BEFORE THE NORTH CAROLINA UTILITIES COMMISSION

In the Matter of: Joint Application of Duke Energy Progress, LLC and North Carolina Electric Membership Corporation for a Certificate of Public Convenience and Necessity to Construct a 1,360 MW Natural Gas-Fueled Combined Cycle Electric Generating Facility in Person County, North Carolina	)	**DOCKET NOS. E-2, SUB 1318 and EC-67, SUB 55**

DIRECT TESTIMONY AND EXHIBITS OF

ELIZABETH A. STANTON, PHD

ON BEHALF OF

SOUTHERN ALLIANCE FOR CLEAN ENERGY, SIERRA CLUB, AND NATURAL RESOURCES DEFENSE COUNCIL

June 24, 2024

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EXHIBITS

I. INTRODUCTION AND QUALIFICATIONS

Q. PLEASE STATE YOUR NAME, POSITION AND BUSINESS ADDRESS.

A. My name is Elizabeth A. Stanton. I am the Executive Director and Principal Economist at the Applied Economics Clinic (AEC) located at 6 Liberty Square, PMB98162, Boston, MA 02109. The Applied Economics Clinic is a non-profit economic and energy consulting group providing expert testimony, analysis, modeling, policy briefs, and reports to public interest groups on the topics of energy, environment, consumer protection, and equity. AEC also serves to train the next generation of expert technical witnesses and analysts by providing applied, on-the-job training to graduate students in related fields and working proactively to support diversity among both student workers and professional staff.

Q. ON WHOSE BEHALF ARE YOU TESTIFYING IN THIS PROCEEDING?

A. I am testifying on behalf of the Southern Alliance for Clean Energy (SACE), Sierra Club, and Natural Resources Defense Council (SACE, *et al.*).

Q. PLEASE SUMMARIZE YOUR QUALIFICATIONS AND WORK EXPERIENCE.

A. I earned my Ph.D. in economics at the University of Massachusetts-Amherst, and have taught economics at Tufts University, the University of Massachusetts-Amherst, and the College of New Rochelle, among others. I am the founder and executive director of the Applied Economics Clinic. I have an extensive publication record, including more than 170 reports, journal articles, books and book chapters as well as more than 50 expert comments and oral and written testimony in public proceedings on topics related to energy, the economy, the environment, and equity. I have submitted expert testimony and comments in Connecticut, Indiana, Illinois, Louisiana, Massachusetts, Minnesota, New Hampshire, Ohio, Pennsylvania, Puerto Rico, Vermont, and several federal dockets. My work includes testimony and comments on climate plans, energy efficiency plans, alternatives to fossil fuel infrastructure, proposed pipelines, energy storage, and the equitable implementation of a new green economy. In my previous position as a principal economist at Synapse Energy Economics, I led studies examining environmental regulation, cost-benefit analyses, and the economics of energy efficiency and renewable energy. Prior to joining Synapse, I was a senior economist with the Stockholm Environment Institute's Climate Economics Group, where I was responsible for leading the organization's work on the Consumption-Based Emissions Inventory (CBEI) model and on water issues and climate change in the western United States.

My articles have been published in Ecological Economics, Renewable Climate Change, Environmental and Resource Economics, Environmental Science & Technology, and other journals. I have published books, including Climate Change and Global Equity (Anthem Press, 2014) and Climate Economics: The State of the Art (Routledge, 2013), which I co-wrote with my colleague at Synapse, Dr. Frank Ackerman. I also coauthored Environment for the People (Political Economy Research Institute, 2005, with James K. Boyce) and was a co-editor of Reclaiming Nature: Worldwide Strategies for Building Natural Assets (Anthem Press, 2007, with Boyce and Sunita Narain). My curriculum vitae is attached as Exhibit EAS-1.

Q. HAVE YOU PROVIDED EXPERT WITNESS TESTIMONY IN PROCEEDINGS BEFORE THE NORTH CAROLINA UTILITIES COMMISSION?

A. No.

Q. HAVE YOU PROVIDED EXPERT WITNESS TESTIMONY IN PROCEEDINGS BEFORE OTHER REGULATORY COMMISSIONS?

A. Yes. I have submitted testimony regarding electric planning and infrastructure approval matters before regulatory commissions in Connecticut, Indiana, Louisiana, Massachusetts, Minnesota, Ohio, Pennsylvania, and Puerto Rico.

II. <u>TESTIMONY OVERVIEW</u>

Q. PLEASE SUMMARIZE YOUR TESTIMONY AND OVERALL IMPRESSIONS OF DUKE ENERGY PROGRESS AND NORTH CAROLINA ELECTRIC MEMBERSHIP CORPORATION'S JOINT APPLICATION FOR A CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY TO BUILD A COMBINED-CYCLE GAS-FUELED GENERATING FACILITY AT THE SITE OF ITS EXISTING ROXBORO PLANT.

A. Duke Energy Progress (DEP) and North Carolina Electric Membership Corporation (NCEMC) have filed for a certificate of public convenience and necessity (CPCN) to construct and operate a combined-cycle combustion turbine addition to its Roxboro, North Carolina power plant (the Proposed

Facility or Roxboro CC) in Dockets No. E-2, Sub 1318 and EC-67, Sub 55 before the North Carolina Utilities Commission (Commission). The Proposed Facility would be a 1,360 megawatt (MW) combined-cycle that the utilities describe as capable of conversion to use with hydrogen fuel and able to run on ultra-low sulfur diesel as a back-up fuel.[1]

I reviewed Duke's CPCN filing as well as its recent modeling results and found concerns related to (1) selective treatment of temporary technical challenges as extended barriers; (2) overestimation of the costs of renewables and storage; (3) underestimation of risks as costs to ratepayers; (4) noncompliance with the federal Clean Air Act; and (5) exposure of ratepayers to costs from delayed plant construction. Based on my assessment I make several recommendations regarding the Commission's determination regarding Duke's CPCN request.

Q. WHAT RECOMMENDATIONS DO YOU HAVE FOR DEP'S ROXBORO CPCN?

A. I recommend that the CPCN determination be rejected or postponed until the Commission is presented with resource portfolios that better represent current market and policy conditions.

Q. WHAT RECOMMENDATIONS DO YOU HAVE FOR THE COMMISSION?

[1] Duke Energy Progress, LLC's and North Carolina Electric Membership Corporation's Joint Application for a Certificate of Public Convenience and Necessity to Construct a 1,360 MW Natural Gas-Fueled Combined Cycle Electric Generating Facility in Person County, North Carolina ("Application"), Exhibit 1B, at 2.

A. I strongly recommend that the Commission require Duke to submit a revised basis for the necessity of this combined cycle plant before ruling on the Roxboro CPCN request. This should include new modeling runs based on the following specifications:

- The results of an independent investigation of solutions to, and costs of, addressing barriers to near-term renewables interconnection.
- New renewable resources modeled at market costs (current modeling includes a 60 percent markup).
- Renewables dominant portfolios that do not include a 20 percent adder on resource costs.
- Near-term builds (when renewable builds are feasible, but gas builds are not) that do not include an 8 percent adder on resource costs.
- Limiting resource costs to market costs. Other costs can be modeled as sensitivities related to risk and uncertainty if presented transparently and even-handedly. If risks of renewables are modeled, so too should risks of gas.
- Use of a more realistic (less than 100 percent) ELCC for gas CCs.
- Modeling to take account of natural gas supply interruptions at peak as well as price volatility.
- Modeling all pathways, portfolios and scenarios to be Section 111 Phase II compliant. In particular, starting in 2032, modeling the costs of conversion to 100 percent hydrogen operation, the cost of green

hydrogen fuel, the costs of uncertain green hydrogen supply, high round-trip efficiency losses, hydrogen leaks and other operational costs; or, alternatively, the full costs of some other plan that will meet Phase II requirements, such as constraining the combined-cycle plant to a 40% or lower capacity factor.

In the event the Commission grants the CPCN:

- Ensure that the total project cost is capped at no more than the cost stated in Duke's petition, [BEGIN CONFIDENTIAL] [redacted],[2] [END CONFIDENTIAL] and that ratepayers will not be responsible for any cost overrun that may arise due to delays in permitting or construction.
- Ensure that ratepayers are not financially responsible for any costs incurred after the plant's commercial online date that might arise due to a discrepancy between the projected and actual capacity factor. If the plant runs less than Duke anticipated (e.g., only 40 percent of the time vs 75 percent), the CPCN Order should include language that protects ratepayers from paying a higher cost per MWh.
- Require Duke to hire a third-party expert at the Company's expense that will lead review and assessment efforts during critical points of the plant's development and construction. The independent reviewer will utilize their expertise to determine whether Duke is exercising good judgment and

[2] DEP Confidential Response to Public Staff Data Request No. 2-3 (Attachment).

engaging in prudent decision-making. If the reviewer finds this is not the case, the Commission would revise or revoke its CPCN order.

III. NORTH CAROLINA CLEAN ENERGY OVERVIEW

Q. WHAT IS NORTH CAROLINA'S CURRENT ENERGY LANDSCAPE?

A. In 2022, nearly 44 percent of North Carolina's electric generation was sourced from natural gas-fired power plants. Nuclear provided 32 percent of the state's electricity generation, and renewables, 14 percent (8 percent of which was solar).[3] Since 2010, North Carolina has retired 32 coal-fired plants amounting to around 4.1 gigawatts of generating capacity. During this period, the state increased its natural gas use five-fold: Generation from natural gas-powered plants increased from 8.5 terawatt-hours (TWh) in 2011 to 49.0 TWh in 2022.[4]

Q. WHAT IS NORTH CAROLINA'S CURRENT POLICY AND REGULATORY LANDSCAPE WITH RESPECT TO GREENHOUSE GAS EMISSIONS, CLIMATE, AND CLEAN ENERGY?

A. In 2018 Governor Roy Cooper signed Executive Order No. 80 (EO 80, "North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy"), prioritizing climate and energy resilience and adaptation planning.[5] The Order also established the North Carolina

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[3] U.S. Energy Info. Admin., Form EIA-860 detailed data with previous form data ("EIA-860") (2022), https://www.eia.gov/electricity/data/eia860/.

[4] *Id*; EIA-860 (2011), https://www.eia.gov/electricity/data/eia860/.

[5] N.C. Exec. Ord. No. 80., *North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy* (Oct. 29, 2018), https://governor.nc.gov/documents/files/executive-order-no-80-north-carolinas-commitment-address-climate-change-and-transition-clean-energy/open.

Climate Change Council comprised of representatives from each cabinet agency and the Governor's Office. EO 80 directed the Council to facilitate the integration of climate mitigation and adaptation goals into agency programs and initiatives.[6] The Order also set an economy-wide emission reduction target of a 40 percent reduction from 2005 levels by 2025.[7]

An additional electric-sector-specific target was added in 2021 when Governor Cooper signed HB 951, bipartisan legislation mandating a 70 percent reduction in power-sector carbon emissions (from 2005 levels) by 2030 and establishing a net-zero emissions requirement by 2050.[8] This legislation came as a result of recommendations from North Carolina's Clean Energy Plan, one of the plans created in response to EO 80.[9]

In 2022, Governor Cooper signed Executive Order 246 (EO 246, "North Carolina's Transformation to a Clean, Equitable Economy") centering equity and justice in addressing social problems related to climate change and adaptation, such as health issues and unemployment, which disproportionately affect underserved and marginalized communities.[10] EO 246 also updated North Carolina's economy-wide emission reduction target

[6] *Id.* at 2.
[7] *Id*. at 1.
[8] N.C. Gen. Stat. § 62-110.9.
[9] N.C. Dep't of Env't Quality, *North Carolina Clean Energy Plan* (2019), https://files.nc.gov/ncdeq/climate-change/clean-energy-plan/NC_Clean_Energy_Plan_OCT_2019_.pdf ("N.C. Clean Energy Plan"), at 58.
[10] N.C. Exec. Ord. No. 246, *North Carolina's Transformation to a Clean, Equitable Economy* (2022), https://governor.nc.gov/executive-order-no-246/open.

to a 50 percent reduction in statewide emissions by 2030 (relative to 2005 levels) with a net-zero target by 2050.[11]

Q. DOES NORTH CAROLINA MAINTAIN A GREENHOUSE GAS EMISSIONS INVENTORY TO TRACK ITS PROGRESS TOWARD ITS ENERGY SECTOR TARGETS LAID OUT IN HB 951?

A. Yes. The North Carolina Department of Environmental Quality (DEQ) maintains a state greenhouse gas inventory that tracks the State's progress toward achieving its targets, including those laid out in HB 951. In its 2024 update, DEQ produced high-level emissions data for key sectors from 1990 to 2020.[12] According to the 2024 inventory update, electric generation and use is the second-highest emitting sector, generating 30 percent of the state's greenhouse gas emissions; the highest emitter is the transportation sector at 36 percent.[13]

Q. IS NORTH CAROLINA ON TRACK TO MEET ITS 70 PERCENT EMISSION REDUCTION GOAL FOR THE POWER SECTOR BY 2030?

A. No. The 2024 greenhouse gas inventory update projects that emissions from all North Carolina electric generation will decline by 68 percent relative to 2005 levels in 2030, falling short of the 70 percent target.[14] (This projection relies on Duke's higher renewables, lower emissions Pathway 1 portfolio, and not its higher gas, higher emission Pathway 3 portfolio. Duke

[11] *Id.* at 2.
[12] N.C. Dep't of Env't Quality, *North Carolina Greenhouse Gas Inventory (1990-2050)* (Jan. 2024), https://www.deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory.
[13] *Id.* at 5.
[14] *Id.*

calls Pathway 1 "unattainable".[15]) These projections were created using data from 2005-2020. During the COVID pandemic, North Carolina experienced a significant reduction in greenhouse gas emissions in all sectors including electric generation. DEQ expects emissions to be higher in 2021 than in 2020.[16] That increase would result in a greater than expected shortfall in reaching the 70 percent reduction requirement.

Q. WHAT POLICY INITIATIVES CAN HELP NORTH CAROLINA ACHIEVE ITS 70 PERCENT ELECTRIC SECTOR EMISSIONS REDUCTION TARGET BY 2030?

A. According to a 2022 report by the Environmental Defense Fund, North Carolina's participation in the Regional Greenhouse Gas Initiative (RGGI) could be integral to achieving its HB 951 emissions reduction target.[17] North Carolina's participation in RGGI has been supported by DEQ.[18] RGGI is a cap-and-trade initiative established in 2009 to reduce carbon emissions from power plants in the Northeast and Mid-Atlantic states. The initiative allows member states to reinvest proceeds gained from auctions of carbon allowances into renewable energy and energy efficiency programs

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[15] 2023 Carolinas Resource Plan, Docket No. E-100, Sub 190 (Aug. 2023) ("CPIRP"), Chapter 3, at 1.

[16] N.C. Dep't of Env't Quality, *DEQ Releases 2024 Update to State Greenhouse Gas Inventory, Showing Continued Declines in NC Climate Pollution Emissions*, (Jan. 31, 2024), https://www.deq.nc.gov/news/press-releases/2024/01/31/deq-releases-2024-update-state-greenhouse-gas-inventory-showing-continued-declines-nc-climate.

[17] Env't Def. Fund & Rural Beacon Initiative, *Power Sector Decarbonization in North Carolina: An Evaluation of the Interplay Between HB 951 and RGGI* (Jul. 2022), https://www.edf.org/sites/default/files/documents/EDF%20%2B%20RBI_Power%20Sector%20Decarbonization%20in%20North%20Carolina_Evaluation%20of%20the%20interplay%20between%20HB951%20and%20RGGI_FINAL_0.pdf, at 2.

[18] ETS-News, *North Carolina legislature defeats hope of joining RGGI*, Int'l Carbon Action P'ship (Jul. 5, 2023), https://icapcarbonaction.com/en/news/north-carolina-legislature-defeats-hope-joining-rggi; N.C. Clean Energy Plan, at 58-59.

benefiting utility consumers.[19] Despite DEQ's support of RGGI, the North Carolina General Assembly passed a budget provision (HB 259) in May 2023 prohibiting the State from participating in RGGI.[20]

Q. WHAT ALTERNATIVE RESOURCES, OTHER THAN NATURAL GAS-FIRED POWER PLANTS, EXIST TO PROVIDE THE ELECTRIC SUPPLY IDENTIFIED AS NECESSARY BY DEP?

A. Affordable, commercially available resources exist that could supply DEP's required generation with carbon neutrality, among them: energy efficiency, other demand-side measures, renewable energy, storage, transmission enhancement, and interconnection enhancement.

In December of 2022, the North Carolina Utilities Commission issued an *Order Adopting Initial Carbon Plan and Providing Direction for Future Planning* requiring "the Commission to direct and oversee the continued transformation of the electric system in North Carolina toward carbon dioxide neutrality."[21]

Duke's August 2023 *Carbon Plan and Integrated Resource Plan* (CPIRP) and its January 2024 *Supplement Planning Analysis* based on the

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[19] Env't Def. Fund & Rural Beacon Initiative, *Power Sector Decarbonization in North Carolina: An Evaluation of the Interplay Between HB 951 and RGGI* (Jul. 2022), https://www.edf.org/sites/default/files/documents/EDF%20%2B%20RBI_Power%20Sector%20Decarbonization%20in%20North%20Carolina_Evaluation%20of%20the%20interplay%20between%20HB951%20and%20RGGI_FINAL_0.pdf, at 19.

[20] N.C. Session Law 2023-134 (2023); Sean M. Sullivan, et al., *Carolinas Environmental Legislative Update*, Williams Mullen (Jun. 3, 2024), https://www.williamsmullen.com/insights/news/legal-news/carolinas-environmental-legislative-update.

[21] *Order Adopting Initial Carbon Plan and Providing Direction for Future Planning*, In the Matter of Duke Energy Progress, LLC, and Duke Energy Carolinas, LLC, 2022 Biennial Integrated Resource Plans and Carbon Plan, Docket No. E-100, Sub 179, at 8 (Dec. 30, 2022).

Fall 2023 updated load forecast estimate the future power needs of Duke's customers[22] but underestimate the potential of deploying carbon-free resources in meeting these needs.

Q. WHY DO DEP AND NCEMC REQUEST A CPCN FOR A CARBON-EMITTING GAS COMBINED-CYCLE UNIT WHEN LESS EXPENSIVE, ZERO-EMITTING RESOURCES ARE AVAILABLE?

A. DEP's CPIRP, Supplemental Plan, and CPCN filing offer several rationales for this choice: exaggerated obstacles to building or interconnecting renewables, contradictory claims of resource "diversity" that would be provided by adding yet more gas generation to an already gas-dominant system, and a putative future conversion to using hydrogen as a fuel for which no technology exists today. My testimony addresses these arguments and provides critiques along with some information missing from the CPIRP and Roxboro CPCN filing.

IV. FIVE CONCERNS WITH THE ROXBORO CPCN

Q. IN REVIEWING THE CPCN FOR THE PROPOSED COMBINED-CYCLE FACILITY, DID YOU HAVE ANY CONCERNS WITH ASSUMPTIONS USED OR INFORMATION PRESENTED?

A. Yes. My concerns include: (1) selective treatment of temporary technical challenges as extended barriers; (2) overestimation of the costs of renewables and storage; (3) underestimation of risks as costs to

[22] *See* CPIRP; Supplemental Planning Analysis, Docket No. E-100, Sub 190 (2024), https://www.duke-energy.com/-/media/pdfs/our-company/carolinas-resource-plan/supplements/supplemental-planning-analysis.pdf?rev=f134d62ba6d645ccb3de2bc227a0d42d ("Supplemental Planning Analysis").

ratepayers; (4) noncompliance with the federal Clean Air Act; and (5) exposure of ratepayers to costs from delayed plant construction.

