PUBLIC SERVICE COMMISSION OF SOUTH CAROLINA

In the Matter of Annual Review of Base Rates for Fuel Costs for Duke Energy Carolinas, LLC	**} } } Docket No. 2016-3-E } }**

Direct Testimony of Thomas Vitolo, PhD

On Behalf of South Carolina Coastal Conservation League and Southern Alliance for Clean Energy

On the Topic of

NEM Methodology 2016 Application

Annual Review of Base Rates for Fuel Costs for Duke Energy Carolinas, LLC

August 19, 2016

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1. INTRODUCTION AND QUALIFICATIONS

Q. Please state your name and business address for the record.

A. My name is Tommy Vitolo, and I am a Senior Associate with Synapse Energy Economics (Synapse) at 485 Massachusetts Avenue, Suite 2, Cambridge, Massachusetts 02139.

Q. Please describe Synapse Energy Economics.

A. Synapse Energy Economics is a research and consulting firm specializing in electricity and natural gas industry regulation, planning, and analysis. Our work covers a range of issues, including integrated resource planning; economic and technical assessments of energy resources; electricity market modeling and assessment; energy efficiency policies and programs; renewable resource technologies and policies; and climate change strategies. Synapse works for a wide range of clients, including attorneys general, offices of consumer advocates, public utility commissions, environmental advocates, the U.S. Environmental Protection Agency, the U.S. Department of Energy, the U.S. Department of Justice, the Federal Trade Commission, and the National Association of Regulatory Utility Commissioners. Synapse has over 25 professional staff with extensive experience in the electricity industry.

Q. Please summarize your professional and educational experience.

A. I have a PhD in systems engineering from Boston University; a master's in financial and industrial mathematics from Dublin City University, Ireland; bachelor's degrees in applied mathematics, computer science, and economics from North Carolina State University; and more than eight years of professional experience as a consultant, researcher, and analyst.

Since joining Synapse in 2011, I have focused on utility resource planning, variable resource integration, avoided costs, and other issues that typically involve

statistical analysis, computer simulation modeling, and stochastic processes. I have filed testimony or reviewed utility filings in 18 states, primarily by evaluating numerical analysis, modeling, and decision strategies of resource plans and certificates of public convenience and necessity applications.

On topics related to the costs and benefits of distributed generation—including net metering issues, avoided costs, bill impacts, and appropriate rate design—I have developed or submitted testimony in Vermont, South Carolina, California, Utah, and Wisconsin. Additionally, I have performed cost and benefits analyses of distributed generation for systems located in Maine, Massachusetts, Mississippi, New York, and North Carolina.

Prior to joining Synapse, I worked as a research assistant at MIT Lincoln Laboratory. My CV is attached as Exhibit TV-1.

Q. On whose behalf are you testifying in this proceeding?

A. I am testifying on behalf of the South Carolina Coastal Conservation League and Southern Alliance for Clean Energy.

Q. Have you testified previously before the South Carolina Public Service Commission ("the Commission")?

A. Yes, I have. I testified in Commission Docket No. 2014-246-E, In re: the Petition of the Office of Regulatory Staff to Establish Generic Proceeding Pursuant to the Distributed Energy Resource Program Act, Act No. 236 of 2014, Ratification No. 241, Senate Bill No. 1189. My testimony in that docket focused on the methodology for calculating the costs and benefits of solar net energy metering. I also testified in Commission Docket Nos. 2016-1-E and 2016-2-E, In re: Duke Energy Progress—Annual Review of Base Rates for Fuel Costs in May, 2016 and In re: South Carolina Electric & Gas Company—Annual Review of Base Rates for Fuel Costs in April, 2016. My testimony in those dockets included input on the 2016 application of the Net Energy Metering ("NEM") Methodology for

valuing distributed energy resources ("DER") in Duke Energy Progress and South Carolina Electric & Gas systems.

