STATE OF NORTH CAROLINA
UTILITIES COMMISSION
RALEIGH

DOCKET NO. E-100, SUB 190

BEFORE THE NORTH CAROLINA UTILITIES COMMISSION

In the Matter of: Biennial Consolidated Carbon Plan and Integrated Resource Plans of Duke Energy Carolinas, LLC, and Duke Energy Progress, LLC, Pursuant to N.C.G.S. § 62-110.9 and § 62-110.1(c)	)	**DIRECT TESTIMONY OF ANDREW YATES, Ph.D., ON BEHALF OF NORTH CAROLINA ENVIRONMENTAL JUSTICE NETWORK AND ENVIRONMENTAL JUSTICE COMMUNITY ACTION NETWORK**

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Q: PLEASE STATE YOUR NAME AND JOB TITLE.

A: My name is Andrew J. Yates and I am a Professor of Economics at the University of North Carolina at Chapel Hill.

Q: ON WHOSE BEHALF ARE YOU TESTIFYING?

A: I am testifying on behalf of the North Carolina Environmental Justice Network and the Environmental Justice Community Action Network.

Q: HAVE YOU EVER TESTIFIED BEFORE ANY STATE UTILITY COMMISSIONS OR REGULATORY BODIES?

A: No.

Q: PLEASE BRIEFLY DESCRIBE YOUR EDUCATION AND PROFESSIONAL BACKGROUND.

A: I have an undergraduate degree in Systems Science and Engineering from Washington University in St. Louis. I have a MS and PhD in Engineering Economic Systems from Stanford University. I have been teaching and conducting research as an academic economist since 1993. I have taught at Wake Forest University, Tulane University, the University of Richmond, Duke University, and most recently at the University of North Carolina at Chapel Hill. My research speciality is environmental economics and I have published over 50 articles in leading economics and science journals. For the last decade I have studied issues related to air pollution from electric power plants. A complete Cirriculum Vitae is given in **Yates Exhibit 1**.

Q: WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A: The purpose of my testimony is to quantify the local air pollution externalities from new natural gas electricity plants proposed in the Duke Energy Carbon Plan Integrated Resource Plan (CPIRP).

Q: WHAT IS A SUMMARY OF YOUR FINDINGS?

A: The baseline analysis shows that costs per year to citizens of North Carolina range from 2.1 to 5.8 millions of dollars per year. Costs to rest of the US range from 7.2 to 10.2 millions of dollars per year. These costs account for the air pollution externalities due to emissions of NO_x and SO_2 from the plants. The variance in cost is due to different possible locations for the plants.

PART 1: Methodology and Analysis

Q: PLEASE DESCRIBE YOUR PREVIOUS ACADEMIC RESEARCH THAT INFORMS THE METHODOLOGY USED IN THIS ANALYSIS.

A: The general methodology used in this report has been developed over a series of academic papers that analyze the air pollution externalities from the electricity grid.[1] The local pollutants considered in these papers are primarily NO_x and SO_2 because of the availability of detailed emissions data and mappings from emissions to damages in dollars. Accordingly, we focus on NO_x and SO_2 as well.

Q: DESCRIBE THE PARTICULAR ANALYSIS UNDERTAKEN FOR THIS TESTIMONY.

A: There are two main steps. The first step is to determine the emissions of pollution from the proposed natural gas plants. The yearly emissions of a given pollutant from a given plant can be written as

$$emissions = emissions\ rate * capacity\ factor * capacity * 8760\ hours. \qquad (1)$$

The emission rate is specified as pounds per MWh and the capacity is specified in MW. The capacity factor (which is unitless) accounts for the fact that plants may be idle some of the

[1] Holland, Stephen, Erin Mansur, Nicholas Muller, and Andrew Yates. (2016) "Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors," *American Economic Review*, 106(12): 3700-3729. Holland, S., E. Mansur, N. Muller, and A. Yates (2019) "Distributional Effects of Air Pollution from Electric Vehicle Adoption," *Journal of the Association of Environmental and Resource Economists*, 6 (S1): S65-S94. Holland, Stephen, Erin Mansur, Nicholas Muller, and Andrew Yates. (2020) "Decompositions and Policy Consequences of an Extraordinary Decline in Air Pollution from Electricity Generation," *American Economic Journal: Economic Policy*, 12(4):244-74. Holland, Stephen, Matthew Kotchen, Erin Mansur, and Andrew Yates. (2022) "Why Are Marginal CO_2 Emissions Not Decreasing for U.S. Electricity? Estimates and Implications for Climate Policy," *Proceedings of the National Academy of Sciences*, 119(8): e2116632119. Holland, S., M. Kotchen, E. Mansur, and A. Yates (2024) "On the Feasibility, Costs, and Benefits of an Immediate Phasedown of Coal for U.S. Electricity Generation", NBER Working Paper 32235.

time. If a given power plants would run flat out in each hour of the year, then the capacity factor would be equal to one.

