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

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

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

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

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

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

Cooper has provided expert testimony more than 400 times for public interest clients, including attorneys general, people's counsels, and citizen interveners before state and federal agencies, courts, and legislators in four dozen jurisdictions in the United States and Canada. Cooper holds a doctorate in Sociology from Yale University.

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PICKING LOSERS

South Carolina Gas & Electric (SCE&G or the company) is in the midst of frantic efforts to find a way to cushion the blow to the company and its shareholders, while dodging the political and regulatory consequences of the rate shock to its customers from the financial meltdown of it V.C. Summer nuclear construction project. At best, the outcome will be very bad for SCE&G ratepayers, at worst it will be catastrophic.

The severity of the economic collapse of the project is testimony to the enormity of the mistake made in choosing to build two, new, untested nuclear reactors that were too big (unnecessary to meet the need for electricity[2]) and far too costly for the utility to undertake (nine times the recommended size of a prudent investment for a small utility).[3]

But SCE&G management is not the only party at fault in this disaster – policy makers bear a significant part of the responsibility. One of the most frequently repeated warnings one hears in public policy debates is 'governments should not be in the business of trying to pick winners.' Since policy makers are not very good at it, it is best left to the marketplace to decide. While one can argue about whether and how the government might improve the ability of the marketplace to pick winners, there would seem to be little doubt that one thing the government should not do is override the decision of the marketplace in an effort to prop up losers.

Unfortunately, that is exactly what South Carolina did ten years ago. Not only did it pick a losing technology, construction of new nuclear reactors, but it supported that technology by embarking upon a quasi-socialist experiment, an experiment that is robbing electricity ratepayers of billions of dollars. The mistake of abandoning sound economic principles came at a particularly bad moment for nuclear power, as shown in my recent analysis, which is summarized in Figure I-1.[4]

While nuclear power was 50% to 100% more costly than the alternatives available in the first quarter century of its major commercial deployment (1975-2000),[5] a technological revolution dramatically lowered cost of alternatives in its second quarter century, rendering it 300% to 400% more costly than the alternatives.[6] Efficiency, renewables, and new storage

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[1] The February 1985 issue of *Forbes* magazine (James Cook, James, "Nuclear Follies," *Forbes*, February 11) painted an eye catching picture of the failure of nuclear power, in America, "The failure of the U.S. nuclear power program ranks as the largest managerial disaster in business history, a disaster on a monumental scale. The utility industry has already invested $125 billion in nuclear power, with an additional $140 billion to come before the decade is out, and only the blind, or the biased, can now think that most of the money has been well spent. It is a defeat for the U.S. consumer and for the competitiveness of U.S. industry, for the utilities that undertook the program and for the private enterprise system that made it possible."

[2] As shown in my 2012 testimony in South Carolina in Docket 2012-203-E, September 6, 2012, https://dms.psc.sc.gov/Attachments/Matter/49c8e565-155d-2817-100d11e901777cdb

[3] Mark Cooper, *All Risk, No Reward*, Institute for Energy and the Environment, Vermont Law School, Dec 2009.

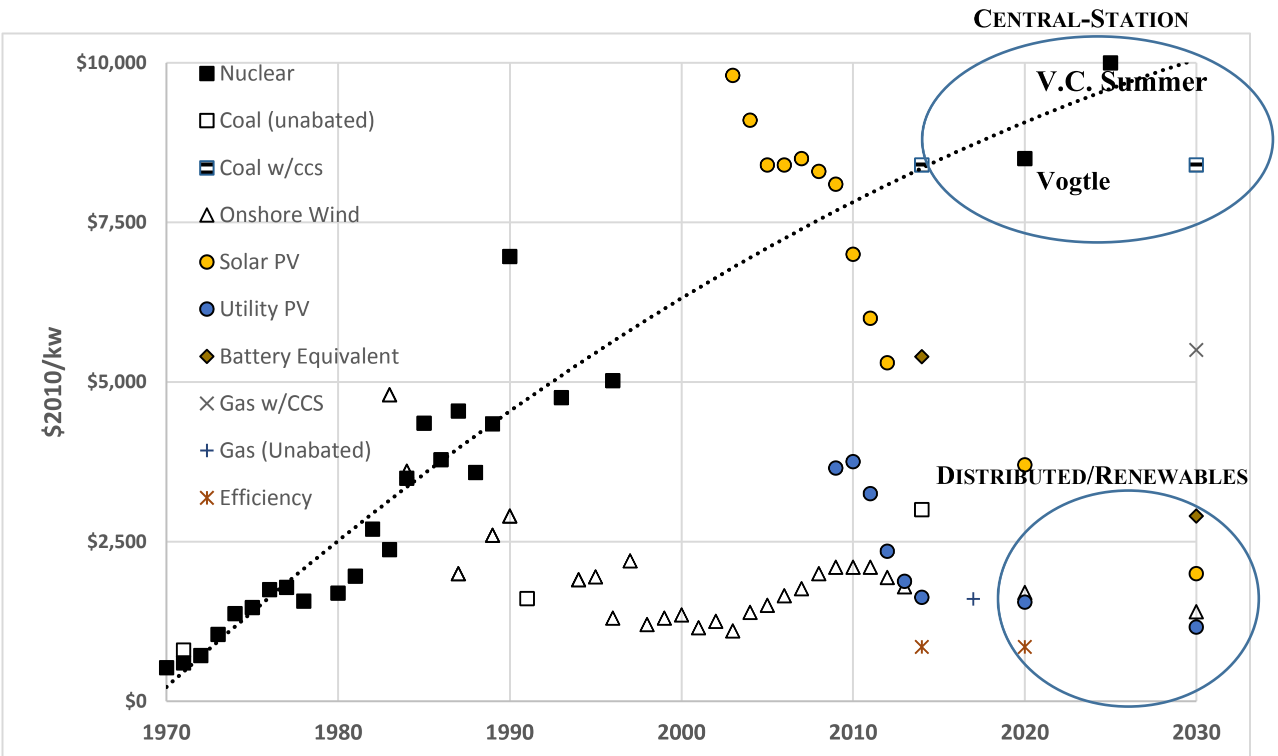
[4] Mark Cooper, *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Power Sector* (Santa Barbara, Praeger, 2017). The history of the earlier period is examined in detail in Mark Cooper, "Nuclear Safety and Nuclear Economics, Fukushima Reignites the Never-ending Debate: Is Nuclear Power Not Worth the Risk at Any Price?" *Symposium on the Future of Nuclear Power*, University of Pittsburgh, March 27–28, 2012.

[5] The history of nuclear economics is discussed in Mark Cooper, "Nuclear Safety and Nuclear Economics, Fukushima Reignites the Never-ending Debate: Is Nuclear Power Not Worth the Risk at Any Price?" *Symposium on the Future of Nuclear Power,* University of Pittsburgh, March 27–28, 2012.

[6] Cooper, 2017, *Political Economy of Electricity,* Chapter 5.

technologies are not only much less costly, they are much more effective with respect to carbon reduction and much cleaner with respect to other pollutants.[7]

FIGURE I-1: PAST, PRESENT AND FUTURE COST OF NUCLEAR POWER V. ALTERNATIVES (overnight cost for capital-intensive technologies, fuel-intensive technologies based on relative cost per 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.

Time to Stop the Bleeding

With the bankruptcy of Westinghouse, the designer, vendor and general contractor for the construction of two nuclear reactors at the V.C. Summer nuclear power station, the South Carolina Public Service Commission has the power and the duty to put an end to the abuse of consumers that will be a drag on the state's economy for decades.