A. Selective treatment of challenges as barriers.

Q. WHAT BARRIERS ARE SET BY DUKE'S CPIRP MODEL TO THE ADOPTION OF ALTERNATIVE (NON-GAS) RESOURCES?

A. Duke's modelers set two kinds of obstacles to the adoption of clean resources: (a) constraints on the amounts of a resource that can be selected by the model in a given time period; and (b) the addition of excessive or unreasonable costs that could cause the model (which is selecting a least-cost portfolio of resources) to reject the resources. In this section I address constraints on the amounts of particular resources adopted. In the following section on the overestimation of the costs of renewables, I address excessive or unreasonable costs.

Q. WHAT SPECIFIC RESTRICTIONS ARE SET ON THE AMOUNTS OF ALTERNATIVE (NON-GAS) RESOURCES ADOPTED?

A. Duke sets annual limits on the adoption of solar, wind, and battery storage in the years before 2032 (see Table 1). In CPIRP and Supplemental Plan modeling, the model seeking to achieve a least-cost portfolio of resources selects low-cost renewable resources up to the constraints added by Duke. Notably, the model bases these selections on economics in the context of the electric-sector carbon emission limits required under State law.[23]

[23] CPIRP, Appendix C, at 7-8.

Table 1. SPA 2-11: Combined DEC/DEP Annual Resource Availability Assumptions

Technology	Initial Plan Assumption		Supplemental Planning Analysis Assumption	
	Annual	Cumulative	Annual	Cumulative
Solar (including SPS)	2028-2030: 1,350 MW 2031+: 1,575 MW	N/a	2028-2030: 1,350 MW 2031: 1,575 MW 2032+: 1,800 MW	N/a
Stand-alone Battery	2027+: 4,400 MW	N/a	2027: 200 MW 2028-2029: 500 MW 2030+: 1,000 MW	N/a
CT	2029+: 4,250 MW	N/a	2029+: 4,250 MW	N/a
CC	2029: 1,360 MW 2030+: 2,720 MW	4,080 MW (3 CC Units)	2029: 1,360 MW 2030+: 2,720 MW	8,160 MW (6 CC Units)
Onshore Wind	2031: 300 MW 2032+: 450 MW	2,250 MW	2031: 300 MW 2032+: 450 MW	2,250 MW
Pumped Storage	2034: 1680 MW	1,680 MW	2034: 1834 MW	1,834 MW
Offshore Wind	2032+: 800 MW	2,400 MW through 2038	2033+: 800 MW	2,400 MW through 2038
Advanced Nuclear	2035: 2 Units	15 Units through 2040	2035: 2 Units	11 Units through 2040

Source: Reproduced from SPA Table 2-11.

Q. WOULD THE MODEL HAVE SELECTED MORE RENEWABLES HAD THE CONSTRAINTS ON ADOPTING SOLAR AND WIND BEEN LIFTED?

A. To the best of my knowledge, given my experience with electric sector modeling and my review of the public materials made available by DEP, almost certainly yes. Duke's CPIRP model selects the maximum amount of renewable resources that it can under the given constraints; if those constraints were lifted, it would select more renewables.

Q. IN THE ABSENCE OF THESE CONSTRAINTS ON RENEWABLES, DO YOU ANTICIPATE THAT THE TOTAL SYSTEM COSTS RELATED TO DUKE'S PLANS WOULD HAVE BEEN LESS COSTLY FOR RATEPAYERS?

A. Again, almost certainly yes. Had the model been permitted to select less expensive resources to do the same job, the total system cost passed along to ratepayers would have been lower.

Q. WHAT REASONING IS OFFERED FOR THE INTRODUCTION OF THESE CONSTRAINTS ON THE ADOPTION OF RENEWABLES?

A. Duke points to numerous challenges associated with the interconnection of renewables, including: increased costs, material sourcing, limited infrastructure capacity, permitting, and timeliness of interconnection.[24]

Q. CAN INTERCONNECTION BE ACCELERATED OR IS THERE A NATURAL PACE THAT CANNOT BE EXCEEDED?

A. The pace of interconnection is entirely dependent on the actions of the utility, the Commission, and State and local decision-makers. Speeding interconnection will require cooperation, creativity, and political will. And it won't be without cost. But those costs need to be compared to the cost of the defeatist assumption that accelerated interconnection is impossible and, therefore, ratepayers must settle for investment in more costly, more risky gas units that (per federal law) will be obsolete by 2032 (see discussion below of the Clean Air Act).

In his expert testimony in the CPIRP proceeding (Docket No. E-100, SUB 190), Michael Goggin reviews several potential solutions to address challenges to rapid interconnection. These include adding interconnection resources, updating interconnection study assumptions,

[24] CPIRP, Appendix I, at 6-8, 14, 19-20, 24; CPIRP, Appendix L, at 20.

using batteries to facilitate interconnection, and grid-enhancing technologies.[25]

Q. WHAT SHOULD DUKE DO INSTEAD OF SELECTIVELY MODELING THESE PARTICULAR TECHNICAL CHALLENGES (RELATED TO INTERCONNECTION) AS ABSOLUTE BARRIERS?

A. To successfully present a least-cost plan for ratepayers that moves the state towards carbon neutrality, Duke should follow a two-step process: First, DEP should hire a neutral, third-party expert to thoroughly investigate the costs of accelerating the pace of interconnection. Second, with these costs in hand, included as part of the true cost of building new renewables, Duke should run its CPIRP model using realistic constraints and realistic costs as I discuss below. Only with this two-step process can true least-cost planning identify the best resources for near- and medium-term investment.

B. Overestimation of the costs of alternatives.

Q. HOW DOES THE COST OF BUILDING A GAS COMBINED-CYCLE UNIT AS MODELED BY DUKE COMPARE TO INDUSTRY STANDARDS FOR THESE COSTS?

A. Duke's overnight capital costs for gas combined-cycle units like the proposed Roxboro CC are the same as or lower than industry standard estimates such as the U.S. Energy Information Administration's (EIA) 2023

[25] Direct Testimony and Exhibits of Michael Goggin, on behalf of the Southern Alliance for Clean Energy, Sierra Club, and Natural Resources Defense Council, with the North Carolina Sustainable Energy Association, Docket No. E-100, Sub 190 (May 2024) https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=63fab8b3-e9df-43e2-973f-4dacd2dc151a, at 13, 34.

Annual Energy Outlook (AEO) values for 2029 (the first year of gas combined-cycle deployment in the Supplemental Analysis) and the National Renewable Energy Laboratory's (NREL) 2023 Annual Technology Baseline (ATB) (see comparison in Table 2). (EIA 2023 AEO is an assessment and projection of long-term energy trends and energy markets through 2050. NREL 2023 ATB provides technology-specific cost and performance parameters across a range of scenarios and assumptions for short- and long-term projections through 2050.)

Table 2. Overnight cost comparison by resource type[26]

Resource Type	SPA First Year of Deployment	*Overnight Costs (2023$ per kW)*		
		Duke Energy 2023 CPIRP	EIA 2023 AEO	NREL 2023 ATB
Gas Combined Cycle	2029	$800 - $1,250	$1,019-$1,153	$1,205
Solar	2028	$1,850	$1,082	$1,218
Onshore Wind	2031	$2,150	$1,367	$1,263
Offshore Wind	2032	$4,150 - $4,850	$3,558	$2,212

Q. HOW DO THE COSTS OF BUILDING NEW RENEWABLE RESOURCES AS MODELED BY DEP COMPARE TO INDUSTRY STANDARDS FOR THESE COSTS?

[26] *Data Sources:* CPIRP, Chapter 2, at 33-39; Supplemental Planning Analysis, at 28; U.S. Energy Info. Admin., *Annual Energy Outlook 2023* (2023), https://www.eia.gov/outlooks/aeo/data/browser/#/?id=123-AEO2023&cases=ref2023&sourcekey=0; Nat'l Renewable Energy Lab'y, *Electricity Annual Technology Baseline (ATB) Data*, (2023), https://atb.nrel.gov/electricity/2023/data.

A. Duke's overnight capital costs for solar, onshore wind, and offshore wind are each 60 percent higher than the average of EIA 2023 AEO for the first year of deployment and NREL 2023 ATB.

Q. DOES DUKE INCLUDE ANY ADDITIONAL OVERESTIMATION OF THE COST OF ALTERNATIVE (NON-GAS) RESOURCES?

A. Yes. Duke includes a 20 percent "cost adder" on all resource costs in its Pathway 1 (P1) resource portfolio, but not in its other portfolios. The P1 resource portfolio is distinguished as the pathway with the most renewables of all categories (see Table 3). DEP explains this adder saying, "As a proxy for these unknown market conditions, the Companies added a 20% cost risk premium to the capital costs for the scope, scale and pace of resource additions in P1 Base for the purposes of this comparison."[27] This cost adder (included after least-cost modeling was conducted) renders total systems costs of the renewables-focused P1 higher relative to total systems costs in other more gas-focused pathways.

[27] CPIRP, Chapter 3, at 26.

Table 3. CPIRP Table 3-2 Modeled Energy Mix by Core Portfolio

Resource Type	2024	2033			2038			2050		
		P1 Base	P2 Base	P3 Base	P1 Base	P2 Base	P3 Base	P1 Base	P2 Base	P3 Base
Grid Edge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Other Renewables	2%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Offshore Wind	0%	5%	3%	0%	4%	3%	0%	3%	2%	1%
Onshore Wind	0%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Solar	6%	26%	21%	20%	26%	25%	25%	20%	21%	22%
Nuclear	46%	41%	41%	41%	51%	48%	48%	70%	68%	68%
Gas	39%	25%	31%	34%	16%	20%	22%	0%	0%	0%
Hydrogen	0%	0%	0%	0%	0%	0%	0%	4%	5%	5%
Coal	6%	0%	0%	1%	0%	0%	0%	0%	0%	0%

Note: Columns may not sum to 100% due to rounding.

Source: Reproduced from CPIRP, p.6.

Q. DOES DUKE INCLUDE ANY OTHER ADDITIONAL OVERESTIMATION OF THE COST OF ALTERNATIVE (NON-GAS) RESOURCES?

A. Yes. Duke includes an additional 8 percent "cost adder" on resource costs in all builds before 2030. Direct testimony submitted by expert witness Maria Roumpani in the CPIRP filing states, "The 8% cost adder affects resources in the near term and essentially puts a penalty on any portfolio that attempts a faster deployment of resources. The adder is eliminated in 2030, largely allowing gas resources to be constructed without the penalty."[28]

Q. DUKE ADDS LIMITS TO THE ADOPTION OF RENEWABLES, USES RENEWABLES COSTS THAT ARE 60 PERCENT HIGHER THAN INDUSTRY STANDARDS, PUTS A 20 PERCENT ADDER ON RESOURCE COSTS IN THE HIGH-RENEWABLE P1 PLAN, AND AN ADDITIONAL 8 PERCENT ADDER ON RESOURCE COSTS IN EARLY

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[28] Direct Testimony and Exhibits of Maria Roumpani, on behalf of the Southern Alliance for Clean Energy, Sierra Club, and Natural Resources Defense Council, with the North Carolina Sustainable Energy Association, Docket No. E-100, Sub 190 (May 2024), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=cb84be19-d0eb-4a70-a4cf-7d6a2a6816d7 ("Roumpani Direct"), at 83.

YEARS WHEN RENEWABLES COULD BE BUILT SOONER THAN GAS POWER PLANTS. ARE RENEWABLES COSTS KNOWN TO BE UNDERESTIMATED OR IN NEED OF CORRECTION IN THE MARKET?

A. No. To my knowledge, there is no reason to think that up-to-date industry-standard renewables resource costs would not be accurate for near-term builds. Duke has not articulated a need for its belt and suspenders and elastic-waist approach of using of two types of adders, 60 percent higher than expected renewables costs, and constraints on renewables adoptions. These compounding adjustments bias the CPIRP model towards selecting gas resources (and/or gas-dominant portfolios) and away from selecting renewable resources.

Q. DESPITE DUKE'S MULTI-PRONGED OVERESTIMATION OF RENEWABLES COSTS, DOES THE CPIRP MODEL STILL SELECT AS MUCH SOLAR AND WIND AS IT CAN GIVEN THE ARTIFICIAL CONSTRAINTS SET BY THE MODELERS?

A. Yes. Even with the high costs and adders, Duke's least-cost model still selects solar and wind to lower ratepayers' costs. Duke's rationale for requesting the CPCN for the Roxboro CC is the CPIRP and Supplemental Plan's selection of gas resources in its least-cost modeling. That modeling, however, was flawed, including multiple biases for gas resources and against renewable resources.

C. <u>Underestimation of the risks of gas.</u>

Q. WHAT DOES IT MEAN FOR A RISK TO BE A COST?

A. A risk is a potential cost. If you have a 50 percent chance of getting caught when speeding, and the ticket will cost $1,000, then economists say that the risk-weighted cost of speeding is $500. While this is an imperfect way of thinking about what may happen (the choices are really $0 or $1,000, and never $500), it is a much better way than counting the cost of speeding at $0 when planning your drive.

Building a new power plant entails a multitude of risks that, if they come to pass, will in all likelihood be costs paid for by ratepayers. Utility IRP models follow exactly this approach (weighing future costs with their presumed risks) in risk-sensitivity analysis. The variables chosen for risk assessment, however, can be quite limited and biases in their selection can skew IRP results.

Q. WHAT RISKS DOES DUKE IGNORE IN ITS MODELING THAT COULD SKEW RESULTS IN FAVOR OF GAS INVESTMENTS?

A. Four types of risk that are absent from, or insufficiently addressed in, Duke's CPIRP and Supplemental Plan modeling concern me due to their potential to skew modeling results in favor of gas investment: (1) natural gas supply risk; (2) natural gas price volatility; (3) costs of conversion to hydrogen operation; and (4) green hydrogen fuel availability.

Q. ARE THERE ANY RISKS TO THE SUPPLY OF NATURAL GAS?

A. Yes. Approval of the Proposed Facility would increase DEP's reliance on natural gas generation. Risks to maintaining a reliable supply of natural gas include extreme weather, supply chain constraints, and equipment issues, as well as federal compliance requirements. During Winter Storm Elliot, multiple gas units experienced outages because of weather and nonweather-related equipment issues. According to a report by PJM, of the 6,596 GWh that could be generated, 1,519 GWh (23 percent) was unavailable. A majority of this loss was associated with gas supply issues, frozen instrumentation and uninsulated pressure transmitters.[29]

Q. DOES DEP TAKE ACCOUNT OF THE RISK OF INTERRUPTIONS TO ITS NATURAL GAS SUPPLY IN ITS MODELING?

A. Duke's CPIRP only lists gas supply sensitivity analyses related to supply available from Gulf Coast resources versus supply available from both Gulf Coast and the Appalachia region.[30] Witness Roumpani discusses Duke's use of a 100 percent effective load carrying capability (ELCC) in modeling new gas resources availability at times of peak customer demand in the CPIRP docket; in comparison, Duke assigns solar an ELCC of 10 percent.[31] As Witness Roumpani notes, "Availability considerations due to weather, supply, and intra-resource correlations should be applied to all resource types. Since the Companies use the ELCC methodology for variable renewable energy and energy-limited resources, the same methodology should be applied to thermal resources recognizing that all resources have limitations based on weather- dependence, potential for outages, flexibility

[29] PJM, *Winter Storm Elliott Event Analysis and Recommendation Report* (Jul 17, 2023), https://pjm.com/-/media/library/reports-notices/special-reports/2023/20230717-winter-storm-elliott-event-analysis-and-recommendation-report.ashx, at 62.
[30] CPIRP, Chapter 2, at 13-14.
[31] Roumpani Direct, at 43, 63.

constraints, and common points of failure (like fuel supply issues, especially in the case of gas generation)."[32]

Failure to consider the risk (and associated risk-weighted cost) of gas supply interruptions in modeling biases modeling results for gas-fired generation and away from renewable resources.

Q. DOES DUKE TAKE ACCOUNT OF THE RISK OF NATURAL GAS PRICE VOLATILITY IN ITS MODELING?

A. While the CPIRP model is tested for its sensitivity to low, medium, and high natural gas price forecasts, Duke does not appear to take account of the risks associated with inter-year (or day by day) fuel price volatility. Duke does discuss addressing risks of clean energy resources, risks of a loss of reliability, risks associated with supply chain challenges, risks of non-completion of the Mountain Valley Pipeline, risks of inaccurate estimation of future customer load, risks of compliance with future environmental laws, risks of uncertain renewable output, and regulatory risks associated with greenhouse gas limits. But no risks (or associated risk-weighted costs) related to notoriously volatile natural gas prices were considered.[33] It should be noted that some utilities have resorted to using ratepayer funds to engage in fuel hedging to reduce natural gas price risks.[34]

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32 *Id.* at 43.
33 CPIRP, Chapter 2.
34 Black & Veatch, *Utilities Turn to Fuel Hedging to Reduce Price Risk*, https://www.bv.com/perspectives/utilities-turn-fuel-hedging-reduce-price-risk/ (last visited Jun. 20, 2024).

Q. DOES DEP PLAN TO CONVERT THE PROPOSED ROXBORO CC TO HYDROGEN?

A. As I discuss below, per the U.S. Environmental Protection Agency's (EPA) Final Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants issued under Clean Air Act Section 111, all new gas units will have to cease operation, reduce operations below a 40 percent capacity factor, or convert to a technology that results in a minimum reduction of 90 percent of CO_2 emissions by 2032.[35] DEP describes the Proposed Facility as "hydrogen-capable" and notes that "[t]he selection of advanced-class CCs reduces technology obsolescence risk, as these resources are suitable for future conversion to operate exclusively on hydrogen."[36]

Q. ARE THE COSTS OF THIS CONVERSION TO HYDROGEN FUEL INCLUDED IN DEP'S CPIRP OR SUPPLEMENTAL PLAN MODELING?

A. No. The costs of conversion to 100 percent hydrogen operation are not included in modeling. I address this issue in more detail below in my section on noncompliance with the Clean Air Act.

Q. ARE THE COSTS OF CONVERSION TO 100 PERCENT HYDROGEN KNOWN AT THIS TIME?

A. To my knowledge, the costs of converting a natural gas combined-cycle generator to 100 percent hydrogen operation are not known and are not included in Duke's modeling. Duke notes that "100% hydrogen capable

[35] New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule, 89 Fed. Reg. 39798, 39916 (May 9, 2024) (to be codified at 40 C.F.R. pt. 60).

[36] Direct Testimony of Michael Quinto, at 29.

turbines are a developing technology, and cost estimates for retrofits and new hydrogen capable units are not available from original equipment manufacturers ("OEMs") at this time. Duke Energy developed cost estimates for use in the Carolinas Resource Plan modeling [which includes a maximum 30 percent hydrogen operation] based on discussions with third-party OEMs."[37]

Most cost estimates look at blending small percentages of hydrogen with natural gas, some extending as high as 30 percent. Appendix K of the CPIRP filing explains that conversion to 100 percent hydrogen use would require significant upgrades (see Table 4) and notes: "While it remains to be seen whether new interstate and intrastate hydrogen pipeline infrastructure systems could be implemented, a near-term plausible solution is for pipelines to blend a low percentage of hydrogen with natural gas into the existing natural gas pipelines."[38]

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[37] CPIRP, Chapter 2, at 40.

[38] CPIRP, Appendix K, at 8.