The second step is to evaluate the damages in monetary terms due to these emissions. The yearly damages can be written as

$$damages = emissions * marginal\ damages.$$

Marginal damages specify the harm in dollars from emitting a pound of pollution at a given location. Because the exact location of the future plants are not yet determined, we consider several different location scenarios. Values for the marginal damages come from the AP3 integrated assessment model.[2] AP3 uses physics to model the dispersion of emissions over space; chemistry to specify how emissions of NO_x and SO_2 combine with other elements in the atmosphere to create particulate matter; epidemiology to map increases in particulate matter into increases in mortality; and finally economics to convert increases in mortality into dollars of damages through value of statistical life techniques. Following 2010 EPA guidelines, AP3 uses a value of statistical life equal to $9.6 million. All values in this report are in terms of 2020 dollars.

Part 2: Data

Q: PLEASE DESCRIBE THE DATA USED IN THIS ANALYSIS.

A: Information about the number of new natural gas plants and their capacity comes from the 2024 update to the Duke Energy CPIRP.[3] To calculate the emissions rate and capacity factor for these plants, we first conduct an analysis of existing natural gas plants. The EPA's Continuous Emissions Monitoring System (CEMS) includes data on emissions of NO_x and SO_2 as well as the quantity of electricity generation from for all natural gas plants larger than 25 MW.[4] We use this data to determine emissions rates for each plant in the year 2022.

[2] Clay, K., A. Jha, N. Muller, and R. Walsh (2019) "The External Costs of Shipping Petroleum Products by Pipeline and Rail: Evidence of Shipments of Crude Oil from North Dakota," *The Energy Journal.* 40(1) 10.5547/01956574.40.1.kcla

[3] Chapter NC Supplement: 2023–2024 Carbon Plan and Integrated Resource Plan Supplemental Planning Analysis, Carolinas Resource Plan Docket No. E-100, Sub 190.

[4] https://campd.epa.gov

Because we expect that the proposed plants will be very clean relative to the existing set of plants, we calculated the 10th percentile of the distribution of emissions rates by plant type (combined cycle or combustion turbine) and use this value as the assumed emission rate for the proposed plants. The capacity factors for the proposed plants are determined in a similar way, although for them we use the 50th percentile because it is likely that the proposed plants will be utilized in a manner similar to existing plants. The values for emission rates and capacity factors are given in Table 1.

Table 1: Emission Rates and Capacity Factors

Plant Type	SO_2 Rate	NO_x Rate	Capacity Factor
Combined Cycle	0.0039	0.0433	0.499
Combustion Turbine	0.0051	0.104	0.056

Notes: Emission rates in lbs per MWh.

There are 5 new proposed combined cycle plants and 5 new proposed combustion turbine plants in the CPIRP. For each location scenario, we place these ten plants in various counties across North Carolina (See Table 2). As indicated in the CPIRP, combined cycle plants one and two are always placed in Person County and combustion turbine plants one and two are always placed in Catawba County. The AP3 model gives marginal damages for each county in the contiguous US for both NO_x and SO_2. We assign marginal damages to each proposed plant based on the county in which it is to be located.

Table 2: Plants and Location

Plant	Type	Capacity MW	Location Scenario 1	Location Scenario 2	Location Scenario 3
1	CC	1360.0	Person	Person	Person
2	CC	1360.0	Person	Person	Person
3	CC	1360.0	Cherokee	Dare	Wake
4	CC	1360.0	Clay	Hyde	Mecklenburg
5	CC	1360.0	Graham	Tyrrell	Guilford
6	CT	900.0	Catawba	Catawba	Catawba
7	CT	900.0	Catawba	Catawba	Catawba
8	CT	850.0	Cherokee	Dare	Guilford
9	CT	850.0	Clay	Hyde	Wake
10	CT	425.0	Graham	Tyrrell	Mecklenburg

Part 3: Results

Q: PLEASE DESCRIBE THE RESULTS THAT YOU FOUND IN YOUR ANALYSIS.

A: The results are shown in Table 3 . Scenario one has higher damages than scenario two. Scenario two places the power plants in the eastern part of the state so some of the pollution blows out to the ocean which lowers damages. Scenario three places the plants in the counties with the largest population in the state. Not surprisingly, this leads to the most damages within NC, although not to the rest of the US. In all scenarios the large majority of damages come from NO_x. A graphical analysis of county by county damages received in NC is shown in Figure 1. The counties in which the plants are located receive a large amount of damages. Damages are also large in counties with a large population, regardless of where the plants are located.