Time is of the essence. This analysis shows the project is a total waste. Even though the bankruptcy was filed on March 29, 2017 in the U.S. Bankruptcy Court of New York, the project is wasting about $120 million per month without an updated work plan, target date or final cost.[8] The order authorizing additional expenditures is based on dates and costs that are a fiction, and probably were at the time the evidence was presented to the Commission.[9] The construction of

[7] Id.
[8] ECSC Summer Conference, *Summer Basics*, June 6, 2017
[9] PSC Order 2016794, Docket 2016-794-E, November 28, 2016, https://dms.psc.sc.gov/Attachments/Order/9aaf3291-dd3a-4ac6-a4db-adda60c21158

the project is just over one-third complete.[10] As much trouble as it has had to date, construction is the most challenging part of a nuclear reactor build.[11] Prudent management would have recognized that the project was doomed by mid-2016 and pulled the plug.[12] Management will waste more money going forward in a futile attempt to complete the project, more than had been sunk into it at the point it should have been abandoned. Future costs may be twice as much as the costs that have been sunk.

This report outlines five steps that can be taken to soften the negative blow to both SCE&G ratepayers and the economy of South Carolina:

- Stop wasting money by abandoning the project.
- Claw back improperly expended sunk costs through reclamation under the bankruptcy laws and reparation for imprudent costs improperly incurred.
- Return to traditional least-cost, used and useful principles for utility resource acquisition.
- Rely on lower cost, cleaner resources, like efficiency, renewables and dynamic system management to meet any growth in demand or reduction in emission of pollutants.
- Mitigate the bill impact by enhancing ratepayer ability to lower their electricity costs with on-bill financing of efficiency, reducing the profit paid on wasted capital expenses, and extending the period for cost recovery.

OUTLINE

The remainder of this analysis is organized as follows.

Section II describes the ill-considered policy established by the legislature and the imprudent decisions made by utility management.

Section III estimates the magnitude of the cost to complete the construction of Summer 2 & 3 and outlines steps to diminish and mitigate the harm of excessive costs, beginning with the abandonment of the project.

Section IV discusses the economic fundamentals that have rendered these reactors "pure waste" as a source of electricity and as a strategy for decarbonization of the electricity sector.

Section V show that the completion of Summer 2 & 3 would create nuclear rate shock.

[10] Quarterly Report of SCE&G Concerning Construction of V.C. Summer Nuclear Station Units 2 and 3, filed with SC PSC on May 5, 2017, https://dms.psc.sc.gov/Attachments/Matter/77289874-6d56-41e9-b50e-e89ddb80bc10," puts construction at 34.3% complete."
[11] Cooper, 2012, Nuclear Safety and Nuclear Economics.
[12] In my earlier testimony on Summer 2 & 3 (see note 2 above), I showed that construction should have been abandoned in 2012.

II. A PERVASIVE PATTERN OF IMPRUDENT DECISION MAKING

THE POLICYMAKERS' FUNDAMENTAL ERROR: ABANDONING MARKET PRINCIPLES

Abandoning the principles of market economics, the legislature was persuaded to allow utilities a guaranteed rate of return on nuclear construction projects under the Base Load Review Act (BLRA). The legislature ordered the Public Services Commission to approve the recovery of costs before nuclear reactors generated any electricity (i.e. before the reactors were "used and useful"), without a demonstration that the reactors were the least-cost options available, and with little opportunity to determine whether the costs were prudently incurred.

The principles that regulation should ensure consumers are only charged for prudently incurred costs from the least-cost options when they received power have been the cornerstone of utility regulation from the beginning because they embody the outcomes that prevail in a vigorously competitive market. In a competitive market, consumers get the use of goods and service at the point-of-sale. Producers bear the risk of making the investments necessary to produce the output. The price includes a rate of return commensurate to the risk that they take. The rate of return is set by competition in the marketplace. Consumers will not pay more for a good or service than the most efficient provider, using the least-cost technology can sell it for. They do not have to pay more than that because they have choices in the marketplace.

Because electricity is not sold in a competitive market in South Carolina, consumers do not have such a choice. Consumers receive service from a monopolist who holds the franchise for the area in which service is provided. Regulation is the primary means of protecting consumers from ineffective management and inefficient or uneconomic technology choices. Because utilities have generally not been subject to vigorous competition, regulation has been imposed that tries to emulate the competitive market outcome – least-cost technologies that are used and useful for consumers. The Base Load Review Act, like similar laws in Florida and Georgia, made an exception and abandoned the principles for nuclear power, with disastrous results.

THE UTILITY'S FUNDAMENTAL ERROR

One can argue that the utility did not have to take the legislature up on the offer, but an opportunity to earn a guaranteed return, in advance, on an asset that would double the rate base (and therefore the income) of the utility for decades, was just too good to pass up. Prudent management could and should have declined the offer.

SCE&G made the management decision to construct new nuclear reactors and rushed to sign an Engineering and Procurement Contract based on the fear (assumption) that there would be a rush of orders. It claimed to be moving quickly to get a better deal, even though the design was not complete and approved. Nothing could have been farther from reality. There were virtually no other orders, the design was not complete and the first utilities bore the brunt of the early foul-ups. The rush to quickly sign an early deal proved to be a very bad idea. SCANA is ultimately responsible for these disastrous management decisions.

Given that the track record of nuclear power in America had been abysmal, with massive cost overruns, disappointing load factors, and early retirements, the utilities should have known better, but they were blinded by huge, guaranteed increases in profits. The results in South Carolina, as elsewhere, have been catastrophic and the utilities insist that they must not be required to bear any responsibility for the outcome. The decision to invest in a first-of-kind, huge nuclear reactor construction project that vastly exceeded the financial capacity of SCANA to undertake was imprudent on the part of the utility.

A Disaster that was Entirely Predictable and Predicted by Public Interest Intervenors

In 2008, Friends of the Earth, with Nancy Brockway as the expert witness (Docket 2008-196-E), offered an extensive critique of the utility's approach to the selection of resources to meet the need for electricity and offered a series of recommendations to the Commission to protect consumers from the faulty decision that was about to be made. Four years later, the Sierra Club, with Mark Cooper as the expert witness (in Docket 2012-203-E), offered an analysis of the state of the project that corroborated all of the concerns expressed earlier by Friends of the Earth, showing that billions had been wasted and ratepayers would be better off in the project was abandoned.

So today, this study commissioned by Friends of the Earth and the Sierra Club demonstrates that consumers, the State of South Carolina and the environment would be much better served if the V.C. Summer project is cancelled and replaced by lower-cost, low-carbon, low-pollution resources. The study directly and fully supports the petition of Friends of the Earth and the Sierra Club to abandon the project.

Nuclear power has never been and is not today competitive with widely available alternatives. A full palate of alternatives to meet the need for electricity was not considered. The utility ignored alternatives like efficiency, demand side management and renewables as options, whose costs were lower and falling dramatically, focusing instead on natural gas, using costs that were inconsistent with the history of the natural gas industry.

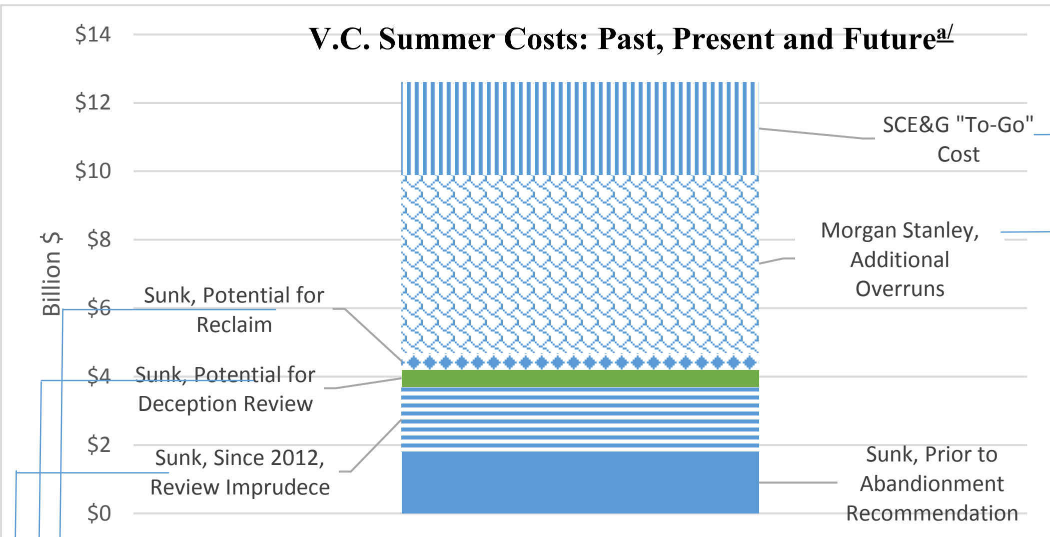
Given the history of the nuclear industry and the unfinished design of the project, the length of the design and construction schedule was far too short and the costs of the project were vastly underestimated. Delay and cost overruns were inevitable. Today the delay is in excess three years and the cost overruns are likely to drive the final cost to twice or more the originally predicted level.

