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Date: June 30, 2023
Commissioner: Douglas
ALJ: Seybert
Witness: Mark Cooper

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Implementing Senate Bill 846 Concerning Potential Extension of Diablo Canyon Power Plant Operations	R.23-01-007 (Filed January 14, 2023)

CORRECTED OPENING TESTIMONY OF MARK COOPER ON BEHALF OF SAN LUIS OBISPO MOTHERS FOR PEACE ON PHASE 1 TRACK 2 ISSUES

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VERIFICATION

The statements in the foregoing document are true and correct to the best of my knowledge. The facts presented in the forgoing document are true and correct to the best of my knowledge, and the opinions expressed therein are based on my best professional judgment.

I declare under penalty of perjury under the laws of the state of California that the foregoing is true and correct. Executed on July 10, 2023, in Silver Spring, md.

Mark Cooper

Mark Cooper

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Dr. Mark Cooper hereby provides his corrected testimony in this proceeding. All corrections to the opening testimony of Mark Cooper initially filed and served on June 30, 2023 are highlighted in yellow.

CHAPTER 1: INTRODUCTION

Q. Please describe your background?

A. My name is Dr. Mark Cooper, I participated in the 2015 proceeding that dealt with the application for a license extension for Diablo Canyon.[1] Since I testified in opposition to the license extension, I have continually updated the analysis a dozen times in at least one major area on which I testified. These include books and chapters, testimony before various state and federal agencies, and research reports (as shown in Attachment MNC-1.1). This experience is located within over forty years as an expert witness and researcher. I have testified almost 500 times before state and federal regulators on energy, communications and technology issues in virtually every state in the United States. I have also testified in several Canadian provinces. My complete resume appears in Attachment A.

In this testimony, I update the earlier analysis I conducted of the Diablo Canyon reactors, adding a number of additional points that seem particularly relevant under the current circumstances, although they are all related to the earlier issues I addressed. There are eighteen issues covered in total. The outline of the issues I address is contained in attachment MNC-1.2

A. CONCLUSIONS

Q. What is your main conclusion?

A. The conclusion of direct relevance to this proceeding, affirmed on an annual basis, is simple.

Now is not the time to double down on expensive nuclear power with subsidies that will cost ratepayers and taxpayers billions of dollars.

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[1] Mark Cooper, 2015, "Declaration of Mark Cooper in Support of San Luis Obispo Mothers for Peace's Motion to File New Contentions Regarding Adequacy of Environmental Report for Diablo Canyon License Renewal Application, before the Atomic Safety and Licensing Board, in The Matter of Pacific Gas And Electric Company Docket Nos. 50-275-LR Diablo Canyon Nuclear Power Plant 50-323-LR Units 1 And 2, Nuclear Regulatory Commission, April.

Now is the time to move forward as rapidly as possible with the transformation of the electricity system to one reliant on distributed alternatives (i.e., efficiency, wind and solar), which are much lower in cost and much more reliable.

This conclusion applies equally to aging nuclear reactors as well as large or small new builds.

The evidence has gotten stronger over the past decade, particularly with respect to the resource tools and approaches that ensure adequate, reliable supply at lower cost in the 21st century electricity system, which is also very low in carbon.

Extending the Diablo Canyon license and subsidizing it to stay online is unjustified and a major step backwards.

Q. Doesn't it make sense for the PUC and utilities to buy nuclear in theses uncertain times?

A. There is certainly risk in all electricity systems, so buying a little insurance always makes sense. However, that does not mean policy makers should abandon the process of evaluating the risk and buying the most appropriate insurance. The "willing suspension of disbelief" may be fine for poetry, but not for public policy.[2] Buying nuclear insurance is bad insurance policy – the wrong decision – for several reasons.

First, there is no guarantee that the aging nuclear reactors will be there when you need them. They need routine maintenance and may be out of service for "emergency reasons. The transmission grid may not be available to deliver their large output. The alternatives are much smaller and distributed, so the loss of one unit may have a much smaller effect on the grid.

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[2] *Wikipedia* defines the concept as follows. "**Suspension of disbelief** is the avoidance—often described as willing—of critical thinking and logic in understanding something that is unreal or impossible in reality, such as something in a work of speculative fiction, in order to believe it for the sake of enjoying its narrative." In noting the origin of the phrase, in Coleridge's writings, Wikipedia summarizes the reason it should not be adopted in a regulatory proceeding; to wit, the semblance of truth should not be the basis for suspending judgement on implausible outcomes. "The phrase first appeared in English poet and aesthetic philosopher Samuel Taylor Coleridge's *Biographia Literaria*, where he suggested that if an author could infuse a "human interest and a semblance of truth" into a story with implausible elements, the reader would willingly suspend judgement concerning the implausibility of the narrative."

Second, subsidizing aging reactors may send the wrong signal to consumers and the marketplace that nuclear power is essential to the long-term solution. It may divert attention from and reduce commitment to the critical task of building the physical and institutional infrastructure to support the 21st century electricity system.

Third, no insurance is free. In this case it costs at least $1.4 billion (the cost may be higher if the utility is convinced to seek federal funds to support operation of the aging reactor). That sum of money would buy a large quantity of alternatives because they are substantially lower in cost. If policy makers are intent on targeting some of the resources at meeting critical needs, they could do so, by focusing on long duration battery storage, geothermal power, of gas combined cycle with carbon capture, which are dispatchable, and more compatible with a 21st century system. They could also diversify resources at specific geographic areas that are deemed to be vulnerable.

Fourth, relying on subsidizing nuclear power to keep it online has serious consequences, as discussed below. It restricts the growth of alternatives. It may stimulate the effort to resist the transformation of the electricity system. It may result in further demands for delay of the transformation and crowd out the alternatives.

B. THE RELEVANCE OF MY ANALYSIS TO THE ISSUES RAISED BY THE ORDER

Q. How is your testimony responsive to the issues raised by the order in this proceeding?

A. The order instituting this proceeding recognizes the broad powers of the Commission in evaluating Diablo Canyon and its potential substitutes. My testimony compares the alternatives broadly and with specificity. For example, in the discussion of basic conditions the order states that "In establishing new retirement dates for Diablo Canyon, several of the conditions that must be considered by the Commission are set forth in Public Utilities (Pub. Util.) Code Section 712.8(c)(2)(B) through (E)."[3] It then cites numerous conditions and seeks comment on issues that my testimony addresses. This section of the order includes addressing issues such as costs of upgrade that "are too high" and "renewables are adequate.“ Question posed to the public include

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[3] Public Utilities Commission of the State of California, Implementing Senate Bill 846 Concerning Potential Extension of Diablo Canyon Power Plant Operations, Rulemaking 23-01-00, p. 2.

adequacy under the loss of load standard, the length of time to ensure an orderly shutdown of Diablo Canyon and what measures should be taken to protect ratepayers in the event that Diablo Canyon is authorized to continue operation beyond it shut down date.

My testimony in Chapters 2 and 3 reaches the clear conclusion that the costs are "too high"[4] and that "new renewable energy and zero-carbon resources are adequate to substitute for Diablo Canyon." To assess the cost conditions, one must consider the short- and long-term costs of all resources, as in Chapter 2 on all resources, Chapter 3 on nuclear. To assess the adequacy of resources one must assess the availability of resources (Chapter 4) and understand how a 21st century electricity system works (Chapter 5). I argue that when examined carefully, the analyses that the order incorporates into the record do not demonstrate the need to extend the operation of Diablo Canyon (Chapter 6). On the contrary the Commission should conclude that 'New renewable energy and zero carbon resources are adequate to substitute for Diablo Canyon." If it does not reach that conclusion, it must take strong measures to protect ratepayers from excessive rates.

Attachments MNC-1.3 and MNC-1.4 present a graphic representation of the challenge of how to view prices, as well as the key theme of my testimony. MNC-1.3 presents my estimation of the cost of supply and demand-side resources necessary to meet the growing need for electricity as the economy decarbonizes. This will be discussed in detail in Chapter 2. MNC-1.4 presents the inappropriate "suspension of disbelief," about prices that afflicts some analysis. Nuclear advocates suspend disbelief for self-interested reasons (to argue for a continuing and growing role of nuclear power). This is discussed in Chapter 3.

Other analysts simply try to assess the future in an "all of the above" approach that considers all possible outcomes. As explained in Chapters 3 and, especially, Chapter 5, the analytic exercise should not be taken as advocacy for any specific outcome. The message these analyses send is that the worst, and highly unlikely outcome, which is a dependence on extremely expensive nuclear power, should be avoided. The advice is that ability to do so, which has become readily apparent, needs policy to be achieved, is discussed in Chapters 4 and 5.

In these comments I build the case for accelerating the transformation of the electricity sector into a 21st century system (see Attachment MNC-1.5. which is one based on distributed

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[4] Id., pp. 2 - 8.

and renewable resources (including energy efficiency as the “hidden fuel) integrated into a dynamic and flexible system that uses advanced communications, computing capacity and control technologies to match and manage supply and demand. The 21st century system is very different from the 20th century system, which made perfect sense, given the available technologies and prevalent view of view externalities, but no longer does. In building this positive case, I also show why nuclear power in general, but even as an insurance policy for the near term, is a very wasteful use of public resources.

C. OUTLINE

Q. Please provide an outline of your testimony.

A. The testimony leading up to these conclusions examines each of the steps through which a thorough evaluation should go. The testimony is divided into five chapters, after this introduction, each of which deals with the main steps that policymakers should take.

Chapter 2 addresses the issue of the cost of acquiring resources in both the long- and short-terms. It examines other aspects of cost estimation beginning with the “hidden fuel”, energy efficiency, which is a low-cost option that is widely available, but frequently overlooked in “supply-side” analysis. It then examines externalities and certain costs of managing an electricity system dependent on renewable resources and grid integration, including firming costs, avoided costs and values and system costs and values. This analysis shows that the resource costs are a good guide to the relative cost of alternatives. The other cost considerations certainly do not outweigh the conclusions based on the estimation of resource cost; in fact, they reinforce it.

Chapter 3 examines high nuclear cost and the failure of innovation in nuclear power. It covers small and large new reactors, as well as aging reactors. It concludes with the problem that nuclear tends to crowd out the alternatives.

Chapter 4 examines the potential to deliver reliable resources in a 21st century electricity that is adequate to meet demand. It begins with efficiency and the important contribution it can make to the declining cost of meeting the need for electricity. It then reviews the availability of supply side options, wind, solar, geothermal, and storage. With the supply-side and the demand-side considered, the analysis then shows that the resources that can be developed clearly meet the need for electricity. The chapter concludes with a discussion of the macro-economic benefits of building a low cost, low carbon electricity system by ending the focus on central station facilities.

Chapter 5 presents a discussion of the physical and institutional structures that must be built to ensure an effective 21st electricity system that delivers adequate, reliable power the cost to consumers and delivers a large macroeconomic benefit to society. It identifies the "no regrets" policies that constitute the first step, then introduces the many tools that are available to produce an adequate supply of reliable electricity. This involves almost four dozen discrete approaches, which are documented by almost 400 sources from the peer-reviewed and trade literatures. The chapter then turns to a discussion of a 21st century system in the context of numerous analyses that have considered the challenges of building a carbon-free electricity sector that is adequate and reliable, even as it shoulders the increasing burden of the electrification of many of the other parts of the national economy.

While there are certainly challenges, the direction in which public policy should head is clear in all these discussions, emphasizing efficiency, renewables, and hybrid projects, woven together in an intelligent, flexible system where supply and demand are integrated. This is the antithesis of the 20th century approach and the one in which nuclear was born and thrived, even though it was always far from the least cost option. To the extent that policy makers conclude that firm, low-carbon power is necessary to complete the process of deep decarbonization, this chapter argues that long duration storage, geothermal and gas with carbon capture are the least cost options.

Chapter 6 presents my conclusions in the context of the empirical analysis contained in chapters 2 through 5. First, it offers a number of methodologies the PUC can use to deal with the complexity of the of current price estimation, with the goal of using the complex information available in a logical and responsible manner to ensure that decisions are reasonably made in pursuit of prudency and least cost to ratepayers. It then presents evidence that the information used in chapters 2-5 is consistent with the experience in California. It then shows that various approaches to evaluating options based on the information before the Commission indicate that extending the life of Diablo Canyon is economically and operationally unjustified. Finally, it presents my recommendation for policies the PUC should follow. These are presented as a hierarchy that the PUC believes is within its powers in unique circumstance of this proceeding with the goal of protecting ratepayers from unjustified increases in cost.

D. RECOMMENDATIONS

Q. How should the PUC handle the proposal to Continue Operation of Diablo Canyon

A. 1. The PUC should not allow PG&E to change its mind and operate the reactor, even though the legislature is throwing money at it.

2. If the PUC cannot follow the first course of action, no matter the reason, it should not allow the utility to collect rates from ratepayers. If the utility wants to operate the reactors for the sums offered by state and federal taxpayers, it can do so, but at no cost to ratepayers.

3. If the PUC cannot follow the second course, no matter the reason, it can impose market discipline. It should require the reactor to accept only the market clearing price for its output, at the relevant time of day. Needless to say, there will be times when that price is zero.

4. If the PUC cannot force the nuclear reactor to bear the burden of curtailments, it should, subject them to a market test by allowing resources to compete for operation at the lowest price,

5. If the PUC finds it necessary to curtail output, the first place it should look is the nuclear reactors, which are higher in cost, unsuited for the operation of the new system and disruptive of the transformation of the system.

6. If the PUC is unable to impose a market test for curtailments, for whatever reason, it should allocate the curtailments in proportion to the share of generation.

7. Regardless of the pricing and operating arrangement, the PUC should insist that the reactor remains online for only the five-year period defined by the subsidy.

CHAPTER 2: THE COST OF ELECTRICITY

A. ASSESSING RESOURCE COSTS

Q. Where should the analysis of costs begin?

A. Evaluating the potential contribution of resources to meeting the need for electricity must take the cost of each resource into account. The first step is to examine long-term costs. Over a 25-year period (roughly to 2050 from the present) most of the existing resources will have to be replaced at least once. This means that the cost of new builds must be taken into account. Of course, over a 50-year period, just about all resources will have to be preplaced.

One way to take the different life spans and other differences between resources (capital intensity, fuel dependence) into account is to express the cost of new generation on a levelized per megawatt hour (MW) basis. There are other costs that must be considered, e.g., externalities, short-term, transmission, system, firming, etc., but the starting point should be the long-term resource costs of generation.

Q. On what data do you base your estimates of long-term costs?

A. For numerous reasons, as shown in Attachment MNC-2.1, over a decade I have used Lazard's estimate as the base: However, I consider two other estimates and projections of costs (EIA[5] and NREL[6] that are compared to the Lazard estimates.

Attachment MNC-1.3 above and 2.2 make clear that the terrain of long-term costs of the various resources has been deeply affected by major technological forces, some increasing cost, others holding cost relatively constant, but the majority driving costs down. The arrows reflect the direction of change, not precise estimates of costs, which are dependent upon uncertain estimates of the base case as well as regional differences,

The dominant trend for wind and solar over the past few decades has been the dramatic decline in the cost of renewable resources that are plentiful in supply in the U. S. This technological revolution has been reinforced by the falling cost of storage (primarily lithium-ion batteries) to turn intermittent resources, like solar, into quasi-firm power. Wind, solar and solar

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[5] Energy Information Administration, Energy Information Administration (EIA), 2018 - 2022, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook.

[6] National Renewable Energy Laboratory, NREL, Annual Technology BASELINE (ATB), 2020-2022.

plus storage are now the least cost resources by far. Other forms of storage may also be attractive, including pumped storage, and other battery materials.

A "non" trend that is important is the continued, low cost of efficiency. Efficiency was the least cost resource for a long period and remains competitive with wind and solar today. Efficiency, which is generally not studied in this context, is included here because it can make a major contribution to lowering (and therefore the ability to meet) demand. The cost of efficiency has been relatively constant and is likely to remain so due to technological improvements and economies of scale.

At the same time, the cost of nuclear has been rising rapidly. As discussed below, this is true of large and small nuclear facilities. Aging facilities are also relatively costly when capital costs that must be incurred to keep these facilities online are taken into account, in addition to the fact that owners appear to intend to capture a return on their investment in the facilities. Similarly, while coal and natural gas are relatively inexpensive, when the cost of carbon capture is included, they are more costly, but new build gas with carbon capture is one-third less costly than even small nuclear,

While the trends are clear and have been analyzed by Lazard in great detail for renewables, there remain differences of opinion about costs. Attachment MNC-2.2 uses the average of the low and high estimates offered by each study (or the average as identified by that study. There are still differences of opinion about the specific costs of individual technologies, as suggested by Attachment MNC-2.2.

First, Lazard has a much higher estimate for large nuclear reactors. EIA has consistently had very low estimates for nuclear power that do not reflect developments in the real world. EIA states that no advanced nuclear reactors are being constructed. NREL appears to agree. However, the low cost for nuclear might be for small modular reactors. The figure for the costs of nuclear is almost exactly what the leading vendor is predicting (with a huge subsidy). The projected costs for SMRs are still too low. Even with this assumption SMRs are extremely costly. As shown in Attachment MNC-2.2, we consider the range for SMRs to be $90 to $150, per MWH.

The second major difference is the very high cost for geothermal given by NREL. While there may be some facilities that cost this much or more, they are not the typical experience. Attachment MNC-2.2 uses the estimate of the average of the other two sources. In both cases we include both the high estimates for nuclear and geothermal. Lazard is also slightly higher than EIA on solar and geothermal, but these differences are small.

Q. Please Describe Your Estimate of Short-Term Costs?

A. Short-term costs point in the same direction as long-term costs and support the same conclusion. The renewables are lower in cost. Although the differences are smaller and once again, there are points of debate and important considerations. Nevertheless, Lazard concludes that "certain renewable energy generation technologies have an LCOE [levelized cost of electricity] that is competitive with the marginal cost of existing conventional generation.[7] This is based on the fact that the low end of the "all in" costs of renewables is below the lowest marginal cost of traditional resources, as shown in Attachment MNC-2.3

There are three assumptions in Lazard's analysis that underestimate the advantage of renewables.

First, there is an assumption implicit in Lazard's analysis that leads to an underestimation of the cost of traditional central station technologies. As is the case with almost all cost estimates, Lazard uses a high-capacity factor for all three of the traditional technologies, which is well above the actual average observed in the U.S. As a result, costs are underestimated.

Second and much more importantly, Lazard compares the full cost of new build wind or solar to the marginal cost of existing conventional generation. This is a very demanding comparison, since it is a comparison of all-in costs for alternatives to marginal costs for central station technologies. It also must be extremely short-term because keeping aging reactors online inevitably involves expenditure of capital. This is particularly true of aging reactors. Thus, Lazard has made an "apples-to-oranges" comparison, albeit for good reason. Since renewables are the "new kid on the block" and new capacity will be necessary to replace existing capacity, it makes sense to show policy makers that even the total costs of new renewables are competitive with marginal costs of existing resources. However, that is not a reason to underestimate the real-world cost of keeping aging reactors online (i.e., to ignore the capital costs necessary to keep them online.

Since the latter assumption can lead policymakers astray, and to give a sense of a comparison that is "apples-to-apples," we should also look at the marginal cost for all types of

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[7] Id., Lazard, 14.0, p. 7,

resources, and the realistic cost of aging reactors. To do so, I begin with an estimate that includes the estimate of the fixed operating costs provided in the long-run analysis (in MNC-2.4), but not the capital cost for any resources.

Needless to say, renewables are very attractive. The important point is crystal clear, as shown in Attachment MNC-2.5, which includes "apples-to-apples" short-term costs and long-term costs. The short-term comparisons are not at odds with the long-term results. Since the alternatives are least cost in the long term and at least competitive in the short term there is no tradeoff necessary. The alternatives are preferable.

Short- and long-term cost estimation is a crucial first step in evaluating resources, but it is only the first step. There are many other considerations that influence the decision to which we now turn, although they do not change the very clear and strong policy conclusion we have reached based on the estimation of costs.

B. OTHER COMPONENTS OF COST: ENERGY EFFICIENCY, THE HIDDEN FUEL

Q. What other elements of costs do you consider?

A. While the cost of acquiring resources is the first step in the analysis, resource cost does not exhaust all of the issues involved in cost estimation. There is another set of costs imposed by resources that inform policymakers, even though they do not override the estimate of resource costs incurred to meet the need for power. This section examines those "other" costs.

First, transmission costs are taken into account in the EIA estimate of resource costs, which have been considered in the averaging of costs for each resource. Therefore, my discussion begins with an examination of the cost of increasing the efficiency of use of electricity because efficiency was not considered a major resource until recently.

Q. Please discuss the cost of efficiency?

A. Efficiency is now seen as a "hidden fuel" that is the equal of the other resources. Moreover, the cost of efficiency is among the lowest of all the resources. As shown in the upper graph of MNC-2.6. the cost of efficiency has remained low for decades and there is every indication that the cost of efficiency is not rising. In fact, vast quantities of energy can be saved at a very low cost, with the economically attractive opportunities expanding as new technologies convert what was known as "technical potential" into "economically attractive." The forward-looking cost is about \$.03/kWh, well below the backward-looking cost.[8] There is also a significant reduction in electricity demand that occurs from the effect of shifting to decentralized technologies that better match supply and demand, which I call the transformation dividend. Thus, efficiency is cost competitive with the other alternatives and can make a substantial contribution to meeting need and deep decarbonization.

Engineering economic analyses provided the initial evidence for the efficiency gap. *Ex ante* analyses indicated that there would be substantial net benefits from promoting and including technologies to reduce energy consumption in consumer durables. As these policies were implemented *ex post* analyses were conducted to ascertain whether the *ex ante* expectations were borne out. The most intense and detailed studies were conducted by utilities subject to regulation. The lower graph in Attachment MNC-2.6 shows the results of analyses of the cost of efficiency in sixteen states over various periods covering the last twenty years. The data points are the annual average results obtained in various years at various levels of energy savings.

The graph demonstrates three points that are important for the current analysis.

First, the authors suggest that declining costs for higher levels of efficiency can be explained by economies of scale, learning, and synergies in technologies. [9] As utilities implement more of the cost-effective measures, costs decline. In addition, when technical potential is higher than achievable savings, then economies of scale, scope, and learning can pull more measures in without raising costs. This analysis supports the assumption that the cost of efficiency will not increase in the mid-term.

Second, consistent with these findings and observations, it is important to briefly note the analysis of minimum efficiency performance standards for consumer appliances and vehicles. There is a long (30+ year) and rich (20+ standards) history that affects billions of devices. This is precisely the type of broad and sustained impact that policies to promote and achieve the transformation to a carbon-free economy will have to have.

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[8] Mark Cooper, 2014, CFA-CEC Presentation on Energy Efficiency Seminar, California Energy Commission, February 20; quote is from Mark Cooper, 2013, *Energy Efficiency Performance Standards: Driving Consumer and Energy Savings,* October, pp. 30-31, and the underlying studies.

[9] Kenji Takahashi and David Nichols, The Sustainability and Cost of Increasing Efficiency Impacts: Evidence from Experience to Date, ACEEE Summer Study on Energy Efficiency in Buildings, 2008.

Third, in the lower graph of MNC-2.6, all three major investor-owned utilities are included. San Diego is used to identify the trend line. PG&E is close to that trend line.

Moreover, as shown in Attachment MNC-2.7, there was a systematic overestimation by regulators of the cost of efficiency improving regulations in consumer durables. The cost for household appliance regulations was overestimated by over 100% and the costs for automobiles were overestimated by about 50 percent. The estimates of the cost from industry were even father off the mark, running three times higher for auto technologies.[10] Broader studies of the cost of environmental regulation find a similar phenomenon, with overestimates of cost outnumbering underestimates by almost five to one with industry numbers being a "serious overestimate."[11]

> The case-study review suggests that energy efficiency investments have an important effect on learning costs. Required efficiency can provide a significant boost to overall productivity within industry. If this relationship holds, the description of energy-efficient technologies as opportunities for larger productivity improvements has significant implications for conventional economic assessments... … This examination shows that including productivity benefits explicitly in the modeling parameters would double the cost-effective potential for energy efficiency improvement, compared to an analysis excluding those benefits.[12]

These findings of declining cost are not merely descriptive. Several analyses have introduced controls for quality and underlying trends using regression techniques. The findings are affirmed in these more sophisticated analyses. [13] With such strong evidence of costs far below predictions by regulators who undertake engineering analysis, many authors have sought

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[10] Hwang, Roland and Matt Peak, 2006, Innovation and Regulation in the Automobiles Sector: Lessons Learned and Implicit on for California CO_2 Standards, April.

[11] Harrington, Winston, 2006, Grading Estimates of the Benefits and Costs of Federal Regulation: A Review of Reviews, Resources for the Future, September, p. 3.

[12] Ernst Worrell, et al., 2003, "Productivity Benefits of Industrial Energy Efficiency Measures," Energy Journal, 11, p. 1081.

[13] Steven Nadel and Andrew Delaski, Appliance Standards: Comparing Predicted and Observed Prices, American Council for an Energy Efficient Economy and Appliance Standards Awareness Project, July 2013.

to identify the processes that account for this systematic phenomenon. For both vehicles and appliances, a long list of demand-side and supply-side factors that could easily combine to produce the result has been compiled.

On the supply-side, a detailed study of dozens of specific energy efficiency improvements pointed to technological innovation.[14] A comprehensive review of *Technology Learning in the Energy Sector* found that energy efficiency technologies are particularly sensitive to learning effects and policy.[15] This was attributed to increases in R&D expenditures, information gathering, learning-by-doing and spillover effects. Increases in competition and competitiveness also play a role on the supply side. A comparative study of European, Japanese and American automakers prepared in 2006, before the recent reform and reinvigoration of the U.S. fuel economy program, found that standards had an effect on technological innovation. The U.S. had lagged because of the long period of dormancy of the U.S. standards program and the fact that the U.S. automakers did not compete in the world market for sales, (i.e., they did not export vehicles to Europe or Japan).

While the supply-side drivers of declining costs are primarily undertaken by manufacturers, a number of demand side effects are also cited, which are the direct result of policy. Standards create market assurance, reducing the risk that cheap, inefficient products will undercut efforts to raise efficiency. Economies of scale lead to accelerated penetration, which stimulates and accelerates learning-by-doing. The effects of demand stimulus by increasing the growth of the economy (macroeconomic stimulus) also accelerates innovation. Experiencing increasing economies of scale and declining costs in an environment that is more competitive, leads to changes in marketing behaviors.

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[14] Worrell, 2003, “Productivity Benefits of Industrial Energy Efficiency Measures,” Energy, 28(11): This examination shows that including productivity benefits explicitly in the modeling parameters would double the cost-effective potential for energy efficiency improvement, compared to an analysis excluding those benefits. (p 1)

[15] Larry Dale, et al., 2009, **“**Retrospective Evaluation of Appliance Price Trends,” *Energy Policy* 37, 2009.

Thus, estimated cost increases resulting from setting higher standards are far too high. There may be a number of factors that produce the result, beyond an upward bias in the original estimate and learning in the implementation, including pricing and marketing strategies.[16]

Q. Why do you believe an analysis of appliance efficiency standards is important?

A. The track record of efficiency standards for household consumer durables is even more eye catching and important because it is a primary driver of residential electricity consumption. Examining the trends in individual consumer durables suggests several important observations.

- First, the implementation of standards improved the efficiency of the consumer durables.
- Second, furnaces have been far less efficient than they should be, since the DOE has set and maintained weak standards.
- Third, after the initial implementation of a standard, the improvement levels off, suggesting that if engineering-economic analyses indicate that additional improvements in efficiency would benefit consumers, the standards should be strengthened on an ongoing basis.
- Fourth the analysis of consumer durables also shows that there was no reduction in the quality or traits of the products. The functionalities were preserved while efficiency was enhanced at modest cost. A recent analysis of major appliance standards adopted after the turn of the century shows a similar and even stronger pattern.[17]

The engineering-economic analysis indicates that although the standards may increase the cost of the consumer durable, the reduction in energy expenditures is larger, resulting in a net benefit to consumers. We have also pointed to evidence that the costs of energy saving technologies tend to be smaller than the *ex-ante* analysis suggests because competition and other

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[16] Sperling, Dan et al., 2004, *Analysis of Auto Industry and Consumer Responses to Regulation and Technological Change and Customization of Consumer Response Models in Support of AB 1493 Rule*making, Institute of Transportation Studies, UC Davis, June 1, emphasized the adaptation of producers in the analysis of auto fuel economy standards.

[17] Steven Nadel and Andrew Delaski, *Appliance Standards: Comparing Predicted and Observed Prices,* American Council for an Energy Efficient Economy and Appliance Standards Awareness Project, July 2013.

factors lower the cost. The experience of the implementation of standards for household consumer durables is consistent with this interpretation. My analysis of digital (computer) energy efficiency standards in California reaches the same conclusion about the effect of efficiency standards.[18]

Attachment MNC-2.8 shows the results of my econometric analysis of the data. [19] The statistical analysis created (dummy) variables that identify each consumer durable and whether a standard was in place or not. We use the year to estimate the underlying trend. Given that the engineering-economic analysis had justified the adoption of standards and that standards were effective in lowering energy consumption, this means the market trend was not sufficient to drive investment in efficiency to the optimal level. The impact of standards is statistically significant and quantitatively meaningful in all cases. The coefficient in column 6 (All Years, All Variables) indicates that the standard lowers the energy consumption by about 8%. This finding is highly statistically significant, with a probability level less than .0001. There is a very high probability that the effect observed is real. The underlying trend is also statistically significant, suggesting that the efficiency of these consumer durables was improving at the rate of 1.35% per year.

Combining the observations on quantity and price for electricity leads to an extremely important and surprising economic transformation, as shown in Attachment MNC-2.9. The link between electricity consumption and economic growth has been broken. In contrast to the three decades after World War II (1950-1980) where electricity consumption per dollar of per capita GDP grew by almost 3 percent, the figure was flat between 1980 and 1995, and declined by 2 percent per year between 1995 and 2019. Since the pandemic GDP growth has been even

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[18] Mark Cooper, 2015, "Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California," *California Energy Commission Workshop on Computer Standards*, April 15.

[19] I have built this analysis in the typical way that multivariate regression analysis is conducted. The dependent variable is energy consumption with the base year set equal to 1. Later years had lower values. We introduce a variable to represent the adoption of a standard. This variable (known as a dummy variable) takes the value of 1 in every year when the standard was in place and a value of zero when it was not. A negative number means that the years in which the standard was in force had lower levels of energy consumption. Similarly, the difference between appliances is handled with dummy variables. We include each appliance except furnaces, which shows how the other appliance performed compared to furnaces. Again, a negative number means that the other appliances had lower levels of energy consumption.

stronger, with 2.5 times the growth compared to 1995-2019, while electricity consumption growth has been only about 2/3rd of the earlier period. The period has been short, so it is too early to ballyhoo the results, but the initial direction is consistent with the argument.

Q. In your opinion, why has this approach to standard setting proved so successful?

A. I have long argued that regulation succeeds when it maintains the fundamentals of a competitive market structure in an approach I call "Command-But-Not-Control" Regulation.[20] There is the profound implication of this regulatory analysis. All of the appliances were subject to what we call "Command-But-Not-Control" regulation.

In this approach, the agency sets a goal, a standard, and producers are allowed to meet that standard however they see fit (see Attachment MNC-2.10). Because they face competition, each producer will choose those technologies and implementation strategies that best reflect their abilities. This has important implications for market and producer performance. The producers, capitalists in a competitive market, will do what they do best, meeting the standards in the least cost manner possible. I have identified six characteristics of a market in which "command-but-not-control" regulation is introduced. When the state decides to pick winners, rather than set goals, as with subsidies for aging reactors, this important process is undermined.

C. EXTERNALITIES AND THE VALUE OF CARBON ABATEMENT

Q. Please discuss externalities as a component of costs?

A. Although the cost of building or acquiring a resource is the crucial first step, there are other costs that a resource may add to or subtract from the resource costs as it is operated in a system. All the resources considered are generally low carbon, so we do not expect the issue of carbon emissions to have much of an impact on the choice between them. This is certainly the case with existing resources, as shown in the upper graph on the left side of Attachment MNC-2.11, in which the higher the score the better. The differences in emissions, even for aging reactors, are inconsequential compared to the cost estimates we have identified. New builds are larger because of the long period of construction, but again small compared to the very large differences we have identified above. The lower graph of Attachment MNC-2.11 confirms the analysis, where a lower score is better. The main resources considered in this analysis are tightly grouped as generally low carbon emitters. In the lower graph of MNC-2.11 I include hydro,

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[20] Mark Cooper, 2017, *Trump's $2 Trillion Mistake,* Chapter III.

although large hydro projects are unlikely to be built. However, pumped storage, a form of hydro, may become important, as well as smaller scale hydro development, so it is useful to have the externalities information. In this graph the higher the score the better.

Differences in non-carbon emissions and other environmentally important characteristics show larger difference in conflicting directions. Nuclear is higher on other emission of pollutants, water, and accidents. Natural gas is very high on pollutants and accidents and moderately high on water use. Renewables are high on land use. For the other pollutants nuclear is much higher. On water and waste nuclear is ranked much lower and the aggregate for non-air pollutants and impacts nuclear is between gas and coal. Thus, these non-air impacts show the poor performance of nuclear compared to the alternative. Therefore, these differences on externalities do not come close to upsetting the basic conclusions based on resource costs.

Attachment MNC-2.12 uses a recent Lazard analysis of the value of carbon reduction for an estimate of the valued of carbon abatement of the main options expressed in a comparison with coal.[21] The original figure included the low estimate for new builds for wind, solar, gas and nuclear. It recognized the high carbon output of unabated gas, so we focus on the cost compared to coal, avoiding an "apples-to-oranges" problem. The point is that nuclear is very costly and relatively constant. All of the entries are for new builds, since this is a long run analysis.

Two important points are underscored by this exhibit. Aging reactors are short term and should not be included, but they are to make a point. First, under the assumption for cost for short to mid-term, they are expensive compared to the other renewables and equal to gas with carbon capture. Gas with carbon capture would be preferable, since it is long term. Second, the growth of competitive, firm (geothermal) and quasi-firm (hybrid systems) as low-cost options has been substantial.

D. LAZARD'S FIRMING COSTS

Q. Does the cost of ensuring adequate supply at crucial moments matter?

A. It does and is one of the major challenges that the transition to a carbon free sector must deal with. However, the impact is being handled and does not alter the observation based on short and long-term costs.

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[21] Lazard, V, 13.0

I begin with an examination of Lazard's "firming" analysis, which is defined as "the incremental costs to firm intermittent resources (see Attachment MNC-2.13). As discussed in Chapter 4, the challenge can be handled with policies to better integrate and manage the grid. However, here I focus on Lazard's estimates of resources in the present and near future (5 years). Taken together, they reflect the great complexity of the analysis, but they also make it clear that firming need not be an obstacle to choosing renewables.

Attachment MNC-2.13. shows Lazard's generic estimated in the left column. It includes the details for the CAISO that use a battery as a "target" cost and also includes hybrid facilities (with storage) options. Lazard did not evaluate the traditional "baseload" facilities which, in theory, do not need "firming." In fact, there is a form of "firming" they do require, reserve margin requirements. Very large nuclear facilities require very large reserve margins, so the utility can meet its need without them. We include both the existing reactors (old) and new builds, which is consistent with the underlying assumption of the Lazard analysis. We treat the "alternative" "baseload," geothermal in the same way, but it involves much smaller plants and therefore demands a much smaller "firming" (reserve requirement) charge. I have assumed $8/MWH firming costs for coal, SMRs and Geothermal, but $32/MWH for large nuclear reactors, which are the largest in size by far. I have also included the long duration energy storage alternative that Lazard states are "expected to be competitive with lithium --ion batteries for large-scale 8-hour systems in the second half of the decade (late 2020s), with "anticipated unit costs at longer durations overcoming lower round-trip efficiency."[22]

The firming analysis sends two strong signals. Three options are lower than an aging reactor in cost, efficiency, solar with long duration storage and wind with long duration storage. Three firm resources are competitive with aging reactors, efficiency (which is firm, but not dispatchable) geothermal and new build gas with CCS. Without the sharp decline in cost and hours when the "firm" resource is needed, efficiency and Hybrid systems (PV+storage) are lower in total cost than any of the traditional resources. With long duration storage, solar is much more attractive, while wind with storage become quite competitive.

Attachment MNC-2-14 shows all the regional costs included in the Lazard analysis. The first major difference between the ISOs is the basis for evaluating the cost of new entry (CONE).

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[22] Lazard, v, 16.0, p.35.

PJM and CAISO use the cost of a fairly costly stand-alone battery. The other ISOs use gas, peaking or combined cycle. We rule out the latter two, since they are high emitters of CO_2. Therefore, they involve an "apples-to-oranges" comparison. As shown in the table, we adjust this to use gasCC with CCS to evaluate alternatives. Although the basis for the CONE was new builds, I include retrofits to round out the analysis.

The full array of regional ISO analyses conducted by Lazard, which we have grouped by technology first, then the ISO, makes it clear that CAISO is the costliest of the regions. And Solar is the most challenging of the resources. It also shows the value of combining intermittent resources and storage. In the presence of storage, especially long duration storage, firming costs are not a problem. Another approach taken by Lazard is to compare use cases on an ISO-by-ISO basis. The CAISO cases are by far the most attractive to investors with the highest return as shown below in Attachment MNC-5.16.

These firming cost evaluations affirm a fundamental fact about firming costs. As solar penetration increases, firming costs go up considerably (see Attachment MNC-2.15). For wind the effect seems to run in the opposite direction. Firming costs of hybrid systems are positively associated with penetration levels, but they increase at less than two thirds the rate of stand-alone solar generators. These simple findings are consistent with much more detailed analyses of system operation. The conclusion is not to "abandon" renewables and distributed resources because they pose a challenge of firming, but to respond to the challenge with policies that better integrate resources and supply and demand, as discussed in Chapters 4 and 5.

E. EIA'S LEVELIZED AVOIDED COST OF ELECTRICITY (LACE)

Q. What is EIA's Approach to the issue of intermitancy?

A. EIA's discussion of these issues takes a different approach, but with some of the same elements are at work. It is part of a triumvirate of costs calculated by EIA.

> The levelized cost of energy (LCOE) and levelized cost of storage (LCOS) represents the average revenue per unit of electricity generated or discharged that would be required to cost the costs of building and operating a generating plant… during an assumed financial life and duty cycle… Along with LCOE and LCOS, we compare economic competitiveness between generation technologies by considering the value of the plant in serving the electricity grid… We sum this into an annualized value… to develop the levelized avoided cost of electricity

> (LACE)… LACE accounts for the difference in the grid services that each technology provides, and it recognizes that intermittent resources, such as wind or solar, have substantially different duty cycles than the baseload, intermediate, and peaking duty cycles of conventional generators… When the LACE of a particular technology exceeds it LCOE or LCOS, that technology would generally be attractive to build.[23]

Attachment MNC-2.16 presents a rank order of the value ratios for the resources considered in this paper. While most of these are taken directly from EIA, we have used some of the assumptions from the earlier analyses.

- First, we set efficiency to be the number one priority, just above geothermal without NREL, another assumption of this paper.
- Second, we refuse to include gas without carbon capture and storage, which keeps the analysis on an apples-to-apples basis.
- Third, we treat the advanced nuclear cost in the EIA analysis as a small reactor, separately from large reactors. We do not provide an estimate for large reactors, which would be the lowest by far.

The rank order should be familiar by now. The most attractive resources are the five main alternatives. Ironically, stand-alone batteries are ranked sixth, ahead of nuclear reactors, gas combined cycle with carbon capture and offshore wind.

The difference between LCOE and LACE can be called "inflexibility waste" to capture the key concept.[24] The avoided cost is less than the levelized cost because resources are inflexible, i.e., unable to adapt their output to the needs of the system. The system cost would be lower if technologies that better fit system needs could be used. Inflexibility waste can be

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[23] Energy Information Administration, 2022, Levelized Cost of New Generation Resources in the Energy Outlook, 2022, pp. 4…1.

[24] Johnson, *et al.*, 2017, "A reduced-form approach for representing the impacts of wind and solar PV deployment on the structure and operation of the electricity system," *Energy Economics* 64 estimate the system cost of ramping various resources as an "efficiency waste." The concept of "inflexibility waste" would include that cost plus the cost of larger reserves made necessary by the need to be able to replace the largest unit on the grid...

lowered in two ways – reducing levelized cost or increasing avoided costs (*i.e.*, a better fit between output and system needs). This is the essence of the system cost approach.

F. LBL'S SYSTEM COSTS

Q. How does LBL's approach to this issue differ from EIA.

A. After extensively discussing the EIA system value approach to improving comparisons between alternatives, analysts at two national laboratories (Lawrence Berkeley National Laboratory and Argonne), suggested an alternative approach that rested on system costs (see Attachment MNC-2.17. The levelized cost of energy was the starting point and the most important factor, as in the system value approach, but the adjustment made was not by subtracting avoided costs from LCOE, but by adding estimates of the unique system cost of individual technologies to the LCOE. The former is a top-down approach, the latter is a bottom-up approach and the authors caution against double counting by combining the two. This approach was also advocated by a major research institution in Germany evaluating the aggressive transition to renewables being pursued in that nation.[25]

The authors of MNC-2.17 have recently updated the underlying analysis, looking at the contribution of renewables to system value (see attachment MNC-2.18). The concept is simple. The authors assume the Purchased Power Agreement (PPAs) cover the cost of production (Lazard's "all-in costs"). The system value is calculated as the sum of the hourly full value of the production of these facilities. For 2021, all four of the main renewable alternatives (geothermal, PV, wind and hybrid systems have positive net values. Over the next four years the value of wind and geothermal increased considerably. The value of hybrid systems is the highest by far and these resources maintain their advantage, although they decline very slightly. The decline might be reversed with the consideration of long duration storage, which could increase the value of Hybrid systems by at least 1/8th and as much as 1/3rd.

G. CONCLUSION

Q. How does the national data compare to California data?

A. Throughout this analysis, I rely primarily on the estimates of three national entities for generic costs of each technology, although Lazard is the primary source for the reasons outlined

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[25] Agora, Energiwende, *The Integration Costs of Wind and Solar Power: an Overview of the Debate on the Effects of Adding Wind and Solar Photovoltaic into Power Systems*, 2015.

at the beginning of the chapter. However, in each chapter, I also rely on California specific estimates where possible, as in Lazard's firming analysis. The reason that the data at the national level and the state level supports similar conclusion is simple; the underlying costs are similar, as shown in Attachment MNC-2.19.

There are, of course, differences in the cost estimates. Lazard dropped biomass in 2016, so I use NREL for 2023. Lazard did not estimate a cost for gas with carbon capture. I use an estimate from 2018 I made for gas with carbon capture based on Lazard's estimate of the capture technology for coal.[26] In 2023 Lazard had an estimate for gas with carbon capture. While Lazard had an estimate for solar thermal with storage in 2018, by 2023 Lazard had switched to PV with storage. The cost of geothermal is Lazard and EIA for 2023. The result is a high correlation for these key technologies (r=.87 linear; r=.97 logarithmic).

Beyond the similarity of current cost estimates, the trends of the past decade and a half are important because they send a strong message about where we are headed. The upper graph in Attachment MNC-2.20 shows the experience over a decade and a half of cost experience as captured by the analyses prepared by Lazard. Nuclear became more expensive, while the key renewables, wind and solar (and storage, not shown as a standalone resource) became much less costly. Coal and gas w/o CCS were stable. The lower graph shows a forward-looking projection of instant (overnight) costs from the CEC written in 2010. It predicted exactly what happened. There is no reason to believe that the past decade and a half is not a good guide to the future in the U.S. and California. In this sense, policy makers should not "suspend their disbelief" about the trends.

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[26] Cooper, Mark, 2021, Building A 21st Century Electricity Sector with Efficiency, Distributed Resources And Dynamic Management:: The Consumer, Economic, Public Health And Environmental Benefit, (with Mel Hall-Crawford (Consumer Federation of America) April 22.

CHAPTER 3: THE CONTINUING FAILURE OF FAILURE OF NUCLEAR POWER TO DELIVER ON ITS PROMISES OF LOWER COST

A. PAST SUBSIDIES AND CURRENT "SPECIAL TREATMENT" OF NUCLEAR POWER

Q. What is the nuclear power's track record on subsidies and declining costs?

A. While the nuclear industry complains about the subsidies that are bringing renewables into the market today and resists programs to promote energy efficiency, analysis of the historical pattern demonstrates that the cumulative value of federal subsidies for nuclear power dwarfs the value of subsidies for renewables and efficiency.[27] Renewables are in the early stage of development, as shown in Attachment MNC 3.1. Nuclear received much larger subsidies in its developmental stage and enjoyed truly massive subsidies since its inception, compared to other resources as it grew. MNC 3.1 calculates the rate of growth in subsidies that would be necessary to bring renewables into parity with the early rate of growth in subsidies enjoyed by central station resources. Renewables are more than a dozen years behind the central station resources, but given the importance of inertia, parity may not be enough to overcome the advantages of incumbency. The dramatic increase in innovative activity despite relatively low levels of R&D subsidy and much lower cumulative subsidization reflects the decentralized nature of innovation in the renewable space, as shown in Attachment 3.2. It leads to a dramatic payoff in terms of declining cost. As we have seen, wind had the earlier success and solar is now catching up.[28] Nuclear power has failed to show these results because it lacks the necessary characteristics.

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

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[27] Marshall, Goldberg, *Federal Energy Subsidies: Not All Technologies Are Created Equal*. Washington, DC: Renewable Energy Policy Project, 2000; Matthew Slavin, "The Federal Energy Subsidy Scorecard: How Renewables Stack Up." *Renewable Energy World.com*, November 3, 2009.; Kadra, Branker, Michael Pathak, and Joshua M. Pearce. "A Review of Solar Photovoltaic Levelized Cost of Electricity, *Renewable and Sustainable Energy Reviews* 15 (2011) (." (Branker and Pearce, *Review of Solar,* 4470–4482; Jeremy, Badcock and Manfred Lenzen. "Subsidies for Electricity-Generating Technologies: A Review." *Energy Policy* 38 (2010): 5038–5047 (hereafter, *(*Badcock and Lenzen. *Subsidies for Electricity-Generating Technologies)*; Pfund, Nancy, and Ben Healey, 2011, *What Would Jefferson Do? The Historical Role of Federal Subsidies in Shaping America's Energy Future*. San Francisco, CA: DBL Investors, 2011. (Hereafter, Pfund and Healey, *What Would Jefferson do?*)

[28] Badcock and Lenzen, 2010, Branker and Pearce, 2011.

the antithesis of 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.

B. CURRENT "SPECIAL TREATMENT"

Q. What is the current state of "special treatment of nuclear power?

A. The above discussion of subsidies focuses on long-term patterns of subsidies and underscores the point that much more was invested in nuclear and fossil fuels. This should not be taken to mean that there are no current subsidies enjoyed by nuclear power. There is no doubt about the advantages that nuclear power enjoys in the current system. In fact, while advocates for nuclear power point to specific subsidies for renewables – production and investment tax credits – there are at least half a dozen policies embedded in current practices that nuclear enjoys. Current special treatments enjoyed by nuclear power are massive. These include:

- the socialization of risk and waste management costs, now under court order o be paid by the Department of Energy to nuclear reactor owners for the failure to provide nuclear waste disposal because no such safe waste repository exists or may ever exist.
- Tax treatment of capital expenditures, which are very large for nuclear power.
- capacity payments from RTOs/ISO,
- high system burdens due to the risk of large outages. i.e., the inflexibility of nuclear, which requires higher reserve margins.
- Nuclear and other centralized resources also get a pass in the treatment of system costs. They have their system costs" socialized" and recovered from ratepayers, while system costs are imposed directly on developers of alternative resources.

As Lovins put it:

> Specifically, variable renewables' grid balancing costs are generally borne by their developers or owners, and are usually <\$5/MWh, nearly always <\$10. Yet coal

and nuclear plants impose analogous costs on the system without being charged for them, at least outside ERCOT. Instead, the grid balancing costs of managing the intermittence (forced outages) of central thermal plants—reserve margin, spinning reserve, cycling costs, part-load penalties—are traditionally socialized, treated as "inevitable system costs," and hardly ever analyzed.

This asymmetry appears to favor fossil-fueled and nuclear plants, because their balancing costs, emerging evidence suggests, may be severalfold greater than those of a well-designed and run portfolio of PV and wind resources. Conversely, variable renewables may need less backup (or storage) than utilities have already bought to manage the intermittence of their big thermal plants.[29]

As shown in Attachment MNC-2.1, above, nuclear has failed to deliver on its price promises. The alternatives have performed much better and hold much greater promise. It is also clear that with a much smaller level of subsidy to drive innovation and economies of scale, the renewables have achieved dramatically declining costs in a little over a decade, which is exactly the economic-mic process that has eluded the nuclear industry for half a century. Attachment MNC-3.2 captures the essence of the subsidy issue by juxtaposing the magnitude and timing of subsidies and the extent of innovation, as measured by patents issued. The ultimate irony is that despite much smaller subsidies to drive innovation and economies of scale, renewables have achieved dramatically declining costs in just over half a decade.

There can be debate about the current level of subsidies, particularly given the difficulty of valuing the nuclear insurance and waste subsidies which are existential rather than material (i.e., without the socialization of liability and waste disposal the industry would not exist). However, there is no doubt that the long-term subsidization of nuclear power vastly exceeds the subsidization of renewables and efficiency by an order of magnitude of 10 to 1.[30]

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[29] Lovins, Amory, B., 2017, Do coal and nuclear deserve above market prices?," The Electricity Journal, 30 (6), July, p. 2.

[30] BWE, German Wind Energy Association. The Full Costs of Power Generation: A Comparison of Subsidies and Societal Cost of Renewable and Conventional Energy Sources. BWE, Berlin, August 2012.; Lucy Kitson, Peter Wooders, and Tom Moerenhout. *Subsidies and External Costs in Electric Power Generation: A Comparative Review of Estimates. Geneva, Switzerland*, 2011; Ann G. Berwick, *Comparing Federal Subsidies for Renewables and Other*

A decision to shift subsidies to the alternatives should have nothing to do with fairness, however. It should be based on the likely payoff of the investment. Analyses of past subsidies globally and in the United States make it clear that renewables are a much better bet,[31] even though the estimates do not include the very large implicit subsidies nuclear enjoys from the socialization of the cost of risk and waste management.[32]

C. THE CONTINUING NUCLEAR COST PROBLEM

Q. Does nuclear power have a continuing cost problem?

A. The current terrain of resource costs is consistent with the earlier analysis, as shown in Attachment MNC-2.1. New nuclear reactors are between five (large) and three (small) times as costly as the alternatives. The large reactors have been under construction for over a decade, and they are still experiencing delays and cost increases. Small reactors do not yet have full regulatory approval (even though it has been accelerated on their behalf), have not entered construction, and are struggling to find takers for their power. As discussed in an earlier paper[33] and shown in Attachment MNC-3.3. SMRs need very large production runs to achieve any cost reduction due to scale and their projected costs have been challenged from the outset.

Attachment MNC-3.4 shows the recent trends of large and small reactor costs and the range used in this study to balance the extremely low estimates that have been assumed for small modular reactors (which are below even the hopes of the current SMR advocates). When combined with the deviations, SMRs is put at $120/per MWH. This is over 20% higher than a new build GasCC w/CS and 5% higher than a retrofit. It is 20% below large reactors. Given the

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Sources of Electric Generation. Massachusetts Department of Public Utilities Massachusetts Solar Summit, June 13, 2012; U.S. GAO. Federal Electricity Subsidies: Information on Research Funding, Tax Expenditures, and Other Activities That Support Electricity Production, GAO-08-102. Washington, DC: U.S. Government Printing Office, 2007.; Goldberg, *Federal Energy Subsidies,* Pfund and Healey, *What Would Jefferson do?*.

[31] Badcock, and Lenzen, 2010.

[32] Zelenika-Zovk and Pearce, *Diverting Indirect Subsidies*, p. 2626,

[33] Mark Cooper**, "**Small modular reactors and the future of nuclear power in the United States," Energy Research & Social Science 3 (2014) 161; "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

recent projected cost increase and subsidy, I use $120/MWH for SMRs. I put the cost of large construction at $150/MWH, given the history of the failure of the nuclear renaissance.

Small modular reactors are the latest in a long line of technologies that the advocates of nuclear power hope will be provide answers to the many problems that have afflicted their industry. Hyped as the dream solution, they turn into a nightmare. Small modular reactors that have been on the drawing board for at least a decade exhibit all of the characteristics of failure. Like the "nuclear renaissance" before it, the initial estimates of cost have doubled before they go into construction and cost overruns really only begin when construction does. While they can find companies to back them and governments to support them, and academics to explain the theory of why they should work, the one thing they cannot do is deliver low-cost power. While SMR advocates also claim it is safer than large units, they achieve that goal not by simply solving safety problems, but by being excused from safety rules (like exclusion zones).

> The estimated costs of the NuScale reactor design have been consistently going up…. Because the NuScale design might have to be modified to resolve the problems flagged by the Nuclear Regulatory Commission, there could be further cost increases even before construction starts. There is a long history of dramatic cost increases when paper designs are first constructed.[34]

Attachments MNC-3.3 and MNC-3.4 above describe the SMR cost problem. It updates my 2014 analysis by including two recent estimates. I have included the current estimate for the only active small modular reactors project. The high cost of nuclear power is apparent and there is nothing in the small modular reactor technology that suggests it will result in a cost revolution for nuclear energy. Using the math of the vendor, the first cost estimate was put at $0.055/kWh, so the current estimate is about twice that before subsidies and construction cost overruns.

On the other hand, as shown in MNC-3.5 renewables are entering the market at very low prices. Put on this "apples-to-apples" comparison basis, they are less than one third the cost of small reactors. A technology that has no future, in terms of high costs, should not be encouraged in the present and aging reactors have additional problems.

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[34] M. V. Ramana, 2020, Eyes Wide Shut: Problems with the Utah Associated Municipal Power Systems Proposal to Construct NuScale Small Modular Nuclear Reactors, Oregon Physicians for Social Responsibility, September.

In other words, SMRs are at least 3 times as costly as the bundle of alternatives (efficiency, wind and solar) and likely to be even more if construction takes place. The economic failure of SMR technology should be the end of nuclear power, since a low-cost, low-carbon, low-pollution electricity system, in which it can play no role, should be in place before any of these reactors are constructed.

D. THE COST OF AGING REACTORS

Q. Does the cost problem extend to aging reactors?

A. Attachment MNC-3.6 provides detail on the cost of aging nuclear reactors. Utilities have threatened to shut down aging reactors that are "losing money" but they never make public what their costs are and what it means to "lose money," i.e., they want all reactors to earn enough to make a contribution to capital cost recovery. In public statements, utilities have claimed they want a full return on investment for these plants – 10% to 18. The obvious point is that with costs in the range of $70/MWh used in this analysis, the cost of alternatives is well below the cost of aging reactors. The Lazard estimates for new and young nuclear, would be well above efficiency and solar and competitive with wind.

A Synapse analysis of the costs of subsidizing aging reactors in Illinois is instructive on this point. Although heavily redacted, it does provide insight into the subsidy question. Based on market clearing prices for energy and capacity, it appears that $0.03/KWH is available in the market. Synapse estimates that Dresden covers its out-of-pocket costs at a subsidy of $ $0.02/KWH. To hit the target rate of return (discount rate) the reactor needs another $0.015/KWH. Thus, the cost with capital recovery and the target discount rate is $0.065/KWH. This is consistent with my earlier analysis of Illinois, New York and aging reactors in general (as described in Attachment MNC-3.6).

The Synapse analysis tells a very different story than the utility does. Without the subsidy, Byron and Dresden generate about $400 million in revenues above costs. The other two reactors that Synapse analyzed exceed the target discount rate for the utility, generating revenues above costs of about $1.3 billion. In the short term, the four reactors are cash flow positive, although Dresden is negative for the first five years and Byron is slightly positive. Over 10 years, they are all positive, generating almost $1.7 billion in cash above operating expenses. The Synapse estimates for subsidies in Illinois make clear that it may not be in the interest of the state to give any subsidy at all.

Q. Does the testimony of Pacific Gas and Electric in the Rulemaking to Implement Senate Bill 846 Concerning Potential Extension of Diablo Canyon Power Plant Operations refute or Rebut Your Analysis of Industry Costs and Cost Trends?

A. No, not at all. On the contrary, it reinforces and supports that analysis in several ways.

Q. Please describe how it supports your testimony.

A. First, I must point out the tentative nature of the analysis. It is laced with redactions that make it difficult to estimate costs that the public deserves to know, wrapped in caveats about the uncertainty of near-term costs, but showing clear trends before the decision not to extend the license.

Second, it describes how it would use the billions offered in subsidies, but never examines any of the alternatives available. PG&E does not have to take the money and the PUC does not have to allow it, if the continued use of Diablo Canyon is not in the intertest of rate payers, or federal and state taxpayers. If it sustains the reliance on power that is not least cost, which I have demonstrated and the utility has failed to rebut, the PUC should reject it.

Third, the CAISO specific costs we have analyzed strongly support the value of alternatives compared to aging reactors.

Fourth, the fiction that nuclear power from aging reactors is low cost because it does not entail the recovery of capital costs, which I have criticized, is demonstrated to be false in the PG& E statement. There were hundreds of millions of capital costs incurred to keep Diablo Canyon online before the decision to retire the reactors and hundreds of millions of dollars in capitals costs projected to be incurred if its life is extended.

Fifth, operating costs are substantial and likely to rise. Attachment MNC-3.6 show that a regression across time indicates a substantial increase.

Sixth, it appears that Diablo Canyon was earning about $50/MWH before the decision to retire it and will be earning at least that much if its life is extended, plus the subsidy. Thus, Diablo Canyon is likely to be receiving more than $70/MWH, if its life is extended. I have used $70/MWh for aging reactors.

Q. Are Your Cost Estimates Consistent with Other Analyses of California Costs?

A. Yes, they are. That consistency is demonstrated in my use of CAISO estimates, e.g., wind, storage and solar in the firming analysis, California specific values in the net value analysis above, as well as showing that my estimate of the cost of aging reactors is right on target with California. I recognize that using the average of a number of estimates introduces some differences with the California data. However, as shown in Attachment MNC-2.19, above, there is a very strong correlation (r > .9) between my estimates and the California evidence.

E. FUNDAMENTAL CONFLICT BETWEEN TECHNOLOGIES: NUCLEAR CROWDS OTHERS OUT

Q. What is the nature of the fundamental conflict between nuclear power and the alternatives.

A. This analysis also lays the groundwork for the broader consideration of technology choice. In the long-term, nuclear new builds are extremely uneconomic, yet the subsidy proposal makes no provision for what will happen at the end of the short-term subsidy period. The grid is stuck with a larger nuclear footprint than economically justified. With power still coming from a large, inflexible source, the challenge remains to replace it. Based on economics, the replacement cannot be nuclear. Therefore, the economically rational approach is to not insulate nuclear from near-term competition, but let it cope with its economic fate, which means retirements should take place sooner, rather than later over the next several decades. This is not only the preferable approach from an economic point of view, but also the preferable approach from the point of view of the transformation to a 21st century electrical system.

The economic conflict of interest between nuclear power and the lower-cost, low-carbon alternatives is not limited to the cost of nuclear power. It is reinforced by fundamental differences between central station power and distributed resources, both in terms of technological competence and institutional requirements. Lovins elaborated earlier on these deep-seated sources of conflict, making it clear that a truce that tries to accommodate both sides is neither very likely, nor good policy.[35]

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[35] Amory B. Lovins and Rocky Mountain Institute, *Reinventing Fire: Bold Business Solutions for the New Energy Era* (Boulder, CO: Rocky Mountain Institute, 2011), 216, "All of the above" scenarios are . . . undesirable for several reasons. . . First, central thermal plants are too inflexible to play well with variable renewables, and their market prices and profits drop as renewables gain market share. Second, if resources can compete fairly at all scales, some and perhaps much, of the transmission built for a centralized vision of the future grid could quickly become superfluous. Third, big, slow, lumpy costly investments can erode utilities and other provider's financial stability, while small, fast granular investments can enhance it. Competition between those two kinds of investments can turn people trying to recover the former investments into foes of the latter—and threaten big-plant owners' financial stability.

If nuclear were subject to current market discipline, its load factor would decline, as would its income. The result would be a much higher cost. In short, this clash is inevitable and has given rise to a frontal assault by nuclear advocates on alternative resources and the institutions that support them.[36] Policymakers should reject the "all of the above" argument because the severely restricted market created by the forced presence of nuclear power will strangle the ability of non-hydro renewables to expand, which is likely to drive the market clearing price down. These low-cost resources compete for a smaller market. If there had been no nuclear carve out, renewables could have competed for and won this load in an orderly fashion, avoiding another "crisis" at the termination of the current subsidy, a "crisis" that the industry will inevitably invoke to demand another round of subsidies.[37]

F, DISTORTING WHOLESALE MARKETS

Q. How do the efforts to subsidize aging reactors distort wholesale markets?

A. Efforts to defend short term subsidies for aging reactors are based on a fundamental dysphemization of the market and its clearing price/process in deregulated states. The wholesale market does what markets are expected to do, find the lowest possible price to clear the market. Central station facility owners claim, without any evidence that this price fails to put a proper value on key attributes of energy resources – attributes that their facilities happen to possess. Evidence of a market failure – i.e., disruption of supply – is lacking. While there has been a "cannibalization" of renewable revenues, they have not been as severe as claimed (curtailments as quite small) and solutions have been offered. Regulators have recognized the challenge and taken steps to address the issue of capacity, but whenever they stick to market principles of least cost competitive supply, nuclear fails, seeking subsidies and doubting the ability of regulators to design adequate programs.

Fourth, renewable, and especially distributed renewable, futures require very different regulatory structures and business models. Finally, supply costs aren't independent of the scale of deployment, so PV systems installed in Germany in 2010 cost about 56–67 percent less than comparable U.S. systems, despite access to the same modules and other technologies at the same global prices.

[36] Mark Cooper, 2015, 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,

[37] Lovins, 2017.

The one example that is frequently cited is not a situation of deficit but one of surplus. There are moments when supply is so plentiful that it is necessary to curtail some output or pay people not to produce to keep the system in balance. Those very rare instances would be reduced, if not eliminated, if a fully integrated system were deployed. Ironically, the behavior of the 20th century electricity system, based on central station generation has its "odd" moments and characteristics too. Above all, the system deploys resources that are rarely used (peakers), only at moments when the price escalates dramatically because there is a shortage of available supplies (peak load hockey-stick prices). The plants are curtailed 85-90% of the time. This evidence is dismissed as part of the system, which the grid operators labor to reduce and control. All systems have moments of stress and their existence of one does not provide evidence of market failure or mean that one system is better than the other.

Here I argue that the manner in which the aging reactors subsidies shrink the market available to non-hydro renewables and keeps aging reactors online, creating a serious distortion in the short term (see Attachment MNC-3.7). By doing so it creates the conditions for another crisis in the future, since nuclear advocates will, once again, argue that the system is not ready to give up nuclear power because of the "underdevelopment" of renewables and demand another round of subsidies. This is linked directly to the broader pattern of crowding out that we observe in the electricity sector (as shown in Attachment MNC-3.8). Reliance on central station facilities crowds out alternatives in the long run, which is also the short run effect of the subsidy program. The short-term problem aging rectors face is that operating costs are quite high, and total costs are higher still—well above recent market clearing prices.

The flashpoint of the conflict over the transformation of the electricity sector (captured is captured in Attachment MNC-3.7, above), which centers on the market clearing price of electricity in those areas where markets (as opposed to regulators) set that price. The downward pressure on the market clearing price, initially driven by gas, but increasingly driven by renewables that are cost competitive with gas, means not only that aging reactors cannot cover their costs, but are not likely to in the future.

As shown in Attachment MNC- 3.8, central station generation has a tendency to crowd out alternatives. The smaller the share of central station facilities, the larger the share of renewables. One can look at this graph and say, it is just arithmetic. When a state has so much nuclear, there is no need for renewables, but that is the point in three respects.

- The math is favored by policy choices and those policy choices have consequences. Resources are denied to alternatives if nuclear output increased by the subsidy.
- For nuclear facilities in particular, especially during the construction phase, utility management resources are devoured by nuclear reactors.
- Since it is a policy choice, it can be reversed, and the share of renewables expanded.

Attachment MNC-3.8 highlights the real world crowding out effect. The graph tells a very clear story. The logarithmic regression explains 44% of the variance in renewable penetration (r=,67), while using a liner fit it accounts for about 31% (r=.55). Each of the central station resources had about the same independent impact and they are uncorrelated, so the combined effect is pronounced. To grasp the impact, the 23 low nuclear states have 26% nonhydro renewables in the generation for 2017. The high nuclear states have 9%. The 8 low coal states have a non-hydro renewable share of 27%, compared to 12% for the high coal states.

CHAPTER 4: ADEQUACY THROUGH EFFICIENCY, DEMAND MANAGEMENT, AND. RENEWABLE SUPPLY WITH STORAGE

A. THE HIDDEN FUEL: ENERGY EFFICIENCY

Q. Why is energy efficiency a hidden fuel?

A. While the cost of key generation resources (wind, solar) is important, there are also two key technological revolutions that have also taken place on the demand side. First and foremost is the large role that energy efficiency can play in the transformation of the electricity system. The second is what I call the transformation dividend, which is a result of the development and application of intelligent technologies to the management of the grid. This is a mixture of supply-side and demand-side developments. Because demand management plays an important role here, I discuss the dividend in the conclusion to this chapter. However, the chapter begins with the much larger and "pure" benefits of energy efficiency.

A recent comment[38] on the International Energy Agency[39] report on energy efficiency note that energy efficiency can be called the "hidden fuel."

> What is the World's most important fuel? (Hint: it is also the energy resource that all countries have in abundance). The answer to this riddle is energy efficiency, which is sometimes referred to as the "hidden fuel." That is the powerful message of the *Energy Efficiency Market Report 2016* published by the International Energy Agency.
>
> A strong energy efficiency policy is vital to achieving the central policy goals of improving energy security and reducing CO2 emissions as well as air pollution in the most cost-effective way. More and More countries are discovering that the safest and cleaned power plant is the one you don't have to build thanks to higher efficiency.
>
> Whereas energy policy has traditionally been dominated by a supply-side bias (i.e.: how do we produce more oil, gas, electricity?), policy makers increasingly understand we need to focus more on the demand side of the equation (i.e.: how

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[38] Noel van Hulst. Hydrogen Envoy at the Ministry of Economic Affairs & Climate Policy of the Netherlands, *The Untapped Potential of Energy Efficiency,* 11 May 2017.

[39] *Energy Efficiency Market Report 2016*, October 2016.

do we consume less energy)[40]

The report cited supports this observation by estimating that about 30% of projected demand could be met with efficiency.

B. U. S. EFFICIENCY POTENTIAL

Q. What role can energy efficiency play in the U.S. decarbonization strategy?

A. Current estimates for the near-term ability to reduce energy consumption without reducing energy services are in the range of 15% for 2030 and 30% for 2050 respectively as shown in Attachment MNC-4.1. It includes some that are 20 years old, as well are more recent estimates, all from leading research institutions in the field. Needless to say, the 30% figure is a good mid-term estimate. Since deep decarbonization requires electrification of transportation, these fuels are important to consider. The potential long-term reduction in consumption of diesel fuel, which is used by heavy duty trucks is considerably larger, primarily because the first fuel economy standards were only recently adopted, almost forty years after the first fuel economy standards for light duty vehicles were adopted.

In an earlier paper, I summarized the analytic consensus, shown in Attachment MNC-4.1 as follows:

> In the past year, four major national research institutions have released reports that document the huge potential for investments in energy efficiency to lower consumers' bills and greenhouse gas emissions, creating a win-win for consumers and the environment. The National Research Council of the National Academy of Sciences has estimated the potential reduction in electricity, natural gas and gasoline at approximately 30 percent, similar to the estimates of NHTSA/EPA. McKinsey and Company and the American Council for Energy Efficient Economy have reached a similar conclusion on electricity and natural gas. Across these three sectors, saving energy costs about one third of the price of producing it. With the publication of these studies, the question is no longer "Can efficiency make a major contribution to meeting the need for electricity in a carbon constrained environment?"

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[40] Van Hulst, 2017, p. 1.

These studies demonstrate that it can.[41]

The figure includes potential efficiency gains in all forms of fossil fuels, in addition to electricity, for several reasons.

First, the existence of the "efficiency gap" across all the uses and the form of energy is testimony to the pervasive market failure that afflicts energy markets. These market imperfections are not the subject of this paper, but they are important to note, as measured by the gap.[42]

Second, the effort to eliminate carbon emissions would inevitably include a significant electrification of the end uses for natural gas, gasoline and diesel, in addition to the decarbonization of the electricity sector. That is, more efficient use of these fossil fuels would still leave each with a substantial carbon footprint. Electrification with zero carbon resources would eliminate that footprint.

Third, although much of the efficiency gap that could be filled involves technologies applied to the use of fossil fuels, i.e., improving the combustion characteristics of internal combustion engines – some of the improvement comes from the design and operating characteristics of the durable good. Those gains are available to improve performance, even with the shift to electrification.

Ironically, although significant progress has been made in capturing energy efficiency gains, the potential contribution of energy efficiency has been quite constant for several decades, since it first attracted attention. The fact that the potential has not been diminished can be explained by factors of technological and economic progress.

Q. Are there resources available to achieve decarbonization while meeting short- and long-term needs?

A. Yes. To assess the opportunity to meet the need for low carbon alternatives with renewables, we begin with the present and work to the future. There is an ongoing debate about

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[41] "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, p. 7.