Table 4. DEP Table K-1 Summary of Current Adopted and Future Provisions for Hydrogen

Item to Enable Hydrogen for New Gas Assets (CT/CCs)	Included in Base CT Scope	Future Consideration
1. Inlet fuel piping designed for Hydrogen capability (pipe size, stainless steel materials, valves, connections, etc.)	Include 30% Hydrogen capability	100% would require significant upgrades
2. Real estate space/connections required for Hydrogen blending skid to tie into inlet fuel piping with minimal piping runs	Required	N/A
3. Hydrogen blending skid equipment	Provide space only	Deploy as needed for future firing
4. Combustion system for 30% Hydrogen blend	Included	N/A
5. Combustion system for 100% Hydrogen	N/A	Future (not yet available from vendors)
6. Heat Recovery Steam Generator capability for 100% Hydrogen (space only for larger Selective Catalytic Reduction catalyst)	Required	N/A
7. Ammonia system (nitrogen oxides ("NOx") control) sized for 100% Hydrogen capability	Recommended/ Included	N/A
8. Fire protection/detection system designed for Hydrogen capability	Recommended/ Included	N/A
9. Inert Purge system for CT Enclosure, with space for purge gas bottle rack	Recommended/Vendor specific	N/A
10. Controls modifications for Hydrogen blending & startup	Provide Input/Output space only	Deploy as needed for future firing

Q. HOW DO THE UNKNOWN COSTS OF CONVERSION TO HYDROGEN OPERATION POSE A COSTLY RISK TO RATEPAYERS?

A. If approved, DEP expects the Roxboro CC to be in operation by 2029.[39] EPA requires newly built gas plants to reduce operations to below a 40 percent capacity factor or to reduce emissions by 90 percent by 2032 (see discussion below). To my knowledge, no equipment is currently

[39] Direct Testimony of Michael Quinto, at 4.

commercially available to achieve a conversion to 100 percent hydrogen operation and the costs of such, as yet nonexistent equipment, are unknown.

In 2032, there will be three choices: (1) the Roxboro CC will be shut down while its "stranded assets" continue to be charged to ratepayers through 2064 and new investments in zero-emissions resources are also charged to ratepayers; (2) the Roxboro CC's capacity factor will be reduced below 40 percent starting in 2032 (down from 75 percent), reducing revenues, raising net costs, and requiring ratepayers to foot the bill for new investments in generation; or (3) ratepayers will assume new, additional costs for converting the unit to operate on hydrogen and running the unit on expensive hydrogen fuel. Because sequestration of carbon is not geologically feasible in the Carolinas, there's no fourth option.[40] It is worth noting that DEP earns a rate of return on the conversion costs as well as the costs of the original investment, and the costs of any replacement investments made necessary if the asset is stranded.

[40] According to the CPIRP, Appendix C, page 100, "CCS has not been considered cost-effective due to the lack of suitable geology to sequester significant volumes of carbon in the Carolinas, and significant costs and challenges to develop interstate pipelines, including challenges related to permitting, property rights, and public acceptance, which would need to be overcome, to transport the captured CO2 to other regions suitable for sequestration. However, although not yet adequately demonstrated, this compliance pathway may become viable given the potential significant costs and challenges with the other compliance pathways. The Companies will continue to investigate the feasibility and viability of CCS as a compliance pathway for the EPA CAA Section 111 Proposed Rule as further information becomes known and the proposed rule is finalized. More information on the Proposed EPA GHG Regulations is discussed in Chapter 3 and in Appendix K."

Q. ARE THERE ANY RISKS ASSOCIATED WITH THE USE OF HYDROGEN AS A FUEL?

A. Yes, and I discuss this below in my section on noncompliance with the Clean Air Act. Among these risks is the lack of a known supply of zero-carbon-emitting hydrogen.

Q. HAS DUKE UNDERESTIMATED THE RISKS OF GAS IN ITS MODELING?

A. Yes, Duke appears to have underestimated (1) natural gas supply risk; (2) natural gas price volatility; (3) costs of conversion to hydrogen operation; and (4) green hydrogen fuel availability.

Q. WHAT IMPACT WOULD UNDERESTIMATING THE RISKS OF GAS HAVE ON DUKE'S PREFERENCE FOR BUILDING A NEW CC FACILITY?

A. Underestimating the risks of new gas facility investments and gas-fired generation reduces the costs of these options in modeling. As a result, both gas options and portfolios with greater shares of gas resources would tend to outperform renewable resources and portfolios with more renewables. Duke uses the superior performance of gas resources and gas-dominant portfolios in its CPIRP and Supplemental Plan modeling as justification for its CPCN request for the Proposed Facility.

D. <u>Noncompliance with the Clean Air Act.</u>

Q. WHAT IS EPA'S 2024 FINAL RULE ON GREENHOUSE GAS STANDARDS FOR FOSSIL FUEL-FIRED POWER PLANTS?

A. On April 25, 2024, EPA issued its *Final Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants* under Section 111 of the

Clean Air Act.[41] EPA's Final Rule introduces carbon emissions standards for fossil fuel-fired power plants, establishing the "best system of emission reduction" (BSER) that qualifying individual plants are mandated to implement by a determined date.[42]

The new Section 111 Rule focuses on existing coal-fired plants and new gas-fired plants. EPA categorizes power plants based on their anticipated retirement dates (coal) or capacity factors (gas). Each plant is assigned a compliance pathway (or BSER) based on these categorizations. Guidelines are also provided for steam electric generating units.

Q. HOW ARE NEW GAS-FIRED GENERATORS CATEGORIZED?

A. Standards for gas-fired generators are based on the facility's capacity factor (or share of hours in operation during a year).[43] The final Section 111 Rule sets three subcategories for new gas-fired generators: low-load, intermediate-load, or base-load. The low-load subcategory includes generators with a capacity factor under 20 percent.[44] New gas generators with a capacity factor between 20 and 40 percent will be classified as

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[41] New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule, 89 Fed. Reg. 39798, 39916 (May 9, 2024) (to be codified at 40 C.F.R. pt. 60).
[42] *Id.* at 39798.
[43] *Id.* at 39930.
[44] *Id.* at 39913.

intermediate-load.[45] The base-load subcategory will include new gas-fired generators with a capacity factor of over 40 percent.[46]

Q. WHAT IS THE BSER FOR THE BASE-LOAD SUBCATEGORY?

A. For the base-load gas subcategory, EPA has set a two-phase BSER. Phase I requires that base-load gas-fired generators comply with the efficient design and operation standards of combined-cycle generation upon start-up.[47] The Phase I standard of performance for smaller base-load units (heat input of 250 million British thermal units per hour (MMBtu/h)) is 900 pounds (lb.) CO_2 per megawatt-hour (MWh), while the required standard for larger base-load units (>2,000 MMBtu/h heat input) is 800 lb. CO_2/MWh.[48] Starting on January 1, 2032, base-load gas-fired generators must comply with a Phase II standard of achieving a 90 percent capture of CO_2 using carbon capture and sequestration technology (CCS).[49] Affected facilities can also meet this 90 percent emission reduction using co-firing with a lower emission fuel.

Q. WHAT IS THE TARGET CAPACITY FACTOR OF THE NEW GAS-FIRED COMBINED-CYCLE UNIT DEP IS PROPOSING TO BUILD AT THE EXISTING ROXBORO PLANT?

A. The Proposed Facility is a 1,360 MW "hydrogen capable, advanced-class combined-cycle natural gas-fueled electric generating combustion turbine

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[45] *Id.*
[46] *Id.*
[47] *Id.* at 39917.
[48] *Id.* at 39947-48.
[49] *Id.* at 39917.

power block with ultra-low sulfur diesel backup."[50] The new combined-cycle would feature a base-load gas-fired generator with what DEP describes as an expected capacity factor of 75 percent in its first five years of operation.[51] The Proposed Facility will be subject to the two-phase BSER requirements of base-load gas generators. When the Proposed Facility first begins operations, it will be subject to the Phase I efficient design and operation standards of new combined-cycle generators.[52] After December 2031, the proposed facility will need to meet the Phase II 90 percent CO_2 capture requirement using either CCS or co-firing with a low emission fuel such as hydrogen.[53] Meeting the 90 percent emission reduction standard using hydrogen fuel would require the use of green (zero-carbon) hydrogen co-firing at a minimum of 96 percent by volume.[54]

Q. WOULD THE PROPOSED FACILITY COMPLY WITH PHASE I OF THE SECTION 111 RULING?

A. DEP's Witness Michael Quinto testifies that the Proposed Facility would be Phase I compliant with an emission rate of 770 lbs. CO_2/MWh.[55]

Q. HOW DOES DEP PLAN TO MAKE THE PROPOSED FACILITY COMPLY WITH PHASE II OF THE SECTION 111 RULING?

[50] Application, Exhibit 1B, at 2.
[51] *Id.* at 10.
[52] New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule, 89 Fed. Reg. 39798, 39916 (May 9, 2024) (to be codified at 40 C.F.R. pt. 60).
[53] *Id.* at 39916-17.
[54] *Id.*
[55] Direct Testimony of Michael Quinto, at 29.

A. If approved, DEP is investigating 100 percent conversion to hydrogen operation but has not said definitively what Phase II compliance method it will use.[56]

Q. WHAT ECONOMIC LIFETIME DOES DEP ANTICIPATE FOR THE PROPOSED FACILITY?

A. DEP expects a 35-year economic lifetime for the Proposed Facility, from 2029 to 2064.[57]

Q. ABOVE, YOU DISCUSS THREE POSSIBLE OUTCOMES FROM DEP'S PLANS TO REMAIN COMPLIANT WITH THE CLEAN AIR ACT. WHAT ARE THEY?

A. For the Proposed Facility to remain compliant with Section 111 of the Clean Air Act, DEP must (1) close the unit after three years of operation in 2032 with all the costs associated with a stranded asset, (2) reduce its capacity factor below 40 percent by 2032, substantially raising costs per unit of electricity produced, or (3) undergo a conversion to hydrogen operation at the expense of ratepayers.

Q. WHAT WOULD THE COSTS BE TO RATEPAYERS OF CLOSING THE UNIT AFTER THREE YEARS OF OPERATION?

A. Closing the unit after three years of operation would incur two kinds of costs. First, DEP would likely seek to recover from ratepayers both the capital costs of the Proposed Facility amortized across 35 years in every year through 2064 and a rate of return to DEP on those capital costs.

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[56] *Id.*; see DEP Confidential Response to Public Staff Data Request No. 9-1.
[57] Direct Testimony of Michael Quinto, at 29.

Second, ratepayers would pay for the replacement resources needed to meet customer demand after the Facility was shuttered.

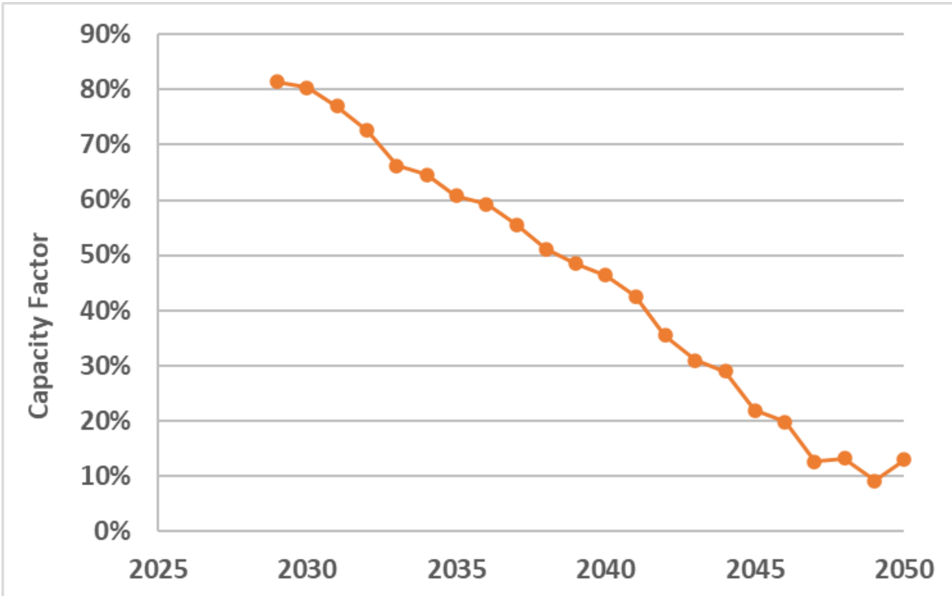
Q. WHAT WOULD THE COSTS BE TO RATEPAYERS OF REDUCING THE PROPOSED FACILITY'S CAPACITY FACTOR BELOW 40 PERCENT STARTING IN 2032?

A. Lowering the capacity factor below 40 percent starting 2032 would incur two kinds of costs. First, ratepayers would continue to pay both the capital costs of the Proposed Facility amortized across 35 years in every year through 2064 and a rate of return to DEP on those capital costs. Second, ratepayers would pay for the replacement resources needed to meet customer demand after the Facility's expected generation was decreased.

Q. WHAT CAPACITY FACTORS DOES DEP EXPECT THE PROPOSED FACILITY TO RUN AT IN THE 2030S AND 2040S?

A. DEP has estimated the costs to ratepayers of building and operating the Proposed Facility based on a capacity factor that stays above 40 percent (EPA standard in its Section 111 ruling) through 2042 (see Figure 1 based on DEP's Supplemental Plan modeling files).

Figure 1. Expected Roxboro combined-cycle capacity factor over time



Data source: See Stanton workpapers; Docket No. E-2, Sub 1318, PS DR 2-15, "Capacity Factors (GADs)"

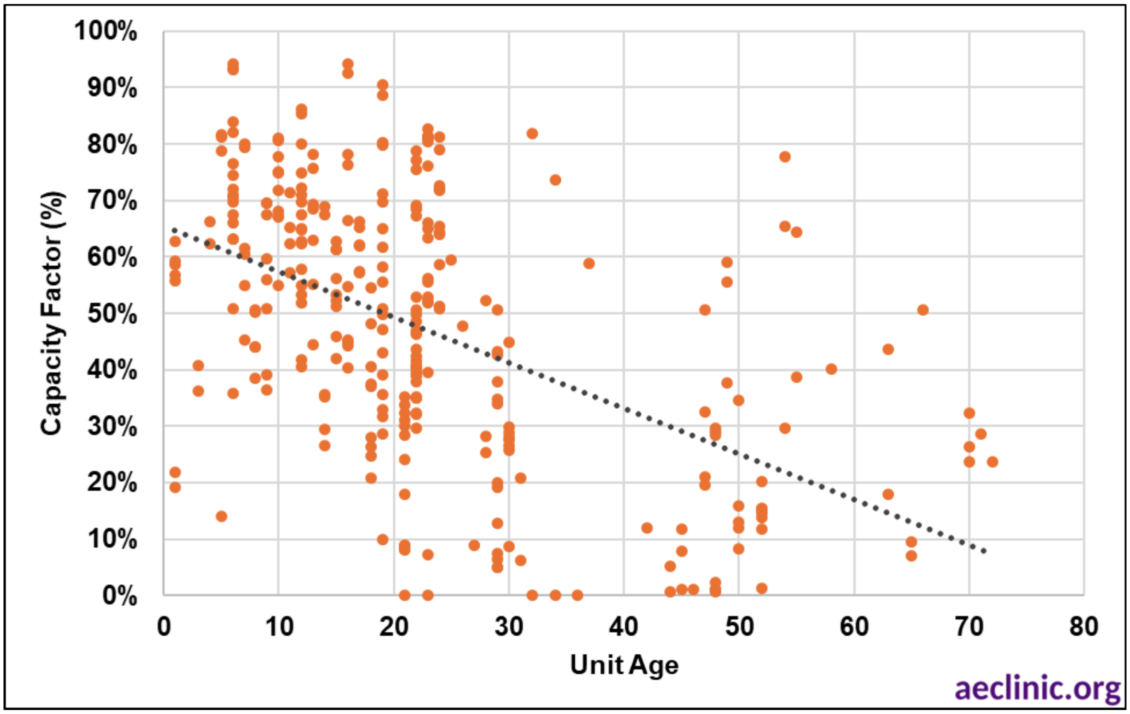
Q. DOES THE OPERATION OF THE PROPOSED FACILITY IN DUKE'S SUPPLEMENTAL PLAN MODELING COMPLY WITH PHASE I OF SECTION 111?

A. No. Section 111 requires any new gas-fired facility to be operating below a 40 percent capacity factor by 2032.

Q. WHAT ARE GAS COMBINED-CYCLES' TYPICAL CAPACITY FACTORS OVER THEIR LIFETIMES?

A. Figure 2 depicts U.S. natural gas combined-cycle generators in operation today by capacity factor and age of unit. The dotted trend line indicates the average capacity factor by age. Duke plans for the Proposed Facility to operate at a 51 percent capacity factor when it is 10 years old and a 13 percent capacity factor when it is 20 years old (see Figure 1 above). In contrast, the average 10-year-old CC is operating at a 58 percent capacity factor and the average 20-year-old CC is operating at a 50 percent capacity factor. This comparison raises serious questions regarding the financing of the Proposed Facility over time and its risk of becoming a stranded asset, even before Section 111 requirements are taken into consideration.

Figure 2. U.S. natural gas combined-cycle generators capacity factors by age[58]



Q. WHAT WOULD THE COSTS BE TO RATEPAYERS OF CONVERTING THE PROPOSED FACILITY TO 100 PERCENT HYDROGEN OPERATION IN 2032?

A. Per Duke, the costs of conversion to 100 percent hydrogen operation are not known.[59] Important costs related to hydrogen operation that are not included in DEP's modeling include: conversion of generation and fuel

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[58] *Data sources:* U.S. Energy Info. Admin., Form EIA-923 detailed data with previous form data ("EIA-923") (2023), https://www.eia.gov/electricity/data/eia923/; EIA-860 (2023), https://www.eia.gov/electricity/data/eia860/.

[59] CPIRP, Appendix K, at 8.

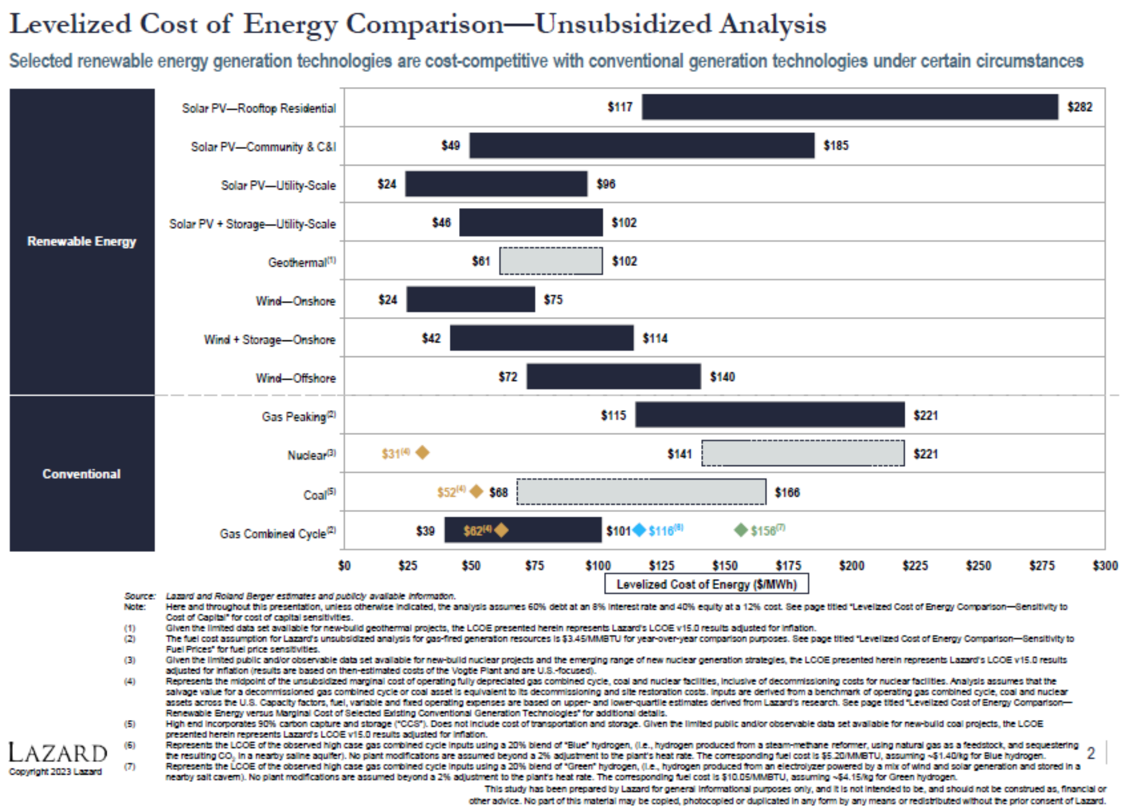
delivery systems, cost of green hydrogen, risks of hydrogen leaks, and high round-trip efficiency losses from green hydrogen electric generation. (See also, Table 4 above.)