Q. What is the purpose of your direct testimony in this proceeding?

A. The purpose of my testimony is to provide input on the 2016 application of the Net Energy Metering ("NEM") Methodology for valuing distributed energy resources ("DER") on Duke Energy Carolinas, LLC's ("DEC" or "the Company") system within South Carolina. DEC includes zero values for most of the NEM Methodology calculations for 2016. My testimony is narrowly focused on providing input on how to proceed with filling in several of these components within the NEM Methodology. Please note my not addressing each of the zero value components does not mean that I agree that zero is the appropriate value for those components.

Q. How is the remainder of your testimony organized?

A. My testimony is organized as follows:

1. Introduction and Qualifications,
2. Summary of Conclusions and Recommendations,
3. Background Information on the NEM and Fuel Cost Proceedings,
4. Net Energy Metering Methodology—2016 Application, and
5. Conclusion.

Q. Are you sponsoring any exhibits?

A. Yes. I am sponsoring the following exhibits:

- TV-1 (Resume of Thomas John Vitolo), and

- TV-2 (Docket No. 2014-246-E Settlement Agreement Attachment A: Net Energy Metering "NEM" Methodology).

2. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Q. Please summarize your primary conclusions.

A. My primary conclusions, discussed and supported in greater detail below, are summarized as follows:

1. Revisions to the "Components of NEM Distributed Energy Resource Value" table would improve clarity and transparency of the NEM Methodology application.

2. It is possible at this time for DEC to make explicit its Avoided Criteria Pollutants value, and appropriate for it to do so.

3. A detailed study of avoided environmental costs as they relate to distributed solar photovoltaic ("PV") generation would allow for DEC to quantify its avoided Environmental Costs value, and would further improve application of the NEM Methodology.

4. A detailed study of avoided transmission and distribution costs and an updated line losses study as they relate specifically to distributed PV generation would further improve application of the NEM Methodology.

Q. Please summarize your primary recommendations.

A. I recommend that the Company revise its "Components of NEM Distributed Energy Resource Value" calculations as presented in Company Witness Felt's Table 2 as follows:

1. Restore the "T&D Capacity" row to the Components of NEM Distributed Energy Resource Value table (Witness Felt Direct Testimony, page 7, table 2).

2. Provide the numeric Avoided Criteria Pollutants value separately from Avoided Energy value. In other words, present the value in the Avoided Criteria Pollutants category/row rather than including only a footnote reference to it within the Avoided Energy Cost category.

To move further towards fully applying the NEM Methodology, I recommend that DEC conduct or commission three studies:

1. A broader environmental cost avoidance study, particularly with regard to (though not limited to) coal-fired generators. This study will serve to quantify the value for which NEM generation reduces exposure to costs related to environmental damage prevention or remediation.

2. An avoided transmission and distribution capacity study. This study should allow DEC to calculate and report its PV-specific NEM Distributed Energy Resource Value of the T&D Capacity component.

3. A line loss study. This study would determine hourly marginal line losses related to avoided energy, generating capacity, and transmission capacity associated with increased distributed PV generation in the jointly-dispatched Duke Carolinas system.

3. BACKGROUND INFORMATION ON THE NEM AND FUEL COST PROCEEDINGS

Q. Please describe your involvement with the generic net energy metering proceeding, Commission Docket No. 2014-246-E.

A. I provided testimony in that docket describing and recommending cost and benefit categories for valuing distributed energy resources, particularly for solar PV resources. That testimony was filed on behalf of South Carolina Coastal Conservation League and Southern Alliance for Clean Energy.

Q. What was the outcome of the generic net energy metering proceeding?

A. The parties in that proceeding reached a settlement agreement that was reviewed and approved by the Commission. The settlement agreement included a methodology framework for valuing the costs and benefits of distributed energy resources including solar PV (the "NEM Methodology"). The NEM Methodology included a list of components, a description of each component, and details for the calculation methodology/value for each component. A copy of the NEM Methodology approved by the Commission in that proceeding is attached as Exhibit TV-2.