[42] See Cooper, 2017, pp. 98, 101, 152-179.

whether renewables can reach 100% of projected load, but that ignores the immediate question of how to get to the future. Resources have to be added in the present to replace aging facilities and retire polluting sources. I have argued that the key principle for making decisions under this type of uncertainty is to move in the right direction.

The analysis generally proceeds at two levels. First, as shown in Attachment MNC-4.2, we see comparisons of how other states and nations are doing in the effort to deploy clean, low carbon alternatives. At least two large states (California and Massachusetts) with large industrial economies have achieved higher levels of contribution from efficiency and non-hydro renewables. The states that have subsidized aging reactors (Illinois and New York) have much lower levels. Other advanced industrial nations have achieved even higher levels of contribution from renewables. States and nations have achieved much larger contributions of non-hydro renewables to their generation needs with California the closest but still far behind.

As the graph in Attachment MNC-4.3 shows, the vast majority of states have an abundance of potential supplies of renewable resources. Only a handful have potential that is less than five times demand. California is in the middle of the states. The renewables are local resources, and they present a new opportunity to diversify supply. Moreover, not only does California have abundant supply, but it is located in a region with a great deal of supply,

C. GENERAL STUDIES OF EMPLOYMENT AND MACROECONOMIC IMPACTS

Q. Can decarbonization expand the economy and employment?

A. Yes. Having shown the current and future economic superiority of the alternatives, I next evaluate the impact that alternatives would have on the other policy goals – decarbonization, macroeconomic growth and job creation. Although I find that economic and growth impacts are the paramount benefit, I begin with a discussion of decarbonization, since that affects and is affected by the economics of resource selection.

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, they should focus on moving toward the alternative electricity system, not move toward a dead end by extending the life of existing reactors.

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. 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 consumer's pocketbook to buy other things. The literature overwhelmingly supports the proposition that the economy is better off relying on the alternatives. The macroeconomic impact of energy policy has taken on great significance in the current round of decision making. Every policy is evaluated for its ability to stimulate growth and create jobs. Assessing the macroeconomic impact of policy choice generally relies on complex models of the economy. Cost savings on energy and economically beneficial energy efficiency investments yield net savings; the reduction in energy costs exceeds the increase in technology costs. Thus, such investments have three effects from the point of view of the economy.

- The increase in economic activity resulting from spending to develop new technology (indirect).
- The economic activity round deploying that technology (direct).
- Finally, there is the induced economic activity that results from an increase in consumer disposable income that flows through the economy, raising the income of the producers of the additional products that are purchased and increasing employment. In short, the decrease in energy expenditures is substantially larger than the increase in technology costs, resulting in an increase in the disposable income of individuals to spend on other things.

These large increases in economic activity leads to increases in employment. The effect is magnified by the fact that the non-energy sectors of the economy are substantially more labor intensive than energy production. The energy sector is less than half as labor intensive as the rest of the economy, so the ratio of job creation for efficiency, compared to other production option in electricity is also two to one.[43] As consumers substitute away from energy, the goods and services they purchase stimulate economic and, disproportionately large, job growth.

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[43] Max Wie, Shana Patadia and Daniel Kammen, 2010, "Putting Renewables and Energy Efficiency to work: How Many Jobs Can the Clean energy Industry Generate in the

D. MACROECONOMIC MULTIPLIERS IN U.S. IN DEMAND-SIDE ENERGY POLICY

Q. How are the macroeconomic effects analyzed?

A. Econometric models that use general flows of resources between economic activities have been used to assess these economic impacts. In a sense, the coefficients in the macro models are representations of the relationships in the economy through which the micro level effects flow. No matter the level or approach, the evidence strongly supports the conclusion that there is a positive impact from both the demand[44] and the supply points of view.[45] Although the uptake on macroeconomic impacts in the U.S. has been slow, Attachment MNC-4.4 shows four examples of the impact on the U.S. economy using two different models for four different locations.

The results differ across studies because the models are different, the impact varies according to the size of the geographic unit studied and because the assumptions about the level and cost of energy savings differ. These differences are not an indication that the approach is wrong. On the contrary, all the analyses conclude that there will be increases in economic activity and employment. Given that there are different regions and different policies being evaluated, we should expect different results.

US?", *Energy Policy,* 38, 2010 (hereafter Wie, *Putting Renewables)*; Rachel Gold, et al., *Appliance and Equipment Efficiency Standards: A Money Maker and Job Creator,* American Council for an Energy Efficient Economy, January 2011; James Heintz, Robert Pollin, Heidi Garrett-Peltier, *How Infrastructure Investments Support the U.S. Economy: Employment, Productivity and Growth,* , Political Economy Research Institute, January 2009.

[44] Lisa Ryan, and Nina Campbell, *Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements.* (Hereafter, Ryan and Campell, *Spreading the Net)*,2012, Insight Series. Paris, France: International Energy Agency, pp. 1…2 …3. For the consuming sectors, it is relatively straightforward to observe how investment in energy efficiency and energy savings can lead to increased spending and economic activity with second round effects such as employment, government revenue, and price effects (if other investment and spending is not crowded out). There are likely to be positive income effects, unless household wage demand increases as the labor supply becomes more competitive.

[45] U.S. EPA, Memorandum To: Docket EPA-HQ-OAR-2009-0472, Subject: Economy-Wide Impacts of Greenhouse Gas Tailpipe Standards, March 4, 2010 (hereafter, *Memorandum).*

The rule of thumb – an approximate doubling of the economic impact – that emerges in the literature reflects the observation on jobs.[46] Similarly, in a study of 52 examples of increases in industrial productivity, where benefit was monetized, the productivity savings were 1.25 times as large as the energy savings.[47] Macroeconomic models measuring the outcome in change in GDP yield a "respending" effect that clusters around 90%. These efforts to model the economic impact of have proliferated with different models[48] being applied to different geographic units, including states[49] and nations.[50] MNC-4.4 shows examples of the multiplier, with the GDP impact expressed as a multiplier of the value of net pocketbook savings. That is, we subtract costs from the estimated value of energy savings. This ensures we do not double count benefits.

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[46] Gold, et al., *Appliance and Efficiency,* "In our experience modeling efficiency investments, we find that re-spending the energy savings typically creates an equivalent number of jobs as implementing the investment." (p. 2)

[47] Worrel, Earnest, et al., 2003, "Productivity Benefits of Industrial Energy Efficiency Measures." *Energy* 28 (2003) (hereafter, Worrel, *Productivity Benefits*), p. 5.

[48] For example, EPA, *Memorandum,* , IGEM; Rachel Gold, et al., *Appliance and Equipment Efficiency Standards: A Money Maker and Job Creator,* American Council for an Energy Efficient Economy, January 2011, (hereafter, Gold, *Appliance and Efficiency),* p. 9, based on the IMPLAN Model, 2009. Howland, Jamie, Derek Murrow, Lisa Petraglie, and Tyler Comings. Energy Efficiency: Engine of Economic Growth. Rockport, ME: Environment Northeast, 2009(hereafter Howland and Murrow, *Energy Efficiency*) and New York State Energy Research & Development Authority. Macro-Economic Impact Analysis of New York's Energy Efficiency Programs: Using REMI Software. Albany NY: NYSERDA, August 4, 2011 (hereafter, NYSERDA, *Macroeconomic*), REMI).

[49] For example, New York (NYSERDA, *Macroeconomic*), New England (Howland and Murrow, *Energy Efficiency*), California (David, Roland-Holst, Revised Standardized Regulatory Impact Assessment: Computers, Computer Monitors, and Signage Displays, prepared for the California Energy Commission, June. 2016) David, Roland-Holst, Samuel Evans, Samuel Heft-Neal, Drew Behnke, Cecilia Han Springer (2016). "Berkeley Energy and Resources (BEAR) Model: SRIA Baseline Forecast for the California Economy." Report prepared for the California Energy Commission) and (Samuel, Evans, and David Roland Holst, *Model Comparison for SRIA Macroeconomic Assessment,* BEAR, June 2017) for a comparison of models.

[50] For example, U.S. has been studied repeatedly, see notes 61 and 62, as have many other countries like the UK, e.g. (Benjamin S. Warr, Robert U. Ayres, and Eric Williams. Increase Supplies, Increase Efficiency: Evidence of Causality Between the Quantity and Quality of Energy Consumption, Warr, Ayres and Williams, 2009) The Cambridge Centre for Climate Change Mitigation Research. The Macro-Economic Rebound Effect and the UK Economy. Cambridge, U.K.: Cambridge Econometrics and Policy Studies Institute, May 2006. notes recent studies on Asian economies, Korea, Canada and Spain,

Ironically, the EPA reviewed the literature on the macroeconomic impact of reduced energy consumption.[51] These impacts, as discussed in EPA analysis are an indirect effect of the rule, a genuine externality. The U.S, regulatory agencies have not recognized this macro-economic benefit in rulemakings to set minimum efficiency standards. The EPA came close in setting the "national plan" for light duty vehicles, commissioning a study of the effect of lowering the cost of driving. Very substantial benefits were identified, but EPA failed to mention them in the final rule, adopting a much lower standard than could have been justified. This approach has become quite common with detailed analyses of energy efficiency across a range of activities (autos, appliances, buildings, industries),[52] sectors (e.g., energy, manufacturing, service, particularly as it impacts use of labor)[53] and with a variety of analytic approaches (qualitative, econometric).[54]

For the purposes of this analysis, I assume that the approach that relies on alternatives has a multiplier that is twice that of nuclear. MNC-4.5 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 technology to produce or conserve energy. Some activities have larger multipliers because the results (savings or spending) circulate faster through the economy. This is true both across sectors, as shown in the right-side graph of Attachment MNC-4.5 and within the electricity sector, as shown in the left side graph of the Attachment.

I have rendered the results of these studies comparable by indexing energy across studies and expressing the outcome as a ratio. The Political Economy Research Institute (PERI) study gives estimates for the impact of investment in nuclear and oil and gas. I equate the energy

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[51] Id., pp. 3-4. "Lower prices allow for additional purchase of investment goods, which, in turn, lead to a larger capital stock. These price reductions also allow higher levels of government spending while improving U.S. competitiveness thus promoting increased exports relative to the growth driven increase in imports. As a result, GDP is expected to increase because of this rule.

[52] Worrel, et al. 2003, identified 70 industrial case studies, with 52 that monetized the benefits.

[53] Wei, and Kammen, 2010.

[54] Ryan and Campbell, *Spreading the Net,* identify a dozen partial equilibrium models that have been applied to regions within nations, individual nations, groups of nations and the global economy. The effects analyze include GDP, employment by sector, public budgets, trade, distribution, and investment.

category from American Council for an Energy Efficient Economy (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.

International Recognition of Macroeconomic Benefits

Ironically, almost a quarter of a century ago, the literature on climate change began recognizing these potential benefits and they have consistently done so since then. A review of the literature by Smith,[55] identifies numerous studies, all conducted in the first decade of the 21st century by leading energy, environmental and economic analysts, which identified various aspects of the "co-benefits" of efficient low carbon generation. Although, the authors identified 13 such studies in a text box, a review of the footnotes shows at least two dozen more studies of major emitting economies (U.S., Australia, China) and the general economic benefits of efficiency and reduced pollution and resource use. The total is well over three dozen. The basic observation about the failure of simplistic economic analysis is the same as the domestic U.S. critique which the author summarized simply, "Most economic modelling to date has failed to include or quantify productivity co-benefits from action on climate change. "[56]

I have organized the climate mitigation strategies into five broad categories in Attachment MNC-4.6. First comes renewables. Then we find two efficiency categories, business and residential. These are the transformation categories we have emphasized throughout this analysis. Next comes transportation efficiency, but recently (after the publication of the underlying paper) electrification of the vehicle fleet has become a central policy point. Thus, between 3/4 and 7/8 of the climate change mitigation measures are deeply entwined with the transformation of the electricity sector.

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[55] Smith, Dr. Michael H., 2015, Doubling Energy & Resource Productivity by 2030 – Transitioning to a Low Carbon Future through Sustainable Energy and Resource Management, ANU discussion Paper..

[56] Id., p. 13.

However, the primary purpose of the work is not to examine the implications of policy for climate change, it is to examine the implication for productivity in the context of doubling the energy efficiency of the economy. Climate change benefits, measured in MNC-4.6 as a reduction in the emissions of carbon, are a welcome co-benefit of improved energy efficiency and partially responsible for improved efficiency. Therefore, we include estimates of the economic gains that result from improved energy efficiency. These estimates of benefits are contained in the text, along with numerous examples and case studies of how they could be achieved. In order to achieve the goal, the author argues for a doubling (100%) increase in energy productivity. The total savings listed in MNC-4.6 far exceeds that level for two reasons. The levels for each individual item may not be achieved, and there is overlap between the categories.

One study on China, cited by the author put it, described the effect of failing to take the economic impacts of energy efficiency into account:

> Positive effects of emissions reduction policies on productivity are typically not fully captured in conventional economic modelling studies. Partial equilibrium modelling of climate change does not take changes in productivity into account. Unless combined with specific estimates of beneficial impacts from mitigation, these analyses by their very nature present only costs not benefits… [L]ack[ing] detailed information about differential productivity between sectors of activities, [they] typically assume that in the baseline and economies follow an efficient pattern of investment and structural change. Thus, by default, a deviation from a model's base case (the hypothetical future scenario against which scenarios with emissions reductions are compared) will show up as a reduction in productivity and economic growth." [57]

Although Smith's focus is on the economic effect of clean energy policies, he also notes that there is a convergence between climate policy and economic policy, as shown in Attachment MNC-4.6. The upper part of the exhibit shows the individual effects across the economy and climate goals. The lower part shows that there is a high correlation (r= .95 linear, .91

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[57] Teng, F. and F. Jotoz, 2014, "Reaping the Benefits of Decarbonizatoin, for China," *CEP, Working paper, 1413, August.*

logarithmic) between carbon reduction and macroeconomic benefits, which I have extracted from his textual discussions. Efficiency and renewables are the top two sources of environmental and economic benefits.

The author then enumerates the co-benefits which have been ignored, including, "energy and resource efficiency, co-generation, renewables, reducing methane leakage, energy efficiency sustainable transport, reducing waste and achieving a transition to a circular economy, reduced energy consumption and waste and deforeststion are significant because most of the significant smart climate change mitigation strategies are productivity enhancing.[58] In this analysis I do not try to quantify the indirect benefits associated with environmental damage of pollution and public health, but we focus on the macroeconomic benefits created by lower cost for alternatives. In general, however, business and residential efficiency are the largest contributors, followed by renewables and energy efficiency.

State Level Analysis of Employment and the Local Economy

Q. Do the analyses of shutting down aging reactors have similar effects?

A. Given that subsidies for aging reactors make no sense on the basis costs, in the two states that have subsidized aging reactors the utilities have tried to claim that there is a net benefit from the ability of aging reactors to keep jobs in the area. The arguments are incorrect. More jobs are added by the alternatives, as suggested by MNC-4.6, above, and Attachment MNC-4.7.

Utility funded studies of the impact of retirement of aging reactors, are riddled with erroneous assumptions. Ultimately the Illinois Department of Commerce analysis presents a more balanced view and raises the question of the impact on the local and state economy. The loss of nuclear reactor-related jobs (direct and indirect) is offset in the early years by construction of alternatives. When the construction jobs expire, the loss of nuclear jobs exceeds the ongoing number of jobs added by the "operation" of replacement resources. However, 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

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[58] Smith 2015, p. 18.

Energy Institute analysis that failed to do so.[59] The oversight is substantial. In the 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.[60]

Similarly, a 2015 Brattle Group Report, entitled "New York 's Upstate Nuclear Power Plants' Contribution to the State Economy Brattle Group" ("Brattle Report")[61] assumes that every kilowatt hour of electricity produced by a retired reactor is replaced with a kilowatt hour generated by natural gas, and 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. All of these assumptions are incorrect.

Above all, 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. Initially there is reliance on gas, but that is eliminated over time. Based on the Brattle Report's assumption at the end of the period of aging reactor subsidies, 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 by aged, 60+ year, outdated nuclear reactor technology.

Attachment MNC-4.8 plots the macroeconomic impacts of this alternative scenario. Since "indirect" jobs represent over 90% of total jobs, the multiplier is far and away the most

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[59] Illinois Commerce Commission, Illinois Power Agency, Illinois Environmental Protection Agency, and Illinois Department of Commerce and Economic Opportunity. *Response To The Illinois General Assembly Concerning House Resolution 1146*. January 5, 2015, p. 150.

[60] Lovins, *Do coal and nuclear,* argues that the jobs claims are little more than climate change blackmail (unsupported by empirical evidence, pp. 23, 28) and that the number decommissioning jobs are unaffected by the timing of plant retirement (p. 24).

[61] Mark Berkman and Dean Murphy, Brattle Group, *New York's Upstate Nuclear Power Plants' Contribution to the State Economy,* prepared for New York State IBEW Utility Labor Council Rochester Building and Construction Trades Council Central and Northern New York Building and Construction, December 2015.

important factor. In this analysis I do not include decommissioning jobs, since those will be captured whenever the reactors close.[62] In this orderly transition, there is no net loss of jobs even from the beginning.

This does not mean that the transformation of the electricity system will not require adjustments, but direct efforts to manage the transition are less costly than the ill-considered subsidization of aging, uneconomic facilities. The Commission, the Governor, or the 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 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.

The above discussion of the benefits of lower utility bills reflecting low-cost efficiency, wind, solar and hybrid systems, show that there is a huge macro-economic benefit, but even those underestimate the value of the transformation of the electricity system. There is an added benefit that I call the "transformation dividend." The alternative system not only reduces demand, but it also shifts it (see Attachment MNC-4.9). Some of the shift is a function of the underlying technology. Efficiency tends to work at all hours of the day, although it has its largest effect when people are awake and using appliances. Some of the shift is part of the effort to increase the value of renewables (i.e., batteries coupled with solar) and some of it is part of the effort to keep the system in balance (i.e., regulatory decisions that provide incentives to build capacity to keep the system in balance). Either way, the dividend is large, has an impact of the viability of the system, and delivers a macroeconomic benefit.

In examining this effect on peak demand, it is important to keep in mind that the magnitude of the effect and the "benefit" must be measured or conceptualized in comparison to where demand could have been, not where it is. It might be growing, but more slowly than would have been the case. The comparison should be with the wildly expensive and

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[62] Lovins, 2017, p. 24, notes that decommissioning jobs will be the same whenever the reactors are shut down and do not affect the employment picture in t/he long-term.

overwhelmingly curtailed, peak load generators. Thus, this aspect of the transformation dividend might be underestimated by a comparison to average prices.

The transformation dividend is built into a variety of analyses. Above we noted that assumption on the low-demand scenario of 10-20 percent. The Regulatory Analysis Project puts the figure at 17%; NYSERDA in New York at 1o-20%. In CAISO, the impact by 2030 is 10-15%. Thus, there is close agreement on the mid-teens as the magnitude of the "transformation dividend."

The Attachment MNC-4.9 shows the basis of this divide at the conceptual level. Efficiency, demand management, renewables and storage lower the overall demand and shift the peak. The smaller system with a lower peak reduces the cost of electricity. It is important to keep the overall process in mind to recognize the benefit of demand reduction and shifting. As shown in the Attachment MNC-4.10. Over the course of a decade and a half there has been a lowering of demand and a shifting, which lowers the total cost below what it otherwise would have been. While it may be attractive to make the mistake of claiming that the current allocation of costs could be different, with more costs recovered from the users of solar power, one would also have to assume that, in the face of higher costs, the benefits of reduced and shifted demand would be smaller, or perhaps eliminated. The environmental and macroeconomic gains would also be foregone. Thus, the transformation is socially and economically beneficial and it is extremely important to take a long-term, holistic view of the process of building as a 21st century system.

CHAPTER 5: BUILDING A LOW CARBON, LOW COST 21ST CENTURY ELECTRCITY SYSTEM

A. TOOLS TO ACHIEVE LOW COST, RELIABLE POWER

Q. What are available to build the 21st century 'system?

A. Low cost and adequate resources are two important ingredients to support the alternative system, as is the commitment to build one, but operating the system remains a challenge. This chapter addresses this issue by making it clear that the tools to successfully operate a 21ST century system are developing rapidly. Delaying or distorting that process by keeping uneconomic, inflexible central station facilities, like aging reactors, online is the opposite of what is needed. Subsidizing existing nuclear reactors is a very bad idea from the point of view of promoting a successful transformation.

In a sense, the resources for a 21st century system have existed for a long time. The sun does not shine more and the wind does not blow more than historically. Technological change has made exploiting these resources less costly and has made energy efficiency much more attractive. Physical technologies – rapid communications and computation abilities – have also made it possible to manage and integrate demand with supply feasible. Building the institutional infrastructure to accomplish this goal, while ensuring adequate, reliable supply is the imminent task. Yet, with so much technological change creating the possibility of an alternative approach, there is strong public interest in an effort to do so.

Thus, it is important to recognize that the 20th century system made perfect sense, in the 20th century. Large, load following central station facilities were inexpensive to develop (except for nuclear) as long as they were excused from the cost of their externalities (including of course, waste and risk of accidents or proliferation, embodied in the Price Anderson Act). That has changed. The system that they built was tailored to their needs, load following with reliance on very high cost, sparsely used peaking facilities. The socialization of system cost and shifting them to ratepayers was attractive, given the low costs resources. That system no longer makes sense on all counts.

High-cost nuclear generation is still more costly than high-cost fossil fuels that must bear their external costs. It is now possible to switch to lower cost alternatives combined that seek to modify and match demand with supply, instead of simply following it. The most difficult challenge is transforming the physical and institutional infrastructure that favor the incumbent facilities to the detriment of the alternatives. That is the topic of this chapter.

Q. Please describe the tools and how they would operate.

A. The upper graph of Attachment MNC-5.1 shows the many tools available to achieve low cost and reliable supply. The lower graph shows the differences between the 20th century system approach and the 21st (repeated from MNC-1.5). In the original analysis of these tools, I identified 41 tools and 260 citations supporting them. In updating this analysis, I have added over 100 citations, but I keep them separate by identifying additions to the list (sub-issues in some cases) for most of the original 41 (as shown in Attachment MNC-5.2). The citations are presented in lieu of a bibliography in the Attachment B.[63]

A decade ago, a California proceeding examined the issue of operating the emerging system. It challenged parties to think about how high levels of renewables could be integrated into the grid. Utilities offered a host of approaches and my summary concluded there were numerous general ways to handle the challenge.[64]

The LBNL analysis[65] of that period shows that the technical and economic processes by which policies work to mitigate the impact of variability are straight forward. [66]

- Geographic diversity, particularly for wind, reduces extremes of generation, Technological diversity fosters a better fit with load.
- Storage allows more energy to be captured and used when needed, by reducing curtailment, increasing and shifting supply, and by increasing demand (and therefore prices) during slack periods.
- Demand shaping allows a better balance between supply and demand.
- Flexibility is a key attribute, achieved by

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[63] Because I give full citations to evidence in the text, I do not include a bibliography. However, most of the sources cited in text also are cited in the list of tools. I list the citations in alphabetical order and I show the number of the citation which can be linked to the tool.

[64] Cooper, 2017.

[65] Mills, Andrew, and Ryan Wiser, 2014, *Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels*. Environmental Energy Technologies Division, Lawrence Berkely National Laboratory.

[66] Ibid., p. 25, 27,

    - sub-hourly scheduling to reduce the magnitude and impact of forecasting error,
    - "quick start' generation, or
    - a portfolio approach that uses a mix of generation assets that can reduce the need for flexibility of individual assets.
- Exploiting the best sites for renewable resources yields much larger economic value—three times the average.

Although the utilities in California[67] put together an analysis that takes a very different approach than the LBNL analysis and seems much more ominous, close examination shows that when the utility analysis introduces mitigation measures, it reaches a similar end point. Consistent with the LBNL analysis. Introduction of mitigating policies immediately solves the problem. The utilities started with a base case of renewables at 33 percent and set up straw men of 40 percent and 50 percent PV scenarios. Not surprisingly, they find that this extreme approach produces major problems in matching supply and demand. However, adding in three blocks of "flexibility solutions" reduces the curtailment of PV generation to the level of the 33 percent penetration, which was virtually zero. The transformation dividend is present in the utility analysis. Pursuing downward "flexibility solutions" yields 15000MW of reduced demand, which is equal to 10 percent of the capacity in the "unmitigated" PV system, and 15 percent of the capacity in the "mitigated" PV system. This is consistent with the RAP on the transformation dividend.[68]

This level of "flexibility solutions" is in the range of the planning reserves. As the penetration of relatively small-scale distributed technologies increases, the need for planning reserves may decline because, in the current baseload approach, it is the threat of the loss of large units that drives up planning reserves. The potential for a trade-off between planning reserves and "flexibility solutions" could have a significant impact on the cost of meeting the need for electricity.

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[67] E3, Higher Renewables Portfolio Standard, E3. Investigating a Higher Renewables Portfolio Standard in California. Energy and Environmental Economics, Inc., January 2015.

[68] Lazar, Jim. *Teaching the "Duck" to Fly*, Regulatory Assistance Project, January 2014, shows various aspect of the transformation reducing load by 10-20%.

While the utility study does not model the specific “flexibility solutions,” it does identify the likely primary candidates, which are the same as those modeled in the LBNL analysis. The utility study finds significant challenges, but also opportunities. The “least regrets” opportunities identified in the study reflect the discussion offered herein, including.

- pursuing a diverse portfolio of renewable resources.
- implementing a long-term, sustainable solution to address over-generation before the issue becomes more challenging.
- implementing distributed generation solutions.
- expanding research and development for technologies to address over-generation are plentiful, including,
    - promising technologies like storage (solar thermal with energy storage, pumped storage, other forms of energy storage including battery storage, electric vehicle charging, thermal energy storage) and
    - flexible loads that can increase energy demand during daylight hours (advanced demand response and flexible loads).
- Technical potential to implement new solutions are also available, including,
    - sub-five-minute operations,
    - creating a large potential export market for excess energy,
    - changing the profile of daily energy demand, and
    - optimizing the thermal generation fleet under high RPS.[69]

B. THE POLICY RECOMMENDATIONS FOR A PATH TO DEEP DECARBONIZATION

Q. Does your earlier discussion of NRELs’ nuclear and geothermal cost resolve the differences and reflect the importance of these erroneous assumptions?

A. No, it does not. It moves in the right direction, but NREL’s discussion of 100% clean energy scenarios raises other issues and is important because the errors point in a different direction.[70]

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[69] E3, *Higher Renewables Portfolio Standard, E3. Investigating a Higher Renewables Portfolio Standard in California.* Energy and Environmental Economics, Inc., January 2015, pp. 31–35.

[70] Denholm, P., et al., 2022, “Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035, NREL/TP-6440-81644.

As shown in Attachments MNC-1.3 and 2.2 above, NREL assumed a low cost for nuclear. In fact, its assumption was even farther off the mark. As shown in Attachment MNC-5.3, NREL not only assumed an unrealistically low cost for nuclear, but it also assumed, contrary to reality, that the cost would decline. The cost scenarios shown in the Attachment MNC-5.3 have no "high-side, for nuclear, only a low side. The decline is substantial, about 40%. In reality estimate for the U.S. SMR project that has been the target of greatest attention has announced a major increase in projected cost. Adding in a huge federal subsidy, the cost is almost three times the NREL low estimate. The only active large reactor project which is a new build is higher still.

For geothermal, NREL's cost estimates are technology specific, but even the lowest cost technology is higher than the current estimates from Lazard and EIA. Even NREL's low geothermal projections are higher than the current projections from others. In any scenario where new build, "baseload" capacity is needed, reality suggests much less nuclear and much more geothermal.

The only scenario in which NREL envisions nuclear increasing its share of output (to 27%)[71] is the "constrained" scenario,[72] which it defines as follows: "**Constrained** is a scenario where additional constraints to deployment of new generation capacity and transmission both limits the amount that can be deployed and increases costs to deploy certain technologies."[73] The high-cost technologies are the renewables, while nuclear is low cost. The constraints and cost assumptions drive this result. However, the "constraints" do not appear to operate on nuclear, even though its share of capacity is double the current share. Nuclear additions are between 40 and 50 times as much as geothermal in this scenario.

NREL notes that the "build rate of nuclear would have to be 4 times as large as the highest ever achieved in the U.S. It fails to note that the high rate was achieved 50 years ago. Compared to the last ten years, the nuclear "build" rate would have to be at least 40 times as high as the current level. In the "unconstrained" scenarios, the build rates of wind and solar would have to be 4 times what had been achieved, certainly a formidable task, but one that is much

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[71] Id., p. xi.

[72] Id., p. 24.

[73] Id., p. vii.

closer to the reality of recent build rates.[74] The necessary nuclear build out is implausible to say the least.

Q. Are there useful observations that can be drawn from the basic NREL supply cost estimates?

A. Yes, there are, but first one must one see through (get past) the unrealistic nature of the assumed nuclear costs and builds and the high cost of geothermal. These studies assume a complete failure of the 21st century system, efficiency, demand management, renewables, storage, and geothermal. There are a series of studies that assume contrary to current reality and history, that the cost of nuclear will fall by 60%, or that costs don't matter,[75] the load factor of nuclear will be 33% higher than it could be in a system based on efficiency and renewables. Attachment MNC-5.4, repeated from MNC 1.4, above, after the specific evidence has been introduced, places the suspension of disbelief by policy makers that is necessary to accept the nuclear scenario in the context of the history of cost trends. The complete reversal of past trends is highly unlikely and not the assumption that policymakers should make.

Q. Putting the suspension of disbelief aside on nuclear and geothermal, what is the message in the NREL study?

A. NREL is polite and calls it the "Constrained" scenario, as shown in Attachment MNC-5.5. The useful advice for policy makers that can be extracted from the NREL study is consistent with my discussion of costs, and demand-side contributions. Policymakers should take existing trends and craft policies to reinforce them. In a sense, public policy can only succeed by striving to prevent the constrained scenario.

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[74] Id., p. xi.

[75] Some, like the Breakthrough Institute abandon cost altogether, Hausfather, Zeke, 2021, *Quantifying Solar Value Deflation in California,* Breakthrough Institute, Jul 14, arguing that "The bottom line is that it doesn't matter what a technology costs; it matters what the electricity system needs… What matters isn't their cost, it's their value." Although I have shown that on value, the current leading application has plenty of value, whereas the high cost of nuclear undermines its potential value. Others, Like Aborn, et al., 2021, *An assessment of the Diablo Canyon Plant for Zero-Carbon Electricity, Desalinization and Hydroproduction,* MIT/Stanford, November, make a series of assumptions all of which are favorable to Diablo Canyon, and which are refuted in this testimony, current and future low cost for the aging reactor, a dash to gas, (ignoring renewables as substitutes),

First, the costs of wind and solar are quite low and there is little uncertainty in these cost estimates.

Second, the same is true of hybrid systems (solar with storage), once one takes the choice of the battery size into account. More hybrid systems and larger batteries are clearly the direction of resource choice.

Third, even with large batteries, hybrid systems are lower in cost than nuclear and geothermal (even with NREL's low-cost assumptions).

Fourth, gas with carbon capture and storage (especially in new builds) is lower in cost than nuclear and geothermal, but higher in cost than solar wind, and hybrid systems.

Fifth, depending on the quality of the resource, even offshore wind is lower in cost than nuclear and geothermal, and competitive with solar and onshore wind in the more attractive locations.

Q. Are these other observations one can make from the NREL study?

A. Yes, there are. Many of the scenarios involve contingencies around interactions with the supply-side core. Although this touches on many of the issues discussed below, it is worth noting that key messages, which reinforce my later observations.

As shown in Attachment MNC-5.5, the first key message is to get as much as possible from the demand side. This holds down costs dramatically. Thus, the NREL paper considers a set of scenarios that includes the long-term demand reduction, which it describes as follows:

> We also evaluated all scenarios with a sensitivity case using electricity demand from the *Long-Term Strategy of the United States* (LTS) (White House 2021a) to reflect an alternative demand-side pathway to reaching a net-zero emissions economy by 2050. The LTS reflects higher levels of energy efficiency and demand-side flexibility, resulting in slower annual load growth of 1.8%/year (compared to 3.4%/year under ADE) and, importantly, lower demand peaks that occur predominantly in summer as compared to the sharp winter peaks assumed for our primary ADE scenarios. In addition to direct electricity demand, both ADE and LTS assumptions include demand for clean hydrogen production for transportation and industrial applications, which may be produced from electrolysis or from natural gas with CCS depending on scenario….

> The need for new generation capacity would be even higher without the energy efficiency and demand-side flexibility measures assumed in the ADE trajectory. Results from the LTS sensitivity cases result in a 16%–20% reduction in the need for new installed capacity compared to the ADE cases due, in part, to the higher levels of energy efficiency assumed in LTS. [76]

The role of demand-side policy is clear. Moreover, the "transformation dividend" that I discuss above is 17%, in the middle of the impact observed by NREL.

A second observation is the importance of strengthening the infrastructure, which here means transmission. As NREL put it, "**Infrastructure Renaissance** assumes improved transmission technologies as well as new permitting and siting approaches that allow greater levels of transmission deployment with higher capacity."[77]

The third message, similar to the earlier NREL analysis, is that low-cost renewable supply is important.

Fourth, high-cost supply or no carbon capture drive up the cost dramatically; gas with carbon capture is the least cost disputable low carbon resource.

Trying to achieve 100% clean energy under the constrained scenario is extremely expensive and, in its reliance on a huge decrease in nuclear cost and increase in the nuclear fleet, very unlikely.

Thus, the policy strategies that can keep the transformation affordable are reduced demand, an infrastructural renaissance, low-cost renewables and carbon capture.

C. EXTRACTING ADVICE FROM OTHER EVALUATIONS OF DEEP DECARBONIZATION SCENARIOS

Q. Are there other studies that take this "positive" view of how to develop a zero-carbon future?

A. There are many such studies that identify the challenges, but lay out scenarios that move toward a low-cost, low carbon future based on the elements I have discussed. The technologies are visible, if not in hand, efficiency, renewables, storage. The challenge is scaling up the distributed technologies, building the physical (transmission) and institutional (regulation and other structures) that support the low-cost technology and ensure the appropriate behaviors by companies and the public.

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[76] Denholm, et al., 2022, p. ix… xi.

[77] Id., p. vii.

The results of the National Academy of Sciences workshop, which put over half a dozen studies into the record, summarized much of the research. The interesting thing is the policy recommendations that the committee offered. Attachment MNC-5.6 lists the issues that the Committee felt were urgent. The attachment includes only the measures that are of the "highest priority and indispensable" to achieve the objective policies. It puts them in two categories, technology development and socioeconomic. The description of the policies is particularly revealing:

> Technological Goals:
>
> **Invest in energy efficiency and productivity**. Examples include **accelerating the rate of increase of industrial energy productivity (dollars of economic output per energy consumed) from the historic 1% per year to 3% per year**. **Electrify energy services in transportation, buildings, and industry.** Examples include, by 2030, moving half of vehicle sales (all classes combined) to EVs, and deploying heat pumps in one-quarter of residences. Produce carbon-free electricity. **Roughly double the share of electricity generated by carbon-free sources from 37% to 75%.** Plan, permit, and build critical infrastructure. **Build critical infrastructure needed for the transition to net zero, including new transmission lines, an EV charging station network, and a CO 2 pipeline network**. Expand the innovation toolkit. Triple federal support for net-zero RD&D.
>
> Socioeconomic Goals:
>
> **Strengthen the U.S. economy.** Use the energy transition to accelerate U.S. innovation, reestablish U.S. manufacturing, increase the nation's global economic competitiveness, and increase the availability of high-quality jobs. Promote equity and inclusion. **Ensure equitable distribution of benefits, risks, and costs of the transition to net zero.** Integrate historically marginalized groups into decision making by ensuring adherence to best-practice public participation laws. Require that entities receiving public funds report on leadership diversity to ensure nondiscrimination. **Support communities, businesses, and workers**.

Ensure **support for those directly and adversely affected by the transition.**

Maximize the cost-effectiveness of the transition to net zero.[78]

Arguably, the things the NAS identifies as policy goals in need of urgent attention covers the same terrain as the NREL study, efficiency, infrastructure (transmission, EV charging stations, pipelines for CO_2, capture, federal RD&D in support of a dramatic increase in low carbon electricity, and macroeconomic benefits. The one issue that the NAS includes that has not been noted heretofore is the equity concerns. These include in general non-discrimination and the incorporation of "historically marginalized groups" and support for the communities, businesses and workers adversely affected by the affected by the transition. The equity concerns weigh heavily on the NAS recommendations. They recommend a carbon tax that is well below what it deemed necessary for equity reasons.[79]

Attachment MNC-5.7 identifies these concerns in policy statements and studies of the groups representing these interests. These concerns are generally met with a call for greater transparency, consultation with affected communities and participation in decision making.

However, throughout the analysis, whenever strategies are laid out, the NAS falls into the "all of the above" camp. They identify low cost renewables but then say "firm" low carbon resources should also be relied on (or at least researched) from a list that includes, "hydropower, energy storage, bioenergy, geothermal, nuclear energy, and carbon capture and sequestration are available to compensate for the intermittency of wind and solar electricity."[80] Accompanying

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[78] National Academies of Sciences, Engineering, and Medicine. 2021. Accelerating Decarbonization of the U.S. Energy System. Washington, DC: The National Academies Press, pp. 7-10.

[79] Id., p. 12, Also, because the direct impacts of an economy-wide price on carbon would fall disproportionately on people with the lowest incomes and the fewest choices, it should be augmented by rebates and by funding programs that promote a fair and just transition. The proposed carbon price is deliberately set at a level that would not by itself cause a 30-year transition to net zero because of concerns about equity, fairness, and competitiveness. For example, the committee was not confident that it could design a package of policies that would address competitiveness and mitigate unfair impacts of a carbon price that starts at or climbs rapidly to \$100/tCO 2. In addition, the committee calls for the establishment of entities within the federal government to bring equitable access to economic opportunities and wealth creation during the energy transition. These policies are designed to help achieve diversity and fairness goals and to support workers, families, and communities through the transition.

[80] Id., p. 41.

this text is a graph from Lazard's version 14.0 of levelized costs (2020). The costs included in this graph involves only the major sources and it contradicts a policy that endeavors to "Maximize the cost-effectiveness of the transition to net zero" because the cost of nuclear is an order of magnitude higher than the alternatives. In an analysis a year earlier, nuclear was over $90 per ton of carbon more costly than wind or solar PV.[81]

As shown in Attachment MNC-5.8, based on various Lazard estimates across time, the weakness of the "all of the above" approach is even more evident, not because nuclear is more expensive but because so many options have become more attractive. Aging reactors were 4th of 7 in the 2020 list, with my addition of aging reactors. New reactors were 6th of 7. Today, using the midpoint of the high and low estimate on Lazard's 2022 list plus my addition of aging reactors and my treatment of small and large reactors, the aging reactors are 8th of 18. For the new builds, which is the long-term view, new reactors were 13th or 14th among 18, depending on whether they are large or small. The expansion of the options in the middle – quasi-firm power from hybrid systems, geothermal, biomass, as well as efficiency, and even gas with carbon capture, which are competitive with aging reactors, and certainly SMRs – is the key technological change that must be recognized by policymakers.

That is exactly the point. The "constrained" scenario of NREL and the "all of the above" approach of the NAS, must assume that everything else fails, efficiency, wind, solar, hybrids, storage, and carbon capture. That is highly unlikely. More importantly for feasibility evaluation of low carbon resources, some of the things that nuclear needs, like must run status, inflexible demand, macro, rather than micro- and nano-grid transmission, are antithetical to the alternatives.

Interestingly, the NAS time frame for the "all of the above" approach is quite short (roughly a decade), ending in 2030, a period in which very little nuclear capacity has been or will be added. Thus, given the history, the most likely "fail" is not the alternatives, but nuclear power.

Q. Are there other approaches that reinforce your conclusions?

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[81] Lazard, v. 13.0.

A. Yes, a particularly interesting approach claims that studies which look at potential scenarios miss the issue of what is feasible to accomplish. Brutshin, et al.[82] examines four dimensions of feasibility, technological, economic, sociocultural and institutional (see Attachment MNC-5.9).

> Long-term mitigation scenarios developed by integrated assessment models underpin major aspects of recent IPCC reports and have been critical to identify the system transformations that are required to meet stringent climate goals. However, they have been criticized for proposing pathways that may prove challenging to implement in the real world and for failing to capture the social and institutional challenges of the transition. There is a growing interest to assess the feasibility of these scenarios, but past research has mostly focused on theoretical considerations. This paper proposes a novel and versatile multidimensional framework that allows evaluating and comparing decarbonization pathways by systematically quantifying feasibility concerns across geophysical, technological, economic, socio-cultural and institutional dimensions. This framework enables to assess the timing, disruptiveness and scale of feasibility concerns, and to identify trade-offs across different feasibility dimensions.[83]

As shown in MNC-5.9, in the upper graph the largest concern is the institutional structure, which is defined by the Governance structure. The middle graph lists the elements of the framework. The lower graph shows the constituent parts of each element and the "cut points used to define the feasibility score.

The authors build a summary governance index based on the average of the 6 World Bank Worldwide Governance Indicators, which are estimations of how effective the government will be in enforcing decarbonization policies. "[W]e find a strong positive correlation between governance levels and environmental performance, with countries with higher governance capacity being among the top environmental performers.[84] The governance score is cross tabulated by an environmental performance score.

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[82] Bruthsin, Elina, et al., 2021, "A multidimensional feasibility evaluation of low- carbon scenarios," Environmental Research Letter, June,

[83] Id., p. 1.

[84] Id., Supplemental Materials.

The second most important source of concern is the economic impact of deep decarbonization policy. GDP is the first indicator, followed by a price on carbon, the investment ratio and the stranding of coal assets (and jobs). These are similar to the issues I raised in Chapter 4, with one exception. I have not mentioned a cost on carbon, although I have noted the analysis of the value of carbon reduction, which was given a monetary value.

I do not consider a price on carbon because I have long argued that the most important policy measures are those that will further the alternatives, in a direct way.[85] While this has been a great debate in the decarbonization literature I have taken the view that "complementary" policies to further the construction of a 21st century system take precedence. I quote at length form authors who take the view of "transitions theory" in economics[86] because the authors raise all of the issues and concerns, I have raised.

> Our work, and the work of a growing number of other energy system scholars, suggests that carbon prices do not directly address the critical challenges of a transition to an energy system completely free of fossil fuels and their associated CO2 emissions. The policy instruments that are more likely to be effective are those that directly support the diffusion of a limited set of technologies needed to replace fossil fuels, in some cases through initial financial support, and increasingly through institutional and infrastructural changes…
>
> The first barrier, for still immature technologies, is typically cost. This is the same barrier that carbon prices address… The reason lies in industry dynamics. It takes time to scale up supply chains for new technologies, typically involving new market entrants with limited financial reserves, meaning that the deployment of capital stock starts slowly and then grows. Meanwhile the price differential between old high-carbon technologies and new low-carbon ones starts large and then shrinks.
>
> The second barrier is a mismatch between the new technology and the existing infrastructure. For example, it has been possible to generate small

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[85] Mark /Cooper, 2017a, Chapter 9.

[86] Patt, Anthony and Johan Lilliestam, 2018, "The Case against Carbon Prices," 2018, *Joule* 2, December, p, 2095.

> amounts of fluctuating PV and wind power without threatening the stability of power transmission and distribution grids… it is becoming apparent that major elements of the grid, from transformer stations to long-distance transmission lines, will need to be upgraded or replaced. We will also need new infrastructures, such as large-scale electricity storage. Unless we adapt the infrastructure, the problems will only grow. Infrastructure development takes coordinated planning and development based on long-term strategic priorities, and this is not something that carbon prices directly address.
>
> The third barrier is institutional. One example is to be found in the rules determining wholesale power prices... Under current power market designs, growing shares of wind power and PV have pushed down wholesale power prices, in some cases well below zero, precisely during their times of peak production. This reduces profits for fossil generation, but even more so for wind and solar themselves. Carbon prices do not directly address this problem, whereas market reforms can…
>
> Simply put, carbon prices are outdated. They made sense as our primary tool against climate change when our climate policy ambitions were limited, and the greatest barrier was cost. Today our ambition is to eliminate CO_2 emissions entirely, and the greatest barriers are associated with infrastructure and institutions. The barrier to technological change that carbon prices address, the higher cost of renewable energy, is ceasing to be relevant. Where such costs are still relevant, technology support instruments are more effective. We do have a window of opportunity to stop climate change within a range of safety, and therefore need to use that time to develop and implement policies that actually make a difference. [87]

In short, as I have shown, we have had the technological cost revolution. We now need the physical (infrastructural) and institutional (regulation) to achieve the goal.

Q. Does feasibility study also consider scenarios?

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[87] Id., pp. 2495… 2496… 2497… 2498.

A. Yes, the paper applies the feasibility methodology to a small number from the IPCC assessment (see Attachment MNC-5.10).[88] It yields important insight consistent with my policy recommendations. As shown in Attachment MNC-5.10, governance matters most when it can deliver low demand. Governance that delivers high energy intensity is a much greater concern. Demand reduction is the key, but concern depends on institutional arrangements.

Q. Are there also studies of many scenarios?

A. Yes, Jenkins has reviewed 40 such studies.[89] While I draw important insights from his very general conclusions, I show below that his recommendations for policy makers leave a lot to be desired.

Renewable resources, supported by storage, demand flexibility and expanded transmission are the obvious first step. These will need policy to expand storage, transmission, and demand flexibility.[90] The initial approach is likely to fall short of the 100% decarbonization scenario so a second set of low carbon resources may be needed, which requires decarbonization with firm resources. These include carbon capture geothermal, biomass, and nuclear,[91] but one important objective is to keep costs down. This is a major concern of the authors with "outsized" importance:

> At the same time, costly routes to decarbonization that substantially increase the price of electricity would make low-carbon electricity a less attractive substitute for oil, natural gas, and coal in transportation, heating, and industry. Finding

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[88] Bruthsin, Elina, et al., 2021., and Supplemental Materials.

[89] Jenkins, Jessse, D., Et al., 2018, "Getting to Zero Carbon Emissions," *Joule* 2, December 2.

[90] Id., pp. 2498-2499, The studies collectively outline two overall paths to decarbonize electricity. [One path] that relies primarily (or even entirely) on variable renewable energy sources (chiefly wind and solar power) renewable energy sources, chiefly wind and solar power supported by energy storage, greater flexibility from electricity demand, and continent-scale expansion of transmission grids; and a second path that relies on a wider range of low-carbon resources including wind and solar as well as ''firm'' resources such as nuclear, geothermal, biomass, and fossil fuels with carbon capture and storage.

[91] Id., p.2506. [W]e find strong agreement in the literature that reaching near-zero emissions is much more challenging—and requires a different set of low-carbon resources…This is chiefly because more modest goals can readily employ natural gas-fired power plants as firm resources.

> feasible and affordable routes to decarbonize the power sector thus takes on outsized importance in global climate mitigation efforts.[92]

Given historic trends and current estimates, I view nuclear power as the primary culprit in increasing the price of electricity. Attachment MNC-5.11 is derived from the article by Jenkins' that lists 40 studies that evaluate models of a zero-carbon system. His big table identifies three key policies that support the alternatives, long duration storage, transmission and flexible demand. The partial references (between 0 & 1, between 1 & 2 and between 2 & 3) represent instances in which some consideration, but not full, was given to one or more factors. There is a high correlation (r- = ~ .8) between inclusion of these three policies and the absence of nuclear power. Nuclear drops from 100% inclusion in the 30% of studies that included none of the factors to 20% in the 50% of studies that included more than two of the factors.

In a sense, the studies of the U.S. are even more extreme (Attachment MNC-5.12). Although the correlation coefficient is of roughly the same magnitude, any study that does not include all of the three policies that support the alternatives, includes consideration of nuclear. The specific magnitude and make-up of the supply mix is not given, but the overall message is the same. Including all the necessary policies to support alternatives makes it much more likely that expensive nuclear power can be avoided. Ignoring these alternatives, nuclear becomes "necessary."

Jenkins argues strongly for an "all of the above" strategy, but his discussion highlights the weakness of a simplistic "probability" approach. He states it is only a hypothetical and he is careful to point out the challenges facing all of the alternatives. He divides them into two groups. One group is composed of low-carbon intermittent resources – "grid expansion, flexible demand, very low [renewables] wind and solar, and seasonal storage."[93] The other group is composed of low carbon "firm" resources – "nuclear power, Carbon Capture and Storage, bioenergy and enhanced geothermal, each have the ability to fill the role in a low-cost, low-carbon portfolio. As shown in Attachment 5.12, Jenkins, et al., provide a detailed road map to the challenges facing deep-decarbonization in these early studies.

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[92] Id., p. 2506.

[93] Id., p. 2509.

His use of information about the current environment is to assume a 1-in-6 chance that the technologies in the first group will fail, while there is a 1-in-2 chance that the technologies in the second group will succeed.[94] He then calculates the joint probability of reaching the goal, given the rate of failure. The probability that all of the first group will succeed is described as like "rolling a dice and not coming up with 1." The likelihood of success if just over 50% [1-(.833)^4 = 1-.48 = .52]. He flips the betting around for the second group calculating "the odds that at least one succeeds is 94% [1-(.5)^4 = .94]. Pursuing both groups "would raise the chance of success of at least one affordable pathway to decarbonize electricity to 97% [.52 + (.94* .48) = .97]

Jenkins is aware of the importance of price and prudence. "Obstacles remain along any path to zero-carbon… It is therefore vitally important the decision makers identify and pursue prudent strategies to improve the odds of feasible and cost effective decarbonization." In advocating for keeping the second groups on the table since it "may fill the critical niche for firm, low-carbon power should other technologies falter." He stresses however, that it must be "low-carbon, affordable and scalable, within the next two decades." The advantages of the low capital cost, high variable cost approach, even among the firm low-carbon resources, are acknowledged in the context of high reliance on variable source from the first groups. These are "economically better suited to pair with high wind and solar shares."

Aside from creating the two baskets of technologies to apply different probabilities, which indirectly reflect the amount and structure of costs, little use is made of information about current costs, variability and cost projections. These are primary concerns in determining prudence and least cost that are the focal point of regulatory review. What happens to the probabilities if we exclude one technology from the second group (i.e., nuclear)? There is good reason to do so.

To summarize the concept, we accept the popular proposition – "Don't put all your eggs in one basket" –which is certainly good advice, which we follow, by having three eggs in the second basket, not four. The reason to exclude nuclear is also summed up in a popular proposition – "One bad apple spoils the bunch" – which is also good advice. The science is that a bad apple emits gases that spread the decay to good apples. In the case of energy policy, one

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[94] Id., p. 2509.

technology may crowd out other technologies, especially when they have a century of advantage built into their existence, when they require rules (must run status) that are antithetical to the logic of the core resources), and they are extremely expensive to boot (violating the prudency/least cost) standard.

What happens to the probability of success if we exclude nuclear. The probability of success declines, but only slightly ([1-(.5^3) = .875). The probability of overall success also declines, but very slightly. Instead of 97% chance of success, we find a 94% ([.52 + (.875*.48=.94]).

What is the "benefit" of accepting this small increase in overall risk. One way to estimate it is the costs of each technology. Ironically, EIA did not estimate future costs of two of the second group (advanced nuclear, and biomass) because no examples of construction existed (ignoring Vogtle and the struggles of Nuscale). The estimates of costs we have used for the other two (gasw/CCS and geothermal) average about $85/MWH. In contrast, we have estimated the costs nuclear at $120/MWH for SMRs and %150/MWH for large reactors.

In attachment MNC-5.13, I consider different levels for the group 1 technologies, which is then used to adjust the bill impact of relying on group 2. In the 60% scenario, I assume group 2 accounts for 40% of the market. In the 80% scenario, I assume group 2 accounts for 20% of the market. The two levels are mentioned in the analysis as the "highest" level that the group 1 technologies could achieve without sharp increases in cost. The assumed cost of group 1 in the base case is cautious and I assume a higher cost for the higher penetration of group 1. Under these assumptions there are substantial cost savings by following the estimated cost. There is a significant cost advantage enjoyed by a group 2 low-cost approaches (CCS and geothermal) and additional advantages to reliance on group one, the core renewables and the supporting technologies. Given the base case costs, the savings are at least 10% of the final bill and as much as 20%, in the low-penetration scenario for group 1.

More importantly, the message for policymakers who are concerned about prudent, least cost achievement of deep decarbonization is clear in light of the analysis in this section. They should seek to ensure maximum contribution of the core renewables (wind, solar and storage) and efficiency. To do so, they should address institutional arrangements, above all, followed by economic issues. The objective of reduced and controlled demand is paramount.

Efficiency is not only an extremely valuable resource, it lowers overall volatility and risk,[95] and its potential is very large. This potential spills over into the benefit of demand response to meet challenges to reliability.

> Moreover, by improving the reliability of the power system and, in the long term, lowering peak demand, DR reduces overall plant and capital cost investments and postpones the need for network upgrades. In this paper a survey of DR potentials and benefits in smart grids is presented. Innovative enabling technologies and systems, such as smart meters, energy controllers, communication systems, decisive to facilitate the coordination of efficiency and DR in a smart grid.[96]

At the same time, it is important to recognize the future role of storage. While wind and solar technologies have gone through a long period (at least a decade) of declining costs that have reached very low levels, the cost of storage is much earlier in that process and promises to deliver ongoing decreases in the cost of and increases in the value of hybrid systems of a similar process. New technologies hold great promise, and some, like pumped storage may support substitution of renewables for solar, as shown in Attachment MNC-5-14.

If the ability to reach the ultimate goal with these resources is doubtful, based on unfolding experience, they should devote their attention to the lower cost options in group two. The worst outcome would be if they are forced to rely on high-cost group 2 resources. Thus, the early days should be devoted to ensuring that policy gets the most out of (is most supportive of) the group 1 resources. Given that the development of resources takes time, a critical question

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[95] Brendon Baatz, James Barrett, and Brian Stickles, 2018, *Estimating the Value of Energy Efficiency to Reduce Wholesale Energy Price Volatility,* ACEEE, April, Report U1803, PP. 20-21, In long-term resource planning, utilities and others must consider the risks associated both with normal price fluctuations and with occasional extreme events like the polar vortex…. Having a correct perception of these risks is critical to effective planning. In the creation of a plan that manages these risks and the costs of hedging against them, energy efficiency can play a role that has largely gone unrecognized so far. By offering electricity services at fixed and low prices, efficiency can reduce the amount of electricity that needs to be purchased when electricity prices are high, thus lowering overall system risk. To the extent that utilities, regulators, and other planners recognize this characteristic of efficiency, its overall value should increase in planning processes, and more efficiency resources should be deployed.

[96] Siano, Pierluigi, 2014," Demand Response and Smart Grids —A survey," *Renewable and Sustainable Energy Reviews* 30.

becomes how and when to declare that policy must resort to high-cost resources. Given that the current supply-demand mix is far short of the suggested limit and the system is far from fully transformed, these core resources should command policy attention. The ultimate problem is very much a problem with "new builds," in the long term. Therefore, current, aging reactors should not be the target of public policy and nuclear power should be the last resource considered, commanding the smallest share of public resources, only if all else fails.

D. CONCLUSION

As with the earlier chapters, although the earlier discussion and Attachments have shown the relevance of the analysis to California, we conclude with observations that link the discussion directly to California.

First, we note a study by the University of California which identified a path toe deep decarbonization.[97] Bending the curve, which is a California policy analysis never mentions nuclear power. In contrast, four of its "10 Scalable Solutions" mention the primary resources I have emphasized – solar, wind, battery, and efficiency (solutions 6, 7, 8, 9). Three of the solutions involve institutional goals (culture 2, 3) and governance models (4). Two involve economic structures (markets 5, regulation 6), along the lines I have discussed. One involves natural systems (e.g., deforestation, 10). Arguably, one might argue that nuclear power could fit under one solution, (maximize use of available technologies, 9), but the example given is a small scale technology, not a primary concern for California, "access to clean cooking for the poorest 3 billion people who spend hours each day collecting solid biomass fuels and burning them indoor for cooking."

The full list of technologies mentioned for encouragement and innovation that apply to California never mentions nuclear, but 14 other technologies, including those listed in Attachment MNC-5.15. These technologies and supporting policies are the core of my recommendation for the development of a 21st century electricity system.

Second, the dramatic change in storage costs, which we have seen chapters 3 and 4, can also be seen in California data, as shown in Attachment MNC-5.16. The upper graph is from the

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[97] University of California, 2015, *Bending the Curve Executive Summary: Ten scalable solutions for carbon neutrality and climate stability,* October 27.

Lazard analysis and it examines both in-front-of-the-meter and behind-the-meter cases. In all cases, CAISO is very attractive in terms of the return to investors. In the upper graph, the behind the meter cases, for commercial and industrial storage are much lower in cost, In the hybrid case, the California case is extremely attractive. This is confirmed in the lower graph which looks at the incremental value of community rooftop solar. The value stack for PG&E is about $58/MWH. This confirms two of my earlier observations. First, since other forms of renewables with storage have lower costs, they are likely to have much higher values. Second, it is important not to jump to conclusions about behind-the-meter costs; all of the potential system costs and benefits should be considered.

CHAPTER 6: ASSESSING AND (MIS)REPRESENTING RELIABILITY

A. THE INDEPENDENT SYSTEM OPERATOR

Q. Is there other evidence that these approaches can work?

A. Yes, the performance of the Independent System Operators recently confronted with very demanding supply-demand events is encouraging. They recognize the challenge but have applied recent experience to navigate through them and they identify additional steps to support effective performance.

The most relevant is the CAISO report on what worked and needs to be improved in the management of the grid. Attachment MNC-6.1 shows the adaptation based on past challenges and the areas for continued improvement. These are exactly what the PUC proceeding, discussed in Chapter 4, identified several years ago – increasing supply, storage, demand response under the control of the ISO and voluntary, coordination with utility and other levels of government, etc. There was similar performance under stress in other ISOs, like MISO. Moreover, while CAISO is a summer peaking area, MISO suffered a winter peak. The challenge was the summer of 2022 in CAISO and the Winter of 2022 in MISO.

The CEC "Diablo Canyon Power Plant: Final Draft analysis of Need to support Reliability" is a perfect example of speculative analysis done for the purpose of convincing its target, in this case the California Public Utility Commission (CPUC) to buy ill-advised, expensive insurance, even though it fails to note the cost of the insurance and the analysis is, in a sense, disavowed:

> DISCLAIMER
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> Staff members of the California Energy Commission (CEC) prepared this report. As such, it does not necessarily represent the views of the CEC, its employees, or the state of California. The CEC, the State of California, its employees, contractors, and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the uses of this information will not infringe upon privately owned

> rights. This report has not been approved or disapproved by the CEC nor have they passed upon the accuracy or adequacy of the information in this report.[98]

There is good reason for this disclaimer. The policy recommended is like trying to kill a gnat with a baseball bat. The analysis does not consider the cost of the policy. It takes no notice of the damage it would do trying to kill the gnat (putting holes in the wall), or even if it successfully killed it.

Given that it accepts the proposition that there is not likely to be a resource shortfall during the period of the subsidy,[99] but it warns that two years later there could be a shortfall, once cannot help but suspect that the hidden agenda is to keep PG&E's nuclear power online until after the subsidy expires. Under the assumptions used in the analysis, one cannot help but suspect that the CEC will come back and claim that more bad insurance is needed, *ad infinitum*. The hidden agenda may well be to keep nuclear power in the mix for a much longer period of time.

The CEC report notes that based on a 20-year record the confluence of events represents a 1-in-14 chance. While it is not as great as the planning probability of a 1-in-10-year chance, the CEC report argues that the probability of the confluence of events in the thirty-year period was only 1-in-27, so 1-in-10 may be too close for comfort, even though it was sufficient. It never says what the alternative should be, but a little arithmetic says the planning horizon should be prepared for 1-in-5 contingencies [(14)/(27))*10) =5.2]. Whether or not that is the right number, is unclear, but underlying analysis fails to recognize the steps taken by the CAISO to deal with the challenge.

In the analysis, the CEC notes that "On February 23,2023, the CPUC ordered load serving entities to procure an additional 4,000 MW of net qualifying capacity, 2,00 MW in 2026

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[98] Implementing Senate Bill 846 Concerning Potential Extension of Diablo Canyon Power Plant Operations, Rulemaking 23-01-007, April 20.

[99] Id., Attachment E: Diablo Canyon Power Plant Extension Final Draft CEC Analysis of Need to Support Reliability SB 846 only requires consideration of 2024 through 2030, the CEC included the analysis developed for the Joint Agency Reliability Planning Assessment, which covered 2023 through 2032. The analysis shows that under the current resource adequacy planning standard, the CPUC's procurement orders, Decision (D) 19-11-016 and D.21-06-035, are sufficient to eliminate shortfalls through 2030, (p.3).

and additional 2,000 in 2027." However, "this additional procurement was not included in the analysis."[100] Including these two additions eliminate any shortfall in the analysis until 2032, which is well beyond the detailed discussion offered in the report.[101] The CEC also delays 2000 mw of 8-hr storage or geothermal by 2 years.

These are not the only ways in which the CEC analysis underestimates resources. It assumes that the deployment of alternatives hits the wall in 2024. It explains this as a function of the challenges that the alternatives face.

> Development is being impacted by [1] supply chain issues, particularly for solar and storage, and [2] interconnection and [3] permitting delays resulting from the large number of projects coming on-line that require safety and environmental reviews. [4] Climate change is impacting grid reliability by causing more frequent extreme events beyond what current planning standards account for, such as record-setting heat, droughts, and wildfires that can impact transmission.[102]

These issues are mentioned at least two dozen times in just 31 pages. Ironically, two of the four challenges are within the power of the PUC and CAISO to address to some extent. Regulatory integration and approval of projects can be accelerated, something on which regulators are working. The climate change issue is beyond their control, but it is driving their responsive actions. The supply chain problems triggered by the COVID pandemic may be fading like the pandemic. Although it is difficult to predict how successful the regulators will be, or how big the supply chain problem will continue to be, 2022 stands as an example of how tight conditions can be dealt with.

As shown in MNC-6.2, even assuming a flat DR performance, there is no shortfall if the historic pattern of growth holds. DR fills the gap in 2024 and supply growth fills it in 2025. Moreover, as described in the CAISO report of 2022, there are several other sources of power available that would more than fill the gap. Attachment MNC-6.2 also shows, cumulatively,

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[100] Id., p. 24.

[101] Id., p. 23.

[102] Id., p. 4.

77% of the Diablo Canyon capacity is excess. Even looking at individual years it is surplus. In three of the five years for which we have analysis, there is no shortfall. Looking at year-to-year shortfalls, about 70% of the capacity is surplus. Put another way, The excess capacity of Diablo Canyon is 3.5 times the capacity that is needed under these assumptions. Looking at what the CEC has assumed about the performance of the system without efforts by the CAISO to do its job, one can argue that the strategy of subsidizing Diablo Canyon is, in fact, to crowd out alternatives for half a decade. This analysis looks very much like nuclear blackmail, intended to convince policymakers to buy bad insurance.

In the next section I examine the regulatory response to a clear case of such blackmails, Exelon Illinois.

B. BASELOAD BIAS, UTILITY SCALE FETISH, & SHORT-RUN MYOPIA IN NUCLEAR LICENSE RENEWAL

The flashpoint of the conflict over the transformation of the electricity sector was discussed in chapter 4, as the "merit order effect: in which[103]—wind backs inefficient natural gas

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[103] The Merit Order Effect has been documented in a number of nations in which renewables have shown strong growth in recent years, demonstrating not only that market clearing prices are lowered, but also that they are lowered by an amount that is larger than any subsidies the resources receive. The result is a net benefit to consumers. See for example, United States: Bob Fagan et al. The Potential Rate Effects of Wind Energy and Transmission in the Midwest ISO Region, Synapse Energy Economics, Inc., May 22, 2012; Richard W. Caperton, Wind Power Helps to Lower Electricity Prices, Center for American Progress, October 10, 2012; Charles River Associates, Analysis of the Impact of Cape Wind on New England Energy Prices, Charles River Associates, February 8, 2010; Canada: Mourad Ben Amor et al., "Influence of Wind Power on Hourly Electricity Prices and GHG (greenhouse gas) Emissions: Evidence that Congestion Matters from Ontario Zonal Data," Energy 66 (2014); Australia: Dylan McConnell et al., "Retrospective Modeling of the Merit-Order Effect on Wholesale Electricity Prices from Distributed Photovoltaic Generation in the Australian National Electricity Market," Energy Policy 58 (2013): Iain MacGill, The Impact of Wind on Electricity Prices in the Australian National Electricity Market, Centre for Energy and Environmental Markets, June 2013; Melbourne Energy Institute, The Impact of Distributed Solar Generation on the Wholesale Electricity Market, June 2013; Ireland: Amy Mahoney and Eleanor Denny, The Merit Order Effect of Wind Generation in The Irish Electricity Market, Department of Economics, Trinity College, Dublin, 2011; Denmark: Jesper Munksgaard and Poul Erik Morthorst, "Wind Power in the Danish Liberalized Power Market—Policy Measures, Price Impact and Investor Incentives," Energy Policy 36 (2008): 3940–3947; Germany: Frank Sensfuss, Mario Ragwitz, and Massimo Genoese, "The Merit-Order Effect:

(and some coal) plants out of the supply needed to clear the market at the peak. This lowers the market clearing price, which results in substantial consumer savings. The downward pressure on market clearing prices has led to a several years of losses for the aging nuclear reactors. Operating costs alone are almost twice the current market clearing price of electricity and things are likely to get worse over time. These reactors cost more to run than the alternatives, so they cannot cover their operating costs or make any contribution to ongoing capital costs that are necessary to keep them online. In the near term, numerous aging reactors are predicted to lose millions of dollars per year, although the amount of the losses will vary from market to market.

Thus, coal, natural gas, and subsidies are not the ones giving aging nuclear reactors heartburn, but rather it is the superior economics of wind (solar in California) and efficiency combined with the increasing operating costs of aging nuclear reactors themselves. It is important to recall that both the Lazard and Jacobson cost projections were estimated as subsidy-free costs. The "merit order" predicament in which nuclear power finds itself is deeply ironic. Historically, nuclear power presented itself as a low-cost option by emphasizing its low operating costs, downplaying its very high initial fixed capital costs, and glossing over ongoing capital costs to keep them online. Two decades of technological innovation in renewables, and the aging of extremely complex nuclear facilities, has put an end to that sleight of hand.

A Detailed Analysis of the Price Effect of Renewable Electricity Generation on Spot Market Prices in Germany," Energy Policy 36 (2008): 3086–3094; Italy: Stefano Clò, Alessandra Cataldi, and Pietro Zoppoli, "The Merit-Order Effect in the Italian Power Market: The Impact of Solar and Wind Generation on National Wholesale Electricity Prices," Energy Policy 77 (2015); Spain: Gonzalo Sáenz de Miera, Pablo del Río González, and Ignacio Vizcaíno, "Analysing the Impact of Renewable Electricity Support Schemes on Power Prices: The Case of Wind Electricity in Spain," Energy Policy 36 (2008); United Kingdom: Richard Green and Nicholas Vasilakos, "The Economics of Offshore Wind," Energy Policy 39 (2011). A separate effect that lowers the market clearing price is the fact that renewables tend to lower the level of concentration of supply, reducing the exercise of market power, Mishra et al., "Mitigating Climate Change"; Paul Twomey and Karsten Neuhoff, "Wind Power and Market Power in Competitive Markets," Energy Policy 38 (2010); Franz Wirl, "Taxes Versus Permits as Incentive for the Intertemporal Supply of a Clean Technology by a Monopoly," Resource and Energy Economics 36 (2014); Bruce Mountain, Market Power and Generation from Renewables: The Case of Wind in the South Australian Electricity Market Australian Economic Report: No. 2, Centre for Strategic Economic Studies Victoria University, Melbourne, June 2012.

Utilities in New York,[104] Illinois,[105] and Ohio[106] asked for above-market prices for six reactors. These reactors have lost hundreds of millions of dollars over the last couple of years, but the utilities claim that the low price of gas is the cause of the problem. This is incorrect in three respects. First, the rising cost of operating reactors accounts for about a third of the problem. Second, the addition of wind, which backs inefficient gas out of the market clearing price, contributes to the shift. Third, demand has declined due to increased efficiency. The price of gas matters as well, but less than the other three factors. Two-thirds of the revenue shortfall experienced by aging reactors is caused by the rising cost of keeping nuclear reactors online, the superior economics of renewables, and the attractiveness of efficiency.

Against this background, a Rocky Mountain Institute's (RMI) study concludes that solar with battery storage will trigger a large wave of "grid defection" in five to ten years.[107] It shows that refusing to offer payment that reflects their value to the consumers who install this equipment could delay the impact by about a decade, but it will arrive in any event. The message, aimed at utilities, is that their interests would be better served if they use the transition to build a system that accommodates and manages the transition, rather than being overwhelmed when it comes. However, one could take the opposite lesson from this analysis. If this one policy (impeding net energy metering) can delay the transition significantly for a decade, utilities might see this as an opportunity to protect their short-term interests and secure an alternative long-term structure. By layering a number of attacks on the alternatives while simultaneously securing policies that advance their economic interests, utilities can significantly delay and alter the shape of the future. This interpretation is more consistent with their behavior, and it suggests that the current battle over fundamental policies—subsidies, rate structures, deployment of

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[104] Malik and Polson, "New York Reactors"; William Opalka," New York Adopts Clean Energy Standard, Nuclear Subsidy," *RTOinsider,* August 1, 2016; William Opalka," CES Under Attack on Multiple Fronts in Rehearing Requests," *RTOinside ,*September 5, 2016

[105] Illinois Commerce Commission et al., *Response*.