The potential for massive, guaranteed profits offered by policy makers was too enticing to turn down and principles of sound management decision making were overridden. The project has gone so badly, however, culminating in the bankruptcy of the principle vendor, that the decision to build the reactors can and should be reviewed, even under the lax oversight of the Base Load Review Act. The "guarantees" policymakers offered to utilities recognized that things could change so much that the decision to continue with the project could be reassessed. The severe problems revealed by the bankruptcy also call into question whether the evidence on which past "prudence" findings was complete and honest. Swift action by the Commission could save SCE&G ratepayers as much as $10 billion.

III. THE BURDEN OF UNUSED AND USELESS ASSETS: A FIVE-PRONGED-APPROACH TO MINIMIZE HARM TO RATEPAYERS AND THE ECONOMY, WHILE PROTECTING THE ENVIRONMENT

The five-pronged-approach outlined in this analysis and summarized in Figure 2, can meet the need for electricity and save ratepayers as much as $10 billion. This description of the stakes starts at the top of the upper graph in Figure III-1 and works down the stack. The amount of resources at stake in the upper graph are then linked to the magnitude of the impacts expressed in both dollar estimates and as a percentage of the total bill (with the 2017 bill as the base).

FIGURE III-1: REVISIT PRUDENCE IN LIGHT OF NEW INFORMATION



Summary of Financial and Bill Impacts of Abandoning V.C. Summer 3 & 4

Cost Category	Total $ Amount Billion	Source	Res. Bill Savings (based on 2017)[b/] $/Month	% of 2017
Stop Wasting Money				
Save "To-Go" costs	$2.50	SCE&G[c/]	$27+	18%
Avoid future cost overruns	$5.20	Morgan Stanley[d/]	$54+	36%
Reduce Sunk costs (Claw Back)				
Reclaim costs under bankruptcy law	$0.50	UBS[e/]	$13	5%
Review deceptive recent decisions	$0.50	UBS[f/]	$16	6%
Revisit prudence given new information	$1.90	Sunk Since, 2012[g/]	$30	11%

Sources and notes

[a/]Mark Cooper, *Surrebuttal Testimony of Dr. Mark Cooper*, September 2012; *Restated and Updated Construction Expenditures*, SCE&G, Appendix 2; Morgan Stanley, *Implications of Potential Westinghouse Bankruptcy Filing*, March 22, 2017.
[b/] SCE&G Cumulative Rate Increases Approved Under the Base Load Review Act.
[c/]Appendix 2: Restated and Updated Construction Expenditures
[d/]Morgan Stanley, p. 1
[e/] UBS, *Mitigating the Nuclear Fallout*, March 30, 2017, p.3, subsequent evidence of poor analysis and management. These "claw backs" could be as much as an additional $2.9 billion. The total potential savings is well over $10 billion.
[f/] Id., p. 3.
[g/] Cost incurred through year-end 2017 (see note c above) minus cumulative rare increases (see note 1 above) minus costs sunk as of yearend 2012 (see note 3 above).

REDUCING THE WASTE

I identify "to-go" costs on the right of the top graph. As of year-end 2016, SCE&G estimated that there were $3.2 billion of costs "to-go" in the V.C. Summer project. Since the utility continues to spend on construction (about $120 million per month), there are $2.5 billion "to-go." I believe a significant part of the recent spending can be "clawed back," as discussed below. To the extent that additional resources are necessary to meet the needed for electricity, doing so with lower cost alternatives would result in a net savings for ratepayers of at least $1 billion. Given the very low rate of growth in demand at present, however, and the much greater flexibility in adding efficiency and renewable capacity, the entire $2.5 billion could be saved. Halting construction today will avoid future cost overruns, which are highly likely given the chaotic state of the project. Per the Morgan Stanley estimate, which is consistent with others, this could save ratepayers additional $5.2 billion.

Measured in terms of bill impacts, the potential to save ratepayers money is huge. The project stands at 18% of the current total monthly bill.[13] "To-go" construction costs would more than double that, under routine assumptions about return of (depreciation) and on (return on investment) capital, as discussed below. Soon the cost of the project could constitute over a third of the bill. Cost overruns could increase the bill impact dramatically. The cost overruns could eventually double the amount being recovered and drive nuclear cost recovery to over one-half of the bill. Abandonment would save these unnecessary costs.

REDUCING THE BURDEN OF SUNK COSTS ON RATEPAYERS

Abandonment would also open the possibility of reducing the burden of sunk costs. I identify "claw back" saving on the left side of the graph. It would be possible to reduce the amount of sunk costs for which ratepayers are on the hook. These "claw backs" include reclamation of costs under the bankruptcy laws, reviewing significant costs agreed to recently, and revisiting the decision to allow the cost overruns in the first place, given the subsequent evidence of poor analysis and management. These "claw backs" could be as much as an additional $2.9 billion. The total potential savings is well over $10 billion.

The agreement reached in late 2016 is now highly suspect. The vendor was asked for a new work plan and schedule, but failed to deliver one. These costs should be disallowed by the Commission.

As of year-end 2016, SCE&G had paid Westinghouse, $1.9 billion out of $4.5 billion of construction costs that had been incurred. Thus, there appears to be a large sum of "sunk" costs that have not been paid yet, much larger than the amount we suggest can be clawed back for the above two reasons. Given the complete breakdown of project management and the failure to have a realistic plan of operation, the entire increase in sunk costs back to 2012 should be examined.

[13] 2-22-17 BLRA Current Rate Impact: "SCE&G's residential customers, served on Rate 8, using 1,000 kWh are currently paying an average of $147.53 per month. Of that amount, $27.03 or 18.32% of the bill is attributable to the Base Load Review Act." http://www.regulatorystaff.sc.gov/Documents/2-22-17%20SCEG%20Current%20BLRA%20Impact.pdf

To the extent that South Carolina needs capacity, it has much lower-cost alternatives available than the new V.C. Summer reactors. In the next section I identify two “uses” to which those resources can be put. Both of which lead to selection of efficiency and renewables.

If the PSC/utility concludes it needs new resources to meet its reserve margins, based upon a realistic analysis of load growth, it should apply the principles of least-cost, used and useful in acquiring those resources.

If the PSC/utility desires to reduce emissions of pollutants, including carbon dioxide, it can use alternatives that deliver more clean power at one-third the cost.

MITIGATING THE BURDEN OF UNUSED AND USELESS INVESTMENTS

Even if the South Carolina Public Service Commission pursues the measures identified above to reduce the magnitude of the harm that will be imposed on ratepayers, there will still be substantial sunk costs that have not resulted in an asset that is used and useful. The burden of the remaining sunk costs can be further mitigated for residential ratepayers by taking a number of steps.

One approach advocated by Friends of the Earth in its original filing dealing with Summer 2 & 3 that is particularly appealing is to allow on-bill financing of residential consumer investments that reduce their electricity bills. This approach is economically productive, since it adds useful assets to the electricity system. Efficiency investment should be favored because they are also far lower in costs than other assets. This approach also has an element of fairness to it. SCE&G was allowed “on-bill financing” of its nuclear project in a break with traditional practice. Affording ratepayers a similar opportunity to alleviate the burden of the failed nuclear construction give them a similar opportunity.