Q. What cost and benefit categories are included in the NEM Methodology approved in the generic net metering docket?

A. As shown in Exhibit TV-2, the components are:

- +/- Avoided Energy
- +/- Energy Losses/Line Losses
- +/- Avoided Capacity
- +/- Ancillary Services
- +/- Transmission and Distribution Capacity
- +/- Avoided Criteria Pollutants
- +/- Avoided CO_2 Emissions Cost
- +/- Fuel Hedge
- +/- Utility Integration & Interconnection Costs
- +/- Utility Administration Costs
- +/- Environmental Costs

Q. What is the relationship between the NEM Methodology and the DEC Fuel Cost proceeding?

A. The settlement agreement approved in the generic net energy metering docket requires the costs and benefits of net metering distributed energy resources to be computed under the NEM Methodology and updated annually, coincident in time with the utilities' fuel cost dockets. The NEM Methodology results are included on the utility's NEM tariff. DEC has filed its update to the methodology calculations for 2016 in the present fuel cost proceeding, as described in the testimony and exhibits of DEC Witnesses Emily O. Felt and Kim H. Smith. The results of the NEM Methodology have a direct impact on the Company's recovery of incremental costs for its Distributed Energy Resource Programs.

Q. When was the NEM Methodology first incorporated into DEC's NEM tariff?

A. DEC filed its first NEM tariff with a value of DER included in 2015, in Commission Docket No. 2015-203-E, Application of Duke Energy Carolinas, LLC for Approval of Renewable Net Metering Rider, RNM-1.

Q. What was your role in the 2015 DEC NEM tariff proceeding?

A. I provided review and guidance to CCL and SACE as they formulated comments to submit to DEC and the Commission.

Q. Do you know the outcome of that proceeding?

A. Yes. The Commission approved the 2015 NEM tariff; and in Directive/Order No. 2015-591 approving the tariff, the Commission encouraged DEC to review and consider comments filed by Office of Regulatory Staff and intervenors—including CCL and SACE—before filing proposed updated renewable net metering tariffs in the future. The comments included many recommendations to DEC for improving its value of DER and NEM Methodology in the 2016 update.

4. NET ENERGY METERING METHODOLOGY—2016 APPLICATION

Q. Did the Company correctly calculate the total value of NEM distributed energy resources?

A. No. The total value of NEM resources calculated by the Company, as shown in Table 2 of Company Witness Felt's testimony, is incomplete and in some places, inaccurate. At a high level, one cost and benefit category was omitted entirely (Avoided Transmission and Distribution Capacity), and only three of the ten cost and benefit categories included in the table include non-zero values. A fourth cost and benefit category, Avoided Criteria Pollutants, is expressed with a zero value although a footnote makes explicit that the non-zero avoided cost is included in the Avoided Energy Cost category. A number of remaining categories have been assigned a value of $0.00000 by the Company without careful study, despite those categories having been found to have non-zero values in a variety of other jurisdictions by a number of other studies.

Best Practices in Reporting Component Values

Q. What are best practices with respect to representing the value of each component with the NEM Distributed Energy Resource valuation?

A. Each component of the valuation should be included, and the full value of each component should be calculated using an appropriate methodology and reported clearly and unambiguously within that component category as a cost (or benefit) associated with that component. Under the language of the 2014 NEM settlement agreement approved in Commission Order 2015-194 in Docket 2014-246-E, all costs and benefits that are "quantifiable" are appropriate for inclusion in the NEM Distributed Energy Resource valuation.[1]

Q. Did DEC include each NEM Distributed Energy Resource valuation component in its reporting?

A. It did not. Witness Felt's Direct Testimony (page 7, table 2) details the components DEC included. Avoided transmission and distribution capacity does not appear in the list.

Q. Did DEC consistently present the values it calculated for each category within the respective category listed in Table 2?

A. No. DEC's presentation of the Value of NEM Distributed Energy Resource by Component (Witness Felt Direct Testimony, page 7, table 2) fails to separately make clear the value of a NEM Distributed Energy Resource component: Avoided Criteria Pollutants. The Avoided Criteria Pollutants value is currently included within the Avoided Energy component category, rather than separately represented.

[1] S.C. PSC Docket No. 2014-246-E, Settlement Agreement, at II.5, *available at* https://dms.psc.sc.gov/Attachments/Matter/46a1fee8-155d-141f-233230a670190eb2.