[106] Tom Sanzillo and Cathy Kunkel, *First Energy: A Major Utility Seeks a Subsidized Turnaround,* Institute for Energy Economics and Financial Analysis, October 2014.

[107] Peter Bronski, et al., 2015, "The Economics of Load Defection How Grid-Connected Solar-PlusBattery Systems Will Compete with Traditional Electric Service, Why It Matters, and Possible Paths Forward," Rocky Mountain Institute, April.

physical facilities, and so on—are strategic, and could profoundly affect the future structure of the industry.

RMI is certainly not the only one to suggest that there is a direct link between policy choices and industry structure. The baseload-dominated electricity system was created by policy support and subsidies for physical and institutional infrastructure that favored a specific type of technology. The dominant incumbents will seek to slow or stop the spread of alternatives by denying their access to a similar process that they understand well. The proposition that industries or technologies whose ascendancy is threatened by new competition tend to respond, carries some weight. It also suggests that actors, such as large energy companies, with substantial investments in the current system and its technologies, and relatively strong political influence, are likely to act to frustrate the implementation of institutional changes that would support the implementation of low carbon technologies.

> Their diffusion can be slowed by effects of path dependence and lock-in of earlier technology systems. . .. High carbon technologies and supporting institutional rule systems have co-evolved, leading to the current state of "carbon lock-in." For example, reductions in cost and the spread of infrastructure supporting coal- and gas-fired electricity generation enabled the diffusion of electricity-using devices and the creation of institutions, such as cost-plus regulation, which encouraged further investment in high carbon generation and networks. This created systemic barriers to investment in low carbon energy technologies.[108]

In short, this clash is inevitable and has given rise to a frontal assault by nuclear advocates on alternative resources and the institutions that support them.[109]

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[108] Peter J. G. Pearson and Timothy J. Foxon, "A Low-Carbon Industrial Revolution? Insights and Challenges from Past Technological and Economic Transformations," *Energy Policy* 50 (2012), 123–124.

[109] Marcus Hildmann, Andreas Ulbig, and Goran Andersson, *Revisiting the Merit-Order Effect of Renewable Energy Sources,* Working Paper, February 11, 2014, show that if baseload facilities could stop acting like baseload facilities, they would fit into to the emerging electricity system. "Given base load power plants that have sufficient operational flexibility in

The False Reliability Crisis: Exelon's Nuclear Retirement Blackmail

Exelon is the largest nuclear utility in the United States (with a total of 14 reactors), and Illinois (with 6 reactors), where it is headquartered, has more nuclear reactors than any other state. The two regional transmission organizations (RTOs) into which Exelon sells power—MISO and PJM—have the largest number of nuclear reactors by far. Exelon claimed that it would have to close many of its reactors if it did not get financial relief. This was part of an aggressive campaign to get more favorable treatment for its reactors from state, regional, and federal policymakers, with Illinois being the focal point.

State policymakers resisted, deflecting the initial demand for new laws to favor nuclear. They called for state agencies to study the impact of the early retirement of aging nuclear reactors, and the outcome was exactly the opposite of what Exelon had hoped for. The State of Illinois agencies' analyses concluded that there would be no crisis that merits subsidies of billions of dollars over the next decade.

First, from both the reliability and carbon-reduction points of view, the amount of at-risk nuclear power is not large enough to warrant immediate subsidization without an evaluation of the cost of the available alternatives. There are a host of approaches to managing the grid that can ensure reliability even as the share of variable renewable resources rises substantially.[110] Therefore, it takes a set of worst-case assumptions devoid of foresight, planning, and preparation to yield a hint of concern about reliability in the near term.

Resources in both RTOs are adequate in the "base case," and continue to be adequate when the at-risk nuclear plants are retired in the "nuclear retirement case." In MISO resources

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terms of fast ramping, start/stop times and minimum operation point requirements, energy-only markets seem to work even for high-RES penetration scenarios." (p. 13).

[110] U.S. Department of Energy, *Wind Vision*, 86–87, "Most North American power markets now integrate wind power into their security-constrained unit commitment and security-constrained economic dispatch process, allowing the dispatch of wind plants along with conventional power plants based on current grid conditions and economics. This effectively gets wind into the real-time economic optimization process for running the power system, and in turn, encourages the participation of wind plants in the day-ahead markets. Security-constrained economic dispatch also makes wind dispatchable and economical, allowing some degree of wind-plant output control by the system operator. This allows wind forecasts to become more useful and valuable to wind plant operators, market participants, and system operators, because wind is better integrated into systems and markets."

remain adequate if the nuclear plants are retired even if there is a "polar vortex" event, but not in the "high load and coal retirement" case. On the other hand, resource adequacy is substandard in PJM in both stress cases; but demand response mitigates the problem in the "high load and coal retirement" case. . .. The IPA attributes the superior resource adequacy in Illinois, even given the premature closures of the nuclear plants, to its initial capacity surplus and to its robust transmission system that enables Illinois to call on out of state capacity support.[111]

RTOs have rules that require notice about decisions to abandon generation, which affords the operator and market participants time to adjust, and also imposes penalties for failing to deliver on existing commitments.[112] Usually, nuclear plant closures are not sudden unheralded events. Rather they are planned and anticipated months or even years in advance. This would be particularly true of a closure prompted by low power prices rather than a serious accident or the unexpected failure of plant equipment.[113]

To the extent that the early retirement of several reactors might put pressure on the electricity system, the Illinois analysis found that responses are available, and that it would not be an Illinois-specific problem but a regional problem. In some senses, such an event immediately triggers mitigating responses. "Thus, the eventual closure of a generating facility could be accompanied by a variety of actions by the affected RTO to alleviate reliability concerns."[114] To the extent that a problem might be caused by the closure of multiple reactors, it would elicit responses from other market participants to mitigate the impact. "Such actions would also have the effect of increasing the supply or availability of other generating resources or the supply of demand response resources… [and] moderate what might otherwise have been a sudden increase in energy market prices.[115] At the same time, the analysis notes that the transmission system has built-in mechanisms that respond to the challenge. The list of immediate

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[111] Illinois Commerce Commission, *Response*, 71–72,

[112] Id., 63; "It is also noteworthy that generating facility owners participating in PJM's Reliability Pricing Model base capacity auctions commit to provide generating capacity three years prior to each delivery year; and the penalties for failing to actually make committed capacity available are steep. In PJM and MISO, generators are required to provide advanced notice of unit deactivations."

[113] Id., 64.

[114] Id.

[115] Id.

potential short-term responses is quite long, including obligations of the utility to assist in preserving system reliability, redispatch and reconfiguration of resources, management of planned outages, and expansion of transmission facilities. [116] These are exactly the responses of CAISO to the recent summer challenge and MISO to a similar winter challenge.

C. PG&E'S DIABLO CANYON EARLY EXTENSION FORAY

Nuclear Regulatory Commission Guidelines

Q. Please describe the flaws the NRC approach.

A. The PG&E application for a license renewal for its Diablo Canyon reactors represents a different point in the reliability debate—a mid-term, general claim about reliability. It also reminds us that institutional inertia in the public/regulatory sector is a critical factor in the transition between modes of production. Indeed, as noted, social institutions (government being the most prominent) are slower to change than economic forces and institutions.[117]

The Nuclear Regulatory Commission's (NRC) Generic Environmental Impact Statement for License Renewal[118] gives guidance to utilities on the general criteria the NRC will apply in license renewal. In its updated GEIS in 2013, the NRC recognized that the energy field is evolving very rapidly, and therefore requires a case-by-case analysis of energy alternatives in license renewal proceedings, using "state-of-the-science" information.[119] However, a close look at the GEIS in the context of the contemporary industry shows quite clearly that two decades of

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[116] Id. "If the retirement or suspension of the generating unit creates a reliability issue, MISO shall: (1) begin negotiations of a potential System Support Resource ("SSR") Agreement with the owner or operator of the Generation Resource; and (2) use reasonable efforts to hold a stakeholder meeting to review alternatives. The list of alternatives to consider and expeditiously approve include (depending upon the type of reliability concern identified): (i) redispatch/ reconfiguration through operator instruction; (ii) remedial action plans; (iii) special protection schemes initiated upon Generation Resource trips or unplanned Transmission Outages; (iv) contracted demand response or Generator alternatives; and (v) transmission expansions. A Generator alternative may be a new Generator, or an increase to existing Generator capacity."

[117] Perez, Carlota, *Technological Revolutions and Financial Capital: The dynamics of Bubbles and Golden Ages,* (Elgar, Northampton, MA) pp. 155-156.

[118] NRC, *2013 Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437)* (Washington, DC: Nuclear Regulatory Commission, 2013).

[119] NRC, *2013 GEIS*, 1-30–1-31.

rapid and dramatic economic and technological change have rendered obsolete even the modified standard that the NRC uses to evaluate request for license renewal.

Under the 1996 Guidelines, the NRC framework for evaluating license renewal requests focused on nuclear reactors as baseload generation facilities.[120] The first page of the section of "Alternatives to License Renewal" concluded by stating that "therefore, NRC has determined that a reasonable set of alternatives should be limited to analysis of single, discrete electric generation sources and only electric generation sources that are technically feasible and commercially viable."[121] In the evaluation of the sources, the NRC invoked the concept of baseload over 30 times. The majority were references to the failure of renewables to meet the baseload criteria.

In the 2013 revision, that standard was revised somewhat. Utility scale replaces baseload as the central concept, while a reliable quantity of replacement capacity equal to the baseload capacity is the target. "The amount of replacement power generated must equal the baseload capacity previously supplied by the nuclear plant and reliably operate at or near the nuclear plant's demonstrated capacity factor." [122] The change is cosmetic, at best.

The NRC continues to exhibit an extremely narrow focus on utility-scale and baseload. In the current technological and economic environment, this focus is tantamount to an irrational baseload bias and a utility-scale fetish that is out of touch with reality. Section 2 of the revised relicensing regulation invokes baseload and utility-scale 25 times in the 16 pages where alternatives are evaluated. The assessment of the alternatives is defined by these two antiquated concepts. Moreover, the identification of alternatives does not include building new generation facilities, efficiency, or integrated management of supply and demand.

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[120] NRC, *2013 GEIS*.

[121] NRC, 1996 Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437) (Washington, DC: Nuclear Regulatory Commission, 1996), 8-1.

[122] NRC, *2013 GEIS*, Section 2 is entitled "The Alternatives including the Proposed Action." The first 16 pages define the criteria by which the alternatives will be evaluated. The final teen pages present a tabular summary of the findings and the bibliography. The middle 17 pages evaluate all the alternatives considered.

Ironically, the NRC suggests that the fact that PG&E is asking for the license renewal ten years in advance is a matter of necessity and routine.[123] This suggests that it takes as long to implement the steps necessary to extend the life of a nuclear reactor as it does to build a new one. Thus, aging reactors suffer from the same drawback that was demonstrated for new reactors in the earlier discussion. They are a very bad investment in a dynamic environment. An erroneous decision to approve the license extension under these circumstances imposes direct and immediate harm on consumers. It reinforces the utility's incentive and ability to resist the superior economic options that have become available, frustrating the transformation of the utility sector.

The Diablo Canyon Application

Q. How does the Diablo Canyon Applications reflect these flaws?

A. The harm of failing to give proper guidance to utilities can be seen clearly in the PG&E application for a license renewal for Diablo Canyon. PG&E continued to apply the standard from the 1996 GEIS. PG&E repeatedly citing the old standard to "disqualify" alternatives. [124] PG&E's

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[123] NRC, *2013 GEIS*, 1-3. Most utilities are expected to begin preparation for license renewal about 10 to 20 years before expiration of their current operating licenses. Inspection, surveillance, test, and maintenance programs to support continued plant operations during the license renewal term would be integrated gradually over a period of years. Any refurbishment-type activities undertaken for the purposes of license renewal have generally been completed during normal plant refueling or maintenance outages before the original license expires.

[124] PG&E, 2015, 7.2-7–7.2-14. This section identifies *standalone* alternatives that PG&E deemed unreasonable, and the bases for these determinations. PG&E accounted for the fact that DCPP provides baseload generation and that any feasible alternative to DCPP would also need to be able to provide baseload power. In performing this evaluation, PG&E relied heavily upon NRC's GElS. 7-2.7, *There may be insufficient operational flexibilities to both meet those renewable power requirements and replace DCPP baseload capacity with wind, solar, and geothermal generation.* Because the power output can only be intermittently generated during the day or during certain seasons, depending on the location, wind turbines are unsuitable for baseload applications. *Wind generation* – therefore, wind generation cannot be considered an adequate replacement of DCPP generation *absent sufficient energy storage to overcome wind's intermittency. Besides pumped-storage hydroelectricity, Compressed Air Energy Storage (CAES) is the technology most suited for storage of large amounts of energy; however, no combination of wind and CAES has yet been proposed at the scale necessary to replace DCPP generation. (7-2.8)* Because solar thermal power is not available 24 hours per day, it is typically not acceptable for baseload applications *absent sufficient energy storage to*

focus on “standalone” energy sources reflects two unsupported biases—one toward reliance on “baseload” generation by a single source, and another toward “utility-scale” generation.

To appreciate why these developments, deserve much more consideration than PG&E gave them, one need only compare PG&E’s Amended Environmental Report with the California Energy Commission’s documents. PG&E rejects the option of geothermal energy based on the assumption that a single new geothermal plant would have to be built in PG&E’s service territory.[125] Conservatively assuming that the PG&E service territory includes half the geothermal resources in the state, geothermal resources are twice as large as Diablo Canyon capacity. Efficiency, renewables, and distributed generation potential are also about twice the size of Diablo Canyon.[126]

Adding in efficiency and other renewable resources, the alternative energy capacity would be four times the capacity of Diablo Canyon. Three-quarters of this capacity (geothermal and efficiency) is not variable, meaning that the 24-hour energy supply provided by Diablo Canyon could be replaced three times. Adding in renewables with storage would increase 24-hour availability of capacity to 3.5 times the capacity of Diablo Canyon. As discussed above, the ability of a well-managed 21st-century electricity grid that actively integrates supply and demand to deliver reliable power (while relying on renewable generation at much higher levels of penetration than would be necessary should Diablo Canyon retire) has been clearly illustrated.

Because PG&E is so focused on disqualifying alternatives based on the erroneous standard of “sufficient, single resource baseload power,” it fails to conduct a responsible analysis of its own data. For example, in updating the Environmental Report from 2010 to 2015, PG&E

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overcome solar's intermittency... As noted above, besides pumped-storage hydroelectricity, CAES is the technology most suited for storage of large amounts of energy; however, no combination of CSP and CAES has yet been proposed at the scale necessary to replace DCPP generation. 7-2.9, While development of battery storage options is ongoing, none are currently available in quantities or capacities that would provide baseload amounts of power. In light of the large contribution of solar PV to potential OG in PG&E service area and limitations on its use as baseload capacity, DG cannot serve as a *reasonable alternative to the baseload generation of DCPP. 7-2.11,* Geothermal plants offer base load capacity similar to DCPP, but it is unlikely to be available *within PG&E's service area* on the scale required to replace the capacity of DCPP. 7-2.12

[125] PG&E, Diablo Canyon Environmental Report, PG&E, 2015, 7.2-12.

[126] PG&E, Diablo Canyon Amended Environmental Report, PG&E, 2014, 7.2-6, 7.2-11, 7.2-12.

provides data to show that a dramatic transformation of the sector is well under way. This trend includes reduced energy demand, greater capacity for managing demand, and greater reserve margins than existed even ten years ago.[127] The dramatic decrease in demand and sharp increase in reserve margins between 2008 and 2014 suggests that there is a lot more leeway to retire large, costly, inflexible reactors like those at Diablo Canyon. The reduction in projected peak demand in a mere six years equals almost twice the total output of Diablo Canyon.

PG&E's analysis of the supply-side of the California electricity sector also obscures a simple fact: non-hydro renewables (i.e., wind and solar) have increased dramatically and are poised to surpass nuclear generation (which has been in decline) in the state. PG&E's analysis is also fundamentally weakened because it fails to recognize the dramatic development in battery technology that has been occurring over the past several years. Instead, PG&E focuses on pumped storage and compressed air. PG&E's failure to address battery technology is particularly egregious in light of the fact that many analysts conclude that batteries will play a key role in the transformation of the electricity system. Declining costs of batteries are a key driver, as discussed, but so too is the increasing array of new technologies and applications, not to mention the additional critical and valuable functions they provide with increasing renewable penetration.

Finally, PG&E makes the argument that Diablo Canyon is needed to reduce carbon emissions.[128] But PG&E relies on the results of a dated, 2009 EPRI analysis and makes no effort to consider its relevance to the current market situation. When change takes place as rapidly as it has in the present electricity sector, half a decade is a long time. In 2009, EPRI may well have still been under the spell of the "nuclear renaissance." The challenge of building 45 nuclear reactors in less than three decades in a nation that has brought one online in the past two decades at an astronomical cost, suggests the utter impossibility of this scenario. More importantly, that scenario is not the only approach to reaching climate change goals. Since 2008, the wind and solar capacity brought online in the United States has increased its total sat more than twice that

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[127] PG&E, Diablo Canyon Environmental Report, 7.2-1.

[128] PG&E, Diablo Canyon Environmental Report, 7.2-2, Finally, overlaying these concerns about the alternative generation technologies are federal and state greenhouse gas emissions reduction goals. According to EPRI, even while adding renewable capacity equal to 4 times today's wind and solar capacity in 2008, the United States would need to maintain all of its current nuclear capacity, and add 45 more nuclear facilities, to meet greenhouse gas emissions reduction goals.

rate, storage dramatically increased the duty cycle of solar and demand grew well below the historical rate, all of which dramatically cut the need for nuclear power.

The recent analysis from the Department of Energy suggested that a simple projection of recent wind deployments would not only cover the shortfall but retire a substantial part of the aging nuclear fleet. PG&E was wrong then and they are even more wrong today. There is less reason to extend the life of Diablo Canyon today than there was when they agreed to shut it down. Given the ability of CAISO to cope with demanding conditions in the past and the likelihood that that capacity will increase if nuclear power does not get in the way, there is no reason to subsidize the continued existence of Diablo Canyon.

D. CONCLUSION

Using Information to Improve Decision Making Risk-Aware Cost Estimates:

Q. Describe alternative approaches to evaluating resource options.

A. As I suggested in Chapter 1, policy makers cannot afford to "suspend disbelief" and hope for cost trends that are not supported (even contradicted) by the historical record. When it comes to price projections, they must deal with uncertainty. A systematic approach that I have advocated has been available in the electricity space for quite some time. It involves calculating "risk-aware" prices that reflect the uncertainty of estimates. Earlier I showed that the near-term uncertainty and price estimates did not contradict the long-term estimate. Because the discussion is clearly long-term and there is no conflict between the short- and long-term conclusions, Attachment MNC-6.3 presents a "risk-aware" estimate of long-term costs.

Risk is measured by the standard deviation of the estimates and the risk aware value is calculated as the Euclidian distance from the origin.[129] The higher the number the higher the risk-aware estimate of cost. I continue to use the estimate for geothermal without NREL, as discussed in chapter 2. However, I included an estimate for Biomass, which Lazard dropped after

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[129] The methodology is described in Cooper, Mark, 2013, "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. The others continued to conclude biomass and nuclear even though there is no ongoing construction of these facilities (according to EIA, which ignores Vogtle and Nuscale). I also include Lazard's estimate of the cost of gas combined cycle with carbon capture as discussed in Chapter 2. Aging reactors do not enter into the long-term analysis, which is based on new builds.

The message from the calculation of risk-aware cost estimates is that there is a set of resources (renewables, i.e., wind, solar and hybrid (solar +batteries) and efficiency) that is much lower. As shown in MNC-6.3, efficiency could be considered part of the low-cost technology in group 2, since it definitely a firm resource. Geothermal with the lower cost estimate is on the border between low-cost group 2 and group 1. The estimates for nuclear, large or small, are much higher. In the long term, even small modular reactors are 2-3 times more costly, while large reactors are 3-4 times more costly. The long-term cost sends a clear message on where the cost to society will be lowest.

Ranking on Multiple Criteria

Another way to view the results in the earlier chapters is to consider the relative ranking of the alternatives. The measures of cost are used to rank the options (see Attachment MNC-6.4). While I have not ranked all the options on each of the dimensions, we do have a ranking for at least three of the four criteria. Since we have not calculated the cost for all options, we compute the average on the basis of those we have estimated. The results follow the earlier discussion. Efficiency and the renewables stand out as the preferable way to meet the need for electricity. They are, in essence, a low marginal cost "baseload" resource. have low marginal cost and very low firming costs. Wind onshore and solar are both low compared to the traditional alternatives.

Spending the money on other things

Another simple way to assess the situation would be to ask what else (other than a subsidy for old nuclear reactors could we buy for the money being offered nuclear (in this case $1.4 billion from the state, but additional tax benefits from the federal income taxes could raise the total to $2,5 billion). We could weatherize about a quarter of a million homes. The foregone benefit depends on how the money is spread out (see Attachment MNC-6.5). In the attachment, I have used two scenarios (reliance on the pure subsidy, i.e., no contribution to capital, or one-half capital contributed by the owner. I use three approaches which are near term (less than 3 years) and appear to be available and attractive, technologically and economically, based upon the Lazard's firming analysis without long duration storage. Since the CEC does not project a shortfall in that period, the build-up of resources from these three strategies appears to be good insurance against a future problem. The important point is that these alternative investments are long-term and the quicker they are built the better.

E. RECOMMENDATIONS

1. The PUC should not allow PG&E to change its mind and operate the reactor, even though the legislature is throwing money at it.

2. If the PUC cannot follow the first course of action, no matter the reason, it should not allow the utility to collect rates from ratepayers. If the utility wants to operate the reactors for the sums offered by state and federal taxpayers, it can do so, but at no cost to ratepayers.

3. If the PUC cannot follow the second course, no matter the reason, it can impose market discipline. It should require the reactor to accept only the market clearing price for its output, at the relevant time of day. Needless to say, there will be times when that price is zero.

4. If the PUC finds it necessary to curtail output, the first place it should look is the nuclear reactors, which are higher in cost, unsuited for the operation of the new system and disruptive of the transformation of the system.

5. If the PUC cannot force the nuclear reactor to bear the burden of curtailments, it should, subject them to a market test by allowing resources to compete for operation at the lowest price,

6. If the PUC is unable to impose a market test for curtailments, for whatever reason, it should allocate the curtailments in proportion to the share of generation.

7. Regardless of the pricing and operating arrangement, the PUC should insist that the reactor remains online for only the five-year period defined by the subsidy.

The conditions imposed on the operation of the aging reactors may seem "onerous", but they are not vindictive. They represent the fundamental principles of the PUC, prudent and least costs at the core of the PUC's mission and are driven by the policy of promoting the transition to a 21st century electricity system.

ATTACHMENT A

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PROFESSIONAL EXPERIENCE:

President, Citizens Research, 1983 - present
Research Director, Consumer Federation of America, 1983-present
Senior Fellow for Economic Analysis, Institute for Energy and the Environment, Vermont Law School 2009-present
Associated Fellow, Columbia Institute on Tele-Information, 2003-2016
Fellow, Donald McGannon Communications Research Center, Fordham University, 2005-2015
Fellow, Silicon Flatirons, University of Colorado, 2009-2014
Fellow, Stanford Center on Internet and Society, 2000-2010
Principle Investigator, Consumer Energy Council of America, Electricity Forum, 1985-1994
Director of Energy, Consumer Federation of America, 1984-1986
Director of Research, Consumer Energy Council of America, 1980-1983
Consultant, Office of Policy Planning and Evaluation, Food and Nutrition Service, United States Department of Agriculture, 1981-1984
Consultant, Advanced Technology, Inc., 1981
Technical Manager, Economic Analysis and Social Experimentation Division, Applied Management Sciences, 1979
Research Associate, American Research Center in Egypt, 1976-1977
Research Fellow, American University in Cairo, 1976
Staff Associate, Checchi and Company, Washington, D.C., 1974-1976
Consultant, Division of Architectural Research, National Bureau of Standards, 1974
Consultant, Voice of America, 1974
Research Assistant, University of Maryland, 1972-1974

TEACHING EXPERIENCE:

Lecturer, Washington College of Law, American University, Spring, 1984 - 1986, Seminar in Public Utility Regulation
Guest Lecturer, University of Maryland, 1981-82, Energy and the Consumer, American University, 1982, Energy Policy Analysis
Assistant Professor, Northeastern University, Department of Sociology, 1978-1979, Sociology of Business and Industry, Political Economy of Underdevelopment, Introductory Sociology, Contemporary Sociological Theory; College of Business Administration, 1979, Business and Society
Assistant Instructor, Yale University, Department of Sociology, 1977, Class, Status and Power
Teaching Assistant, Yale University, Department of Sociology, 1975-1976, Methods of Sociological Research, The Individual and Society
Instructor, University of Maryland, Department of Sociology, 1974, Social Change and Modernization, Ethnic Minorities

Instructor, U.S. Army Interrogator/Linguist Training School, Fort Hood, Texas, 1970-1971

PROFESSIONAL ACTIVITIES:

Member, Advisory Committee on Appliance Efficiency Standards, U.S. Department of Energy, 1996 - 1998

Member, Energy Conservation Advisory Panel, Office of Technology Assessment, 1990-1991

Fellow, Council on Economic Regulation, 1989-1990

Member, Increased Competition in the Electric Power Industry Advisory Panel, Office of Technology Assessment, 1989

Participant, National Regulatory Conference, The Duty to Serve in a Changing Regulatory Environment, William and Mary, May 26, 1988

Member, Subcommittee on Finance, Tennessee Valley Authority Advisory Panel of the Southern States Energy Board, 1986-1987

Member, Electric Utility Generation Technology Advisory Panel, Office of Technology Assessment, 1984 - 1985

Member, Natural Gas Availability Advisor Panel, Office of Technology Assessment, 1983-1984

Participant, Workshop on Energy and the Consumer, University of Virginia, November 1983

Participant, Workshop on Unconventional Natural Gas, Office of Technology Assessment, July 1983

Participant, Seminar on Alaskan Oil Exports, Congressional Research Service, June 1983

Member, Thermal Insulation Subcommittee, National Institute of Building Sciences, 1981-1982

Round Table Discussion Leader, The Energy Situation: An Open Field For Sociological Analysis, 51st Annual Meeting of the Eastern Sociological Society, New York, March, 1981

Member, Building Energy Performance Standards Project Committee, Implementation Regulations Subcommittee, National Institute of Building Sciences, 1980-1981

Participant, Summer Study on Energy Efficient Buildings, American Council for an Energy Efficient Economy, August 1980

Member, University Committee on International Student Policy, Northeastern University, 1978-1979

Chairman, Session on Dissent and Societal Reaction, 45th Annual Meeting of the Eastern Sociological Society, April, 1975

Member, Papers Committee, 45th Annual Meeting of the Eastern Sociological Society, 1975

Student Representative, Programs, Curricula and Courses Committee, Division of Behavioral and Social Sciences, University of Maryland, 1973-1974

President, Graduate Student Organization, Department of Sociology, University of Maryland, 1973-1974

HONORS AND AWARDS:

Ester Peterson Award for Consumer Service, 2010

American Sociological Association, Travel Grant, Uppsala, Sweden, 1978

Fulbright-Hayes Doctoral Research Abroad Fellowship, Egypt, 1976-1977

Council on West European Studies Fellowship, University of Grenoble, France, 1975

Yale University Fellowship, 1974-1978

Alpha Kappa Delta, Sociological Honorary Society, 1973

Phi Delta Kappa, International Honorary Society, 1973

Graduate Student Paper Award, District of Columbia Sociological Society, 1973

Science Fiction Short Story Award, University of Maryland, 1973

Maxwell D. Taylor Award for Academic Excellence, Arabic, United States Defense Language Institute, 1971

Theodore Goodman Memorial Award for Creative Writing, City College of New York, 1968

New York State Regents Scholarship, 1963-1968

National Merit Scholarship, Honorable Mention, 1963

PUBLICATIONS:

ENERGY

Books and Chapters

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

"Energy Justice in Theory and Practice: Building a Pragmatic, Progressive Road Map," in Thijs de Graf, Benjamin K. Sovacool, Arunabha Gosh, Florian Kern, and Michael T. Klare (Eds.) *The Palgrave Handbook of the International Political Economy of Energy,* (PALGRAVE, Macmillan, 2016)

"Recognizing the Limits of Markets, Rediscovering Public Interest in Utilities," in Robert E. Willett (ed), *Electric and Natural Gas Business: Understanding It*! (2003 and Beyond) (Houston: Financial Communications: 2003)

"Protecting the Public Interest in the Transition to Competition in Network Industries," The Electric Utility Industry in Transition (Public Utilities Reports, Inc. & the New York State Energy Research and Development Authority, 1994)

"The Seven Percent Solution: Energy Prices, Energy Policy and the Economic Collapse of the 1970s," in *Energy Concerns and American Families in the 1980s* (Washington, D.C.: The American Association of University Women Educational Foundation, 1983)

"Natural Gas Policy Analysis," in Edward Mitchell (Ed.), Natural Gas Pricing Policy (Washington, D.C.: American Enterprise Institute, 1983)

Equity and Energy: Rising Energy Prices and the Living Standard of Lower Income Americans (Boulder, Colorado: Westview Press, 1983)

Articles and 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.

"Renewable and distributed resources in a post-Paris low carbon future: The key role and political economy of sustainable electricity," *Energy Research & Social Science,* 19 (2016) 66-93.

"The Unavoidable Economics of Nuclear Power." *Corporate Knights*, January 22, 2014.

Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California.Presentation at the California Energy Commission's Energy Academy, February 20, 2014.

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

"The EPA carbon plan: Coal loses, but nuclear doesn't win," *Bulletin of the Atomic Scientists,* 70, 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, 67, 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

"The Failure of Federal Authorities to Protect American Energy Consumers From Market Power and Other Abusive Practices," *Loyola Consumer Law Review,* 19:4 (2007)

"Too Much Deregulation or Not Enough," *Natural Gas and Electricity*, June 2005

"Real Energy Crisis is $200 Billion Natural Gas Price Increase," Natural Gas and Electricity, August 2004

"Regulators Should Regain Control to Prevent Abuses During Scarcity," Natural Gas, August 2003

"Economics of Power: Heading for the Exits, Deregulated Electricity Markets Not Working Well," *Natural Gas*, 19:5, December 2002

"Let's Go Back," Public Power, November-December 2002

"Conceptualizing and Measuring the Burden of High Energy Prices," in Hans Landsberg (Ed.), High Energy Costs: Assessing the Burden (Washington, D.C.: Resources For the Future, 1982)

"Energy Efficiency Investments in Single Family Residences: A Conceptualization of Market Inhibitors," in Jeffrey Harris and Jack Hollander (Eds.), *Improving Energy Efficiency in Buildings: Progress and Problems* (American Council for An Energy Efficient Economy, 1982)

"Policy Packaging for Energy Conservation: Creating and Assessing Policy Packages," in Jeffrey Harris and Jack Hollander (Eds.), *Improving Energy Efficiency in Buildings: Progress and Problems* (American Council for An Energy Efficient Economy, 1982)

"The Role of Consumer Assurance in the Adoption of Solar Technologies," *International Conference on Consumer Behavior and Energy Policy,* August, 1982

"Energy and the Poor," *Third International Forum on the Human Side of Energy*, August, 1982

"Energy Price Policy and the Elderly," *Annual Conference, National Council on the Aging*, April, 1982

"Energy and Jobs: The Conservation Path to Fuller Employment," *Conference on Energy and Jobs conducted by the Industrial Union Department of the AFL-CIO,* May 1980

Research Reports

Building A Least Cost, Low-Carbon, Electricity System With Efficiency, Wind, Solar & Intelligent Grid Management: Why Nuclear Subsidies Are An Unnecessary Threat To The Transformation (Friends of the Earth, July 15, 2021

Building A 21st Century Electricity Sector With Efficiency, Distributed Resources And Dynamic Management:: The Consumer, Economic, Public Health And Environmental Benefit, (with Mel Hall-Crawford (Consumer Federation of America) April 22, 2021.

The Green New Deal Can Build a Progressive, Capitalist, Low Cost, Low Carbon, Electricity Sector, If it Avoids the Nuclear Power and Fossil Fuel Potholes Along the Way, April 2019. *Institute for Energy and the Environment,* Vt Law School.

Avoiding Nuclear and Fossil Fuel Potholes, A Green New Deal Has a Clear Path to a Clean, Low Cost, Low Carbon, Progressive, Capitalist Electricity Sector, Institute for Energy and the Environment, April 2019

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

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.

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

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, Institute For Energy And The Environment, Vermont Law School, July 2013.

Energy Efficiency Performance Standards: The Cornerstone of Consumer-Friendly Energy Policy, October 2013

The Zero Emissions Vehicle Program: Clean Cars States Lead in Innovation,October 24, 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

Capturing The Value Of Offshore Wind. Mainstream Renewable Power, October 2012.

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

U.S. Oil Market Fundamentals and Public Opinion, Consumer Federation of America, May 2010

Building on the Success of Energy Efficiency Programs to Ensure an Affordable Energy Future, Consumer Federation of America, February 2010

The Impact of Maximizing Energy Efficiency on Residential Electricity and Natural Gas Utility Bills in a Carbon-Constrained Environment: Estimates of National and State-By-State Consumer Savings,Consumer Federation of America November 2009

Shifting Fuel Economy Standards into High Gear, Consumer Federation of America, November 24, 2009

A Consumer Analysis of Energy Efficiency and Renewable Energy Standards: The Cornerstone of Consumer-Friendly Energy/Environmental Policy, Consumer Federation of America, May 2009

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

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

A Consumer Analysis of the Adoption of the California Clean Cars Program in Other States: Florida, Consumer Federation of America, November 2008

A Boom for Big Oil – A Bust for Consumers: Ana analysis of Policies to Meet American Energy Needs, Consumer Federation of America, September 2008

Climate Change and the Electricity Consumer: Background Analysis to Support a Policy Dialogue, Consumer Federation of America, June 2008

Ending America's Oil Addiction: A Quarterly Report on Consumption, Prices and Imports, Consumer Federation of America, April 2008

A Consumer Analysis of the Adoption of the California Clean Cars Program in Other States: Arizona, Consumer Federation of America, March 2008

A Step Toward A Brighter Energy Future, Consumer Federation of America, December 2007

A Consumer Analysis of the Adoption of the California Clean Cars Program in Other States: New Mexico, Consumer Federation of America, November 2007

Not Time to Waste: America's Energy Situation Is Dangerous, But Congress Can Adopt New Policies to Secure Our Future, Consumer Federation of America, October 2007

Technology, Cost and Timing, Consumer Federation of America, July 2007

Florida's Stake in the Fuel Economy Battle, July 2007

Big Oil v. Ethanol, Consumer Federation of America, July 2007

Too Little, Too Late: Why the Auto Industry Proposal To Go Low and Slow on Fuel Economy Improvements Is Not in the Consumer or National Interest, Consumer Federation of America, July 2007

The Senate Commerce Committee Bill Is Much Better For Consumers and The Nation Than the Automobile Industry Proposal, Consumer Federation of America, June 2007

Rural Households Benefit More From Increases In Fuel Economy, Consumer Federation of America, June 207

A Consumer Pocketbook And National Cost-Benefit Analysis of "10 in10", Consumer Federation of America, June 2007

Time to Change the Record on Oil Policy, Consumer Federation of America, August 2006

50 by 2030: Why $3.00 Gasoline Makes the 50-Miles Per Gallon Car Feasible, Affordable and Economic, Consumer Federation of America, (May 2006)

The Role of Supply, Demand, Industry Behavior and Financial Markets in the Gasoline Price Spiral (Prepared for Wisconsin Attorney General Peggy A. Lautenslager, May 2006)

Debunking Oil Industry Myths and Deception: The $100 Billion Consumer Rip-Off (Consumer Federation of America and Consumers Union, May 3, 2006)

The Role of Supply, Demand and Financial Markets in the Natural Gas Price Spiral (prepared for the Midwest Attorneys General Natural Gas Working Group: Illinois, Iowa, Missouri, Wisconsin, March 2006)

The Impact of Rising Prices on Household Gasoline Expenditures (Consumer Federation of America, September 2005)

Responding to Turmoil in Natural Gas Markets: The Consumer Case for Aggressive Policies to Balance Supply and Demand (consumer Federation of America, December 2004)

Record Prices, Record Oil Company Profits: The Failure Of Antitrust Enforcement To Protect American Energy Consumers (Consumer Federation of America, Consumers Union, September 2004)

Fueling Profits: Industry Consolidation, Excess Profits, & Federal Neglect: Domestic Causes of Recent Gasoline and Natural Gas Price Shocks (Consumer Federation of America and Consumers Union, May 2004)

Spring Break in the U.S. Oil Industry: Price Spikes, Excess Profits and Excuses (Consumer Federation of America, October 2003)

How Electricity Deregulation Puts Pressure On The Transmission Network And Increases It's Cost (Consumer Federation of America, Consumers Union and U.S. PIRG, August 2003)

A Discouraging Word (or Two, or Three, or Four) About Electricity Restructuring in Texas, Pennsylvania, New England and Elsewhere Consumer Federation of America, U.S. Public Interest Research Group and Consumers Union, March 2003)

All Pain, No Gain: Restructuring and Deregulation in the Interstate Electricity Market (Consumer Federation of America, September 2002)

U.S. Capitalism and the Public Interest: Restoring the Balance in Electricity and Telecommunications Markets (Consumer Federation of America, August 2002)

Electricity Deregulation and Consumers: Lesson from a Hot Spring and a Cool Summer (Consumer Federation of America, August 30, 2001)

Ending the Gasoline Price Spiral: Market Fundamentals for Consumer-Friendly Policies to Stop the Wild Ride (Consumer Federation of America, July 2001)

Analysis of Economic Justifications and Implications of Taxing Windfall Profits in the California Wholesale Electricity Market (Consumer Federation of America and Consumers Union, June 13, 2001)

Behind The Headlines Of Electricity Restructuring A Story Of Greed, Irresponsibility And Mismanagement Of A Vital Service In A Vulnerable Market (Consumer Federation of America, March 20, 2001)

Reconsidering Electricity Restructuring: Do Market Problems Indicate a Short Circuit or a Total Blackout? (Consumer Federation of America, November 30. 2000)

Mergers and Open Access to Transmission in the Restructuring Electric Industry (Consumer Federation of America, April 2000)

Electricity Restructuring and the Price Spikes of 1998 (Consumer Federation of America and Consumers Union, June 1999)

The Residential Ratepayer Economics of Electric Utility Restructuring (Consumer Federation of America, July 1998)

Consumer Issues in Electric Utility Restructuring (Consumer Federation of America, February 12, 1998)

A Consumer Issue Paper on Electric Utility Restructuring (American Association of Retired Persons and the Consumer Federation of America, January, 1997)

Transportation, Energy, and the Environment: Balancing Goals and Identifying Policies, August 1995

A Residential Consumer View of Bypass of Natural Gas Local Distribution Companies, February 1988

The National Energy Security Policy Debate After the Collapse of Cartel Pricing: A Consumer Perspective, January 1987

The Energy, Economic and Tax Effects of Oil Import Fees, October 25, 1985

The Bigger the Better: The Public Interest in Building a Larger Strategic Petroleum Reserve, June 12, 1984

The Consumer Economics of CWIP: A Short Circuit for American Pocketbooks, April, 1984

Public Preference in Hydro Power Relicensing: The Consumer Interest in Competition, April 1984

Concept Paper for a Non-profit, Community-based, Energy Services Company, November 1983

The Consumer and Energy Impacts of Oil Exports, April 1983

Up Against the Consumption Wall: The Impact of Rising Energy Prices on Lower Income Consumers, March 1983

A Decade of Despair: Rising Energy Prices and the Living Standards of Lower Income Americans, September 1982

The Impact of Rising Energy Prices on the Delivery of Public Service by Local Governments, August 1982

The Impact of Rising Energy Prices on the Low-Income Population of the Nation, the South, and the Gulf Coast Region, July, 1982

A Comprehensive Analysis of the Impact of a Crude Oil Import Fee: Dismantling a Trojan Horse, April 1982

The Past as Prologue II: The Macroeconomic Impacts of Rising Energy prices, A Comparison of Crude Oil Decontrol and Natural Gas Deregulation, March, 1982

The Past as Prologue I: The Underestimation of Price Increases in the Decontrol Debate, A Comparison of Oil and Natural Gas, February 1982

Oil Price Decontrol and the Poor: A Social Policy Failure, February 1982

Natural Gas Decontrol: A Case of Trickle-Up Economics, January 1982

A Comprehensive Analysis of the Costs and Benefits of Low-Income Weatherization and Its Potential Relationship to Low Income Energy Assistance, June 1981

Summary of Market Inhibitors, February 1981

Program Models and Program Management Procedures for the Department of Energy's Solar Consumer Assurance Network Project: A Rapid Feedback Evaluation, February 1981

An Analysis of the Economics of Fuel Switching Versus Conservation for the Residential Heating Oil Consumer, October 1980

Energy Conservation in New Buildings: A Critique and Alternative Approach to the Department of Energy's Building Energy Performance Standards, April, 1980

The Basics of BEPS: A Descriptive Summary of the Major Elements of the Department of Energy's Building Energy Performance Standards, February, 1980

COMMUNICATIONS AND MEDIA

Books and Chapters

“The Future of Journalism: Addressing Pervasive Market Failure with Public Policy,” in R.W. McChesney and Victor Picard (eds.), Will the Last Reporter Turn out the Lights (New York: New Press, 2011)

“Broadband in America: A Policy of Neglect is not Benign,” in Enrico Ferro, Yogesh K. Dwivedi, J. Ramon Gil-Garcia, and Michael D. Williams, Eds., *Overcoming Digital Divides: Constructing an Equitable and Competitive Information Society,”* IGI Global Press, 2009.

“Political Action and Internet Organization:An Internet-Based Engagement Model,” in Todd Davies and Seeta Pena Gangaharian, Eds., *Online Deliberation: Design, Research and Practice,* CSLI press.

“When Counting Counts: Marrying Advocacy and Academics in the Media Ownership Research Wars at the FCC,” forthcoming in Lynn M. Harter, Mohan J. Dutta, and Courtney Cole, Eds., *Communicating for Social Impact: Engaging Communication Theory, Research, and Pedagogy***,** Hampton Press.

The Case Against Media Consolidation (Donald McGannon Communications Research Center, 2007)

Open Architecture as Communications Policy (Stanford Law School, Center for Internet and Society: 2004)

Media Ownership and Democracy in the Digital Information Age: Promoting Diversity with First Amendment Principles and Rigorous Market Structure Analysis (Stanford Law School, Center for Internet and Society: 2003)

Cable Mergers and Monopolies: Market Power In Digital Media and Communications Networks (Washington, D.C.: Economic Policy Institute, 2002)

"When Law and Social Science Go Hand in Glove: Usage and Importance of Local and National News Sources, Critical Questions and Answers for Media Market Analysis,"forthcoming in, Philip Napoli, Ed. *Media Diversity and Localism: Meaning and Metrics, (*Lawrence Erlbaum, 2007)

"The Importance of Open Networks in Sustaining the Digital Revolution," in Thomas M. Lenard and Randolph J. May (Eds.) *Net Neutrality or Net Neutering*(New York, Springer, 2006)

"Reclaiming The First Amendment: Legal, Factual And Analytic Support For Limits On Media Ownership," Robert McChesney and Benn Scott (Eds), *The Future of Media* (Seven Stories Press, 2005)

"Building A Progressive Media And Communications Sector," Elliot Cohen (Ed.), News Incorporated: Corporate Media Ownership And Its Threat To Democracy (Prometheus Books, 2005)

"Hyper-Commercialism In The Media: The Threat To Journalism And Democratic Discourse," Snyder-Gasher-Compton-(Eds), *Converging Media, Diverging Politics: A Political Economy Of News In The United States And Canada*(Lexington Books, 2005)

"The Digital Divide Confronts the Telecommunications Act of 1996: Economic Reality versus Public Policy," in Benjamin M. Compaine (Ed.), *The Digital Divide: Facing a Crisis or Creating a Myth?* (Cambridge: MIT Press, 2001)

Articles and Papers:

"Business Data Services after the 1996 Act: Structure, Conduct, Performance in the Core of the Digital Communications Network The Failure of Potential Competition to Prevent Abuse of Market Power," Telecommunications Policy Research Conference, September, 2016.

with Gene Kimmelman, "Antitrust and Economic Regulation: Essential and Complementary Tools to Maximize Consumer Welfare and Freedom of Expression in the Digital Age," *Harvard Law & Policy Review* 9-2 (2015)

"The ICT Revolution in Historical Perspective: Progressive Capitalism as a Response to Free Market Fanaticism and Marxist Complaints in the Deployment Phase of the Digital Mode of Production." *Telecommunication Policy Research Conference Session on Innovation,* September 28, 2015.

"The Long History and Increasing Importance of Public Service Principles For 21st Century Public Digital Communications Networks," *Journal on Telecommunications and High Technology Law*, 2014

"From the Public Switched Telephone Network to the Public Digital Communications Network: Interconnection, Interoperability, Universal Service & Innovation at the Edge," *Interconnection Policy for the Internet Age, The Digital Broadband Migration: The Future of Internet-Enabled Innovation, Silicon Flatirons,* February 10-11, 2013

"Why Growing Up is Hard to Do: Institutional Challenges for Internet Governance in the "Quarter Life Crisis of the of the Digital Revolution," *Journal on Telecommunications and High Technology Law,* 2013. 11(1).

"Structured Viral Communications: The Political Economy and Social Organization of Digital Disintermediation," *Journal on High Telecommunications and High Technology Law,* 9:1, 2011.

"Crowd Sourcing Enforcement: Building a Platform for Participatory Regulation in the Digital Information Age," presentation at *The Digital Broadband Migration: The Dynamics of Disruptive Innovation*, *Silicon Flatirons Ctr*. Feb. 12, 2011

"The Central Role of Wireless in the 21st Century Communications Ecology: Adapting Spectrum and Universal Service Policy to the New Reality," *Telecommunications Policy Research Conference*, September 2011

"Round #1 in the Digital Intellectual Property Wars: Economic Fundamentals, Not Piracy, Explain How Consumers and Artists Won in the Music Sector," *Telecommunications Policy Research Conference,* September 2008.

"When The Market Does Not Reign Supreme: Localism And Diversity In U.S. Media Policy," *International Communications Association*, forthcoming, May 2008

"Minority Programming: Still at The Back of the Bus," *International Communications Association*, May 2008, with Adam Lynn

"Traditional Content Is Still King as the Source of Local News and Information," *International Communications Association*, forthcoming, May 2008

"Junk Science And Administrative Abuse In The Effort Of The FCC To Eliminate Limits On Media Concentration," *International Communications Association,* May 2008.

"Contentless Content Analysis: Flaws In The Methodology For Analyzing The Relationship Between Media Bias And Media Ownership," forthcoming, *International Communications Association,* May 2008.

"Network Neutrality," *Toll Roads? The Legal and Political Debate Over Network Neutrality,* University of San Francisco Law School, January 26, 2008

with Derek Turner, 2007, "The Negative Effect of Concentration and Vertical Integration on Diversity and Quality in Video Entertainment," Telecommunications Policy Research Conference, 2007

"The Lack of Racial and Gender Diversity in Broadcast Ownership and The Effects of FCC Policy: An Empirical Analysis," *Telecommunications Research Policy Conference*, September 2007, with Derek Turner

"New Media and Localism: Are Local Cable Channels and Locally Focused Websites Significant New and Diverse Sources of Local News and Information? An Empirical Analysis," *Telecommunications Research Policy Conference*, September 2007, with Adam Lynn

"A Case Study of Why Local Reporting Matters: Photojournalism Framing of the Response to Hurricane Katrina in Local and National Newspapers," *International Communications Association*, May 2007.

"Will the FCC Let Local Media Rise from the Ashes of Conglomerate Failure," *International Communications Association*, May 2007.

"The Failure of Federal Authorities to Protect American Energy Consumers From Market Power and Other Abusive Practices," *Loyola Consumer Law Review,* 19:4 (2007)

"The Central Role of Network Neutrality in the Internet Revolution," *Public Interest Advocacy Center*, Ottawa Canada, November 24, 2006

"Governing the Spectrum Commons," September 2006. *Telecommunications Policy Research Conference*, October 2006

"Accessing the Knowledge Commons in the Digital Information Age," *Consumer Policy Review,* May/June 2006

"Independent, Non-Commercial Video," *Beyond Broadcast,*Berkman Center, Harvard University, May 12, 2006

"Defining Appropriation Right in the Knowledge Commons of the Digital Information Age: Rebalancing the Role of Private Incentives and Public Circulation in Granting Intellectual Monopoly Privileges," *Legal Battle Over Fair Use, Copyright, and Intellectual Property,* March 25, 2006

"The Economics of Collaborative Production: A Framework for Analyzing the Emerging Mode of Digital Production," *The Economics of Open Content: A Commercial Noncommercial Forum,*MIT January 23, 2006

"From Wifi to Wikis and Open Source: The Political Economy of Collaborative Production in the Digital Information Age," *Journal on Telecommunications and High Technology Law,* 5:1, 2006

"Information is a Public Good," *Extending the Information Society to All: Enabling Environments, Investment and Innovation, World Summit on the Information Society,* Tunis, November 2005

"The Importance of Collateral Communications and Deliberative Discourse in Building Internet-Based Media Reform Movements," *Online Deliberation: Design, Research and Practice/DIAC,* November, 2005

"Collaborative Production in Group-Forming Networks: The 21st Century Mode of Information Production and the Telecommunications Policies Necessary to Promote It," *The State of Telecom: Taking Stock and Looking Ahead*, Columbia Institute on Tele-Information, October 2005

"The Economics of Collaborative Production in the Spectrum Commons," *IEEE Symposium on New Frontiers in Dynamic Spectrum Access Networks,* November 2005

"Independent Noncommercial Television: Technological, Economic and Social Bases of A New Model of Video Production," *Telecommunications Policy Research Conference,* October 2005

"Spectrum as Speech in the 21st Century," *The Public Airwaves as a Common Asset and a Public Good: Implications for the Future of Broadcasting and Community Development in the U.S.,* Ford foundation, March 11, 2005

"When Law and Social Science Go Hand in Glove: Usage and Importance of Local and National News Sources, Critical Questions and Answers for Media Market Analysis,Telecommunications Policy Research Conference, October 2004

"Dividing the Nation, Digitally: When a Policy Of Neglect is Not Benign," *The Impact of the Digital Divide on Management and Policy: Determinants and Implications of Unequal Access to Information Technology,*Carlson School of Management, University of Minnesota, August 28, 2004.

"Limits on Media Ownership are Essential," *Television Quarterly,*Spring Summer 2004

"Applying the Structure, Conduct Performance Paradigm of Industrial Organization to the Forum for Democratic Discourse," *Media Diversity and Localism, Meaning, Metrics and Public Interest, Donald* McGannon Communications Research Center, Fordham University, December 2003

"Cable Market Power, Pricing And Bundling After The Telecommunications Act Of 1996: Explorations Of Anti-Consumer, Anticompetitive Practices," *Cable TV Rates: Has Deregulation Failed?,* Manhattan Institute, November 2003

"Hope And Hype Vs. Reality: The Role Of The Commercial Internet In Democratic Discourse And Prospects For Institutional Change," *Telecommunication Policy Research Conference,* September 21, 2003

"Ten Principles For Managing The Transition To Competition In Local Telecommunications Markets, *Triennial Review Technical Workshop National Association of Regulatory Utility Commissioners,* Denver CO, July 27, 2003

"Universal Service: A Constantly Expanding Goal," *Consumer Perspectives on Universal Service: Do Americans Lose Under a Connection-based Approach?* (Washington, D.C.: New Millennium Research Council, June 2003)

"The Evidence Is Overwhelming: Diversity, Localism And The Public Interest Are The Victims Of Concentration, Conglomeration And Consolidation Of The Commercial Mass Media Concentration And Local Markets," The Information Policy Institute and The Columbia Institute On Tele-Information The National Press Club, Washington, DC, March 11, 2003

"Loss Of Diversity, Localism And Independent Voices Harms The Public Interest: Some Recent Examples," *The Information Policy Institute and The Columbia Institute On Tele-Information* The National Press Club, Washington, DC, March 11, 2003

"Open Communications in Open Economies and Open Societies: Public Interest Obligations are Vital in the Digital Information Age," *Convergence: Broadband Policy and Regulation Issues for New Media Businesses in the New Millennium* Georgetown University Law Center, Advanced Computer and Internet Law Institute March 5, 2003.

"The Political Economy Of Spectrum Policy: Unlicensed Use Wins Both The Political (Freedom Of Speech) And Economic (Efficiency) Arguments," *Spectrum Policy: Property Or Commons?* Stanford Law School, March 1, 2003

"What's 'New" About Telecommunications in the 21st Century Economy: Not Enough to Abandon Traditional 20th century Public Interest Values" *Models of Regulation For the New Economy*, University of Colorado School of Law, February 1, 2003

"Comments on *Broadband: Bringing Home the Bits,Columbia Institute for Tele-Information,* March 18, 2002

"Fair Use and Innovation First, Litigation Later: Why digitally Retarding Media (DRM) Will slow the Transition to the Digital Information Age," *Online Committee, Federal Communications Bar Association,*January 29, 2003 "Open Communications Platforms: Cornerstone of Innovation and Democratic Discourse In the Internet Age," *Journal on Telecommunications, Technology and Intellectual Property,* 2:1, 2003,

"Foundations And Principles Of Local Activism In The Global, New Economy," *The Role of Localities and States in Telecommunications Regulation: Understanding the Jurisdictional Challenges in an Internet Era,* University of Colorado Law School, `April 16, 2001

"The Role Of Technology And Public Policy In Preserving An Open Broadband Internet," *The Policy Implications Of End-To-End,*Stanford Law School, December 1, 2000

"Inequality In The Digital Society: Why The Digital Divide Deserves All The Attention It Gets," *Cardozo Arts and Entertainment Law Journal,*2002, first presented at Bridging The Digital Divide: Equality In The Information Age, Cardozo School Of Law, November 15, 2000

“Picking Up The Public Policy Pieces Of Failed Business And Regulatory Models,” *Setting The Telecommunications Agenda,* Columbia Institute For Tele-Information November 3, 2000

“Progressive, Democratic Capitalism In The Digital Age,” *21st Century Technology and 20th Century Law: Where Do We Go from Here? The Fund for Constitutional Government, Conference on Media, Democracy and the Constitution,* September 27, 2000

“Open Access To The Broadband Internet: Technical And Economic Discrimination In Closed, Proprietary Networks,” *University of Colorado Law Review,* Vol. 69, Fall 2000

“Antitrust As Consumer Protection In The New Economy: Lessons From The Microsoft Case, Hastings Law Journal, 52: 4, April 2001, first presented at *Conference On Antitrust Law In The 21st Century Hasting Law School,* February 10, 2000

“Evolving Concepts of Universal Service,” *The Federalist Society,* October 18, 1996

"Delivering the Information Age Now," *Telecom Infrastructure: 1993, Telecommunications Reports,* 1993

"Divestiture Plus Four: Take the Money and Run," *Telematics,* January 1988

"Regulatory Reform in Telecommunications: A Solution in Search of a Problem," *Telematics,* 4:11, November 1987.

"The Line of Business Restriction on the Regional Bell Operating Companies: A Plain Old Anti-trust Remedy for a Plain Old Monopoly," Executive Leadership Seminar on Critical Policy Developments in Federal Telecommunications Policy, The Brookings Institution, October 7, 1987

"The Downside of Deregulation: A Consumer Perspective After A Decade of Regulatory Reform," *Plenary Session, Consumer Assembly,* February 12, 1987

"Regulatory Reform for Electric Utilities, Plenary Session, *Consumer Federation of American, Electric Utility Conference,* April 4, 1987

"Round Two in the Post-Divestiture Era: A Platform for Consumer Political Action," *Conference on Telephone Issues for the States -- 1984: Implementing Divestiture,* May, 1984

Research Reports

Digital Disintermediation and Copyright in the 21st Century: Lessons From The Transformation Of The Music Sector, November 2013

E-Book Price Fixing Violates The Antitrust Laws And Harms Consumers, April 9, 2012

Efficiency Gains and Consumer Benefits of Unlicensed Access to the Public Airwaves: the Dramatic Success of Combining Market Principles and Shared Access,January 2012

The Impact of the Vertically Integrated, Television-Movie Studio Oligopoly on Source Diversity and Independent Production, Independent Film and Television Association, October 2006

How Bigger Media Will Hurt Alaska, Arkansas, California, Florida, Maine, Michigan, Montana, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Virginia, Washington, Media and Democracy Coalition, October 2006

Mapping the Terrain in the Battle Over Access to Knowledge in the Digital Information Age (June 2006)

Online Deliberation: Mapping The Field; Tapping The Potential From The Perspective Of A Media/Internet Activist *(*August 2005)

Broken Promises and Strangled Competition: The Record of Baby Bell Merger and Market Opening Behavior (Consumer Federation of America, June 2005)

Over a Barrel: Why Aren’t Oil Companies Using Ethanol to Lower Gasoline Prices? (Consumer Federation of America, May 2005)

Reflections Of A Media Activist On New Strategies For Justice: Linking Corporate Law With Progressive Social Movements (May 2005)

Time for the Recording Industry to Face the Music: The Political, Social and Economic Benefits of Peer-to-Peer Communications Networks (Consumer Federation of America, Consumers Union, Free press, U.S. Public Interest Research Group, March 2005)

Expanding the Digital Divide and Falling Behind in Broadband (Consumer Federation of America and Consumers Union, October 2004)

Time to Give Consumers Real Cable Choices: After Two Decades of Anti-consumer Bundling and Anti-Competitive Gate keeping (Consumer Federation of America and Consumers Union, July 2004)

The Public Interest in Open Communications Networks (Consumer Federation of America, July 2004)

Caution Flag in the FCC's Race to Eliminate the Unbundled Network Element Platform (consumer Federation of America, June 2003)

New Survey Finds Americans Rely on Newspapers Much More than Other Media for Local News and Information: FCC Media Ownership Rules Based on Flawed Data(Consumer Federation of America, Consumers Unions, January 2004)

Cable Market Power, Pricing And Bundling After The Telecommunications Act Of 1996: Explorations Of Anti-Consumer, Anticompetitive Practices (Consumer Federation of America and Consumers Union, November 2003)

Competition At The Crossroads:Can Public Utility Commissions SaveLocal Phone Competition? (Consumer Federation of America, October 7, 2003)

Free TV Swallowed by Media Giants: The Way It Really Is, September 15, 2003 (Consumer Federation of America, Consumers Union and Center for Digital Democracy, September 15, 2003)

Abracadabra! Hocus-Pocus! Making Media Market Power Disappear With The FCC's Diversity Index (Consumer Federation of America and Consumers Union, July 2003)

Promoting The Public Interest Through Media Ownership Limits: A Critique Of The FCC's Draft Order Based On Rigorous Market Structure Analysis And High Competitive Standards (Consumer Federation of America and Consumers Union, May 2003)

Public Opinion Opposes The FCC's March Toward Concentrated Media Markets (Consumer Federation of America, April 2003)

Democratic Discourse in the Digital Information Age: Legal Principles and Economic Challenge (Consumer Federation of America, February 2003)

Cable Mergers, Monopoly Power and Price Increases (Consumer Federation of America and Consumers Union, January 2003)

Public Support for a Citizen-Friendly Media and Communications Industry in the Digital Age: A Review of Recent Survey Evidence (Consumer Federation of America, October 2002)

The Battle for Democratic Discourse: Recapturing a Bold Aspiration for the First amendment (Consumer Federation of America, October 2002)

Does the Digital Divide Still Exist? Bush Administration Shrugs, But Evidence Says "Yes" (Consumer Federation of America, Consumers Union, Civil Rights Forum, May 30, 2002)

The Failure of 'Intermodal Competition in Cable and Communications Markets (Consumer Federation of America and Consumers Union, April, 2002).

Competitive Processes, Anticompetitive Practices and Consumer Harm in the Software Industry: An Analysis of the Inadequacies of the Microsoft-Department of Justice Proposed Final Judgment (Jan. 25, 2002)

A Roadblock On The Information Superhighway: Anticompetitive Restrictions On Automotive Markets (Consumer Federation of America, February 2001)

Lessons From 1996 Telecommunications Act: Deregulation Before Meaningful Competition Spells Consumer Disaster (Consumer Federation of America, February 2000)

Florida Consumers Need Real Local Phone Competition: Access To Monopoly Wires Is The Key (Consumer Federation of America, January 2001)

The Real Deal: The Comparative Value of Verizon's Local Telephone Rates (New Jersey Citizen Action, December 2000)

Maryland Consumers Need Real Local Phone Competition: Fair Access to Monopoly Wires Is the Key (Consumer Federation of America, December 7, 2000)

Bailing Out Of A Bad Business Strategy: Policymakers Should Not Sacrifice Important Public Policies To Save AT&T's Failed Business Plans (Consumer Federation of America, October 2000)

Setting The Record Straight From A Consumer Perspective On Verizon's Radical Rate Restructuring Proposal (Citizen Action, October 2000)

Disconnected, Disadvantaged and Disenfranchised (Consumer Federation of America and Consumers Union, October 11, 2000)

Open Access Phase II (Consumer Federation of America, July 13, 2000)

Who Do You Trust? AOL And AT&T … When They *Challenge*The Cable Monopoly Or AOL And AT&T. When They *Become* The Cable Monopoly?, (Consumer Federation of America, Consumers Union and Media Access Project, February 2000)

Monopoly Power, Anticompetitive Business Practices and Consumer Harm in the Microsoft Case (Consumer Federation of America, December 1999)

Keeping the Information Superhighway Open for the 21st Century (Consumer Federation of America, December 1999)

Creating Open Access to the Broadband Internet: Overcoming Technical and Economic Discrimination in Closed, Proprietary Network (Consumer Federation of America, December 1999)

The Consumer Harm Caused By The Microsoft Monopoly: The Facts Speak For Themselves And They Call For A SternRemedy (Consumer Federation of America, November 1999)

A Consumer Perspective On Economic, Social And Public Policy Issues In The Transition To Digital Television: Report Of The Consumer Federation Of America To People For Better TV (Consumer Federation of America, October 29, 1999)

Transforming the Information Superhighway into a Private Toll Road: Ma Cable and Baby Bell Efforts to Control the High-Speed Internet (Consumer Federation of America, October 1999)

Transforming the Information Superhighway into a Private Toll Road: The Case Against Closed Access Broadband Internet Systems (Consumer Federation of America and Consumer Action, Sept. 20, 1999)

Breaking the Rules: AT&T's Attempt to Buy a National Monopoly in Cable TV and Broadband Internet Services (Consumer Federation of America, Consumers Union and Media Access Project, Aug. 17, 1999)

Economic Evidence in the Antitrust Trial: The Microsoft Defense Stumbles Over the Facts (Consumer Federation of America, March 18, 1999)

The Consumer Cost of the Microsoft Monopoly: $10 Billion of Overcharges and Counting (Consumer Federation of America, Media Access Project and U.S. PIRG, January1999)

The Digital Divide (Consumer Federation of America and Consumers Union, February 1999)

The Consumer Case Against the SBC-Ameritech Merger (Consumer Federation, et. al, January 20, 1999)

The Consumer Case Against Microsoft (Consumer Federation of America, October 1998)

The Need for Telephone Lifeline Programs in New Jersey: An Update (Center for Media Education and the Consumer Federation of America, July 1998)

Competition in Local Markets: Is the Glass 98 Percent Empty or 2 Percent Full (Consumer Federation of America, February 17, 1998)

Two Years After the Telecom Act: A Snapshot of Consumer Impact (Consumer Federation of America, January 21, 1998)

Stonewalling Local Competition: The Baby Bell Strategy to Subvert the Telecommunications Act of 1996 (Consumer Federation of America, January 1998)

The Need for Telephone Lifeline Programs in Kentucky (Kentucky Youth Advocates and Center for Media Education, October 1997)

Money for Nothing: The Case Against Revenue Replacement in the Transition to Local Exchange Competition: A Consumer View of the Gap Between Efficient Prices and Embedded Costs, American Association of Retired Persons, Consumer Federation of America, Consumers Union, January 1997

Low Income Children and the Information Superhighway: Policies for State Public Service Commissions After the Telecommunications Act of 1996, Prepared for the Alliance for South Carolina's Children, January 1997

Excess Profits and the Impact of Competition on the Baby Bells, Consumer Federation of America, September 1996

Universal Service: An Historical Perspective and Policies for the 21st. Century, Benton Foundation and the Consumer Federation of America, August 1996

A Consumer View of Missouri Telephone Legislation: House Bill 1363 Would Mandate Consumer Overcharges and Telephone Company Excess Profits, Consumer Federation of America, March 20, 1996

Evolving Notions of Universal Service (Consumer Federation of America, October 18, 1996)

Economic Concentration and Diversity in the Broadcast Media: Public Policy and Empirical Evidence, December 1995

Federal Deregulation and Local Telephone and Cable TV Rates: Rate Shock in the 1980s and Prospects in the 1990s, November 1995

Basic Service Rates and Financial Cross-Subsidy of Unregulated Baby Bell Activities: The Importance of Effective Competition for Local Service Before Deregulation of Profits and Cross-Ownership, October, 1995

Federal Policy and Local Telephone and Cable TV Rates: Rate Shock in the 1980s and Prospects for the 1990S, October 1995

Mergers and Deregulation on the Information Superhighway: The Public Takes a Dim View: Results of a National Opinion Poll, September 1995

Competition and Consumer Protection in the Florida Telecommunications Legislation, Prepared for the Florida Office of the People's Counsel, April 1995

The Meaning of the Word Infrastructure, June 30, 1994

Protecting the Public Interest in the Transition to Competition in Network Industries, June 14, 1994

Local Exchange Costs and the Need for A Universal Service Fund: A Consumer View, May 1994

Milking the Monopoly: Excess Earnings and Diversification of the Baby Bells Since Divestiture, February 1994

A Consumer Road Map to the Information Superhighway: Finding the Pot of Gold at the End of the Road and Avoiding the Potholes Along the Way, January 26, 1994

Consumers with Disabilities in the Information Age: Public Policy for a Technologically Dynamic Market Environment, 1993

Selling Information Services During 800 and 900 Number Calls: The Need for Greater Consumer Protection, October 2, 1992

The Economics of Deregulation and Reregulation in the Cable Industry: A Consumer View, September 1992

Developing the Information Age in the 1990s: A Pragmatic Consumer View, June 8, 1992

Divestiture Plus Eight: The Record of Bell Company Abuses Since the Break-up of AT&T, December 1991

Transmission Planning, Citing, and Certification in the 1990s: Problems, Prospects and Policies, August 1990

Expanding the Information Age for the 1990s: A Pragmatic Consumer Analysis, January 11, 1990

Divestiture Plus Five: Residential Telephone Service Five Years After the Breakup of AT&T, December 1988

Public Opinion About Deregulation and Regulation in the Transportation and Communications Industries, May 1988

Telecommunications Policy Regarding Deregulation, May 1988

Universal Telephone Service in Ohio: A Review of Recent Evidence, November 12, 1987

The Role of Natural Gas in Solving the Clean Air Problem: Reconciling Consumer and Environmental Interests, April 19, 1988

Divestiture Plus Four: Take the Money and Run, December 1987

The Telecommunications Needs of Older, Low Income and General Consumers in the Post-Divestiture Era, October 1987

Bulk Commodities and the Railroads After the Staggers Act: Freight Rates, Operating Costs and Market Power, October 1987

Divestiture Plus Three: Still Crazy After All These Years, December 1986

Low Income Households in the Post Divestiture Era: A study of Telephone Subscribership and Use in Michigan, October 1986

Sorry Wrong Numbers: Federal Agency Analyses of Telephone Subscribership in the Post-Divestiture Era, February 1986

Industrial Organization and Market Performance in the Transportation and Communications Industries, July 1985

Ringing Off the Wall: An Alarming Increase in Residential Phone Rates, 1984-986, May 12, 1985

Divestiture: One Year Later, December 19, 1984

OTHER

Books and Chapters

The Transformation of Egypt: State and State Capitalism in Crisis (Baltimore: Johns Hopkins University Press, 1982)

"Egyptian State Capitalism In Crisis: Economic Policies and Political Interests," in Talal Asad and Roger Owen (Eds.), *Sociology of Developing Societies: The Middle East* (London: Macmillan Press, 1983). First published in The *International Journal of Middle Eastern Studies,* X:4, 1979

"Revoluciones Semi-legalesen el Mediterraneo," in Jesus De Miguel (Ed.), *Cambio Social en La Europa Mediterranea (Barcelona: Ediciones Peninsula, 1979).* First presented as "The Structure of Semi-legal Revolutions: Between Southern Mediterranean and Western European Patterns," *9th World Congress of the International Sociological Society,* Uppsala, Sweden, August, 1978

Articles and Papers

"The Failure of Market Fundamentalism: What Are The Issues In The ICT Sector?" *The New Economics of ICT: Implications of Post-Neoclassical Economics for the Information Communications Technology Sector, Columbia University, March 20, 2009*

"Restoring the Balance of Public Values and Private Incentives in American Capitalism," *Too Much Deregulation or Not Enough,* Cato Institution, November 1, 2002

"Freeing Public Policy From The Deregulation Debate: The Airline Industry Comes Of Age (And Should Be Held Accountable For Its Anticompetitive Behavior), *American Bar Association, Forum On Air And Space Law, The Air and Space Lawyer*, Spring 1999

"An Uninformed Purchase," *Best's Review: Life/Health Insurance Edition,* July 1987

"The Trouble with the ICC and the Staggers Act," *Pacific Shipper,* June 1, 1987

"The Leftist Opposition in Egypt," *Conference on Sadat's Decade: An Assessment*, conducted by the Middle Eastern Studies Program of the State University of New York at Binghamton, April, 1984

"The Crisis in the Rental Housing Market: Energy Prices, Institutional Factors and the Deterioration of the Lower Income Housing Stock," *53rd Annual Meeting of the Eastern Sociological Society*, March, 1983

"State Capitalism and Class Structure in the Third World: The Case of Egypt," International Journal of Middle East Studies, XIV:4, 1983

"The Militarization and Demilitarization of the Egyptian Cabinet," *International Journal of Middle East Studies,* XIII: 2, 1982

"Sociological Theory and Economic History: The Collegial Organizational Form and the British World Economy," *51st Annual Meeting of the Eastern Sociological Society*, March, 1981

"The Failure of Health Maintenance Organizations: A View from the Theory of Organizations and Social Structure," *50th Annual Meeting of the Eastern Sociological Society*, March, 1980

"Impact of Incentive Payments and Training on Nursing Home Admissions, Discharges, Case Mix and Outcomes," *Massachusetts Sociological Society,* November, 1979

"The State as an Economic Environment," *7th Annual New England Conference on Business and Economics*, November, 1979

"The Domestic Origins of Sadat's Peace Initiative*," Yale Political Union*, March, 1979

"State Capitalism and Class Structure: The Case of Egypt," *49th Annual Meeting of the Eastern Sociological Society*

March, 1979

"The Welfare State and Equality: A Critique and Alternative Formulation from a Conflict Perspective," *48th Annual Meeting of the Eastern Sociological Society*, April, 1978

"A Comparative Evaluation of Operation Breakthrough," *Annual Meeting of the Environmental Research Design Association, April*, 1975

"Plural Societies and Conflict: Theoretical Considerations and Cross National Evidence," *International Journal of Group Tensions,* IV:4, 1974. First presented at the *44th Annual Meeting of the Eastern Sociological Society*, March, 1974

"Racialism and Pluralism: A Further Dimensional Analysis," *Race and Class,* XV:3, 1974

"Personality Correlates of Technology and Modernization in Advanced Industrial Society (with Ed Dager), *8th Annual Meeting of the International Sociological Society,* August, 1974

"Toward a Model of Conflict in Minority Group Relations," Annual Meeting of the District of Columbia Sociological Society, May, 1973

"A Re-evaluation of the Causes of Turmoil: The Effects of Culture and Modernity," *in A Reader in Collective Behavior and Social Movements* (F.E. Peacock: New York, 1978). First published in *Comparative Political Studies*, VII:3, 1974. First presented at the *43rd Annual Meeting of the Eastern Sociological Society*, March, 1973

"The Occurrence of Mutiny in World War I: A Sociological View," *International Behavioral Scientist*, IV:3, 1972

Research Reports

with Barbara Roper, Reform of Financial Markets: the Collapse Of Market Fundamentalism and the First Steps to Revitalize the Economy, April 2009

Credit Unions In A 21st Century Financial Marketplace: Economic And Organizational Underpinnings Of Institutional Success (Consumer Federation of America, 2004)

Unconventional Wisdom: Ten New State Polls Offer a Chance to Rethink How Americans View the Assault Weapons Ban (Consumer Federation of America and the Educational Fund to Stop Gun Violence, July 13, 2004)

Public Opinion About quality, Self-Dealing and Billing for Ancillary Medical Tests, October 17, 1991

A Consumer Perspective on Direct Billing: The Next Step in Reforming the Market for Ancillary Medical Services, July 1991

Clearing the Air on Airline Deregulation, May 22, 1991

Airport Pricing of Access for Off-Premise Auto Rental Companies: The Growing Pattern of Abuse, April 24, 1990

Public Opinion About Health Care Purchases: Cost, Ease of Shopping and Availability, April 27, 1989

Bailing Out the Savings and Loans Who Bears the Burden Under Alternative Financing Approaches, March 9, 1989

Airport Fees for Auto Rental Companies: A Consumer Perspective, June 1988,

Reforming the Interstate Commerce Commission: Getting the Facts Straight, February 10, 1988

The Benefits of the Modernization of the Tort Law in the Context of the Social Movement for Improved Safety and Quality in the National Economy, September 1987

The Potential Costs and Benefits of Allowing Banks to Sell Insurance, February 10, 1987

Confusion and Excess Cost: Consumer Problems in Purchasing Life Insurance, January 21, 1987

The Costs and Benefits of Exclusive Franchising: The Case of Malt Beverages, September 17, 1986

Punitive Damages in Product Liability Cases: Setting the Record Straight, September 1986

Local Rate Increases in the Post-Divestiture Era, Excessive Returns to Telephone Company Capital, September 1986

Trends in Liability Awards: Have Juries Run Wild, May 1986

Farm worker Demographics, National and State Planning Packages, May 1986

The Great Train Robbery: Electric Utility Consumers and the Unregulated Rail Monopoly Over Coal Transportation, Overview, The Rail Monopoly Over Bulk Commodities, A Continuing Dilemma for Public Policy, August 1985

Deregulation of the Dairy Industry, November 1983

Meal Production Costs in School Food Kitchens: An Economic Analysis of Production Processes and Efficiencies, December 1981

A Study of Program Management Procedures in the Campus-based and Basic GRANTS Programs: Final Report, March 1980

A Study of Program Management Procedures in the Campus-based and Basic Grants Programs: Site Visit Report, December 1975

A Comparative Evaluation of Operation Breakthrough, Chapter 3, August 1975

Judging the Merits of Child Feeding Programs, 1975

A Comparative Evaluation of Ongoing Programs in Columbia, Kenya, and the Philippines, 1974

TESTIMONY:

FEDERAL AGENCIES AND COURTS

"Comments of Dr. Mark Cooper." In the Matter of Carbon Pollution Emission Guidelinesfor 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.