Duke mentions the U.S. Department of Energy's (DOE) plan to reduce green hydrogen costs from $5 per kilogram (kg) to $1/kg by 2031.[60] A $5/kg green hydrogen price is equivalent to approximately $35/MMBtu, compared to current natural gas prices of $3 or $4/MMBtu. A future $1/kg green hydrogen price would be $7/MMBtu.[61] As I discuss below, availability for purchase of substantial quantities of green hydrogen is also unlikely in the near term.

Lazard's April 2023 *Levelized Cost of Energy Analysis—Version 16.0* (an industry standard for near-term electric-sector resource costs) estimates a $156 per megawatt-hour (MWh) cost for a new gas combined-cycle operating with a 20 percent green hydrogen blend, compared to a range of $39 to $101 per MWh for 100 percent natural gas operation.

[60] Off. of Energy Efficiency & Renewable Energy, *Hydrogen Shot*, U.S. Dep't of Energy, https://www.energy.gov/eere/fuelcells/hydrogen-shot (last visited Jun. 20, 2024); CPIRP, Appendix K, at 17.
[61] Emma Penrod, *Hydrogen could compete with natural gas by 2030, but there's a catch: report*, Util. Dive (Mar. 15, 2024), https://www.utilitydive.com/news/blue-green-hydrogen-natural-gas-brattle-edf/710397/.

Figure 3. Lazard 16.0 Levelized cost of energy



Source: Reproduced from Lazard 16.0.

The cost of conversion to 100 percent hydrogen operation, the cost to purchase green hydrogen fuel, and the levelized cost of operation using hydrogen are all evidence of costs not included in Duke's CPIRP and Supplemental Plan modeling, which is used as justification for the request for CPCN for the Proposed Facility. The omission of these additional costs to ratepayers biases Duke's analysis in favor of preferring new gas resources.

Q. IS ALL HYDROGEN CARBON-EMISSION FREE?

A. No. Most hydrogen is produced using fossil fuels. According to the International Energy Agency (IEA), the average emissions intensity of global hydrogen production was 12 to 13 kilograms of CO_2-equivalent emissions per kilogram of hydrogen produced in 2021.[62]

Q. WHAT IS GREEN HYDROGEN?

A. Green hydrogen is produced from electrolysis of water using electricity from renewable resources.[63] Globally, about 0.04 percent of all hydrogen produced is green hydrogen. Another 0.03 percent is produced using carbon capture and storage, which is typically injected back into oil and gas wells to enhance fuel extraction productivity.[64]

Q. DOES GREEN HYDROGEN REDUCE NET CARBON EMISSIONS?

A. Yes, green hydrogen reduces net carbon emissions. Hydrogen production from the electrolysis of water requires an energy input; if this energy comes from renewable resources (i.e., if the hydrogen is "green"), then the hydrogen production process is free of CO_2 emissions.

According to a report by the International Renewable Energy Agency, green hydrogen is susceptible to energy losses at each stage of the value chain, with the total amount of losses depending on end use.[65] Round-trip

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[62] *Id.*

[63] Yahya Anouti, et al., *The Dawn of Green Hydrogen*, Strategy& (2020), https://www.strategyand.pwc.com/m1/en/reports/2020/the-dawn-of-green-hydrogen/the-dawn-of-green-hydrogen.pdf.

[64] Timur Gül, et al., *Global Hydrogen Review 2022*, Int'l Energy Agency (2022), https://www.iea.org/reports/global-hydrogen-review-2022, at 71.

[65] Emanuele Bianco & Herib Blanco, *Green Hydrogen: A Guide to Policy Making*, Int'l Renewable Energy Agency (2020), https://www.irena.org/publications/2020/Nov/Green-hydrogen.

efficiency (RTE) refers to the ratio of energy output after storage to the amount of energy placed in storage, and low values correspond to large energy losses.[66] The RTE of green hydrogen is around 30 percent according to researchers from Frankfurt University of Applied Sciences.[67] Other technologies like lithium-ion batteries have typical RTEs of 77 percent to 98 percent, indicating less energy is lost in storage.[68] The large share of energy lost from the storage process makes green hydrogen a far less efficient technology compared to other clean energy sources.

The emission reductions achieved from blending hydrogen (from any energy source) with gas are non-linear; that is, 10 percent hydrogen in a fuel blend does not lead to a 10 percent emission reduction because the difference between gas and hydrogen's volumetric density leads to less hydrogen in the fuel blend on a heat input basis (see Figure 1).[69] Even increasing the hydrogen blend share to 50 percent achieves less than 25

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66 Nat'l Renewable Energy Lab'y, *Annual Technology Baseline: Utility-Scale Battery Storage*, https://atb.nrel.gov/electricity/2021/utility-scale_battery_storage (last visited Jun. 20, 2024).

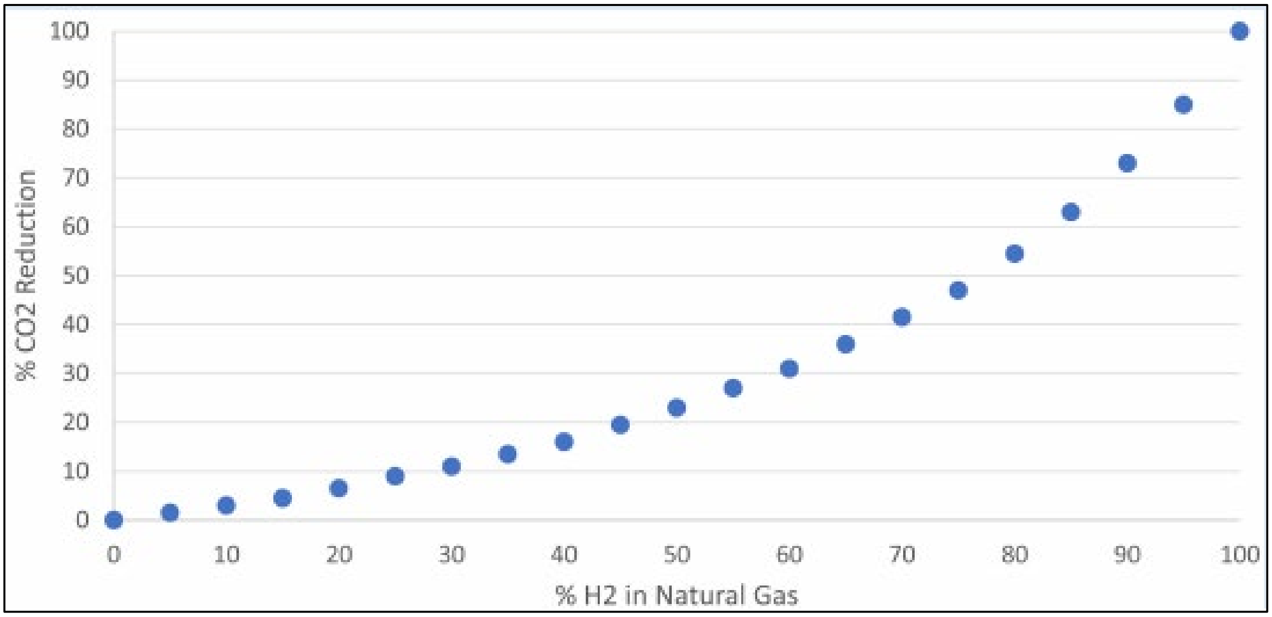
67 Enno Wagner, et al., *Energy Storage with Highly-Efficient Electrolysis and Fuel Cells: Experimental Evaluation of Bifunctional Catalyst Structures*, 66(5) Topics in Catalysis (Jan. 13, 2023), https://link.springer.com/article/10.1007/s11244-022-01771-7#:~:text=While%20the%20PEM%20system%20reaches,as%20an%20alternative%20to%20batteries, at 546-59.

68 Kendall Mongird, et al., *2020 Grid Energy Storage Technology Cost and Performance Assessment*, U.S. Dep't of Energy (Dec. 2020), https://www.pnnl.gov/sites/default/files/media/file/Final%20-%20ESGC%20Cost%20Performance%20Report%2012-11-2020.pdf, at 13.

69 Jeffrey Goldmeer, *Power to Gas: Hydrogen for Power Generation*, GE Power (Feb. 2019), https://www.gevernova.com/content/dam/gepower-new/global/en_US/downloads/gas-new-site/resources/GEA33861%20Power%20to%20Gas%20-%20Hydrogen%20for%20Power%20Generation.pdf.

percent emission reductions.[70] Only when hydrogen fuel is 100 percent of a fuel mix does green hydrogen result in zero carbon emissions.[71]

Figure 4. CO_2 emission reduction for hydrogen-gas fuel blends by volume



Source: Reproduced from Electric Power Research Institute. November 19, 2019. Technology Insights Brief: Hydrogen-Capable Gas Turbines for Deep Decarbonization. Figure 1. Available at: https://www.epri.com/research/products/000000003002017544.

Q. IS GREEN HYDROGEN A ZERO GREENHOUSE GAS EMISSION FUEL SOURCE?

A. No. Green hydrogen is not a zero greenhouse gas emission fuel source: Even if hydrogen is produced with 100 percent renewable energy, green hydrogen combustion has been found to emit nitrous oxide (NOx) and any leaked hydrogen itself is an indirect greenhouse gas. A 2018 study in the

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[70] Elec. Power Rsch. Inst., *Technology Insights Brief: Hydrogen-Capable Gas Turbines for Deep Decarbonization* (Nov. 19, 2019), https://www.epri.com/research/products/000000003002017544, Figure 1.

[71] Mehmet Salih Cellek & Ali Pınarbaşı, *Investigations on Performance and Emission Characteristics of an Industrial Low Swirl Burner While Burning Natural Gas, Methane, Hydrogen-Enriched Natural Gas and Hydrogen as Fuels*, Int'l J. of Hydrogen Energy, 43 (2) (Jan. 11, 2018), https://doi.org/10.1016/j.ijhydene.2017.05.107.

International Journal of Hydrogen Energy found that burning hydrogen produces up to six times the NOx emissions of methane, which is the largest constituent of natural gas, because hydrogen's high flame temperature results in a high rate of thermal nitrogen monoxide (NO).[72] Both hydrogen and NOx are indirect greenhouse gases that lead to ozone formation in atmosphere.

Q. WHAT DOMESTIC INFRASTRUCTURE EXISTS FOR THE PRODUCTION OF GREEN HYDROGEN?

A. As of December 2020, there were 1,608 miles of hydrogen pipeline in the United States (compared to over 300,000 miles of methane gas transmission pipeline), over 90 percent of which are located along the Gulf Coast.[73] Nearly all existing shipment of hydrogen takes place in dedicated hydrogen pipeline infrastructure. According to reporting by Reuters, as of July 1, 2021, upwards of 24 U.S. energy firms, including Dominion Energy and Sempra Energy, had begun producing or testing blending hydrogen in gas pipelines.[74]

Q. IS 100 PERCENT GREEN HYDROGEN FUEL CURRENTLY FEASIBLE TO TRANSPORT IN EXISTING GAS PIPELINE SYSTEMS?

A. No, 100 percent hydrogen is not currently feasible in gas pipeline systems. There are serious technical barriers to green hydrogen deployment, starting

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[72] *Id.*

[73] Paul W. Parfomak, *Pipeline Transportation of Hydrogen: Regulation, Research, and Policy*, Congressional Research Service, R46700 (Mar. 2, 2021), https://crsreports.congress.gov/product/pdf/R/R46700 ("CRS Report"), at 3.

[74] Stephanie Kelly & Scott Disavino, *U.S. natgas companies put hydrogen to the test*, Reuters (Jul. 1, 2021), https://www.reuters.com/business/sustainable-business/us-natgas-companies-put-hydrogen-test-2021-07-01/.

with the infrastructure investments necessary to transport hydrogen using existing gas pipelines. Operators including Southern California Gas Company and San Diego Gas & Electric Company have begun or proposed projects to blend hydrogen in gas pipelines, citing the claim that up to 20 percent hydrogen concentrations by volume can be handled by existing pipelines.[75] However, an NREL study recommends that injection of hydrogen into current fossil gas pipelines be limited to 15 percent of total gas volume (85 percent methane content), with that feasibility varying by location.[76] According to the Congressional Research Service, in the U.S. pipeline infrastructure's current state, no more than 20 percent of the volume of gas it carries can be hydrogen.[77] Above a 25 percent hydrogen concentration, equipment must be upgraded to be resistant to hydrogen explosions and "unplanned ignition".[78]

Q. ARE THERE SAFETY CONCERNS WITH THE USE OF GREEN HYDROGEN?

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[75] CRS Report at 6; Southern California Gas Co., San Diego Gas & Electric Co., Pacific Gas and Electric Co., and Southwest Gas Corp. Joint Application Regarding Hydrogen-Related Additions or Revisions to the Standard Renewable Gas Interconnection Tariff, before Pub. Util. Comm'n of the State of Cal., (Nov. 20, 2020), https://www.socalgas.com/sites/default/files/2020-11/Utilities_Joint_Application_Prelim_H2_Injection_Standard_11-20-20.pdf.

[76] M. W. Melaina, et al., *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues*, Nat'l Renewable Energy Lab'y (Mar. 2013), https://www.nrel.gov/docs/fy13osti/51995.pdf; Jacek Jaworski, et al., *Study of the Effect of Addition of Hydrogen to Natural Gas on Diaphragm Gas Meters*, Energies (Jun. 11, 2020), https://www.mdpi.com/1996-1073/13/11/3006.

[77] CRS Report at 3.

[78] Jeff St. John, *Green Hydrogen in Natural Gas Pipelines: Decarbonization Solution or Pipe Dream?*, gtm (Nov. 30, 2020), https://www.greentechmedia.com/articles/read/green-hydrogen-in-natural-gas-pipelines-decarbonization-solution-or-pipe-dream.

A. Yes, the existing gas pipeline system cannot ensure the safe transport of hydrogen fuel. A study conducted by the Gas Technology Institute (GTI) for NREL shows that, since hydrogen is the smallest of all molecules, it is three times more likely to leak from existing steel or iron pipelines than fossil gas and methane;[79] estimates from the Congressional Research Service estimate that about 10 percent of hydrogen produced will leak in the processes of production, storage, and transport.[80]

Hydrogen is less dense than gas as well, and research published in the journal *Gases* finds that hydrogen necessitates larger and thus costlier infrastructure for the same volume of energy delivery.[81] Blending hydrogen into gas pipeline systems can lead to risk of infrastructural degradation and explosions without equipment upgrades, and according to law firm Morgan Lewis, there are no safety codes for a gas-hydrogen blend.[82] Blending hydrogen into the system may embrittle existing steel pipes as well.

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[79] Z. Zhou & D. Ersoy, *Review Studies of Hydrogen Use in Natural Gas Distribution Systems*, prepared by Gas Tech. Inst. for NREL (2010), at 17.

[80] *Id.*; CRS Report at 3; Tracey K. Tromp, et al., *Potential environmental impact of a hydrogen economy on the stratosphere*, Science, 300, 1740-1742 (Jun. 13, 2003), https://doi.org/10.1126%2Fscience.1085169.

[81] Abubakar Jibrin Abbas, et al., *An Investigation into the Volumetric Flow Rate Requirement of Hydrogen Transportation in Existing Natural Gas Pipelines and Its Safety Implications*, Gases, 1, 156-179 (2021), https://doi.org/10.3390/gases1040013.

[82] M. W. Melaina, et al., *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues*, Nat'l Renewable Energy Lab'y (Mar. 2013), https://www.nrel.gov/docs/fy13osti/51995.pdf; Jeff St. John, *Green Hydrogen in Natural Gas Pipelines: Decarbonization Solution or Pipe Dream?*, gtm (Nov. 30, 2020), https://www.greentechmedia.com/articles/read/green-hydrogen-in-natural-gas-pipelines-decarbonization-solution-or-pipe-dream; Kirstin E. Gibbs & Arjun Prasad Ramadevanahalli,

Q. IS GREEN HYDROGEN COST-EFFECTIVE?

A. No. Green hydrogen is not cost-effective when compared to natural gas or to alternatives resources. Green hydrogen is costlier than natural gas, per thousand cubic feet, according to global estimates and U.S. EIA data.[83] Research from IRENA concludes that the high costs of green hydrogen are the result of production, transport, conversion, and storage costs as well as a lack of to-scale deployment.[84] IRENA also finds that green hydrogen production costs are 2-3 times higher, in dollars per kilogram, than corresponding costs for "grey" hydrogen (i.e. hydrogen extracted from natural gas using steam-methane reforming, which results in substantial carbon emissions), due largely to a lack of dedicated infrastructure and inefficient production processes.[85]

Q. DO ANY GAS-FIRED GENERATORS RUN ON 100 PERCENT HYDROGEN FUEL TODAY?

Considerations For Transporting a Blended Hydrogen Stream in Interstate Natural Gas Pipelines, Morgan Lewis (Jun. 11, 2021), https://www.morganlewis.com/pubs/2021/06/considerations-for-transporting-a-blended-hydrogen-stream-in-interstate-natural-gas-pipelines.

[83] Yahya Anouti, et al., *The Dawn of Green Hydrogen*, Strategy& (2020), https://www.strategyand.pwc.com/m1/en/reports/2020/the-dawn-of-green-hydrogen/the-dawn-of-green-hydrogen.pdf; BloombergNEF, *Hydrogen Economy Outlook* (2020); LAZARD, *LAZARD's Levelized Cost of Hydrogen-Version 2.0* (2021), at 12; Hydrogen Council, *Hydrogen decarbonization pathways: Potential supply scenarios* (2021); Int'l Renewable Energy Agency, *Green Hydrogen: A Guide to Policy Making* (Nov. 2020), https://www.irena.org/publications/2020/Nov/Green-hydrogen, at 14; U.S. Energy Info. Admin., *Natural Gas Prices*, https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm (last visited Jun. 20, 2024).

[84] Int'l Renewable Energy Agency, *Geopolitics of the Energy Transformation: The Hydrogen Factor* (Jan. 2022), https://www.irena.org/publications/2022/Jan/Geopolitics-of-the-Energy-Transformation-Hydrogen.

[85] Int'l Renewable Energy Agency, *Green Hydrogen: A Guide to Policy Making* (Nov. 2020), https://www.irena.org/publications/2020/Nov/Green-hydrogen, at 14, 17.

A. No. EPA's *Hydrogen in Combustion Turbine Electric Generating Units Technical Support Document* explains that generators able to run on 100 percent hydrogen are not currently available at the scale of a power plant.[86]

Q. IF AT SOME FUTURE DATE IT BECOMES FEASIBLE AND COST-EFFECTIVE TO CONVERT A GAS-FIRED GENERATOR TO RUN ON 100 PERCENT HYDROGEN, WOULD THAT RESULT ZERO GREENHOUSE GAS EMISSIONS?