Accounting measures can also reduce the burden on ratepayers. Costs sunk in an unused and useless asset can receive a lower rate of return. Since future risks are gone and ratepayers have borne the burden of the past risk, a risk free rate of return might even be justified.

The recovery period can be set to achieve the outcome that is preferred. Shortening the period increases the initial cost impact, but reduces the total burden. Lengthening the period does the opposite.

In the case of these accounting measures to mitigate the rate impact, there need be no concern about “sending a bad signal” that would dissuade utilities from making this type of investment in the future. This was an exception that went badly and dissuading its use in the future is a good idea.

IV. ECONOMIC FUNDAMENTALS SUPPORTING ABANDONMENT

The question today, as it was five years ago when I first testified in the V.C. Summer proceeding, is –

Would ratepayers be better off if the utility abandoned the plant and met the need for electricity in the least-cost manner possible?

The answer is, as it was five years ago, unequivocally yes.

The economic characteristics of new nuclear reactors are so bad that, even with $4.5 billion sunk, the "to-go" costs of completing the V.C. Summer reactors would be substantially greater than the cost of the alternatives.

In order to evaluate the key question carefully and reach that conclusion we must consider not only the "to-go" cost of nuclear, but also the cost of the alternatives that would be necessary to meet the needs of the state for electricity.

HIGH AND RISING CONSTRUCTION COSTS

Under the guise of a self-proclaimed "nuclear renaissance" advocates of nuclear power touted new, more modular designs (including the AP1000 promoted by Westinghouse) that would prevent a recurrence of the cost overruns that afflicted the industry in the 1970s and 1980s. Pressuring federal and state policymakers, they were granted subsidies and regulatory relief to support and facilitate construction.

Unfortunately history repeated itself. The design of the reactors (the AP1000 included), which was supposed to be complete before construction began, underwent 19 revisions before it was finalized, well after construction had begun in South Carolina. Foul-ups and inferior quality plagued the construction from the outset. Today the reactors are years behind schedule and billions over budget. Law suits and disputes between the vendor and the utility, attempting to affix blame for the screw-up, abound.

Table IV-1 presents an analysis of the cost overruns based on a Morgan Stanley report that sought to understand past and potential for future cost overruns. I include a recent estimate for the projected cost of Vogtle from the Georgia PC staff, which corroborates the Morgan Stanley estimate. The staff estimate is only 3% lower. We have found no second independent estimate of the V.C. Summer costs, but the close agreement between Morgan Stanley and the PSC Staff for Georgia makes the Morgan Stanley V.C. Summer estimate seem credible.

It is important to keep in mind that SCE&G owns a larger share of the Summer project than Georgia Power owns of Vogtle (55% v. 45%) with a proposal on the table to increase its share[14]). SCE&G's costs are larger in the aggregate. This is taken into account by showing the cost per kilowatt of capacity, which is a standard measure. Because Vogtle is farther along than V.C. Summer,[15] Morgan Stanley assumed Summer would face greater risk of future cost

[14] SCE&G has 55% of V.C. Summer, with a proposal to increase it to 60%; Georgia Power has 45.7% of Vogtle,

[15] 70% v. 60% in total; 43% v. 35% in construction

overruns. For both projects, costs are likely to end up being twice the original estimate, which is consistent with the historical experience of similar ventures.[16]

TABLE IV-1: THE TOSHIBA FINANCIAL CATASTROPHE (Billion $, except for cost /kw)

	VOGTLE GEORGIA POWER	V.C. SUMMER SCE&G	TOTAL
TOSHIBA			
Early Overruns	$0.95	$1.3	$2.25
Recent Settlement	1.4	1.7	3.1
Future	0.95	2.0	2.95
Total	3.3	5.0	8.3
OWNER COST			
Future losses	0.94	1.5	2.45
TOTAL OVERRUNS	4.24	6.5	10.75
ORIGINAL ESTIMATE	4.44	6.1	10.54
TOTAL COST	8.68	12.6	21.29
GEORGIA PSC STAFF	8.44		
COST= $/KW			
Original	4040	4955	4498
With Overruns	8500	10024	9260

Source: Morgan Stanley, *Implications of Potential Westinghouse Bankruptcy Filing,* March 22, 2017.

Because the contracts included some protections intended to shield ratepayers from cost overruns, Toshiba/Westinghouse took some of the risk of cost overruns. Things got so bad that Westinghouse could not bear those risks, so it declared bankruptcy. The utilities stepped in to absorb the ongoing costs as they tried to sort out when, whether, and at what cost the projects could be completed. Southern Company has gone so far as to insulate Westinghouse/Toshiba from future cost overruns.[17]

Since neither Westinghouse/Toshiba nor the utilities represent ratepayers, the insulation will be paid for by ratepayers in their utility bills. A commensurate guarantee to ratepayers would be that they will not bear any burden from future delays and cost overruns – utility and vendor stockholders should bear that risk. But, as shown below, even such a guarantee is not the best outcome for consumers. They still end up paying more than if the project is abandoned. This conclusion reflects supply-side and demand-side factors.

DECLINING COST OF ALTERNATIVES

New nuclear reactors are not uneconomic because they cost so much, they are uneconomic because they cost so much more than alternative resources that could be used to meet the need for electricity.

As shown in Figure I-1, above, long term trends underlie the fifty-year failure of nuclear economics. The small, early, turnkey reactors that vendors used to promote nuclear power looked like they might be competitive with coal. However, once reactors and reactor

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[16] Cooper, 2012, Nuclear Safety and Nuclear Economics.

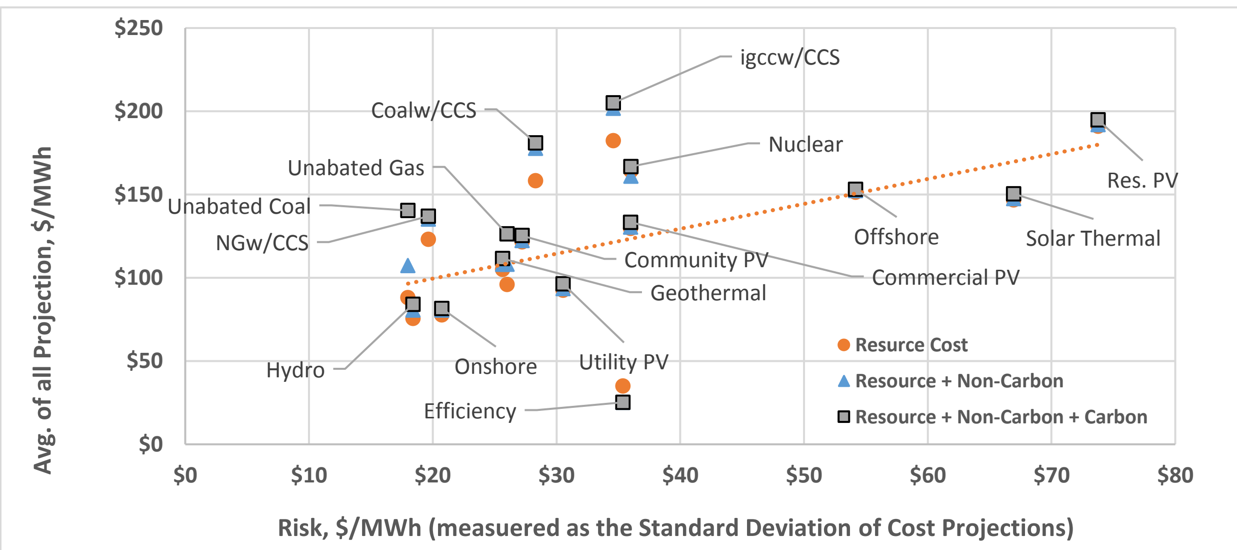
[17] Toshiba Corporation, "Toshiba and Vogtle Owners Reach Agreement on Nuclear Power Plant Construction Project in Georgia," June 10, 2017; Walton, Robert, "Southern, Westinghouse strike $3.7B deal to complete Vogtle Nuclear plant," *Utility Dive,* June 12, 2017.