Comments Of The Consumer Federation Of America, In the Matter of Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auction Revisions to Rules Authorizing the Operation of Low Power Auxiliary Stations in the 698-806 MHz Band, Public Interest Spectrum Coalition, Petition for Rulemaking Regarding Low Power Auxiliary Stations, Including Wireless Microphones, and the Digital Television Transition, Amendment of Parts 15, 74 and 90 of the Commission's rule, Regarding Low Power Auxiliary Stations, Including Wireless, Federal Communications Commission, Docket No. 12-268 ET, WT Docket No. 08-166, WT Docket No. 08-167, Docket No. 10-24, January 25, 2013

American Federalism At Its Best: Why The Environmental Protection Agency Should Grant A Clean Air Act Waiver To California For Its Advanced Clean Cars Program, Environmental Protection Agency, September 19, 2012

Comments of the Consumer Federation of America on Proposed Final Judgment as to Defendants Hachette, HarperCollins and Simon & Schuster, United States v. Apple, Inc., et al., 12-cv-2826 (DLC) (SDNY), United States District Court For the Southern District of New York, June 25, 2012,

Comments Of Consumer Groups, Proposed Rule 2017 And Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Docket Nos., EPA-HQ-OAR-2010-0799; FRL-9495-2, NHTSA 2010–0131, February 13, 2012

Statement Of Dr. Mark Cooper, Director Of Research, Joint NHTSA-EPA Hearings On Fuel Economy Standards For 2017-2025, January 2012

Statement Of Dr. Mark Cooper, Director Of Research, Consumer Federation Of America to The Federal Communications Commission Broadband Workshop On The Unserved And Underserved, August 12, 2009

Comment Of The Consumer Federation Of America In The Matter Of Applications Of Cellco Partnership C/B/A Verizon Wireless And SpectrumcoLLC For Consent To Assign Licenses, WT Docket No.12-4, Application Of Cellco Partnership D/B/A, Verizon Wireless And Cox TMI Wireless, LLC For Consent To Assign Licenses, July 9, 2012,

Letter Urging Close Scrutiny Of UMG-EMI Merger, Subcommittee On Antitrust, Competition Policy And Consumer Rights, United States Senate, Committee On The Judiciary, April 26, 2012

Comments Of The Consumer Federation Of America To The U.S. Department Of Commerce Internet Policy Task Force, Docket No. 101214614 ‐ 0614 ‐ 01, RIN 0660 ‐ XA22, Information Privacy And Innovation In The Internet Economy, January 28, 2011

Comments of the Consumer Federation of America on the Proposed Horizontal Merger Guidelines, Before the Federal Trade Commission, FTC File No. PO92700, June 4, 2010

"Reply Comments -- National Broadband Plan, Public Notice #30, Center for Media Justice, Consumer Federation of America, Consumers Union, Open Technology Initiative, Public Knowledge, on Broadband Adoption," Before the Federal Communications Commission, In the Matter of A National Broadband Plan for Our Future, GN Docket No. 09-47, 09-51, 09-137, January 27, 2010

"Comments of the Consumer Federation of America," before the Environmental Protection Agency and Department of Transportation, *Proposed Rulemaking to Establish Light-Duty Vehicles Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards,* November 27, 2009

"Statement of Mark Cooper to the Joint SEC-CFTC Meeting on Harmonization of Regulation," September 2, 2009.

"Comments of The Consumer Federation Of America On November 2008 Report Of L.R. Christensen Associates, Inc." United States Of America, Surface Transportation Board, Ex Parte No. 680, *Study Of Competition In The Freight Rail Industry*, December 22, 2008

"Comments on the Draft Environmental Impact Statement of Consumer Federation of America, et al.," *Notice of Proposed Rulemaking: Average Fuel Economy Standard; Passenger Cars and Light Trucks, Model Years 2011-2015,* August 18, 2008

"Comment and Technical Support Appendices of the Consumer Federation of America," *Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011-2015,* July 1, 2008

"Behavioral Marketing Principles," with Susan Grant, Federal Trade Commission, April 10, 2008

"Reply Comments of Consumer Federation of America and Consumers Union," *In the Matter of the Petition of Free Press, et al. for Declaratory Ruling that Degrading an Internet Application Violates the FCC's Internet Policy Statement and Does not Met an Exception for "Reasonable Network Management," and Vuze, Inc. to Establish Rule Governing Network Management Practices by Broadband Network Operators, Broadband Industry Practices, Commercial Availability of Navigation Devices,* WC Docket No. 07-52, CS Docket No. 97-80, February 28, 2008

"Comments on Behavioral Tracking and Targeting," Federal Trade Commission, *Town Hall Meeting on Ehavioral Advertising: Tracking, Targeting and Technology*, November 16, 2007

"Comments of the Consumer Federation of America, Consumers Union and Free Press, *In the Matter of Broadband Industry Practices,* WC Docket No. 07-52, June 15, 2007

"Petition to Deny of Common Cause, Consumer Federation of America, Consumers Union and Free Press," *In the Matter of Consolidated Application for Authority to transfer Control of XM Sirius Radio Inc, and Sirius Satellite Radio Inc,* MB Docket No. 07-57, July 9, 2007

"Comment of the Texas Office of Public Utility Counsel, Consumer Federation of America and Consumers Union," In the Matter of Intercarrier Compensation, CC Docket No. 91-92, October 25, 2006

"Statement," Local Hearing, Federal Communications Commission, Los Angeles, October 2006

"Affidavit," with Trevor Roycroft, In the Matter of Review of AT&T Inc. and BellSouth Corporation, Application for Consent to Transfer of Control, WC Docket No. 06-74.

"Comments and Reply Comments of the Consumer Federation Of America and Consumers Union In Opposition To The Transfer Of Licenses," Applications of Adelphia Communications Corporation, Comcast Corporation and Time Warner Cable Inc., For Authority to Assign and/or Transfer Control of Various Licenses, Before the Federal Communications Commission, MM Docket No. 05-192

"Comments of Consumer Federation of America, Consumers Union and Free Press," *In the Matter of the Commission's Cable Horizontal and Vertical Ownership Limits and Attribution Rules,* MM Docket No. 92-264, August 8, 2005

"Petition to Deny of the Consumer Federation of America, Consumers Union, and USPIRG, *In the Matter of Applications of SBC Communications Inc. and AT&T Corporation to Transfer Control of Section 214 and 308 Licenses and Authorizations and Cable Landing Licenses,* WC Docket No. 05-65, April 25, 2005

"Petition to Deny of the Consumer Federation of America, Consumers Union, and USPIRG, *In the Matter of Applications of Verizon Communications Inc. and MCI Inc. Applications for Approval of Transfer of Control of Section*, WC Docket No. 05-75, May 9, 2005

"Comments of the Consumer Federation of America and Consumers Union," before the Federal Communications Commission, *In the Matter of Broadcast Localism* MB Docket No. 04-233, November 1, 2004

"Comments and Reply Comments of Dr. Mark Cooper on Behalf of the Texas Office of Public Utility Counsel and the Consumer Federation of America," before the Federal Communications Commission, *In the Matter of Final Unbundling Rules,* Docket Nos. WC-04-313, CC-01-338, October 4, October 19, 2004.

"Comments and Reply Comments of Consumers Union and the Consumer Federation of America," *In the Matter of Comments Requested on a La Carte and Themed Tier Programming and Pricing Options for Programming Distribution on Cable Television and Direct Broadcast Satellite Systems,* before the Federal Communications Commission, MB Docket No. 04-207, July 13, 2004, August 13, 2004

"Affidavit of Mark Cooper," Prometheus Radio Project, et al. v. Federal Communications Commission and United States of America*,* No. 03-3388, et al., August 6, 2004

"Comments Of Consumer Federation Of America and Consumers Union," *In The Matter Of IP-Enabled Services, Petition Of SBC Communications Inc. For Forbearance,* Before The Federal Communications Commission, WC Docket No. 04-29, 04-36, July 14, 2004

"Testimony of Mark Cooper," before the Federal Energy Regulatory Commission, Solicitation Processes for Public Utilities, June 10, 2004

"Petition to Deny and Reply to Opposition of the Consumer Federation of America and Consumers Union," In the Matter of Applications for the Transfer of Control of Licenses and Authorization from AT&T Wireless Services, Inc., and its Subsidiaries to Cingular Wireless Corporation, before the Federal Communications Commission, WT Docket No. 04-70, May3, May 20, 2004

"Opposition to the Petitions for Reconsideration, Reply comments of the Consumer Federation of America," *In the Matter of Digital Broadcast Content Protection, Implementation of Section 304 of the Telecommunications Act of 1996, Commercial Availability of Navigation Devices, Compatibility Between Cable Systems and Consumer Electronic Equipment,* before the Federal Communications Commission, Docket Nos. MB-02-230, CS-97-80, PP-00-67, March 15, 2004

"Petition for Reconsideration of the Consumer Federation of America and Consumers Union," In The Matter Of 2002 Biennial Regulatory Review – Review of the Commission's Broadcast Ownership Rules and Other Rules Adopted Pursuant to Section 202 of the Telecommunications Act of 1996, Cross-Ownership of Broadcast Stations and Newspapers Rules and Policies Concerning Multiple Ownership of Radio Broadcast Stations in Local Market, Definition of Radio Markets, Federal Communications Commission, MB Docket No. 02-277, MM Docket Nos. 00-244, 01-235, 01-317, September 4, 2003

"Reply Comments Of Consumer Federation Of America," In the Matter of Second Periodic Review of the Commission's Rules and Policies Affecting the Conversion To Digital Television, Public Interest Obligations of TV Broadcast Licensees, Children's Television Obligations Digital Television Broadcaster, Standardized and Enhanced Disclosure Requirements for Television Broadcast Licensee, Public Interest Obligations, Before the Federal Communications Commission, MB Docket No. 03-15,RM 9832, MM Docket Nos. 99-360, 00-167, 00-168, May 21, 2003

"Reply Comments of the Consumer Federation of America," In the Matter of Digital Broadcast Copy Protection, Federal Communications Commission, MB Docket NO. 02-230, February 18, 2003

"Comments of Consumer Federation of America, Consumers Union, Center for Digital Democracy, Media Access Project," In The Matter Of 2002 Biennial Regulatory Review – Review of the Commission's Broadcast Ownership Rules and Other Rules Adopted Pursuant to Section 202 of the Telecommunications Act of 1996, Cross-Ownership of Broadcast Stations and Newspapers Rules and Policies Concerning Multiple Ownership of Radio Broadcast Stations in Local Market, Definition of Radio Markets, Federal Communications Commission, MB Docket No. 02-277, MM Docket Nos. 00-244, 01-235, 01-317, Comments January 3, 2003, Reply Comments February 3, 2003

"Comments of the Texas Office of Public Utility Counsel, The Consumer Federation of America, Consumers Union," In the Matter of Petition for Declaratory Ruling that AT&T's Phone-to-Phone IP Telephony Services are Exempt from Access Charges, Federal communications Commission, WC Docket No. 02-361, January 18, 2003

"Comments of Arizona Consumers Council, California Public Interest Research Group, Colorado Public Interest Research Group, Columbia Consumer Education Council, Consumer Assistance Council (MA) Consumer Federation of America, Florida Consumer Action Network, Massachusetts Consumers' Council, North Carolina Public Interest Research Group, Oregon State Public Interest Research Group, Texas Consumers' Association, The Consumer's Voice, US Action, Virginia's Citizens' Consumer Council, In the Matter of Digital Broadcast Copy Protection, Federal Communications Commission, MB Docket NO. 02-230, December 6, 2002

"Initial Comments of the Consumer Federation of America," Remedying Undue Discrimination through Open Access Transmission Service and Standard Electricity Market Design, Federal Energy Regulatory Commission, Docket No. RM-01-12-000, October 15, 2002

"An Economic Explanation of Why the West and South Want to Avoid Being Infected by FERC's SMD and Why Market Monitoring is Not an Effective Cure for the Disease," SMD Market Metrics Conference, Federal Energy Regulatory Commission, October 2, 2002

"Bringing New Auto Sales and Service Into the 21st Century: Eliminating Exclusive Territories and Restraints on Trade Will Free Consumers and Competition," Workshop on Anticompetitive Efforts to Restrict Competition on the Internet, Federal Trade Commission, October 7, 2002

"Once Money Talks, Nobody Else Can: The Public's first Amendment Assets Should Not Be Auctioned to Media Moguls and Communications Conglomerates," In the Matter of Spectrum Policy Task Force Seeks Public Comment on Issues Related to Commission's Spectrum Policy, Federal Communications Commission, DA 02-1221, ET Docket No. 02-135, July 8, 2002

"Comments Of The Texas Office Of Public Utility Counsel, Consumer Federation Of America, Consumers Union, Media Access Project, And The Center For Digital Democracy," Federal Communications Commission, *In the Matter of Appropriate Framework for Broadband Access to the Internet Over Wireline Facilities Universal Service Obligations of Broadband Providers Computer III Further Remand Proceedings: Bell Operating Company Provision of Enhanced Services; 1998 Biennial Regulatory Review –Review of Computer III and ONA Safeguards And Requirements,* CC Dockets Nos. 02-3395-20, 98-10, July 1, 2002

"Comments of the Consumer Federation of America, Consumers Union, Center for Digital Democracy, The Office of Communications of the United Church of Christ, Inc., National Association of Telecommunications Officers and Advisors, Association for Independent Video Filmmakers, National Alliance for Media Arts and Culture, and the Alliance for Community Media." Federal Communications Commission, In the Matter of Implementation of Section 11 of the Cable Television Consumer Protection and Competition Act of 1992 Implementation of Cable Act Reform Provisions of the Telecommunications Act of 1996 The Commission's Cable Horizontal and Vertical Ownership Limits and Attribution Rules Review of the Commission's Regulations Governing Attribution Of Broadcast and Cable/MDS Interests Review of the Commission's Regulations and Policies Affecting Investment In the Broadcast Industry Reexamination of the Commission's Cross-Interest Policy, CS Docket No. 98-82, CS Docket No. 96-85, MM Docket No. 92-264, MM Docket No. 94-150, MM Docket No. 92-51, MM Docket No. 87-154

"Reply Comments of the Consumer Federation of America, Consumers Union, Center for Digital Democracy, and Media Access Project," in Federal Communications Commission, In the Matter of Implementation of Section 11 of the Cable Television Consumer Protection and Competition Act of 1992 Implementation of Cable Act Reform Provisions of the Telecommunications Act of 1996 The Commission's Cable Horizontal and Vertical Ownership Limits and Attribution Rules Review of the Commission's Regulations Governing Attribution Of Broadcast and Cable/MDS Interests Review of the Commission's Regulations and Policies Affecting Investment In the Broadcast Industry Reexamination of the Commission's Cross-Interest Policy*,* CS Docket No. 98-82, CS Docket No. 96-85, MM Docket No. 92-264, MM Docket No. 94-150, MM Docket No. 92-51, MM Docket No. 87-154.

"Petition to Deny of Arizona Consumers Council, Association Of Independent Video And Filmmakers, CalPIRG, Center For Digital Democracy, Center For Public Representation, Chicago Consumer Coalition, Civil Rights Forum On Communications Policy, Citizen Action Of Illinois, Consumer Action, Consumer Assistance Council, Consumer Federation Of America, Consumer Fraud Watch, Consumers United/Minnesotans For Safe Food, Consumers Union, Consumers' Voice, Democratic Process Center, Empire State Consumer Association, Florida Consumer Action Network, ILPIRG (Illinois), Massachusetts Consumers Coalition, MassPIRG, Media Access Project, Mercer County Community Action, National Alliance For Media Arts And Culture, MontPIRG, New York Citizens Utility Board, NC PIRG, North Carolina Justice And Community Development Center, OsPIRG(Oregon State), Oregon Citizens Utility Board, Texas Consumer Association, Texas Watch, United Church Of Christ, Office Of Communication, Inc., US PIRG, Virginia Citizens Consumer Council, WashPIRG, Wisconsin Consumers League, " In the Matter of Application for Consent to the Transfer of Control of Licenses Comcast Corporation and AT&T Corporation, Transferors, to AT&T Comcast Corporation, Transferee*,* April 29, 2002

"Tunney Act Comments of Consumer Federation of America, Connecticut Citizen Action Group, ConnPIRG, Consumer Federation of California, Consumers Union, Florida Consumer Action Network, Florida PIRG, Iowa PIRG, Massachusetts Consumer's Coalition, MassPIRG, Media Access Project, U.S. PIRG", in the *United States v. Microsoft Corp*, Civil Action No. 98-1232, (Jan. 25, 2002)

"Comments of Consumer Federation of America, et al," In the Matter of Implementation of Section 11 of the Cable Television Consumer Protection and Competition Act of 1992, Implementation of Cable Act Reform Provisions of the 'Telecommunications Act of 1996, The Commission's Cable Horizontal and Vertical Ownership Limits and Attribution Rules, Review of the Commission's Regulations Governing Attribution of Broadcast and Cable MDS Interests, Review of the Commission's Regulations and Policies Affecting Investment in the Broadcast Industry, Reexamination of the Commission's Cross-Interest Policy, CS Docket Nos. 98-82, 96-85; MM Docket Nos. 92-264, 94-150, 92-51, 87-154, January 4, 2002.

"Comments of Consumers Union, Consumer Federation of America, Civil Rights Forum, Center for Digital Democracy, Leadership Conference on Civil Rights and Media Access Project, before the Federal Communications Commission, In the Matter of Cross Ownership of Broadcast Station and Newspaper/Radio Cross-Ownership Waiver Policy, MM Docket No. 01-235, 96-197; December 3, 2001)

"Motion To Intervene And Request For Rehearing Of The Consumer Federation Of America," before the Federal Energy Regulatory Commission, San Diego Gas & Electric Company, Complaint, v. All Sellers of Energy and Ancillary Services Into Markets Operated by the California Independent System Operator and the California Power Exchange, Docket Nos. EL00-95-000 et al,

"Reply Comments of the Consumer Federation Of America," before the Federal Energy Regulatory Commission, San Diego Gas & Electric Company, Complaint, v. All Sellers of Energy and Ancillary Services Into Markets Operated by the California Independent System Operator and the California Power Exchange, Docket Nos. EL00-95-000 et al,

"Reply Comments Of Texas Office Of Public Utility Counsel, Consumer Federation Of America, Consumers Union," Federal Communications Commission, In The Matter Of Inquiry Concerning High Speed Access To The Internet Over Cable And Other Facilities, GN Docket No. 00-185, January 11, 2001

"Comments Of Texas Office Of Public Utility Counsel, Consumer Federation Of America, Consumers Union," Federal Communications Commission, In The Matter Of Inquiry Concerning High Speed Access To The Internet Over Cable And Other Facilities, GN Docket No. 00-185, December 1, 2000

"Statement before the *en banc* Hearing in the Matter of the Application of America Online, Inc. and Time Warner, Inc. for Transfer of Control," Federal Communications Commission, July 27, 2000

"Petition to Deny of Consumers Union, the Consumer Federation of America, Media Access Project and Center for Media Education," In the Matter of Application of America Online, Inc. and Time Warner for Transfer of Control, CS 00-30, April 26, 2000

"Comments Of The Consumer Federation Of America, In the Matter of Application of SBC Communications Inc. and Southwestern Bell Telephone Company and Southwestern Bell Communications Services, Inc. D/B/A Southwestern Bell long Distance for Provision of In-Region, InterLATA Services in Texas, Before the Federal Communications Commission, CC Docket No. 00-4, February 28, 2000

"Consumer Federation Of America, Request For Reconsideration Regional Transmission Organizations," Federal Energy Regulatory Commission, Docket No. RM99-2-000; Order No. 2000, January 20, 2000

"Reply Comments Of Texas Office Of Public Utility Counsel Consumer Federation Of America Consumers Union (Joint Consumer Commentors), In the Matter of Access Charge Reform Price Cap Performance Review for Local Exchange Carriers Low Volume Long Distance Users Federal-State Joint Board On Universal Service, Before The Federal Communications Commission, CC Docket No. 96-262, CC Docket No. 94-1, CC Docket No. 99-249, CC Docket No. 96-45, December 3, 1999.

"Reply Comments Of The Consumer Federation Of America, Consumers Union, and AARP, Proposed Transfer Of Control SBC And Ameritech," Before the Federal Communications Commission, Cc Docket No. 98-141, November 16, 1999

"Comments Of Texas Office Of Public Utility Counsel Consumer Federation Of America Consumers Union (Joint Consumer Commentors), In the Matter of Access Charge Reform Price Cap Performance Review for Local Exchange Carriers Low Volume Long Distance Users Federal-State Joint Board On Universal Service, Before The Federal Communications Commission, CC Docket No. 96-262, CC Docket No. 94-1, CC Docket No. 99-249, CC Docket No. 96-45, November 12, 1999.

"Reply Comments Of Texas Office Of Public Utility Counsel Consumer Federation Of America Consumers Union (Joint Consumer Commentors), In the Matter of Low Volume Long Distance Users Federal-State Joint

Board On Universal Service, Before The Federal Communications Commission, CC Docket No. 99-249, October 20, 1999.

"Comments Of The Consumer Federation Of America," In the Matter of Application of New York Telephone Company (d/b/a/ Bell Atlantic – New York, Bell Atlantic Communications, Inc. NYNEX Long Distance Company and Bell Atlantic Global Networks, Inc., for Authorization To Provide In-Region, InterLATAServices in New York, Before the Federal Communications Commission, CC Docket No. 99-295, October 20, 1999

"Comments Of Texas Office Of Public Utility Counsel Consumer Federation Of America Consumers Union (Joint Consumer Commentors), In the Matter of Low Volume Long Distance Users Federal-State Joint Board On Universal Service, Before The Federal Communications Commission, CC Docket No. 99-249, September 20, 1999

"Reply Comments of Consumer Federation of America on Joint Petition for Waiver," before the Federal Communications Commission, In the Matter of Implementation of the Subscriber Carrier Selection Changes Provision of the Telecommunications Act of 1996, Policies and Rule Concerning Unauthorized Changes of Consumers Long Distance Carriers, CC Docket NO. 94-129, FCC 98-334

"Joint Comments of Texas Office Of Public Utility Counsel Consumer Federation Of America National Association Of State Utility Consumer Advocates Consumers Union," In the Matter of Federal-State Joint Board On Universal Service Access Charge Reform Before The Federal Communications Commission, Before The Federal Communications Commission, CC Docket No. 96-45, CC Docket No. 96-262, July 23, 1999

"Affidavit of Dr. Mark N. Cooper on Behalf of Consumer Intervenors," RE: In the Matter of Applications for Consent to the Transfer Of Control of Licenses and Section 214 Authorizations from Ameritech Corporation, Transfer, to SBC Communications Inc., Transferee, Before The Federal Communications Commission, CC Dkt. No. 98-141, July 17, 1999.

"Reply comments of the Consumer Federation of America, Consumers Union and AARP, before the Federal communications Commission, before the Federal Communications Commission, Proposed Transfer of Control SBC and Ameritech, CC Docket" No. 98-141, November 16, 1998.

"Comments and Reply Comments of the Consumer Federation of America, International Communications Association and National Retail Federation Petition," before the Federal Communications Commission, In the Matter of Access Charge Reform, Price Cap Performance Review for Local Exchange Carriers, Consumer Federation of America, International Communications Association and National Retail Federation Petition Requesting Amendment of the Commission's Rules Regarding Access Charge Reform and Price Cap Performance Review for Local Exchange Carriers, Federal Communications Commission, CC Docket Nos. 96-262, 94-1, RM9210, October 25, 1998, November 9, 1998.

Letter to William E. Kennard, on behalf of The Consumer Federation of America, in Reciprocal Compensation of Internet Traffic, November 5, 1998.

Preserving Affordable Basic Service Under the '96 Telecom Act, to the Federal Communications Commission and the Federal-State Joint Board, October 29, 1998.

"Reply Comments Of The Consumer Federation Of America And Consumers Union," before The Federal Communications Commission. In The Matter Of Deployment Of Wireline Services Offering Advanced Telecommunications Capability, Etc., CC Docket Nos. 98-147, 98-11 98-26, 98-32, 98-78, 98-91, CCB/CPD Docket N. 98-15 RM 9244, October 16, 1998

"The Impact of Telephone Company Megamergers on the Prospect for Competition in Local Markets, before the Federal communications Commission, before the Federal Communications Commission, Proposed Transfer of Control SBC and Ameritech, CC Docket" No. 98-141, October 15, 1998

The Impact of Telephone Company Megamergers on the Prospect for Competition in Local Markets, Comments of The Consumer Federation of America and Consumers Union, before the Federal communications Commission, before the Federal Communications Commission, Proposed Transfer of Control SBC and Ameritech, CC Docket" No. 98-141, October 15, 1998

Letter to William E. Kennard, on Behalf of the Consumer Federation of America, in Re: Pass through of Access Charge Reductions, August 13, 1998.

"Statement of Dr. Mark N. Cooper, on behalf of the Consumer Federation of America," In the Matter of Federal-State Joint Board On Universal Service Forward Looking Mechanisms for High Cost Support for Non-Rural LECs, June 8, 1998.

"Reply Comments of Consumers Union and the Consumer Federation of America, before the Federal Communications Commission," In the Matter of Consumer Federation of America, International Communications Association and National Retail Federation Petition Requesting Amendment of the Commission's Rules Regarding Access Charge Reform and Price Cap Performance Review for Local Exchange Carriers, Federal Communications Commission, Docket No. RM9210, February 17, 1998

"Statement of Dr. Mark N. Cooper, on Behalf of the Consumer Federation of America," Before the Federal Communications Commission, Re: Cable TV Rates, December 18, 1997.

Letter to William Kennard, on Behalf of The Consumer Federation of America, Re: Long Distance Basic Rates, November 26, 1997.

Letter to William E. Kennard, on behalf of the Consumer Federation of America, Re; Proposed Revision of Maximum Collection Amounts for Schools and Libraries and Rural Health Care Providers, Public Notice, CC Docket No. 96-45; DA 98-872, May 21, 1998.

"Reply Comments of Consumers Union and the Consumer Federation or America," In the Matter of Consumer Federation or America, International Communications Association and National Retail Federation Petition Requesting Amendment of the Commission's Rules Regarding Access Charge Reform and Price Cap Performance Review for Local Exchange Carriers, Federal Communications Commission, Docket No. RM9210, February 17, 1998.

"Reply Comments of the Consumer Federation of America," In the Matter of Application by BellSouth Corporation, BellSouth Telecommunications, Inc., and BellSouth Long Distance, Inc., for Provision of In-Region, InterLATA Services in Louisiana, Federal Communications Commission, CC Docket No. 97-231, December 19, 1997

Letter to Reed Hundt, on Behalf of the Consumer Federation of America, Re: CC Docket NO. 92-237: Carrier Identification Codes, October 15, 1997

"Statement of Dr. Mark N. Cooper, on Behalf of the Consumer Federation of America," before the Federal Communications Commission, In Re: Petition of Consumers Union and the Consumer Federation of America to Update Cable TV Regulation and Freeze Existing Cable Television Rates, MM Docket Nos. 92-264, 92-265, 92-266, September 22, 1997

"Reply Comments of Consumer Federation of America and Consumer Action on Remand Issues in the Pay Telephone Proceeding," Federal Communications Commission, In the Matter of Implementation of the Pay Telephone Reclassification and Compensation Provisions of the Telecommunications Act of 1996, CC Docket NO. 96-128, DA 97-1673 (Remand), September 9, 1997.

Letter to Reed Hundt, Consumer Federation of America, Re: Ameritech 271 Application for Michigan, CC Docket No. 97-137, August 11, 1997.

"Statement of Dr. Mark N. Cooper," Federal Communications Commission, Hearing on Cable Television Competition and Rates, December 18, 1997

"Reply Comments of the Consumer Federation of America," In the Matter of Application by BellSouth Corporation, et. al. For Provision of In-Region, InterLATA Services in South Carolina, Federal Communications Commission, CC Docket No. 97-208, November 14, 1997

"Statement of Dr. Mark N. Cooper," In Re: Petition of Consumers Union and the Consumer Federation of America to Update Cable TV Regulation and Freeze Existing Cable Television Rates, Federal Communications Commission, September 22, 1997.

"The Telecommunication Act of 1996: The Impact on Separations of Universal Service and Access Charge Reform," before the Federal State Joint Board on Separations, February 27, 1997

"Comments of the Consumer Federation of America," before the Federal Communications Commission In the Matter of Federal-State Joint Board on Universal Service, CC Docket No. 96-45, August 2, 1996

"In the Matter of Allocation of Costs Associated with Local Exchange Carrier Provision of Video Programming Services," before the Federal Communications Commission, In the Matter of Allocation of Costs Associated with Local Exchange Carrier Provision of Video Programming Services, CC Docket No. 96-122, June 12, 1996

"Comments of Consumer Federation of America," before the Federal Communications Commission, In the Matter of the Local Competition Provisions of the Telecommunications Act of 1996, 1996

"Statement of Dr. Mark N. Cooper," Before the Federal Communications Commission, In Re: Review of the Commission's Regulations Governing Television Broadcasting, MM Docket No. 91-221, July 10, 1995

"Cost Analysis and Cost Recovery on the Information Superhighway, Evidence of Dr. Mark N. Cooper on behalf of the National Anti-poverty Organization and Federation Nationale des Associations Consumateurs du Quebec," before the Canadian Radio-Television and Telecommunications Commission, Review of Regulatory Framework, Public Notice CRTC 92-78, April 13, 1995

"Affidavit in Support of the Petition for Relief of the Center for Media Education, Consumer Federation of America, the United Church of Christ, the National Association for the Advancement of Colored People, and the National Council of La Raza, May 24, 1994

"Response of the Consumer Federation of America and the Center for Media Education to Bell Atlantic's Request for an Expedited Waiver Relating to Out-of-Region Interexchange Services and Satellite Programming Transport," Department of Justice, In Re: United States of America v. Western Electric Company, Inc., and American Telephone and Telegraph Company, Civil No. 82-0192 (HHG), March 8, 1994

"Petition to Deny: Center For Media Education and Consumer Federation of America," before the Federal Communications Commission, In the Matter of the Application of U.S. West Communications Inc., for Authority Under Section 214 of the Communications Act of 1934, as Amended, to Construct, Operate Own and Maintain Facilities and Equipment to Provide Video Dialtone Service in Portions of the Denver, Portland, Oregon, and Minneapolis -St. Paul Service Area, March 4, 1994

"Comments of the Consumer Federation of America," before the Federal Communications Commission, In the Matter of Implementation of Sections of the Cable Television Consumer Protection Act of 1992, MM Docket No. 92-266, January 27, 1993

"Evidence of Mark N. Cooper: Submission of the National Anti-poverty Organization," before the Canadian Radio-Television and Telecommunications Commission, Review of Regulatory Framework, Public Notice CRTC 92-78, April 13, 1992

"Comment of Mark N. Cooper on Behalf of the Center for Science in the Public Interest," before the Food and Drug Administration, In the Matter of Regulatory Impact Analysis of the Proposed Rule to Amend the food and Labeling Regulations, Docket No. 91N-0219, February 25, 1992

"Comment of Mark N. Cooper on Behalf of the Center for Science in the Public Interest," before the U.S. Department of Agriculture, In the Matter of Preliminary Regulatory Impact Analysis of the Proposed Regulations for Nutrition Labeling of Meat and Poultry, Docket No. 91-006, February 25, 1992

"Comment of the Consumer Federation," before the Federal Communications Commission, In the Matter of Rules and Policies Regarding Calling Number Identification Service, CC Docket No. 91-281, January 1992 "Comments of the Consumer Energy Council of America Research Foundation," before the Environmental Protection Agency, 40 CFR Part 73, December 12, 1991

"Comments of the Consumer Energy Council of America Research Foundation," before the Environmental Protection Agency, 40 CFR Part 73, July 5, 1991

"Affidavit of Dr. Mark N. Cooper on Abuse of the Monopoly Franchise by the Regional Bell Operating Companies in the Marketing of Optional Services," United States District Court for the District of Columbia, United States of America v. Western Electric Company and American Telephone and Telegraph Company, C.A. No. 82-0192, October 17, 1990

"Health Claims in Food Labeling and Advertising: Reexamining the Public Interest After Two Decades of Dispute," Food and Drug Administration, Food Labeling: Advanced Notice of Proposed Rule making, January 5, 1990

"Comments of the Consumer Federation of America, in the Matter of Medicare and Medicaid Programs: Fraud and Abuse OIG Anti-Kickback Provisions, 42 CFR Part 1001, Department of Health and Human Services, March 24, 1989

"Comments of the Consumer Federation of America in the Matter of Railroad Cost Recovery Procedures -- Productivity Adjustment, Ex Parte No. 290 (Sub-No. 4), Interstate Commerce Commission, December 16, 1988

"Answer of the Consumer Federation of America to the Petition of International Flight Attendants," U.S. Department of Transportation, Docket N. 45792, September 20, 1988

"Joint Comments of the Consumer Federation of America and the Environmental Action Foundation," Federal Energy Regulatory Commission, Dockets Nos. RM88-4, 5,6-000, July 18, 1988

"Comments of the Consumer Federation of America in Opposition to the Request to Reopen and Set Aside Consent Order," Federal Trade Commission, Docket No. 9033, July 5, 1988

"Comments of the Consumer Federation of America on the Initiation of National Security Investigations of Imports of Crude Oil and Refined Petroleum Products," Notice of Investigation Under Section 232 of the Trade Expansion Act of 1962, U.S. Department of Commerce, January 28, 1988

"Policies and Rules Concerning Dominant Carriers: The FCC's Price Cap Proposal," Federal Communications Commission, CC. Docket No. 87-313, October 19, 1987

"On Behalf of the Consumers' Association of Canada," Re: CRTC Telecomm Public Notice 187-15, Bell Canada and British Columbia Telephone Company: Rate Rebalancing and Revenue Settlement Issue, Before the Canadian Radio-Television Commission, August 21, 1987

"Comments of the Consumer Federation of America on the Department of Energy's Study of the Impact of Falling Oil Prices on Crude Oil Production and Refining Capacity in the United States, U.S. Department of Energy, November 30, 1986

"Comments of the Consumer Federation of America on the Notice of Proposed Rule making Issued May 30, 1985," before the Federal Energy Regulatory Commission, Docket No. RM85-1-000 (Part A-D), July 15, 1985

"Comments of the Consumer Federation of America and U.S. Public Interest Research Group, in the Matter of MTS and WATS Market Structure and Amendment of Part 67 of the Commission's Rules and Establishment of a Joint Board" Before the Federal Communications Commission, CC Docket Nos. 78-72 and 80-286, April 26, 1985

"On Behalf of the California Human Development Corporation, et al., v. Raymond L. Donovan, Secretary, U.S. Department of Labor," United States District Court for the District of Columbia, Case No. 83-3008, March 20, 1984

"Utility Fuels, Inc. v. Burlington Northern Railroad Co., Fort Worth and Denver Ry. Co, and Atchison, Topeka and Santa Fe Ry. Co, before the Interstate Commerce Commission, Docket No. 39002, December 16. 1983, on Behalf of Utility Fuels, Inc.

"In the Matter of the Petition of the State of Michigan Concerning the Effects of Certain Federal Decisions on Local Telephone Service," before the Federal Communications Commission, CC Docket No. 83-788, September 26, 1983

"In the Matter of Coal Rate Guidelines -- Nationwide, ExParte No. 347 (Sub No. 1)," before the Interstate Commerce Commission, July 28, 1983

"Federal Energy Conservation Programs," before the United States Environmental Protection Agency, July 14, 1981

"Building Energy Performance Standards," before the Department of Energy, March 27, 1980

"Comment on the Incremental Pricing Provisions of the Natural Gas Policy Act," before the Federal Energy Regulatory Commission, Docket No. RM 80-10

FEDERAL CONGRESSIONAL

Testimony Of Dr. Mark Cooper On Competition In The Evolving Digital Marketplace, Subcommittee On Courts And Competition Policy, Committee On The Judiciary, U.S. House Of Representatives, September 16, 2010

Testimony of Dr. Mark Cooper on Is There Life After *Trinko*and *Credit Suisse?*

The Role of Antitrust in Regulated Industries, Subcommittee on Courts and Competition Policy Committee on the Judiciary, U.S. House of Representatives, June 15, 2010

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 behalf of Consumer Federation of America, Free Press Consumers Union before the Commerce Committee, U.S. Senate regarding

"Consumers, Competition and Consolidation in the Video Broadband Market," March 11, 2010

Dr. Mark Cooper on behalf of Consumer Federation of America, Free Press, Consumers Union before the, U.S. House of Representatives, Committee on the Judiciary, Subcommittee on Antitrust, Competition Policy and Consumer Rights Regarding

"Competition in the Media and Entertainment Distribution Market," February 25, 2010

Dr. Mark Cooper, on behalf of Consumer Federation of America, Free Press, Consumers Union before the U.S. House of Representatives, Subcommittee on Communications, Technology, and the Internet of the Committee on Energy and Commerce regarding "An Examination of the Proposed Combination of Comcast and NBC Universal," February 4, 2010

Dr. Mark Cooper, on behalf of Consumer Federation of America, Free Press, Consumers Union before the Senate Subcommittee on Antitrust, Competition Policy and Consumer Rights Judiciary Committee on "The Comcast /NBC Universal Merger: What Does the Future Hold for Competition and Consumers?", February 4, 2010

Testimony of Dr. Mark Cooper "Too Big to Fail? The Role of Antitrust Law in Government-Funded Consolidation in the Banking Industry," Subcommittee on Courts and Competition Policy, Committee on the Judiciary, United States House of Representatives, March 17, 2009

"Excessive Speculation In Energy Commodities," Agriculture Committee, United States House of Representatives, July 10, 2008

"Oversight of Energy Markets and Oil Futures Contract," Joint Hearing of the Senate Appropriations Subcommittee on Financial Services and General Government and The and the Committee on Agriculture, Nutrition and Forestry United States Senate, June 17, 2008

"Energy Market Manipulation and Federal Enforcement Regimes," Committee On Commerce, Science And Transportation, United States Senate, June 3, 2008

"The Financial State of the Airline Industry and the Potential Impact of a Delta/Northwest Merger," Senate Committee on Commerce Science and Transportation, Aviation Subcommittee, May 7, 2008

"Consumer Effects of Retail Gas Prices," before the Judiciary Committee Antitrust Task Force, United States House of Representatives, May 7, 2008

"Pumping up Prices: The Strategic Petroleum Reserve and Record Gas Prices," Select Subcommittee on Energy Independence and Global Warming, United States House of Representative, April 24, 2008

"Federal Trade Commission Reauthorization," Senate Energy and Commerce Committee, September 12, 2007

"Prices at the Pump: Market Failure and the Oil Industry," House Judiciary Committee, May 16, 2007

"Competition and the Future of Digital Music," House Judiciary Committee, Antitrust Task Force, February 28, 2007

"The State of the Airline Industry: The Potential Impact of Airline Mergers and Industry Consolidation," Senate Committee on Commerce, Science and Technology, January 24, 2007

"Vertically Integrated Sports Networks and Cable Companies," Senate Judiciary Committee, December 7, 2006

"Universal Service," House Committee on Energy and Commerce, June 21, 2006

"Price Gouging," Senate Committee on Commerce, Science and Transportation, May 23, 2006

"Gasoline: Supply, Price and Specifications," House Committee on Energy and Commerce, May 10, 2006

"Competition and Convergence," Senate Committee on Commerce, Science and Transportation, March 30. 2006

"Antitrust Should Promote Competition on Top of Well Regulated Infrastructure Platforms," Antitrust Modernization Commission, December 5, 2005

"Video Competition in 2005 – More Competition or New Choices for Consumers," Subcommittee on Antitrust, Competition Policy and Consumer Rights, United States Senate, October 19, 2005

"An Oversight Hearing on Record High Gasoline Prices and Windfall Oil Company Profits," Senate Democratic Policy Committee, September 19, 2005

"Hurricane Katrina's Effect on Gasoline Supply and Prices," Committee on Energy and Commerce, U.S. House of Representative, September 7, 2005

“”The Merger Tsunami is Drowning Competition in the Communications Marketplace,” House Energy and Commerce Committee, March 2, 2005

“Testimony of Dr. Mark Cooper on Behalf of the Consumer Federation of America on The Digital Transition – What Can We Learn from Berlin, The Licensed-Gatekeeper Model of Spectrum Management is Kaput,” Subcommittee on Telecommunications and the Internet, Committee on Energy and Commerce, U.S. House of Representatives, July 21, 2004.

“Testimony of Mark Cooper on behalf or The Consumer Federation of America and Consumers Union on the Status of the U.S. Refining Industry,” Subcommittee on Energy and Air Quality, Committee on Energy, U.S. House of Representatives, July 15, 2004

“Testimony of Dr. Mark N. Cooper on Behalf of the consumer Federation of American and Consumers Union on Environment Regulation in Oil Refining,” Environment and Public Works Committee, May 12, 2004

“Testimony Of Dr. Mark Cooper, On Behalf Of Consumer Federation Of America And Consumers Union On Crude Oil: The Source Of Higher Prices? Before TheSenate Judiciary Committee, Antitrust, Competition Policy And Consumer Rights Subcommittee, April 7, 2004

“Testimony of Mark Cooper on Cable Market Power in Multichannel Video Program Distribution,” Subcommittee on Antitrust, Senate Judiciary Committee, February 11, 2004

“Testimony Of Dr. Mark Cooper, Director Of Research On Gasoline Price Volatility,” Senate Commerce Committee, October 9, 2003

“Testimony Of Dr. Mark N. Cooper Director Of Research On Media Ownership,” Before The Senate Commerce Committee, Washington, D. C., October 2, 2003

“Statement of Dr. Mark Cooper on Behalf of the Consumer Federation of America and Consumers Union on The Federal Response to the 2003 Blackout: Time to Put the Public Interest First,” Subcommittee on Oversight of Government Management, The Federal Workforce and the District of Columbia, Committee on Government Affairs, United States Senate, September 10, 2003

“From Cheap Seats To Expensive Products, Anticompetitive Practices From The Old Economy Can Rob Consumers Of The Benefits Of The Internet Statement of Dr. Mark Cooper on behalf of The Consumer Federation Of America,” before The Subcommittee On Commerce, Trade And Consumer Protection, July 18, 2002

“The Financial Status of the Airline Industry,” Committee on Commerce, Science and Transportation, United States Senate, September 20, 2001

“Statement Of Dr. Mark Cooper on Electricity Markets: California,” Subcommittee On Energy And Air Quality House Energy And Commerce Committee’s Subcommittee, March 22, 2001

“Statement of Dr. Mark N. Cooper on Mergers Between Major Airlines: The Anti-Competitive And Anti-Consumer Effects Of The Creation Of A Private Cartel,” Subcommittee On Commerce, Trade And Consumer Protection Committee On Energy And Commerce United States House of Representatives, March 21, 2001

“Statement Of Dr. Mark N. Cooper On The Aviation Competition Restoration Act,” Committee On Commerce, Science And Transportation, United States Senate March 13, 2001

“Statement Of Dr. Mark Cooper on Digital Television,” Senate Commerce Committee, March 1, 2001

“The Proposed United Airlines-US Airways Merger,” Antitrust Committee, United States Senate, June 14, 2000

“Testimony of Dr. Mark N. Cooper on behalf of the Consumer Federation of America and Consumers Union,” Electricity Restructuring at the Federal Level, Subcommittee on Energy and Power, U.S. House of Representatives, October 6, 1999

“Testimony of Dr. Mark N. Cooper on Electricity Competition: Consumer Protection Issues,” before the Subcommittee on Energy and Power, Energy and Commerce Committee, United States House of Representatives, May 26, 1999

“Testimony of Dr. Mark N. Cooper on The Regulation of Public Utility Holding Companies,” Committee on Banking, Housing, and Urban Affairs, United States Senate, April 29, 1997

"Testimony of Dr. Mark N. Cooper on Behalf of the Consumer Federation of America and the Environmental Action Foundation on Exempting Registered Holding Companies from the Public Utility Holding Company Act for Diversification into Telecommunications," Committee on Energy and Commerce, United States House of Representatives, July 29, 1994

"Testimony of Dr. Mark N. Cooper on Universal Service and Local Competition and S. 1822," before the Commerce Committee, United States Senate, May 17, 1994

"Testimony of Dr. Mark N. Cooper Director of Research of the Consumer Federation of America on H.R. 3636, The National Communications Competition and Information Infrastructure Act of 1993, and H.R. 3626, The Antitrust Reform Act of 1993 and the Communications Reform Act of 1993" before the Subcommittee on Telecommunications and Finance, Committee on Energy and Commerce, United States House of Representatives, February 3, 1994

"Testimony of Dr. Mark N. Cooper on Major Mergers in the Telecommunications Industry," Subcommittee on Antitrust, Monopolies and Business Rights, November 16, 1993

"Testimony of Dr. Mark N. Cooper on Physician Ownership and Referral Arrangements," before the Subcommittee on Oversight, Committee on Ways and Means, October 17, 1991

"Testimony of Dr. Mark N. Cooper on Airline Competition and Consumer Protection," Subcommittee on Aviation, Committee on Public Works and Transportation, U. S. House of Representatives, May 22, 1991

"Testimony of Dr. Mark N. Cooper on Regulatory Reform in the Electric Utility Industry," Subcommittee on Energy and Power Energy and Commerce Committee, United States House of Representatives, May 2, 1991

"Testimony of Dr. Mark N. Cooper on Telephone Consumer Privacy and Advertising Rights," Subcommittee on Telecommunications and Finance, Energy and Commerce Committee, United States House of Representatives, April 24, 1991

"Testimony of Dr. Mark N. Cooper on Regulatory Reform in the Electric Utility Industry," before the Committee on Energy and Natural Resources, U.S. Senate, March 14, 1991

"Testimony of Mark Cooper and Scott Hempling on Electric Utility Policies of the Federal Energy Regulatory Commission," before the Subcommittee on Environment, Energy and Natural Resources of the Government Operations Committee, U.S. House of Representatives, October 11, 1990

"Testimony of Dr. Mark N. Cooper on Caller Identification," before the Subcommittee on Technology and the Law, Judiciary Committee, U.S. Senate, August 1, 1990

"Testimony of Dr. Mark N. Cooper on Airport Gross Receipts Fees," before the Subcommittee on Economic and Commercial Law, Judiciary Committee, U.S. House of Representatives, June 28, 1990

"Testimony of Dr. Mark N. Cooper on Airport Gross Receipts Fees," before the Subcommittee on Antitrust, Monopolies and Business Rights, Judiciary Committee, U.S. Senate, April 24, 1990

"Testimony of Dr. Mark N. Cooper on Independent Power Producers and the Public Utility Holding Company Act of 1935" Subcommittee on Energy and Power, Committee on Energy and Commerce, United States House of Representatives, September 14, 1989

"Testimony of Dr. Mark N. Cooper on Acid Rain Legislation, Subcommittee on Energy and Power, Committee on Energy and Commerce, United States House of Representatives, September 7, 1989

"Testimony of Gene Kimmelman and Dr. Mark N. Cooper on Competitive Issues in the Cable Television Industry, before the Subcommittee on Antitrust, Monopolies and Business Rights, Judiciary Committee, United States Senate, April 12, 1989

"Testimony of Peggy Miller and Dr. Mark N. Cooper, on the Savings and Loan Crisis," before the Ways and Means Committee, United States House of Representatives, March 9, 1989

"Testimony of Dr. Mark N. Cooper on The Ethics in Patient Referrals Act of 1989 and Physician Self-Referral," before the subcommittee on Health, Committee on Ways and Means, United States House of Representatives, March 2, 1989

"Joint Testimony of the Consumer Federation of American and the Citizen Labor Energy Coalition on Bypass of Natural Gas Local Distribution Companies," before the Subcommittee on Energy Regulation and Conservation, Committee, on Energy and Natural Resources, United States House of Representatives, September 29, 1988

"Independent Power Producers and the Public Utility Holding Company Act of 1935, Subcommittee on Energy and Power of the Energy and Commerce Committee, U.S. House of Representatives, September 14, 1988

"Physician Self-Dealing and Quality Control in Clinical Laboratory Testing," Energy and Commerce Committee, U.S. House of Representatives, July 6, 1988

"Joint Testimony of the Consumer Federation of American and the Citizen Labor Energy Coalition on Bypass of Natural Gas Local Distribution Companies," before the Subcommittee on Energy and Power, Energy and Commerce Committee, United States House of Representatives, May 25, 1988

"Administrative Modifications in the Implementation of the Public Utility Regulatory Act of 1978," before the Committee on Energy and Natural Resources, U.S. Senate, February 2, 1988

"Excess Deferred Taxes," before the Subcommittee on Select Revenue Measures, Ways and Means Committee, U.S. House of Representatives, December 14, 1987

"Electric Utility Regulation," Testimony before the Subcommittee on Energy and Power of the Energy and Commerce Committee, U.S. House of Representatives, September 23, 1987

"Bank Sale of Insurance," Banking Committee, U.S. Senate, July 30, 1987

"Consumer Impacts of Airline Bankruptcies," before the Subcommittee on Aviation, Committee on Public Works and Transportation, U.S. House of Representatives, June 10, 1987

"Oversight of the Rail Industry and the Staggers Act," before the Subcommittee on Surface Transportation, Committee on Commerce, Science and Transportation, June 9, 1987

"Oil Industry Taxes," before the Committee on Finance, U.S. Senate, June 5, 1987

"Comprehensive Natural Gas Legislation," before the Subcommittee on Regulation, Committee on Energy and Natural Resources, U.S. Senate, May 20, 1987

"Federal Policy Toward the Insurance Industry," before the Judiciary Committee, February 18, 1987.

"Railroad Antimonopoly Act of 1986," before the Subcommittee on Commerce, Transportation and Tourism of the Energy and Commerce Committee, U.S. House of Representatives, June 5, 1986

"Comprehensive Natural Gas Legislation," before the Subcommittee on Regulation, Energy and Natural Resources Committee, U.S. Senate, May 20, 1986

"Electric Utility Regulation," before the Subcommittee on Energy Conservation and Power, Energy and Commerce Committee, U.S. House of Representatives, March 20, 1986

"Oil Import Fees," Committee on Energy and Natural Resources, U.S. Senate, March 20, 1986

"Implementation of Staggers Rail Act or 1980," Subcommittee on Commerce, Transportation and Tourism, Energy and Commerce Committee, U.S. House of Representatives, March 13, 1986

"Implementation of the Staggers Rail Act of 1980," before the Subcommittee on Surface Transportation of the Committee on Commerce, Science and Transportation, U.S. Senate, November 4, 1985

"Recent Developments in the Natural Gas Industry," before the Subcommittee on Energy Regulation and Conservation of the Energy and Natural Resource Committee, U.S. Senate, July 11, 1985

"The Consumer Impact of the Proposed Norfolk Southern/Conrail Merger," before the Subcommittee on Commerce, Transportation and Tourism of the Energy and Commerce Committee, U.S. House of Representatives, July 10, 1985

"The Consumer Impact of the Unregulated Railroad Monopoly in Coal Transportation," before the Subcommittee on Monopolies and Commercial Law of the Judiciary Committee, U.S. House of Representatives, June 27, 1975

"The World Energy Outlook," before the Subcommittee on Environment, Energy and Natural Resources of the Government Operations Committee, United States House of Representatives, April 1, 1985

"Phantom Tax Reform," before the Subcommittee on Energy Conservation and Power of the Committee on Energy and Commerce, U.S. House of Representatives, June 12, 1984

"Legislative Proposals Governing Construction Work In Progress," before the Subcommittee on Energy Regulation of the Energy and Natural Resources Committee, United States Senate, April 12, 1984

"Legislation Affecting Oil Company Mergers," before the Subcommittee on Energy and Mineral Resources of the Committee on Energy and Natural Resources, United States Senate, April 10, 1984

"Legislative Proposals Governing Corporate Mergers and Takeovers," before the Subcommittee on Monopolies and Commercial Law of the Committee on Judiciary, United States House of Representatives, March 23, 1984

"Review of Federal Policies Affecting Energy Conservation and Housing," before the Subcommittee on Housing and Community Development of the Committee on Banking, Finance and Urban Affairs, United States House of Representatives, March 21, 1984

"The Staggers Rail Act of 1980," before the Subcommittee on Commerce, Transportation and Tourism of the Committee on Energy and Commerce, United States House of Representatives, July 27, 1983

"Oversight Hearings on the Staggers Rail Act of 1980," before the Subcommittee on Surface Transportation of the Committee on Commerce, Science and Transportation, United States Senate, July 26-27, 1983

"The Export of Alaskan Crude Oil," before the Subcommittee on East Asian and Pacific Affairs of the Committee on Foreign Relations, United States Senate, July 19, 1984

"Economics of Natural Gas Deregulation," before the Joint Economic Committee, United States Congress, April 15, 1983

"Bills to Amend the Export Administration Act," before the Subcommittee on International Finance and Monetary Policy of the Committee on Banking, Housing and Urban Affairs, United States Senate, April 14, 1983

"Reauthorization of the Export Administration Act," before the Subcommittee on International Economic Policy and Trade of the Committee on Foreign Affairs, United States House of Representatives, April 12, 1983

"Pending Natural Gas Legislation," before the Subcommittee on Fossil and Synthetic Fuels of the Committee on Energy and Commerce, United States House of Representatives, March 22, 1983

"Energy Conservation and Jobs," before the Subcommittee on Energy Conservation and Power of the Committee on Energy and Commerce, United States House of Representatives, March 15, 1983

"Natural Gas Hearings," before the Committee on Energy and Natural Resources, United States Senate, March 10, 1983

"The Impacts of Various Energy Tax Options," before the Subcommittee on Fossil and Synthetic Fuels of the Committee on Energy and Commerce, June 15, 1982

"Various Energy Tax Options," before the Subcommittee on Energy and Agricultural Taxation of the Committee on Finance, United States Senate, June 9, 1982

"Natural Gas Policy and Regulatory Issues," before the Committee on Energy and Natural Resources, United States Senate, March 23, 1982

"The Economic Implications of Natural Gas Deregulation," before the Subcommittee on International Trade, Finance and Security Economics of the Joint Economic Committee, United States Congress, February 18, 1982

"The Implementation of Title I of the Natural Gas Policy Act of 1978," before the Committee on Energy and Natural Resources, United States Senate, November 5, 1981

"State and Local Energy Block Grants," before the Committee on Energy and Natural Resources, United States Senate, October 16, 1981

"The National Home Weatherization Act of 1981," before the Subcommittee on Energy Conservation and Supply of the Committee on Energy and Natural Resources, United States Senate, July 15, 1981

"An Alternative Energy Budget," before the Subcommittee on Energy Conservation and Power of the Energy and Commerce Committee, United States House of Representatives, February 27, 1981

"Institutional Analysis of Policy Options to Promote Energy Conservation in New Buildings," before the Subcommittee on Energy Development and Applications of the Committee on Science and Technology, United States House of Representatives, September 25, 1980

"Building Energy Performance Standards," before the Subcommittee on Energy Regulation of the Committee on Energy and Natural Resources, United States Senate, June 26, 1980

"Analysis of No. 2 Distillate Prices and Margins with Special Focus on the Department of Energy's Methodology," before the Subcommittee on Environment, Energy and Natural Resources of the Government Operations Committee, United States House of Representatives, February 12, 1980

STATE AND PROVINCE

State Policymakers Should Accelerate the Transition to Reliance on Efficiency, Renewables, and Intelligent Grid, Management, Energy Committee, Montana Legislature, May 20. 2021

Affidavit of Mark Cooper on Behalf of Nuclear Information Resource Service, et al., In the Matter of Hudson River Sloop Clearwater, Inc., Goshen Green Farms, LLC, Nuclear Information And Resource Service, Indian Point Safe Energy Coalition, And Promoting Health And Sustainable Energy, Inc., Petitioners-Plaintiffs, For A Judgment Pursuant To Article 78 Of The Cplr Against- New York State Public Service Commission, Along

With Kathleen Burgess In Her Official Capacity As Secretary, Audrey Zibelman, In Her Official Capacity As Chair, Patricia L. Acampora, Gregg C. Sayre, And Diane X. Burman, In Their Official Capacities As Commissioners, Respondents-Defendants, And, Constellation Energy Nuclear Group, LLC, With Subsidiaries And Affiliates Exelon Generation Company, Llc, R.E. Ginna Nuclear Power Plant, LLC, Nine Mile Point Nuclear Station, LLC, Nominal Respondents-Defendants, Supreme Court Of The State Of New York County Of Albany, Index No. 07242-16).

Direct Testimony of Dr. Mark Cooper on Behalf of Friends of the Earth and Sierra Club, Docket Nos, 2017-207-E, 2017-305-E And 2017-370-E

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

"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 Clear 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 Clear Energy," Before the *Florida Public Service Commission*, FPSC Docket No. 090009-EI, July 15, 2009

"State Regulators, Commodity Markets, And The Collapse Of Market Fundamentalism,Joint Session of the Consumer Affairs and Gas Committees on "Excessive Speculation in Natural Gas Markets: How To Safeguard Consumers," National Association of Regulatory Utility Commissioners, February 17, 2009

"21st Century Policies to Achieve 21st Century Goals," prepared for Wisconsin Citizens Utility Board, Investigation into the Level of Regulation for Telecommunications Providers Updating Telecommunications Regulation in Wisconsin, PSC Docket 5-TI-1777, March 25, 2008

"Comments of the Consumer Federation of America, Consumers Union, and New York Public Interest Research Group Calling for Review and Denial of the Plan for Merger," In the Matter of Joint Petition of Verizon New York Inc. and MCI for a Declaratory Ruling Disclaiming Jurisdiction Over or in the Alternative, for Approval of Agreement and Plan of Merger, Public Service Commission, State of New York, Case No. 05-C-0237, April 29, 2005

"Rebuttal Testimony of Dr. Mark Cooper on Behalf of AARP," In re: Application of the National School Lunch Program and Income-Based Criterion at or Below 135% of the Federal Poverty Guidelines as Eligibility Criteria for the Lifeline and Link-up Programs, before the Florida Public Service Commission, Docket No. 040604-TL, December 17, 2004

"Direct and Rebuttal Testimony Of Dr Mark N. Cooper On Behalf Of Texas Office Of Public Utility Council," Impairment Analysis Of Local Circuit Switching For The Mass Market, Public Utility Commission Of Texas, Docket No. 28607, February 9, 2004**,** March 19, 2004

"Direct Testimony Of Dr Mark N. Cooper On Behalf Of AARP," Before The Florida Public Service Commission, Docket No. 030867-Tl, 030868-TL, Docket No. 030869-Tl, October 2, 2003

"Affidavit of Dr. Mark Cooper on Behalf of the Wisconsin Citizen Utility Board," Petition of Wisconsin Bell, Inc., for a Section 271 Checklist Proceeding, before the Public Service Commission of Wisconsin, 6720-TI-170, June 10, 2002

"Opposition of the Consumer Federation of America and TURN," In the Matter of the Application of Comcast Business Communications, Inc. (U-5380-C) for Approval of the Change of Control of Comcast Business Communications, Inc., That Will Occur Indirectly as a Result of the Placement of AT&T Broadband and Comcast Corporation Under a New Parent, AT&T Comcast Corporation, In the Matter of the Application of AT&T Broadband Phone of California, LLC (U-5698-C) for Approval of the Change of Control of AT&T Broadband Phone of California, LLC That Will Occur Indirectly as a Result of the Placement of AT&T Broadband and Comcast Corporation Under a New Parent, AT&T Comcast Corporation, Public Utilities Commission Of The State Of California, Application 02-05-010 02-05-011, June 7, 2002

"Protecting the Public Interest Against Monopoly Abuse by Cable Companies: Strategies for Local Franchising Authorities in the AT&T Comcast License Transfer Process, Statement to the City of Boston," May 14, 2002

"Prefiled Testimony Of Dr. Mark N. Cooper On Behalf Of The Virginia Citizen Consumers Council," <u>In The Matter Of Application Of Virginia Electric And Power Company For Approval Of A Functional Separation Plan</u>, Virginia State Corporation Commission, Case No. Pue000584, August 24, 2001

"Direct Testimony Of Dr. Mark N. Cooper On Behalf Of The Attorney General Of Oklahoma, <u>Before The Oklahoma Corporation Commission</u> Application Of Ernest G. Johnson, Director Of The Public Utility Division, Oklahoma Corporation Commission, To Require Public Service Company of Oklahoma To Inform The Commission Regarding Planning Of Energy Procurement Practices And Risk Management Strategies And For A Determination As To Appropriate Methods To Lessen The Impact Of Energy Price Volatility Upon Consumers, Cause No. Pud 2001-00096, May 18, 2001

"Direct Testimony Of Dr. Mark N. Cooper On Behalf Of The Attorney General Of Oklahoma, <u>Before The Oklahoma Corporation Commission</u> Application Of Ernest G. Johnson, Director Of The Public Utility Division, Oklahoma Corporation Commission, To Require Oklahoma Gas and Electric Company To Inform The Commission Regarding Planning Of Energy Procurement Practices And Risk Management Strategies And For A Determination As To Appropriate Methods To Lessen The Impact Of Energy Price Volatility Upon Consumers, Cause No. Pud 2001-00095, May 18, 2001

"Direct Testimony Of Dr. Mark N. Cooper On Behalf Of The Attorney General Of Oklahoma, <u>Before The Oklahoma Corporation Commission</u> Application Of Ernest G. Johnson, Director Of The Public Utility Division, Oklahoma Corporation Commission, To Require Arkla, A Division of Reliant Energy Resources Corporation To Inform The Commission Regarding Planning Of Energy Procurement Practices And Risk Management Strategies And For A Determination As To Appropriate Methods To Lessen The Impact Of Energy Price Volatility Upon Consumers, Cause No. Pud 2001-00094, May 18, 2001

"Direct Testimony Of Dr. Mark N. Cooper On Behalf Of The Attorney General Of Oklahoma, <u>Before The Oklahoma Corporation Commission</u> Application Of Ernest G. Johnson, Director Of The Public Utility Division, Oklahoma Corporation Commission, To Require Oklahoma Natural Gas Company To Inform The Commission Regarding Planning Of Energy Procurement Practices And Risk Management Strategies And For A Determination As To Appropriate Methods To Lessen The Impact Of Energy Price Volatility Upon Consumers, Cause No. Pud 2001-00097, May 14, 2001

"Affidavit Of Mark N. Cooper On Behalf Of The Office Of Consumer Advocate," Before <u>The Pennsylvania Public Utility Commission</u>, Consultative Report On Application Of Verizon Pennsylvania Inc., For FCC Authorization To Provide In-Region Interlata Service In Pennsylvania Docket M-00001435, February 10, 2001

"Statement of Dr. Mark N. Cooper before the Governor's Task on Electricity Restructuring," Las Vegas Nevada, November 30, 2000

"Open Access," <u>Committee on State Affairs of the Texas House of Representatives</u>, August 16, 2000

"Prepared Statement Of Dr. Mark N. Cooper, Director Of Research Consumer Federation of America, on *Internet Consumers' Bill of Rights,*" Senate Finance Committee Annapolis, Maryland March 7, 2000

"Prepared Statement Of Dr. Mark N. Cooper, Director Of Research Consumer Federation of America, on *Internet Consumers' Bill of Rights,*" House Commerce and Governmental Matter Committee Annapolis, Maryland February 29, 2000

"Comments Of The Consumer Federation Of America On The Report Of The Expert Review Panel, To The Budget And Fiscal Management Committee, Metropolitan King County Council," October 25, 1999

"Testimony Of Dr. Mark N. Cooper On Behalf Of AARP," In The Matter Of The Commission Ordered Investigation Of Ameritech Ohio Relative To Its Compliance With Certain Provisions Of The Minimum Telephone Service Standards Set Forth In Chapter 4901:1-5, Ohio Administrative Code, October 20, 1999

"Testimony of Dr. Mark N. Cooper on behalf of Residential Customers, <u>In the Matter of the Investigation on the Commission's Own Motion Into all Matters Relating to the Merger of Ameritech Corporation and SBC Communications Inc.</u> before the Indiana Utility Regulatory Commission in Cause NO. 41255, June 22, 1999

"Testimony of Dr. Mark N. Cooper, on behalf of the Pennsylvania Office of Consumer Advocate," before the Pennsylvania Public Utility Commission, <u>In the Matter of the Joint Petition for Global Resolution of Telecommunications Proceedings</u>, Docket Nos. P-00991649, P-oo981648, June 1999

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the Pennsylvania Office of Consumer Advocate," before the Pennsylvania Public Utility Commission, In the Matter of the Acquisition of GTE by Bell Atlantic, Docket Nos. A-310200F0002, A-311350F0002, A-310222F0002, A-310291F0003, March 23, 1999

"Testimony of Dr. Mark N. Cooper on Behalf of AARP," In the Matter of the SBC Ameritech Merger, Before The Public Utilities Commission Of Ohio, Case No. 99-938-TP-COI, December 1998

"Preserving Just, Reasonable and Affordable Basic Service Rates," on behalf of the American Association of Retired Persons, before the Florida Public Service Commission, Undocketed Special Project, 980000A-SP, November 13, 1998.