Table 3: Damages by Scenario

Scenario	NC Damages			All other States Damages		
	SO_2	NO_x	Total	SO_2	NO_x	Total
1	494.2	2120.9	2615.0	2268.3	7966.4	10234.7
2	387.3	1702.4	2089.7	1677.8	5555.8	7233.6
3	1067.6	4688.3	5755.9	2090.8	7218.0	9308.8

Notes: Damages in thousands of 2020 dollars per year.

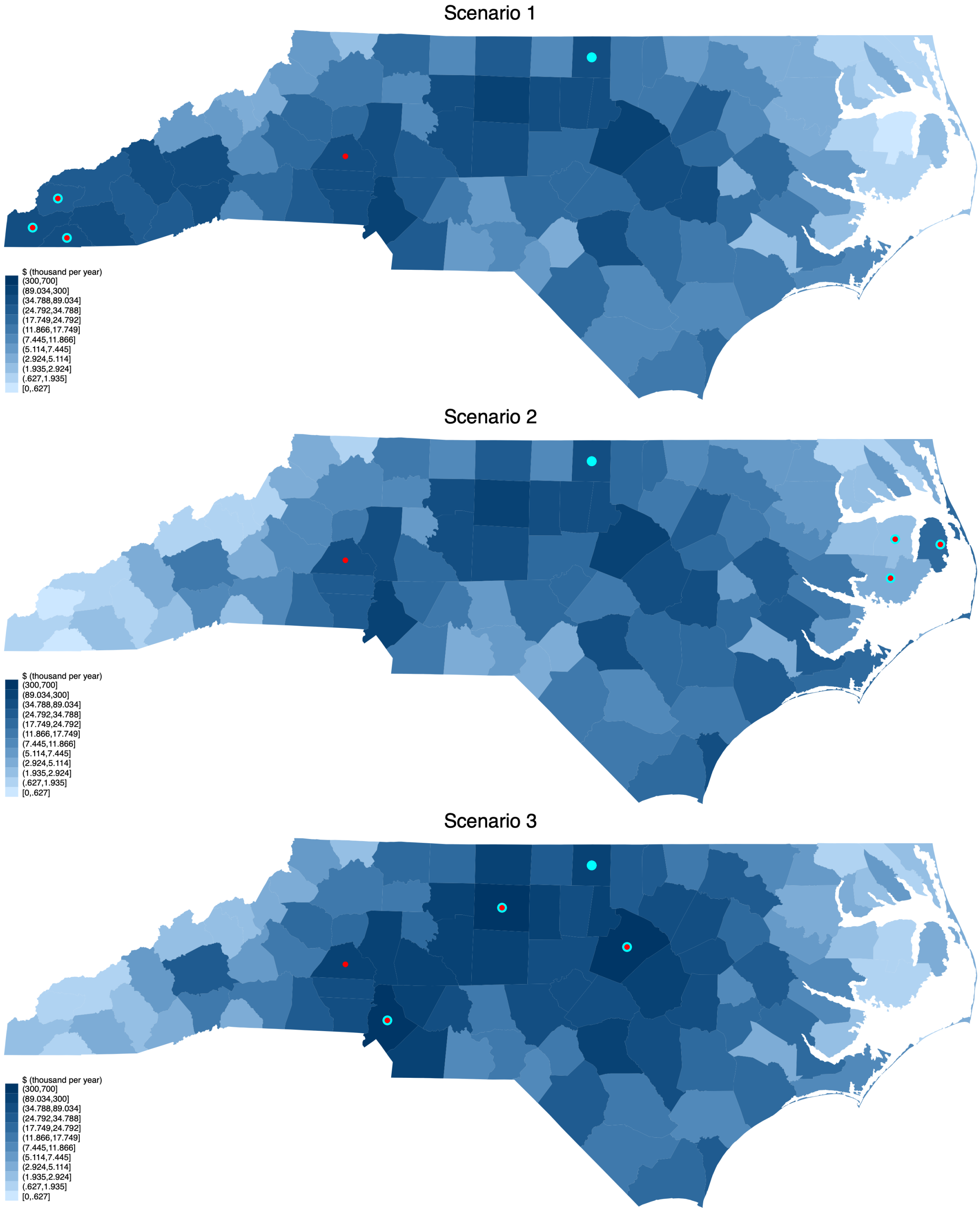

Figure 1: Local Damages by County in NC

Notes: Red dots indicate location of new Combustion Turbine plants. Cyan dots indicate location of new Combined Cycle plants. Damages is thousands of 2020 dollars per year. In each scenario there are two Combined Cycle plants in Person county and two Combustion Turbine plants in Catawba county.

Q: PLEASE DESCRIBE SENSITIVITY ANALYSIS AND HOW IT IS USED IN YOUR ANALYSIS.