A. No. According to research published in *Nature communications*, Hydrogen is an indirect greenhouse gas due to its interactions with the hydroxy radical producing tropospheric methane and ozone.[87] Hydrogen can also increase stratospheric water vapor, resulting in stratospheric cooling and tropospheric warming.[88] Hydrogen molecules leak easily, and leakages will increase as more hydrogen is transported.

Q. HOW ARE THE CPIRP AND SUPPLEMENTAL PLANS' NON-COMPLIANCE WITH THE NOW-FINAL EPA'S SECTION 111 RULE IMPORTANT TO THIS CPCN REQUEST FOR THE PROPOSED FACILITY?

A. Duke justifies its request for a CPCN for the Proposed Facility based on its CPIRP and Supplemental Plan models which preference gas resources and pathways that are dominated by gas resources. That modeling was conducted without the correct constraints needed to represent the EPA rule. As a result, starting in 2032, several different categories of costs will

[86] U.S. Env't Protection Agency, *Hydrogen in Combustion Turbine Electric Generating Units Technical Support Document*, Docket ID No. EPA-HQ-OAR-2023-0072 (2023), https://www.epa.gov/system/files/documents/2023-05/TSD%20-%20Hydrogen%20in%20Combustion%20Turbine%20EGUs.pdf.
[87] Matteo B. Bertagni, et al., *Risk of the hydrogen economy for atmospheric nature*, Nature Communications (Dec. 13, 2022), https://www.nature.com/articles/s41467-022-35419-7.
[88] *Id*.

be imposed on ratepayers that were not modeled and, therefore, not included in Duke's recommendation that Proposed Facility will benefit ratepayers. I strongly recommend that CPIRP modeling be rerun with a correct representation of EPA Section 111 Phase II as well as correction for several other modeling errors that I discuss in this testimony before the Commission makes a decision regarding whether or not to grant the CPCN.

E. <u>Costs of delayed plant construction.</u>

Q. IS THERE REASON TO BELIEVE THAT THE PROPOSED FACILITY WOULD NOT BE IN OPERATION BY 2029 AS DEP EXPECTS?

A. SACE, et al. Expert Witness Robert G. James testifies in this docket that "DEP's failure to employ reasonable and generally accepted standards of good engineering and construction practice in its execution of the preparation phase of its proposed Project will lead to an increased likelihood of cost increases and construction delays."[89]

Q. WHAT IMPACTS CAN CONSTRUCTION DELAYS HAVE ON PROJECT COSTS?

A. Power plant construction delays have commonly been associated with cost increases arising from supply chain bottlenecks, labor shortages, and public opposition to the harmful environmental impacts of these plants.

Q. ARE YOU AWARE OF ANY EXAMPLES OF POWER PLANT CONSTRUCTION DELAYS CAUSING INCREASES TO PLANNED COSTS?

[89] Direct Testimony of Robert G. James, at 3.

A. Yes. A limited search for delays to power plants produced a list of projects with delays that varied in length from 9 months to over 7 years, imposing additional costs on ratepayers ranging from $29.3 million to over $21 billion (see Table 6).

Table 5. Examples of power plant construction delays and results added costs[90]

Plant Operator	Plant Name	Fuel Type	Scheduled Completion	Length of Delay	Cost of Delay	Status
Duke Energy[a]	Edwardsport Generating Station (IN)	Coal (618 MW)	2011	2 years	$1.5 billion	Completed
Kemper[b]	IGCC (MS)	Coal (582 MW)	2013	3 years	$4 billion	Canceled
Georgia Power[c]	Plant Vogtle (GA)	Nuclear (4,536 MW)	2017	7 years	$21 billion	Completed
Dominion Energy[d]	Summer Nuclear Generating Station (SC)	Nuclear (973 MW)	2019	1 year	$1.2 billion	Canceled
Clean Energy Future Trumbull[e][f][g]	Trumbull Energy Center (OH)	Fossil gas (950 MW)	2020	6 years	$1.4 billion	Under construction
Ohio State Energy Partners[h]	OSU CHP Plant (OH)	Fossil gas (105.5 MW)	2021	3 years	$143 million	Under construction
El Paso Electric[i]	Newman 6 (TX)	Fossil gas (228 MW)	2022	9 months	$37 million	Completed
Lakeland Electric[j]	RICE Plant (FL)	Fossil gas (120 MW)	2023	1 year	$29.3 million	Under construction
NET Power, Inc.[k]	Odessa SN1 (TX)	Fossil gas (370 MW)	2026	1 year	$250 million	Under construction

[90] *Data Sources:* [a] Sonal Patel, *Duke Hit Hard by Exorbitant O&M Costs at Edwardsport IGCC Facility*, Power Magazine (Sept. 27, 2018), https://www.powermag.com/duke-hit-hard-by-exorbitant-om-costs-at-edwardsport-igcc-facility/; [b] Associated Press, *Another Kemper delay adds $38M to power plant cost*, Clarion Ledger (May 1, 2017),

Q. HAVE STATE UTILITY COMMISSIONS EVER DENIED UTILITY REQUESTS TO BUILD AND OPERATE POWER PLANTS DUE TO INCREASED COSTS RELATED TO DELAYS?

A. Yes. In 2019, the Indiana Utility Regulatory Commission (IURC) denied Vectron South's request for a CPCN to construct an 850-MW combined cycle gas plant since the proposed facility "does not present an outcome which reasonably minimizes the potential risk that customers could sometime in the future be saddled with an uneconomic investment…"[91] IURC noted the importance of understanding and considering the risk of stranded assets during the pre-approval process of proposed projects: "Because unwinding assured cost recovery should an asset become

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https://www.clarionledger.com/story/business/2017/05/01/another-kemper-delay-adds-38m-power-plant-cost/101181808/; [c] Clarion Energy Content Directors, *Vogtle Unit 4 successfully connected to grid after delay*, Power Engineering (Mar. 4, 2024), https://www.power-eng.com/nuclear/reactors/vogtle-unit-4-successfully-connected-to-grid-after-delay/; [d] Alex Crees, *The failed V.C. Summer nuclear project: A timeline*, Choose Energy (Dec. 4, 2018), https://www.chooseenergy.com/news/article/failed-v-c-summer-nuclear-project-timeline/; [e] Clarion Energy Content Directors, *After delays, 950 MW CCGT project gets underway using Siemens turbines*, Power Engineering (Nov. 11, 2022), https://www.power-eng.com/gas/after-delays-950-mw-ccgt-project-gets-underway-using-siemens-turbines/; [f] *Energy Company Expects to Break Ground on Plant*, Construction Equipment Guide (Apr. 2, 2019), https://www.constructionequipmentguide.com/energy-company-expects-to-break-ground-on-plant/44422; [g] *Long-Delayed Power Plant Project Now $2.3 Billion*, The Business Journal (Nov. 2022), https://businessjournaldaily.com/article/journal-opinion-long-delayed-project-now-2-3b/; [h] Taylor Dorrell, *Controversial Ohio State power plant incurs delays, rising costs*, Matter News (Feb. 29, 2024), https://www.matternews.org/community/developus/controversial-ohio-state-power-plant-incurs-delays-rising-costs; [i] Diego Mendoza-Moyers, *Consumer advocate challenges El Paso Electric as utility's newest power plant comes in $37 million over budget*, El Paso Matters (Jul. 11, 2023), https://elpasomatters.org/2023/07/11/el-paso-electric-plant-to-cost-more-than-expected-increase-utility-bills/; [j] Sara-Megan Walsh, *Lakeland Electric's new power plant is $29.3M over budget and more than a year delayed*, The Ledger (Jun. 2, 2023), https://www.theledger.com/story/news/local/2023/06/02/lakeland-electrics-new-power-plant-is-delayed-and-47-3m-over-budget/70276747007/; [k] Mary B. Powers & Debra K. Rubin, *Developer NET Power Delays $1B Texas Net-Zero Power Plant Start*, Engineering News-Record (Nov. 18, 2023), https://www.enr.com/articles/57639-developer-net-power-delays-1b-texas-net-zero-power-plant-start.

[91] Indiana Utility Regulatory Commission Order, Cause No. 45052 (Apr. 24, 2019), https://iurc.portal.in.gov/_entity/sharepointdocumentlocation/4dfb39e0-9f66-e911-8151-1458d04ef938/bb9c6bba-fd52-45ad-8e64-a444aef13c39?file=45052_ord_20190424102046480.pdf, at 28.

uneconomic is not a commonly employed regulatory option, it is prudent to ensure during the pre-approval process that we understand and consider the risk that customers could sometime in the future be saddled with an uneconomic investment."[92]

In 2019, the Rhode Island Energy Facility Siting Board denied Invenergy's request to construct and operate an 850- to 1,000-MW natural gas facility due to "lengthy delays" that were vastly caused by the Company.[93]

Q. HAVE STATE UTILITY COMMISSIONS EVER APPROVED UTILITY REQUESTS TO BUILD AND OPERATE POWER PLANTS WITH CONDITIONS TO EVALUATE OR EXCLUDE COSTS?

A. Yes. In 1997, the Alabama Public Service Commission approved Alabama Power Company's request to build 800 MW of combined-cycle generation but conditioned its approval on the Company not including the proposed facility in its calculation of stranded costs passed onto ratepayers: "[A]s a condition to this Order [approving Alabama Power's CPCN application to build 800 MW of combined-cycle generation], the Commission shall accept the Company's offer that the costs associated with the combined cycle facility described herein will not be included in any calculation of retail stranded costs."[94] Two years later, in a subsequent order, the PSC

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[92] *Id.* at 20.

[93] Rhode Island Energy Facility Siting Board Decision and Order, SB-2015-06 (Nov. 5, 2019), https://ripuc.ri.gov/sites/g/files/xkgbur841/files/efsb/EFSB_Order_140.pdf, at 13.

[94] Alabama Public Service Commission Report and Order, Docket No. 26115 (Dec. 31, 1997), at 11.

approved an increase in the combined-cycle generating capacity to 1,075 MW, but included the same condition regarding stranded costs.[95]

In 2022, the Virginia State Corporation Commission approved a cost sharing provision for Dominion Energy's Coastal Virginia Offshore Wind Commercial Project should the construction costs exceed the Company's estimated $9.8 billion. The cost sharing provision was designed with three stages: (1) costs between $9.8 and $10.3 billion are to be paid 100 percent by customers; (2) costs between $10.3 and $11.3 billion are split evenly between customers and the Company; and (3) costs between $11.3 and $13.7 billion are to be paid 100 percent by the Company.[96]

Q. HAVE UTILITY REQUESTS TO BUILD AND OPERATE POWER PLANTS EVER BEEN DENIED DUE TO STATE CLIMATE GOALS?

A. Yes. In 2021, The New York Department of Environmental Conservation denied air permits for two gas-fired power plants on the basis that they were inconsistent with the State's greenhouse gas emission targets.[97]

Q. DO YOU RECOMMEND THAT THE COMMISSION GRANT THE CPCN?

A. No, I do not. I strongly recommend that the Commission reject Duke's CPCN request or, at a minimum, require Duke to submit new CPIRP

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[95] Alabama Public Service Commission Report and Order, Docket No. 26115 (Apr. 5, 1997).
[96] *Order on Reconsideration*, Virginia State Corporation Commission Case No. PUR-2021-00142 (Dec. 2022), https://www.scc.virginia.gov/docketsearch/DOCS/7pj901!.PDF.
[97] Notice of Denial of Title V Air Permit for Astoria Gas Turbine Power, N.Y. Dep't of Env't Conservation ID: 2-6301-00191/00014 (Oct. 27, 2021) https://extapps.dec.ny.gov/docs/administration_pdf/nrgastoriadecision10272021.pdf; Notice of Denial of Title V Air Permit for Danskammer Energy Center, N.Y. Dep't of Env't Conservation ID: ID: 3-3346-00011/00017 (Oct. 27, 2021) https://extapps.dec.ny.gov/docs/administration_pdf/danskammer10272021.pdf.

modeling results before ruling on the Roxboro CPCN request. New modeling runs should include the following specifications:

- The results of an independent investigation of solutions to, and costs of, addressing barriers to near-term renewables interconnection.
- New renewable resources modeled at market costs (current modeling includes a 60 percent markup).
- Renewables dominant portfolios that do not include a 20 percent adder on resource costs.
- Near-term builds (when renewable builds are feasible, but gas builds are not) that do not include an 8 percent adder on resource costs.
- Limiting resource costs to market costs. Other costs can be modeled as sensitivities related to risk and uncertainty if presented transparently and even-handedly. If risks of renewables are modeled, so too should risks of gas.
- Use of a more realistic (less than 100 percent) ELCC for gas CCs.
- Modeling to take account of natural gas supply interruptions at peak and price volatility.
- Modeling all pathways, portfolios and scenarios to be Section 111 Phase II compliant. In particular, starting in 2032, modeling the costs of conversion to 100 percent hydrogen operation, the cost of green hydrogen fuel, the costs of uncertain green hydrogen supply, high round-trip efficiency losses, hydrogen leaks and other operational costs; or,

alternatively, the full costs of some other plan that will meet Phase II requirements.

Q. WHAT ACTIONS DO YOU RECOMMEND THE COMMISSION TAKE IF IT GRANTS THE CPCN?

A. I recommend the Commission take the following actions in the event it grants the CPCN:

- Ensure that the total project cost is capped at no more than the cost stated in Duke's petition, [BEGIN CONFIDENTIAL] [redacted],[98] [END CONFIDENTIAL] and that ratepayer will not be responsible for any cost overrun that may arise due to delays in permitting or construction.
- Ensure that ratepayers are not financially responsible for any costs incurred after the plant's commercial online date that might arise due to a discrepancy between the projected and actual capacity factor. If the plant runs less than Duke anticipated (e.g., only 40 percent of the time vs 75 percent), the CPCN Order should include language that protects ratepayers from paying a higher cost per MWh.
- Require Duke to hire a third-party expert at the Company's expense that will lead review and assessment efforts during critical points of the plant's development and construction. The independent reviewer will utilize their expertise to determine whether Duke is exercising good judgment and

[98] DEP Confidential Response to Public Staff Data Request No. 2-3 (Attachment).

engaging in prudent decision-making. If the reviewer finds that this is not the case, the Commission would revise or revoke its CPCN order.

V. CONCLUSION

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

CERTIFICATE OF SERVICE

I certify that the parties of record on the service list have been served with the Direct Testimony of Elizabeth A Stanton, Ph.D. on Behalf of Southern Alliance for Clean Energy, Sierra Club, and Natural Resources Defense Council either by electronic mail or by deposit in the U.S. Mail, postage prepaid.

This the 24th day of June, 2024.

s/ David L. Neal

David L. Neal

EXHIBIT EAS-1

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Applied Economics Clinic, Arlington, MA. *Executive Director and Senior Economist*, February 2017 – Present.

The Applied Economics Clinic provides technical expertise to public service organizations working on topics related to the environment, consumer rights, the energy sector, and community equity. Dr. Stanton is the Founder and Director of the Clinic (www.aeclinic.org).

Liz Stanton Consulting, Arlington, MA. Independent Consultant, August 2016 – January 2017.

Providing consulting services on the economics of energy, environment and equity.

Synapse Energy Economics Inc., Cambridge, MA. *Principal Economist*, 2012 – 2016.

Consulted on issues of energy economics, environmental impacts, climate change policy, and environmental externalities valuation.

Stockholm Environment Institute - U.S. Center, Somerville, MA. *Senior Economist*, 2010 – 2012; *Economist*, 2008 – 2009.

Wrote extensively for academic, policy, and general audiences, and directed studies for a wide range of government agencies, international organizations, and nonprofit groups.

Global Development and Environment Institute, Tufts University, Medford, MA. *Researcher*, 2006 – 2007.

Political Economy Research Institute, University of Massachusetts-Amherst, Amherst, MA. *Editor and Researcher – Natural Assets Project*, 2002 – 2005.

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University of Massachusetts-Amherst, Amherst, MA

Doctor of Philosophy in Economics, 2007

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Papers and Reports

Statio, T., J.R. Castigliego, S. Patel, and E.A. Stanton. 2024. *Home heating in Massachusetts: What Influences Future Costs?* Applied Economics Clinic. Prepared for Home Energy Efficiency Team. [Online]

J.R. Castigliego, E. Selgia, E.A. Stanton. 2023. *Space Heating with Heat Pumps: The Need for Alternative Rate Designs in Massachusetts.* Applied Economics Clinic. Prepared on behalf of Green Energy Consumers Alliance (GECA). [Online]

E.A. Stanton. 2023. *Testimony on OVEC Power Plants Subsidies and Ohio Consumer Charges.* Applied Economics Clinic. Prepared on behalf of Office of the Ohio Consumers' Counsel. [Online]
Lala, C., E.A. Stanton, J.R. Castigliego, J. Bonner, S. Patel, S. Peddada, E. Tavares, A. Zhang, M. Majumder, D. Jiang, J. Burt; R. Bueno and K. Hewitt. 2023. *Puerto Rico's 2019 and 2021 Greenhouse Gas Inventories Report.* Applied Economics Clinic. Prepared on behalf ofPuerto Rico Department of Natural and Environmental Resources. [Online]

Lala, C., E. Seliga, and E.A. Stanton. 2023. *Assessing TVA's IRP Planning Practices.* Applied Economics Clinic. Prepared on behalf of Southern Environmental Law Center. [Online]

Stasio, T., E. Seliga, and E.A. Stanton. 2023. *Massachusetts MLPs Exemption from RPS: Impacts on Clean Energy*. Applied Economics Clinic. Prepared on behalf of Massachusetts Climate Action Network. [Online]

Lala, C., J.R. Castigliego, S. Peddada, and E.A. Stanton. 2023. *Carbon Capture, Utilization, and Storage and Louisiana's Power Sector*. Applied Economics Clinic. Prepared on behalf of Union of Concerned Scientists (UCS) and Louisiana Against False Solutions Coalition. [Online]

Burt, J., T. Stasio, S. Peddada, E. Seliga and E.A. Stanton, 2023. *Impact of Refinery Row on the City of Corpus Christi.* Applied Economics Clinic. Prepared on behalf of the Indigenous Peoples of the Coastal Bend. [Online]

Woods, B., S. Peddada, J. Bonner, and E.A Stanton,. 2023. *Comparing Connecticut's Electric Vehicle Charging Program with Others from around the United States.* Applied Economics Clinic. Prepared on behalf of Connecticut Office of Consumer Counsel. [Online]

Stasio, T., S. Peddada, E. Seliga, and E.A. Stanton. 2023. *Electric Justice: A Toolkit for the mid-Atlantic Region*. Applied Economics Clinic. Prepared on behalf of PJM Cities and Communities Coalition. [Online]

Burt, J., T. Stasio, S. Peddada, E, Seliga, and E.A. Stanton. 2022. *Cumulative Impact Assessment of the North Brooklyn Pipeline Project. Applied Economics Clinic*. Prepared on behalf of Sane Energy and Alliance for Green Economy. [Online]

Lala, C., B. Woods, S. Peddada, G. Lewis, T. Rakotoarisoa, E. Seliga, E.A. Stanton, and E. Tavares 2022. *Energy Storage Benefit-Cost Analysis*. Applied Economics Clinic. Prepared on behalf of Clean Energy State Alliance. [Online]

Stasio, T., E. Seliga, and E.A. Stanton. 2022. *Boston Tree Equity Analysis. Applied Economics Clinic*. Prepared for GreenRoots and Speak for the Trees. Available at: [Online]