Avoided Criteria Pollutants

Q. How has DEC presented the value associated with the Avoided Criteria Pollutants category?

A. DEC listed the value for Avoided Criteria Pollutants as $0.00000/kWh but included a footnote stating that "Avoided Criteria Pollutants are included in avoided energy." (Witness Felt Direct Testimony, page 7, table 2).

Q. Is there a better way to provide the value associated with the Avoided Criteria Pollutants category?

A. Yes. DEC should calculate the value of the Avoided Criteria Pollutants, expressed in $ per kWh, for both Small PV and Large PV, and then list that calculated value on the Avoided Criteria Pollutants line and deduct that amount from the Avoided Energy Cost line. The calculation should be straightforward, as the hourly dispatch models used to calculate avoided energy cost typically report the costs associated with Avoided Criteria Pollutants as a specific and distinct category. This remedy will not change the total reported value of NEM distributed energy resource for Small PV or Large PV, but it will provide additional clarity on the value of each component.

Avoided Transmission and Distribution Capacity

Q. Is Avoided Transmission and Distribution Capacity a NEM Methodology category?

A. Yes. Avoided Transmission and Distribution Capacity is a cost and benefit category to be included in the NEM Methodology, as agreed to by the Company and other parties in Commission Docket No. 2014-246-E.

Q. Did DEC include the Avoided Transmission and Distribution Capacity value in its NEM DER valuation?

A. DEC did not include the Avoided Transmission and Distribution Capacity value component in its NEM DER Valuation table, Table 2 of Witness Felt's testimony. This may have been a typographical error, given that Witness Felt states on page 6, line 17 of her Direct Testimony that Table 2 "lists the components of value in the standardized methodology." If DEC has made a determination that the value of Avoided Transmission and Distribution Capacity is $0.00000 per kWh, it has failed to provide support for this determination, in addition to failing to list it in the valuation categories.

Environmental Costs

Q. How has DEC presented the value associated with the 2016 Environmental Costs?

A. DEC represented the value as $0.00000. (Witness Felt Direct Testimony, page 7, table 2).

Q. Please comment on DEC's use of a zero value for the Environmental Costs component.

A. It is not clear from DEC testimony that the Company has attempted to calculate or quantify this component at this time. Despite DEC's approach, it is unreasonable to assume that the current value is zero.

Q. Why is a zero value inappropriate for the Environmental Costs component?

A. There are many environmental costs that can be avoided through the decreased use of conventional combustion technologies such as coal, oil, and natural gas. Some, like criteria pollutant costs, have been calculated by DEC, as explained above. Other costs, such as the costs related to management and disposal of waste

and wastewater produced by coal-fired generators, are substantial but their avoidance does not appear to have been included.

Q. Please provide an example of additional costs that you believe should have been included in DEC's calculation of avoided Environmental Costs.

A. I will provide three examples of such costs related to coal generation. DEC's four coal-fired power plants, as well as the coal-fired power plants owned by Duke Energy Progress, LLC that are dispatched for the benefit of DEC customers,[2] generate large quantities of coal ash waste and wastewater effluent. These wastes are regulated under the U.S. EPA's recently revised Coal Combustion Residuals (CCR) rule and Effluent Limitation Guidelines and Standards for Steam Electric Power Generating Units (ELG), respectively, as well as by the North Carolina Coal Ash Bill.[3] The utility incurs costs to manage these wastes, and implementation of the newly adopted rules will impose new requirements on companies like DEC and Duke Energy Progress, LLC. Therefore, to the extent that NEM distributed energy resources reduce the dispatch of the coal units, those NEM resources are allowing the Company to avoid the environmental costs associated with coal ash waste and wastewater effluent.

<u>CCR</u>

As an example, DEC's Marshall Plant is a 2,090 megawatt coal-fired power plant located in Terrell, NC. The plant currently has approximately 30 million tons of coal ash stored on-site in ash ponds and landfills, and continues to generate more as it operates. Ash ponds are considered high risk structures, especially in light of numerous recent failures that led to the unintentional release of millions of tons of coal ash waste. Under EPA's new CCR rule, existing ash ponds like the one storing ash at the Marshall plant must comply with several new requirements.