"Telecommunications Service Providers Should Fund Universal Service," Joint Meeting Communications Committee and Ad Hoc Committee on Consumer Affairs, NARUC 110th Annual Convention, November 8, 1998

"Testimony of Dr. Mark N. Cooper on behalf of AARP, In the Matter of the Joint Application for Approval of Reorganization of Illinois Bell Telephone Company d/b/a Ameritech Illinois and Ameritech Illinois Metro, Inc. Into SBC Communications Inc., in Accordance with Section 7-204 of the Public Utility Act, Illinois Commerce Commission, Docket NO. 98-055, October 1998

"Testimony and Supplemental Testimony of Dr. Mark N. Cooper on Behalf of the Attorney General," before the Department of Public Utilities, State of Connecticut, Joint Application of SBC Communications Inc. and Southern New England Telecommunications Corporation for Approval of Change of Control, Docket No. 9802-20, May 7, 1998.

"Affidavit of Mark N. Cooper on Behalf of the Consumer Federation of America," before the Public Utilities Commission of the State of California, Rulemaking on the Commission's Own Motion to Govern Open Access to Bottleneck Services and Establish a Framework for Network Architecture Development of Dominant Carrier Networks, Investigation on the Commission's Own Motion Into Open Access and Network Architecture Development of Dominant Carrier Networks, Order Instituting Rulemaking on the Commission's Own Motion Into Competition for Local Exchange Service, Order Instituting, R. 93-04-003, I.93-04-002, R. 95-04-043, R.85-04-044. June 1998.

"Stonewalling Local Competition, Consumer Federation of America," and Testimony of Dr. Mark N. Cooper on behalf of Citizen Action before the Board of Public Utilities, In the Matter of the Board's Investigation Regarding the Status of Local Exchange Competition in New Jersey (Docket No. TX98010010), March 23, 1998.

"Direct Testimony of Mark Cooper on Behalf of Residential Consumers," In the matter of the Investigation on the Commission's own motion into any and all matters relating to access charge reform including, but not limited to high cost or Universal Service funding mechanisms relative to telephone and telecommunications services within the state of Indiana pursuant to IC-8-1-2-51, 58, 59, 69; 8-1-2.6 Et Sec., and other related state statues, as well as the Federal Telecommunications Act of 1996 (47 U.S.C.) Sec. 151, Et. Sec., before the Indiana Utility Regulatory Commission, April 14, 1998

"Affidavit of Mark N. Cooper on Behalf of the Texas Office of Public Utility Counsel," In the matter of Application of SBC. Communications Inc., Southwestern Bell Telephone Company Service Inc., d/b/a Southwestern Bell Long Distance, for Provision of In-Region InterLATA Service Texas, Public Utility Commission of Texas, Project 16251, April 1, 1998

"Comments of The Consumer Federation of America," Re: Case 97-021 - In the Matter of Petition of New York Telephone Company for approve of its statement of generally accepted terms and conditions pursuant to Section 252 of the Telecommunications Act of 1996 and Draft Filing of Petition for InterLATA Entry pursuant to Section 271 of the Telecommunications Act of 1996, before the State of New York, Public Service Commission, March 23, 1998.

"Access Charge Reform and Universal Service: A Primer on Economics, Law and Public Policy," Open Session, before the Washington Transport and Utility Commission, March 17, 1998

"Responses of Dr Mark N. Cooper on behalf of the American Association of Retired persons and the Attorney General of Washington," Public Counsel Section, before the Washington Transport and Utility Commission, March 17, 1998,

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the North Carolina Justice and Community Devilment Center," In the Matter of Establishment of Intrastate Universal Service Support Mechanisms Pursuant to

G.S.62-110 (f) and Section 254 of the Telecommunications Act of 1996, before the North Carolina Utilities Commission, Docket No. P-100, SUB 133g, February 16, 1998

Comments of The Consumer Federation of America," Re: Case 97-021 - In the Matter of Petition of New York Telephone Company for approve of its statement of generally accepted terms and conditions pursuant to Section 252 of the Telecommunications Act of 1996 and Draft Filing of Petition for InterLATA Entry pursuant to Section 271 of the Telecommunications Act of 1996, before the State of New York, Public Service Commission, January 6, 1998.

"Testimony of Dr. Mark N. Cooper on Behalf of the Arizona Consumers Council," In the Matter of the Competition in the Provision of Electric Services Throughout the State of Arizona, The Arizona Corporation Commission, January 21, 1998

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the Virginia Citizens Consumers Council," Virginia Electric Power Company, Application of Approval of Alternative Regulatory Plan, State Corporation Commission of Virginia, December 15, 1997

"Electric Industry Restructuring: Who Wins? Who Loses? Who Cares?" Hearing on Electric Utility Deregulation, National Association of Attorneys General, November 18, 1997

"Direct Testimony of Dr. Mark N. Cooper in Response to the Petition of Enron Energy Services Power, Inc., for Approval of an Electric Competition and Customer Choice Plan and for Authority Pursuant to Section 2801 (E)(3) of the Public Utility Code to Service as the Provider of Last Resort in the Service Territory of PECO Energy Company on Behalf of the American Association of Retired Persons," Pennsylvania Public Utility Commission v. PECO, Docket No. R-00973953, November 7, 1997.

"Policies to Promote Universal Service and Consumer Protection in the Transition to Competition in the Electric Utility Industry," Regulatory Flexibility Committee, Indiana General Assembly, September 9, 1997

"Reply Testimony of Dr. Mark N. Cooper on Behalf of the Attorney General of Arkansas," In the Matter of Rulemaking Proceeding to Establish Rules and Procedures Necessary to Implement the Arkansas Universal Service Fund, Arkansas Public Service Commission, Docket No. 97-041-R, July 21, 1997

"Statement of Dr. Mark N. Cooper," In the Matter of the Rulemaking by the Oklahoma Corporation Commission to Amend and Establish Certain Rules Regarding the Oklahoma Universal Service Fund, Cause No. RM 970000022.

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the Alliance for South Carolina's Children," In Re: Intrastate Universal Service Fund, before the Public Service Commission of South Carolina, Docket NO. 97-239-C, July 21, 1997

"Direct Testimony of Dr. Mark N. Cooper on Behalf of Kentucky Youth Advocate, Inc.," In the Matter of Inquiry into Universal Service and Funding Issues, before the Public Service Commission Commonwealth of Kentucky, Administrative Case NO. 360, July 11, 1997

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the Office of Public Utility Counsel, Application of Southwestern Bell Telephone Company for Non-Rate Affecting Changes in General Exchange Tariff, Section 23, Pursuant to PURA95 s.3.53 (D), before the Public Utility Commission of Texas, July 10, 1997

"Testimony of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons," Application of Pennsylvania Power and Light Company for Approval of its Restructuring Plan Under Section 2806 of the Public Utility Code, Pennsylvania Public Utility Commission, Docket No. R-00973954, July 2, 1997

"Testimony of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons," Application of PECO Company for Approval of its Restructuring Plan Under Section 2806 of the Public Utility Code, Pennsylvania Public Utility Commission, June 20, 1997

"Initial Testimony of Dr. Mark N. Cooper on Behalf of the Attorney General of Arkansas," In the Matter of Rulemaking Proceeding to Establish Rules and Procedures Necessary to Implement the Arkansas Universal Service Fund, Arkansas Public Service Commission, Docket No. 97-041-R, June 16, 1997

"A New Paradigm for Consumer Protection," National Association of Attorney's General, 1997 Spring Consumer Protection Seminar, April 18, 1997.

"Statement of Dr Mark N. Cooper," Project on Industry Restructuring, Public Utility Commission of Texas, Project No. 15000, May 28, 1996

“Direct Testimony of Dr. Mark N. Cooper Submitted on behalf of The American Association of Retired Persons, before the Public Service Commission, State of New York, In the Matter of Competitive Opportunities Case 94-E-0952 New York State Electric and Gas Co. 96-E-0891; Rochester Gas and Electric Corp. 96-E-0898 Consolidated Edison Company of New York, Inc. 96-E-0897

“Direct Testimony of Dr. Mark N. Cooper on Behalf of Office of Consumer Advocate,” before the Pennsylvania Public Utility Commission, Pennsylvania Public Utility Commission Bureau of Consumer Services v. Operator Communications, Inc. D/b/a Oncor Communications, Docket No. C-00946417, May 2, 1997

“Direct Testimony of Dr. Mark N. Cooper, on Behalf of New York Citizens Utility Board, the Consumer Federation of America, the American Association of Retired Persons, Consumers Union, Mr. Mark Green, Ms. Catherine Abate, the Long Island Consumer Energy Project,” before the Public Service Commission, State of New York, Proceeding on Motion of the Commission as the Rates, Charges, Rules and Regulations of New York Telephone Company, NYNEX Corporation and Bell Atlantic Corporation for a Declaratory Ruling that the Commission Lacks Jurisdiction to Investigate and Approve a Proposed Merger Between NYNEX and a Subsidiary of Bell Atlantic, or, in the Alternative, for Approval of the Merger, Case 96-c-603, November 25, 1996

“Consumer Protection Under Price Cap Regulation: A Comparison of U.S. Practices and Canadian Company Proposals,” before the CRTC, Price Cap Regulation and Related Matters, Telecom Public Notice CRTC, 96-8, on behalf of Federation Nationale des Associations de Consommateurs du Quebec and the National Anti-Poverty Organization, August 19, 1996

“Responses of Dr. Mark N. Cooper on Behalf of the Attorney General of Oklahoma,” In the Matter of the Rulemaking by the Oklahoma Corporation Commission to Establish Rules and Regulations Concerning Universal Service, Cause NO. RM 96000015, May 29, 1996

“Statement of Dr. Mark N. Cooper on Behalf of the Attorney General of Oklahoma,” In the Matter of the Oklahoma Corporation Commission to Establish Rules and Regulations Concerning Pay Telephones, Cause NO. RM 96000013, May 1996

“Statement of Dr. Mark N. Cooper on Behalf of the Attorney General of Oklahoma,” In the Matter of An Inquiry by the Oklahoma Corporation Commission into Alternative Forms of Regulation Concerning Telecommunications Service, Cause NO. RM 950000404

“Statement of Dr. Mark N. Cooper to the System Benefits Workshop,” Project on Industry Restructuring, Project No. 15000, before the Public Utility Commission of Texas, May 28, 1996

“Remarks of Dr. Mark N. Cooper, Panel o n Service Quality from the Consumer Perspective,” NARUC Winter Meetings, Washington, D.C., February 26, 1996

"Attorney General's Comments," Before the Arkansas Public Service Commission, In the Matter of the Non-Traffic Sensitive Elements of Intrastate Access Charges and Carrier Common Line and Universal Service Fund Tariffs of the Local Exchange Companies, Docket NO. 86-159-U, November 14, 1995

"Reply Comments and Proposed Rules of the Oklahoma Attorney General," Before the Corporation Commission of the State of Oklahoma, In the Matter of the Rulemaking of the Oklahoma Corporation Commission to Establish Rules and Regulations for Local Competition in the Telecommunications Market, Cause No. RM 950000019, October 25, 1995

"Remarks of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons to the Members of the Executive Committee," Indiana Utility Regulatory Commission, in the Matter of the Investigation on the Commission's Own Motion into Any and All Matters Relating to Local Telephone Exchange Competition Within the State of Indiana, Cause No. 39983, September 28, 1995

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the Office of Public Utility Counsel," before the Public Utility Commission of Texas, Petition of MCI Telecommunications Corporation for an Investigation of the Practices of Southwestern Bell Telephone Company Regarding the 713 Numbering Plan Area and Request for a Cease and Desist Order Against Southwestern Bell Telephone Company, SOAH Docket No. 473-95-1003, September 22, 1995

"Rebuttal Testimony of Dr. Mark N. Cooper on Behalf of the Office of the Attorney General State of Arkansas," Before the Arkansas Public Service Commission, In the Matter of an Earnings Review of GTE Arkansas Incorporated, Docket NO. 94-301-U, August 29, 1995

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the Office of Public Utility Counsel," before the Public Utility Commission of Texas, Petition of MCI Telecommunications Corporation for an Investigation of the Practices of Southwestern Bell Telephone Company Regarding the 214 Numbering Plan Area and Request for a Cease and Desist Order Against Southwestern Bell Telephone Company, Docket NO. 14447, August 28, 1995

"Direct Testimony of Mark N. Cooper On Behalf of the Office of the People's Counsel of the District of Columbia," Before the Public Service Commission of the District of Columbia, In the Matter of Investigation Into the Impact of the AT&T Divestiture and Decisions of the Federal Communications Commission on the Chesapeake and Potomac Telephone Company's Jurisdictional Rates, July 14, 1995

"Comments of Consumer Action and the Consumer Federation of America," Before the Public Utilities Commission of California, Order Instituting Rulemaking on the Commission's Own Motion into competition for Local Exchange Service, Docket Nos. R. 95-04-043 and I. 95-04-044, May 23, 1995

"Testimony of Dr. Mark N. Cooper on Behalf of the Arkansas Attorney General," before the Arkansas Public Service Commission, In the Matter of an Earnings Review of Southwestern Bell Telephone Company, Docket NO. 92-260-U, April 21, 1995

"Promoting Competition and Ensuring Consumer Protection on the Information Superhighway, Testimony of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons and the Consumer Federation of America on Proposed Revisions of Chapter 364," Committee on Commerce and Economic Opportunities, Florida Senate, April 4, 1995

"Direct Testimony and Exhibits of Dr. Mark N. cooper on Behalf of the Division of consumer Advocacy," In the Matter of Public Utilities Commission Instituting a Proceeding on Communications, Including an Investigation of the Communications Infrastructure in Hawaii, docket No. 7701, March 24, 1995

"Promoting Competition and Ensuring Consumer Protection on the Information Superhighway, Testimony of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons and the Consumer Federation of America on Proposed Revisions of Chapter 364," Florida House of Representative, March 22, 1995

"Prepared Testimony of Dr. Mark N. Cooper on Behalf of the Office of the Attorney General State of Arkansas," Before the Arkansas Public Service Commission, In the Matter of an Earnings Review of GTE Arkansas Incorporated, Docket NO. 94-301-U, March 17, 1995

"Statement of Dr. Mark N. Cooper," DPUC Investigation into The Southern New England Cost of Providing Service, Docket No. 94-10-01, January 31, 1995

"Statement of Dr. Mark N. Cooper," DPUC Exploration of Universal Service Policy Options, Docket No. 94-07-08, November 30, 1994

"Statement of Dr. Mark N. Cooper," DPUC Investigation of Local Service Options, including Basic Telecommunications Service Policy Issues and the Definition of Basic Telecommunications Service, Docket No. 94-07-07, November 15, 1994

"Testimony of Dr. Mark N. Cooper on Behalf of Attorney General of the Commonwealth of Kentucky, Utility and Rate Intervention Division, before the Public Service Commission, Commonwealth of Kentucky, Case No. 94-121, August 29, 1994

"Testimony of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons," before the Public Utilities Commission of Ohio, In the Matter of the Application of the Ohio Bell Telephone Company for Approval of an Alternative Form of Regulation and In the Matter of the Complaint of the Office of Consumers' Counsel, v. Ohio Bell Telephone Company, Relative to the Alleged Unjust and Unreasonable Rates and Charges, Case Nos. 93-487-TP-ALT, 93-576-TP-CSS, May 5, 1994

"Reply Testimony of Dr. Mark N. Cooper on Behalf of the Attorney General of Arkansas," before the Arkansas Public Service Commission, in the Matter of the Consideration of Expanded Calling Scopes and the Appropriate NTS Allocation and Return on Investments for the Arkansas Carrier Common Line Pool, Docket No. 93125-U, May 4, 1994

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the Attorney General of Arkansas," before the Arkansas Public Service Commission, in the Matter of the Consideration of Expanded Calling Scopes and the Appropriate NTS Allocation and Return on Investments for the Arkansas Carrier Common Line Pool, Docket No. 93125-U, April 22, 1994

"Comments of Dr. Mark N. Cooper on Behalf of Consumers Union, Southwest Regional Office, before the Public Utility Commission of Texas, Request for Comments on the Method by which Local Exchange Services are Priced, Project No. 12771, April 18, 1994

"Comments of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons," Before the Tennessee Public Service Commission, Inquiry for Telecommunications Rule making Regarding Competition in the Local Exchange, Docket No. 94-00184, March 15, 1994

"Rebuttal Testimony of Dr. Mark N. Cooper on Behalf of the Virginia Citizens Consumer Council, Inc., before the State Corporation Commission at Richmond, Commonwealth of Virginia, In the Matter of Evaluating Investigating the Telephone Regulatory Case No. PUC930036 Methods Pursuant to Virginia Code S 56-235.5, March 15, 1994

"Testimony of Dr. Mark N. Cooper on Behalf of the Virginia Citizens Consumer Council, Inc., before the State Corporation Commission at Richmond, Commonwealth of Virginia, In the Matter of Evaluating Investigating the Telephone Regulatory Case No. PUC930036 Methods Pursuant to Virginia Code S 56-235.5, February 8, 1994

"Testimony of Dr. Mark N. Cooper on Behalf of The American Association of Retired Persons, Citizen Action Coalition, Indiana Retired Teachers Association, and United Senior Action, before the Indiana Utility Regulatory Commission, Cause No. 39705, December 17, 1993

"Testimony of Dr. Mark N. Cooper on Behalf of the Virginia Citizens Consumer Council, Inc.," before the State Corporation Commission at Richmond, Commonwealth of Virginia, In the Matter of Evaluating the Experimental Plan for Alternative Regulation of Virginia Telephone Companies, Case No. PUC920029, October 22, 1993

"Testimony of Dr. Mark N. Cooper on Behalf of the Attorney General," before the Arkansas Public Service Commission, In the Matter of An Earnings Review of Southwestern Bell Telephone Company, Docket No. 92-260-U, 93-114-C, August 5, 1993

"Rebuttal Testimony of Dr. Mark N. Cooper on Behalf of the Attorney General," before the Public Service Commission of the State of Missouri, The Staff of the Missouri Public Service Commission vs. Southwestern Bell Telephone and Telegraph Company, Case No. TO-93-192, April 30, 1993

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the Office of Consumer Counsel," before the Public Utilities Commission of the State of Colorado, In the Matter of the Investigatory Docket Concerning Integrated Service Digital Network, Docket No. 92I-592T

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the People's Counsel," before the Florida Public Service Commission, Comprehensive Review of the Revenue Requirement and Rate Stabilization Plan of Southern Bell Telephone and Telegraph Company, Docket No. 900960-TL, November 16, 1992

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons," before the Florida Public Service Commission, Comprehensive Review of the Revenue Requirement and Rate Stabilization Plan of Southern Bell Telephone and Telegraph Company, Docket No. 900960-TL, November 16, 1992

"Testimony of Dr. Mark N. Cooper" before the Regulatory Flexibility Committee, General Assembly, State of Indiana, August 17, 1992

"Testimony of Dr. Mark N. Cooper On Behalf of the Consumer Advocate," before the Public Service Commission of South Carolina, Petition of the Consumer Advocate for the State of South Carolina to Modify Southern Bell's Call Trace Offering, Docket No. 92-018-C, August 5, 1992

"Telecommunications Infrastructure Hoax," before the Public Service Commission of Colorado, Conference on ISDN for the Rest of Us, April 23, 1992

"Testimony of Dr. Mark N. Cooper on Behalf of the Consumer Federation of America," before the Corporation Commission of the State of Oklahoma, In the Matter of the Corporation Commission's Notice of Inquiry Regarding Telecommunications Standards in Oklahoma, Cause No. PUD 1185, February 28, 1992

"Testimony of Dr. Mark N. Cooper on Behalf of the Consumer Federation of America," before the Georgia Public Service Commission, In the Matter of A Southern Bell Telephone and Telegraph Company Cross-subsidy, Docket No. 3987-U, February 12, 1992

"Testimony of Dr. Mark N. Cooper on Behalf of the Consumer Federation of America," before the Arkansas Public Service Commission, in the Matter of an Inquiry into Alternative Rate of Return Regulation for Local Exchange Companies, Docket No. 91-204-U, February 10, 1992

"Statement on Behalf of the Consumer Federation of America on HB 1076," before the Missouri General Assembly, January 29, 1992

"Testimony on behalf of the American Association of Retired Persons and the Consumer Federation of America," before the Legislative P.C. 391 Study Committee of the Public Service Commission of Tennessee, January 13, 1992

"Direct Testimony on Behalf of the "Consumer Advocate," Public Service Commission State of South Carolina, In the Matter of the Application of Southern Bell Telephone and Telegraph Company for Approval of Revision to its General Subscribers Service Tariff (Caller ID), Docket No. 89-638-C, December 23, 1991

"Comments of the Consumer Federation of America on Proposed Telecommunications Regulation in New Jersey (S36-17/A-5063)," New Jersey State Senate, December 10, 1991

"Comments of the Consumer Federation of America," Before the Public Service Commission, State of Maryland, In the Matter of a Generic Inquiry by the Commission Into the Plans of the Chesapeake and Potomac Telephone Company of Maryland to Modernize the Telecommunications Infrastructure, Case No. 8388, November 7, 1991

"On Behalf of the Office of Consumers Counsel," before the Public Utilities Commission of Ohio, In the Matter of the Application of the Ohio Bell Telephone Company to Revise its Exchange and Network Services Tariff, P.U.C.O. No. 1, to Establish Regulations, Rates, and Charges for Advanced Customer Calling Services in Section 8. The New Feature Associated with the New Service is Caller ID, Case No. 90-467-TP-ATA; In the Matter of the Application of the Ohio Bell Telephone Company to Revise its Exchange and Network Service Tariff, P.U.C.O. No 1, to Establish Regulations, Rates and Charges for Advanced Customer Calling Services in Section 8., The New Feature Associated with the New Service is Automatic Callback, Case No. 90-471-TP-ATA, September 3, 1991

"On Behalf of the American Association of Retired Persons," Before the Senate Select Telecommunications Infrastructure and Technology Committee, 119th Ohio General Assembly, July 3, 1991

"On Behalf of the Cook County State's Attorney," before the Illinois Commerce Commission, In Re: Proposed Establishment of a Custom Calling Service Referred to as Caller ID and Related Custom Service, Docket Nos. 90-0465 and 90-0466, March 29, 1991

"On Behalf of the Vermont Public Interest Research Group," before the Public Service BoardIn Re: Investigation of New England Telephone and Telegraph Company's Phonesmart Call Management Services, Docket No. 54-04, December 13, 1990

"On Behalf of the Office of Consumer Advocate," before the State of Iowa, Department of Commerce, Utilities Division, In Re: Caller ID and Related Custom Service, Docket No. INU-90-2, December 3, 1990

"On Behalf of the Office of Public Counsel," before the Florida Public Service Commission, In Re: Proposed Tariff Filings by Southern Bell Telephone and Telegraph Company When a Nonpublished Number Can be Disclosed and Introducing Caller ID to Touchstar Service, Docket No. 891194-TI, September 26, 1990

"On Behalf of the Office of Public Advocate," before the Public Service Commission, State of Delaware, In the Matter of: The Application of the Diamond State Telephone Company for Approval of Rules and Rates for a New Service Known as Caller*ID, PSC Docket No. 90-6T, September 17, 1990

"On Behalf of the Maryland People's Counsel," before The Public Service Commission of Maryland, In the Matter of Provision of Caller Identification Service by the Chesapeake and Potomac Company of Maryland, Case No. 8283, August 31, 1990

"On Behalf of the Office of Attorney General," before the Commonwealth of Kentucky, Public Service Commission, In the Matter of the Tariff Filing of GTE South Incorporated to Establish Custom Local Area Signaling Service, Case No. 90-096, August 14, 1990

"On Behalf of the Consumers' Utility Counsel," before the Georgia Public Service Commission Re: Southern Bell Telephone Company's Proposed Tariff Revisions for Authority to Introduce Caller ID, Docket No. 3924-U, May 7, 1990

"Testimony of Dr. Mark N. Cooper on Caller Identification" before the Committee on Constitutional and Administrative Law, House of Delegates, Annapolis, Maryland, February 22, 1990

"On Behalf of the Office of People's Counsel of the District of Columbia," before the Public Service Commission of the District of Columbia in the Matter of the Application of the Chesapeake and Potomac Telephone Company to Offer Return Call and Caller ID within the District of Columbia, Case No. 891, February 9, 1990

"On Behalf of the Office of Consumer Advocate" before the Pennsylvania Public Utility Commission in the Matter of Pennsylvania Public Utility Commission v. The Bell Telephone Company of Pennsylvania, Docket NO. R-891200, May 1989.

"Statement of Dr. Mark N. Cooper, Joint Hearing on the Public Utility Holding Company Act of 1935," Committees on Finance and Technology and Electricity, National Association of Regulatory Utility Commissioners, February 28, 1989

"On Behalf of Manitoba Anti-poverty Organization, the Manitoba Society of Seniors and the Consumers Association of Canada (Manitoba)" before the Public Utilities Board in the Matter of the Request of Manitoba Telephone System for a General Rate Review, February 16, 1989

"On Behalf of the Ohio Consumers Counsel, In the Matter of the Application of GTE MTO Inc. for Authority to Increase and Adjust its Rates and Charges and to Change Regulations and Practices Affecting the Same, Case No. 87-1307-TP- Air," before the Public Utility Commission of Ohio, May 8, 1988

"On Behalf of the Evelyn Soloman, Proceeding on Motion of the Commission as to the Rates, Charges and Regulations of Niagara Mohawk Power Corporation, Case Nos. 29670 and 29671," before the State of New York Public Service Commission, February 16, 1988

"An Economic Perspective - The Status of Competition in the Telecommunications Industry and Its Impact on Taxation Policy," Before the Joint Subcommittee on the Taxation of The Telecommunications Industry, December 8, 1987

"On Behalf of the Office of Consumer Counsel, State of Washington," In the Matter of the Petition of AT&T Communications of Pacific Northwest, Inc. for Classification as a Competitive Telecommunications Company, March 24, 1987

"On Behalf of Manitoba Anti-poverty Organization and the Manitoba Society of Seniors," before the Public Utilities Board in the Matter of the Request of Manitoba Telephone System for a General Rate Review, March 16, 1987

"On Behalf of the Office of Consumers' Counsel, State of Ohio," In the Matter of the Application of the Ohio Bell Telephone Company for Authority to Amend Certain of its Intrastate Tariffs to Increase and Adjust the Rates and Charges and to Change its Regulations and Practices Affecting the Same, Case No. 84-1435-TP-AIR, April 6, 1986

“On Behalf of Manitoba Anti-poverty Organization and Manitoba Society of Seniors," before the Public Utilities Board in the Matter of the Request of Manitoba Telephone System for a General Rate Review, February 6, 1986

"On Behalf of Mississippi Legal Services Coalition, in the Matter of Notice by Mississippi Power and Light of Intent to Change Rates" Before the Mississippi Public Service Commission, April 15, 1985

"On Behalf of the Universal Service Alliance, in the Matter of the Application of New York Telephone Company for Changes in it Rates, Rules, and Regulations for Telephone Service, State of New York Public Service Commission, Case No. 28961, April 1, 1985

"On Behalf of North Carolina Legal Services, in the Matter of Application of Continental Telephone Company of North Carolina for an Adjustment of its Rates and Charges, Before the North Carolina Utilities Commission, Docket No. P-128, Sub 7, February 20, 1985

"On Behalf of the Consumer Advocate in re: Application of Southern Bell Telephone and Telegraph Company for Approval Increases in Certain of Its Intrastate Rates and Charges," Before the South Carolina Public Service Commission, Docket No. 84-308-c, October 25, 1984

"On Behalf of the Office of the Consumers' Counsel in the Matter of the Commission Investigation into the Implementation of Lifeline Telephone Service by Local Exchange Companies," Before the Public Utilities Commission of Ohio, Case No. 84-734-TP-COI, September 10, 1984

"On Behalf of North Carolina Legal Services Resource Center in the Matter of Application Southern Bell Telephone and Telegraph Company for an Adjustment in its Rates and Charges Applicable to Intra-state Telephone

Service in North Carolina," Before the North Carolina Utilities Commission, Docket No. P-55, Sub 834, September 4, 1984

"On Behalf of Mississippi Legal Services Coalition in the Matter of the Citation to Show Cause Why the Mississippi Power and Light Company and Middle South Energy Should not Adhere to the Representation Relied Upon by the Mississippi Public Service Commission in Determining the Need and Economic Justification for Additional Generating Capacity in the Form of A Rehearing on Certification of the Grand Gulf Nuclear Project," Before the Mississippi Public Service Commission, Docket No. U-4387, August 13, 1984

"On Behalf of the Mississippi Legal Services Corporation Re: Notice of Intent to Change Rates of South Central Bell Telephone Company for Its Intrastate Telephone Service in Mississippi Effective January 1, 1984," before the Mississippi Public Service Commission, Docket No. U-4415, January 24, 1984

"The Impact of Rising Energy Prices on the Low Income Population of the Nation, the South, and the Gulf Coast Region," before the Mississippi Public Service Commission, Docket No. U4224, November 1982

"In the Matter of the Joint Investigation of the Public Service Commission and the Maryland Energy Office of the Implementation by Public Utility Companies Serving Maryland Residents of the Residential Conservation Service Plan," before the Public Service Commission of the State of Maryland, October 12, 1982

"The Impact of Rising Utility Rates on he Budgets of Low Income Households in the Region of the United States Served by the Mississippi Power Company and South Central Bell Telephone Company," before the Chancery Court of Forrest County, Mississippi, October 6, 1982

"The Impact of Rising Energy Prices on the Low Income Population of the Nation, the South and the Gulf Coast Region," before the Mississippi Public Service Commission, Docket No. U-4190, August 1982

ATTACHMENT B

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Citations Supporting Building a 21st Century Systems

1 Martinot, Eric. 2016. “Grid Integration of Renewable Energy: Flexibility, Innovation, Experience”. *Annual Review of Environment and Resources.* 41

2 Miller M, Martinot E, Cox S, Speer B, Zinaman O, et al. 2015. *Status report on power system transformation.* Report NREL/TP--6A20--63366. A report of the 21st Century Power Partnership. Golden, CO: National Renewable Energy Laboratory

3 MIT Energy Initiative. 2011. *The future of the electric grid: an interdisciplinary MIT study. Cambridge, MA*

4 National Renewable Energy Laboratory (NREL). 2015. *Power systems of the future*. Report NREL/TP--6A20--62611. A report of the 21st Century Power Partnership. Golden, CO

5 Wiser, Ryan, Andrew Mills and Joachim Seel, 2017. *Impact of Variable Renewable Energy on Bulk Power System Assets, Pricing and Costs,* Argonne and Lawrence Berkeley National Laboratories.

6 Edison Foundation Institute for Electric Innovation. 2014. *Innovations across the grid: partnerships transforming the power sector*. Washington, DC: Edison Foundation

7 Mills, Andrew and Ryan Wiser. 2014. *Strategies for Mitigating*, 24, Power Partnership, *Flexibility in 21st Century Power Systems,* NREL, May 1

8 Orvis, Robbie and Sonia Aggarwal. 2017. *A Roadmap for Finding Flexibility in Wholesale Markets: Best Practices for Market Design and Operations in a High Renewables Future.* Energy Innovation, Policy and Technology. October

9 Gimon, Eric. 2017. b*On Market Designs for a Future with a High Penetration of Variable Renewable Generation*, Submitted to the U.S. Department of Energy Future Markets Workshop*,* September 8. Energy Innovation LLC

10 Loutan. Clyde and Vahan Gevogian. 2017. *Using Renewables to Operate a L:ow-Carbon Grid: Demonstration of Advanced Reliability Services from a Utility-Scale Solar PV Plant. CAISO, NREL*

11 Fox--Penner P. 2010. *Smart Power: Climate Change, the Smart Grid and the Future of Electric Utilities.* Washington DC: Island Press

12 Cochran, Jaquelin, et al. 2013. *Market Evolution: Wholesale Electricity Market Design for 21st Century Power Systems*. NREL

13 Navigant, 2017. *2017 Utiity Demand Resonse Snapshot.* Smart Electric Power Alliance

14 Botterud, Audun. 2017. *Electricity Markets and Renewable Energy: United States vs. Europe.* Argonne National Laboratory. January 27

15 Hirth, Lion. 2016. “The benefits of flexibility: The value of wind energy with hydropower”. Applied Energy. 181

16 Riva, Alberto Dalls, Janos Hethey and Aisma Vitina. 2017. *Impaxt of Wind Turbine Technology on the System Value of Wind in Europe.* Ea Energy Analyses

17 Hirth, Lion. 2018. “What Caused the Drop in Euripean Electricity Pries? A Factor Decomposition analysis." *The Energy Journal. 39*

18 Chang, Judy W., Et al., 2017. *Advancing Past “Baseload” to a Flexible Grid How Grid Planners and Power Markets Are Better Defining System Needs to Achieve a Cost-Effective and Reliable Supply Mix.* NRDC. June.

19 Greenpeace. 2015. *Energy [R]evolution: A Sustainable world energy outlook.* Amsterdam

20 REN21. 2013. *Renewables global futures report.* Paris

21 Hand MM, Baldwin S, DeMeo E, Reilly JM, Mai T, et al. 2012. *Renewable electricity futures study*. Report NREL/TP--6A20–52409, vol. 1–4. Golden, CO: NREL

22 Lovins A and Rocky Mountain Institute. 2011. *Reinventing Fire: Bold Business Solutions for the New Energy Era*. White River, VT: Chelsea Green

23 California Public Utilities Commission. 2015. *Beyond 33% renewables: grid integration policies for a low-carbon future*. Energy Division Staff White Paper. San Francisco

24 NREL. 2014. *Flexibility in 21st century power systems*. Report 61721. A report of the 21st Century Power Partnership. Golden, CO

25 Jones L. 2014. *Renewable Energy Integration: Practical Management of Variability, Uncertainty, and Flexibility in Power Grids.* London: Elsevier

26 IEA. 2014. *The Power of Transformation: Wind, Sun and the Economics of Flexible Power Systems*. Paris

27 Lazar, Jim. 2016. Teaching the "Duck" to Fly, Regulatory Analysis Assistance Project, January

28 IEA--RETD (Renewable Energy Technology Deployment). 2014. *RE-integration: integration of variable renewable electricity sources in electricity systems—lessons learnt and guidelines*. Paris: OECD

29 EIA. 2017c. "Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2017."

30 Gimon, Eric. 2017a. *Flexibility, Not Resilience, is the Key to Wholesale Electricity Market Reform.*

31 Madrigal M, Porter K. 2013. *Operating and planning electricity grids with variable renewable generation: review of emerging lessons from selected operational experiences and desktop studies*. Washington, DC: World Bank

32 Cochran J, Bird L, Heeter J, Arent DJ. 2012. *Integrating Variable Renewable Energy In Electric Power Markets: Best Practices from International Experience*. Report NREL/TP--6A00--53732. Golden, CO: NREL

33 Hogan, Mike. 2012. *Aligning Power Markets to Deliver Value.* Regulatory Analysis Project

34 Holttinen H. 2013. *Expert Group Report on Recommended Practices: Wind Integration Studies, International Energy Agency Wind Task 25*. Paris: IEA

35 Lew, Deborah. 2017. The Power of Small: The Effects of Distributed Energy Resources on System Reliability. *IEEE Power and Energy Magazine,* 6

36 Lovins, Amory B. 2017. " Reliably integrating variable renewables: Moving grid flexibility resources from models to results." *The Electricity Journal.* 30

37 National Renewable Energy Laboratory (NREL), 2016. Forecasting Wind and Solar Generation: Improving System Operations.

38 Karier, T., Fazio, J., 2017. How hydropower enhances the capacity value of renewables and energy efficiency. El. J. 30

39 Forsberg, Charles W., et al. 2017. "Converting Excess Low-Price Electricity into High-Temperature Stored Heat for Industry and High-Value Electricity Production." *The Electricity Journal* 30 (6)

40 IRENA. 2015. *The age of renewable power: designing national roadmaps for a successful transformation.* Bonn

41 Agora Energiewende. 2015. *The European power system in 2030: flexibility challenges and integration benefits.* Berlin

42 Electric Power Research Institute (EPRI). 2015. *The integrated grid: realizing the full value of central and distributed energy resources.* Palo Alto, CA.

43 Safaei, H., Keith, D., 2015. How much bulk energy storage is needed to decarbonize electricity? Energy Environ. Sci.

44 Scholz, Yvonne, Hans Christian Gils, and Robert C. Pietzcker. 2017. "Application of a High-Detail Energy System Model to Derive Power Sector Characteristics at High Wind and Solar Shares." *Energy Economics* 64

45 Droste--Franke B, Paal BP, Rehtanz C, Sauer DU, Schneider JP, et al. 2012. *Balancing Renewable Electricity: Energy Storage, Demand Side Management, and Network Extension from an Interdisciplinary Perspective.* New York: Springer

46 Stark, Greg. 2015. "A Systematic Approach to Better Understanding Integration Costs." Golden, CO: National Renewable Energy Laboratory.

47 Advanced Energy Economy Institute. 2015. *Toward a 21st century electricity system in California.* San Francisco

48 Nelson J and Wisland L. 2015. *Achieving 50 percent renewable electricity in California.* Oakland, CA: Union of Concerned Scientists

49 Stenclik, Derek, Paul Denholm and Babu Chalamala. 2017. Maintaining Balance: The Increasing Role of Energy Storage for Renewable Integration. *IEEE Power and Energy Magazine,* 6

50 Fang, Tingting & Risto Lahdelma (2016): "Optimization of combined heat and power production with heat storage based on sliding time window method", *Applied Energy* 162

51 Brinkman G, Jorgenson J, Ehlen A, Caldwell H. 2016. *California low carbon grid study: analysis of a 50% emission reduction in California.* Report NREL/TP--6A20--64884. Golden, CO: NREL

52 Lew D, Schroder M, Miller N, Lecar M. 2015. *Integrating high levels of variable energy resources in California.* Report prepared for Large--Scale Solar Association. Schenectady, NY: GE Energy Consulting

53 Martinot E. 2015. *Grid integration of renewables in China: learning from the cases of California, Germany, and Denmark*. A White Paper for the China Variable--Generation Integration Group. Beijing: China Energy Research Institute

54 Agora Energiewende. 2015. *The Energiewende in the power sector: state of affairs 2014: a review of the significant developments and an outlook for 2015*. Berlin

55 Agora Energiewende. 2015. *The solar eclipse 2015: outlook for the power system 2030*. Berlin (In German.)

56 German Federal Ministry for Economic Affairs and Energy. 2015. *An electricity market for Germany's energy transition*. White Paper. Berlin

57 Agora Energiewende. 2015. *Understanding the energiewende*. Berlin

58 Agora Energiewende. 2015. *The Danish experience with integrating variable renewable energy: lessons learned and options for improvement*. Berlin

59 Agora Energiewende. 2015. *A snapshot of the Danish energy transition*. Berlin

60 Strøm S, Andersen AN. 2014. The Danish case: Taking advantage of flexible power in an energy system with high wind penetration. See Ref. 25, pp. 239--252

61 Bird L, Cochran J, Wang X. 2014. *Wind and solar energy curtailment: experience and practices in the United States*. Report NREL/TP--6A20--60983. Golden, CO: NREL

62 Fine S, Kumaraswamy K. 2014. Policies for accommodating higher penetration of variable energy resources: US outlook and perspectives. See Ref. 25, pp. 13--26

63 MacDonald, Alexander E., et al. 2016. "Future Cost-Competitive Electricity Systems and Their Impact on US CO2 Emissions." *Nature Clim. Change* 6 (5).

64 Ott A. 2014. Case study: demand response and alternative technologies in (PJM) electricity markets. See Ref. 25, pp. 265--274

65 U.S. Federal Energy Regulatory Commission (FERC). Order No. 1000 -- Transmission Planning and Cost Allocation. Washington DC

66 Hogan M, Weston F, Gottstein M. 2015. *Power market operations and system reliability in the transition to a low-carbon power system: a contribution to the market design debate*. Brussels, Belgium: Regulatory Assistance Project

67 European Network of Transmission System Operators for Electricity (ENTSO--E). 2014. *Ten-year network development plan and regional investment plan*. Brussels

68 Eurelectric. 2010. *Power choices: pathways to carbon-neutral electricity in europe by 2050.* Brussels

69 Wiser, Ryan, Galen Barbose, and Mark Bolinger. 2017. "Retail Rate Impacts of Renewable Electricity: Some First Thoughts." Berkeley, CA: Lawrence Berkeley National Laboratory.

70 Weidman, Joseph and Tom Beach. 2013. "Distributed Generation Policy: Generation on Both Sides of the Meter," *The Electricity Journal.* 26 (8)

71 UKERC. 2017. "The Costs and Impacts of Intermittency – 2016 Update." UK Energy Research Centre.

72 Agora. 2015. "The Integration Costs of Wind and Solar Power An Overview of the Debate on the Effects of Adding Wind and Solar Photovoltaic into Power Systems." Berlin, Germany: Agora, Energiewende.

73 Bloom, Aaron. 2017. It's Indisputable: Five Facts About Planning and Operating Modern Power Systems. *IEEE Power and Energy Magazine,* 6

74 Agora Energiewende. 2015. *The integration costs of wind and solar power.* Berlin

75 Hirth L, Ueckerdt F, Edenhofer O. 2015. Integration costs revisited—An economic framework for wind and solar variability. *Renewable Energy* 74: 925--939.

76 Milligan M, Ela E, Hodge BM, Krby B, Lew D, et al. 2011. Integration of variable generation, cost--causation, and integration costs. *Electricity Journal* 24: 51--63

77 Pudjianto D, Djapic P, Dragovic J, Strbac G. 2013. *Grid integration cost of photovoltaic power generation*. Report prepared for PVParity.eu. London: Imperial College Energy Futures Lab

78 Cochran, Jaquelin, et al. 2014. *Flexibilty in 21st Century Power Systems,* NREL

79 Palensky P, Kupzog F. 2013. Smart grids. *Annual Review of Environment and Resources* 38: 201--226

80 IEA. 2011. *Technology roadmap: smart grids*. Paris

81 Komor P, Hoke A, Kempener R. 2014. Seven steps to a smarter grid. *The Electricity Journal*

82 Cole, Wesley, Jeffrey Logan, Daniel Steinberg, James McCall, James Richards, Benjamin Sigrin, and GianPorro. 2016. "2016 Standard Scenarios Report: A U.S. Electricity Sector Outlook." Golden, CO: National Renewable Energy Laboratory.

83 Gifford, Raymond L. and Matthew S. Larson. 2016. *State Actions in Organized Markets States Strive to 'Fix' Markets and Retain Base Load Generation, Wilkinson, Barker, Nauer, LLC. September7*

84 Cochran J, Lew D, Kumar N. 2013. *Flexible coal: evolution from baseload to peaking plant*. Report BR--6A20--60575. Golden, CO: NREL and 21st Century Power Partnership

85 Balling, L. 2011. Fast cycling and rapid start--up: new generation of plants achieves impressive results. *Modern Power Systems* 31: 35--41

86 Bajwa, Maheen and Joseph Cavicchi. 2017. "Growing Evidence of Increased Frequency of Negative Electricity Prices in U.S. Wholesale Electricity Markets." IAEE Forum. Fourth Quarter

87 Oates, David Luke and Paulina Jaramillo. 2013. "Production cost and air emissions impacts of coal cycling in power systems with large-scale wind penetration." *Environ. Res. Lett.* 8

88 IRENA. 2015. *From baseload to peak: renewables provide a reliable solution.* Abu Dhabi

89 Lund H, Möller B, Mathiesen BV, Dyrelund A. 2010. The role of district heating in future renewable energy systems. *Energy* 35: 1381--1390

90 UN Environment Programme. 2015. *District energy in cities: unlocking the potential of energy efficiency and renewable energy*. Paris

91 Würtenberger L, Bleyl JW, Menkveld M, Vethman P, van Tilburg X. 2012. *Business models for renewable energy in the built environment.* Prepared for IEA--RETD. Petten: Energy Research Center of the Netherlands

92 Sioshansi FP. 2012. Why the time has arrived to rethink the electric business model. *The Electricity Journal* 25(7): 65--74.

93 Department of Energy Notice of Proposed Rulemaking, Docket No. RM17-3-000 "Grid Resiliency Pricing Rule" September 28, 2017, ("NOPR") published in the Federal Register Vol. 82 No. 194 Tuesday October 10, 2017 (82 FR 46,940).

94 Celebi , Metin, et al. 2017. Evaluation of the DOE's Proposed Grid Resiliency Pricing Rule . October 23.

95 Hogan, William W. and Susan L. Pope. 2017. Priorities for the Evolution of Energy Only Electricity Market Design in ERCOT, FTI Consulting. May 9

96 Makovich, Lawrence and James Richards. 2017. *Ensuring Resilient and Efficient Electricity Generation The value of the current diverse US power supply portfolio.* IHS Markit. September

97 Jing Wu et al., "Integrating Solar PV (Photovoltaics) in Utility System Operations: Analytical Framework and Arizona Case Study," *Energy* 85 (2015);

98 Jason Rauch, "Price and Risk Reduction Opportunities in the New England Electricity Generation Portfolio," *Electricity Journal* 27 (2014).

99 Eichman, Joshua D., et al. 2013. Scott Samuelson. "Exploration of the Integration of Renewable Resources into California's Electric System Using the Holistic Grid Resource Integration and Deployment (HiGRID) Tool." *Energy* 50

100 100 IEA. 2014. Technology roadmap: energy storage. Paris

101 101 California Independent System Operator, CPUC, California Energy Commission. 2015. Advancing and maximimizing the value of energy storage technology: a California roadmap. Folsom, CA

102 102 Sarah Becker et al., "Features of a Fully Renewable US Electricity System: Optimized Mixes of Wind and Solar PV and Transmission Grid Extensions," Energy 72 (2014);

103 103 Sarah Becker et al., "Transmission Grid Extensions During the Build-Up of a Fully Renewable Pan-European Electricity Supply," Energy 64 (2014).

104 104 Sioshansi FP. 2014. Distributed Generation and Its Implications for the Utility Industry. London: Academic

105 105 Federal Energy Regulatory Commission (FERC). 2014. Demand response and advanced metering. Staff Report. Washington, DC

106 106 Bayer, Benjamin. 2015. Current practice and thinking with demand response for power system flexibility in U.S. and German electricity markets. Current Sustainable and Renewable Energy Reports 2: 55–62.

107 107 Dupont B, Jonghe CD, Olmos L, Belmans R. 2014. Demand response with locational dynamic pricing to support the integration of renewables. Energy Policy 67: 344–354

108 108 Kiliccote S, Sporborg P, Sheikh I, Huffaker E, Piette MA. 2010. Integrating renewable resources in california and the role of automated demand response. Report LBNL--4189E. Berkeley, CA: Lawrence Berkeley National Laboratory.

109 109 Navigant Consulting. 2012. Potential role of demand response resources in maintaining grid stability and integrating variable reneawble energy under California's 33 percent renewable portfolio standard. San Francisco, CA

110 110 Shariatzadeh F, Mandal P, Srivastava A. 2015. Demand response for sustainable energy systems: a review, application and implementation strategy. Renewable and Sustainable Energy Reviews 45:343--350

111 111 Broad D, Dragoon K. 2014. Demand response for integrating variable renewable energy: a Northwest perspective. See Ref. 25, pp. 253--264

112 112 Allcott, H. 2011. Rethinking real--time electricity pricing. Resource and Energy Economics 33: 820–842

113 113 Hahn T, Schönfelder M, Jochem P, Heuveline V, Fichtner W. 2013. Model--based quantification of load shift potentials and optimized charging of electric vehicles. Smart Grid and Renewable Energy 4: 398--408.

114 114 San Roman TG, Momber I, Abbad MR, Miralles AS. 2011. Regulatory framework and business models for charging plug--in electric vehicles: infrastructure, agents, and commercial relationships. Energy Policy 39:6360--6375

115 115 Obi M, Bass R. 2016. Trends and challenges of grid--connected photovoltaic systems—a review. Renewable and Sustainable Energy Reviews 58:1082--1094

116 116 IEA--RETD. 2014. Residential prosumers – drivers and policy options. Paris

117 117 Findlay C. 2011. Strength in numbers: merging small generators as virtual power plants.

118 118 Navigant Research. 2016. Virtual Power Plants: Demand Response, Supply--Side, and Mixed Asset VPPs. http://www.navigantresearch.com/research/virtual--power--plants. Viewed 2/1/16

119 119 EWE AG and e--Energy. 2014. eTelligence final report. Oldenburg, Germany

120 120 Lew D, Bird L, Milligan M, Speer B, Xi Wang, et al. 2013. Wind and solar curtailment. Report NREL/CP--5500--60245. Golden, CO: NREL

121 121 Li C, Shi H, Cao Y, Wang J, Kuang Y et. al. 2014. Comprehensive review of renewable energy curtailment and avoidance: a specific example of China. Renewable and Sustainable Energy Reviews 41:1067--1079

122 122 Jacobsen HK, Schroeder ST. 2012. Curtailment of renewable generation: economic optimality and incentives. Energy Policy 49:663--675

123 Henriot, A. 2015. Economic curtailment of intermittent renewable energy sources. Energy Economics 49:370--379

124 Kane L, Ault G. 2014. A review and analysis of renewable energy curtailment schemes and principles of access: transitioning towards business as usual. Energy Policy 72:67--77

125 Mills AD, Wiser RH. 2015. Strategies to mitigate declines in the economic value of wind and solar at high penetration in California. Applied Energy 147:269--278

126 IRENA. 2015. Grid investments for renewables. Abu Dhabi

127 NREL. 2013. The Western wind and solar integration study. Report NREL/TP--5500--55588. Golden, CO.

128 NREL. 2011. Eastern wind integration and transmission study. Report NREL/SR--5500--47078. Golden, CO

129 Milligan M, Ela E, Lew D, Corbus D, Wan Y. 2010. Advancing wind integration study methodologies: implications of higher levels of wind. In Proceedings of American Wind Energy Association, Windpower 2010, Dallas, TX

130 Sarah Becker et al., "Renewable Build-Up Pathways for the US: Generation Costs Are Not System Costs," Energy 81 (2015).

131 Martinot E, Kristov L, Erickson JD. 2015. Distribution system planning and innovation for distributed energy futures. Current Sustainable and Renewable Energy Reports 2: 47–54.

132 New York State Department of Public Service. 2014. Reforming the energy vision. Albany, NY: New York State Department of Public Service

133 Union of the Electricity Industry. 2013. Active distribution system management: a key tool for the smooth integration of distributed generation. Brussels: Eurelectric.

134 Sterling J, Davidovich T, Cory K, Aznar A, McLaren J. 2015. The flexible solar utility: preparing for solar's impacts to utility planning and operations. Report NREL/TP--6A20--64586. Golden, CO: NREL

135 EPRI. 2012. Integrating smart distributed energy resources with distribution management systems. Palo Alto, CA

136 Union of Concerned Scientists. 2015. Renewables and reliability: grid management solutions to support California's clean energy future. Cambridge, MA

137 Nivad Navid, Reserve Requirement Identification with the Presence of Variable Generation, UVIG Spring Technical Meeting, April 26, 2012;

138 Ela E, V Gevorgian, P Fleming, YC Zhang, M Singh, et al. 2011. Operating reserves and variable generation. Report NREL/TP--5500--51978. Golden, CO: NREL

139 Ela E, Gevorgian V, Fleming P, Zhang YC, Singh M, et al. 2014. Active power controls from wind power: bridging the gaps. Report NREL/TP--5D00--60574. Golden, CO: NREL

140 Hirth L, Ziegenhagen I. 2013. Control power and variable renewables: a glimpse at German data. Milan, Italy: Fondazione Eni Enrico Mattei

141 General Electric International, Inc. PJM Renewable Integration Study, March 31, 2014; ;

143 Foley AM, Leahy PG, Marvuglia A, McKeogh EJ. 2012. Current methods and advances in forecasting of wind power generation. Renewable Energy 37: 1–8.

144 Australian Energy Market Operator. 2014. Australia wind energy forecasting system. Canberra

145 Botterud A. 2014. Forecasting renewable energy for grid operations.

146 Ela E, Milligan M, Bloom A, Botterud A, Townsend A, Levin T. 2014. Evolution of wholesale electricity market design with increasing levels of renewable generation. Report NREL/TP--5D00--61765. Golden, CO: NREL

147 Morales JM, Conejo AJ, Hadsen H, Pinson P, Zugno M. 2015. Integrating Renewables in Electricity Markets. Operational Problems. New York: Springer

147 Yoram Krozer, "Cost and Benefit of Renewable Energy in the European Union," Renewable Energy 50 (2013);

148 Agora Energiewende. 2014. Negative electricity prices: causes and effects. Berlin

149 149 Lehr RL. 2013. New utility business models: utility and regulatory models for the modern era. The Electricity Journal 26(8): 35--53

150 150 Giorgia Oggioni, F. H. Murphy, and Yves Smeers, "Evaluating the Impacts of Priority Dispatch in the European Electricity Market," Energy Economics 42 (2014);

151 151 Mills, Andrew and Ryan Wiser. 2014. Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels. Environmental Energy Technologies Division. Lawrence Berkely National Laboratory.

152 152 Power Partnership. 2014. Flexibility in 21st Century Power Systems, NREL, May 1

153 153 Blade, Gavin. 2017."Steel for fuel: Xcel CEO Ben Fowke on his utility's move to a renewable-centric gri.," Utility Dive, July 11

154 154 Bikash Kumar Sahu, Moonmoon Hiloidhari, and D. C. Baruah, "Global Trend in Wind Power with Special Focus on the Top Five Wind Power Producing Countries." Renewable and Sustainable Energy Reviews 19 (2013).

155 155 E3, 2015. Higher Renewables Portfolio Standard, E3. Investigating a Higher Renewables Portfolio Standard in California. Energy and Environmental Economics, Inc., January, 2015

156 156 Pfenninger, Stefan, et al. 2014. "Potential for Concentrating Solar Power to Provide Baseload and Dispatchable Power." Nature Climate Change 4

157 157 Renewables International, "Little Power Storage or Coal Power Needed for 40% Green Power Supply," Renewablesinternational.net, August 10, 2012; Imperial College, Integration of Renewable Energy.

158 158 Steve Propper, Evolution of the Grid Edge: Pathways to Transformation (GTM Research, 2015);

159 159 Mills, Andrew and Ryan Wiser. 2013. Solar Valuation in Utility Planning Studies. Clean Energy States Alliance: RPS Webinar. January

160 160 Aggarawal, Sonia and Robbie Orvis. 2016. "Grid Flexibility,: Methods for Modernizing the Power Grid," Energy Innovation," March

161 161 Cochran, J. et al. 2012. Integrating Variable Renewable Energy in Electric Power Markets: Best Practices from International Experience. Golden, CO: National Renewable Energy Laboratory

162 162 Holttinen, H. et al. 2013. "The Flexibility Workout: Managing Variable Resources and Assessing the Need for Power System Modification." IEEE Power & Energy. 11(6)

163 163 Holttinen, H. et al. 2013. Design and Operation of Power Systems with Large Amounts of Wind Power. Final summary report, IEA WIND Task 25, Phase two 2009–2011;

164 164 VTT Technology. www.ieawind.org/task_25/PDF/T75.pdf. IEA. 2014. "The Power of Transformation: Wind, Sun and the Economics of Flexible Power Systems." Paris: OECD, IEA

165 165 Miller, M. et al. 2013. RES-E-NEXT: Next Generation of RES-E Policy Instruments. International Energy Agency's Implementing Agreement on Renewable Energy Technology Deployment (IEA-RETD)

166 166 Milligan, M. et al. 2012. Markets to Facilitate Wind and Solar Energy Integration in the Bulk Power Supply: An IEA Task 25 Collaboration. Golden, CO: National Renewable Energy Laboratory

167 167 Schwartz, L., ed. 2012. Meeting Renewable Energy Targets in the West at Least Cost: The Integration Challenge. Western Governors' Association

168 168 RichardsAuthor Vitae, James, Piyush SabharwallAuthor Vitae, Matthew Memmott. 2017. "Economic comparison of current electricity generating technologies and advanced nuclear options." The Electricity Journal, 30(10) 168

169 169 Oggioni, Giorgia, F. H. Murphy, and Yves Smeers, 2014, "Evaluating the Impacts of Priority Dispatch in the European Electricity Market," Energy Economics 42

170 170 Imperial College, 2014. Integration of Renewable Energy. June 12

171 171 AEMO, 100 Percent Renewables Study: Modelling Outcomes, AEMO, July 2013;

172 172 Duthu, Ray C. and Thomas H. Bradley. 2015. "An Evaluation of Customer-Optimized Distributed Generation in New England Utility and Real-Time Markets," The Electricity Journal 28

173 173 Martínez Ceseña, Eduardo A., et al., 2015.Nicholas Good, and Pierluigi Mancarella, “Electrical Network Capacity Support from Demand Side Response: Techno-Economic Assessment of Potential Business Cases for Small Commercial and Residential End-Users,” Energy Policy 82

174 174 General Electric International, Inc. 2014. PJM Renewable Integration Study, March 31

175 175 Falsafi, Hananeh, Alireza Zakariazadeh, and Shahram Jadid. 2014. “The Role of Demand Response in Single and Multi-Objective Wind-Thermal Generation Scheduling: A Stochastic Programming,” Energy 64

176 176 Arif, Ahmer, Fahad Javed, and Naveed Arshad. 2014. “Integrating Renewables Economic Dispatch with Demand Side Management in micro-Grids: A Genetic Algorithm-Based Approach,” Energy Efficiency 7

177 177 Biegela, Benjamin et al. 2014. “Value of Flexible Consumption in the Electricity Markets,” Energy 66

178 178 Bergaentzlé, Claire Cédric Clastres, and Haikal Khalfallah. 2014. “Demand-Side Management and European Environmental and Energy Goals: An Optimal Complementary Approach,” Energy Policy 67

179 179 O’Connell, Niamh, et al. 2014. “Benefits and Challenges of Electrical Demand Response: A Critical Review,” Renewable and Sustainable Energy Reviews 39 (2014).

180 180 Elliston, MacGill, and Diesendorf, 2013, “Least Cost 100% Renewable Electricity Scenarios;” Australian Energy Management Organization,

181 181 Liebreich, Michael . 2017. “Six Design Principles for the Power Markets of the Future” Bloomberg New Energy Finance, May 24

182 182 Arif, Ahmer, Fahad Javed, and Naveed Arshad. . 2014. “Integrating Renewables Economic Dispatch with Demand Side Management in micro-Grids: A Genetic Algorithm-Based Approach,” Energy Efficiency 7

183 183 Pierpont, Brendan and David Nelson. 2017. Markets for Low-carbon, Low-cost Electricity Systems. Climate Policy Initiative, September

184 184 Pierpont, Brendan, et al. 2017. The Flexibility: Path Markets for Low-carbon, Low-cost Electricity Systems. Climate Policy Initiatiev. April,

185 185 Denholm, Paul, Kara Clark, and Matt O’Connell. 2016. On the Path to SunShot: Emerging Issues and Challenges in Integrating High Levels of Solar into the Electrical Generation and Transmission System. Golden, CO: National Renewable Energy Laboratory. NREL

186 186 Shallenberger, Krysti. 2017. “How utility pilot programs are driving renewable energy integration,” Utility Dive, September 18

187 187 Bouzid, Allal M., et al. 2015. “A Survey on Control of Electric Power Distributed Generation Systems for Micro Grid Applications,” Renewable and Sustainable Energy Reviews 44

188 188 Rasmussen, Morton Grud, et al. 2011.“Optimal Combination of Storage and Balancing in a 100% Renewable European Power System,” in Proceedings of the 10th International Workshop on Large-Scale Integration of Wind Power into Power Systems as Well as on Transmission Networks for Offshore Wind Power Plants, 682–684. Energynautics

189 189 Schaber, Katrin , Florian Steinke, and Thomas Hamacher. 2013. Managing Temporary Oversupply from Renewables Efficiently: Electricity Storage Versus Energy Sector Coupling in Germany, International Energy Workshop, Paris, July

190 190 Rodriguez, Rolando A. 2014. “Transmission Needs Across a Fully Renewable, European Power System,” Renewable Energy 63 (2014);

191 191 Rasmussen, Morten Grud Gorm Bruun Andresen, and Martin Greiner, “Storage and Balancing Synergies in a Fully or Highly Renewable Pan-European Power System,” Energy Policy 51 (2012);

192 192 Greiner et al., 2012. “A 100% Renewable Power System in Europe: Let the Weather Decide,” Mineralogical Magazine, 77(5).

193 193 Barbose, Galen, et al. 2016. On the Path to SunShot: Utility Regulatory and Business Model Reforms for Addressing the Financial Impacts of Distributed Solar on Utilities. Golden, CO: National Renewable Energy Laboratory. NREL

194 194 Palmintier, Bryan, et al. 2016. On the Path to SunShot: Emerging Issues and Challenges in Integrating Solar with the Distribution System. Golden, CO: National Renewable Energy Laboratory. NREL

195 195 Chung, Donald, Kelsey Horowitz, and Parthiv Kurup. 2016. On the Path to SunShot: Emerging Opportunities and Challenges in U.S. Solar Manufacturing. . Golden, CO: National Renewable Energy Laboratory. NREL

196 196 Sobotka, Katarzyna. 2009. “A Wind-Power Fuel Cell Hybrid System Study: Model of Energy Conversion for Wind Energy System with Hydrogen Storage.” Master’s thesis, The School for Renewable Energy Science, Akureyri, Iceland.

197 197 Bose, Tapan K., et al., . Stand-Alone Renewable Energy System Based on Hydrogen Production, Institut de recherche sur l’hydrogène, Université du Québec à Trois-Rivières, Canada, IEEE Xplore Digital Library, 19(3).

198 198 National Renewable Energy Laboratory, 2017, Wind-to-Hydrogen Project, Hydrogen and Fuel Cells Research

199 199 Boie, Inga, et al., 2014, “Efficient Strategies for the Integration of Renewable Energy into Future Energy Infrastructures in Europe – An Analysis Based on Transnational Modeling and Case Studies for Nine European Regions,” Energy Policy 67

200 200 Pleßmann, Guido, et al. 2014. Matthias Erdmann, Markus Hlusiak, and Christian Breyer. “Global Energy Storage Demand for a 100% Renewable Electricity Supply.” Energy Procedia 46

201 201 Komiyama, Ryoichi and Yasamusa Fuji. 2014. “Assessment of Massive Integration of Photovoltaic System Considering Rechargeable Battery in Japan with High Time-Resolution Optimal Power Generation Mix Model,” Energy Policy 66

202 202 Elkind, Ethan M. 2010The Power of Energy Storage: How to Increase Deployment in California to Reduce Greenhouse Gas Emissions, Center for Law and the Environment, Berkeley, and Environmental Law Center, UCLA, July 2010;

203 203 Hasan, Nor Shahida, et al. 2013 “Review of Storage Schemes for Wind Energy Systems,” Renewable and Sustainable Energy Reviews 21

204 204 Koohi-Kamali, et al. 2013. “Emergence of Energy Storage Technologies as the Solution for Reliable Operation of Smart Power Systems: A Review,” Renewable and Sustainable Energy Reviews 25

205 205 Díaz-González, Francisco et al. 2012. “A Review of Energy Storage Technologies for Wind Power Applications,” Renewable and Sustainable Energy Reviews 16

206 206 Ippolito, M. G., et al. 2014, “Multi-Objective Optimized Management of Electrical Energy Storage Systems in an Islanded Network with Renewable Energy Sources under Different Design Scenarios,” Energy 64

207 207 McElroy, Lu, Xi, Michael B., et al. 2013. “Optimal Integration of Offshore Wind Power for a Steadier, Environmentally Friendlier, Supply of Electricity in China.” Energy Policy 62

208 208 Steinke, Florian, Philipp Wolfrum, and Clemens Hoffman. 2013. “Grid vs. Storage in a 100% Renewable Europe,” Renewable Energy 50

209 209 Gao, Dan, et al. 2014. “An Integrated Energy Storage System Based on Hydrogen Storage: Process Configuration and Case Studies with Wind Power,” Energy 66

210 210 Kucsera, Dénes and Margarethe Rammerstorfer. 2014. “Regulation and Grid Expansion Investment with Increased Penetration of Renewable Generation,” Resource and Energy Economics 37

211 211 Cau, Giorgio , et al. 2014. “Energy Management Strategy Based on Short-Term Generation Scheduling for a Renewable Microgrid Using a Hydrogen Storage System,” Energy Conversion and Management 87

212 212 Gireesh, Shrimali, Melissa Lynes, and Joe Indvik. 2015. “Wind Energy Deployment in the U.S.: An Empirical Analysis of the Role of Federal and State Policies.” Renewable and Sustainable Energy Reviews 43

213 213 Bouzid, Allal M., et al. 2015. “A Survey on Control of Electric Power Distributed Generation Systems for Micro Grid Applications,” Renewable and Sustainable Energy Reviews 44

214 214 Woo, C.K. and J. Zarnikau, 2017, “A solar rate option for the development of behind-the-meter photovoltaic systems.” The Electricity Journal, 30 (3). 214

215 215 Liu, Y. and C.K. Woo. 2017. “California's renewable generation and pumped hydro storage's profitability.” The Electricity Journal, 30 (3).

216 216 Schaber, Katrin, Florian Steinke, and Thomas Hamache. 2013. Managing Temporary Oversupply from Renewables Efficiently: Electricity Storage Versus Energy Sector Coupling in Germany, International Energy Workshop, Paris, July

217 217 Feldman, David, and Mark Bolinger. 2016. On the Path to SunShot: Emerging Opportunities and Challenges in Financing Solar. Golden, CO: National Renewable Energy Laboratory. NREL

218 218 Woodhouse, Michael, et al. 2016. On the Path to SunShot: The Role of Advancements in Solar Photovoltaic Efficiency, Reliability, and Costs . Golden, CO: National Renewable Energy Laboratory. NREL

219 219 U.S. Department of Energy. 2015. Wind Vision: A New Era for Wind Power in the United States. March 12

220 220 Heymans, Catherine et al. 2014. “Economic Analysis of Second Use Electric Vehicle Batteries for Residential Energy Storage and Load-Levelling,” Energy Policy 71

221 221 Reber, Timothy J., Koenraad F. Beckers, and Jefferson W. Tester. 2014. “The Transformative Potential of Geothermal Heating in the U.S. Energy Market: A Regional Study of New York and Pennsylvania,” Energy Policy 70

222 222 Loisel, Rodica, Guzay Pasaoglu, and Christian Thiel. 2014. “Large-Scale Deployment of Electric Vehicles in Germany by 2030: An Analysis of Grid-To-Vehicle and Vehicle-To-Grid Concepts,” Energy Policy 65

223 223 Parsons, George R., et al. 2014.“Willingness to Pay for Vehicle-To-Grid (V2G) Electric Vehicles and Their Contract Terms,” Energy Economics 42 (2014).