Stanton, E.A., J. Castigliego, M. Majumder, E. Taveres, and S. Peddada, 2022. *Expert Memo: Review of Memphis Light, Gas, and Water RFP Update and Staff Power Supply*. Applied Economics Clinic. Prepared for the Southern Environmental Law Center. [Online]

Woods, B., J.R. Castigliego, E. Seliga, S. Peddada, T. Stasio, and E.A. Stanton. 2022. *Barriers and Opportunities for Green Jobs in New Jersey*. Applied Economics Clinic. [Online]

Castigliego, J.R., S. Alisalad, S. Peddada, and E.A. Stanton. 2022. *Economic Impacts of a Clean Energy Transition in New Jersey.* Applied Economics Clinic. [Online]

Stasio, T., J.R. Castigliego, C. Lala, and E.A. Stanton. 2022. *Risk Assessment of Florida Power and Light and NextEra Energy Clean Energy Transition Plans*. Applied Economics Clinic. Prepared for Environmental Defense Fund. [Online]

Stasio, T., J. R. Castigliego, S. Alisalad, and E. A. Stanton. 2022. *Decarbonizing Building Heat in Massachusetts*. Applied Economics Clinic. Prepared for Home Energy Efficiency Team. [Online]

Woods, B., S. Alisalad, E. Tavares, M. Majumder, and E. Stanton. 2021. *Equity Measurement and Targeting Underserved Communities in Massachusetts' 2022-2024 Energy Efficiency Plan*. Applied Economics Clinic. Prepared for Green Justice Coalition. [Online]

Stasio, T., B. Woods, J.R. Castigliego, and E. Stanton. 2021. *Equity Assessment of Electrification Incentives in the District of Columbia*. Applied Economics Clinic. Prepared for The Office of the People's Counsel for the District of Columbia. [Online]

Castigliego, J.R., E. Stanton, S. Alisalad, and E. Tavares. 2021. *Energy Storage for Winter Grid Reliability: How Batteries Became a Low-Cost Solution for Power Assurance in Massachusetts*. Applied Economics Clinic. Prepared for Clean Energy Group. [Online]

Stanton, E., G. Lewis, and C. Lala. 2021. *An Analysis of EPA's Proposed Revised 2023 and later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards*. Applied Economics Clinic. Prepared for the Office of the California Attorney General. [Online]

Castigliego, J.R., C. Lala, and E.A. Stanton. 2021. *Net Emission Savings Benefit for a Battery Storage Facility in Wendell, Massachusetts*. Applied Economics Clinic. Prepared for Borrego. [Online]

Castigliego, J.R., E.A. Stanton, S. Alisalad, T. Stasio, and E. Tavares. 2021. *PJM's Capacity Market: Clearing Prices, Power Plants, and Environmental Justice.* Applied Economics Clinic. [Online]

Stanton, E.A., G. Lewis, and C. Lala. 2021. *An Analysis of NHSTA's Preliminary Regulatory Impact Analysis of 2021 Proposed Rulemaking for Model Years 2024-2026 Light-Duty Vehicle CAFE Standards*. Applied Economics Clinic. Prepared for the Office of the California Attorney General and the California Air Resource Board. [Online]

Woods, B., E.A. Stanton, and S. Alisalad. 2021. *Recommendations for Cities and States to Improve Equity Evaluation and Reporting in Energy Efficiency Programming*. Applied Economics Clinic. Prepared for American Council for an Energy-Efficient Economy. [Online]

Woods, B., E.A. Statnton, E. Tavares, and S. Alisalad. 2021 *ConnectedSolutions: A Program Assessment for Massachusetts.* Applied Economics Clinic. Prepared for Clean Energy Group. [Online]

Woods, B., and E.A. Stanton. 2021. *Comments on Astoria Gas Turbine Power LLC's Proposed Gas-Fired Combustion Turbines*. Applied Economics Clinic. Prepared for New York Lawyers for the Public Interest and Earthjustice. [Online]

Castigliego, J.R., C. Lala, E. Tavares, and E.A. Stanton. 2021. *Estimating the Net Change in Carbon Dioxide Emissions for Solar Projects in Massachusetts*. Applied Economics Clinic.

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

Prepared for Borrego. [Online]

Castigliego, J.R., T. Stasio, S. Alisalad, and E.A. Stanton. 2021. *Assessment of Backup Diesel Generators in Massachusetts*. Applied Economics Clinic. Prepared for Bloom Energy. [Online]

Castigliego, J.R., T. Stasio, S. Alisalad, and E.A. Stanton. 2021. *Assessment of Backup Diesel Generators in New York City*. Applied Economics Clinic. Prepared for Bloom Energy. [Online]

Castigliego, J.R., T. Comings, S. Alisalad, and E.A. Stanton. 2021. *Background Report: Benefits of Coal Ash Cleanup and Remediation*. Applied Economics Clinic. Prepared for Earthjustice. [Online]

Stanton, E.A., T. Stasio, and C. Lala. 2021. *Comments on 2021 Guidance Towards Updating the U.S. Social Cost of Greenhouse Gases*. Applied Economics Clinic. Prepared for Friends of the Earth. [Online]

Woods, B. and E.A. Stanton. 2021. *Initial Assessment of the Climate Justice Working Group's Recommended Policy Priorities – Tracking Equity and Justice*. Applied Economics Clinic. Prepared for the Massachusetts' Climate Justice Working Group (CJWG). [Online]

Kasina, S., B. Wheatle, C. Duff, L. Mettetal, L. Alagappan, N. Schlag, B. Woods, and E.A. Stanton. 2021. *State of Maine Renewable Energy Goals Market Assessment*. Energy and Environment Economics (E3) and Applied Economics Clinic. Prepared for the Maine Governor's Energy Office. [Online]

Castigliego, J.R., S. Alisalad, T. Stasio, and E.A. Stanton. 2021*. Inflection Point: When Heating with Gas Costs More*. Applied Economics Clinic. Prepared for HEET. [Online]

Castigliego, J.R., T. Stasio, and E.A. Stanton. 2020. *Fixing Massachusetts' Leaky Pipes: When Will It Be Paid Off?* Applied Economics Clinic*.* Prepared in Response to Gas Leak Allies. [Online]

Woods, B., E.A. Stanton, and D. Wamsted. 2020. *Risks Outweigh Rewards for Investors Considering PJM Natural Gas Projects*. Prepared for the Energy Foundation. [Online]

Woods, B., S. Alisalad, M. Majumder, and E.A. Stanton. 2020 *Municipal Light Plants and Energy Efficiency.* Prepared for Massachusetts Climate Action Network. [Online]

Stanton, E.A. and AEC Staff. 2020. *Visualizations of Racial Inequity*. Applied Economics Clinic. Prepared for Renew New England. [Online]

Castigliego, J. and E.A. Stanton. 2020. *Planning for the Future: Massachusetts Cleans Up Its Heating.* Applied Economics Clinic. Prepared for Gas Leak Allies. [Online]

Stanton, E.A., J. Castigliego, B. Woods, and E. Tavares. 2020. *A Needs Assessment of the Hopkinton-Ashland Transfer Line Replacement Project.* Applied Economics Clinic. Prepared for Town of Ashland. [Online]

Woods, B., E.A. Stanton, and E. Tavares. 2020. *New England Housing Costs: Rent as a Share of Income*. Applied Economics Clinic. [Online]

Woods, B., S. Alisalad and E.A. Stanton. 2020. *Running Behind: New York State's Renewable Transformation*. Applied Economics Clinic. Prepared for Earthjustice. [Online]

Stanton, E.A., B. Woods, E. Tavares, and S. Alisalad. 2020. *New Orleans' Renewable Portfolio Standard: Cost-Effective, Reliable, Resilient*. Applied Economics Clinic. Prepared for Alliance for Affordable Energy. [Online]

Stanton, E.A., B. Woods, J. Castigliego, E. Tavares and S. Alisalad. 2020. *A Whole New Ballgame: Indiana Coal and the New Energy Landscape*. Applied Economics Clinic. Prepared for Citizens Action Coalition of Indiana. [Online]

Stanton, E.A., A. Sommer, C. Hotaling, and C. Neme. 2019. *Report on Indiana Michigan Power Company 2018-19 IRP*. Applied Economics Clinic. Prepared for Citizens Action Coalition of Indiana and Earthjustice. [Online]

Stanton, E.A., B. Woods, J. Castigliego, and E. Tavares. 2019. *Massachusetts Gas versus Massachusetts Climate Goals*. Applied Economics Clinic. Prepared for Gas Leak Allies. [Online]

Stanton, E.A., T. Stasio and B. Woods. 2019. *Marginal Cost of Emissions Reductions in Massachusetts*. Applied Economics Clinic. Prepared for Green Energy Consumer Alliance. [Online]

Woods, B. and E.A. Stanton. 2019. *Technosilvicultural Reclamation for Environmental Emission Sequestration*. Applied Economics Clinic. Prepared for Home Energy Efficiency Team and Speak for the Trees. [Online]

Woods, B., E. Tavares, S. Alisalad, and E.A. Stanton. 2019. *Puerto Rico Integrated Resource Plan: Lessons from Hawaii's Electric Sector*. Applied Economics Clinic. Prepared for Earthjustice. [Online]

Woods, B., E. A. Stanton. 2019. *A Future for Indiana Coal: Emissions and Costs of Alternative Electric Generation*. Applied Economics Clinic. Prepared for Citizens Action Coalition of Indiana. [Online]

Stanton, E.A. S. Alisalad, and M. Majumder. 2019. *Comparative Costs of Alaska Fire Management*. Applied Economics Clinic. Prepared for Union of Concerned Scientists. [Online]

Stanton, E.A. and E. Tavares. 2019. *An Analysis of the Need for the Atlantic Coast Pipeline Extension to Hampton Roads, Virginia*. Applied Economics Clinic. Prepared for Mothers Out Front. [Online]

Woods, B., E. A. Stanton, T. Comings, and E. Tavares. *Emission Reduction Synergies for Massachusetts Community Choice Energy Programs, Heat Pumps and Electric Vehicles*. Applied Economics Clinic. Prepared for Green Energy Consumers Alliance. [Online]

Stanton, E.A. and E. Tavares. 2019. *Analysis of the Mountain Valley Pipeline Southgate Project*. Applied Economics Clinic. Prepared for Appalachian Voices. [Online]

Stanton, E.A. 2019. *Update to Pennsylvania Long-Term Renewables Contracts Benefits and Costs*. Applied Economics Clinic. Prepared for Mid-Atlantic Renewable Energy Coalition (MAREC). [Online]

Lopez, R., T. Comings, E.A. Stanton, and E. Tavares. 2019. *Home Heat Pumps in Massachusetts*. Applied Economics Clinic. Prepared for Green Energy Consumers Alliance. [Online]

Woods, B., E.A. Stanton, and E. Tavares. 2019. *Fixing Massachusetts' Gas Leaks Pays for Itself*. Applied Economics Clinic. Prepared for Gas Leak Allies. [Online]

Woods, B. and E.A. Stanton. 2019. *Social Equity Analysis of Carbon Free Boston*. Applied Economics Clinic. Prepared for Green Ribbon Commission. [Online]

Woods, B., E.A. Stanton, and R. Lopez. 2019. *Performance-Based Incentives for Gas Utilities*. Applied Economics Clinic. Prepared for Gas Leak Allies. [Online]

Woods, B. and E.A. Stanton. 2019. *Massachusetts Non-Energy Benefits of Battery Storage.* Applied Economics Clinic. Prepared for Clean Energy Group. [Online]

Stanton, E.A. 2019. *Updated Massachusetts Battery Storage Measures: Benefits and Costs.* Applied Economics Clinic. Prepared for Clean Energy Group. [Online]

Comings, T., B. Woods, E.A. Stanton, and E. Tavares. 2019. *Duke Energy Integrated Resource Plans in North Carolina.* Applied Economics Clinic. Prepared for Southern Environmental Law Center. [Online]

Stanton, E.A., B. Woods, A. Sommer, and C. Hotaling. 2019. *Evaluation of Northern Indiana Public Service Company's 2018 Integrated Resource Plan.* Applied Economics Clinic. Prepared for Citizens Action Coalition of Indiana. [Online]

Stanton, E.A., R. Lopez, and B. Woods. 2018. *Review of Proposed CAFE and CO_2 Standards.* Applied Economics Clinic. Prepared for California Attorney General Office and California Air Resources Board. [Online]

Stanton, E.A., R. Lopez, B. Woods, T. Stasio, and A. Sommer. 2018. *Report on Indiana's 2018 Draft Statewide Analysis of Future Resource Requirements of Electricity*. Applied Economics Clinic. Prepared for Citizens Action Coalition of Indiana. [Online]

Stanton, E.A. 2018. *Massachusetts Battery Storage Measures: Benefits and Costs.* Applied Economics Clinic. Prepared for Clean Energy Group. [Online]

Stanton, E.A. 2018. *Review of Massachusetts Efficiency Program Administrator's April 2018 Draft 2019-2021 Energy Efficiency Plan.* Applied Economics Clinic. Prepared for Conservation Law Foundation. [Online]

Stanton, E.A., and T. Comings. 2018. *Massachusetts Clean Energy Bill Provisions Boost Jobs.* Applied Economics Clinic. Prepared for Barr Foundation. [Online]

Stanton, E.A., T. Comings, R. Wilson, S. Alisalad, E.N Marzan, C. Schlegel, B. Woods, J. Gifford, E. Snook, and P. Yuen. 2018. *An Analysis of the Massachusetts 2018 'Act to Promote a Clean Energy Future' Report.* Applied Economics Clinic. Prepared for Barr Foundation. [Online]

Woods, B., C. Schlegel, and E.A. Stanton. 2018. *Massachusetts' Clean Energy Policy Overview.* Applied Economics Clinic. Prepared for Barr Foundation. [Online]

Comings, T., E.A. Stanton, and B. Woods. 2018. *The ABCs of Boston CCE*. Applied Economics Clinic. Prepared for Barr Foundation. [Online]

Stanton, E.A., E.N. Marzan, and S. Alisalad. 2018. *Accessing Energy Efficiency in Massachusetts.* Applied Economics Clinic. Prepared for Conservation Law Foundation. [Online]

Stanton, E.A., R. Wilson, and B. Woods. 2018. *Missed Opportunities for Energy Efficiency in Virginia*. Applied Economics Clinic. Prepared for the Consumers Union. [Online]

Stanton, E.A., T. Comings, and A. Sommer. 2018.*The Husker Energy Plan: A New Energy Plan for Nebraska*. Applied Economics Clinic. Prepared for the Nebraska Wildlife Foundation. [Online]

Stanton, E.A., A. Sommer, T. Comings, and R. Wilson. 2017. *Benefits of Long-Term Renewable Contracts for Pennsylvania*. Applied Economics Clinic. Prepared for Mid-Atlantic Renewable Energy Coalition (MAREC). [Online]

Stanton, E.A., A. Sommer, T. Comings, and R. Wilson. 2017. *Pennsylvania Long-Term Renewables Contracts Benefits and Costs*. Applied Economics Clinic. Prepared for Mid-Atlantic Renewable Energy Coalition (MAREC). [Online]

Comings, T., E.A. Stanton, and B. Woods. 2017. *An Analysis of Community Choice Energy for Boston.* Applied Economics Clinic. Prepared for Barr Foundation. [Online]

Wilson, R., T. Comings, and E.A. Stanton. 2017. *Ratepayer Impacts of ConEd's 20-Year Shipping Agreement on the Mountain Valley Pipeline.* Applied Economics Clinic. Prepared for the Environmental Defense Fund. [Online]

Sommer, A. and E.A. Stanton. 2017. *Report on Vectren 2016* IRP. Applied Economics Clinic. Prepared on behalf of Earthjustice, Indiana Distributed Energy Alliance, Sierra Club, and Valley Watch. Submitted to the Indiana Utility Regulatory Commission. [Online]

Sommer, A. and E.A. Stanton. 2017. *Report on Indiana Power & Light 2016* IRP. Applied Economics Clinic. Prepared on behalf of Earthjustice, Indiana Distributed Energy Alliance, Sierra Club, and Valley Watch. Submitted to the Indiana Utility Regulatory Commission. [Online]

Sommer, A. and E.A. Stanton. 2017. *Report on Northern Indiana Public Service Company's 2016* IRP. Applied Economics Clinic. Prepared on behalf of Earthjustice, Indiana Distributed Energy Alliance, Sierra Club, and Valley Watch. Submitted to the Indiana Utility Regulatory Commission. [Online]

Stanton, E.A., P. Knight, P. Luckow, A. Allison, T. Vitolo, J. Barnes, B. Inskeep, and C. Barnes. 2016. *Envisioning Pennsylvania's Energy Future: Powering the Commonwealth's Energy Needs with 100 Percent Renewables by 2050.* Prepared by Synapse Energy Economics and EQ Research for Delaware Riverkeeper Network. [Online]

Wilson, R., S., Fields, P. Knight, E. McGee, W. Ong, N. Santen, T. Vitolo, and E.A. Stanton. 2016. *Are the Atlantic Coast Pipeline and the Mountain Valley Pipeline Necessary?* Prepared by Synapse Energy Economics for Southern Environmental Law Center and Appalachian Mountain Advocates. [Online]

Knight, P. and E.A. Stanton. 2016. *"Sorting Out New England's Pipeline Needs: A Round Up of Recent Studies and What They Mean".* Synapse Energy Economics White Paper. [Online]

Stanton, E.A., P. Knight, A. Allison, T. Comings, A. Horowitz, W. Ong, N. R. Santen, and K. Takahashi. 2016. *The RGGI Opportunity 2.0: RGGI as the Electric Sector Compliance Tool to Achieve 2030 State Climate Targets.* Prepared by Synapse Energy Economics for Sierra Club, Pace Energy and Climate Center, and Chesapeake Climate Action Network. [Online]

Jackson, S., P. Luckow, E.A. Stanton, A. Horowitz, P. Peterson, T. Comings, J. Daniel, and T. Vitolo. 2016. *Reimagining Brayton Point: A Guide to Assessing Reuse Options for the Somerset Community*. Prepared by Synapse Energy Economics for Coalition for Clean Air South Coast, Clean Water Action, and Toxics Action Center. [Online]

Stanton, E. A., P. Knight, A. Allison, T. Comings, A. Horowitz, W. Ong, N. R. Santen, and K. Takahashi. 2016. *The RGGI Opportunity: RGGI as the Electric Sector Compliance Tool to Achieve 2030 State Climate Targets.* Prepared by Synapse Energy Economics for Sierra Club, Pace Energy and Climate Center, and Chesapeake Climate Action Network. [Online]

Luckow, P., E.A. Stanton, S. Fields, W. Ong, B. Biewald, S. Jackson, and J. Fisher. 2016. *Spring 2016 National Carbon Dioxide Price Forecast*. Synapse Energy Economics White Paper. [Online]

Knight, P., A. Allison, W. Ong, N. R. Santen, and E.A. Stanton. 2016. *Cutting Electric Bills with the Clean Power Plan.* Prepared by Synapse Energy Economics for The Energy Foundation. [Online]

Horowitz, A., S. Jackson, A. Allison, and E.A. Stanton. 2016. *Environmental Justice and the Clean Power Plan.* Prepared by Synapse Energy Economics for The Energy Foundation. [Online]

Jackson, S., N. R. Santen, P. Knight, S. Fields, B. Biewald, and E.A. Stanton. 2015. *Clean Power Plan Handbook: A Guide to the Final Rule for Consumer Advocates.* Prepared by Synapse Energy Economics for National Association of State Utility Consumer Advocates. [Online]

Wilson, R., T. Comings, and E.A. Stanton. 2015. *Analysis of the Tongue River Railroad Draft Environmental Impact Statement.* Prepared by Synapse Energy Economics for Sierra Club and Earthjustice. [Online]

Knight, P., S. Fields, S. Jackson, W. Ong, N. R. Santen, B. Biewald, and E.A. Stanton. 2015. *Multi-State Compliance with the Clean Power Plan in CP3T.* Prepared by Synapse Energy Economics for the National Association of State Utility Consumer Advocates. [Online]

Vitolo, T., P. Luckow, S. Fields, P. Knight, B. Biewald, and E.A. Stanton. 2015. *Lower Electric Costs in a Low- Emission Future.* Prepared by Synapse Energy Economics for The Energy Foundation. [Online]

Stanton, E. A., T. Comings, S. Jackson, and E. Karaca. 2015. *Atlantic Coast Pipeline Benefits Review.* Prepared by Synapse Energy Economics for Southern Environmental Law Center. [Online]

Wilson, R., M. Whited, S. Jackson, B. Biewald, and E.A. Stanton. 2015. *Best Practices in Planning for Clean Power Plan Compliance.* Prepared by Synapse Energy Economics for the National Association of State Utility Consumer Advocates. [Online]

Fields, S., S. Jackson, P. Knight, and E.A. Stanton. 2015. *Internal briefing on Clean Power Plan compliance in Ohio.* Prepared by Synapse Energy Economics for Office of the Ohio Consumers' Counsel.