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[2] S.C. PSC Docket Nos. 2011-158-E and 2011-68-E, Settlement Agreement, *available at* http://www.regulatorystaff.sc.gov/Documents/News%20Archives/DukeProgressSettlement.pdf.

[3] 2014 N.C. Sess, Laws 122; 2014 N.C. Ch. 122; 2013 N.C. SB 729.

These include location restrictions, groundwater monitoring and corrective action requirements, closure requirements, and post-closure care. Furthermore, construction of new ash ponds is severely restricted by the new rule.

The CCR rule also places new restrictions on landfills. Existing landfills must comply with groundwater monitoring and corrective action requirements, operating criteria (e.g., weekly and annual inspections, fugitive dust controls, and run-on, run-off controls), closure requirements, and post-closure care, in addition to recordkeeping, notifications, and publicly accessible website requirements. New landfills (and lateral expansions of existing landfills) must also meet location restrictions regarding: proximity to the uppermost aquifer, wetlands, fault areas, seismic impact zones, and unstable areas, as well as design criteria regarding composite liner and leachate collection and removal systems.

These requirements have costs, and each additional ton of coal ash generated will have a higher cost than it did before these rules were adopted. Since NEM DER resources serve to avoid generation at DEC's and Duke Energy Progress's coal plants, they also help avoid these costs. Therefore, DEC should calculate the value of this benefit.

ELG

Coal-fired power plants generate a number of polluted wastewater streams. The four units at the Marshall Plant, for example, are equipped with wet flue gas desulfurization unit (FGD or "scrubber") technology for the removal of sulfur dioxide, which generates one of the wastewater streams regulated by the new ELG rule. FGD wastewater can contain mercury, arsenic, selenium, and other harmful pollutants. The ELG rule requires the treatment or elimination of these wastewater streams in order to reduce the discharge of these contaminants into surrounding waterways.

To the extent that NEM resources are avoiding generation at DEC's and Duke Energy Progress' coal plants, they are also reducing the generation of these and other wastewater streams. DEC should calculate the value of this benefit.

North Carolina Coal Ash Bill

As described in its petition seeking an Accounting Order to Defer Certain Coal Ash Remediation Costs filed with this Commission on May 6, 2016 in SC Public Service Commission Docket No. 2016-196-E, DEC and Duke Energy Progress, LLC must comply with the North Carolina Coal Ash Bill,[4] which, among other things, prohibits new ash pond construction and expansion of existing ash impoundments at coal-fired power plants. To the extent that NEM resources are avoiding coal generation and thus the generation of coal ash, these resources are providing a benefit that should be valued by DEC and included in the Environmental Costs category as an avoided cost.

Q. How would you recommend DEC proceed with respect to determining its company- and state-specific avoided Environmental Costs component value?

A. NEM distributed energy resources allow for landfills and ash ponds to fill more slowly, for less wastewater to treat, and for deferral of the construction of new structures. All of this has a real economic value that is attributable to the NEM resources and should be quantified and included in DEC's calculations. Therefore, DEC should conduct or commission a detailed study of avoided environmental costs as they relate to distributed PV generation. This would allow for DEC to quantify its avoided Environmental Costs value, and would further improve application of the NEM Methodology.

[4] North Carolina Coal Ash Bill, 2014 N.C. Sess, Laws 122; 2014 N.C. Ch. 122; 2013 N.C. SB 729, as amended.

Transmission and Distribution Capacity Costs

Q. How has DEC presented the value associated with the 2016 avoided Transmission and Distribution Costs?

A. DEC failed to include a component value for Transmission and Distribution (T&D) Capacity, for both Small and Large PV. If DEC intends to include a value of $0.00000 per kWh for avoided Transmission and Distribution Capacity costs, this determination has not been supported in the filed testimony.

Q. Do you agree with a $0.00000 assessment for avoided Transmission and Distribution Capacity costs?

A. In my opinion, it is unlikely the avoided T&D Capacity value is actually zero for DEC. Of the 15 studies included in Rocky Mountain Institute's "A Review of Solar PV Benefit & Cost Studies, 2nd Edition,"[5] 12 studies included avoided transmission and distribution benefits within the avoided cost categories. All 12 included a non-zero avoided cost associated with transmission and distribution capacity.