construction scaled up and spread across the nation, costs escalated rapidly. The "Great Bandwagon Market," as it came to be known with 250 active reactors projects in the late 1960s and early 1970s, ended in a wreck. No new reactors were ordered for three decades after 1978. Over one quarter of the projects never materialized or had orders canceled before construction began. One-fifth of the reactors that went into construction were abandoned. About 15% of all reactors built were retired early because of a combination of safety and operating problems that rendered them uneconomic, even for the owners.[18]

The "nuclear renaissance" that the industry hyped forty years later, proved to be a fairy tale, rather than a renaissance. The ugly economic results of nuclear power of the early commercialization was repeated. Of 30 projects contemplated in the U.S., only two went into construction, the two that have now led to the bankruptcy of the vendor. The ultimate cause of the collapse was, once again, the high cost of nuclear meeting much lower cost alternatives. .

Combined cycle natural gas plants had become the "go to" technology just before and after the start of the 21st century – gas, not nuclear, backed out coal. Gas costs have generally declined, continuing the pressure on nuclear reactors, but the current and future pressure on reactors will come from new technologies. Today, as shown in Figure I-1, above, the emergence of a new 21st electricity system, based on renewables and distributed generation along with efficiency and demand response closely managed with dynamic integration of supply and demand, is the focal point of investment. Figure IV-1 provides much greater detail on the cost of alternatives in the time frame that the V.C. Summer reactors will come on line. It adds several important dimensions to the analysis.

FIGURE IV-1: RENEWABLE AND DISTRIBUTED RESOURCES ARE LEAST-COST



Source: Updated from Mark Cooper. *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Sector*. Santa Barbara, Praeger. 2017. Figure 11.3 and accompanying text. Reprinted from, Energy Economist, Platts, May 2017.

- First, the uncertainty surrounding cost estimates is captured by using the standard deviation of all of the cost estimates as the X-axis, while the Y-axis

[18] Cooper, 2012, *Nuclear Safety and Nuclear Economics.*

shows the average of those estimates. The standard deviation is frequently used to portray the risk of investment in electricity cost analysis.[19]

- Second, it provides estimates that incorporate the cost of non-carbon pollution and CO_2 emissions, which are monetized costs of carbon emissions and the emissions of other pollutants like SO_2, NOX, particulates, etc.[20]

Figure IV-1 shows that the basic finding that there are a number of alternatives that are lower in cost is reinforced when these considerations are incorporated. Efficiency, wind, and utility PV are not only lower in cost, they are less risky and cleaner. Figure III-1 also shows that by taking this broader, long-term perspective we find additional low carbon, low pollution resources that are much more attractive than nuclear power.

SLOWING DEMAND GROWTH AND EXCESS CAPACITY CAUSED BY NEW NUCLEAR REACTORS

The severe cost disadvantage suffered by new nuclear reactors is magnified by another of their characteristics – their huge size. As shown in Figure II-2, the growth of demand has slowed dramatically over the course of the past decade, but nuclear reactors bring huge increments of capacity to the network that create a condition of massive excess capacity.

The upper graph of Figure IV-2 shows the track record of company estimates of future peak demand. Over the last decade the utility has dramatically overestimated demand and has never caught up to reality.

The middle graphs of Figure IV-2 shows the impact of making various assumptions about the rate of growth of demand. In the case of the V.C. Summer reactors, assuming a growth rate consistent with the decade since the costs have been incurred for their construction, the situation of excess capacity is essentially permanent. The assumption of flat demand is not only consistent with recent experience, it is also more appropriate for the available technologies, which can be added in small increments in relatively short periods of time.

The lower graph of Figure IV-2 shows the excess capacity above the target reserve margin under the two growth scenarios – flat growth and half the growth rate assumed by the company.

In terms of physical quantities, the magnitude of the excess is huge. Under the flat growth assumption, there are 16,000 MW-years of excess capacity over the eleven years of operation of the nuclear reactors in the Integrated Resource Plan. Under the assumption of .8% growth there are over 8,000 megawatt years of excess capacity. Even one unit creates significant excess capacity. Under the zero growth assumption, excess capacity is almost 7,000 MW-years.

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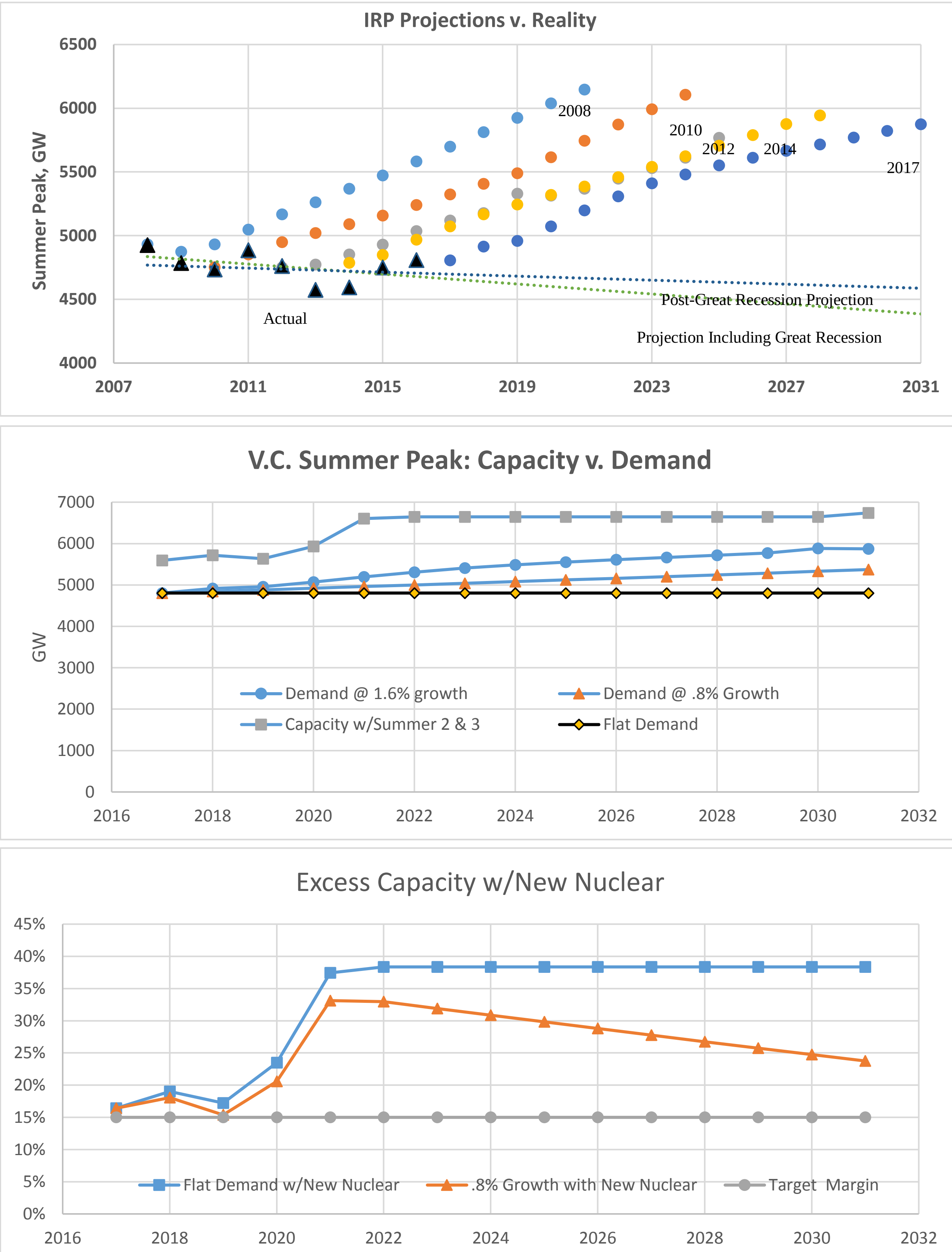
[19] Wikipedia defines the standard deviation as follows (https://en.wikipedia.org/wiki/Standard_deviation): "In statistics, the standard deviation… is a measure that is used to quantify the amount of variation or dispersion of a set of data values. A low standard deviation indicates that the data points tend to be close to the mean (also called the expected value) of the set, while a high standard deviation indicates that the data points are spread out over a wider range of values…The standard deviation… is the square root of its variance… A useful property of the standard deviation is that, unlike the variance, it is expressed in the same units as the data." The derivation and application of risk concepts (including the standard deviation of individual assets and portfolios of assets constructed to reduce risk) are described in Cooper, 2017, *Political Economy of Electricity*, Chapter 5, Chapters 10 and 11.

