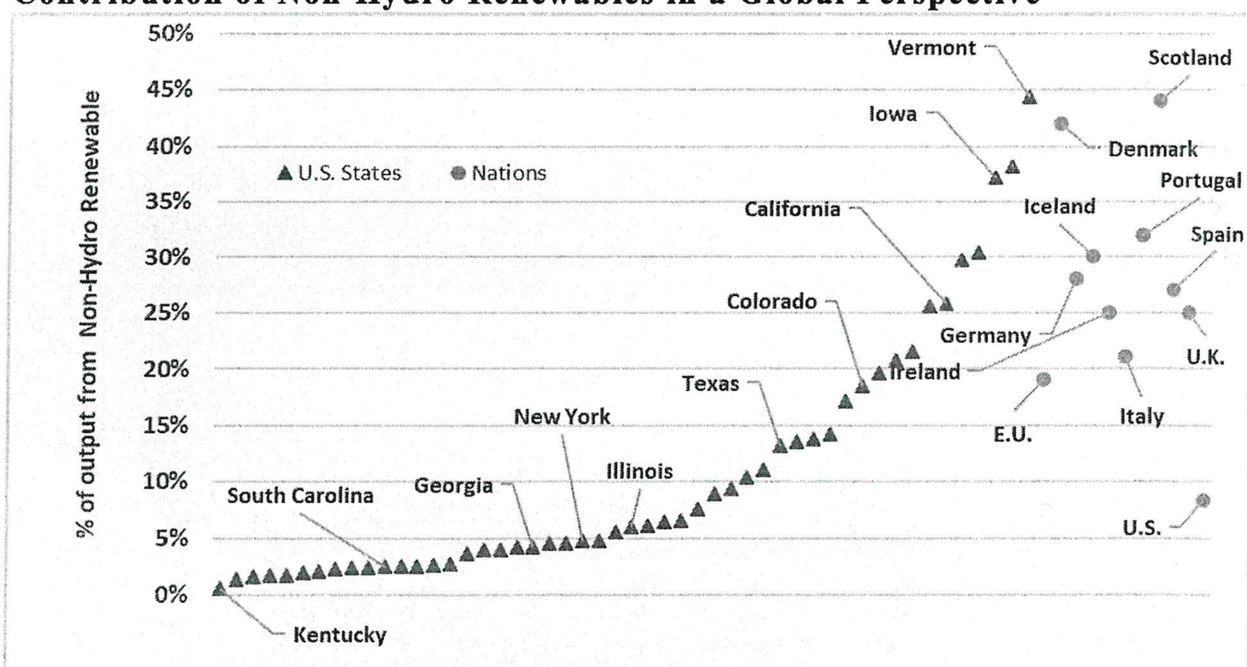
**MNC-11:**

**CONTRIBUTION OF EFFICIENCY AND NON-HYDRO RENEWABLES (% OF DEMAND)**



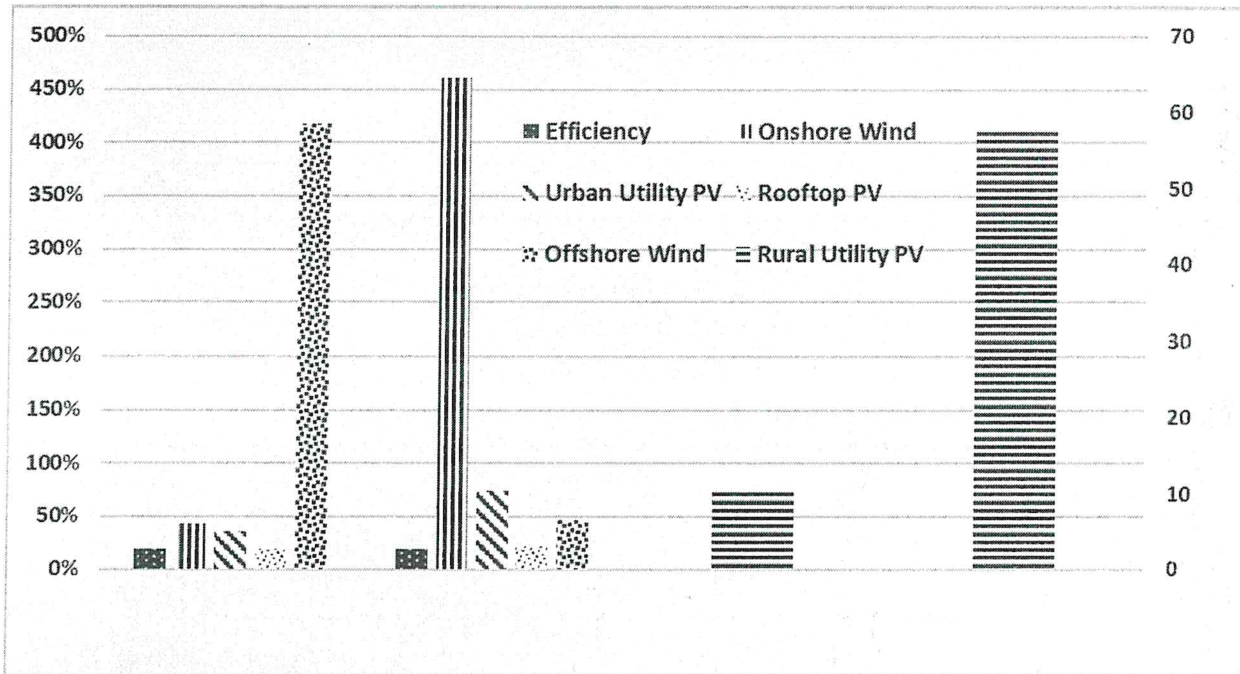

Source: ACEEE, *The 2018 State Energy Efficiency Scorecard*, 2018, p. 28; Energy Information Administration, Electric Supply Monthly, generation and non-hydro renewables.

**Contribution of Non-Hydro Renewables in a Global Perspective**




Source: Lovins, Amory B. 2017. "Reliably integrating variable renewables: Moving grid flexibility resources from models to results." The Electricity Journal, 30(10 )https://en.wikipedia.org/wiki/List_of_U.S._states_by_electricity_production_from_renewable_sources;

**MNC-12:**
**POTENTIAL CONTRIBUTION OF RESOURCES AS A PERCENT OF 2016 LOAD**




Source: Calculated by author as described in text.