Because every utility has a unique transmission and distribution topology and configuration, a utility-specific study is the best way to accurately quantify DEC's specific avoided T&D Capacity value. That value is almost certainly a non-zero value.

Q. How would you recommend DEC proceed with respect to determining its company- and state-specific Avoided T&D component value?

A. As an initial matter, DEC should include the T&D component in its list of values in Table 2 of Witness Felt's testimony. Furthermore, to the extent that DEC lacks

[5] L. Hansen & V. Lacy, Rocky Mountain Institute, *A Review of Solar PV Benefit and Cost Studies*, *available at* http://www.rmi.org/Knowledge-Center%2FLibrary%2F2013-13_eLabDERCostValue.

sufficient capability and information to quantify both the costs and benefits related to the transmission and distribution impacts of DER adoption, I recommend that DEC conduct or commission a utility- and state-specific avoided transmission and distribution cost study to correctly determine its avoided T&D Capacity costs, rather than including a zero value for this component. It would likely be appropriate for DEC and Duke Energy Progress, LLC to jointly commission a study covering both territories in their entirety, dividing the avoided costs between the two entities as appropriate.

Line Losses

Q. How has DEC presented the value associated with the 2016 line loss calculations?

A. Table 2 at page 7, lines 1-17 of Witness Felt's Direct Testimony provides a line loss value of $0.00219 for Small PV and $0.00218 for Large PV. I believe that the discrepancy between the DEC and Duke Energy Progress, LLC line loss values filed earlier this year are noteworthy: in Commission Docket No. 2016-1-E, Duke Energy Progress, LLC asserted line losses nearly 25 percent less, $0.00167/kWh for Small PV and $0.00168/kWh for Large PV. The discrepancy between the DEC and Duke Energy Progress, LLC values and the efficiencies attributable to joint DEC-Progress operations underscore the appropriateness of a new study.

Q. Do you have any recommendations regarding DEC's line loss calculations?

A. Yes. I recommend that DEC conduct a new or updated line loss study for marginal line losses on the joint Duke Energy Progress-Duke Energy Carolinas system in order to quantify avoided energy, generating capacity, and transmission capacity costs associated with line losses. The study should be specific to the Companies' expected future hourly load forecasts and expected generator and transmission infrastructure. The study should use a solar PV profile rather than a fixed constant output profile, since most NEM resources in the near future are

expected to be PV resources in DEC territory. In response to S.C. Coastal Conservation League and Southern Alliance for Clean Energy's discovery request 1-3 in the current proceeding, DEC provided line loss factors that appear to be unique to DEC (rather than accounting for the merger with Progress Energy) and dated summer 2012.[6] This data does not appear to account for the Duke Energy – Progress Energy merger, and therefore does not account for the two companies jointly dispatching to meet combined load. Finally, a description of how the Company has calculated its line losses should be included in testimony for future NEM Methodology updates.

Additional Components

Q. Is there anything you would like to add regarding other components in the value of NEM Distributed Energy Resource methodology?

A. As mentioned earlier in my testimony, DEC has included zero values for most of the components in the 2016 application of the value of NEM Methodology. My testimony is narrowly focused on providing input on how to proceed with filling in several of these components within the NEM Methodology. Beyond those addressed in detail in my testimony, the components DEC has valued at zero include fuel hedge; ancillary services; avoided CO_2 emissions costs; and integration, interconnection, and administrative costs. That I have not addressed all of these zero value components does not mean I agree that zero is the appropriate value. These components may warrant closer scrutiny in future annual updates.

[6] Duke Energy Carolinas, "Duke Energy – Carolinas, Development of Demand Loss Factors, Summer 2012," Data Response to CCL and SACE Data Request 1-3.

5. CONCLUSION

Q. Do you have any recommendations for the Commission?

A. My recommendations for the Commission appear in Section 2 of my testimony, beginning on page 4.

Q. Does this conclude your testimony?

A. Yes.

Thomas J. Vitolo, Ph.D., Senior Associate

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PROFESSIONAL EXPERIENCE

Synapse Energy Economics Inc., Cambridge, MA. *Senior Associate,* 2015 – present*, Associate*, 2011 – 2015.