[20] These are based on a literature review discussed in Cooper, 2017, *Political Economy of Electricity*, Chapter 5 and applied in Chapter 11. Efficiency is assumed to emit no pollutants.

FIGURE IV-2: DEMAND GROWTH: IRP PROJECTIONS V. REALITY



Source: Projections, SCE&G Integrated Resource Plans, various years, page 2. Actual, 2017, p.33

In other words, from the point of view of meeting the needs for electricity, the construction of V.C. Summer 2 & 3 have become pure waste. Even if we hypothesize the need for some capacity, the amount is small and the cost per MW is a fraction of the cost of the nuclear reactors. As I demonstrated in my testimony in South Carolina in 2012 and elsewhere, the only way that the utilities could pretend that building reactors made economic sense was to assume a high level of demand, ignore excess capacity, and restrict the consideration of alternatives by focusing on high gas prices, which were atypical of gas price history and have not be in evidence since construction began.[21]

The pattern of expenditures for excess capacity adds insult to injury for consumers. It requires consumers to pay extra for a lot of expensive, excess capacity in the early years. Since money has a time value to consumers (the opportunity cost of capital or the discount rate), a dollar taken today denies consumers the opportunity to use that money for another purpose. Even if we use a conservative, consumer oriented discount rate of 3%, the expenditure for power from the new reactor has 7% more value than the pattern of expenditures for renewables. This could add as much as $350 million to the harm imposed on consumers by the project.

DECARBONIZATION

One of the most frequent claims put forward to justify the subsidization of nuclear reactors (old and new) is the claim that they are essential for decarbonization of the electricity sector. As is the case for all things nuclear, they are a brutally inefficient way to achieve that goal.

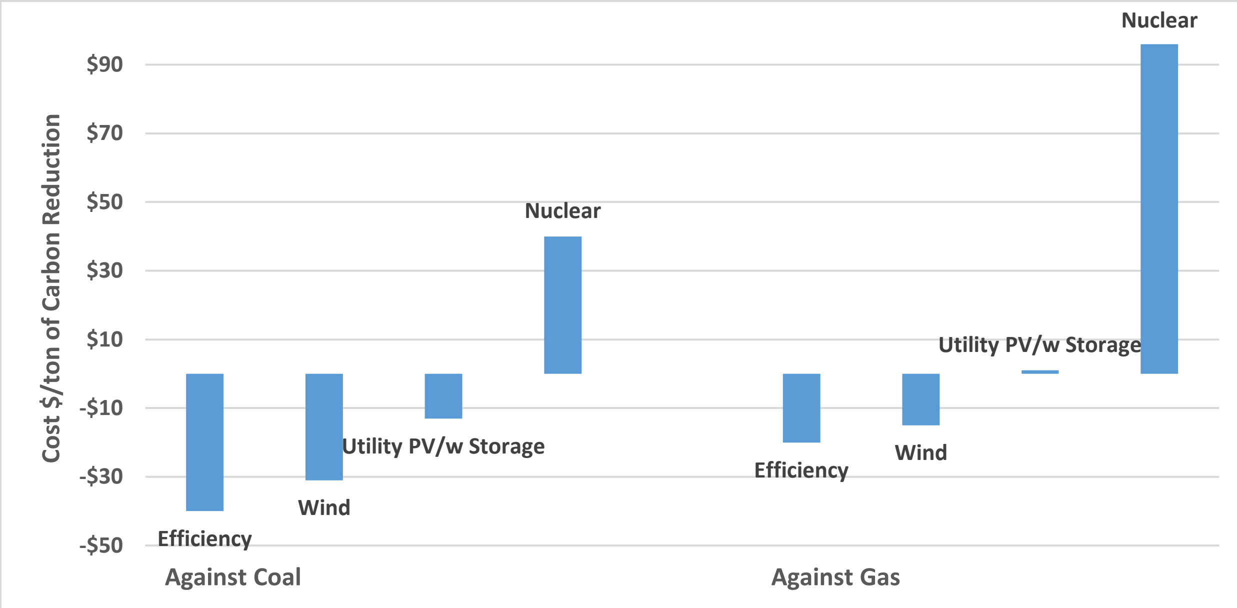
New reactor construction is particularly inefficient at decarbonization because it takes so long. While nuclear reactors are dithering in the construction phase, alternatives could be online meeting the need for electricity with carbon free resources. Between the carbon intensive construction process and the long construction period, one quarter of the advantage of nuclear *vis-à-vis* coal is squandered. Moreover, such huge units are brought online that it makes managing the retirement schedule more difficult.

The key underlying problem with nuclear power's role in decarbonization is the same as its general problem; it costs too much. Figure IV-3 shows Lazard's most recent analysis of the cost of carbon reduction. I have added in efficiency by using a price of $35/MWh, which is well above the midpoint of the Lazard's estimate of the cost of efficiency.

Efficiency and wind have a negative cost of carbon reduction, when either coal or gas are being replaced, because their resources costs are lower than the resource costs of the power they are replacing. Utility scale solar has negative costs for carbon abatement when coal is replaced and has a zero cost when gas is replaced. Nuclear power is much more costly.

[21] "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, Chapter 4.

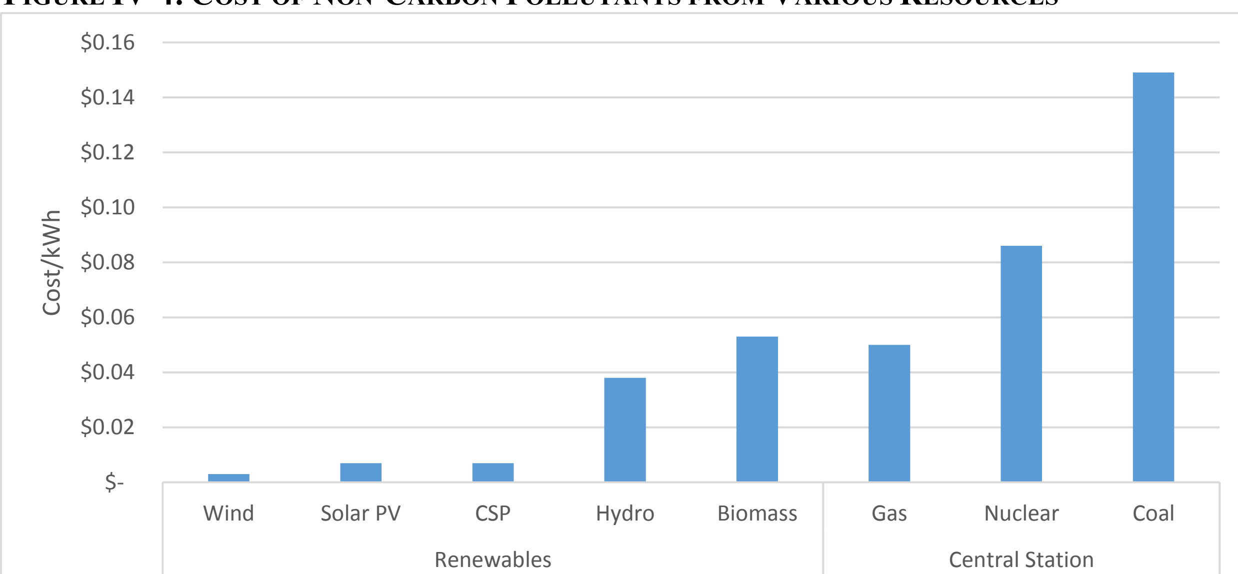
FIGURE IV-3: THE COST OF CARBON ABATEMENT



Source: Lazard, 2016. Lazard's Levelized Cost of energy analysis – Version 10.0. December, p. 6. Efficiency is from Lazard, 2015. Lazard's Levelized Cost of energy analysis – Version 9.0. November. p. 2. Lazard gives a range of 0-$50/MWh. The $35/MWh, is used in Mark Cooper. *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Sector.* (Santa Barbara. 2017) Chapter 5.