224 224 Naus, Joeri, et al., 2014. “Smart Grids, Information Flows and Emerging Domestic Energy Practices,” Energy Policy 68

225 225 Park, Chan-Kook, Hyun-Jae Kim, and Yang-Soo Kim. 2014. “A Study of Factors Enhancing Smart Grid Consumer Engagement,” Energy Policy 72 (2014)

226 226 Guido, Pepermans. 2014. “Valuing Smart Meters.” Energy Economics 45

227 227 Ren, Guizhou Guoqing Ma, and Ning Cong. 2015. “Review of Electrical Energy Storage System for Vehicular Applications,” Renewable and Sustainable Energy Reviews 41

228 228 Ravindranath, Mohana. 2014. “At GSA, an ‘Internet of Things’ Experiment,” Washington Post, August 31, 2014; Owen Poindexter, “The Internet of Things Will Thrive on Energy Efficiency,” Government Technology, July 29

229 229 Stephenson, W. David. 2014. “Internet of Things Could Offset Government Inaction on Climate,” Greenbiz.com, November 17

230 230 Johnson, Nils et al. 2017, “A reduced-form approach for representing the impacts of wind and solar PV deployment on the structure and operation of the electricity system.” Energy Economics. 64 230

231 232 Ueckerdt, Falko et al., 2017. “Decarbonizing global power supply under region-specific consideration of challenges and options of integrating variable renewables in the REMIND model,” Energy Economics. 64 232

232 233 Weiss, Jürgen. et al. 2017. “The electrification accelerator: Understanding the implications of autonomous vehicles for electric utilities.” The Electricity Journal, 30 (10). 233

233 234 Faruqui Author Vitae, Ahmad, and Sanem SergiciAuthor Vitae, , Cody Warner. “Arcturus 2.0: A meta-analysis of time-varying rates for electricity.” The Electricity Journal, 30 (10). 234Author Vitae

234 234 Pietzcker, Robert C. et al. 2017. “System integration of wind and solar power in integrated assessment models: A cross-model evaluation of new approaches.” Energy Economics. 64 231

235 235 Faruqui Author Vitae, Ahmad and Author VitaeKirby Leyshon. 2017. Fixed charges in electric rate design: A survey.” The Electricity Journal, 30 (10). 235

236 236 Lovins, Amory B. 2017. “Reliably integrating variable renewables: Moving grid flexibility resources from models to results.” The Electricity Journal, 30(10) 236

237 237 Yue-wei Wu, Tiffany and VarunRai. 2017. “Quantifying diversity of electricity generation in the U.S.” The Electricity Journal, 30(7) 237

238 238 Cavicchi, Joseph. 2017. “Rethinking government subsidies for renewable electricity generation resources.” The Electricity Journal, 30(6) 238

239 239 Tsai, Chen-Hao and Gürcan Gülen. 2017. “Are zero emission credits the right rationale for saving economically challenged U.S. nuclear plants?” The Electricity Journal, 30(6) 239

240 240 May, Nils, 2017. “The impact of wind power support schemes on technology choices.” Energy Economics. 65 240

241 241 Vergados, Dimitrios J.,. et al. 2016. Prosumer clustering into virtual microgrids for cost reduction in renewable energy trading markets,” Sustainable Energy, Grids and Networks, 7 241

242 242 Kästel, Peter and Bryce-Gilroy Scott. 2015. . “Economics of pooling small local electricity prosumers—LCOE & self-consumption.” Renewable and Sustainable Energy Reviews. 51 242

243 243 Benes, Keith J. and Caitlin Augustin. 2016. “Beyond LCOE: A simplified framework for assessing the full cost of electricity,” The Electricity Journal, 29 (8). 243

244 244 EIA, 2013, Assessing the Economic Value of New Utility-Scale Electricity Generation Projects, Workshop Discussion Paper: LCOE and LACE, July,

245 245 Fowler, Luke and Autumn T. Johnson. 2017. “Overlapping authorities in U.S. energy policy,” The Electricity Journal, 30 (9). 245

246 246 Seetjen, Thomas A. et al. 2016. Solar PV integration cost variation due to array orientation and geographic location in the Electric Reliability Council of Texas. Applied Energy. 180 246

247 247 Deetjen, Thomas A. et al. 2017. “The impacts of wind and solar on grid flexibility requirements in the Electric Reliability Council of Texas.” Energy. 123 247

248 248 Janko, Samantha A. Michael R .Arnold and Nathan G. Johnson. 2016. “Implications of high-penetration renewables for ratepayers and utilities in the residential solar photovoltaic (PV) market.” Applied Energy. 180 248

249 249 Eryilmaz, Derya and SanemSergici. 2016. “Integration of residential PV and its implications for current and future residential electricity demand in the United States.” The Electricity Journal, 29 (8). 249

250 250 Costello, Kenneth W. 2016. “Ways for utility regulation to grapple with new developments in the U.S. Electricity Industry.” The Electricity Journal, 29 (2). 250

251 251 EIA, 2017, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2017,

252 252 Ela, E. et al., 2016. “Wholesale electricity market design with increasing levels of renewable generation: Incentivizing flexibility in system operations.” The Electricity Journal, 29 (2). 252

253 253 Milligan, Michael et al. 2016. “Wholesale electricity market design with increasing levels of renewable generation: Revenue sufficiency and long-term reliability.” The Electricity Journal, 29 (2). 253

254 254 Kaatz, Joe.2017. “Resolving the conflict between new and old: A comparison of New York, California and other state DER proceedings.” The Electricity Journal, 29 (2). 254

255 255 Newcomb, James, et al. 2013. Distributed Energy Resources: Policy Implications of Decentralization.” The Electricity Journal, 26(8) 255

256 256 Richards, James and Wesley J. Cole. 2017. “Assessing the impact of nuclear retirements on the U.S. power sector.” The Electricity Journal, 30 (9). 256

257 257 Jacobson, Mark Z., et al. 2015. 100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for 139 Countries. December 13.

258 258 Deep Decarbonization Pathways Project. 2015. Pathways to Deep Decarbonization 2015 Report. Paris: SDSN – IDDRI, 2015.

259 259 Greenpeace International, Global Wind Energy Council, and Solar Power Europe. 2015. energy [r]evolution: A Sustainable World Energy Outlook 2015. Amsterdam, The Netherlands: Greenpeace International.

260 260 Mills, Andrew and Ryan Wiser. 2014. Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels. Environmental Energy Technologies Division. Lawrence Berkely National Laboratory,

261 Lazard, *Levelized Cost of Energy*, v. 12.0 - 16.0, 15.0, 14.0, 13.0, 13.0,

262 EIA, 2018 - 2022, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook.*

263 NREL, Annual Technology BASELINE (ATB), 2020-2022,

264 Denholm, P., et al., 2022, "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035, NREL/TP-6440-81644.

265

266 Bolinger, Mark, 2023, "Mind the gap: Comparing the net value of geothermal, wind, solar, and solar+storage in the Western United States," Renewable Energy, 2005.

267 Acar, Canan and Ibrahim Dincer, 2017, "Environmental impact assessment of renewables and conventional fuels for different end use purposes," Int. J. pf Global Warming, 13.

268 Cooper, Mark, 2016, "Energy Justice in Theory and Practice: Building a Pragmatic, Progressive Road Map," in Thijs de Graf, Benjamin K. Sovacool, Arunabha Gosh, Florian Kern, and Michael T. Klare (Eds.) *The Palgrave Handbook of the International Political Economy of Energy,* (PALGRAVE, Macmillan,).

269 Cooper, Mark, 2017 *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Power Sector* (Praeger)

270 Will Gorman, 2022, "Are coupled renewable-battery power plants more valuable than independently sited installations?," Energy Economics, 107

271 Millstein et al., 2021, Solar and wind grid system value in the United States: The effect of transmission congestion, generation profiles, and curtailment," *Joule* 5, July 21.

272 Shaukat, N., et al., 2081, "A survey on consumers empowerment, communication technologies, and renewable generation penetration within Smart Grid," *Renewable and Sustainable Energy Reviews,* 81 (1), January.

273 Prol Karl W., Steininger and David Zilberman, 2020, "The cannibalization effect of wind and solar in the California wholesale electricity market in the California wholesale electricity market," *Energy Economics,* 85

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

275 Cooper, Mark, 2018, Affidavit of Mark Cooper, Petitioners-Plaintiffs, For a Judgement pursuant to Article 78 of the CPLR, Index No. 07242-16, December.

276 Cooper, Mark, 2021, State Policymakers Should Accelerate the Transition to Reliance on Efficiency, Renewables, and Intelligent Grid, Management, Energy Committee, Montana Legislature, May 20.

277 Cooper, Mark, 2015, *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, Vt Law School, May.

278 Cooper, Mark, 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.*

279 Cooper, Mark, 2018, *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.

280 J. Bistline, et. Al., 2022, "Actions for reducing US emissions at least 50% by 2030," *Science,* 376.

281 DNV, 2022, *Pathway to net zero emissions, eto.DNV*

282 E. Larson, et al., 2021, "Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Final Report," *Princeton University, O*ctober.

283 National Academies, *Accelerating Decarbonization of the U.S. Energy System*," National Academies of Sciences, Engineering, and Medicine. The National Academies Press

284 U.S. Department of Energy, 2019*, GeoVision: Harnessing the Heat beneath Our Feet, May.*

285 P. Thomsen, 2018, "Geothermal selection in California resource planning: preliminary results from the CPUC's IRP tools and recommendations for future development and analysis," GRC Transactions, 42.

286 N.A. Sepulveda, et al., 2081, "The role of firm low-carbon electricity resources in deep decarbonization of power generation," Joule, 2

287 Jenkins, J.D., M. Luke, and S. Thernstrom, "Getting to zero carbon emissions in the electric power sector," Joule, 2.

288 C.K. Woo, et al., Merit-order effects of renewable energy and price divergence in California's day-ahead and real-time electricity markets," Energy Pol, 92

289 Cooper, Mark, 2019, *Avoiding Nuclear and Fossil Fuel Potholes, A Green New Deal Has a Clear Path to a Clean, Low Cost, Low Carbon, Progressive, Capitalist Electricity Sector*, Institute for Energy and the Environment, April.

290 C.F. Williams, et al., 2008, "Assessment of Moderate- and High-Temperature Geothermal Resources of the United States, *US Geological Survey Fact Sheet 2008-3082*

291 P. Thomsen, 2021, "The increasing comparative value of geothermal in California–trends and forecasts for mid-2019," *Proceedings of the World Geothermal Congress 2020+1, Reykjavik, Iceland, April-October*

292 R. Wiser, et al., 2021, *Land-Based Wind Market Report,* Lawrence Berkeley National Laboratory, Berkeley.

293 M. Bolinger, et al., 2021, *Utility-Scale Solar*, Lawrence Berkeley National Laboratory, Berkeley, CA

294 M. Bolinger,et al., 2022, *Hybrid Power Plants: Status of Operating and Proposed Plants*, Lawrence Berkeley National Laboratory, Berkeley

295 J. Rand, et al., 2021, *Queued up: Characteristics of Power Plants Seeking Transmission Interconnection as of the End of 2021*, Lawrence Berkeley National Laboratory, Berkeley,

296 M. Bolinger, R. Wiser and E. O'Shaughnessy, 2022, "Levelized cost-based learning analysis of utility-scale wind and solar in the United States," Science, 25 (6).

297 N. Schlag, et al., 2020, "Capacity and reliability planning in the era of decarbonization: practical application of effective load carrying capability in resource adequacy," *Energy Environ. Econ. Inc.*

298 D. Millstein, P. Dobson and, S. Jeong, "The potential to improve the value of U.S. Geothermal electricity generation through flexible operations," *J. Energy Resour. Technol.,* 143 (1)

299 S. Ericson, et al., 2022, *Influence of Hybridization on the Capacity Value of PV and Battery Resources,* National Renewable Energy Laboratory,

300 California Public Utilities Commission (CPUC), 2022, *2020 resource adequacy report*, April

301 Working Group, 2022, *Future of Resource Adequacy Working Group Report*, February.

302 M. Junginger, A. Louwen (Eds.), *Technological Learning in the Transition to a Low-Carbon Energy System*, Academic Press

303 Long Duration Energy Storage (LDES) Council and McKinsey & Company, 2022, *A Path towards Full Grid Decarbonization with 24/7 Clean Power Purchase Agreements*

304 W. Ricks, J. Norbeck, J. Jenkins, 2022, "The value of in-reservoir energy storage for flexible dispatch of geothermal power," *Appl. Energy, 313.*

305 Mark Bolinger, et al., 2022. Utility-Scale Solar, Edition Empirical Trends in Deployment, Technology, Cost, Performance, PPA Pricing, and Value in the United States, Lawrence Berkeley National Laboratory.

306 Aman, M.M., ET AL., 2014, "A review of safety, health and environmental (SHE) issues of solar energy systems", Renewable and Sustainable Energy Reviews, 41 (1).

307 Asdrubali, F., Baldinelli, G., D'Alessandro, F. and Scrucca, F. (2015) "Life cycle assessment of electricity production from renewable energies: review and results harmonization," *Renewable and Sustainable Energy Reviews,* 42 (1).

308 Turconi, R., Boldrin, A. and Astrup, T., 2013, "Life cycle assessment (LCA) of electricity generation technologies: overview, comparability, and limitations," Renewable and Sustainable Energy Reviews, 28 (1).

309 Antweiler, W., 2021, "Microeconomic models of electricity storage: Price forecasting, arbitrage limits, curtailment insurance, and transmission line utilization." *Energy Econ*, 101, 105390 https://doi.org/10.1016/j.eneco.2021.105390.

310 Bistline, J., et al., 2020, "Energy storage in long-term system models: a review of considerations, best practices, and research needs. *Prog. Energy* 2,

311 Bloom, A., et al., 2020*, The Value of Increased HVDC Capacity Between Eastern and Western U.S. Grids: Interconnections Seam Study*, NREL

312 Crespo Montanes, et al., 2021, *Keep it Short: Exploring the Impacts of Configuration Choices on the Recent Economics of Solar-plus-Battery and* Wind-plus-Battery Hybrid Energy Plants. Lawrence Berkeley National Laboratory.

313 Geske, J. and Green, R., 2020." Optimal storage, investment and management under uncertainty: it is costly to avoid outages!" *Energy J.* 41.

314 Gorman, W., Mills, 2020, "Motivations and options for deploying hybrid generator-plus-battery projects within the bulk power system," Electr. J.

315 Hobbs, B.F. and Oren, S.S., 2019, “Three waves of U.S. reforms: following the path of wholesale electricity market restructuring,” *IEEE Power Energy Mag.*

316 McPherson, M., et al., 2020, “Impacts of storage dispatch on revenue in electricity markets” *J. Energy Storage* 31.

317 Murphy, C.A., Schleifer, A. and Eurek, K., 2021, A taxonomy of systems that combine utility-scale renewable energy and energy storage technologies. *Renew. Sust. Energ. Rev.* 139.

318 Schleifer, A.H., et al., 2021, “The evolving energy and capacity values of utility-scale PV-plus-battery hybrid system architectures,” *Adv. Appl. Energy* 2.

319 Sengupta, M., et al., 2018, “The national solar radiation data base (NSRDB),” *Renew. Sust. Energ. Rev.* 89,

320 Stephen, G., Hale, E. and Cowiestoll, B., 2020.” Managing Solar Photovoltaic Integration in the Western United States: Resource Adequacy Considerations,” *NREL*/TP-6A20-72472

321 Ziegler, M.S., et al., 2019, “Storage requirements and costs of shaping renewable energy toward grid Decarbonization,” *Joule* 3.

322 Figueiredo, N.C., and da Silva, 2019, “The ‘‘Merit-order effect’’ of wind and solar power: volatility and determinants, Renew. Sustain. Energy Rev. 102.

323 O’Shaughnessy, E., Cruce, J.R., and Xu, K., 2020, “Too much of a good thing? Global power: volatility and determinants, Renew. Sustain. Energy Rev. 102.

324 Kim, J.H., et al., *Enhancing the value of solar energy as solar and storage penetrations* increase. SSRN

325 Hamilton, S.D., et al., 2020,” How does wind project performance change with age in the United States?” Joule 4.

326 Bolinger, M., et al., 2020, “System-level performance and degradation of 21 GWDC of utility-scale PV plants in the United States, *J. Renew. Sustain. Energy* 12.

327 Wiser, R.H., Bolinger, M., and Seel, J., 2020, *Benchmarking utility-scale PV operational* expenses and project lifetimes: results from a survey of US solar industry professionals, Lawrence Berkeley National Laboratory.

328 Ferierra, Paula, et al., 2023, “Assessing the societal impact of smart grids: Outcomes of a collaborative research project,” *Technology in Society,* 72, February.

329 Su, Wencong. et al., 2011, A Survey on the electrification of transportation in a Smart Grid environment. Industrial informatics, IEEE Trans, vol. 8(1).

330 Cooper, Mark, 2019, *The Green New Deal Can Build a Progressive, Capitalist, Low Cost, Low Carbon, Electricity Sector, If it Avoids the Nuclear Power and Fossil Fuel Potholes Along the Way*, *Institute for Energy and the Environment,* Vt Law School., April.

331 McKinsey Global Institute (2012) The Resource Revolution. McKinsey Global Institute and Vivid Econom*ics (2013) Economic Growth and Energy Efficiency. Vivid Economics

332 Holmes, K. J., et al., 2021, “Scaling deep decarbonization technologies,” *Earth's Future*, 9

333 Ahlstrom, M. (2019). Renewable electricity, storage and electrification: Amazing progress, transformations and challenges. Presented at NASEM workshop Deployment of Deep Decarbonization Technologies.

334 Allam, R. J., et al., 2017, Demonstration of the Allam cycle: An update on the development status of a high efficiency supercritical carbon dioxide power process employing full carbon capture. *Energy Procedia,* 114.

335 Cochran, J. (2020). Case study—Modeling to support LADWP's IRP and stakeholder engagement. Presented at NASEM workshop Models to Inform Planning for the Future Electric Power in the US

336 Gallagher, K. (2019). Policy approaches to deep decarbonization in the United States. Presented at NASEM workshop deployment of deep decarbonization technologies

337 Haggerty, J. (2019). Societal & policy issues: Decarbonization & resource peripheries. Presented at NASEM workshop deployment of deep decarbonization technologies. R

338 Kaufman, N., Barron, A. R., Krawczyk, W., Marsters, P., & McJeon, H. (2020). A near-term to net zero alternative to the social cost of carbon for setting carbon prices. Nature Climate Change, 10, 1

339 Meckling, J., Sterner, T., & Wagner, G. (2017). Policy sequencing toward decarbonization. Nature Energy, 2.

340 Penney, V. (2021). Electric cars are better for the planet and often your budget, too. The New York Times.

341 Shaner, M. R., Davis, S. J., Lewis, N. S., & Caldeira, K. (2018). Geophysical constraints on the reliability of solar and wind power in the United States. Energy & Environmental Science, 11(4).

342 Sutley, N. (2019). Deployment of deep decarbonization pathways. Presented at NASEM workshop Deployment of Deep Decarbonization Technologies.

343 Victor, D., Geels, F. W., & Sharpe, S. (2019). Accelerating the low carbon transition: The case for stronger, more targeted and coordinated international action. Brookings Institution.

344 Williams, J. H. (2019). Decarbonizing the United States: Challenges of scale, scope, and rate.

345 Williams, J. H., Jones, R. A., Haley, B., Kwok, G., Hargreaves, J., Farbes, J., & Torn, M. S. (2021). Carbon-neutral pathways for the United States. AGU Advances, 2(1)

346 Rhodes, Joshua D., 2022, *The Impoact of Renewables in Ercot,"* IdeaSmiths, October.

347 Jesse D. Jenkins, et al., 2021, "Mission net-zero America: The nation building path to a prosperous, net-zero emissions economy," *Joule,* 5, November.

348 Gambhir, A. (2019). Planning a low-carbon energy transition: what can and can't the models tell us? Joule 3.

349 Geels, F.W., et al., 2017, "Sociotechnical transitions for deep decarbonization," *Science* 357.

350 Pye, S., et al., 2021. Modelling net-zero emissions energy systems requires a change in approach, *Clim. Policy,* 21.

351 International Energy Agency (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector.

352 Iyer, G., et, al., 2017, "Measuring progress from nationally determined contributions to mid-century strategies," Nat.Clim. Chang. 7.

353 Iyer, G., et al., 2017, *GCAM-USA Analysis of U.S. Electric Power* Sector Transitions, Pacific Northwest National Laboratory, technical_reports/PNNL-26174.

354 Cole, W.J., et al., 2021, "Quantifying the challenge of reaching a 100% renewable energy power system for the United States" Joule 5.

355 Denholm, P., et al., 2021, "The challenges of achieving a 100% renewable electricity system in the United States. Joule 5.

356 Berkeley Lab, 2021, Generation, storage, and hybrid capacity in interconnection queues.

357 National Academies of Sciences, Engineering, and Medicine, 2021, *Accelerating* decarbonization of the U.S. Energy System, The National Academies Press.

358 BI, Zicheng, et. al.,2015, " Plug-in vs. wireless charging: Life cycle energy and greenhouse gas emissions for an electric bus system," Applied Energy, 146, May.

359 Clarke, W. (2019). The outlines of deep decarbonization. Presented at NASEM workshop deployment of deep decarbonization technologies.

360 Larson, E., Greig, C., Jenkins, J., Mayfield, E., Pascale, A., Zhang, C., et al. (2020). Net-zero America by 2050: Potential pathways, deployments, and impacts. Princeton U

361 Williams, J. H. (2019). Decarbonizing the United States: Challenges of scale, scope, and rate. Presented at NASEM workshop of Deep Decarbonization Technologies. Retrieved from

362 Williams, J. H., et al., 2021, Carbon-neutral pathways for the United States. *AGU advancing Space and Earth Science)*

363 Rennert, K. et al., 2022, "Comprehensive Evidence Implies a Higher Social Cost of CO2," Nature, August.

364 Zeitler, E., Kerxhalli Kleinfield and M., & DeBoer, R. (2021). Scaling deep decarbonization technologies. Earth's Future, *AGU advancing Space and Earth Science) AGU*, October.

365 W. Pettitt, B. Schmidt and J. Robins, "Baseline geothermal power capacity in the USA and California," *GRC Transactions*, 44.

366 Gerrard, M. (2019). Legal pathways to deep decarbonization in the United States. Presented at NASEM workshop deployment of deep decarbonization technologies.

367 Teng,

368 Cooper, Mark, 2021, *Building A 21st Century Electricity Sector With Efficiency, Distributed Resources And Dynamic Management:: The Consumer, Economic, Public Health And Environmental Benefit,* (with Mel Hall-Crawford (Consumer Federation of America) April 22.

369 Cooper, Mark, 2021, *Building A Least Cost, Low-Carbon, Electricity System With Efficiency, Wind, Solar & Intelligent Grid Management: Why Nuclear Subsidies Are An Unnecessary Threat To The Transformation* (Friends of the Earth_, July 15.

370 Jones, Christopher M., 2018, Pages 35–51 DOI: 10.17645/up.v3i2.1218 Article Carbon Footprint Planning: Quantifying Local and State Mitigation Opportunities for 700 California Cities, *Urban Planning,* 3(2).

371 Hunter, Garfield Wayne, et al., 2019, Sustainability of Low Carbon City Initiatives in China: A Comprehensive Literature Review, *Sustainability Review.*

372 Baynes, Timothy M. and Daniel B. Müller, 2016, "Chapter 6 A Socio-economic Metabolism Approach to Sustainable Development and Climate Change Mitigation," in Roland Clift and Angela Druckman (Eds.), *Taking Stock of Industrial Ecology*, Springer International.

373 Neelakshi Joshi1, et al., 2022, “What does neighbourhood climate action look like? A scoping literature review,” *Climate Action,* 1(10).

374 Renewable and Sustainable Energy Reviews 120 (2020) 109618 Available online 30 November 2019 1364-0321/© 2019 Elsevier Ltd. All rights reserved.

375 Das, H.S., et al., 2020, “Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review,” *Renewable and Sustainable Energy Reviews* 120.

376 Patt, Anthony and Johan Lilliestam, 2018, “The Case against Carbon Prices,” 2018, *Joule* 2, December.

377 Jenkins, Jesse D., et al., 2018, Getting to Zero Carbon Emissions in the Electric Power Sector,” *Joule* 2, December.

378 Patrizio, Piera, et al., 2018, “Reducing US Coal Emissions Can Boost Employment ,” *Joule* 2, December.

ATTACHMENT MNC
1.1 - 6.5

ANALYSES PREPARED SINCE EARLIER DIABLO CANYON TESTIMONY

Books and Chapters

"Energy Justice in Theory and Practice: Building a Pragmatic, Progressive Road Map," in Thijs de Graf, Benjamin K. Sovacool, Arunabha Gosh, Florian Kern, and Michael T. Klare (Eds.) *The Palgrave Handbook of the International Political Economy of Energy,* (PALGRAVE, Macmillan, 2016)

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

Testimony

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

Affidavit of Mark Cooper, Petitioners-Plaintiffs, For a Judgement pursuant to Article 78 of the CPLR, Index No. 07242-16, December 2018.

State Policymakers Should Accelerate the Transition to Reliance on Efficiency, Renewables, and Intelligent Grid, Management, Energy Committee, Montana Legislature, May 20. 2021

Research Reports

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, Vt Law School, May, 2015.

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

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.

Avoiding Nuclear and Fossil Fuel Potholes, A Green New Deal Has a Clear Path to a Clean, Low Cost, Low Carbon, Progressive, Capitalist Electricity Sector, Institute for Energy and the Environment, April 2019,

The Green New Deal Can Build a Progressive, Capitalist, Low Cost, Low Carbon, Electricity Sector, If it Avoids the Nuclear Power and Fossil Fuel Potholes Along the Way, April 2019. *Institute for Energy and the Environment,* Vt Law School.

Building A 21st Century Electricity Sector With Efficiency, Distributed Resources And Dynamic Management:: The Consumer, Economic, Public Health And Environmental Benefit, (with Mel Hall-Crawford (Consumer Federation of America) April 22, 2021.

Building A Least Cost, Low-Carbon, Electricity System With Efficiency, Wind, Solar & Intelligent Grid Management: Why Nuclear Subsidies Are An Unnecessary Threat To The Transformation (Friends of the Earth, July 15, 2021

MNC-1.2

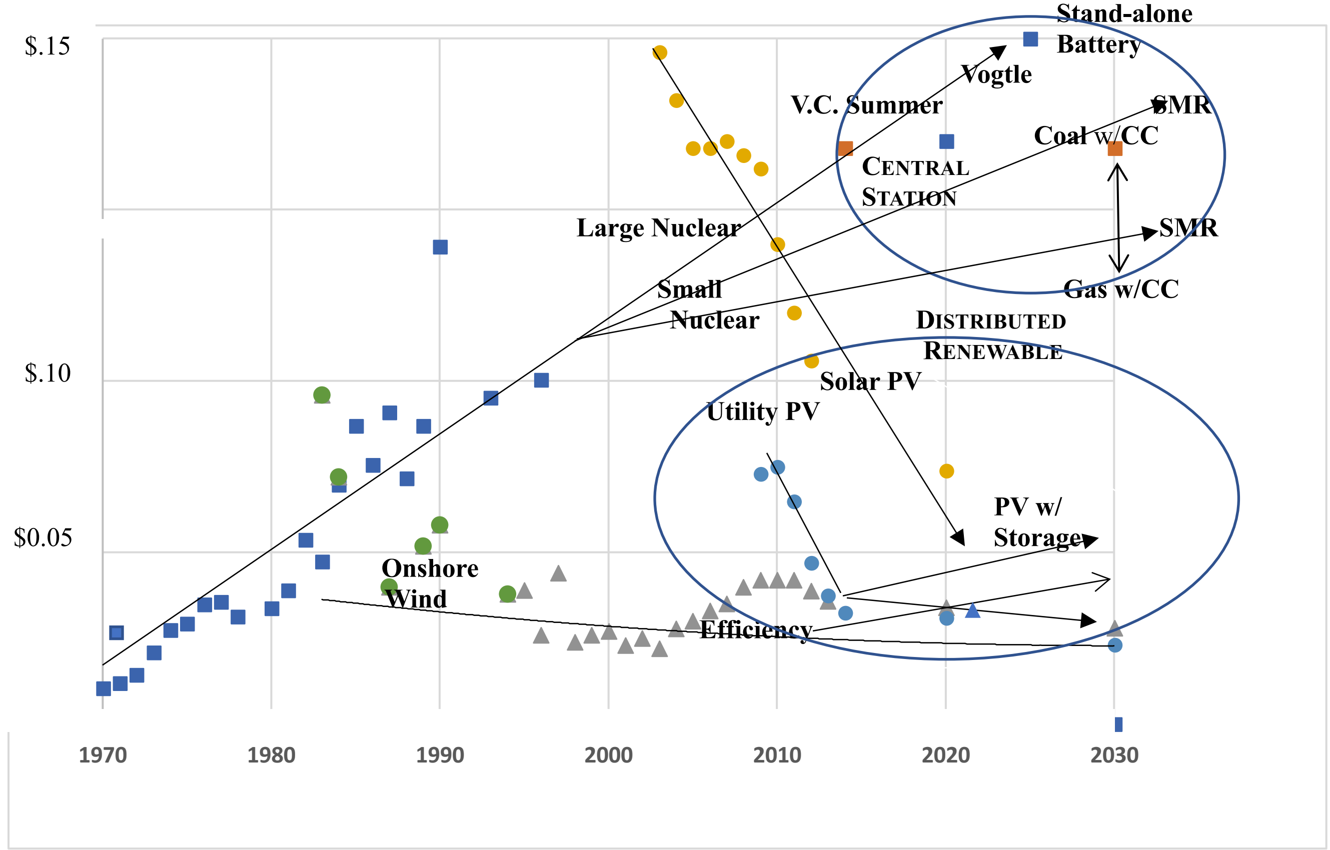
AREAS OF ANALYSIS

Analysis areas	Nuclear		Distributed Alternatives
Cost			(**New or expanded**)
Long-Term	All ,	High	Low
Short-Term	Aging,	Escalating, Capital Cost	Low "all in", **very low marginal**
Projections	All	Escalating to flat	Declining to flat
System	Large	High operating reserve	**equal to low**
Transformation	All	Crowding Out	**Need to refocus on distributed**
Reliability	All	Load following	**Load shaping, Diversity**
	All	Risk of Outage	**Increasing tools of integration**
Transmission	All	Need creating	**Local independence**
Resource Adequacy	All	Old Transmission dependent	**Declining Demand**
Macroeconomic	All	Negative	Positive
Climate	All	Low	Low
Health	All	Mixed	Mixed
Clean Energy Scenarios			
Probability	All	Highly unlikely	**Likely but Challenging**
Cost	All	High	Moderate to low

Sources: The Original Analysis was primarily articulated in Mark Cooper, 2015, "Declaration of Mark Cooper in Support Of San Luis Obispo Mothers For Peace's Motion to File New Contentions Regarding Adequacy of Environmental Report for Diablo Canyon License Renewal Application, before the Atomic Safety and Licensing Board, in The Matter Of Pacific Gas And Electric Company Docket Nos. 50-275-LR Diablo Canyon Nuclear Power Plant 50-323-LR Units 1 And 2, Nuclear Regulatory Commission, April. The Updates Can Be Found in Mark Cooper, *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Power Sector* (Praeger, 2017); *Trump's $2 Trillion Mistake, The War on Energy Efficiency, November 2017 (Consumer Federation of America); The Green New Deal Can Build a Progressive, Capitalist, Low Cost, Low Carbon, Electricity Sector, If it Avoids the Nuclear Power and Fossil Fuel Potholes Along the Way*, April 2019. *Institute for Energy and the Environment,* Vt Law School; *Building A 21st Century Electricity Sector With Efficiency, Distributed Resources And Dynamic Management:: The Consumer, Economic, Public Health And Environmental Benefit,* (with Mel Hall-Crawford (Consumer Federation of America) April 22, 2021; *Building A Least Cost, Low-Carbon, Electricity System With Efficiency, Wind, Solar & Intelligent Grid Management: Why Nuclear Subsidies Are An Unnecessary Threat To The Transformation* (Friends of the Earth, July 15, 2021

BROAD, LONG-TERM RESOURCE COST TRENDS

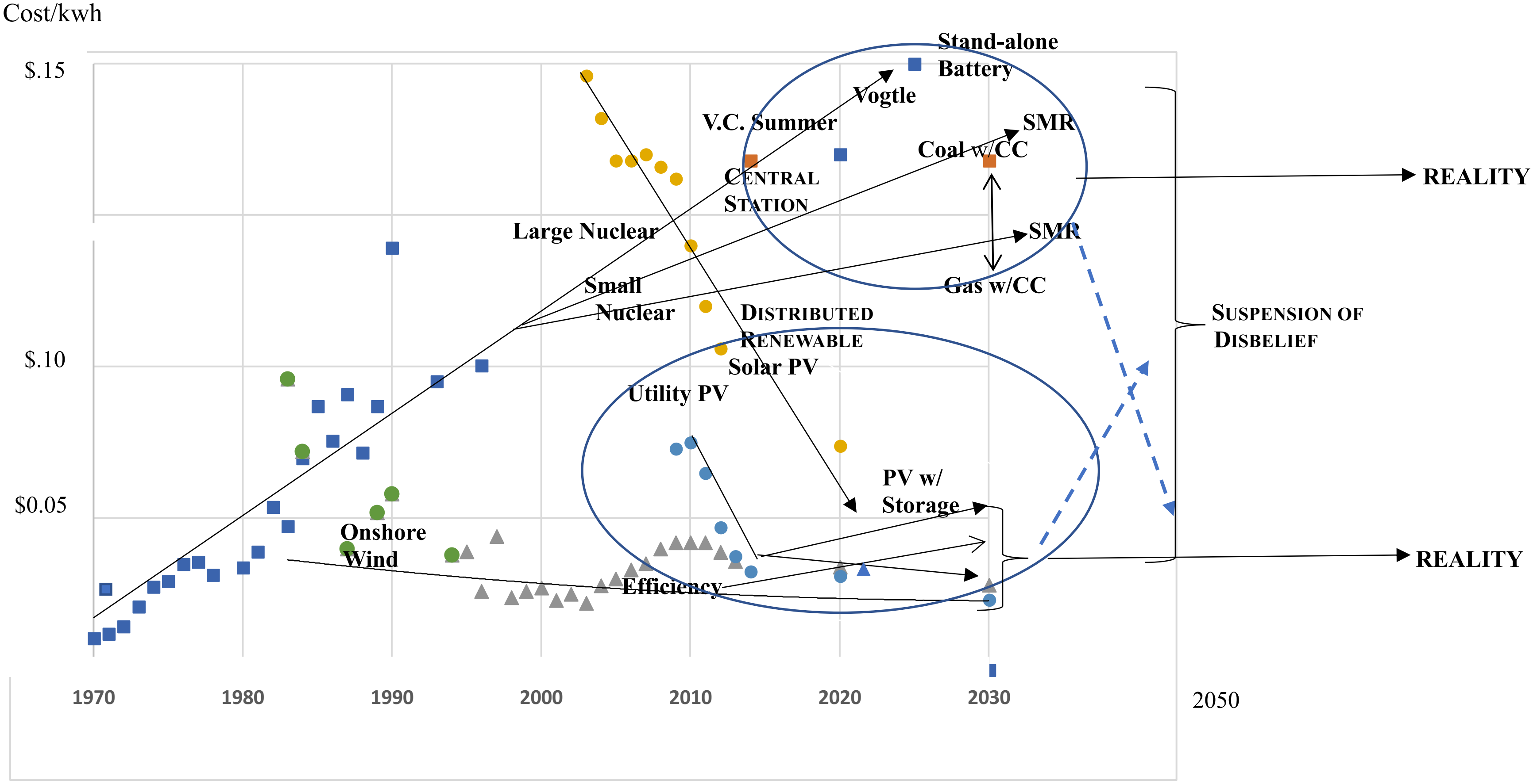
Cost/kwh



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).

MNC-1.4

THE SUSPENSION OF DISBELIEF ABOUT LONG-TERM RESOURCE COST TRENDS



Source: Attachment MNC-1.3, as updated in text.

FUNDAMENTAL DIFFERENCES BETWEEN CENTURIES AND SYSTEMS

Characteristic	20th Century	21st Century
Goal	Redundancy (as resilience)	Flexibility (resilience as a result)
Operational objective	Increase capacity to follow load	Integrate & match supply and demand
Configuration, size	Island set by economies of generations	Interconnection set by value
Supply-Demand	Segregation	Integration
Demand driver	Dumb load	Smart Retailer
System cost recovery	High, lumpy and fixed	Variable targeted and local
Organization	Centralized	Distributed
Challenges	Increase capacity to follow load	Integrate & match supply and demand
Flash point	50 most expensive hours (>$10,000)	50 least expensive hours (< $0)
Market power	High	Low
Optimization Target	Meet peaks	Shave peaks, Fill valleys (shed & shift)
End users role	Passive	Active & Prosumer
Flow:		
Output	Hub & Spoke, linear	Networked, Dynamic & Transparent
Information	Aggregate	Transparent, local
Resources:		
Physical	Fuel, Cement and Boiling Water	Steel, Silicon and Intelligence
Intellectual	Engineering judgement	Communications, Advanced Control
Capital	High for base, low for peak	Moderate for both
Energy intensity	High, concentrated	Low, diffuse

Source: Adapted form Carlotta Perez, 2009, *Technological Revolutions and Techno-economic Paradigms,* Working Papers in Technology Governance and Economic Dynamics, 18, January.

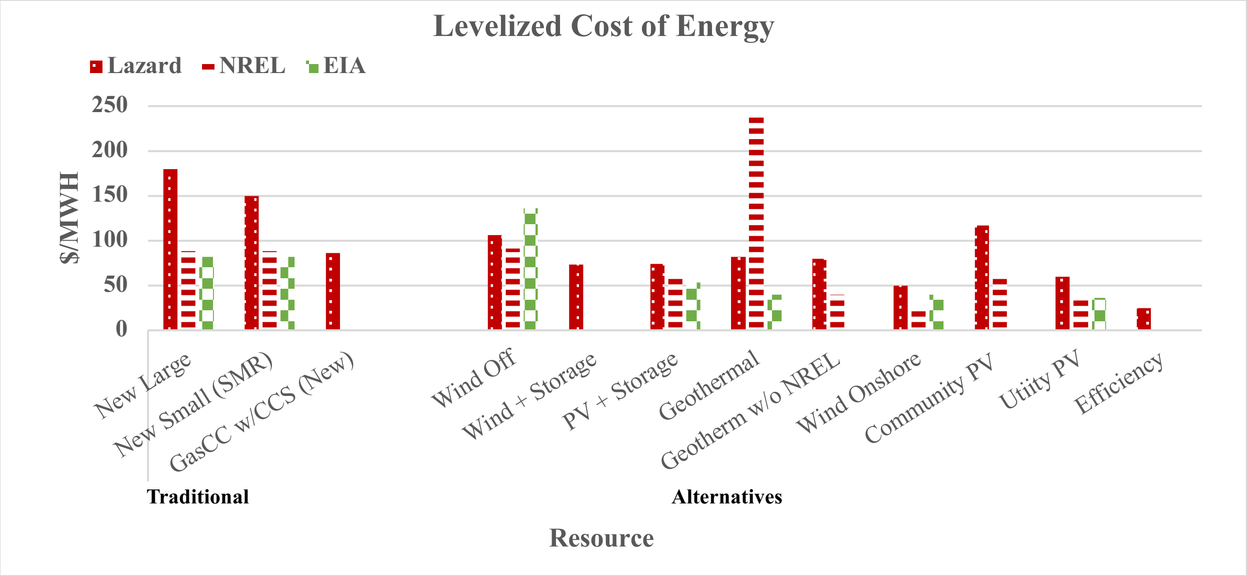
MNC-2.1

10 REASONS WHY LAZARD IS A GOOD BASIS FOR COST ESTIMATION

1. First and foremost, Lazard's projections have tracked the actual development of costs over the past decade and a half much more closely than others. Lazard's estimates reflect the behaviors of those building the resources in the marketplace,
2. From the outset, Lazard's analysis included efficiency.
3. Lazard's was among the first of the comprehensive analyses to note the strong do7. wnward trend in the cost of solar and to begin arguing that solar was cost-competitive for peak power in some major markets.
4. The analysis included estimates for coal with carbon capture and storage, and later added the cost of natural gas with carbon capture and storage.
5. The analysis includes regional estimates for resources whose economics vary by location.
6. The more recent analysis adds important storage technologies, utility-scale solar with storage, and utility-scale battery storage. It also presents a cost trend for storage that is similar to the trends from other renewable and distributed sources.
7. The annual reports included natural gas peaking capacity costs and, in a recent analysis, added a cross-national comparison of peaking technologies that might displace gas as the peaker resource.
8. The analysis has also added comparisons of carbon abatement costs, as the determination to deal with climate change has grown.
9. Lazard also recognized the importance of combining generation (especially solar) with battery storage (hybrid systems)and has now published six such evaluations. After significant deployment of renewables with storage, the report examined the cost of these installations.
10. Most recently, the unique costs associated with "firming" intermittent resources has been estimated.

MNC-2.2

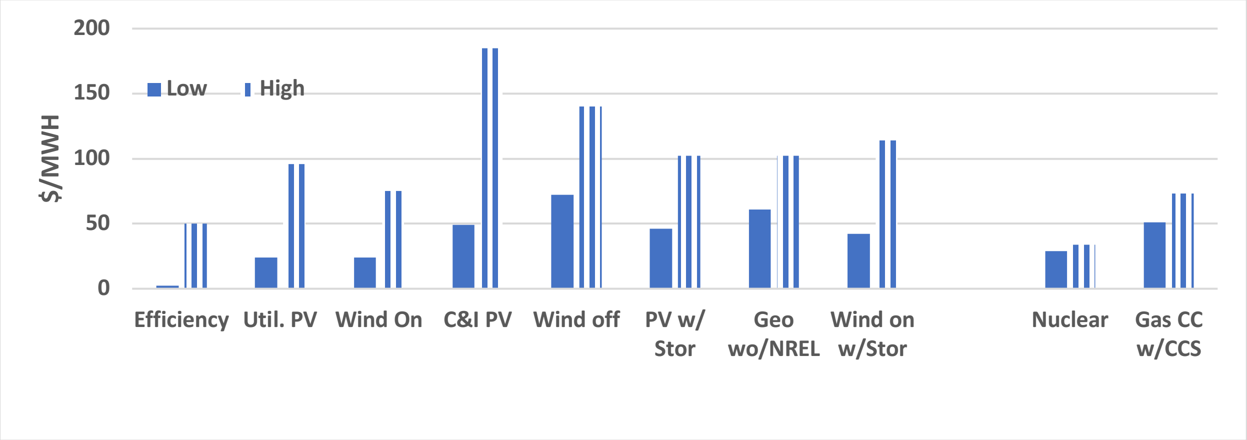
LONG-TERM COSTS



Sources: Lazard, Levelized Cost of Energy, v, 16.0, 2023; NREL, Annual Technology BASELINE (ATB), 2020-2022, Energy Information Administration (EIA), 2018 - 2022, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook.

MNC-2.3

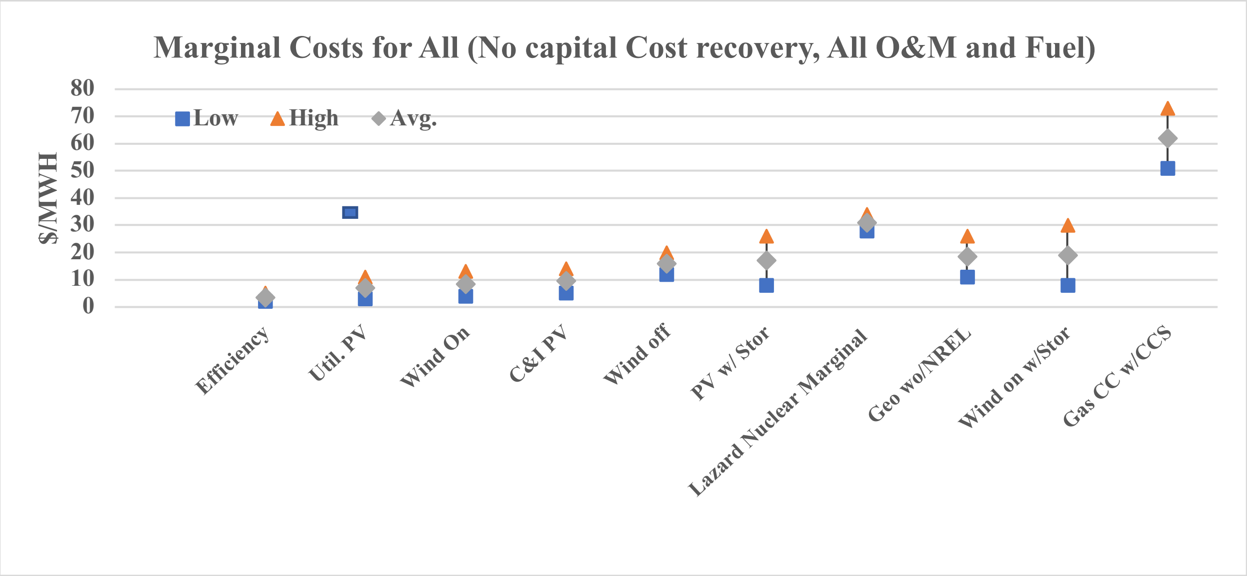
ALL-IN RENEWABLES V. MARGINAL TRADITIONAL: COMPARING APPLES-TO-ORANGES



Sources: See Attachment MNC-2.2 and Lazard, *Levelized Cost of Energy*, v. 16.0, p. 7

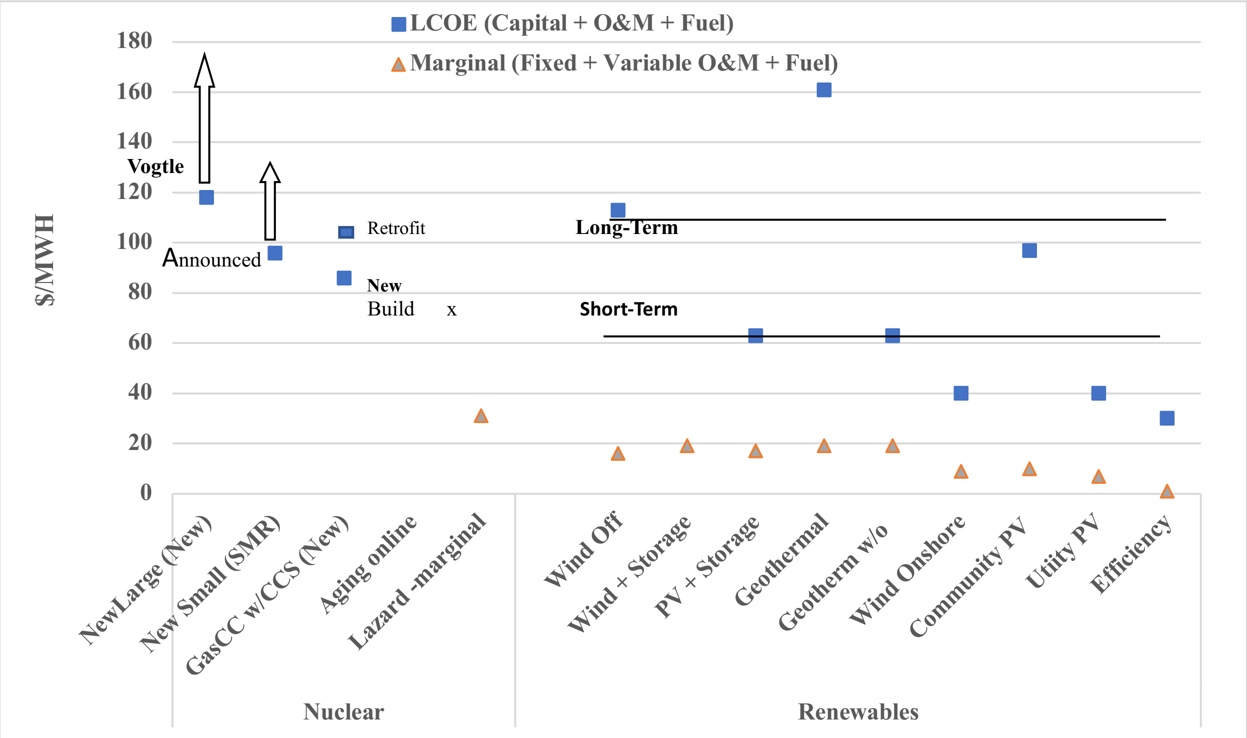
MNC-2.4

MARGINAL ANALYSIS – COMPARING APPLES-TO-APPLES



MNC-2. 5

SHORT-TERM REINFORCES CONCLUSIONS BASED ON THE LONG-TERM

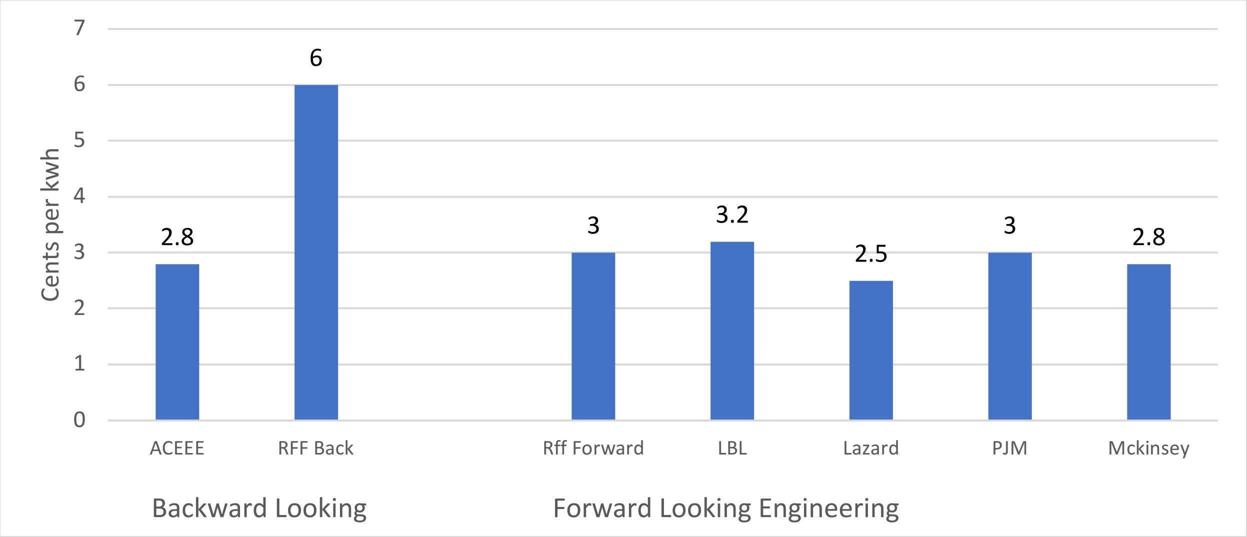


Traditional	**Alternatives**

Sources: See Attachment MNC-2.2 and Lazard, *Levelized Cost of Energy*, v. 16.0, p. 7

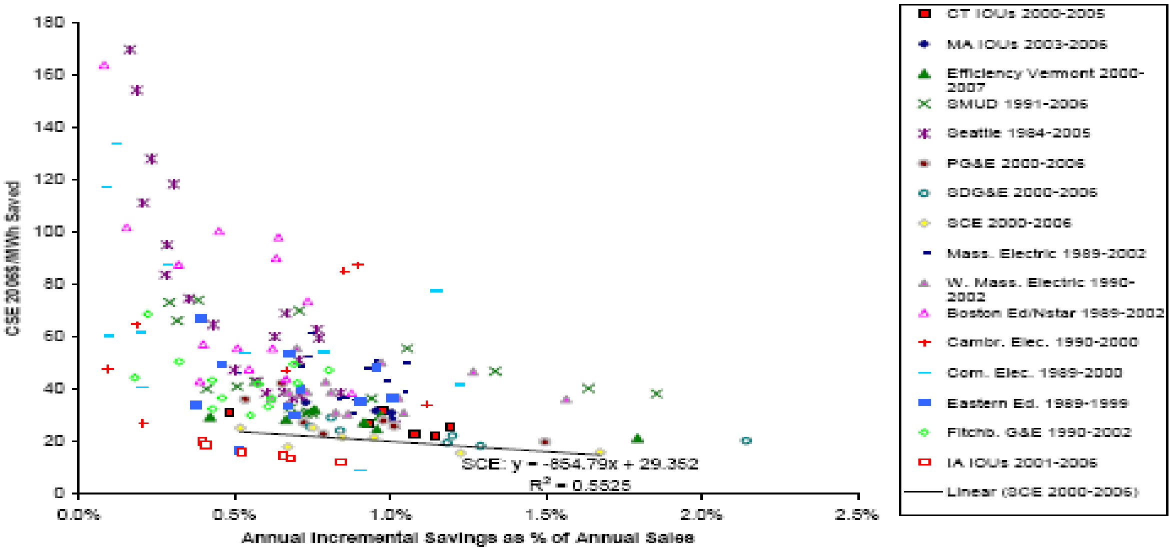
MNC-2.6

THE COST OF SAVED ELECTRICITY



Source: 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).

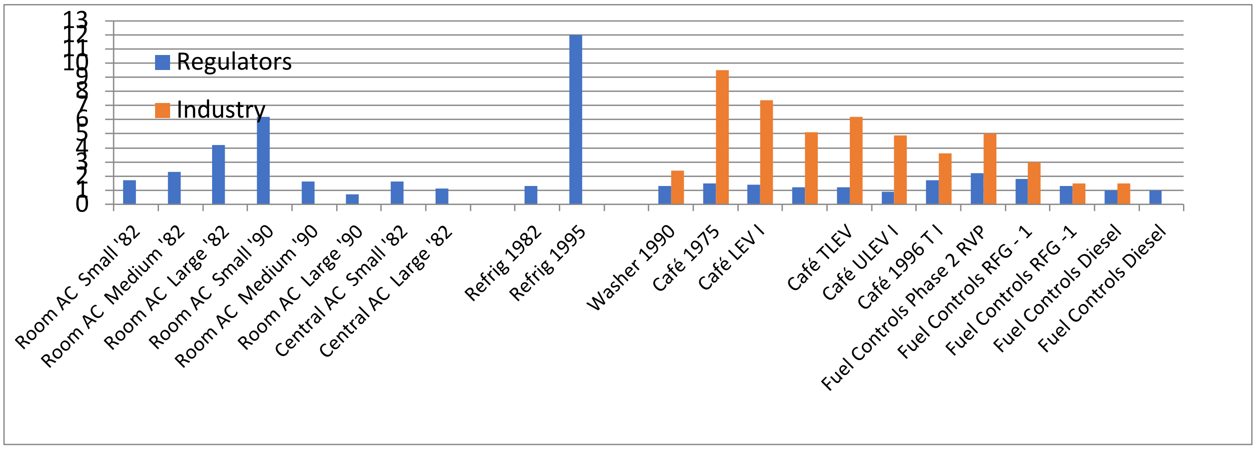
UTILITY COST OF SAVED ENERGY VS. INCREMENTAL ANNUAL SAVINGS AS A % OF SALES



Source: 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.

MNC-2.7

THE PROJECTED COSTS OF REGULATION EXCEED THE ACTUAL COSTS: RATIO OF ESTIMATED COST TO ACTUAL COST BY END-USE AND SOURCE



Sources: Winston Harrington, Richard Morgenstern and Peter Nelson, "On the Accuracy of Regulatory Cost Estimates," *Journal of Policy Analysis and Management* 19(2) 2000, *How Accurate Are Regulatory Costs Estimates?,* Resources for the Future, March 5, 2010; ; Winston Harrington, *Grading Estimates of the Benefits and Costs of Federal Regulation: A Review of Reviews,* Resources for the Future, 2006; Roland Hwang and Matt Peak, *Innovation and Regulation in the Automobile Sector: Lessons Learned and Implications for California's* CO_2 *Standard,* Natural Resources Defense Council, 2.7pril 2006; Larry Dale, et al., "Retrospective Evaluation of Appliance Price Trends," *Energy Policy* 37, 2009.

MNC-2.8

MULTIVARIATE ANALYSIS OF APPLIANCE STANDARDS IMPACT ON ENERGY USE

Variable	Statistic	5-years before/after				All Years			
		1	2	3		4	5	6	
Standard	β	-.1637	-.1386	-.1086		-.2260	-.1079	-.0803	-
	Std. Err.	(..0485)	(.0587)	(.0382)	(.0366)	(.0414)	(.0227)		
	p <	.000	.023	.007		.000	.010	.001	
Trend	β	NA	-.0053	-.0111		NA	- .0107	-.0135	
	Std. Err.		(.0081)	(.008)			(.0026)	(.0019)	
	p <		.51	.176			.000	.000	
Refrig	β	NA	NA	-.2775		NA	NA	-.2242	
	Std. Err.			(.0382)			(.0289)		
	p <			.000				.000	
Washer	β	NA	NA	-.2889		NA	NA	-.2144	
	Std. Err.			(.0561)			(.0391)		
	p <			.000				.000	
RoomAC β		NA	NA	.0478		NA	NA	-.0895	
	Std. Err.			(.0642)			(.0321)		
	p <			.383				.009	
CAC	β	NA	NA	-.0050		NA	NA	.0383	
	Std. Err.			(.0292)			(.0260)		
	p <			.864				.143	
R^2	.20	.21		.85		.29	.36	.75	

Statistics are Beta coefficient and robust standard errors.

Source: Mark Cooper, *Trump's $2 Trillion Mistake, The War on Energy Efficiency, November 2017 (Consumer Federation of America); Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California*. Presentation at the California Energy Commission's Energy Academy, February 20, 2014.

MNC-2.9

ANNUAL CHANGE IN U.S ELECTRICITY GENERATION PER DOLLAR OF GDP/PER CAPITA

Period	Annual % Change Electricity	GDP/capita	Electricity/ GDP/capita	
1950-1980	+6.4	+3.5	+2.89	
1980-1995	+1.9	+2.2	-0.000	\
1995-2019	+1.3	+3.3	-2.0	

Source: U.S. Energy Information Administration, *Monthly Energy Review,* various, and; ***US Real GDP by Year,***

MNC-2.10

ELEMENTS OF "COMMAND-BUT-NOT-CONTROL" REGULATION

Long-Term: Setting a high standard for the next fifteen years is intended to foster and support a long-term perspective for automakers and the public, by reducing the marketplace risk of investing in new technologies. The long-term view gives the automakers time to re-orient their thinking, retool their plants and help re-educate the consumer. The industry spends massive amounts on advertising and expends prodigious efforts to influence consumers when they walk into the show room. By adopting a high standard, auto makers will have to expend those efforts toward explaining why higher fuel economy is in the consumer interests. Consumers need time to become comfortable with the new technologies.

Product Neutral: The new approach to standards accommodates consumer preferences; it does not try to negate them. The new approach to standards is based on the footprint (size) of the vehicles and recognizes that SUVs cannot get the same mileage as compacts. Standards for larger vehicles will be more lenient, but every vehicle class will be required to improve at a fast pace. This levels the playing field between auto makers and removes any pressure to push consumers into smaller vehicles.

Technology-neutral: Taking a technology neutral approach to the long-term standard unleashes competition around the standard that ensures that consumers get a wide range of choice at the lowest cost possible, given the level of the standard. There will soon be hundreds of models of electric and hybrid vehicles using four different approaches to electric powertrains (hybrid, plug-in, hybrid plug-in, and extended range EVs), offered across the full range of vehicles driven by American consumers (compact, mid-size family sedans, large cars, SUVs, pickups), by half a dozen mass market oriented automakers. At the same time, the fuel economy of petroleum powered engines can be dramatically improved at consumer-friendly costs and it will continue to be the primary power source in the light duty fleet for decades.

Responsive to industry needs: Establishing a long-term performance standard recognizes the need to keep the standards in touch with reality. The standards can be set at a moderately aggressive level that is clearly beneficial and achievable. With thoughtful cost estimates, consistent with the results of independent analyses of technology costs, a long-term performance standard will contribute to a significant reduction of cost.

Responsive to consumer needs: The approach to standards should be consumer-friendly and facilitate compliance. An attribute-based approach ensures that the standards do not require radical changes in the available products or the product features that will be available to consumers. We include the principle that standards should be attributed based as the key to this criterion. Consumers purchase and use durables for specific purposes. The attributes of the durables are extremely important. To the extent that agencies design standards to ensure consumers get the functionalities they need, the standards will be more effective. The setting of a coordinated national standard that lays out a steady rate of increase over a long-time period gives the market and the industry certainty and time to adapt to change.

Procompetitive: All of the above characteristics make the standards pro-competitive. Producers have strong incentives to compete around the standard to achieve them in the least cost manner, while targeting the market segments they prefer to serve. Well-designed performance standards that follow these principles command but they do not control. They ensure consumer needs are met while delivering energy savings and increasing consumer and total social welfare.

Source: Mark Cooper, xx, *Trump's $2 Trillion Mistake*, Consumer Federation America, Chapter IV.

MNC-2.11

EXTERNALITIES

Lifecycle Carbon Emissions with Lost Opportunity of Delay
(Grams of CO_2/ kwh)

	Life Cycle			Cost of Construction delay Total		
	Low	Avg.	High	Low	Avg.	High
Efficiency		1				
Wind	4	10	7	1		
CSP	9	10	11	10		
Solar	19	32	59	1		
Geothermal	15	35	55	6	38	44
New Gas w/CCS	44			44		
Nuclear: Old		58				
New	9	40	70	59	106	120

Non-Carbon Environnemental Impacts

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

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.

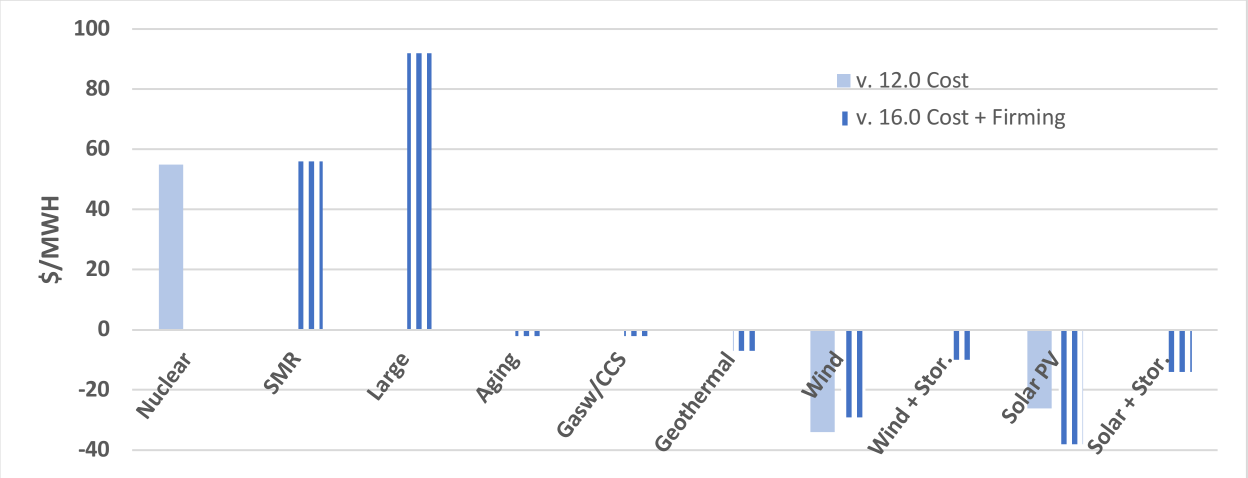
Rank Order of External Impacts

Pollutant[a/]	CO2	NOX/ SOX	Land	Water	Water Use	Solid Dischg.	Bio Waste	Avg. NON- CO_2	Rank on [b/] non-air impacts Original Scale	Converted to 3.0 scale
Resource										
Efficiency	3	3	3	3	3	3	3	3	9.98	2.99
Hydro	3	1.89	3	1	1.5	2	2	1.98	2.65	.80
Geothermal	2.92	2.3 2	2.8	2	3	2	3	2.05	7.96	2.39
Wind	2.87	3	2.85	1	3	3	2	2.47	7.30	2.19
Solar	2.8	2.86	2.83	1	2.5	1	3	2.37	6.98	2.09
Nuclear	2.61	2.13	2.76	1	0	0	0	1.13	0.98	0.29
Gas	0.78	1.42	1.62	1	2	1.5	2	1.54	5.62	1.69
Coal	0	0.74	0.15	0	0	0.5	1	0.3	0.98	0.29

Source: [a/] Acar, Canan and Ibrahim Dincer, 2017, "Environmental impact assessment of renewables and conventional fuels for different end use purposes," *Int. J. pf Global Warming,* 13. [b/] Dincer, Ibrahim, 2018, "Energetic and Environmental Dimensions," *Exergetic,* Table 7.

MNC-2.12

VALUE OF CARBON ABATEMENT



Source: Based on Lazard, which uses low Levelized Cost, v. 14.0. Updated with Lazard v. 16.0 costs adding aging reactors, hybrid (storage systems, and firming costs.

MNC-2.13

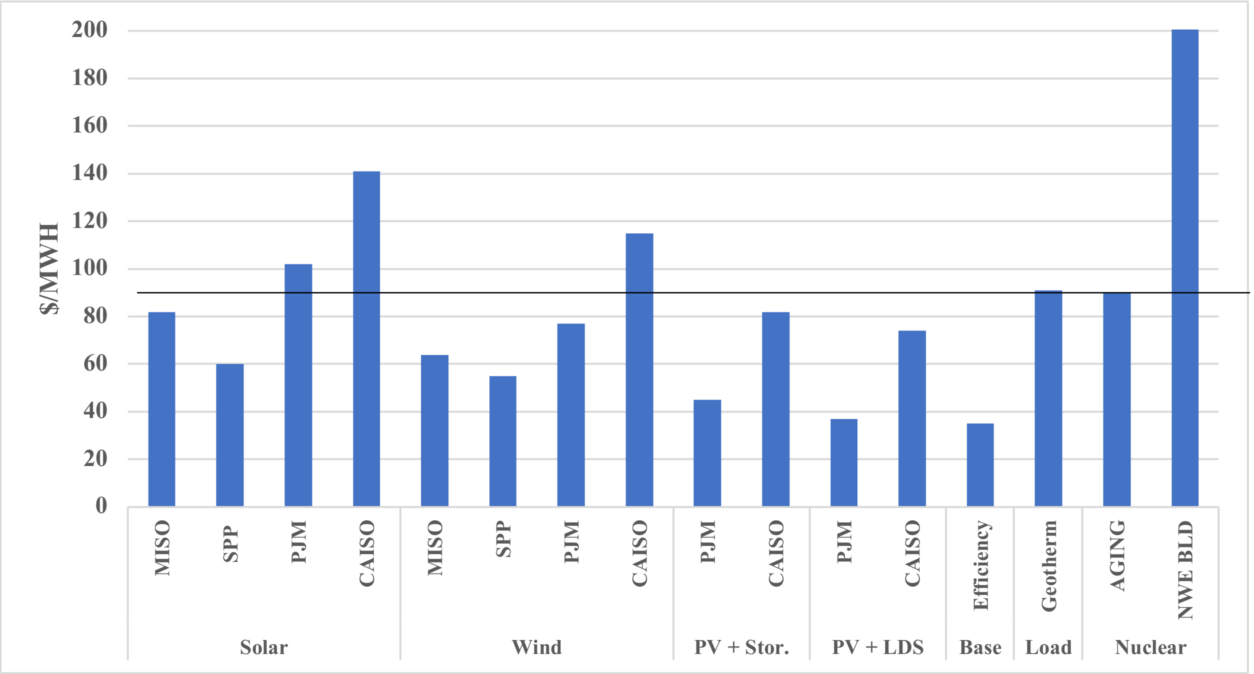
LAZARD'S FIRMING ANALYSIS

Alternative Resource	**Generic Avg.**	**CAISO/ PJM**	**Res- ource**	**Firm- ing**	**Total**	**Total w/ LDES**	**Key assumptions**
<u>Cost of Firm New Entry</u>							
Stand Alone Battery	229	229					
Gas Peaking	115-221						Ruled out. high carbon
GasCC	39-101						“ “
GasCC w/ CS retro	103		103	8 - 16	111-124		Low is 90%, High is 30% Capacity Factor
GasCC w/ CS New	86		86	8 - 16	94-123		“ “
LDS at Scale, avg.	192						Average
Low cost	180						Electorchem., Mechanical
<u>Intermittent Alternatives</u>							
Solar	141		43	98	141		
Solar + Storage	150		32	50	82		100% resource, 50%
Solar + Long Dur. Stor. (low)			32			41-62	firming due to capacity
Wind on			60	72	132		“ “
Wind on + Storage	286		60	52	113		“ “
Wind + Long Dur. Stor.			60			374-9	
<u>Alternative “Baseload”</u>							
Efficiency	35			0	35		No firming or
							0 reserve margin
Geo w/o NREL w/reserve rqt.	82		82	9	90		Geothermal
							plants are 1/4 of
<u>Traditional “Baseload”</u>							one Diablo unit
Aging Reactors w/reserve	70		70	8 - 32	78 -102		Low is 1 unit at
							90%, High is 2 New
New Small Reactor w/reserve			120	8	128		at 80%, with firming
New Reactor w/reserve	141-221		141-221	8-32	148-253		“ “

Source: Lazard, *Levelized Cost of Energy, V. 16.0, pp. xx.*

MNC-2.14

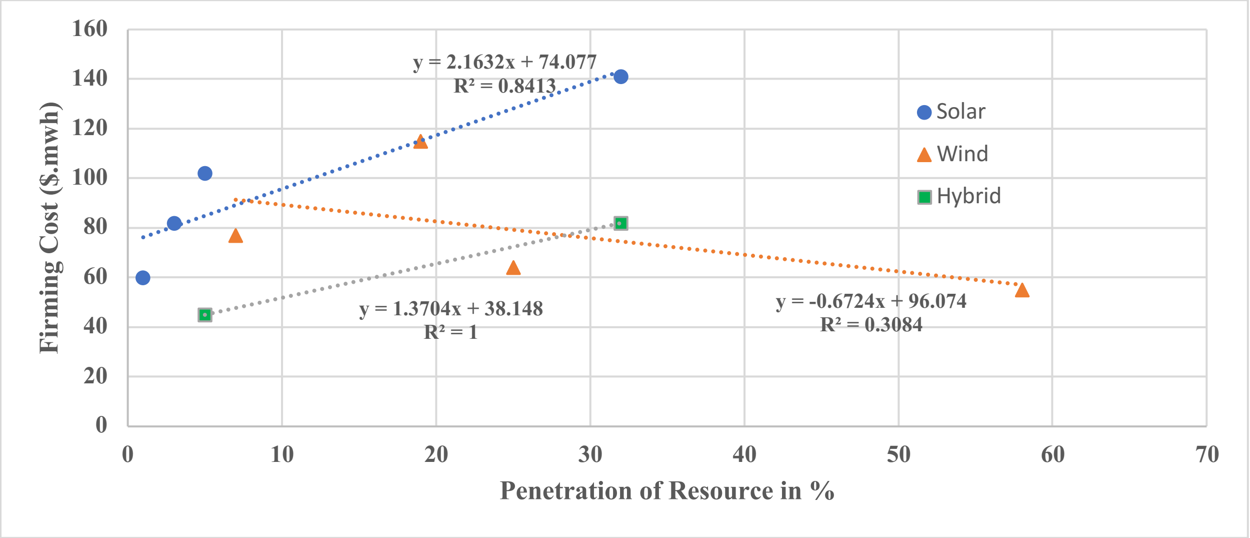
REGIONAL FIRMING ANALYSIS



Penetration 3% 1% 5% 32% 25% 58% 7% 19% 5% 32%

MNC-2.15

RESOURCE PENETRATION AND FIRMING COSTS



Source: Lazard, *Levelized Cost of Energy, V. 16.0,* pp. 7, 8, 31. 35, 37-40

MNC-2.16

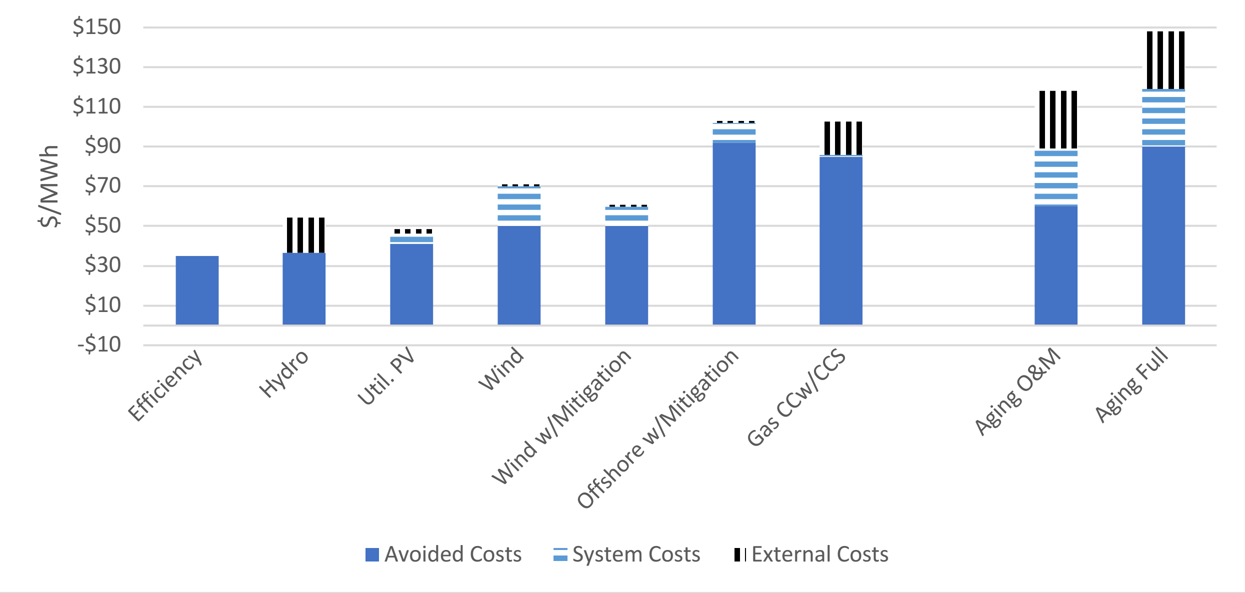
VALUE COST RATIO

Resource	Value Ratio
Efficiency	1.26
Geo w/o NREL	1.25
Solar	1.02
Solar + Storage	0.94
Wind on	0.92
Stand Alone Battery	0.79
Small Nuclear	0.55
Aging Reactors	0.55
GasCC w/ CS New	0.43
GasCC w/ CS retro	0.36
Wind Off	0.35

Source: Energy Information Administration (EIA), 2022, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook*, pp. 12-13

MNC-2.17

ESTIMATES OF TOTAL SYSTEM COST



Source: EIA, 2018, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018*, February Tables 2 and 3, for the adjustment to levelized costs to account for the value of output, using capacity weighted averages where available and unsubsidized costs. Wiser, Ryan, Andrew Mills and Joachim Seel, 2015. Argonne and Lawrence Berkeley National Laboratories, Chapter 5. Lazard, 2018. Lazard's Levelized Cost of Energy Analysis – Version 12.0 for LCOE, 10. For carbon costs, NRC, 2010, *The Hidden Cost of Electricity*, for non-carbon pollution costs of gas, with other resources expressed as a multiple of gas.