A: Sensitivity analysis is often used to account for the fact that there may be uncertainty about some important variables. Here we focus on uncertainty in variables that we have constructed, we do not attempt to analyze uncertain variables in the AP3 model. Correspondingly, we consider alternative values for NO_x emission rates and capacity factors. In the baseline, the NO_x rates are set equal to the 10th percentile of the distribution in CEMS. We add a High case, in which the rates are equal to the 20th percentile, and a Low case, in which the rates are equal to the 5th percentile. For capacity factors, the baseline, High and Low percentiles are 50, 60, and 40 respectively. Table 4 shows the results of the sensitivity analysis for Scenario 1. Although the results are slightly more sensitive to the value of the NO_x emission rates, the overall message is that the estimates of damages are fairly robust to changes in assumptions about emission rates and capacity factors.

Table 4: Sensitivity Analysis for Scenario 1

Case	NC Damages			All other States Damages		
	SO_2	NO_x	Total	SO_2	NO_x	Total
CF Low	417.5	1772.3	2189.8	1927.8	6720.0	8647.8
CF High	568.7	2482.0	3050.7	2586.9	9191.2	11778.2
NOX Low	494.2	1874.3	2368.4	2268.3	7079.4	9347.7
NOX High	494.2	2873.0	3367.2	2268.3	10487.7	12756.0
Baseline	494.2	2120.9	2615.0	2268.3	7966.4	10234.7

Notes: Damages in thousands of 2020 dollars per year. Baseline uses 50th percentile for distribution of capacity factors and 10th percentile for distribution of NO_x emission rates in CEMS. CF Low uses 40th percentile for capacity factors, CF High uses 60th percentile. NO_x High uses 20th percentile for emission rates, NO_x Low uses 5th percentile for emission rates.

Part 4 : Caveats

Q: ARE THERE ANY FACTORS THAT CONTRIBUTE TO POLLUTION THAT YOU HAVE NOT ACCOUNTED FOR IN YOUR ANALYSIS?

A: There are a number of factors that are not quantified in this analysis. We have not accounted for direct emissions of particulate matter from the plants. The expansion of natural gas plants may generate additional air pollution from natural gas pipelines that feed the plants. We assumed that the air pollution effects simply add to the existing pollution burden, ignoring any possible non-linear interactions between them. In addition to air pollution, there may be other negative effects associated with the plants such as water pollution, effects on marine life, visibility, and so on.

Q: WHAT ARE YOUR FINAL THOUGHTS ABOUT THE ANALYSIS?

A: Overall, this assessment of air pollution from expanding the fleet of natural gas plants has been fairly conservative. As discussed above, there are additional types of pollution that have not been included. We have assumed that the new plants are very clean relative to existing plants and that they will be utilized in the same manner as the average existing plant. Due to these considerations, the actual value of damages may be greater than what has been presented here.

Q: DOES THIS CONCLUDE YOUR TESTIMONY?

A: Yes.

Exhibit 1
Curriculum Vitae of Andrew J Yates

Updated April, 2024

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EDUCATION

	Stanford University, Stanford CA.
1992	Ph.D. *Engineering Economic Systems.* Dissertation : An Efficiency Hierarchy For Constrained Economies
1988	M.S. *Engineering Economic Systems.*
	Washington University, St. Louis, Missouri.
1987	B.S. *Systems Science and Engineering*, Magna cum laude.

EXPERIENCE

	University of North Carolina at Chapel Hill, Chapel Hill, NC.
2018-	*Professor, Department of Economics and Environment, Ecology, and Energy Program.*
2016-2018	*Associate Professor, Department of Economics and Curriculum for the Environment and Ecology.* Received tenure in Spring 2016.
2013-2015	*Assistant Professor, Department of Economics and Curriculum for the Environment and Ecology.* Teaching Environmental Economics, Environmental Economic Theory, Environmental Markets: Science and Economics, Energy Economics, Intermediate Microeconomics.
	Duke University, Durham, NC.
Fall 2012	*Visiting Associate Professor, Nicholas School for the Environment.* Taught Resource and Environmental Economics, Theory of Environmental Policy: Taxes and Permits.
	University of Richmond, Richmond, VA.
2002- 2012	*Associate Professor, Department of Economics.* Received tenure in Spring 2004. Taught Advanced Environmental Economics, Introductory Statistics, Mathematical Economics Capstone, and Environmental Economics.
	Tulane University, New Orleans, LA.
2001	*Associate Professor, Department of Economics.* Received tenure in Spring 2001.
1998- 2001	*Assistant Professor, Department of Economics.* Taught Introductory Economics, Mathematical Economics, Environmental Economics, Intermediate Microeconomics, and Decisions Under Uncertainty.
	Wake Forest University, Winston Salem, NC.
1993- 1998	*Assistant Professor, Department of Economics.* Taught Introductory Economics, Intermediate Microeconomics, Environmental Economics, Political Economy of Environmental Policy, Seminar in Mathematical Economics, and Decision Analysis.