It is also important to note that nuclear power is not an attractive resource when other pollutants are considered, as shown in Figure IV-4. While nuclear is less costly than coal, renewables impose much smaller costs on society in terms of emissions of non-carbon pollutants. In fact, just as nuclear power is "pure" waste when considering the economics of meeting need for electricity, so too it is close to "pure waste" when considering the economics of meeting the need for low carbon, low pollution resources.

FIGURE IV-4: COST OF NON-CARBON POLLUTANTS FROM VARIOUS RESOURCES



Source: Adapted from Mark Cooper. *The Political Economy of Electricity: Progressive Capitalism and the Struggle*

Reliance on these alternatives represents a shift in the approach to meeting the need for electricity, while responding to the need to decarbonize the electricity sector. Being a new approach, nuclear advocates have raised questions about the ability of the system to deliver reliable power. The concerns are unfounded. Many states and nations are relying on much higher levels of penetration to deliver electricity with no diminution of reliability. These utilities are using a variety of approaches (identified in Table III-2) to meet the need for electricity in a reliable, low cost, low carbon system.

TABLE IV-2: DYNAMIC SYSTEM MANAGEMENT WITH INFORMATION, COMMUNICATIONS & CONTROL TECHNOLOGIES

DEMAND	SUPPLY
Efficiency	Dispatchable Storage
Target peaks	Solar thermal
Aggressive demand response	Utility strategic
Manage water heating	Distributed Storage
Smart controllers	Community and Individual
Rates	Air conditioning & Water
Target fixed cost recovery	Electric vehicles
Time of use	Generation
Grid Management	Geographic Diversity
Expand balance area	Technological Diversity
Improve forecasting	Peak Targeted Solar
Integrated power transactions	Quick start/rapid ramp
Import/export	

Source: Mark Cooper, *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Sector.* (Santa Barbara. 2017), Chapter 6 and 8.

A moment's reflection on the characteristics of these resources should lay any concerns to rest. Efficiency has a 100% load factor. Demand response has a 100% load factor at the peak. Utility solar with battery storage has a load factor of 50% (as modeled by Lazard), which is close the SCE&G average load factor.[22]

Natural gas, to the extent it is needed, has a great deal of flexibility and has been used to meet peak demand for decades.

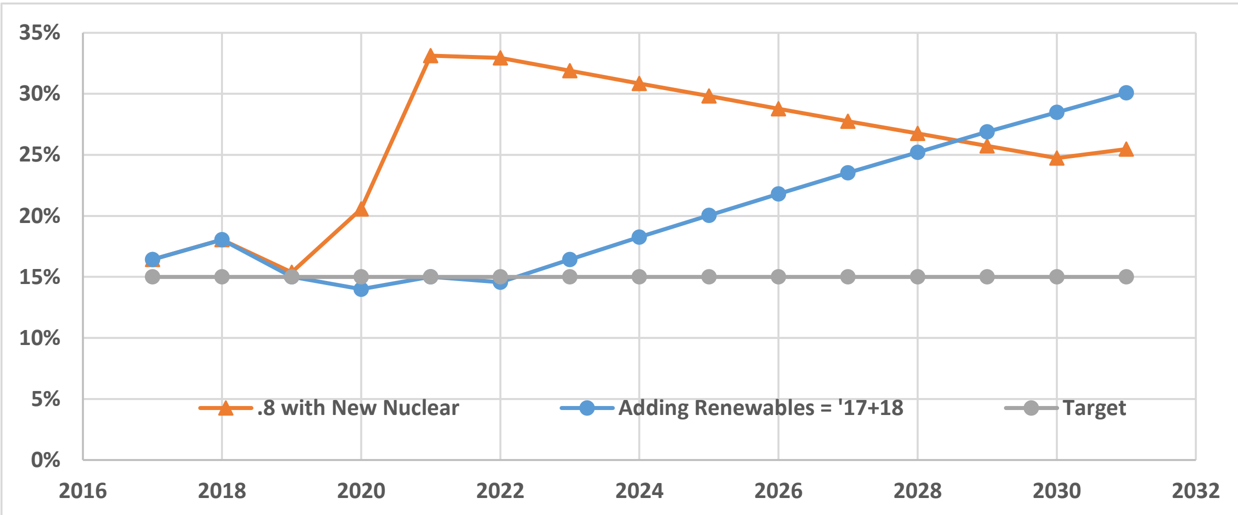
The new system that better matches supply and demand by managing both lowers the required size of the system by 10-20%.[23] This effect, which I call a "transformation dividend," provides a substantial cost savings that can be used to reinforce the reliability of the system if need be (e.g. expanding the transmission grid, adding rapid ramping technologies) without raising the cost compared to the base case assumptions.

Figure IV-5 projects a steady rate of increase in the low carbon alternatives until the capacity added exceeds the amount added by the nuclear units. The constraint placed on the addition of the low carbon alternatives assumes that SCE&G can add an amount each year equal to the amount the utility projects to add in the next two years. This is an extremely cautious

[22] Based SCE&G Integrated Resource Plan, 2017, total sales (p.2) divided by the average peak capacity (p.31).
[23] Cooper, *The Political Economy of Electricity*, Chapter 6.

estimate. It shows that the reserve margin is acceptable and the low carbon resources mount quickly to offset the nuclear capacity, even against the overly optimistic claims for the date of operation.

FIGURE IV-5: SMALL, ANNUAL INCREMENTS OF RENEWABLES DISPLACING CARBON EMITTERS WITHOUT EXCESS CAPACITY



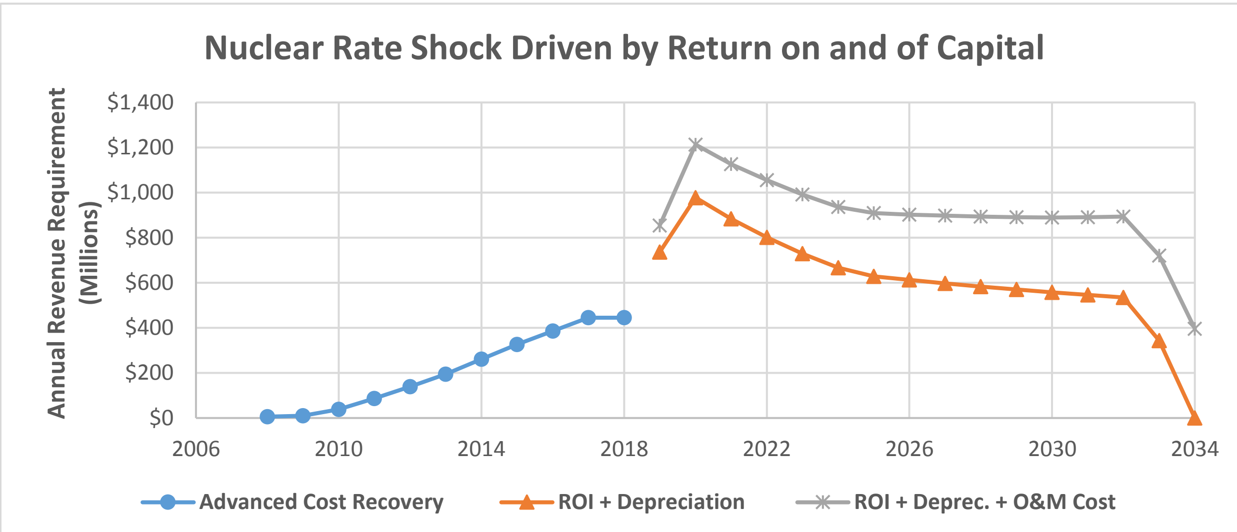
Source: SCE&G Integrated Resource Plan, 2017, p. 9.