MNC-2.18

PPA PRICES AND NET VALUE FOR MAIN RENEWABLE RESOURCE

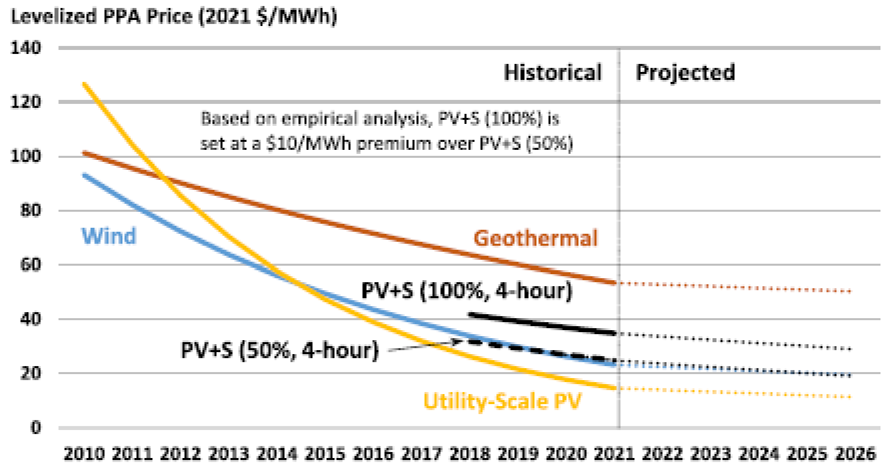


Fig. 4. PPA price trends and extrapolation based on 2022 ATB.

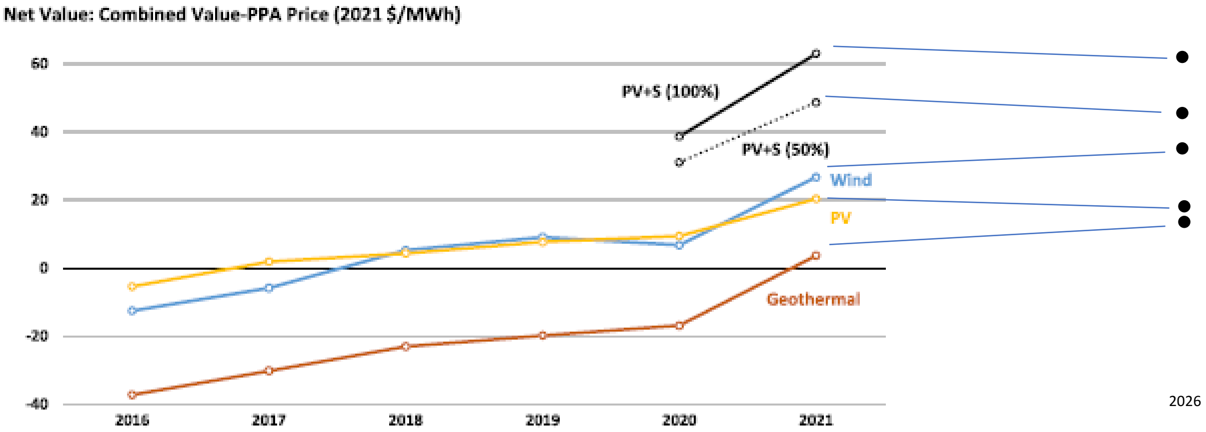
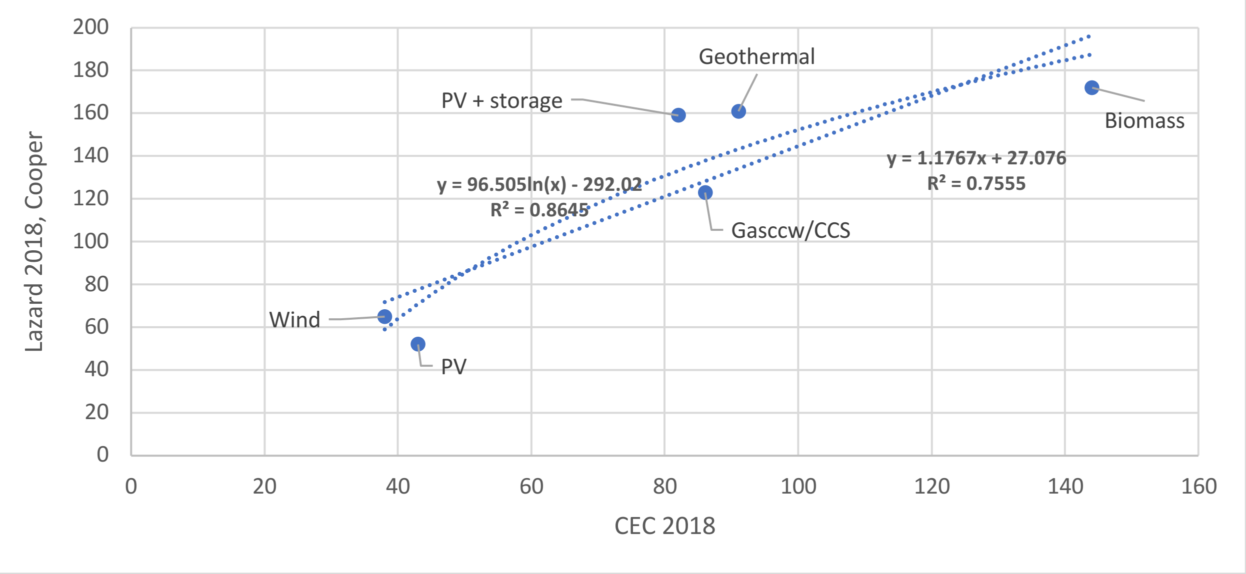


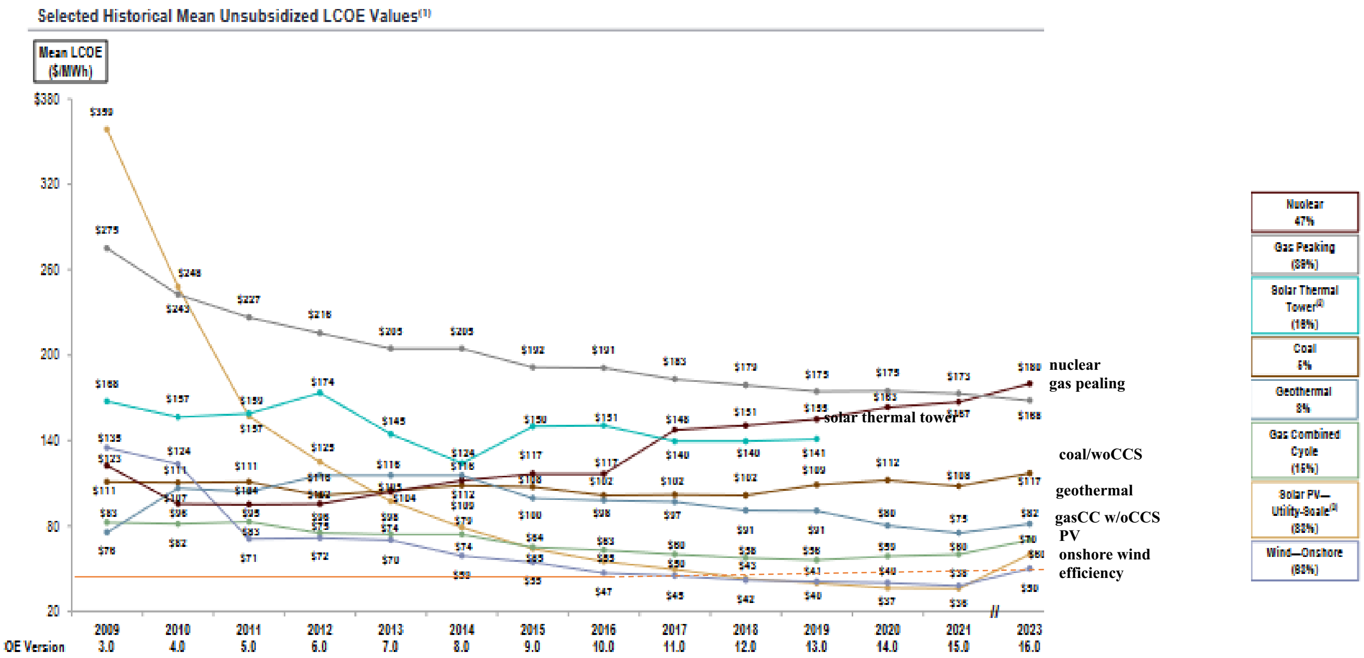
Fig. 7. Net value of PV, wind, geothermal, and PV + S in the West.

Source: Bolinger, Mark, et al., 2023, "Mind the Gap: Comparing the Net Value of Geothermal, Wind, Solar, and Solar+Storage in the Western United States," *Science Direct.*

COMPARISON OF LEVELIZED COSTS ($/MWH)



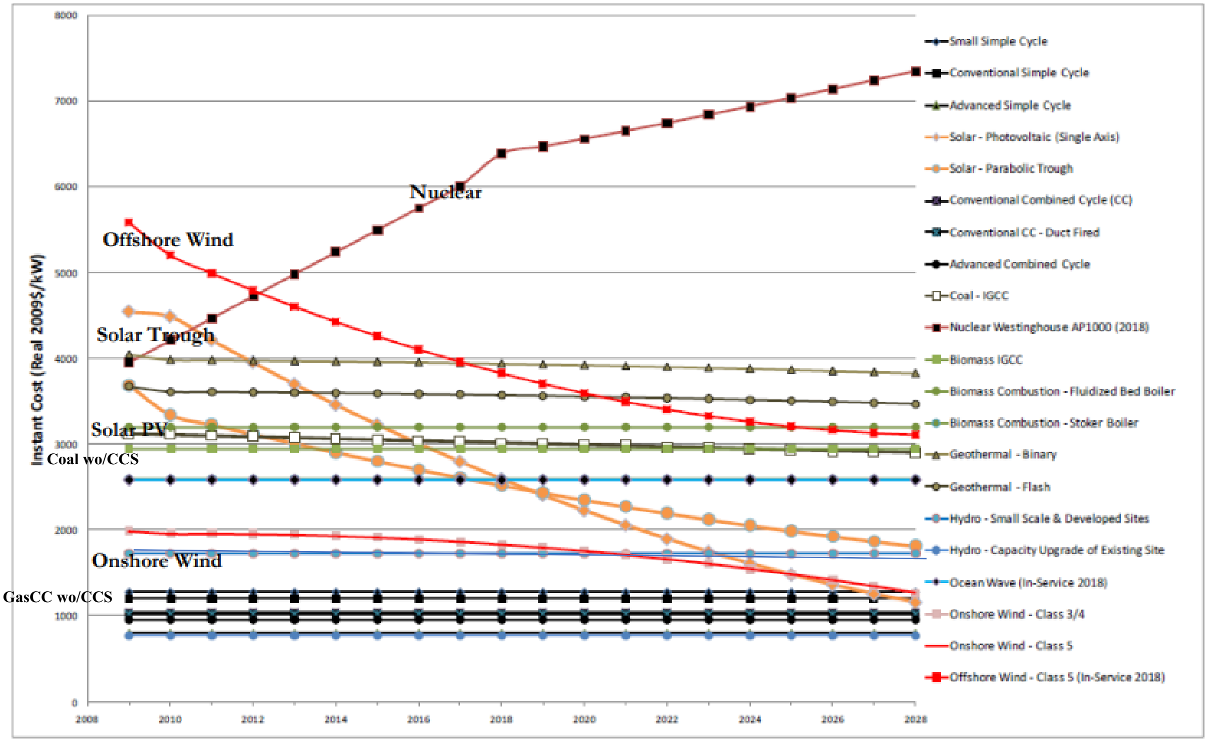
Sources, Staff Report, 2019, "Estimated Cost of New Utility-Scale Generation in California: 2018 Update," California Energy Commission, May, Lazard, 2018, 2022, MNC-2.1, NREL, ATB, 2022, for Biomass.



Source: Lazard v. 16.0, p.

EXHIBIT VI-7: CALIFORNIA ENERGY COMMISSION OVERNIGHT COST TRENDS (JANUARY 2010)

Figure 3: Average Instant Cost Trend (Real 2009 $/kW)

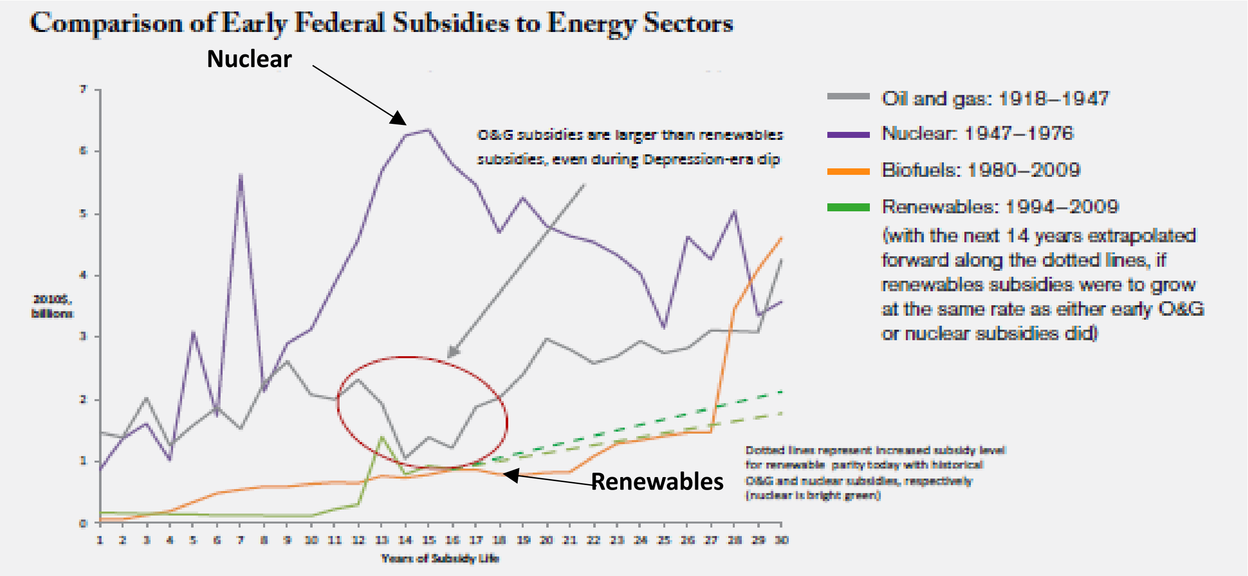


Source: Energy Commission

Source: Mark Cooper, 2012, Nuclear Safety and Nuclear Economics, Fukushima Reignites the Never-Ending Debate: Nuclear Safety at an Affordable Cost, Can We Have Both? Is Nuclear Power Not Worth the Risk at Any Price? Symposium on the Future of Nuclear Power University of Pittsburgh March 27-28.

MNC-3.1

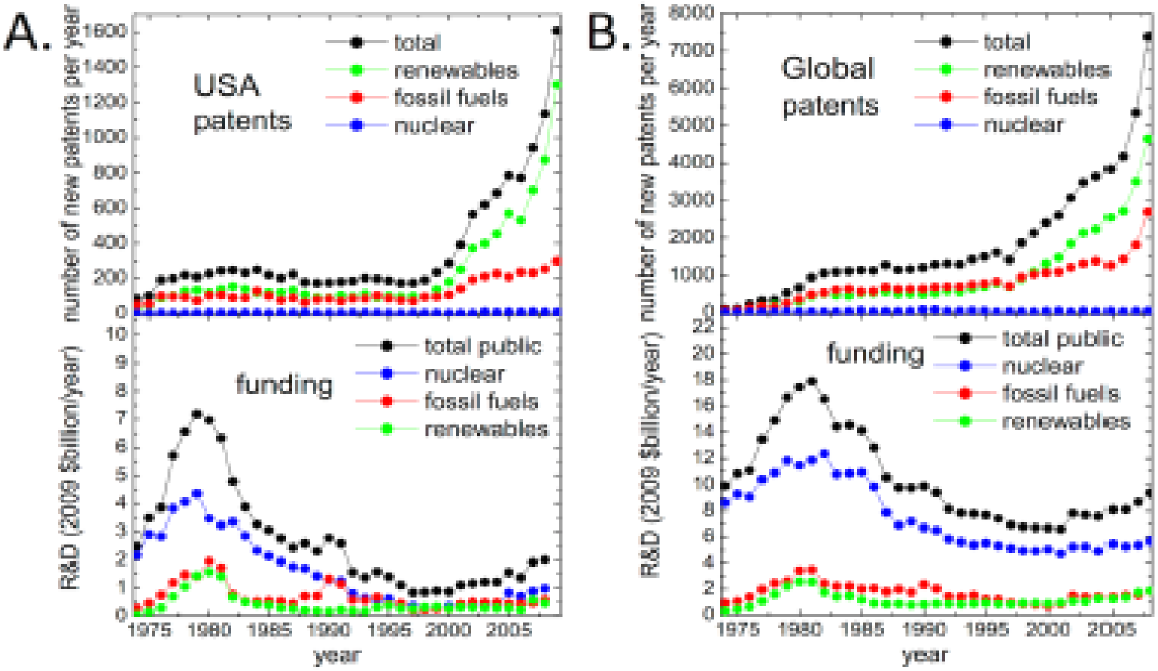
FEDERAL SUBSIDIES FOR INFANT ENERGY INDUSTRIES AND BEYOND



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. A similar conclusion, from the point of view of the effectiveness of subsidies in innovation can be found in Bettencourt, Louis 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-3.2

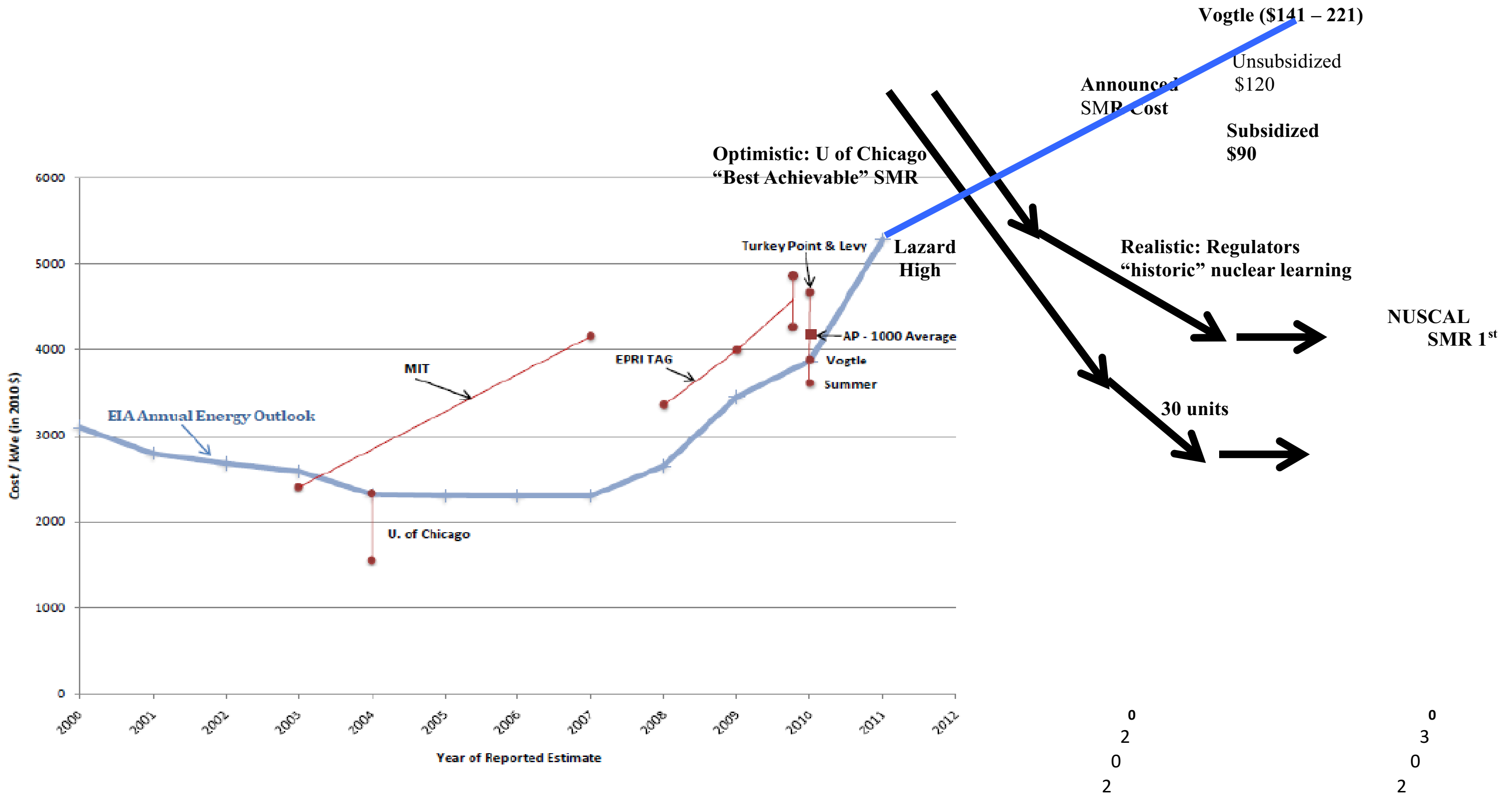
INNOVATION AND PUBLIC SUPPORT FOR R&D



Source: Bettencourt, Louis 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-3.3

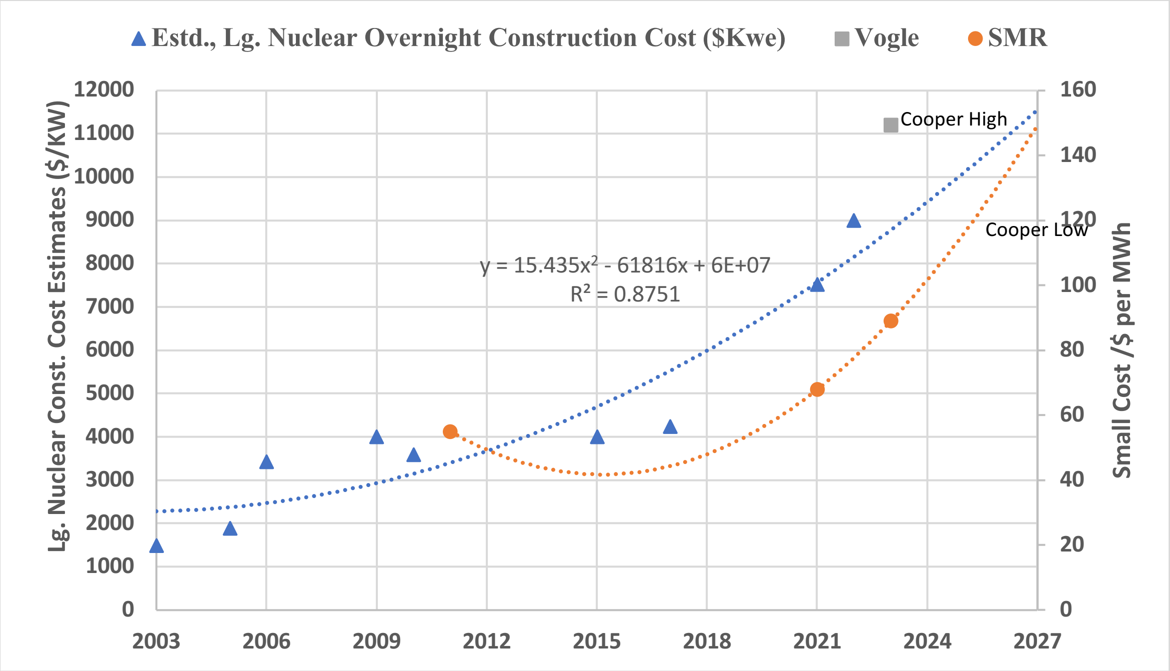
UNIVERSITY OF CHICAGO RECAP OF ENTHUSIAST/UTILITY ESTIMATES OF OVERNIGHT COST FOR NEW GW-SCALE NUCLEAR PLANTS AND SMRS



Sources: Mark Cooper, “Small modular reactors and the future of nuclear power in the United States,” Energy Research & Social Science 3 (2014) 161; Rosner, Robert and Stephen Goldberg, 2011, *Small Modular Reactors – Potentially Key Contributors to Future Nuclear Power Generation in the U.S.*, Center for Strategic and International Studies, December 1; Rosner, Robert, et al., Analysis of GW-Scale Overnight Capital Costs, EPIC, University of Chicago, Technical Paper Nov. 2011. For the cost and other problems with the only active U.S. small modular Reactor see, h. V. Ramana, *2020, Eyes Wide Shut: Problems with the Utah Associated Municipal Power Systems Proposal to Construct NuScale Small Modular Nuclear Reactors,* Oregon Physicians for Social Responsibility.

MNC-3.4

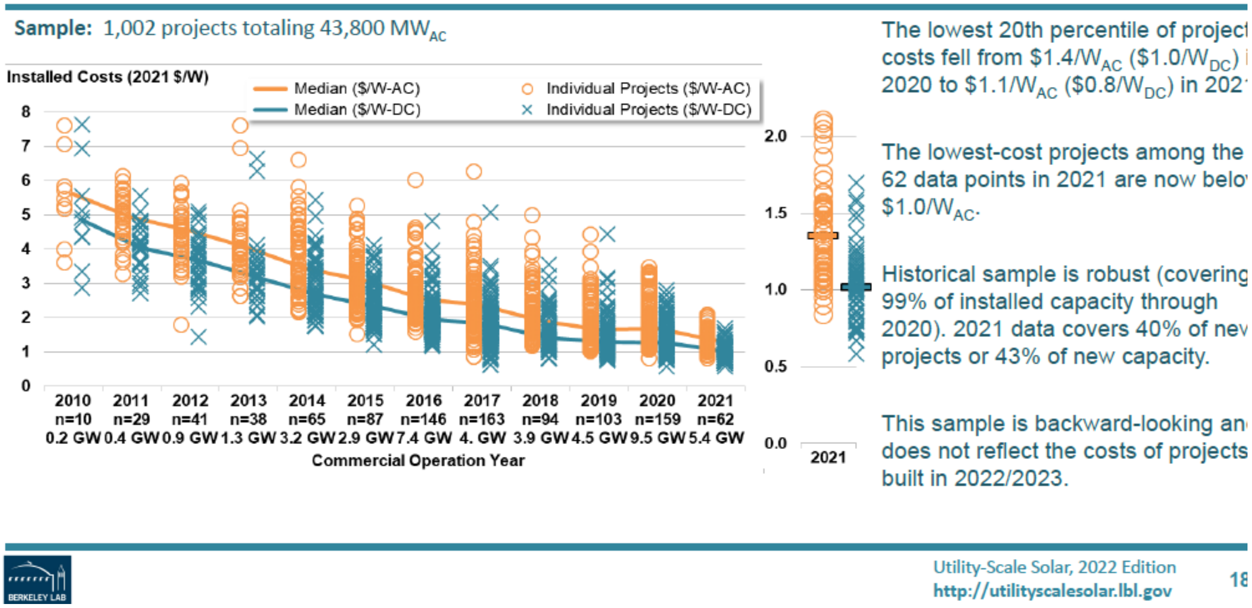
RECENT ESTIMATES AND TRENDS OF NUCLEAR NEW BUILD COSTS



Sources: David Schlissel, 2023, *Eye-popping new cost estimates released for NuScale small modular reactor,* IEEA, January 11, David Kemp and Peter Van Doren, 2023, “Cost Escalation and Delays for Small Modular Reactors Suggest Caution about Nuclear Power Renaissance,” *CATO,* March 23, David Kemp and Peter Van Doren , 2022, “Nuclear Power in the Context of Climate Change, Comparing the Cost of Nuclear and Fossil Fuel Power Plants with a Carbon Tax,” *CATO,* July 26

SHARPLY DECLINING PRICES OF RENEWABLES IN THE 2ND DECADE OF THE 21ST CENTURY

Solar



Sample: 1,002 projects totaling 43,800 MW_{AC}

The lowest 20th percentile of project
costs fell from $1.4/$W_{AC}$ ($1.0/$W_{DC}$) i
2020 to $1.1/$W_{AC}$ ($0.8/$W_{DC}$) in 202

The lowest-cost projects among the
62 data points in 2021 are now belo
$1.0/$W_{AC}$.

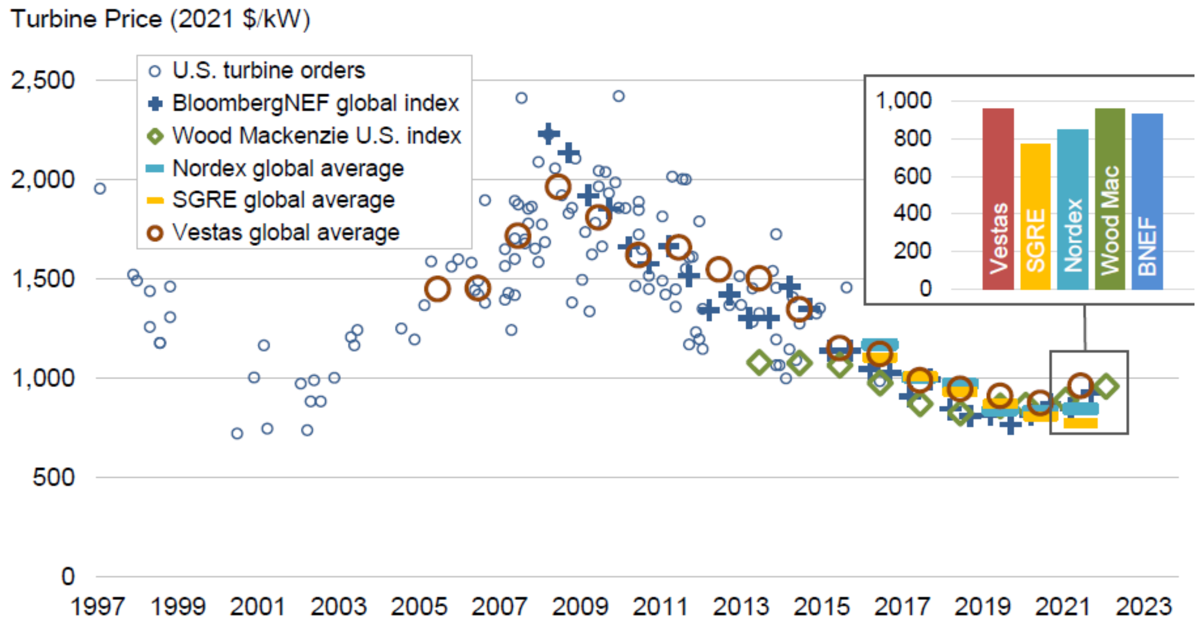
Historical sample is robust (covering
99% of installed capacity through
2020). 2021 data covers 40% of nev
projects or 43% of new capacity.

This sample is backward-looking an
does not reflect the costs of projects
built in 2022/2023.

Utility-Scale Solar, 2022 Edition
http://utilityscalesolar.lbl.gov

18

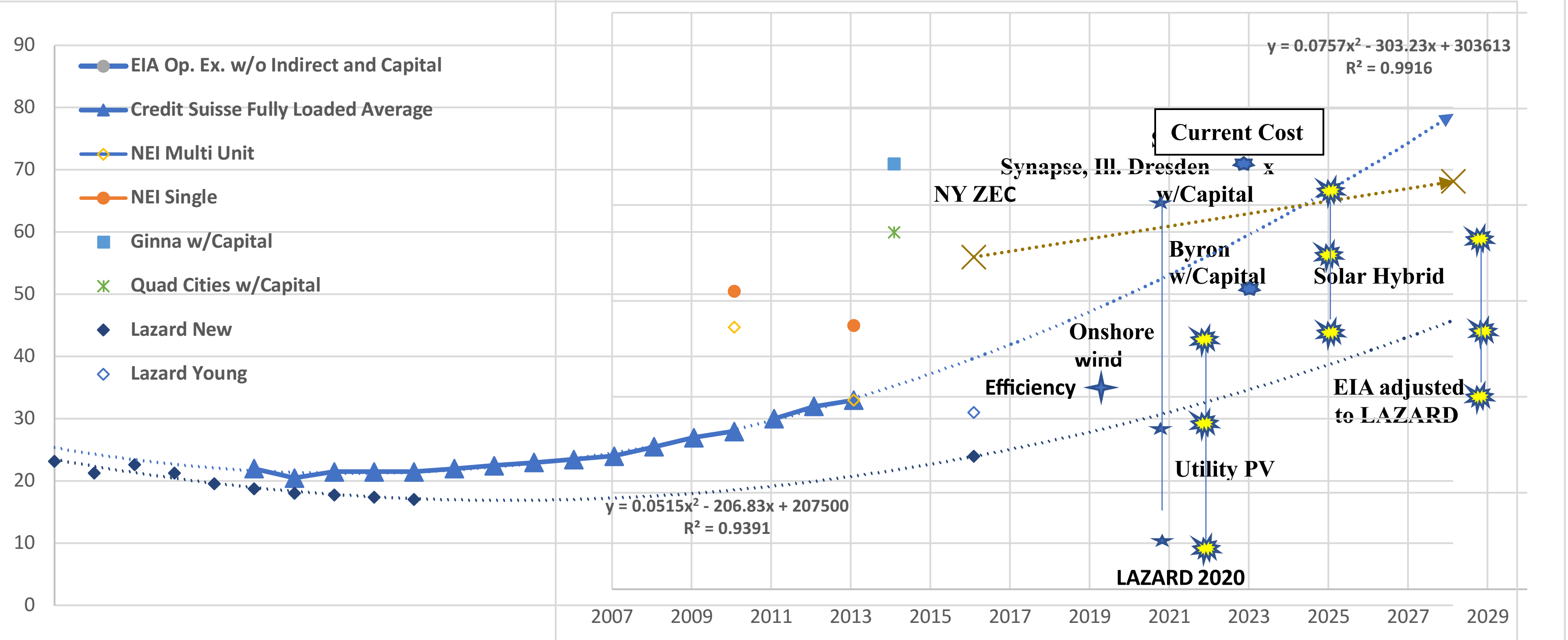
Wind



Sources: Berkeley Lab, annual financial reports, forecast providers

MNC-3.6

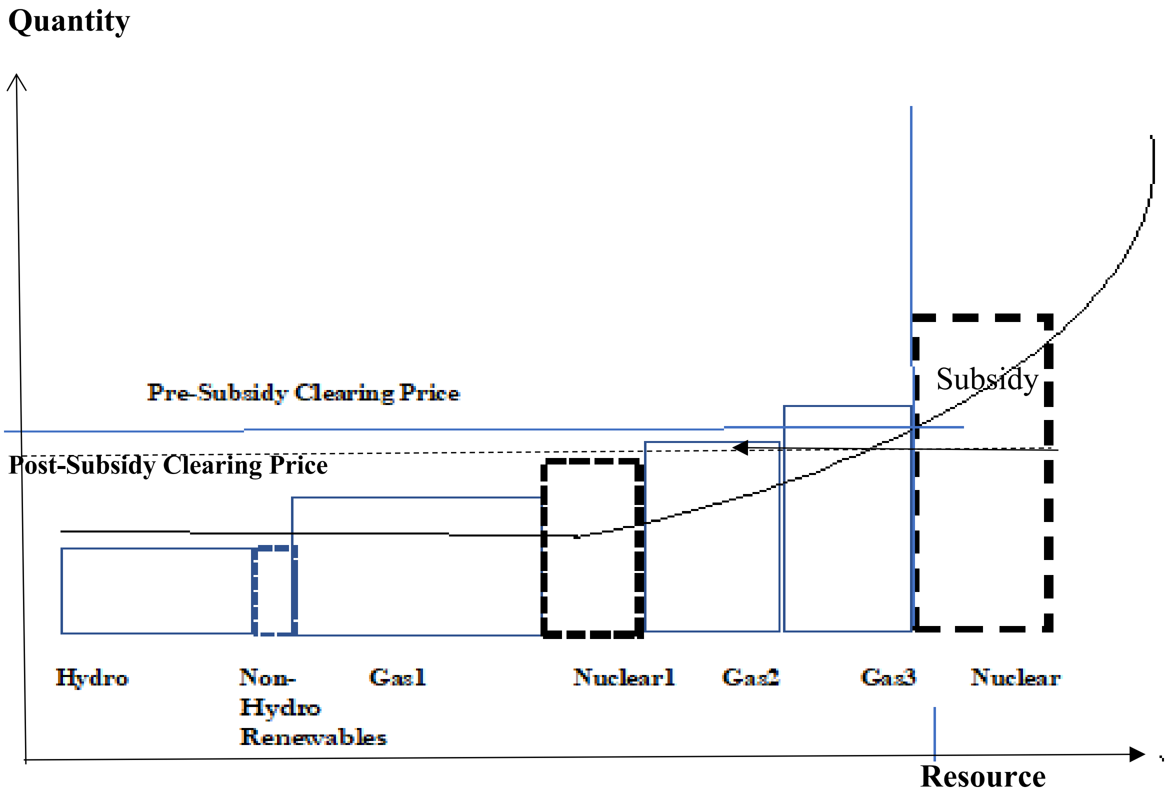
COST OF AGING REACTORS COMPARED TO ALTERNATIVES



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. Energy Information Administration, Electricity Annual, 2015, Table 8.3. Lazard, *Levelized cost of Energy Analysis,* 14.0; Bhandari, Divita, et al., *Exelon Nuclear Fleet Audit, Findings and Recommendations*, Synapse, April 14, 2021,

MNC-3.7

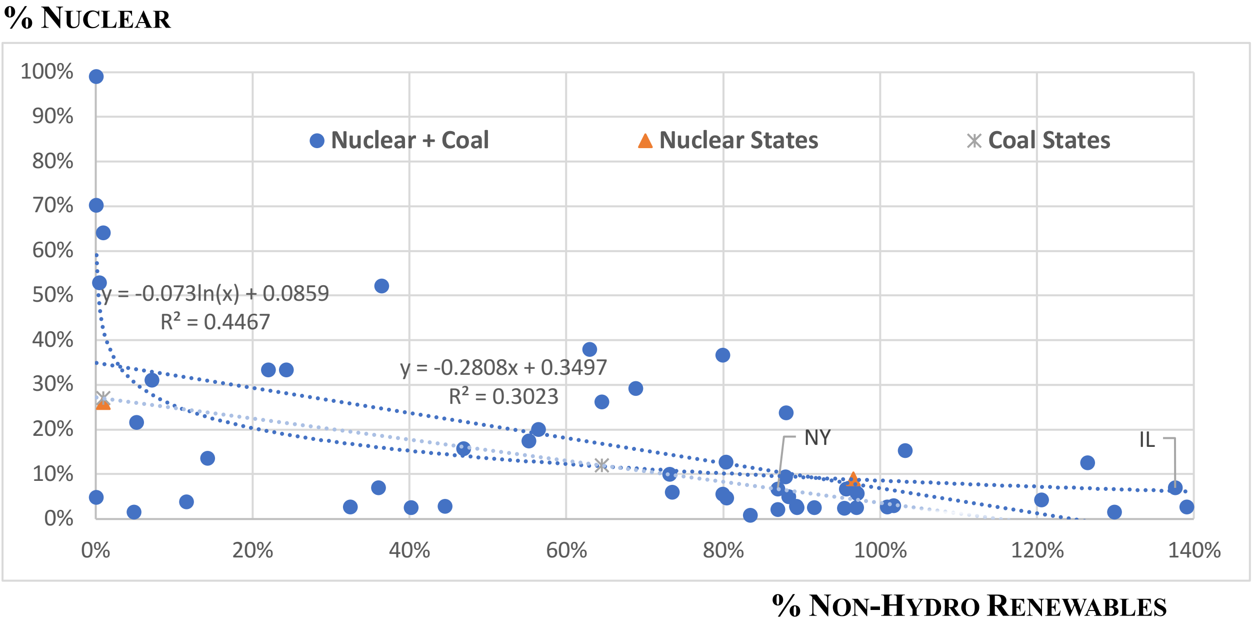
MARKET DISTORTION CAUSED BY THE AGING NUCLEAR REACTOR SUBSIDY, CROWDING OUT NON-HYDRO-RENEWABLES



Source: Based on Mark Cooper, 2017a, *The Political Economy of Electricity, Progressive Capitalism and the Struggle to Build a Sustainable Power Sector,* p. 184 presents the conceptual figure, p. 194 present the real world situation in Illinois.

MNC-3.8

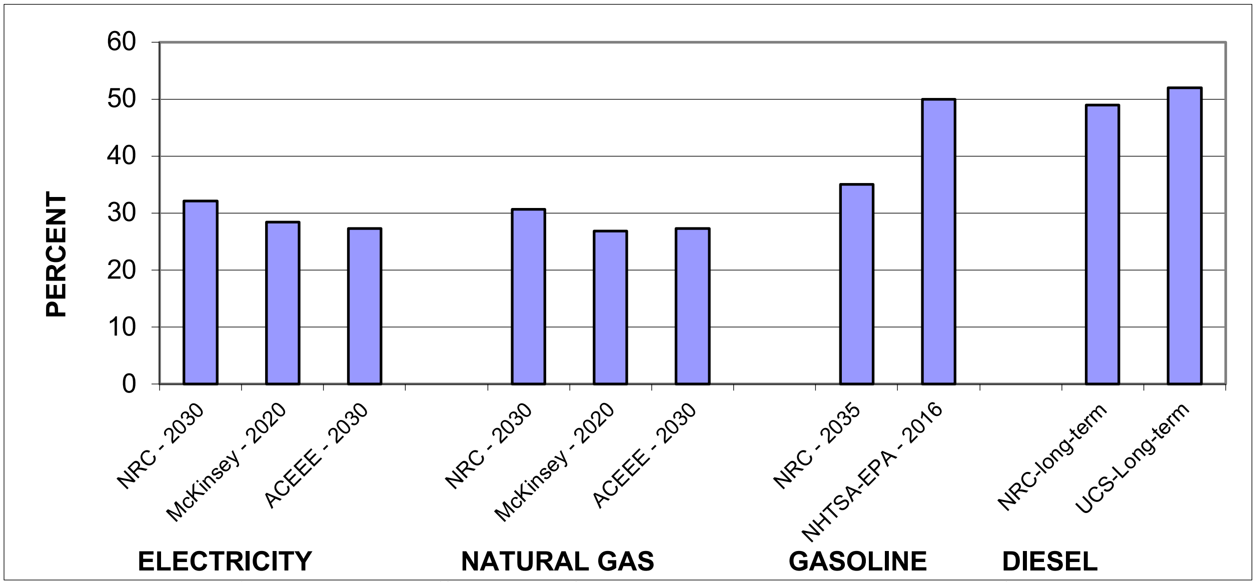
NUCLEAR V. NON-NUCLEAR STATES



Source: U.S. Energy Information Administration, *Electricity Generation, database,* 2018

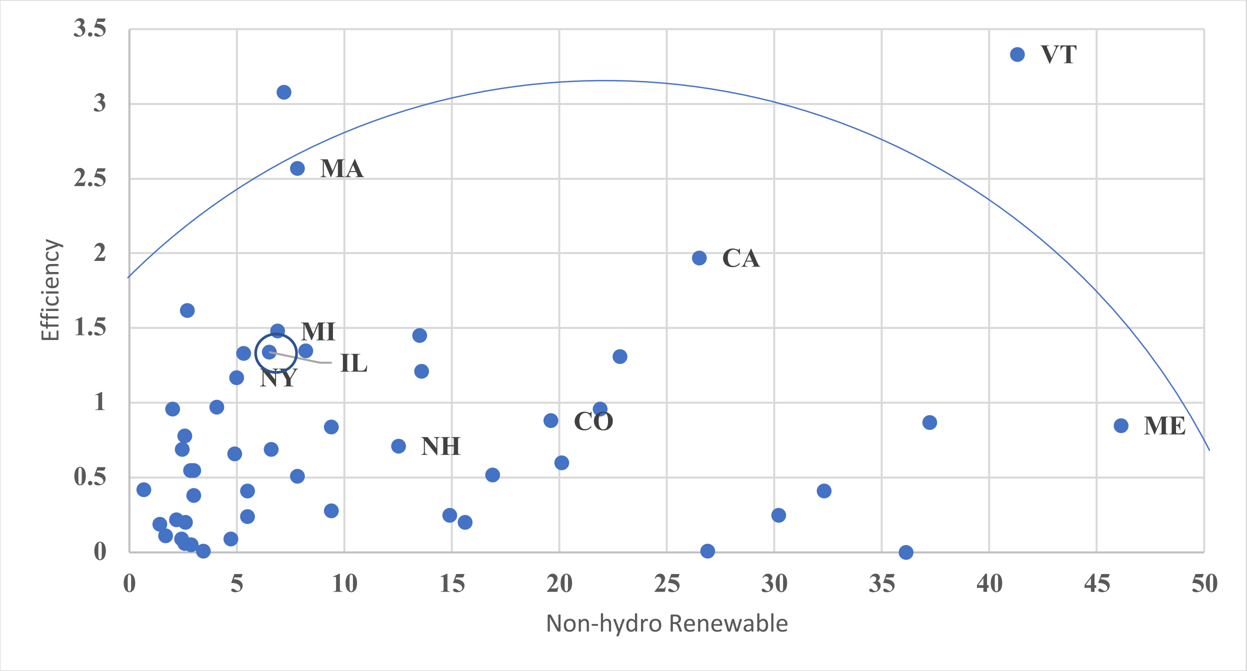
MNC-4.1:

EFFICIENCY GAP ACROSS U.S. ENERGY MARKETS: TECHNICALLY FEASIBLE, ECONOMICALLY PRACTICABLE POTENTIAL ENERGY SAVINGS



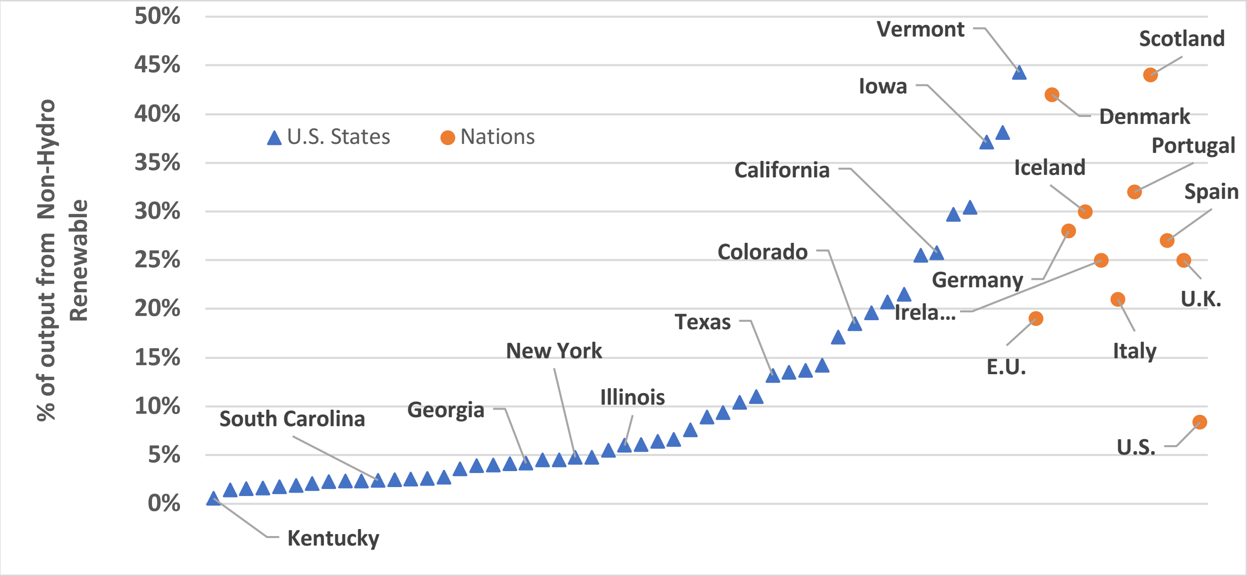
Sources: Cooper, Mark, 2013, *Energy Efficiency Performance Standards: The Cornerstone of Consumer-Friendly Energy Policy,* Comments of the Consumer Federation of America, October.. Electricity and natural gas savings based on Gold, Rachel, Laura, et. al., Energy Efficiency in the American Clean Energy and Security Act of 2009: Impact of Current Provisions and Opportunities to Enhance the Legislation, American Council for an Energy Efficient Economy, September 2009), 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 Brow, Sam Borgeson, Jon Koomey and Peter Biermayer, U.S. Building-Sector Energy Efficiency Potential (Lawrence Berkeley National Laboratory, September 2008). Gasoline based on: National Highway Traffic Safety Administration, *Corporate Average Fuel Economy for MY2012-MY 2016 Passenger Cars and Light Trucks*, *Preliminary Regulatory Impact Analysis*, Tables 1b, and 10. The 7 percent discount rate scenario is used for the total benefit = total cost scenario; NAS -2010, National Research Council of the National Academy of Science, *America's Energy Future* (Washington, D.C.: 2009), Tables 4.3, 4.4; MIT, 2008, Laboratory of Energy and the Environment, On the Road in 2035: Reducing Transportation's Petroleum Consumption and GHG Emissions Cambridge: July, 2008), Tables 7 and 8; EPA-NHTSA - 2010, Environmental Protection Agency Department of Transportation In the Matter of Notice of Upcoming Joint Rulemaking to Establish 2017 and Later Model Year Light Duty Vehicle GHG Emissions and CAFE Standards, Docket ID No. EPA-HQ-OAR-0799 Docket ID No. NHTSA-2010-0131, Table 2, CAR – 2011. Diesel based on: Northeast States Center for a Clear Air Future, International Council on Clean Transportation and Southwest Research Institute, *Reducing Heavy Duty Long Haul Combination Truck Fuel Consumption and* CO_2 *Emissions,* October *2009;* Don Air, *Delivering Jobs: The Economic Costs and Benefits of Improving the Fuel Economy of Heavy-Duty Vehicles,* Union of Concerned Scientists, May 2010; Committee to Assess Fuel Economy for Medium and Heavy Duty Vehicles, *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles,* National Research Council, 2010.

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

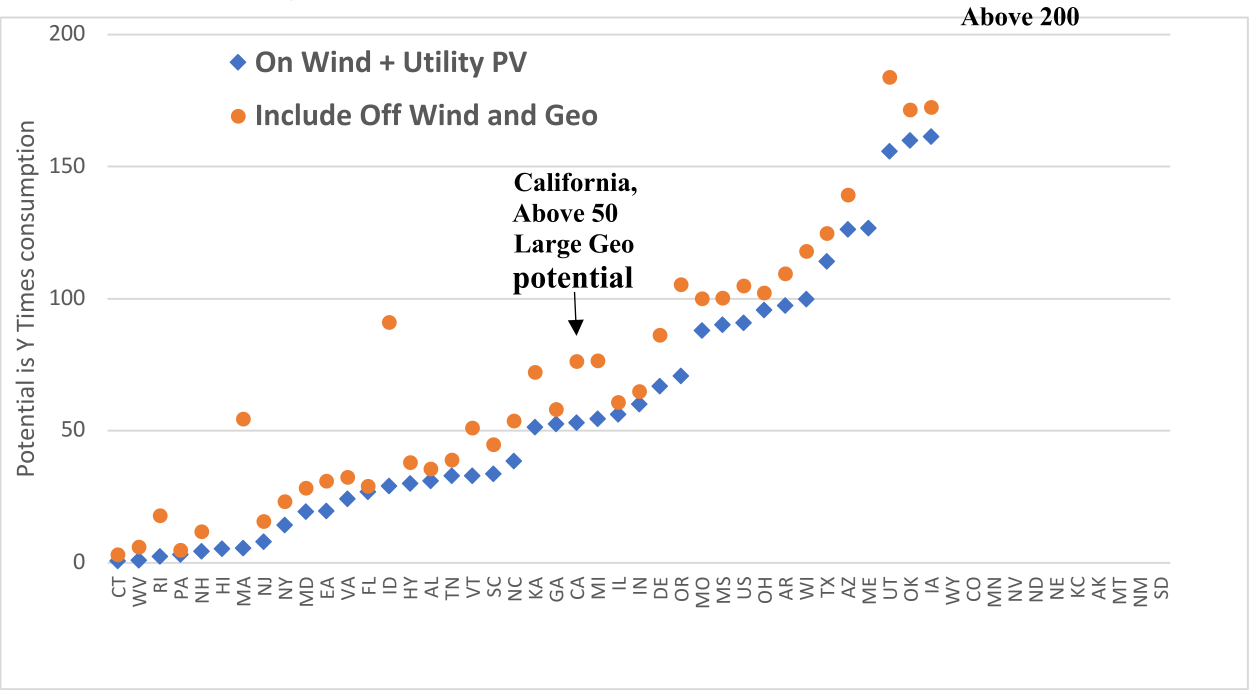


Source: Lovins, Amory B. 2017. "Reliably integrating variable renewables: Moving grid flexibility resources from models to results." The Electricity Journal, 30(10)

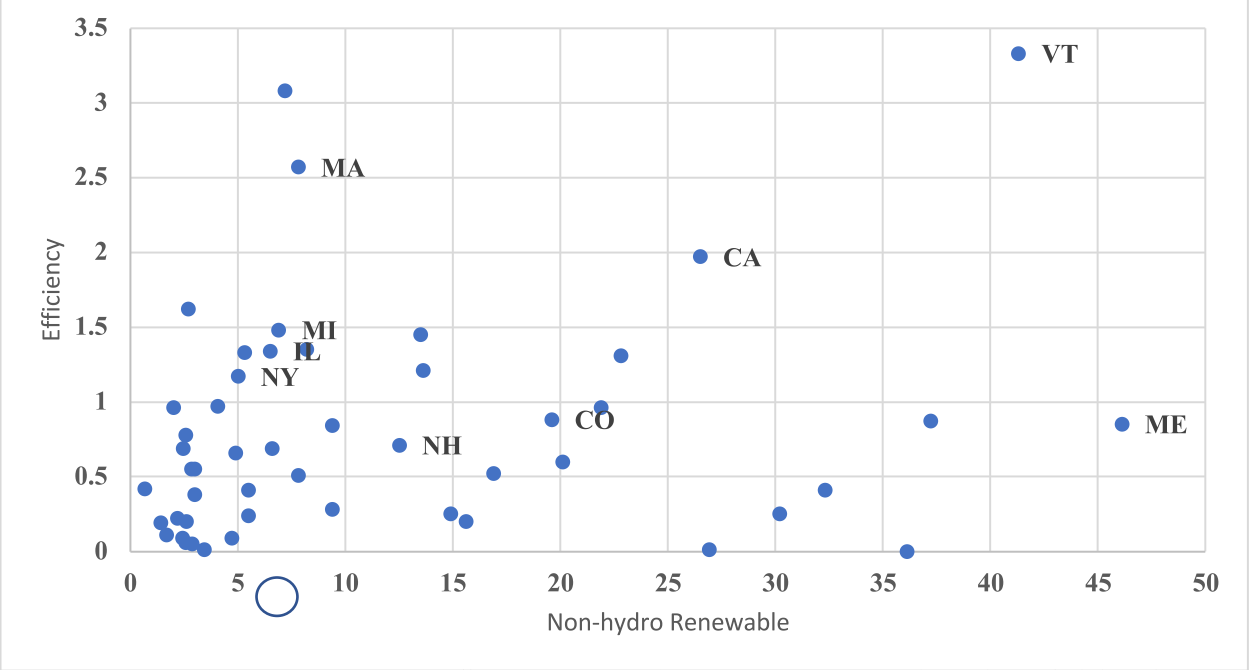
MNC-4.3

ASSESSING THE ADEQUACY OF SUPPLY, POTENTIAL SUPPLY COMPARED TO DEMAND

Onshore Wind, Utility PV, Off Wind and Geothermal



Contribution of Efficiency and Non-Hydro Renewables to Meeting Need (% of Total, 2017)



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

MNC-4.4

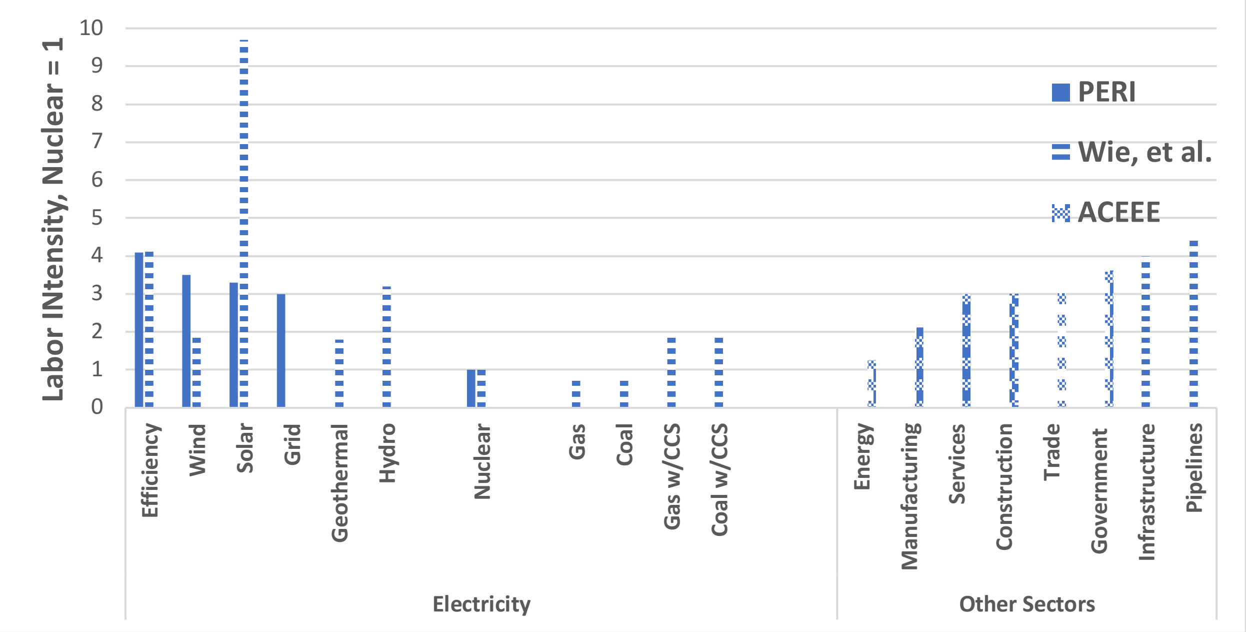
Macroeconomic Multipliers as a Multiple of Net Pocketbook Savings

Modeler	Model Date	Policy Assessed	Region	GDP/$ of Net Savings	
				Base Case	Rebound Adjustment
Roland-Holst	DEAR	Computer Standard	California	1.8	2.0
ENE	REMI	Utility Efficiency	Northeast	2.2	2.4
Cadmus	REMI	Utility Efficiency	Wisconsin	2.5	2.8
Arcadia	REMI	Utility Efficiency	Canada	2.7	3.0

Sources: David Roland-Holst, 2016, *Revised Standardized Regulatory Impact Assessment: Computers, Computer Monitors, and Signage Displays,* prepared for the California Energy Commission, June. ENE, *Energy Efficiency: Engine of Economic Growth: A Macroeconomic Modeling Assessment*, October 2008. Cadmus, 2015, *Focus on Energy, Economic Impacts 2011–2014*, December. Arcadia Center, 2014, *Energy Efficiency: Engine of Economic Growth in Canada: A Macroeconomic Modeling & Tax Revenue Impact Assessment,* October 30,

MNC- 4.5

MACROECONOMIC MULTIPLIERS FOR ELECTRICITY RESOURCES & ECONOMIC SECTORS



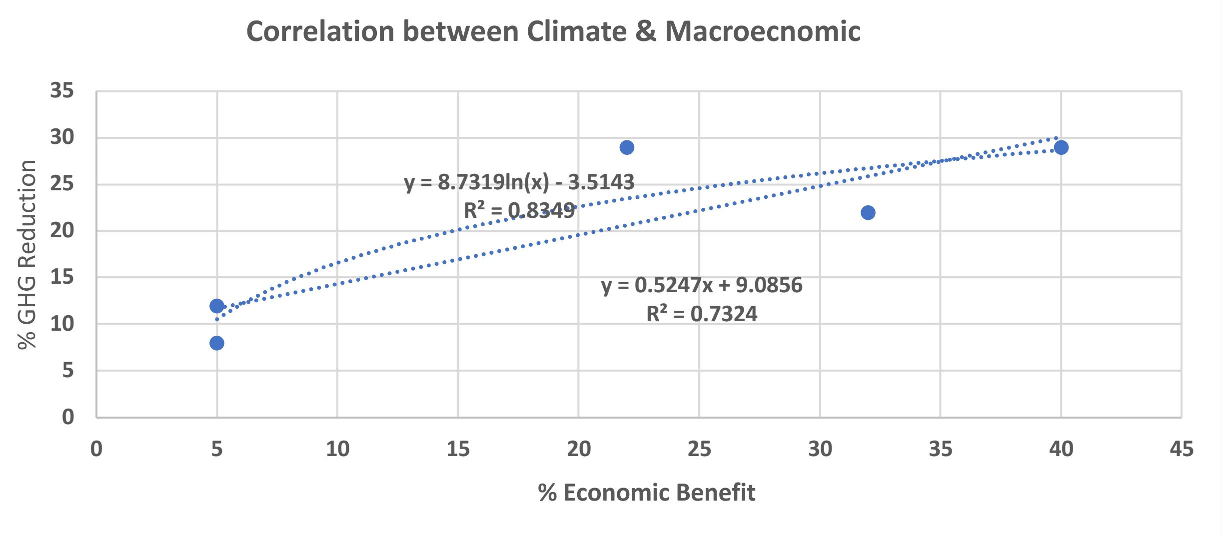
Sources: Wie, Max Shana Patadia and Daniel Kammen, 2010, “Putting Renewables and Energy Efficiency to work: How Many Jobs Can the Clean energy Industry Generate in the US?”, *Energy Policy,* 38. Rachel Gold, et al., *Appliance and Equipment Efficiency Standards: A Money Maker and Job Creator,* American Council for an Energy Efficient Economy, January 2011, p. 9, based on the IMPLAN Model, 2009., *How Infrastructure Investments Support the U.S. Economy: Employment, Productivity and Growth,* James Heintz, Robert Pollin, Heidi Garrett-Peltier, Political Economy Research Institute, January 2009.

MNC- 4.6

STRATEGIES FOR LIMITING CLIMATE CHANGE & INCREASING ENERGY PRODUCTIVITY

	Greenhouse Gas Reductions				Improved Energy Productivity		
	GtC		% of Total		% Incr. in GDP		% of Total
Strategies							
Mitigation				Macro -economic			
Energy		5 7/8	33	Energy Cost		45	22
Renewables							
Solar	4 ¼			Low cost supply	40		
Wind	1			Peak Load reduction	5		
Geothermal	1/8						
Conventional fuel efficiency	½						
Efficiency Primarily Business		4	22	Industrial Savings		60	29
Building Const.	1½			Materials	30		
Waste & recycling	1			Automation	10		
Motors	½			Buildings	20		
Processes	1						
Efficiency Primarily Residential*		3 7/8	22	Ambient Quality (also labor)		61	29
Transportation		3 ¼	18	Ventilation	11		
Cars (fewer miles	2			Lighting	23		
(more efficiency)				Temperature	18		
Trucks* (efficiency)	¾			Hospital stay length	9		
Air	½						
Cropping & Grazing		1	6	Agriculture		25	12
Deforestation Halt		1	6	Forestry		17	12
Total		18	100	(with overlap)		208	

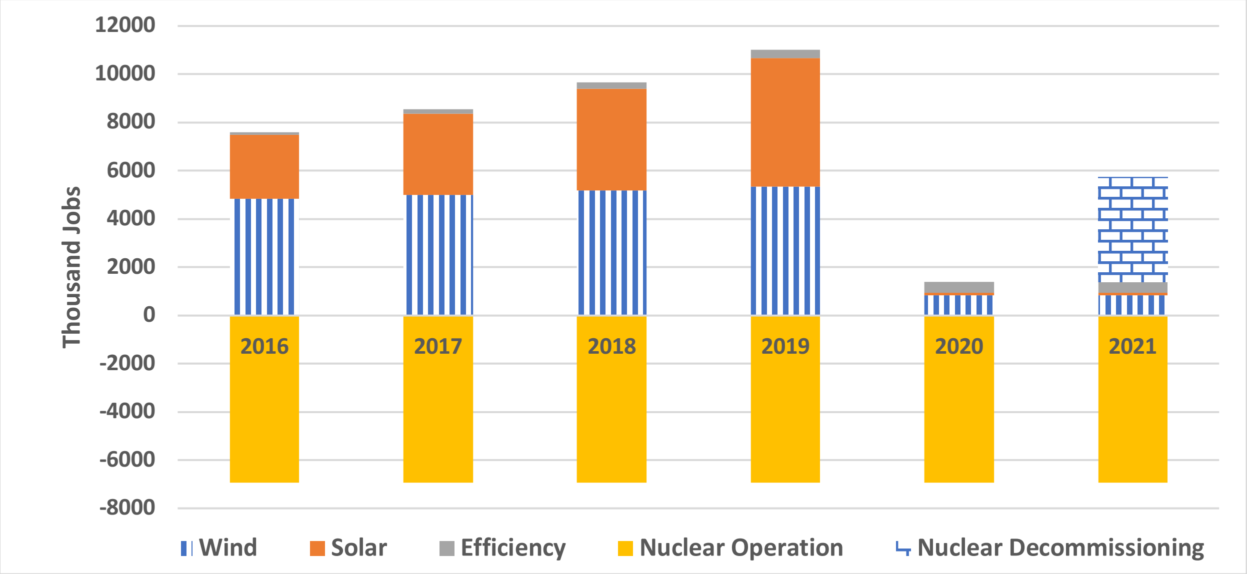
* Includes ½ black carbon.