	Political Economy Research Center, Bozeman, Montana.
1992-1993	*Post-doctoral Fellow.*

PEER REVIEWED PUBLICATIONS

1. H. Fell, S. Holland, and A. Yates, "Optimal subsidies for green hydrogen generation", to appear, *Journal of the Association of Environmental and Resource Economists.*
2. A. Bruno, P. Weber, and A. Yates, "Can Bitcoin Mining Increase Renewable Electricity Capacity?", *Resource and Energy Economics*, 74, 2023, 101376.
3. A. Zeighami, J. Kern, A. Yates, P. Weber, and A. Bruno, "U.S. West Coast Droughts and Heat Waves Exacerbate Pollution Inequality and Can Undermine Emissions Control Policies", *Nature Communications*, 14, 2023, https://doi.org/10.1038/s41467-023-37080-0
4. S. Holland, M. Kotchen, E. Mansur, and A. Yates, "Why marginal CO_2 emissions are not decreasing for U.S. electricity: Estimates and implications for climate policy", *Proceedings of the National Academy of Sciences*, Vol. 119, No. 8, 2022, e21663291.
5. S. Cicala, S. Holland, E. Mansur, N. Muller, and A. Yates, "Expected health effects of reduced air pollution from COVID-19 social distancing", *Atmosphere*, Vol. 12, 2021, 951.
6. A. R. El-Khattabi, S. Eskaf, J. Isnard, L. Lin, B. McManus, and A. Yates, "Heterogeneous responses to price: Evidence from residential water consumers", *Journal of Environmental Economics and Management*, Vol. 107, 2021, 102430.
7. S. Holland, E. Mansur, and A. Yates, "The electric vehicle transition and the economics of banning gasoline vehicles", *American Economic Journal: Economic Policy*, Vol. 13, 2021, pp. 316-344.
8. S. Holland, E. Mansur, N. Muller, and A. Yates, "Measuring the environmental benefits from transportation electrification: Urban electric buses", *Energy Policy*, Vol. 148, 2021, 111921.
9. S. Holland, E. Mansur, N. Muller, and A. Yates, "Decompositions and policy consequences of an extraordinary decline in air pollution from electricity generation", *American Economic Journal: Economic Policy*, Vol 11, No. 4, 2020, pp. 244-274.
10. E. Meyer, B. Foster, G. Characklis, C. Brown, and A. Yates, "Integrating physical and financial approaches to manage environmental financial risk on the Great Lakes", *Water Resources Research*, Vol. 56, No. 5, 2020, pp. 1-17.
11. S. Holland, E. Mansur, N. Muller, and A. Yates, "Distributional effects of air pollution from electric vehicle adoption", *Journal of the Association of Environmental and Resource Economists*, Vol. 6, No. S1, 2019, pp. S65-S94.
12. Z. Mozenter, A. Yates, K. Schnier, J. Hughes, and G. Characklis, "Understanding water utility attitudes toward water transfers and risk: Pre-test results", *Journal of Water Resources Planning and Management*, Vol. 144, 2018.
13. D. Bielen and A. Yates, "Optimal regulation of pollution with stochastic exposure, acute damages, and chronic damages", *Journal of Cleaner Production*, Vol. 162, 2017, pp. 96-108.
14. S. Holland, E. Mansur, N. Muller, and A. Yates, "Are there environmental benefits from driving electric vehicles? The importance of local factors," *American Economic Review*, Vol. 106, 2016, pp. 3700-3729.
15. S. Holland, E. Mansur, N. Muller, and A. Yates,"Damages and expected deaths due to excess NOx emissions from 2009-2015 Volkswagen diesel vehicles," *Environmental Science and Technology*, Vol. 50, 2016, pp. 1111-1117.

16. S. Holland and A. Yates, "Optimal trading ratios for pollution permit markets," *Journal of Public Economics*, Vol. 125, 2015, pp. 16-27.

17. W. Pizer and A. Yates, "Terminating links between emission trading programs," *Journal of Environmental Economics and Management*, Vol. 71, 2015, pp. 142-159.

18. M. Doyle, L. Patterson, Y. Chen, K. Schnier, and A. Yates, "Optimizing the scale of markets for water quality trading," *Water Resources Research*, Vol. 50, 2014, pp. 7231-7244.

19. K. Schnier, M. Doyle, J. Rigby, and A. Yates, "Bilateral oligopoly in pollution permit markets: experimental evidence," *Economic Inquiry*, Vol. 52, 2014, pp. 1060-1079.

20. T. BenDor, T. Guo, and A. Yates, "Optimal advanced credit releases in ecosystem service markets," *Environmental Management*, Vol. 53, 2014, pp. 496-509.

21. A. Yates, M. Doyle, J. Rigby, and K. Schnier, "Market power, private information, and the optimal scale in pollution permit markets with application to North Carolina's Neuse River," *Resource and Energy Economics*, Vol. 35, 2013, pp. 256-276.