V. ADVANCED COST RECOVERY DOES NOT ELIMINATE RATE SHOCK

Pocketbook Impacts

Projecting the rate impacts of V.C. Summer 2 & 3 is challenging given all the unknowns about the final cost, the amount of sunk costs already recovered and how costs that have not been recovered costs will be treated. Figure V-1 assumes that when the reactors come on line the costs that have not be recovered in advance will be treated in the usual way new costs are handled in utility cost recovery.[24]

Figure V-1: The Nuclear Rate Shock of V.C. Summer 2 & 3



Source: Cost Recovery pattern from, MIT, "Update of the Cost of Nuclear Power," MIT 2009, applied to V.C. Summer $5.7 billion costs unrecovered when the reactors come on line at the last authorized dates. See Appendix Table V-1a for the financial Model assumptions.

By the end of 2017, ratepayers will have covered $1.9 billion of the total cost, which is today put at $7.7 billion. Assuming no rate increases in 2018 and 2019, the total collected would be about $2 billion and the cost to be recovered would be $5.7 billion. I use that figure to model the rate impact of completing the Summer reactors.

The current average residential nuclear cost recovery is 18 percent of the total revenue, which works out to just under $27/customer. Without further delays and cost increases, under this scenario, rates to cover the incremental nuclear costs will almost double when the first reactor comes online and almost triple when the second reactor comes online. Cost overruns would make the burden greater. Rates will decline slowly, as the reactors are depreciated.

Some of this rate shock could be dampened by retirement of other facilities, but that would mean replacing low cost power (old generation or wholesale purchases) with expensive

[24] Figure V-1 applies a standard cost recovery model, taken from the 2009 MIT study "Update of the Cost of Nuclear Power" to the V.C. Summer costs. MIT modeled a 1000 MW reactor costing $4.1 billion. The data from SCE&G is for 1231 MW of nuclear capacity. I make the following assumptions to project rate impacts based on the MIT model. I also scale up the operating costs (20%) to reflect the larger capacity operated. I scale the depreciation costs up from the MIT study to reflect the higher to-go costs, which are recovered over 15 years. I assume the advanced cost recovery is return on investment intended to reduce the buildup of AFUDC. Once the reactor comes on line, I reduce the return on investment to match the depreciating value of the reactor.

power. It is safe to say that the rate impact will at least double the current level. Moreover, if "replacement" is the name of the game, it could be done much more cost effectively with efficiency and renewables.

CONCLUSION

This paper has shown that a huge mistake was made when policymakers decided to suspend the sound principles of utility regulation for nuclear reactor construction. Those principles existed to ensure that the monopoly provision of electric service emulated competitive market outcomes, which ensure utilities are allowed to recover costs only for assets that are used and useful in delivering least cost electricity to ratepayers.

The years of delay and cost overruns suffered by the Summer project were entirely predictable based on the fifty-year experience of the nuclear industry. Nuclear power is simply uneconomic, propped up by decisions to socialize its costs, but with the bankruptcy of Westinghouse and the financial collapse of its parent, Toshiba, the management disaster has turned into a catastrophe for ratepayers and the economy of South Carolina.

The only economically sensible response is to cancel the construction, minimize the burden of sunk costs and use much lower cost, much cleaner resources, like efficiency, demand management, utility scale photovoltaics, battery storage, and other distributed resources to meet the need for electricity.

This paper shows that even under the unjustifiably optimistic projection of no future delays and cost overruns, ratepayers will be better off if the utility abandons the project, even if ratepayers are forced to bear the costs that have been sunk to date. The more realistic assumption that there will be further delays and overruns makes abandonment even more beneficial and compelling.

This economic conclusion arises from two fundamental facts in the current electricity marketplace. First, the cost of alternatives have fallen dramatically, so that new nuclear reactors which were too costly to build in the first place have become grossly uneconomic – costing three to four times as much as the alternatives. Second, nuclear reactors are huge, but demand growth has slowed and alternatives can be delivered in flexible, small units. The construction of Summer 3 and 4 result in massive amounts of excess capacity. These reactors are not only pure waste, but they are very expensive waste.

The paper also identifies a series of steps that can be taken to reduce the burden of sunk costs, which makes abandonment more attractive. Each of those steps is associated with a decision point at which the South Carolina Public Service Commission could have halted cost recovery or can find that costs were imprudent. The stark choice facing the Commission could not be more dramatic.

Under the worst case scenario of completion of construction with additional delays and cost overruns, the "to go" costs of nuclear could balloon to almost $8 billion and drive the nuclear component of the typical residential bill up to $100 per month or two-thirds of the typical bill.

In the best-case scenario, with aggressive efforts to claw back or reduce sunk costs. The burden can be held to under $3 billion, and the rate impact would be no greater than it is today, about $27 per month or one-fifth of the typical residential bill.

From the ratepayer economic point of view, Summer 2 and 3 are “pure waste.” Given the available alternative from the point of view of reducing carbon emissions, Summer 2 & 3 are so grossly uneconomic that they are tantamount to pure waste. Repealing the fundamental consumer protections of used and useful, least-cost supply has resulted in assets that are essentially useless. Abandoning the project will save ratepayers and the state billions of dollars.

APPENDIX TABLE V-1a: MIT NUCLEAR ANALYSIS ASSUMPTIONS

Table 5: Base Case Assumptions and Inputs for the Levelized Cost

	Input	Units	Nuclear [A]
[1]	Capacity	MW	1,000
[2]	Capacity Factor		85%
[3]	Heat rate	Btu/kWh	10,400
[4]	Overnight Cost	$/kW	4,000
[5]	Incremental capital costs	$/kW/year	40
[6]	Fixed O&M Costs	$/kW/year	56
[7]	Variable O&M Costs	mills/kWh	0.42
[8]	Fuel Costs	$/mmBtu	0.67
[9]	Waste fee	$/kWh	0.001
[10]	Decommissioning cost	$ million	700
[11]	Carbon intensity	kg-C/mmBtu	
[12]	Inflation Rate		3.0%
[13]	O&M real escalation		1.0%
[14]	Fuel real escalation		0.5%
[15]	Tax Rate		37%
[16]	Debt fraction		50%
[17]	Debt rate		8%
[18]	Equity rate		15%
[19]	WACC (weighted avg cost of capital)		10.0%
[20]	Construction Schedule		
	Year -5		
	Year -4		10%
	Year -3		25%
	Year -2		31%
	Year -1		25%
	Year 0		10%
[21]	Depreciation Schedule		
	Year 1		5.00%
	Year 2		9.50%
	Year 3		8.55%
	Year 4		7.70%
	Year 5		6.93%
	Year 6		6.23%
	Year 7		5.90%
	Year 8		5.90%
	Year 9		5.91%
	Year 10		5.90%
	Year 11		5.91%
	Year 12		5.90%
	Year 13		5.91%
	Year 14		5.90%
	Year 15		5.91%
	Year 16		2.95%
	Year 17		
	Year 18		
	Year 19		
	Year 20		
	Year 21		
[22]	Plant Life		40 years