Conducts research, authors reports, and prepares expert testimony. Consults on issues related to renewable resources, distributed energy resources, integrated resource planning, municipal utility planning, coal asset valuation, renewable energy and carbon markets, compliance, and cost-benefit analysis.

Jointown Group Co., Ltd., Wuhan, China. *Systems Engineer Intern*, Summer 2007.

Developed and implemented a modified (*s*,*S*) inventory management scheme for over 20,000 warehoused pharmaceutical products, resulting in more orders filled, lower carrying costs, and a reduction in the frequency of product expiration.

MIT Lincoln Laboratory, Division 6, Group 65, Lexington, MA. *Research Assistant*, 2003 **–** 2006.

Designed algorithm and implemented software to create autonomous wireless point-to-point topologies for aerial, land-based, and nautical vehicles as part of an Optical & RF Combined Link Experiment (ORCLE) funded by Defense Advanced Research Projects Agency (DARPA).

EDUCATION

Boston University, Boston, MA
Doctor of Philosophy in Systems Engineering, 2011. Developed algorithms to discover degree constrained minimum spanning trees in sparsely connected graphs.

Dublin City University, Dublin, Ireland
Master of Science in Financial and Industrial Mathematics, 2001. Researched partial differential equations modeling fluid flow over an erodible bed.

North Carolina State University, Raleigh, North Carolina
Bachelor of Science in Applied Mathematics, 2000. *Summa Cum Laude*.
Bachelor of Science in Computer Science, 1999. *Summa Cum Laude*.
Bachelor of Science in Economics, 1998. *Summa Cum Laude*.

TESTIMONY

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Public Service Commission of South Carolina (Docket No. 2016-1-E): Direct testimony regarding Duke Energy Progress' NEM Methodology 2016 Application of Base Rates for Fuel Costs. On behalf of South Carolina Coastal Conservation League and Southern Alliance for Clean Energy. May 19, 2016.

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Hornby, R., D. White, T. Vitolo, T. Comings, K. Takahashi. 2012. *Potential Impacts of a Renewable and Energy Efficiency Portfolio Standard in Kentucky*. Synapse Energy Economics for Mountain Association for Community Economic Development and Kentucky Sustainable Energy Alliance.

Keith, G., B. Biewald, E. Hausman., K. Takahashi, T. Vitolo, T. Comings, P. Knight. 2011. *Toward a Sustainable Future for the U.S. Power Sector: Beyond Business as Usual 2011*. Synapse Energy Economics for Civil Society Institute.

PRESENTATIONS AND POSTER SESSIONS

Vitolo, T. 2016. “Some Value of Solar Remarks.” Presentation for EUCI’s “Net Energy Metering and Utility Solar Rates” seminar, July 21, 2016.

Vitolo, T., P. Luckow. 2016. "New Renewable Generation Capacity – Why Here and Not There?" Webinar by Synapse Energy Economics, June 22, 2016.

Vitolo, T., D. Lescohier, E. Frey, L. O. Pehlke. 2016. "Comparing Two Brookline Water Department Rate Proposals." Presentation to Brookline Board of Selectmen, Brookline, MA, June 21, 2016.

Vitolo, T. 2016. "Value of Solar: What & How, Who & Where, and Why." Presentation for the Solar Market Pathways Sustainable Communities Leadership Academy, Boston, MA, June 7, 2016.

Vitolo, T. 2016. "Local Action Big Results: Community Choice Aggregation." Presentation at Brookline Climate Week 2016, March 30, 2016.

Vitolo, T. 2016. "Getting a Local Energy Project Up and Running: Community Choice Aggregation." Presentation for Local Environmental Action Conference 2016, March 13, 2016.

Vitolo, T. 2016. “How That Thing in Your Pocket Will Cut Carbon Emissions in Half.” Lecture for the Boston University City Planning and Urban Affairs Program, March 8, 2016.

Vitolo, T. 2015. Oral testimony regarding Belmont proposed distributed generation compensation policy. Presentation to Net Metering Working Group, Belmont, MA, July 16, 2015.