22. S. Datta, R. Shreremeta, and A. Yates, "Best-of-three Contest Experiments: Strategic versus Psychological Momentum," *International Journal of Industrial Organization*, Vol. 31, 2013, pp. 287-296.

23. A. Yates, "On a Fundamental Advantage of Permits over Taxes for the Control of Pollution", *Environmental and Resource Economics*, Vol. 51, 2012, pp. 583-598.

24. A. Yates, "Winner-pay Contests", *Public Choice*, Vol. 147, 2011, pp. 93-106.

25. M. Doyle and A. Yates, "Ecosystem Service Markets Under No-Net-Loss Regulation", *Ecological Economics*, Vol. 69, 2010, pp. 820-827.

26. D. Malueg and A. Yates, "Testing Contest Theory: Evidence from Best-of-three Tennis Matches", *Review of Economics and Statistics*, Vol. 92, 2010, pp. 689-692.

27. D. Malueg and A. Yates, "Bilateral Oligopoly, Private Information, and Pollution Permit Markets", *Environmental and Resource Economics*, Vol. 43, 2009, pp. 553-572.

28. D. Malueg and A. Yates, "Strategic Behavior and Private Information in the EU Permit Trading System'", *Environmental and Resource Economics*, Vol. 43, 2009, pp. 413-432.

29. J. Heckelman and A. Yates, "Senate Elections with Independent Candidates", *Journal of Theoretical Politics*, Vol. 20, 2008, pp. 31-46.

30. K. Hutchinson and A. Yates, "Crime on the Court: A Correction," *Journal of Political Economy*, Vol. 115, 2007, pp. 515-519.

31. D. English and A. Yates, "Citizens' Demand for Permits and Kwerel's Incentive Compatible Mechanism for Pollution Control," *Economics Bulletin*, Vol. 17 No. 4, 2007, pp. 1-9.

32. D. Malueg and A. Yates, "Equilibria in Rent-Seeking Contests with Homogeneous Probability Functions," *Economic Theory*, Vol. 27, 2006, pp. 719-727.

33. D. Malueg and A. Yates, "Citizen Participation in Pollution Permit Markets", *Journal of Environmental Economics and Management*, Vol. 51, 2006, pp. 205-217.

34. D. Malueg and A. Yates, "Comparative Statics in Two-Player Contests," *European Journal of Political Economy*, Vol. 21, 2005, pp. 738-752.

35. D. Malueg and A. Yates, "Rent Seeking with Private Values," *Public Choice*, Vol. 119, 2004, pp. 161-178. Reprinted in R. Congleton, A. Hillman, and K. Konrad (Eds.) *Forty Years of Research on Rent Seeking*, Springer, 2008.

36. S. Smith. and A. Yates, "Optimal Pollution Permit Endowments in Markets with Endogenous Emissions," *Journal of Environmental Economics and Management* Vol. 46, 2003, pp. 425-445.

37. J. Heckelman and A. Yates, "And a Hockey Game a Broke Out: Crime and Punishment in the NHL," *Economic Inquiry*, Vol. 41, 2003, pp. 705-712
38. S. Smith and A. Yates, "Should Consumers be Priced Out of Pollution Permit Markets?" *Journal of Economic Education*, Vol. 34, 2003, pp. 181-189.
39. E. Stone, A. Yates, and A. Caruthers, "Risk Taking in Decision Making for Others versus the Self," *Journal of Applied Social Psychology,* Vol. 32, 2002, pp. 1797-1824.
40. A. Yates, "Decentralization in Pollution Permit Markets," *Journal of Public Economic Theory,* Vol. 4, 2002, pp. 641-660.
41. J. Heckelman and A. Yates, "Incumbency Preservation through Electoral Legislation: The Case of the Secret Ballot," *Economics of Governance,* Vol. 3, 2002, pp. 47-57.
42. A. Yates and J. Heckelman, "Rent Setting in Multiple Winner Rent Seeking Contests," *European Journal of Political Economy*, Vol. 17, 2001, pp. 835-852.
43. A. Yates and M. Cronshaw, "Pollution Permit Markets with Intertemporal Trading and Asymetrical Information," *Journal of Environmental Economics and Management*, Vol. 42, 2001, pp. 104-118.
44. A. Yates, "On the Separation of Risk Assessment and Risk Management," *Journal of Environmental Planning and Management*, Vol. 44, 2001, pp. 509-524.
45. A. Yates, "The Knowledge Problem, Entrepreneurial Discovery, and Austrian Market Process Theory," *Journal of Economic Theory*, Vol. 91, 2000, pp. 59-85. Reprinted in S. Gloria-Palermo (Ed.) *Modern Austrian Economics*, Pickering and Chatto, 2002.
46. A. Yates and R. Stroup, "Media Coverage and EPA Pesticide Decisions," *Public Choice*, Vol. 102, 2000, pp. 297-312.
47. A. Yates, "Optimality and Lindahl Equilibrium," *Journal of Economic Research*, Vol. 4, 1999, pp. 37-60.
48. I. Speizer and A. Yates, "Polygyny and African Couple Research," *Population Research and Policy Review* Vol. 17, No. 6, December 1998, pp. 551-570.
49. A. Yates, "The Equal Marginal Value Principle: A Graphical Analysis with Environmental Applications," *Journal of Economic Education*, Vol. 29, No. 1, Winter 1998, pp. 23-31.
50. A. Yates and D. Luenberger, "An Efficiency Hierarchy for Constrained Economies," *Public Finance / Finances Publiques* Vol. 52 No. 2, 1997, pp. 270-288.
51. A. Yates, "Hotelling and the New York Stock Exchange." *Economics Letters*, Vol. 56, No. 1, 1997, pp. 107-110.
52. A. Yates, "The Unobserved Relation Regressions Model with an Application to Used Truck Prices," *Southern Economic Journal*, Vol. 64, No. 1, July 1997, pp. 45-55.
53. A. Yates, "A Sufficiency Result for Constrained Economies," *Journal of Mathematical Economics*, Vol. 27, No. 4, May 1997, pp. 411-424.