Luckow, P., E.A. Stanton, S. Fields, B. Biewald, S. Jackson, J. Fisher, and R. Wilson. 2015. *2015 Carbon Dioxide Price Forecast.* Synapse Energy Economics White Paper. [Online]

Knight, P., A. Allison, E.A. Stanton. 2015. *Preliminary Clean Power Plan Analysis for Kentucky.* Prepared by Synapse Energy Economics for Kentuckians for the Commonwealth.

Stanton, E. A., P. Knight, J. Daniel, B. Fagan, D. Hurley, J. Kallay, E. Karaca, G. Keith, E. Malone, W. Ong, P. Peterson, L. Silvestrini, K. Takahashi, and R. Wilson. 2015. *Massachusetts Low Gas Demand Analysis: Final Report.* Prepared by Synapse Energy Economics for the Massachusetts Department of Energy Resources. [Online]

Fields, S., E.A. Stanton, P. Knight, B. Biewald, J. Daniel, S. Jackson, E. Karaca, J. Rosenkranz, and K. Takahashi. 2014. *Calculating Alabama's 111(d) Target*. Prepared by Synapse Energy Economics for the Southern Environmental Law Center. [Online]

Fields, S., E.A. Stanton, P. Knight, B. Biewald, J. Daniel, S. Jackson, E. Karaca, J. Rosenkranz, and K. Takahashi. 2014. *Calculating Georgia's 111(d) Target*. Prepared by Synapse Energy Economics for the Southern Environmental Law Center. [Online]

Fields, S., E.A. Stanton, P. Knight, B. Biewald, J. Daniel, S. Jackson, E. Karaca, J. Rosenkranz, and K. Takahashi. 2014. *Alternate Scenarios for 111(d) Implementation in North Carolina*. Prepared by Synapse Energy Economics for the Southern Environmental Law Center. [Online]

Stanton, E. A., S. Jackson, B. Biewald, and M. Whited. 2014. *Final Report: Implications of EPA's Proposed "Clean Power Plan."* Prepared by Synapse Energy Economics for the National Association of State Utility Consumer Advocates. [Online]

Stanton, E. A., J. Daniel, T. Vitolo, P. Knight, D. White, and G. Keith. 2014. *Net Metering in Mississippi: Costs, Benefits, and Policy Considerations.* Prepared by Synapse Energy Economics for the Public Service Commission of Mississippi. [Online]

Knight, P., E.A. Stanton, B. Biewald, J. Daniels, S. Fields, S. Jackson, A. Napoleon, J. Rosenkranz, and K. Takahashi. 2014. *Internal briefing on Clean Power Plan implementation in Virginia.* Prepared by Synapse Energy Economics for Sierra Club.

Jackson, S. and E.A. Stanton. 2014. *Internal briefing on Clean Power Plan implementation in Minnesota.* Prepared by Synapse Energy Economics for Sierra Club.

Knight, P., E.A. Stanton, B. Biewald, J. Daniels, S. Fields, S. Jackson, A. Napoleon, J. Rosenkranz, and K. Takahashi. 2014. *Internal briefing on Clean Power Plan implementation in Florida.* Prepared by Synapse Energy Economics for Sierra Club.

E.A. Stanton, S. Jackson, B. Biewald, M. Chang, J. Daniels, S. Fields, P. Knight, A. Napoleon, M. Whited, and K. Takahashi. 2014. *Internal briefing on Clean Power Plan implementation in Arizona, Montana, Nevada, and Utah.* Prepared by Synapse Energy Economics for Sierra Club.

E.A. Stanton, S. Jackson, B. Biewald, M. Chang, J. Daniels, S. Fields, P. Knight, A. Napoleon, and K. Takahashi. 2014. *Internal briefing on Clean Power Plan implementation Illinois.* Prepared by Synapse Energy Economics for Sierra Club.

Luckow, P., E.A. Stanton, B. Biewald, S. Fields, S. Jackson, J. Fisher, and F. Ackerman. 2014. *CO_2 Price Report, Spring 2014: Includes 2013 CO_2 Price Forecast.* Synapse Energy Economics White Paper. [Online]

Fisher, J., P. Knight, E.A. Stanton, and B. Biewald. 2014. *Avoided Emissions and Generation Tool (AVERT): User Manual. Version 1.0*. Prepared by Synapse Energy Economics for the U.S. Environmental Protection Agency. [Online]

Stanton, E. A., M. Whited, and F. Ackerman. 2014. *Estimating the Cost of Saved Energy in Utility Efficiency Programs.* Prepared by Synapse Energy Economics for the U.S. Environmental Protection Agency.

Stanton, E. A., F. Ackerman, and J. Daniel. 2013. *Comments on the 2013 Technical Update of the Social Cost of Carbon*. Prepared by Synapse Energy Economics for the Environment, Economics and Society Institute. [Online]

Luckow, P., E.A. Stanton, B. Biewald, J. Fisher, F. Ackerman, and E. Hausman. 2013. *2013 Carbon Dioxide Price Forecast.* Synapse Energy Economics White Paper. [Online]

Stanton, E. A., S. Jackson, G. Keith, E. Malone, D. White, and T. Woolf. 2013. *A Clean Energy Standard for Massachusetts.* Prepared by Synapse Energy Economics for the Massachusetts Clean Energy Center and the Massachusetts Departments of Energy Resources, Environmental Protection, and Public Utilities. [Online]

Knight, P., E.A. Stanton, J. Fisher, and B. Biewald. 2013. *Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT).* Prepared by Synapse Energy Economics for Energy Foundation. [Online]

Hornby, R., P. Chernick, D. White, J. Rosenkranz, R. Denhardt, E. Stanton, J. Glifford, B. Grace, M. Chang, P. Luckow, T. Vitolo, P. Knight, B. Griffiths, and B. Biewald. 2013. *Avoided Energy Supply Costs in New England: 2013 Report.* Prepared by Synapse Energy Economics for the Avoided-Energy-Supply-Component (AESC) Study Group. [Online]

Stanton, E. A., T. Comings, K. Takahashi, P. Knight, T. Vitolo, and E. Hausman. 2013. *Economic Impacts of the NRDC Carbon Standard.* Prepared by Synapse Energy Economics for the Natural Resources Defense Council. [Online]

Stanton, E.A. 2013. Background research, consulting and support related to the Danish Energy Agency, Organisation for Economic Co-operation, and the UNEP Riso Centre's "*National Greenhouse Gas Emissions Baseline Scenarios: Learning from Experiences in Developing Countries.*" [Online]

Whited, M., D. White, S. Jackson, P. Knight, and E.A. Stanton. 2013. *Declining Markets for Montana Coal*. Prepared by Synapse Energy Economics for Northern Plains Resource Council. [Online]

Stanton, E. A. and F. Ackerman. 2013*. Climate Impacts on Agriculture: A Challenge to Complacency?* Global Development and Environment Institute Working Paper 13-01. [Online]

Stanton, E. A., F. Ackerman, T. Comings, P. Knight, T. Vitolo, and E. Hausman. 2013. *Will LNG Exports Benefit the United States Economy?* Prepared by Synapse Energy Economics for the Sierra Club. [Online]

Ackerman, F., T. Vitolo, E. Stanton, and G. Keith. 2013. *Not-so-smart ALEC: Inside the attacks on renewable energy*. Prepared by Synapse Energy Economics for the Civil Society Institute. [Online]

Ackerman, F., E.A. Stanton, and R. Bueno. 2012. *Climate Policy and Development: An Economic Analysis.* Economics for Equity and the Environment (E3 Network) Working Paper. [Online]

Stanton, E. A. and M. Taylor. 2012. *A Good Environment for Jobs.* Economics for Equity and the Environment (E3 Network) Working Paper. [Online]

Stanton, E. A., F. Ackerman, and R. Bueno. 2012. *Reason, Empathy, and Fair Play: The Climate Policy Gap.* UNDESA Working Paper No.113. [Online]

Erickson, P., M. Lazarus, E.A. Stanton, C. Chandler, R. Bueno, F. Ackerman, C. Munitz, and J. Cegan. 2012. *Greenhouse Gas Emissions in King County: An Updated Geographic-plus Inventory, a Consumption-based Inventory, and an Ongoing Tracking Framework.* Prepared by Stockholm Environment Institute-U.S. Center for King County, Washington. [Online]

Stanton, E. A., J. Cegan, R. Bueno, and F. Ackerman. 2012. *Estimating Regions' Relative Vulnerability to Climate Damages in the CRED Model*. Stockholm Environment Institute-U.S. Center Working Paper WP-US-1103. [Online]

Stanton, E.A. 2012. *Development without Carbon as Climate Policy.* Economics for Equity and the Environment (E3 Network) Working Paper. [Online]

Ackerman, F., E.A. Stanton, and R. Bueno. 2012. *Epstein-Zin utility in DICE: Is risk aversion irrelevant to climate policy?* Economics for Equity and the Environment (E3 Network) Working Paper. [Online]

Stanton, E. A., R. Bueno, J. Cegan, and C. Munitz. 2011. *King County Community Greenhouse Gas Emissions Inventory – Consumption Methodology: Technical Report.* Prepared by Stockholm Environment Institute-U.S. Center for King County, Washington. [Online]

Stanton, E. A., R. Bueno, and M. Davis. 2011. *Real People, Real Impacts: The Climate Impact Equity Lens.* Stockholm Environment Institute-U.S. Center Report. [Online]

Stanton, E. A. and R. Bueno. 2011. *The CIEL Backgrounder: Understanding the Climate Impact Equity Lens.* Stockholm Environment Institute-U.S. Center Report. [Online]

Stanton E.A. 2011. *Development without Carbon: Climate and the Global Economy through the 21st Century.* Stockholm Environment Institute-U.S. Center Report. [Online]

Erickson, P., M. Lazarus, E.A. Stanton, and F. Ackerman. 2011. *Consumption-Based Greenhouse Gas Emissions Inventory for Oregon – 2005: Summary Report.* Prepared by Stockholm Environment Institute-U.S. Center for the State of Oregon Department of Environmental Quality. [Online]

Stanton, E.A., R. Bueno, F. Ackerman, P. Erickson, R. Hammerschlag, and J. Cegan. 2011. *Consumption-Based Greenhouse Gas Emissions Inventory for Oregon – 2005: Technical Report.* Prepared by Stockholm Environment Institute-U.S. Center for the State of Oregon Department of Environmental Quality. [Online]

Ackerman, F. and E.A. Stanton. 2011. *The Social Cost of Carbon.* Economics for Equity and the Environment (E3 Network) White Paper. [Online]

Stanton, E.A., R. Bueno, J. Cegan, and C. Munitz. 2011. *Consumption-Based Emissions Inventory for San Francisco: Technical Report.* Prepared by Stockholm Environment Institute-U.S. Center for the City of San Francisco, California. [Online]

Stanton, E. A. and F. Ackerman. 2011. *Developing Baselines for Climate Policy Analysis.* Prepared by Stockholm Environment Institute-U.S. Center as additional guidance for "United Nations Environmental Programme (UNEP) MCA4climate Initiative: A practical framework for planning pro-development climate policies." [Online]

Ackerman, F. and E.A. Stanton. 2011. *A practical framework for planning pro- development climate policies*. Prepared by Stockholm Environment Institute-U.S. Center as additional guidance for *"United Nations Environmental Programme (UNEP) MCA4climate Initiative: A practical framework for planning pro-development climate policies."* [Online]

Ackerman, F. and E.A. Stanton. 2011. *The Last Drop: Climate Change and the Southwest Water Crisis*. Stockholm Environment Institute-U.S. Center Report funded by the Kresge Foundation. [Online]

Stanton, E. A. and E. Fitzgerald. 2011. *California Water Supply and Demand: Technical Report*. Stockholm Environment Institute-U.S. Center Report funded by the Kresge Foundation. [Online]

Bueno, R. and E.A. Stanton. 2011. *Casting DICE for 350 ppm.* Stockholm Environment Institute-U.S. Center Working Paper WPUS-1101. [Online]

Stanton, E. A. and F. Ackerman. 2010. *Emission Reduction, Interstate Equity, and the Price of Carbon*. Prepared by Stockholm Environment Institute-U.S. Center Economics for Equity and the Environment (E3 Network). [Online]

Stanton, E. A. and F. Ackerman. 2010. *No State Left Behind: A Better Approach to Climate Policy*. Economics for Equity and the Environment (E3 Network) White Paper. [Online]

Ackerman, F., E.A. Stanton, and R. Bueno. 2010. *CRED: A New Model of Climate and Development.* United Nations Department of Economic and Social Affairs Working Paper No.96. [Online]

Stanton, E. A., M. Davis, and A. Fencl. 2010. *Costing Climate Impacts and Adaptation: A Canadian Study on Coastal Zones*. Prepared by Stockholm Environment Institute-U.S. Center for the National Round Table on the Environment and the Economy Economic Risks and Opportunities of Climate Change Program. [Online]

Ackerman, F. and E.A. Stanton. 2010. *The socio-economic implications of climate change on FYR Macedonia and national policy options on adaptation.* United Nations Development Programme (UNDP) Report.

Ackerman, F., E.A. Stanton, S. DeCanio, E. Goodstein, R. Howarth, R. Norgaard, C. Norman, and K. Sheeran. 2009. *The Economics of 350: The Benefits and Costs of Climate Stabilization*. Economics for Equity and the Environment (E3 Network), Stockholm Environment Institute-U.S. Center, and Ecotrust Report. [Online]

Stanton, E. A., F. Ackerman, and K. Sheeran. 2009. *Understanding Interstate Differences in U.S. Greenhouse Gas Emissions*. Stockholm Environment Institute-U.S. Center Working Paper WP-US-1004. [Online]

Stanton, E. A., F. Ackerman, and K. Sheeran. 2009. *Greenhouse Gases and the American Lifestyle: Understanding Interstate Differences in Emissions*. Economics for Equity and the Environment (E3 Network), and Ecotrust Report. [Online]

Stanton, E. A., F. Ackerman, and F. Resende. 2009. *The Socio-Economic Impact of Climate Change in Armenia*. Stockholm Environment Institute-U.S. Center for the United Nations Development Programme (UNDP). [Online]

Stanton, E. A. and F. Ackerman. 2008. *Generated User Benefits and the Heathrow Expansion: Understanding Consumer Surplus*. Prepared by Stockholm Environment Institute-U.S. Center for Friends of the Earth England, Wales and Northern Ireland. [Online]

Stanton, E. A. and F. Ackerman. 2008. *Out of the Shadows: What's Behind DEFRA's New Approach to the Price of Carbon*. Prepared by Stockholm Environment Institute-U.S. Center for Friends of the Earth England, Wales and Northern Ireland. [Online]

Bueno, R., C. Herzfeld, E.A. Stanton, and F. Ackerman. 2008. *The Caribbean and Climate Change: The Costs of Inaction*. Prepared by Stockholm Environment Institute-U.S. Center for Environmental Defense Fund. [Online]

Ackerman, F. and E.A. Stanton. 2008. *The Cost of Climate Change: What We'll Pay if Global Warming Continues Unchecked*. Prepared by Stockholm Environment Institute-U.S. Center for Natural Resources Defense Council. [Online]

Stanton, E.A. 2008. Literature review of water resources infrastructure and related environmental costs and benefits for "*Default Case Study Values and Management Options for WEAP in Massachusetts.*" Prepared by Stockholm Environment Institute-U.S. Center for Keep Water Local, a project of the Massachusetts Riverways Program, Commonwealth of Massachusetts.

Stanton, E.A. and F. Ackerman. 2007. *Florida and Climate Change: The Costs of Inaction*. Prepared by Global Development and Environmental Institute – Tufts University for Environmental Defense. [Online]

Stanton, E.A. 2007. *United States-Specific Human Development Index: Methodology and Data*. Report commissioned by American Human Development Report Project, as a technical background paper to *The Measure of America: American Human Development Report 2008-2009*.

Ackerman, F. and E.A. Stanton. 2006. *Climate Change – the Costs of Inaction.* Prepared by Global Development and Environmental Institute – Tufts University for Friends of the Earth England, Wales and Northern Ireland. [Online]

Ackerman, F. and E.A. Stanton. 2006. *Implications of REACH for the Developing Countries*. Global Development and Environmental Institute – Tufts University for European Parliament, Directorate- General for External Policies of the Union. [Online]

Testimony and Expert Comments

Stanton, E.A. 2023. *Surrebuttal Testimony on Washington Gas Light Company's Application to the District of Columbia.* Testimony to the District of Columbia Public Service Commission on behalf of the Office of the People's Counsel for the District of Columbia. Formal Case No. 1169. [Online]

Stanton, E.A. 2022. *Testimony on the United Illuminating Company's Proposed Clean Energy Transformation Initiatives.* Testimony to Connecticut state Public Utilities Regulatory Commission on behalf of Connecticut Office of Consumer Counsel, Docket No. 22-08-08. [Online]

Stanton, E.A. 2022. *Testimony on Washington Gas Light Company's Application to the District of Columbia.* Testimony to the Public Service Commission of the District of Columbia on behalf of the Office of the People's Counsel for the District of Columbia, Formal Case No. 1169. [Online].