Source: Smith, Dr. Michael H., 2015, Doubling Energy & Resource Productivity by 2030 – Transitioning to a Low Carbon Future through Sustainable Energy and Resource Management, ANU discussion Paper.

MNC-4.7

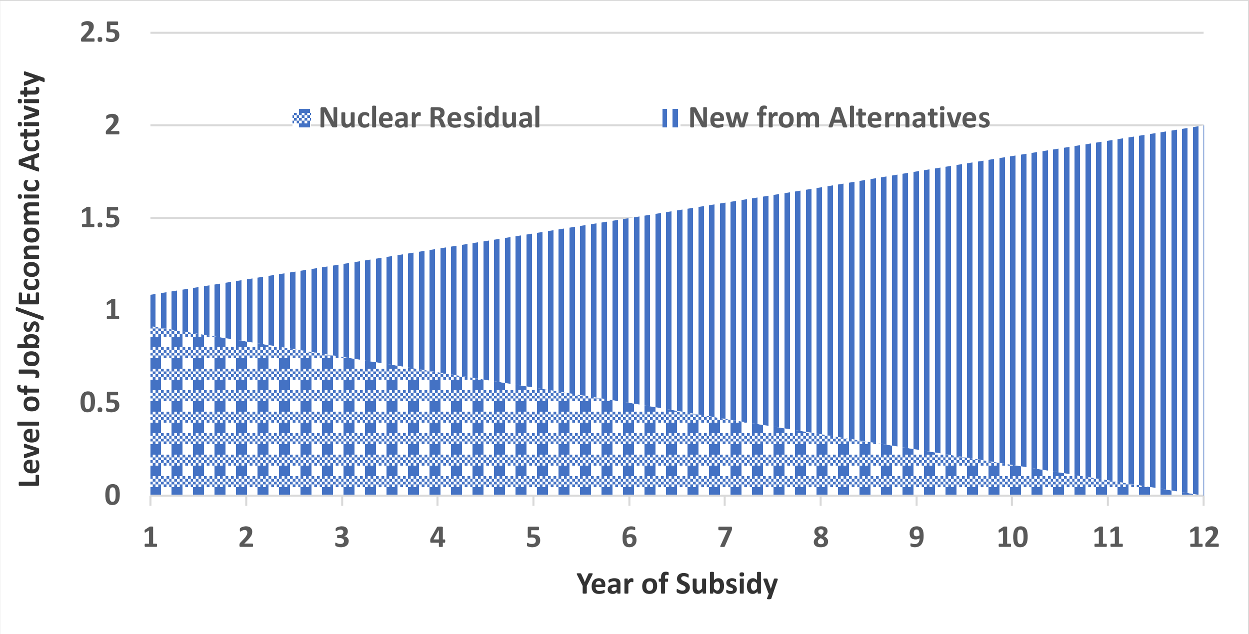
JOBS IMPACT OF EARLY RETIREMENT AND REPLACEMENT, INCLUDING DECOMMISSIONING



Sources: Illinois Commerce Commission, Illinois Power Agency, Illinois Environmental Protection Agency, Illinois Department of Commerce and Economic Opportunity, *Potential Nuclear Power Plant Closings in Illinois: Impacts and Market-Based Solutions, Response to The Illinois General Assembly Concerning House Resolution 1146*, January 5, 2015, p. 139. Decommissioning is discussed on p. 134.

MNC-4.8

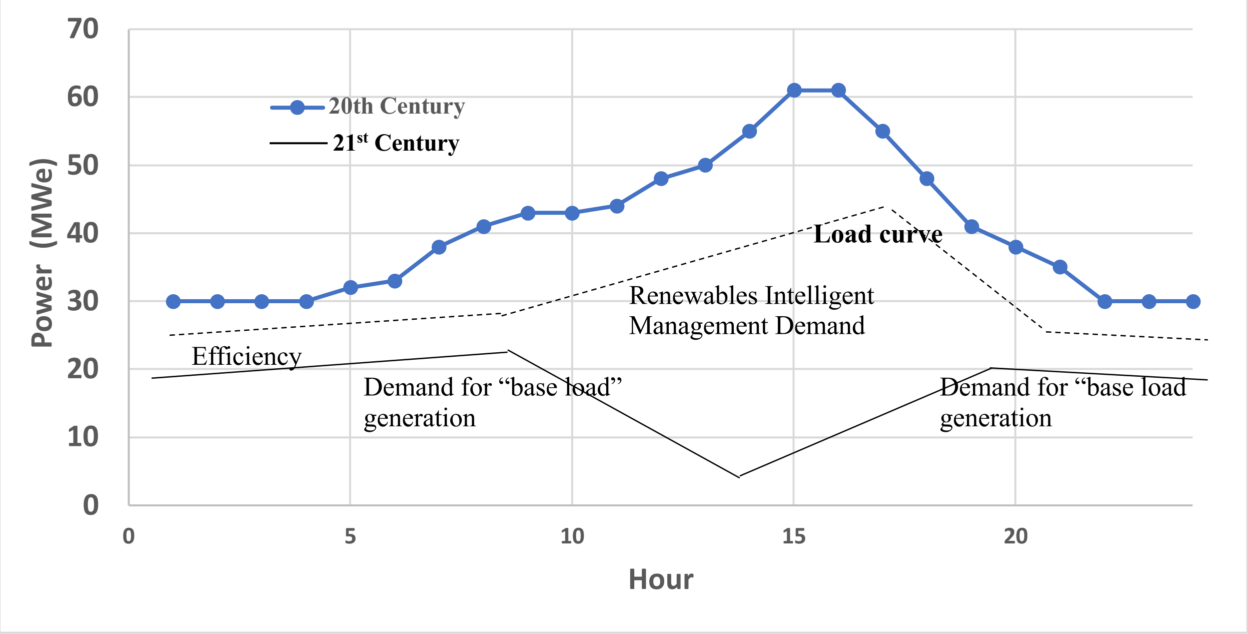
IMPACT OF RETIRING UPSTATE REACTORS: JOBS/MACROECONOMIC IMPACT



Source: Adapted from Mark Berkman and Dean Murphy, *New York's Upstate Nuclear Power Plants' Contribution to the State Economy prepared for New York State IBEW Utility Labor Council, Rochester Building and Construction Trades Council, Central and Northern New York Building and Construction Trades Council,* Brattle Group, December 2015

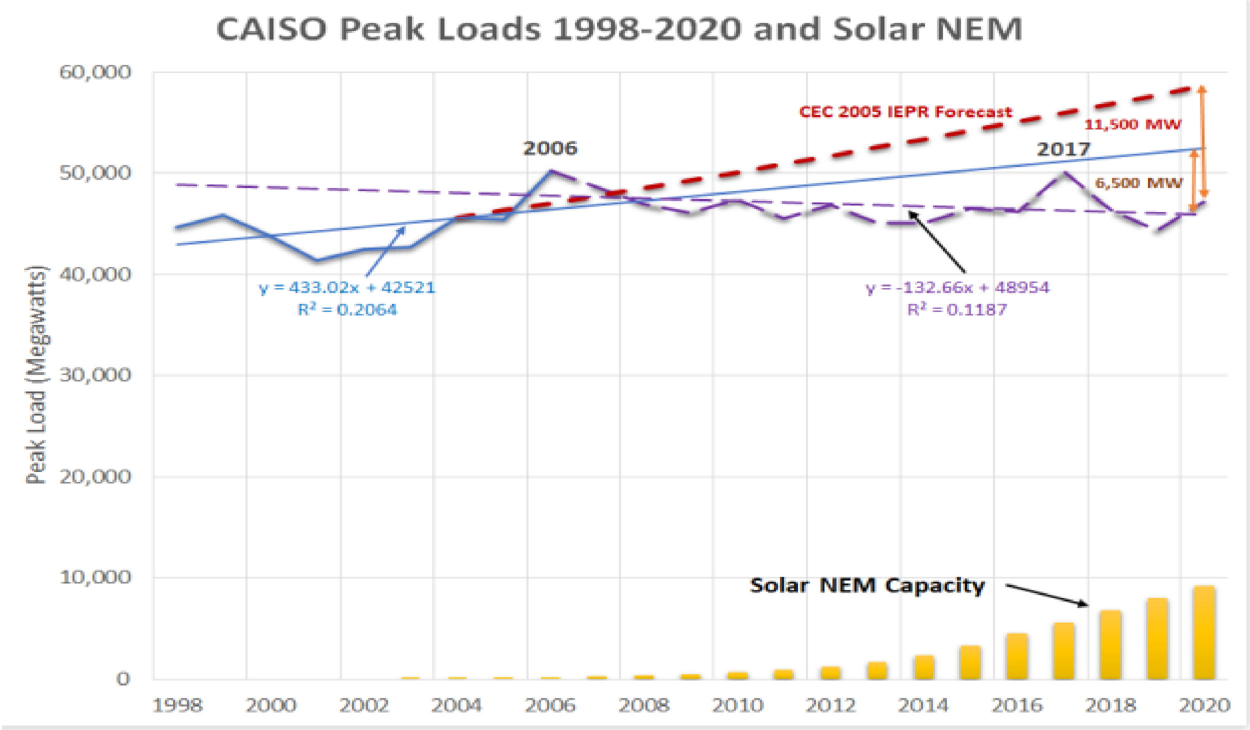
MNC-4.9

CONCEPTUAL LOAD REDUCTION AND SHIFT IN THE TRANSFORMATION



MNC-4.10

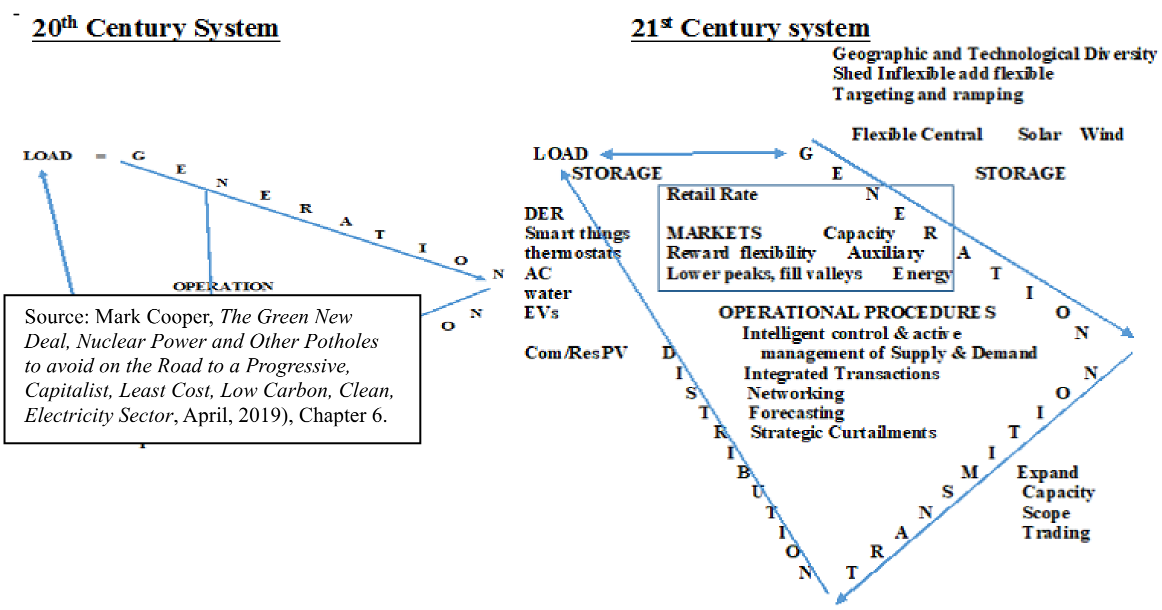
CAISO PEAK LOADS 1998-220 AND SOLAR NEM



Source: Economics Outside the Cube, Musings from M.Cubed on the environment, energy and water, April 18, 2023.

MNC-5.1

CREATING THE 21ST CENTURY ELECTRICITY SYSTEM:



Source: Mark Cooper, *The Green New Deal, Nuclear Power and Other Potholes to avoid on the Road to a Progressive, Capitalist, Least Cost, Low Carbon, Clean, Electricity Sector*, April, 2019), Chapter 6.

FUNDAMENTAL DIFFERENCES BETWEEN CENTURIES AND SYSTEMS

Characteristic	**20th Century**	**21st Century**
Goal	Redundancy (as resilience)	Flexibility (resilience as a result)
Operational objective	Increase capacity to follow load	Integrate & match supply and demand
Configuration, size	Island set by economies of generations	Interconnection set by value
Supply-Demand	Segregation	Integration
Demand driver	Dumb load	Smart Retailer
System cost recovery	High, lumpy and fixed	Variable targeted and local
Organization	Centralized	Distributed
Challenges	Increase capacity to follow load	Integrate & match supply and demand
Flash point	50 most expensive hours (>$10,000)	50 least expensive hours (< $0)
Market power	High	Low
Optimization Target	Meet peaks	Shave peaks, Fill valleys (shed & shift)
End users role	Passive	Active & Prosumer
Flow:		
Output	Hub & Spoke, linear	Networked, Dynamic & Transparent
Information	Aggregate	Transparent, local
Resources:		
Physical	Fuel, Cement and Boiling Water	Steel, Silicon and Intelligence
Intellectual	Engineering judgement	Communications, Advanced Control
Capital	High for base, low for peak	Moderate for both
Energy intensity	High, concentrated	Low, diffuse

Source: The most recent version, with the contrast between the 20th and 21st century systems is available in Mark Cooper and Mel Hall Crawford, 2021, *Building,* Chapter 4.

MNC-5.2

PERFORMANCE MEASURES & TOOLS TO MANAGE A 21ST CENTURY ELECTRICITY SYSTEM

1.	Penetration: States	1, 2, 23, 47, 51, 52
2	Nations	1, 32, 36, 53, 54, 55, 56, 57, 58, 59 60, 66, 154
	a. Recent	269, 278, 289, 341, 352, 374, 377,380, 381
3	Cost: General Components	1, 5, 9, 10, 16, 18, 29, 36, 46, 47,63, 69, 71, 75, 76, 77, 98, 116, 130, 137, 147, 150, 183, 184, 246
	a. Recent estimates	261, 262, 263, 368,369
4	System cost/value	5, 75, 155, 184, 217, 243,244, 260
	a. Recent Estimates	267, 325-327, 386
5	Challenges: With solutions	5, 8, 9, 10, 12, 93, 94, 215, 232
	a. Recent, Deep Decarbonization	276, 376, 269, 274, 280-283, 286, 289, 300, 301, 322, 336, 337, 339, 342-345, 347-351, 353-355, 357,358-368, 371-373 378, 379, 382, 383, 385, 389, 393, 399,
	b. Equity	128, 141, 151, 161, 182, 187, 189, 236
6	Pure negatives	83, 87, 95, 96, 214, 230
	a. Recent	357, 388, 391, 400
7	**Generation** (100% Scenarios)	257, 258, 259, 278, 279
7	a. Wind and Solar	261-263, 269, 293, 294, 299, 306-308, 312, 314, 317-319, 324, 325, 330, 332, 333, 341, 346, 396, 397
8	Geographic diversity	5, 7, 8, 12, 36, 151, 152, 153 , 237
9	Technological diversity	7, 8, 10, 15, 36, 38, 44, 102, 151, 237, 240, 246, 247
	a. Recent	289, 302, 304, 341, 377
10	Peak targeted solar	7, 155, 156, 246, 247
11	Quick start/rapid ramp	1, 7, 10, 23, 151, 246
12	Shed inflexible baseload	7, 27, 151, 230, 232, 247
13	Shift to flexible	5, 7, 160, 161, 162, 163, 164, 165, 166, 167, 232
14	Flexible central	1, 2, 26, 60, 84, 85, 183
15	Firm renewables	1, 2, 10, 19, 22, 24, 26, 88
	a. Geothermal	264, 266, 284, 285, 290, 291, 298, 365, 377
16	Value ancillary services;	1, 2, 5, 8,12, 48, 52, 59, 60, 138, 139, 140, 182, 183, 185
17	Avoid lumpy investment	7, 155
18	**Load**	1, 3, 26, 70, 105, 106, 107, 108, 109, 110, 111, 112, 113
	a. Recent	368-370
19	Supply-side	7, 169,
20	Target peaks	7, 27, 151, 240
21	Use more in slack, less scarcity	1, 7, 105, 160
22	Demand-side	7, 12, 13, 27, 36, 172, 173, 174, 175, 176, 177, 178, 179, 85
	a. Recent	368, 369
23	Aggressive demand response	7, 27, 151, 175, 177, 178, 179, 181
24	Smart controllers manage use	7, 8, 27, 186, 187
25	**Transmission**	1, 2, 3, 5, 7, 22, 24, 25, 26, 28, 31, 34, 40, 41, 57, 65, 67, 68, 103, 126, 127, 128, 129, 181, 183, 185, 188, 189, 190, 191, 192
	a. Recent	287, 311, 356
26	Expand balance areas	5, 7, 27, 151, 160, 181
27	**Storage**	1, 5, 7, 8, 12, 19, 20,21,22,23, 41, 43, 49, 100, 101, 102, 151, 157, 185, 194, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 230
	a. Including Hybrid systems, Long Duration	261, 270, 271, 302, 309, 310, 314, 316, 333, 342, 384
28	Dispatchable, traditional	1, 36, 111, 183, 232
29	Distributed (virtual powerplant)	1, 2, 11, 13, 27, 36, 39, 45, 56, 115, 116, 117, 118, 119, 194, 233, 254
	a. including Virtual Power Plants Alternative Grid (micro, etc.)	368, 369

30	Electric vehicles	1, 11, 13, 35, 104, 113, 114,233
	a. Recent	340, 348, 375
31	**Operational Procedures**	1, 7, 12, 25, 26, 136, 212, 213,231, 250, 252
32	Flexibility/integration	1, 5, 8, 9, 10, 13, 17, 18, 24, 26, 30, 31, 32, 34, 36, 72, 73, 78, 82, 97, 99, 127, 147, 173, 171, 180, 183, 185, 194, 230, 231, 245, 253
	a. Recent (Firming load)	261, 269, 320
33	Integrated Transactions	8, 9, 18, 241, 242
	a. Recent	320, 368, 387
34	Strategic Curtailment	1, 8, 23, 61, 120, 121, 122, 123, 124, 125, 248, 249
35	Improve forecasting	1, 7, 12, 36, 37, 53, 143, 144, 145, 151,, 215, 216, 217, 218, 219
36	**Market Design**	1, 2, 8, 12, 13, 18, 23, 26, 32, 33, 40, 41, 56, 57, 58, 59, 60, 62, 94, 146, 147, 148, 181, 183, 184, 248, 250, 252
	a. Recent	278, 276, 315, 373, 322, 376-378, 394
37	Positive and Negative prices	1, 5, 8, 10, 17, 57, 148, 181, 235, 238, 253
	a. Recent	269
38	Target fixed cost recovery;	9, 14, 181, 183, 184
	a. Recent	373
39	TOU (cut peaks, fill valleys)	7, 8, 9, 27, 64, 105, 106, 107, 108, 109, 110, 111, 112, 93, 193, 220, 221, 222, 223, 234, 235, 239
40	Smart Grid	1, 3, 7, 8, 11, 12, 22, 42, 79, 80, 81 ,82, 119, 131, 132, 133, 134, 135, 224, 225, 226, 227, 228, 229
	a. Recent	272, 328, 329, 371, 399
41.	CHP	2, 26, 50, 54, 89, 90

Source: Originally presented in Mark Cooper,

MNC-5.3

NREL CAPITAL COST PROJECTIONS V. REALITY

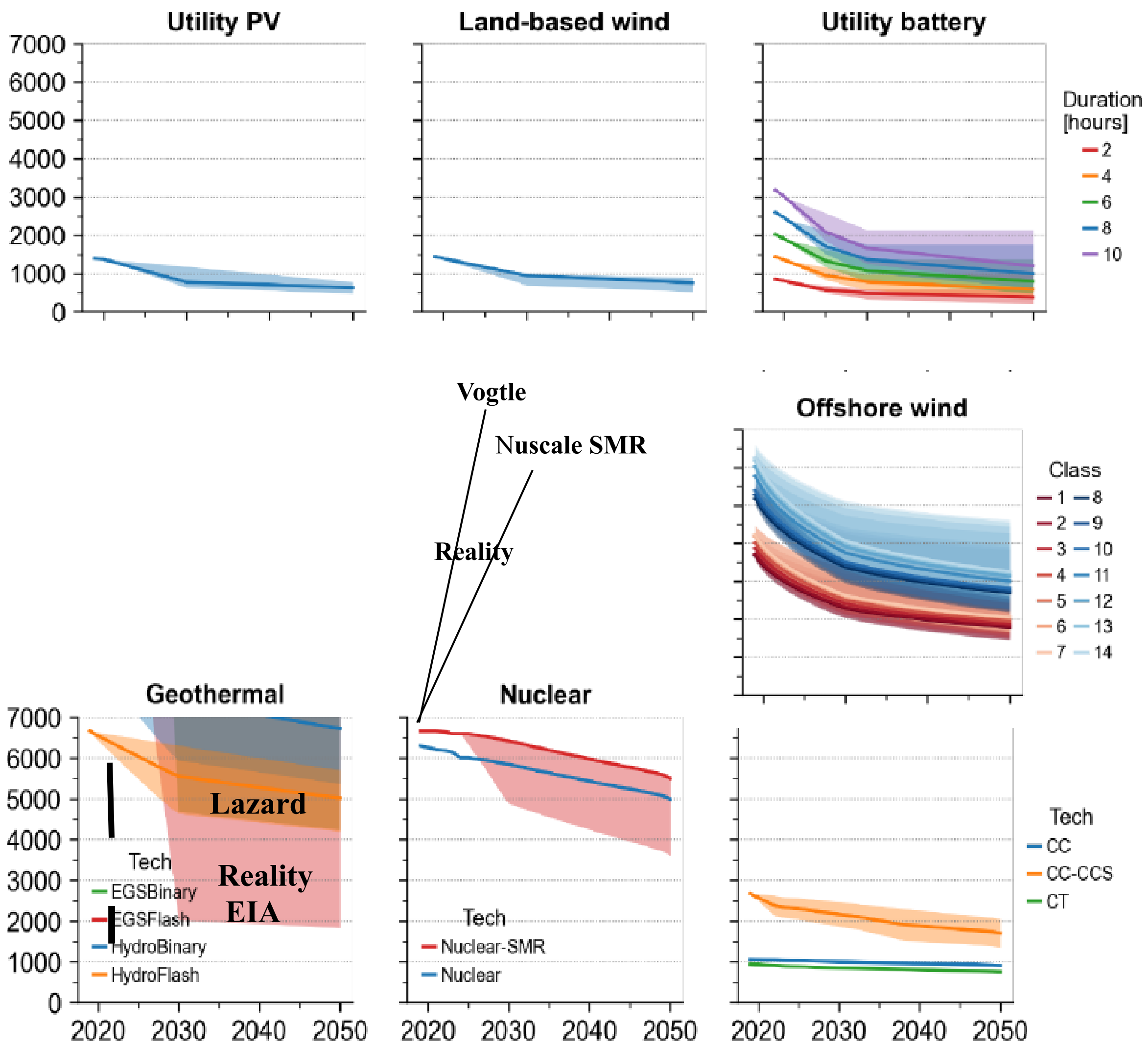


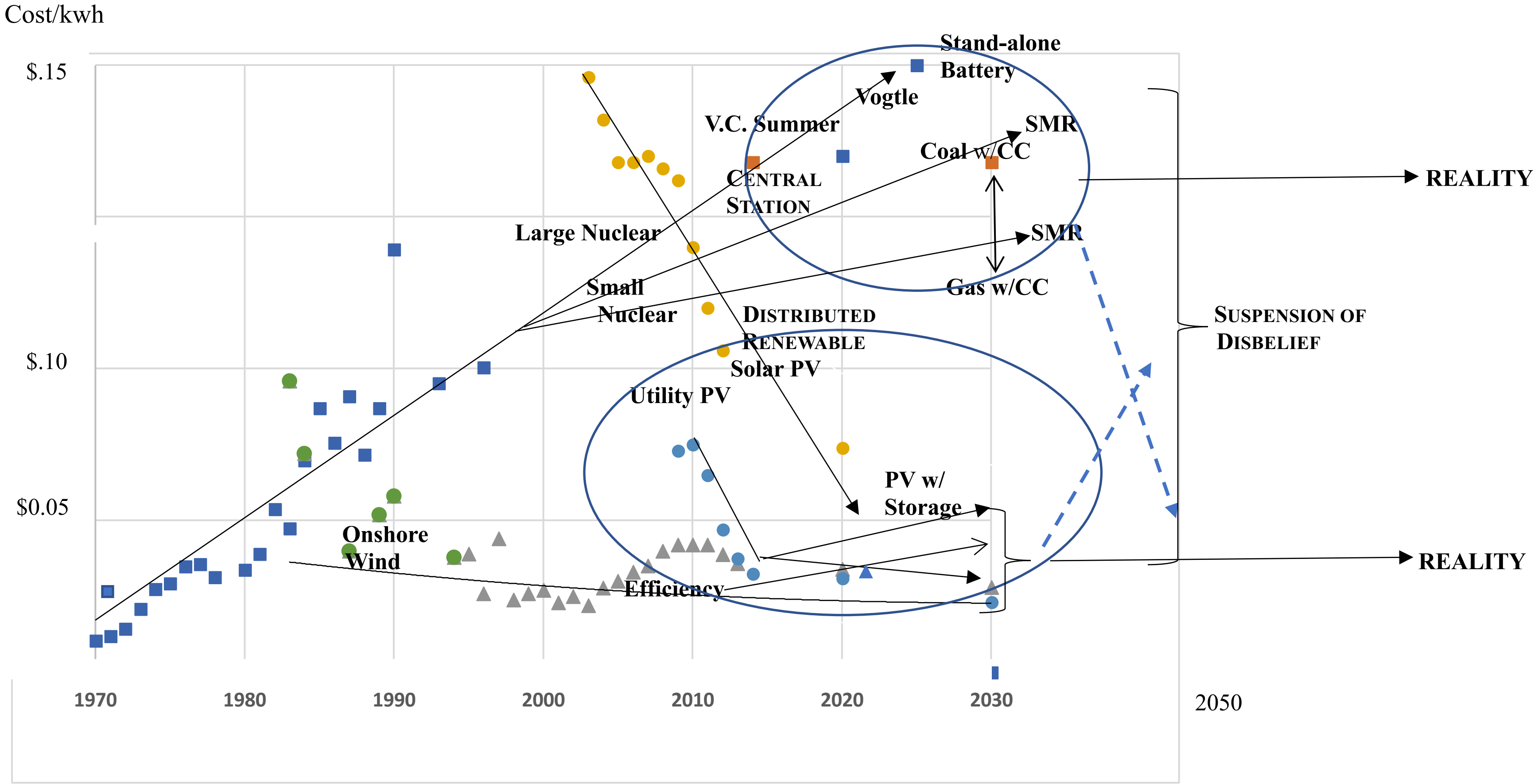
Figure B3. Overnight capital cost inputs for utility-scale solar PV, land-based wind, utility-scale battery energy storage, concentrated solar power (CSP), biopower, offshore wind, geothermal, nuclear, and natural gas under moderate (center line), advanced (bottom of shaded area), and conservative (top of shaded area) cost assumptions

All costs except nuclear and geothermal "advanced" costs are from the 2021 ATB. The advanced cost case for nuclear is based on a trajectory that achieves capital cost targets of $4,500/kW in 2035 and $3,600/kW by 2050. The advanced geothermal cases were generated for this report and will be documented in the 2022 ATB. Additional cost details and other input costs are documented in the 2021 ATB (NREL 2021).

Source: Denholm, P., et al., 2022, "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035, NREL/TP-6440-81644, p. 108.

MNC-5.4

THE SUSPENSION OF DISBELIEF ABOUT LONG-TERM RESOURCE COST TRENDS



Source: Attachment MNC-1.3, as updated in text.

MNC-5.5

NREL COST RESULTS FOR ALL SENSITIVITY CASES

Average cost ($/MWh) in 2035 for all sensitivities, broken down by cost category

Source: Denholm, P., et al., 2022, "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035, NREL/TP-6440-81644, p. 91.

SUMMARY OF POLICIES DESIGNED TO MEET NET-ZERO CARBON EMISSIONS GOALS WITH HIGHEST PRIORITY AND INDISPENSABLE TO ACHIEVE THE OBJECTIVE: THE NATIONAL ACADEMY OF SCIENCES, ACCELERATING DECARBONIZATION OF THE U.S. ENERGY SYSTEM.

Technological Policies deemed urgent:

Set national standards for light-, medium-, and heavy-duty zero-emissions vehicles, and extend and strengthen stringency of Corporate Average Fuel Economy (CAFE) standards. Light-duty zero-emission vehicle (ZEV) standard ramps to 50% of sales in 2030; medium- and heavy-duty to 30% of sales.

Set manufacturing standards for zero-emissions appliances, including hot water, cooking, and space heating. Department of Energy (DOE) continues to establish appliance minimum efficiency standards. Standard ramps down to achieve close to 100% all-electric in 2050;

Establish educational and training programs to train the net-zero workforce, with reporting on diversity of participants and job placement success.

Increase clean energy and net-zero transition research, development, and demonstration (RD&D) that integrates equity indicators.

Amend the Federal Power Act and Energy Policy Act by making changes to facilitate needed new transmission infrastructure.

Increase clean energy and net-zero transition RD&D that integrates equity indicators.

Socioeconomic Policies deemed urgent:

Economy-wide price on carbon. Carbon price level not designed to directly achieve net-zero emissions. Additional programs will be necessary to protect the competitiveness of import/export exposed businesses.

Establish White House Office of Equitable Energy Transitions; Establish criteria to ensure

equitable and effective, energy transition funding; Sponsor external research, to support development and evaluation of equity indicators and public engagement; Report annually on

energy equity indicators and triennially on transition impacts and opportunities.

Recipients of federal funds and their contractors must meet labor standards, including Davis-Bacon Act prevailing wage requirements; sign Project Labor Agreements (PLAs) where relevant;

and negotiate Community Benefits (or Workforce) Agreements (CBAs) where relevant.

Ensure that Buy America and Buy American provisions are applied and enforced for key materials and products in federally funded projects.

Establish an environmental product declaration library to create the accounting and reporting infrastructure to support the development of a comprehensive Buy Clean policy.

Establish a federal Green Bank to finance low- or zero-carbon technology, business creation, and infrastructure.

Establish educational and training programs to train the net-zero workforce, with reporting on diversity of participants and job placement success.

Increase funds for low-income households for energy expenses, home electrification, and weatherization.

Increase electrification of tribal lands.

Establish National Laboratory support to subnational entities for planning and implementation of net-zero transition.

Establish 10 regional centers to manage socioeconomic dimensions of the net-zero transition.

Establish local community block grants for planning and to help identify especially at-risk communities. Greatly improve environmental justice (EJ) mapping and screening tool and reporting to guide investments

Source: National Academies, 2021, *Accelerating Decarbonization of the U.S. Energy System*, Table S.1.

MNC-5.7

EQUITY ISSUES IN DEEP DECARBONIZATION POLICY ANALYSIS

Energy Justice Issues # of Studies	Unduplicated	Principles of Energy Justice # of Mentions	Duplicated
Climate	27	Place-based	26
Green jobs & economic	13	Root causes, inequality	31
Energy transition	9	Balance of power	29
Sustainable Development	7	New systems of governance	25
Economic democracy	7	Rights-based approach	20
Transportation	5	Rejecting false solutions	34

Source: Elmallah, Salma, et al., 2022, "Frontlining energy justice: Visioning Principles for energy transitions from community-based organizations in the United States," Energy Research and Social Science, 94.

MNC-5.8

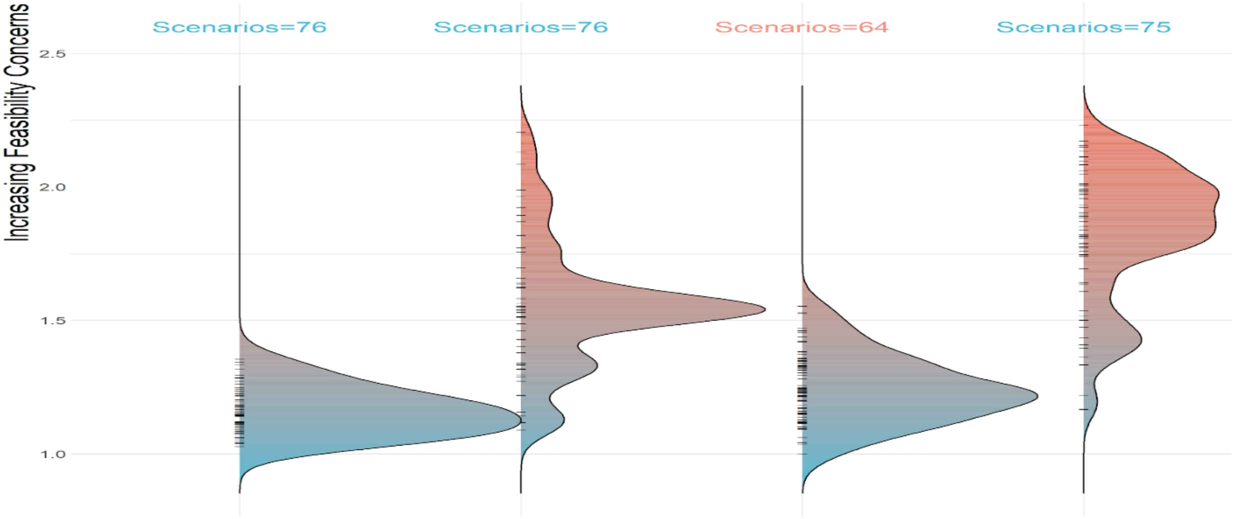
COST OF POWER ($/MWH)

Resource	Type of power	Lazard	
		2014	2022
Efficiency*	Firm	35	35
Wind on	Int.	41	60
Solar PV	Int.	37	43
Wind Off	Int.		106
Com. & Ind. PV	Int.	115	117
Rooftop PV	Int.	187	148-253
Solar Hybrid	Quasi-Firm		53-82
Wind Hybrid	Quasi-Firm		84-113
Geothermal	Firm		91
Aging Reactors	Firm	78-102	78-102
Biomass**	Firm		85
Gasw/CCs New	Firm		90-142
Gasw/CCs Retro	Firm		111-161
Long Duration Storage			
Electrochem.	Firm		114
Mechnical	Firm		187
Thermal	Firm		216
Nuclear, Large	Firm	155	181
SMR	Firm		128

*Last entered in v. 9.0; **Last entered in v. 8.0

Source: National Academy of Science, 2014, p. 41, adapted from Lazard, v. 14.0, 16.0

FEASIBILITY CONCERNS (2020-2100)



Technology
Electricity,
established
scale up wind, solar, nuclear
emerging
scale up, Coals w/ccs,
Transportation
Electrification
Scale up biomass w/ccs

Economic
Mitigation costs and efforts
GDP loses, carbon costs,
stranded coal
Energy Demand decline
Land
Decline of livestock
Increase in forest cover
Decrease in pasture cover

Social cultural
Education, Gender

Institutional
Governance
Low
High
Emissions
reduction
(decadeal)
Low (<20%)
High (>20%)

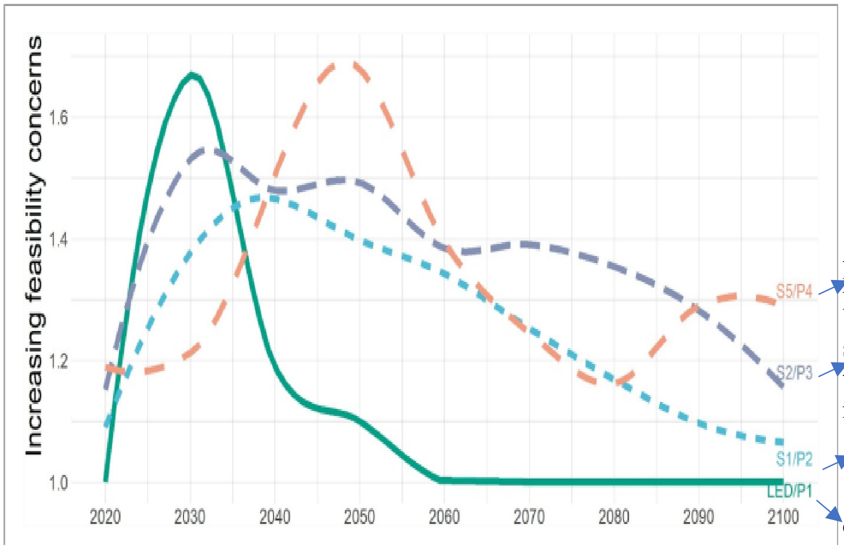
		Medium Feasibility concern threshold	*High Feasibility concern threshold*
Economic	GDP loss**	3	5
	Carbon price***	30	60
	Investment ratio**	1.1	1.2
	Coal stranded**	20	50
Technological	Wind**	10	20
	Solar**	10	20
	Nuclear**	5	10
	Biomass**	1	3
	Biomass CCS**	1	3
	Coal CCS**	1	3
	Transport Elect**	5	10
	Transport biofuels**	10	15
Socio-cultural	Final Demand**	5	10
	Transport Demand**	5	10
	Residential Demand**	5	10
	Industrial Demand**	5	10
	Livestock change**	0.2	0.5
	Pasture drop**	3	5
	Forest increase**	1	3
Institutional	Governance (score) ****		0.6
	CO_2 per capita drop****		15

Legend, Each variable is generally expressed aa one of three Categories: * levels, 1= low, 2= moderate, 3= high. In many cases, the categories have "meanings", i.e., ** = %, or *** = $/ton, In some cases, the categories are **** = indices.

Source: Brutschin, Elina, et al., 2021, "A multidimensional feasibility evaluation of low- carbon scenarios*,"* *Environmental Research Letter*, June, Figure 2 and Supplemental Materials.

MNC-5.10

ILLUSTRATION OF FEASIBILITY CONCERNS AGGREGATED OVER ALL DIMENSIONS FOR THE PERIOD 2020–2100 FOR FOUR ILLUSTRATIVE PATHWAYS FROM THE 1.5 ◦C SCENARIO ENSEMBLE.



high levels of governance but highly resource-intensive lifestyles

supply-side mitigation & technological carbon dioxide removal

high levels of governance, more resource efficient lifestyles

demand-side mitigation, & negative emissions only from afforestation

Scenarios compare the evolution over time of overall feasibility concerns of four illustrative pathways from the 2018 IPCC Special Report that reach the 1.5◦C goal

S2/P3: which relies on supply-side mitigation and technological carbon dioxide removal;

LED/P1: the low energy demand scenario which relies on demand-side mitigation and negative emissions only from afforestation

S1/P2: sustainable development pathway with high levels of governance and more resource-efficient lifestyles

S5/P4: high levels of governance but highly resource-intensive lifestyles

Source: Brutschin, Elina, et al., 2021, “A multidimensional feasibility evaluation of low- carbon scenarios*,”* *Environmental Research Letter*, June, Figure 5.

MNC-5.11

THE TERRAIN OF CHALLENGES FOR DEEP DECARBONIZATION

Continent-Scale Transmission Expansion: First, in order to smooth renewable energy variation across wider regions, high-VRE scenarios routinely entail a continent-scale expansion of long-distance transmission capacity.

Flexible Demand: Most scenarios highly reliant on wind and solar assume that sources of electricity consumption will become much more flexible and responsive to power system needs in the future. …{T}hese scenarios envision reshaping demand to match variable supply, rather than shaping supply to match variable demand, as is commonplace in all power systems today. Electrification of transportation, heating, and industry will increase demand for electricity, as discussed above, but some of these new sources of demand could also become flexible resources.

Inefficient Utilization Requires Very-Low-Cost Wind and Solar to Make Overcapacity Economical
Either ''Firm'' Generation or ''Seasonal'' Storage Is Needed to Ensure Reliability in Wind- and Solar-Dominated Scenarios

This means that resources with low capital costs and high variable costs (e.g., bioenergy, hydrogen, or natural gas fueled power plants) are economically better suited to pair with high wind and solar shares.,,, Considerable uncertainty remains about the real-world cost, timing, and scalability of these storage options.

Firm Low-Carbon Resources Can Lower Decarbonization Costs: Most of the challenges associated with very high shares of wind or solar energy can be avoided by adopting a more balanced portfolio of resources. Across decarbonization scenarios that harness variable renewables alongside firm low-carbon generation resources—including nuclear power, coal or natural gas plants with CCS, and greater shares of firm renewable resources such as bioenergy or geothermal power plants—total installed capacity is more closely sized to peak demand, all resources enjoy higher asset utilization, and substantial curtailment of renewable energy output is avoided.

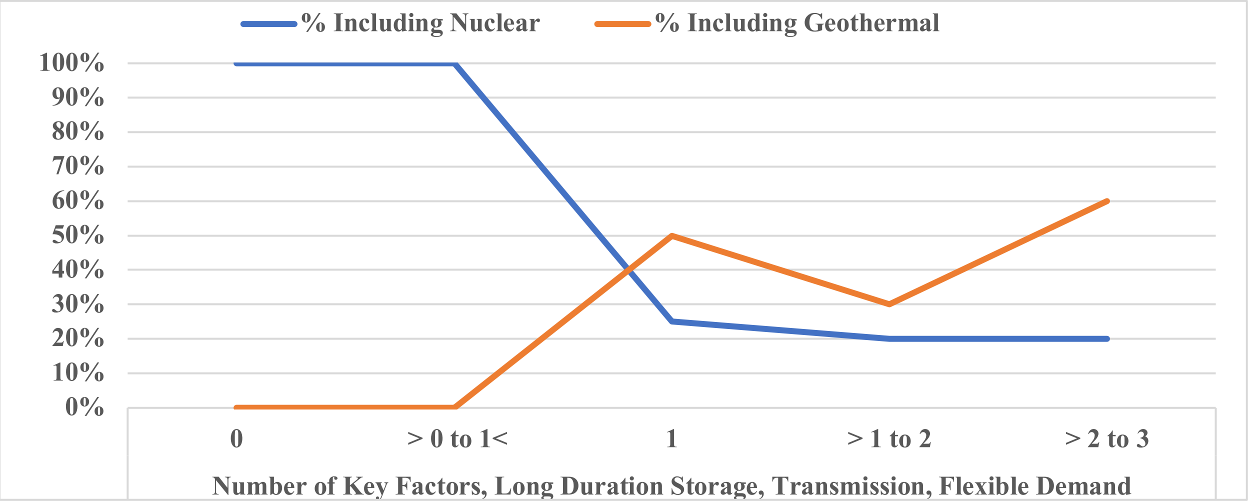
However, all currently available firm low-carbon energy sources face challenges that may impede adoption at the scale or pace desired for climate stabilization. Worldwide, deployment of new nuclear power is barely keeping pace with retirement of aging reactors, while high-profile cost overruns and bankruptcies have plagued nuclear construction in the United States and Europe. Carbon-capture technologies continue to make progress at the demonstration scale, but commercial deployment remains nearly nonexistent. Furthermore, while solid biomass use is rapidly increasing, driven particularly by renewable energy policies in Europe, researchers have raised serious questions about the net life-cycle greenhouse gas benefits of biomass from both managed forests and dedicated energy crops. Reservoir hydropower systems are mature, but new construction is geographically limited and entails substantial environmental impact, including the release of methane. Conventional geothermal energy technologies are constrained to locations with ideal geological conditions, while enhanced or engineered geothermal systems, which could unlock widespread resource potential, are pre-commercial.

Source: Jenkins, Jesse D., et al., 2018,"Getting to Zero Carbon Emissions in the Electric Power Sector," *Joule* 2, December.

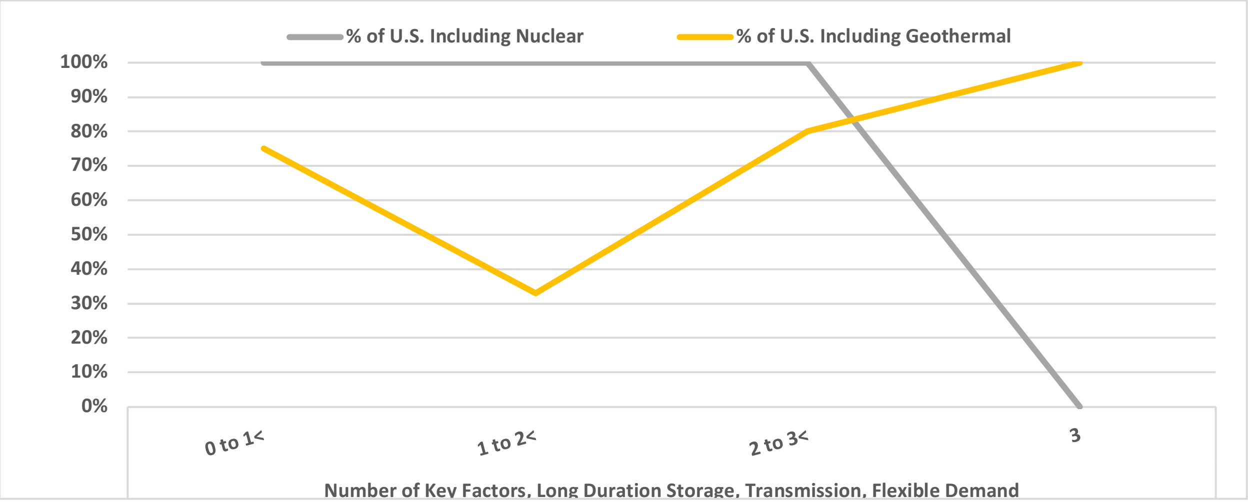
MNC- 5.12

KEY ASSUMPTIONS ABOUT POLICIES AFFECTING ALTERNATIVE RESOURCES & RELIANCE ON NUCLEAR POWER, 40 DEEP DECARBONIZATION STUDIES

Global



United States



Source: Jenkins, Jesse D., et al., 2018,"Getting to Zero Carbon Emissions in the Electric Power Sector," *Joule* 2, December.

MNC-5.13

IMPACT ON COST OF DIFFERENT PATHS TO DEEP DECARBONIZATION

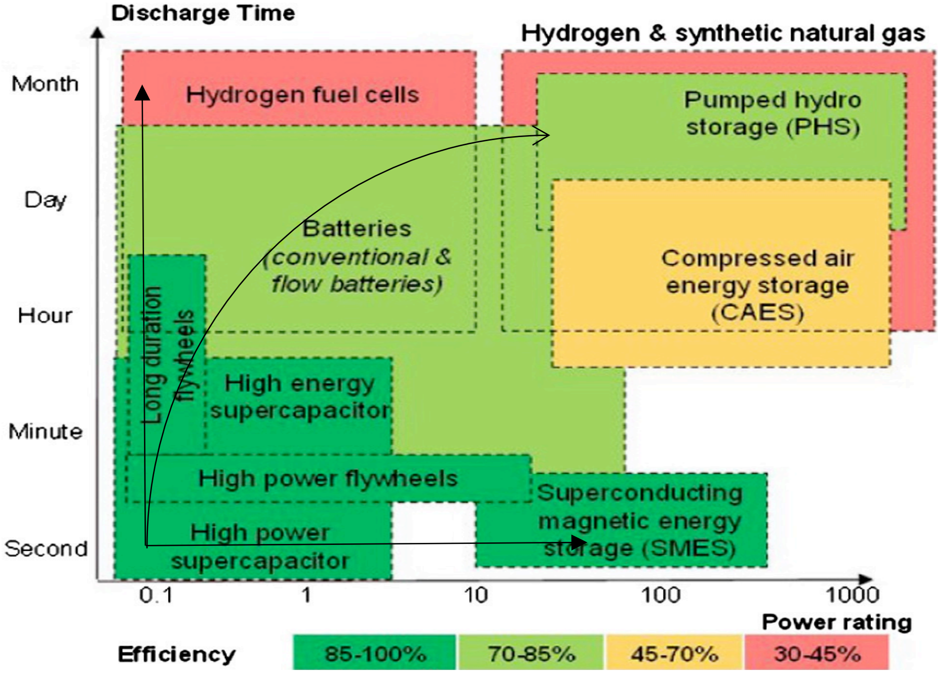
Cost Advantage ($/MWH) Adjusted for Market Share of Group 1 (i.e. bill impact)

	Lo v Hi Cost Group 2		Group 1 v. Lo. Group 2		Group 1 v. Hi Group 2	
Group 1, Share/Cost	60%/$60	80%/$70	60%/$60	80%/$70	60%/$60	80%/$70
Hi-Cost Group 2						
SMR ($120)	14	7	10	6	24	10
Large ($150)	26	13	36	16	36	16

Source: Author as described in text,

MNC-5.14

POTENTIAL STORAGE EXPANSION PATHS



Source: Véronique Dias 1, et al. 2017, Position paper on Energy Transition Energy Transition Workshop, Université Libre de Bruxelles, Belgium, March 9.

MNC 5.15

BENDING THE CURVE: EXECUTIVE SUMMARY, 10 SCALABLE SOLUTIONS FOR CARBON NEUTRALITY AND CLIMATE STABILITY

General structure

1. Replacing fossil fuels with carbon neutral technologies
2. Foster a global culture of climate action through coordinated public communications and education at the global and local scale
3. Deepen the global culture of climate collaboration
4. Scale up subnational models of governance and collaboration.
5. adopt market-based instruments to create efficient incentives
6. Narrowly target direct regulatory measures at high emission sectors no covered by market-based policies

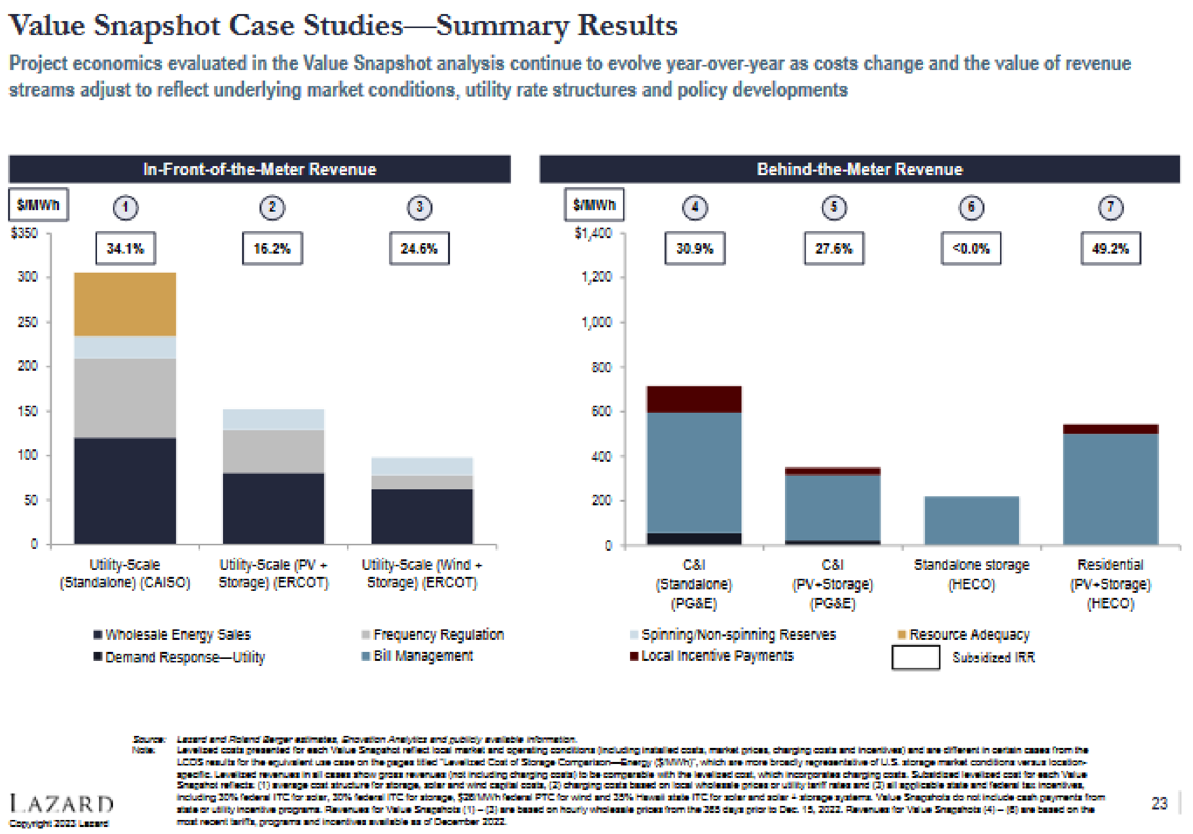
7-9 Technologies for increasing clean supply and decreasing demand

   a. photovoltaics,
   b. wind turbines,
   c. battery and development of lower-cost storage for applications in transportation including:
      - batteries,
      - hydrogen fuel cells for vehicles,
   d. Storage generally including
      - super-capacitors,
      - compressed air,
      - hydrogen and thermal storage,
   e. efficient end use devices
      - lighting,
      - air conditioning,
      - appliances,
      - advances in heat pumps,
   f. smart buildings,
   g. industrial processes,
   h. system integration
   i “access to clean cooking for the poorest 3 billion people

10. **Regenerate damaged natural ecosystems** and restore soil organic carbon to improve natural sinks

Source: University of California, 2015, *Bending the Curve Executive Summary: Ten scalable solutions for carbon neutrality and climate stability*, October 27.

THE ECONOMICS OF STORAGE AT THE CASE STUDY LEVEL



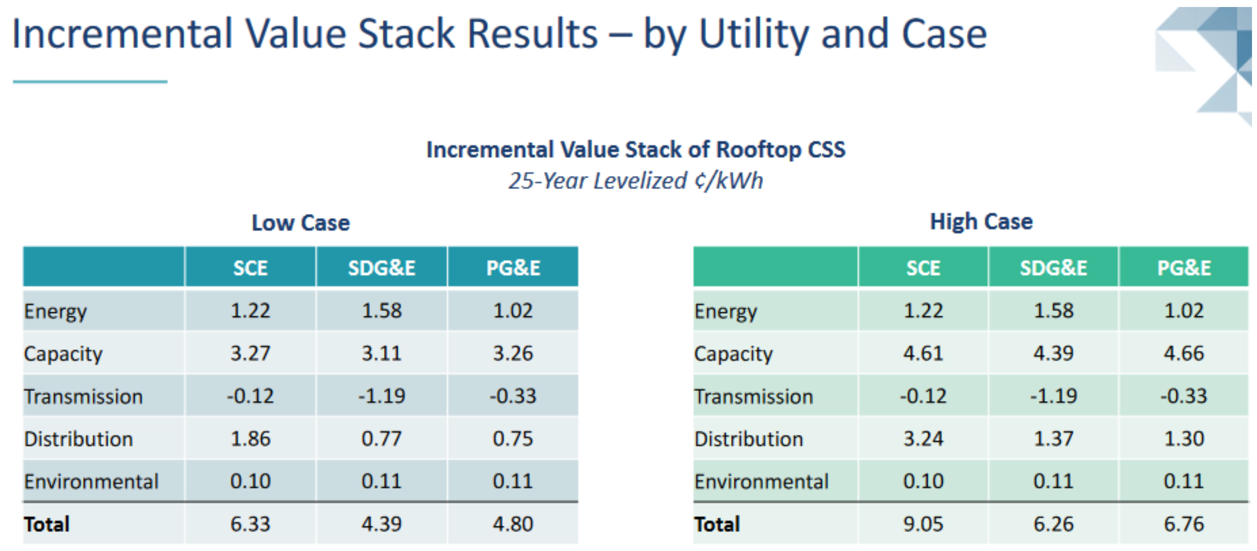
Value Snapshot Case Studies—Summary Results

Project economics evaluated in the Value Snapshot analysis continue to evolve year-over-year as costs change and the value of revenue streams adjust to reflect underlying market conditions, utility rate structures and policy developments

Source: Lazard and Roland Berger estimates, Enovation Analytics and publicly available information.
Note: Levelized costs presented for each Value Snapshot reflect local market and operating conditions (including installed costs, market prices, charging costs and incentives) and are different in certain cases from the LCOS results for the equivalent use case on the pages titled "Levelized Cost of Storage Comparison—Energy ($/MWh)", which are more broadly representative of U.S. storage market conditions versus location-specific. Levelized revenues in all cases show gross revenues (not including charging costs) to be comparable with the levelized cost, which incorporates charging costs. Subsidized levelized cost for each Value Snapshot reflects: (1) average cost structure for storage, solar and wind capital costs, (2) charging costs based on local wholesale prices or utility tariff rates and (3) all applicable state and federal tax incentives, including 30% federal ITC for solar, 30% federal ITC for storage, $26/MWh federal PTC for wind and 35% Hawaii state ITC for solar and solar + storage systems. Value Snapshots do not include cash payments from state or utility incentive programs. Revenues for Value Snapshots (1) – (3) are based on hourly wholesale prices from the 365 days prior to Dec. 15, 2022. Revenues for Value Snapshots (4) – (6) are based on the most recent tariffs, programs and incentives available as of December 2022.

LAZARD

23



Incremental Value Stack Results – by Utility and Case

Incremental Value Stack of Rooftop CSS

25-Year Levelized ¢/kWh

Low Case

	SCE	SDG&E	PG&E
Energy	1.22	1.58	1.02
Capacity	3.27	3.11	3.26
Transmission	-0.12	-1.19	-0.33
Distribution	1.86	0.77	0.75
Environmental	0.10	0.11	0.11
Total	6.33	4.39	4.80

High Case

	SCE	SDG&E	PG&E
Energy	1.22	1.58	1.02
Capacity	4.61	4.39	4.66
Transmission	-0.12	-1.19	-0.33
Distribution	3.24	1.37	1.30
Environmental	0.10	0.11	0.11
Total	9.05	6.26	6.76

Chapman, Tom, et al., 2023, *Analysis of the Incremental Value of Rooftop Community Solar + Storage in California*, Brattle, June 6.

CALIFORNIA INDEPENDENT SYSTEM OPERATOR (CAISO) REPORT ON SUMMER, 2022

Despite the sustained heat wave and unprecedented load levels, the California Independent System Operator (ISO) did not order rotating outages and maintained reliable system operations at all times. [1] As we continue to integrate new resources… our experience and lessons learned during the September 2022 heat wave will help us navigate the next climate-driven challenge.[2] This would not have been possible without,[3]

1. Increased capacity through resource adequacy procurement since summer 2020, the significant mobilization of new generating resources
    - pricing
    - grid battery storage, integration of new capacity, including the highly effective use of recently added lithium-ion batteries; and conservation, including more than 3,500 MW of lithium-ion battery storage
    - ISO visible demand response
2. Enhanced, unprecedented levels of communication and coordination between the ISO, state and federal agencies, and industry that have occurred over the past two years; coordination; awareness, and communications internally, and with neighboring balancing authority areas, including those participating in the WEIM, external stakeholders
    - robust advance planning;
    - utilization of both market and non-market resources;
3. Market enhancements developed and implemented over the past two years, including
    - clarification of scheduling priorities,
    - enhancements to resource sufficiency evaluations and
    - electricity market pricing designed to incentivize generation during periods of high demand.
4. The use of new state programs to provide non-market resources to address extreme events, voluntary load reduction
5. Close coordination with load-serving entities during the ISO's highest emergency alert level,
6. Geographic diversity of extreme heat across the West,;
7. The ISO both received emergency assistance energy and provided it to other balancing authority areas experiencing stressed system conditions.
    - imports

At the same time, the ISO's analysis of the event reveals several issues that led to unintended consequences that impacted specific components of the market. [4]

- additional software improvements that are needed,
- especially for the clearing of exports and the resource sufficiency test used in the Western Energy
    - Imbalance Market (WEIM)
    1. Ensuring storage resources are appropriately charged and accounted for in ISO systems to avoid manual corrective action.
    2. Ensuring exports are awarded based on their intended priorities
    3. Over and under-counting of capacity available to the ISO in the WEIM resource sufficiency evaluation.

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[1] California ISO, *Summer Market Performance Report, Sept. 2022,* November, 2 (hereafter, CAIOS Report) p.12

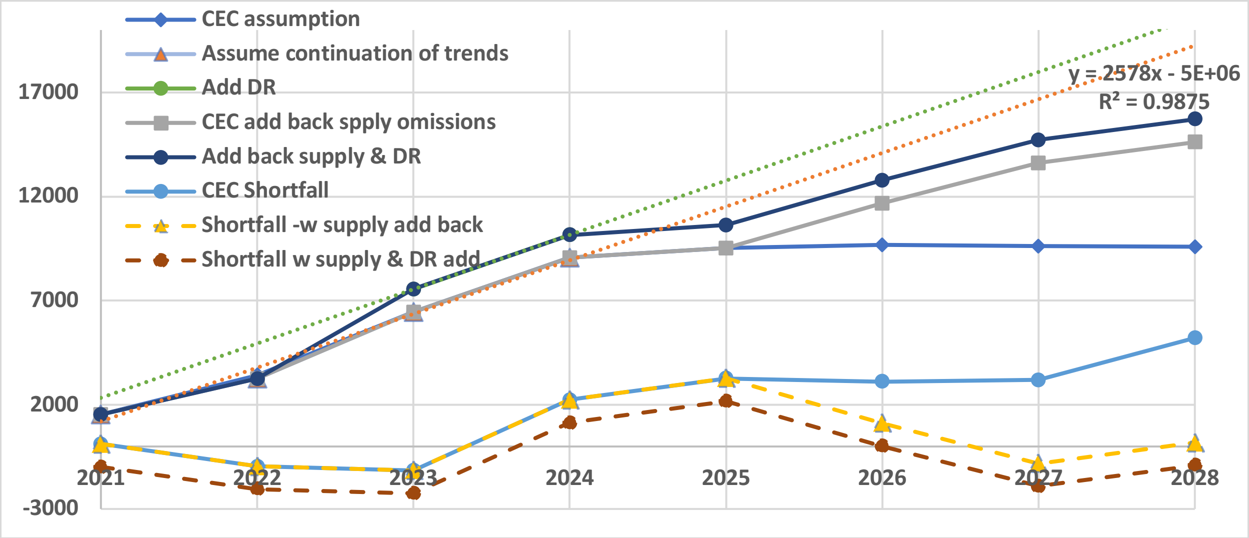
[2] CAIOS Report., p. 16

[3] CAIOS Report, pp. 12, 13-15

[4] CAIOS Report, pp. 12, 15-16.

MNC-6.2

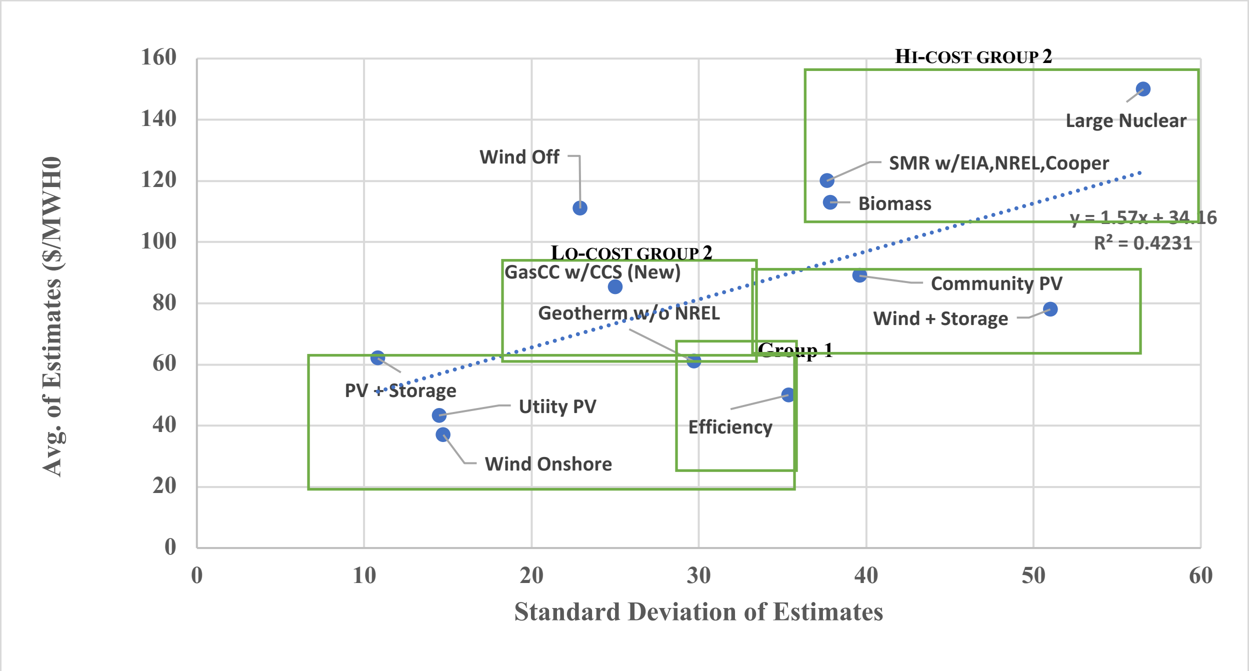
CEC'S MISCHARACTERIZATION OF THE PG&E NET LOAD CONDITION



Source: Public Utilities Commission of the State of California, Implementing Senate Bill 846 Concerning Potential Extension of Diablo Canyon Power Plant Operations, Rulemaking 23-01-00, Attachment E: Diablo Canyon Power Plant Extension, Final Draft CEC Analysis of Need to Support Reliability, modified as described in text.

MNC-6.3

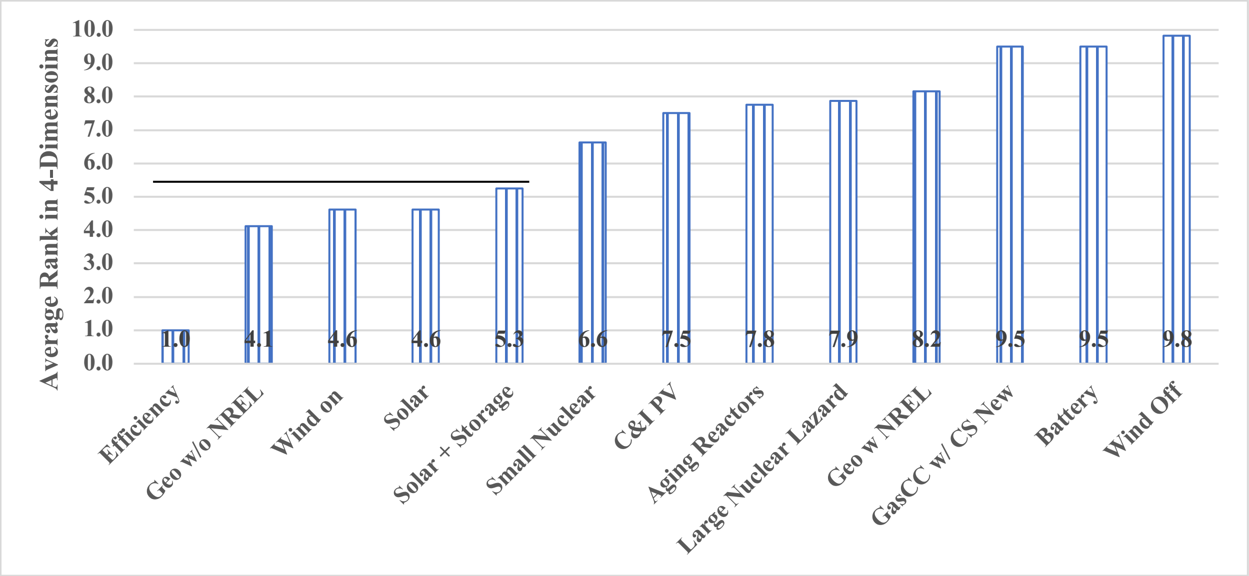
RISK-AWARE LONG-TERM COST ESTIMATION



Source: LCOE, Energy Costs, Lazard, 16.0, 2023; Energy Information Administration (EIA), 2023, *Levelized Cost of Energy*; National, Renewable Energy Laboratory (NREL), 2022, *Annual Technology Baseline (ATB), 2022 Electricity,* and discussion in chapter 2. Risk-Aware is calculated as the Euclidian distance from the origin. Using standard deviation and Average cost. The Method is described in Mark Cooper, "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.

MNC-6.4

AVERAGE RANK ACROSS 4-DIMENSIONS
(Risk-Aware Price: long & short, Firming, Value-Ratio)



MNC-6.5

WHAT MONEY CAN BUY: A LOT, BUT IT DEPENDS ON ASSUMPTIONS

	Subsidy Facilities	1-Cycle Life-time capacity (MW) Annual	Owners Facilities	Cover 50% capacity (MW) Annual	Load Factor	Effective Load Carry Capacity (MW) (CAISO) 1-Cycle	Owners 50%
Geothermal	2	500	4	1000	85%	425	850
Solar Hybrid	54	5400	108	10800	51%	2754	5508
Efficiency (30% savings)					90%	184	

(over 5 years growth is .9% per year, rather than 1.4%)

Source: uses average Lazard.16.0 capital, for the case used in the firming analysis for solar and the geothermal general analysis. Assumes $2.5 billion in Federal and state subsidies; rounded to the nearest "whole" plant.