MANUSCRIPTS IN PREPARATION

S. Holland, E. Mansur, and A. Yates, "Electrification in the Long Run".

S. Holland, E. Mansur, V. Verdier, and A. Yates, "Regularization from Economic Constraints: A New Estimator for Marginal Emissions".

S. Holland, M. Kotchen, E. Mansur, and A. Yates, "On the Feasibility, Costs, and Benefits of an Immediate Phasedown of Coal for U.S. Electricity Generation".

RESEARCH GRANTS

The coupled, co-evolving roles of drought and electricity systems in humans' exposure to air pollution, *National Science Foundation*, 2020-2024, Role: Co-PI, Effort 0.5 month per year. With J. West, T. Pavelsky, J. Kern, and S. Skiles, Total Budget from NSF $1,599,708

Designing Robust and Adaptive Water Management Strategies in Regions Transitioning from Abundance to Scarcity, *National Science Foundation*, 2014-2018, Role: Co-PI, Effort: 1 month per year. With G. Characklis, L. Band, J. Hughes, and P. Reed, Total Budget from NSF $1,701,235.

The Proper Scale of Environmental Markets with Applications to Nitrogen Trading in the Neuse River Basin, *National Science Foundation*, 2009-2013, Role: PI, Effort: 1 month per year. With M. Doyle and K. Schnier, Total Budget from NSF $540,583.

PROFESSIONAL ACTIVITIES

Co-editor, *Journal of the Association of Environmental and Resource Economists*, 2014-2022.
Co-editor, *Journal of Environmental Economics and Management*, 2010-2013.

Referee

American Economic Journal: Applied Economics
American Economic Review
B.E. Journal of Theoretical Economics
Contemporary Economic Policy
Econometrica
The Energy Journal
Environmental and Resource Economics
European Journal of Political Economy
Games and Economic Behavior
International Economic Review
International Journal of Industrial Organization
Journal of Economic Research
Journal of Economic Behavior and Organization
Journal of the European Economic Association
Journal of Public Economic Theory
Journal of Sports Economics
Mathematical Social Sciences
Public Choice
Review of Economics and Statistics
Review of Industrial Organization
Southern Economic Journal
Theory and Decision
American Economic Journal: Economic Policy
American Journal of Agricultural Economics
Canadian Journal of Economics
Economic Theory
Ecological Economics
Energy Policy
Environmental Science and Technology
European Economic Review
Health Effects Institute
International Journal of Economic Theory
Journal of Economic Education
Journal of Economic Surveys
Journal of Environmental Economics and Management
Journal of Public Economics
Journal of Optimization Theory and Applications
Journal of the Assoc. of Environ. and Resource Econ.
Management Science
Quarterly Journal of Economics
Review of Economic Design
Scandinavian Journal of Economics
Strategic Behavior and the Environment
Water Resources Research

RECENT PRESENTATIONS

"Decarbonization and Electrification in the Long Run", Bern Energy Economics Workshop, August 2021, NBER Summer Institute, July 2022, EPIC-China, November 2022.

"Measuring the environmental benefits from transportation electrification: Urban electric buses", NBER conference on New Directions in Transportation Economics, June 2021.

"Decompositions and policy consequences of an extraordinary decline in air pollution from electricity generation", NBER Spring Meeting, Stanford CA, March 2019, University of Kansas, May 2019.

"Second best dynamic subsidies for the adoption of electric durable goods", Workshop on Environmental

Taxes v. Other Approaches: What Have We Learned? University of Maryland, September 2018.