Stanton, E.A. 2022. *Testimony on the District of Columbia Public Service Commission Formal Case Number 1167 Regarding Washington Gas and Light Company's 5 and 30 Year Plans Affidavit.* Testimony to the District of Columbia Public Service Commission on behalf of the Office of the People's Counsel for the District of Columbia, Formal Case No. 1167. [Online]

Stanton, E.A. 2022. *Testimony on the District of Columbia Public Service Commission Formal Case Number 1167 Regarding Potomac Electric Power Company's 5 and 30 Year Plans Affidavit.* Testimony to the District of Columbia Public Service Commission on behalf of the Office of the People's Counsel for the District of Columbia, Formal Case No. 1167. [Online]

Stanton, E.A. 2022. *Testimony on the Proceeding on Motion of the Commission as to Rates, Charges, Rules and Regulations of Consolidated Edison Company of New York, Inc. for Electric Service*. Testimony to the New York State Public Service Commission on behalf of We Act for Environmental Justice and Alliance for a Green Economy, Case 22-E-0064/65. [Online]

Stanton, E.A. 2022. *Testimony on Eversource Energy's Certificate of Environmental Impact and Public Interest regarding the East Eagle Street Substation*. Testimony for the Commonwealth of Massachusetts Energy Facilities Citing Board on behalf of GreenRoots, Inc., and the Conservation Law Foundation, Docket No. EFSB 22-01. [Online]

Stanton, E.A., and J.R. Castigliego. 2022. *Testimony on National Grid's Off-Peak Charging Rebates in Massachusetts*. Testimony to Massachusetts' Department of Public Utilities on behalf of Green Energy Consumers Alliance, Docket No. 21-91. [Online]

Stanton, E.A., and J.R. Castigliego. 2022. *Testimony on Eversource's Off-Peak Charging Rebates in Massachusetts*. Testimony to Massachusetts' Department of Public Utilities on behalf of Green Energy Consumers Alliance, Docket No. 21-90. [Online]

Stanton, E.A. 2021. *Testimony on the Enbridge Energy Limited Partnership Proposed Replacement and Relocation of Line 5*. Testimony for Michigan Public Service Commission on behalf of The Environmental Law & Policy Center, The Michigan Climate Action Network, and the Bay Mills Indian Community. [Online]

Stanton, E.A. 2020. *Testimony on Dominion Energy South Carolina's 2020 Rate Case.* Testimony for Public Service Commission of South Carolina on behalf of Sierra Club, Docket No. 2020-125-E. [Online]

Stanton, E.A. 2020. *Surrebuttal Testimony on Pennsylvania's Duquesne Light Default Service Plan*. Testimony for Pennsylvania Public Utility Commission on behalf of MAREC Action, Docket No. 20-3019522. [Online]

Stanton, E.A. 2020. *Testimony on Pennsylvania's Duquesne Light Default Service Plan*. Testimony for Pennsylvania Public Utility Commission on behalf of MAREC Action, Docket No. 20-3019522. [Online]

Stanton, E.A. 2020. *Comments on AltaGas Climate Business Plan.* Comments to the Public Service Commission of the District of Columbia on behalf of DC Office of the People's Counsel, Formal Case No. 1142. [Online]

Stanton, E.A., B. Woods, and E. Tavares. 2020. *Comments on Massachusetts Decarbonization Roadmap*. Comments to the Massachusetts Executive Office of Energy and Environmental Affairs on behalf of Conservation Law Foundation. [Online]

Stanton, E.A., 2020. *Testimony on Algonquin Gas Transport Agreement*. Testimony to Massachusetts' Department of Public Utilities on behalf of the Town of Weymouth, Docket No. 19-132. [Online]

Stanton, E.A. 2019. *Testimony on Puerto Rico Electric Power Authority (PREPA) Least Cost Integrated Resource Plan*. Testimony to Puerto Rico Energy Bureau on behalf of Environmental Defense Fund, Docket No. 2018-0001. [Online]

Stanton, E.A. 2019. *Testimony on New Hampshire's Liberty Gas Supply Planning*. Testimony to the New Hampshire Public Utilities Commission on behalf of Conservation Law Foundation, Docket No.17-189. [Online]

Stanton, E.A. 2019. *Testimony on New Hampshire's Liberty Gas Supply Planning*. Testimony to the New Hampshire Public Utilities Commission on behalf of Conservation Law Foundation, Docket No. 17-152. [Online]

Stanton, E.A. 2019. *Comment on Transco's Assessment of Net Greenhouse Gas Emissions from NYC's Proposed NESE Pipeline*. Testimony to the New York State Department of

Environmental Conservation on behalf of Natural Resources Defense Council, ID No. 2-9902-00109/00006 WQC. [Online]

Stanton, E.A. 2019. *Testimony on NISPCO's Petition for Approval of Roaming Bison Wind Farm PPA.* Applied Economics Clinic. Prepared for Citizens Action Coalition of Indiana. [Online]

Stanton, E.A. 2019. *Testimony on NIPSCO's Petition for Approval of Jordan Creek Wind Farm PPA.* Applied Economics Clinic. Prepared for Citizens Action Coalition of Indiana. [Online]

Stanton, E.A. 2019. *Testimony in NIPSCO's 2019 Rate Case.* Applied Economics Clinic. Prepared for Citizens Action Coalition of Indiana. [Online]

Stanton, E.A. and R. Lopez. 2019. *Comment on National Grid's Proposed Off-Peak Charging Rebate*. Testimony to the Massachusetts Department of Public Utilities on behalf of Green Energy Consumers Alliance, Docket No. 18-150. [Online]

Comings, T., E.A. Stanton, and E. Tavares. 2019. *Comments on Xcel Energy Minnesota's 2018 Mankato Proposal.* Applied Economics Clinic. Prepared for Sierra Club. [Online]

Stanton, E.A. 2018. *Testimony Regarding the Joint Statewide Three-Year Energy Efficiency Plan for Massachusetts, 2019-2021.* Applied Economics Clinic. Prepared for Conservation Law Foundation. [Online]

Stanton, E.A. 2018. *Massachusetts Comprehensive Energy Plan: Comments on Stakeholder Meeting Presentation.* Applied Economics Clinic. Prepared for Conservation Law Foundation. [Online]

Stanton, E.A. 2018. *Minnesota Power EnergyForward Testimony*. Testimony to the Minnesota Public Utilities Commission on behalf of Minnesota Center for Environmental Advocacy and Fresh Energy, PUC Docket No. E-015/GR-17-568. [Online]

Stanton, E.A. 2018. *Testimony Regarding the Joint Statewide Three-Year Energy Efficiency Plan for Massachusetts, 2019-2021.* Testimony to the Commonwealth of Massachusetts Department of Public Utilities on behalf of Conservation Law Foundation, D.P.U. 18-110 – D.P.U. 18-119. [Online]

Stanton, E.A. 2018. *Comment on August 2018 Analysis of the Avoided Costs of Compliance of the MA GWSA*. Applied Economics Clinic. [Online]

Stanton, E.A. 2018. *Testimony Regarding Consistency of Petition with [Eversource] Portfolio Objectives, Adequacy of Alternatives Considered, and Consistency with State Environmental Policies.* Testimony to the Commonwealth of Massachusetts Department of Public Utilities on behalf of the Conservation Law Foundation, Docket No. DPU 17-175. [Online]

Stanton, E.A. 2018. *Testimony Regarding Consistency of Petition with [National Grid] Portfolio Objectives, Adequacy of Alternatives Considered, and Consistency with State Environmental Policies.* Testimony to the Commonwealth of Massachusetts Department of Public Utilities on behalf of the Conservation Law Foundation, Docket No. DPU 17-174. [Online]

Stanton, E.A. 2018. *Testimony Regarding Consistency of Petition with [Columbia Gas] Portfolio Objectives, Adequacy of Alternatives Considered, and Consistency with State Environmental Policies.* Testimony to the Commonwealth of Massachusetts Department of Public Utilities on behalf of the Conservation Law Foundation, Docket No. DPU 17-172. [Online]

Stanton, E.A. 2018. *Testimony Regarding Consistency of Petition with [Berkshire Gas] Portfolio Objectives, Adequacy of Alternatives Considered, and Consistency with State Environmental Policies.* Testimony to the Commonwealth of Massachusetts Department of Public Utilities on behalf of the Conservation Law Foundation, Docket No. DPU 17-145. [Online]

Stanton, E.A. 2017. *Testimony on Entergy New Orleans' Request to Construct New Orleans Power Station.* Testimony to the Council for the City of New Orleans on behalf of Alliance for Affordable Energy, Deep South for Environmental Justice, 350 Louisiana- New Orleans, and the Sierra Club, Docket No. UD-16-02. [Online]

Stanton, E.A. 2017. *Testimony Regarding Natural Gas Price Hedging in Florida.* Testimony to the Florida Public Service Commission on behalf of the Sierra Club, Docket No. 20170057-EI. [Online]

Stanton, E.A. 2017. *Testimony Regarding the Petition of Vectren for Approval of Its Proposed Demand Side Management and Energy Efficiency Programs for 2016-2018.* Testimony to the Indiana Utility Regulatory Commission on behalf of Citizens Action Coalition of Indiana, Cause No.44927 DSM-4. [Online]

Stanton, E.A. 2017. *Testimony Regarding Brockton Power Co., LLC.* Testimony to the Commonwealth of Massachusetts Department of Environmental Protection Office of Appeals and Dispute Resolution on behalf of the Residents of Brockton, West Bridgewater, and East Bridgewater, OADR Docket No. 2011-025 & 026. [Online]

Stanton, E.A. 2017. *Declaration in the matter of Clean Water Action, et al. v. E. Scott Pruitt, regarding the U. S. EPA's Steam Electric Effluent Limitation Guidelines*. Declaration prepared on behalf of Earthjustice and Environmental Integrity.

Stanton, E.A. 2017. *Testimony Regarding Northern Indiana Public Service Company's CPCN for Environmental Compliance Projects.* Testimony to the Indiana Utility Regulatory Commission on behalf of Citizens Action Coalition of Indiana, Cause No.448872.

Stanton, E.A. 2017. *Testimony Regarding the Petition of Duke Energy Indiana, Inc. for Approval of Its Proposed Demand Side Management and Energy Efficiency Programs for 2016-2018.* Testimony to the Indiana Utility Regulatory Commission on behalf of Citizens Action Coalition of Indiana, Cause No.43955 DSM-4. [Online]

Stanton, E.A. 2017. *Expert Comments Regarding Massachusetts' Department of Environmental Protection's Rulemaking Required by Section 3(d) of the Global Warming Solutions Act.* Expert comments submitted by Conservation Law Foundation. [Online]

Stanton, E.A. 2016. *Testimony Regarding the National Grid Analysis of Economic Benefits of Proposed Access Northeast Gas Pipeline.* Testimony to the Massachusetts Department of Public Utilities on behalf of Conservation Law Foundation, Docket No. 16-05. [Online]

Stanton, E.A. 2016. *Testimony Regarding the Eversource Analysis of Economic Benefits of Proposed Access Northeast Gas Pipeline.* Testimony to the Massachusetts Department of Public Utilities on behalf of Conservation Law Foundation, Docket No. 15-181. [Online]

Stanton, E.A. 2016. *Testimony on Byron Fleet Benefits.* Testimony to the Illinois Property Tax Appeal Board on behalf of Whitt Law, Docket Nos. 12-01248 and 12-02297.

Stanton, E.A., P. Knight, F. Ackerman, and N. R. Santen. 2015. *Byron Fleet Benefit Rebuttal.* Expert comments submitted by Whitt Law to the Illinois Property Tax Appeal Board, Docket Nos. 12-01248 and 12-02297.

Nogee, A., M. Chang, P. Knight, and E.A. Stanton. 2015. *Electricity Market Restructuring and the Nuclear Industry*. Expert comments submitted by Whitt Law testimony regarding Byron Station to the Illinois Property Tax Appeal Board, Docket Nos. 12-01248 and 12-02297.

Stanton, E.A. 2015. *Testimony on the Economic Analyses of a Proposed Brockton Power Company Generating Facility*. Testimony before the Massachusetts Department of Environmental Protection on behalf of Alternatives for Community & Environment, Docket No. 2011-025 & 026. [Online]

Stanton, E.A. and P. Knight. 2015. *Testimony in Opposition to HB 208 Repealing the New Hampshire Regional Greenhouse Gas Initiative*. Testimony to the Science, Technology and Energy Committee on behalf of New Hampshire's Office of Consumer Advocate. [Online]

Stanton, E.A. 2014. *Testimony Regarding the Cost of Compliance with the Global Warming Solutions Act*. Testimony to the Commonwealth of Massachusetts Department of Public Utilities on behalf of the Massachusetts Department of Energy Resources and the Department of Environmental Protection, Docket No. DPU 14-86. [Online]

Stanton E.A., F. Ackerman, and J. Daniel. 2014. *Comments on the 2013 Technical Update of the Social Cost of Carbon*. Submitted to the U.S. Office of Management and Budget as part of Environment, Economics, and Society Institute comments, Docket No. OMB-2013-0007. [Online]

Stanton, E.A. 2013. *Testimony Regarding the Prudency of Public Service of New Hampshire's Scrubber Project at Merrimack Station.* Testimony on behalf of the Conservation Law Foundation. Testimony to the New Hampshire Public Utilities Commission, Docket No. DE 11-250. [Online]

Stanton E.A., J. Daniel, F. Ackerman, and S. Jackson. 2013. *Review of EPA's June 2013 Steam Electric Effluent Limitations and Guidelines (40 CFR Part 423).* Submitted as part of Earthjustice/Sierra Club/Environmental Integrity Project testimony, Docket No. EPA-HQ-OW-2009-0819. [Online]

Stanton, E.A., P. Knight, and F. Ackerman. 2013. *LaSalle Fleet Benefit Rebuttal.* Expert comments submitted by Whitt Law to the Illinois Property Tax Appeal Board, Dockets No. 09-04906.001-I-3, 09-04906.002-I-310-03549.001, 10-03549.002, 12-00643.001, 12-00643.002, 12-00643.003.

Nogee A., M. Chang, P. Knight, and E.A. Stanton. 2013. *Electricity Market Restructuring and the Nuclear Industry.* Expert comments submitted by Whitt Law testimony regarding LaSalle Station to the Illinois Property Tax Appeal Board, Dockets No. 09-04906.001-I-3, 09-04906.002-I-310-03549.001, 10-03549.002, 12-00643.001, 12-00643.002, 12-00643.003.

Stanton, E.A. 2013. *Testimony Regarding Vermont Gas System's Petition for Authorization to Construct New Natural Gas Transmission Pipeline*. Testimony on behalf of the Conservation Law Foundation to the State of Vermont Public Service Board, Docket No. 7970. [Online]

Ackerman, F., and E.A. Stanton. 2011. *Regulation of Cooling Water Intake Structures at Existing Facilities.* Comments submitted to the U.S. Environmental Protection Agency, Docket ID EPA-HQ-OW-2008-0667. [Online]

Ackerman, F. and E.A. Stanton. 2010. *Testimony on EPA's 'Coal Combustion Residuals: Proposed Rule'.* Comment submitted as part of Earthjustice/Environmental Integrity Project testimony, Docket ID EPA-HQ-RCRA- 2009-6040. [Online]

Journal Articles

Stanton, E. A. 2019. "Kitchen Tables, Board Rooms and Other Potentially Disruptive Locales: The Role of Consumer Action in Carbon Emission Reduction." *Western New England Law Review*, 41(3), 553-562.

Luckow, P., J. Daniel, S. Fields, E.A. Stanton, and B. Biewald. 2014. "CO_2 Price Forecast: Planning for Future Environmental Regulations." *EM Magazine*, *June 2014*, 57-59. [Online]

Stanton, E.A. 2014. "What Carbon Costs Us." *Economists for Peace & Security Quarterly* 27 (4), 7-8. [Online]

Ackerman, F., E.A. Stanton, and R. Bueno. 2013. "Epstein-Zin utility in DICE: Is risk aversion irrelevant to climate policy?" *Environmental and Resource Economics* 56 (1), 73-84. [Online]

Stanton, E.A. 2012. "Modeling Pessimism: Does Climate Stabilization Require a Failure of Development?" *Environmental Development* 3, 65-76. [Online]

Stanton, E.A. 2012. "The Tragedy of Maldistribution: Climate, Sustainability, and Equity." *Sustainability* 4 (3): 394-411. [Online]

Erickson, P., D. Allaway, M. Lazarus, and E.A. Stanton. 2012. "A Consumption-Based GHG Inventory for the U.S. State of Oregon." *Environmental Science & Technology* 46 (7), 3679-3686. [Online]

Ackerman, F., E.A. Stanton, and R. Bueno. 2011. "CRED: A new model of climate and development." *Ecological Economics* 85, 166-176. [Online]

Ackerman, F. and E.A. Stanton. 2012. "Climate Risks and Carbon Prices: Revising the Social Cost of Carbon." *Economics: The Open-Access, Open-Assessment E-Journal* 6 (2012-10), 1-25. [Online]

Ackerman, F., E.A. Stanton, S. DeCanio, E. Goodstein, R. Howarth, R. Norgaard, C. Norman, and K. Sheeran. 2010. "The Economics of 350." *Solutions* 1 (5),49-56. [Online]

Ackerman, F., E.A. Stanton, and R. Bueno. 2010. "Fat Tails, Exponents, Extreme Uncertainty: Simulating Catastrophe in DICE." *Ecological Economics* 69 (8), 1657-1665. [Online]

Stanton, E.A. and F. Ackerman. 2009. "Climate and development economics: Balancing science, politics and equity." *Natural Resources Forum* 33 (4), 262-273. [Online]

Stanton, E.A., F. Ackerman, and S. Kartha. 2009. "Inside the Integrated Assessment Models: Four Issues in Climate Economics." *Climate and Development* 1 (2), 166-184. [Online]

Stanton, E.A. 2009. "Negishi welfare weights in integrated assessment models: The mathematics of global inequality." *Climatic Change* 107 (3), 417-432. [Online]

Ackerman, F., E.A. Stanton, C. Hope, and S. Alberth. 2009. "Did the Stern Review Underestimate U.S. and Global Climate Damages?" *Energy Policy* 37 (7), 2717-2721. [Online]

Ackerman, F. and E.A. Stanton. 2008. "Can Climate Change Save Lives? A comment on 'Economy-wide estimates of the implications of climate change: Human health'". *Ecological Economics* 66 (1), 8-13. (Previous edition appeared as Global Development and Environment Institute Working Paper No.06-05.) [Online]

Ackerman, F., E.A. Stanton, B. Roach, and A. S. Andersson. 2008. "Implications of REACH for Developing Countries." *European Environment* 18 (1): 16-29. [Online]

Ackerman, F., E.A. Stanton, and R. Massey. 2007. "European Chemical Policy and the United States: The Impacts of REACH." *Renewable Resources Journal* 25 (1). (Previously published as Global Development and Environment Institute Working Paper No.06-06.) [Online]

Books and Book Chapters

Ackerman, F. and E.A. Stanton. 2015. "Climate Impacts on Agriculture: A Challenge to Complacency?". *The Oxford Handbook of the Macroeconomic of Global Warming,* eds. Bernard, L. and W. Semmler. New York: Oxford University Press. (Previous edition appeared as Global Development and Environment Institute Working Paper No.13-01.) [Online]

Ackerman, F. and E.A. Stanton. 2014. *Climate and Global Equity*. London: Anthem Press.

Ackerman, F. and E.A. Stanton. 2013. *Climate Economics: The State of the Art (Routledge Studies in Ecological Economics)*. Oxford: Routledge.

Stanton, E.A. 2011. "Greenhouse Gases and Human Well-Being: China in a Global Perspective." *The Economics of Climate Change in China: Towards and Low-Carbon Economy* eds. Gang, F., N. Stern, O. Edenhofer, X. Shanda, K. Eklund, F. Ackerman, L. Lailai, K. Hallding. London: Earthscan. (Previous version appeared as Stockholm Environment Institute-U.S. Center Working Paper WP-US-0907.) [Online]

Boyce, J. K., E.A. Stanton, and S. Narain, eds. 2007. *Reclaiming Nature: Worldwide Strategies for Building Natural Assets*. London: Anthem Press.

Boyce, J. K., E.A. Stanton, and S. Narain. 2007. "Land Reform and Sustainable Development." *Reclaiming Nature: Worldwide Strategies for Building Natural Assets,* eds. Boyce, J. K., E.A. Stanton, and S. Narain. London: Anthem Press.

Stanton, E.A. 2007. "Inequality and the Human Development Index." PhD dissertation, University of Massachusetts-Amherst, 2007. [Online]

Stanton, E.A. and J. K. Boyce. 2005. *Environment for the People*. Political Economy Research Institute: Amherst, MA.

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