"Distributional effects of air pollution from electric vehicle adoption", London School of Economics, December 2016, Toulouse School of Economics, December 2016, University of Hamburg, December 2016, AERE Summer Conference, June 2017.

"Measuring the spatial heterogeneity in environmental externalities from driving: A comparison of gasoline and electric vehicles", AEA Annual Meeting, January 2015. NBER Energy and Environmental Economics Spring Meeting, March 2015. USAEE Annual Meeting, October 2015. Southern Economic Association Annual Meeting, November 2015. University of Maryland, March 2016.

"The optimal scale for water quality markets", PERC Summer Workshop, July 2014.

"Optimal trading ratios for pollution permit markets", East Carolina University, February 2014. Triangle Resource and Environmental Economics seminar series, March 2014.

"Linking and Delinking Pollution Permit Markets", AERE summer conference, June 2013.

"Permit Markets for Non-uniformly Mixed Pollution: Trading Ratios Versus Zones", AERE summer conference, June 2012.

"Optimal Contracts for Wetland Mitigation", Southern Economic Association annual meeting, November 2011.

"Market Power, Private Information, and Scale in Pollution Permit Markets", AERE summer conference, June 2011. Resources for the Future research seminar, May 2011.

UNDERGRADUATE HONOR THESIS SUPERVISION

1. Andrew Conroy, Economics, UNC "Bitcoin mining and electrical grid reliability', 2024.
2. Pallavi Maladkar, Economics, UNC "Impact of carbon emissions regulation policies in Canadian provinces on greenhouse gas emissions and macroeconomics measures, 2024.
3. Hannah Rubenstein, Economics, UNC "Charging the Renewable Transition: Modeling the Role of Battery Storage in the Energy Grid", 2023.
4. Harrison Cho, Economics, UNC " The Airborne Toxic Event: The Effects of Socioeconomic Characteristics on Ambient Air Pollution and the Decision to Over Pollute", 2020.
5. Shuhan Xia, Economics, UNC "The short run effects of the double score policy in China", 2018.
6. Jailing Jiang, Economics, UNC "Environmental Policy and Air Pollution", 2017.
7. Robert Harris, Economics, UNC "Price volatility in renewable energy certificate markets: Implementing rate standards", 2016.
8. John Burrows, Curriculum for the Environment and Ecology, UNC "Resilient timber construction in the era of climate change: lessons from the mountain pine beetle", 2014.
9. John Schmale, Economics, UNC "The impact of the EU carbon price changes on the stock performance of European electricity firms", 2014.
10. Gregory Grissom, Economics, UNC "Determining the Optimal Subsidy for Plug-in Electric Vehicles in the United States by County", 2013.

GRADUATE STUDENT DISSERTATION COMMITTEES

Main Advisor

1. Julien Isnard, Economics, UNC: Defended November 2022.
2. Abe Martin, Economics, UNC: Defended May 2021.

Reader

1. Estonia Black, Economics UNC: Defended April 2023.
2. Johanna Kangas, Agriculture and Forestry, University of Helsinki, Defended April 2022 (external pre-examiner).
3. Andrey Minaev, Economics, UNC: Defended March 2021.
4. A. R. El-Khattabi, City and Regional Planning, UNC: Defended March 2020.
5. Eddie Watkins, Economics, UNC: Defended April 2019.
6. Aisling Winston, Economics, UNC: Defended June 2018.
7. Brad Shrago, Economics, UNC: Defended May 2017.
8. Evan Johnson, Public Policy, UNC: Defended April 2016.
9. Matthew Horne, Economics, UNC: Defended March 2016.
10. Justin Contat, Economics, UNC: Defended July 2015.
11. Kenneth Reddix II, Economics, UNC: Defended May 2015.
12. Yiyi Lui, Economics, UNC: Defended May 2015.
13. Dave Bielen, Economics, Duke: Defended April 2015.
14. Melati Nungsari, Economics, UNC: Defended March 2015.
15. Kimmo Ollikka, Economics and Management, University of Helsinki: Defended April 2014 (external pre-examiner).

SERVICE

Economics Department

Interim Chair (Spring 2019)

Advisory Committee (2014-2015) Curriculum Committee (2015-2016, Chair 2016-2017, 2020-2023, Chair 2022-2023) Recruiting (2017-2018, 2021-2022, 2023-2024) Personnel Committee (2019-2021) Post-Tenure Review Committee (2018-2021), Advisory Committee (2023-2024)

Curriculum for the Environment and Ecology

Graduate Exam Committee (ad hoc), Internal Planning Committee (ad hoc) Graduate Admissions Committee (2015-2017), Recruiting (2018-2019), Director of Graduate Studies (2018-2021), Program Review: Graduate Program (2022-2023), Executive Committee (2023-)

University

Board of Advisors, Center for Climate, Energy, Environment and Economics, UNC Law School (2016-2020)
Sustainability Advisory Committee (2015-2020)