Vitolo, T. 2015. “Avoided Costs Associated with Distributed Generation and the Intersection of DG Valuation and Integrated Resource Planning.” Presentation in Salt Lake City, UT, May 12, 2015.

Stanton, E. A., B. Biewald, D. Hurley, P. Peterson, T. Vitolo. 2015. "Clean Energy Advocates Bootcamp: Understanding Supply and Demand in New England." Presentation in Cambridge, MA, February 12, 2015.

Vitolo, T. 2015. Oral testimony regarding the Dallman 31/32 coal-fired power plant retrofit or retire decision. Presentation to Springfield Committee of the Whole, Springfield, Illinois, February 10, 2015.

Vitolo, T. 2015. "Community Solar in Context." Presentation at Brookline Climate Week 2015, February 4, 2015.

Vitolo, T. 2014. "Net Metering and Mississippi." Presentation at the 13th Annual Southern BioProducts and Renewable Energy Conference, November 13, 2014.

Vitolo, T. 2014. Comments in New York Association for Energy Economics panel regarding the operation and economics of Indian Point Nuclear Plant, November 4, 2014.

Vitolo, T. 2013. "How Big an Issue is Intermittency? Integrating Renewables into a Reliable, Low-Carbon Energy Grid," Presentation for Civil Society Institute webinar, April 17, 2013.

Vitolo, T. 2009. "RPS in the USA: The Present Impact and Future Possibilities of Renewable Portfolio Standards in America." Presentation at Boston University Energy Club Seminar Series.

Vitolo, T. 2007. "An ILP Approach to Spanning Tree Problems on Incomplete Graphs with Heterogeneous Degree Constraints." Presentation at INFORMS Annual Meeting.

Vitolo T., J. Hu., L. Servi, V. Mehta. 2005. "Topology Formulation Algorithms for Wireless Networks with Reconfigurable Directional Links." Proceedings of the IEEE Military Communications Conference, October 2005.

Vitolo, T. 2004. "Topology Design and Traffic Routing for Wireless Networks with Node-Based Topological Constraints." Presentation at Boston University CISE Seminar Series.

ADDITIONAL EXPERIENCE

TEACHING

- Guest Lecturer, Boston University City Planning and Urbans Affairs Program, 2015 – present
- Graduate Teaching Fellow, Boston University College of Engineering. *Introduction to Engineering Computation*, 2009
- Guest Lecturer, Boston University Department of Systems Engineering, *Case Studies in Inventory Management*, 2007-2008
- Guest Lecturer, Boston University Department of Systems Engineering, Solving Linear Programs with CPLEX, 2003-2008

GOVERNMENT SERVICE

- *Constable*, Brookline, MA, 2010 – present
- *Town Meeting Member*, Brookline, MA, 2007 – present
- *Bicycle Advisory Committee Member*, Brookline, MA, 2007 – present.

OTHER INFORMATION

FELLOWSHIPS AND SCHOLARSHIPS

- National Science Foundation IGERT Fellowship, 2006 – 2008
- National Science Foundation GK-12 Fellowship, 2002 – 2003
- Mitchell Scholarship, 2000 – 2001
- Park Scholarship, 1996 – 2000

ADDITIONAL SKILLS

- Computer Applications: Microsoft Office, LaTeX
- Programming: Fortran, C, C++, perl, MATLAB, CPLEX

AFFILIATIONS

- Center for Computation Science, Boston University, 2006 – 2010
- Center for Information and Systems Engineering, Boston University, 2002 – 2010

Resume dated August 2016.

Settlement Agreement Attachment A

Net Energy Metering ("NEM") Methodology

+/- Avoided Energy
+/- Energy Losses/Line Losses
+/- Avoided Capacity
+/- Ancillary Services
+/- Transmission and Distribution ("T&D") Capacity
+/- Avoided Criteria Pollutants
+/- Avoided CO_2 Emission Cost
+/- Fuel Hedge
+/- Utility Integration & Interconnection Costs
+/- Utility Administration Costs
+/- Environmental Costs
= **Total Value of NEM Distributed Energy Resource**

The following table details the components of the Methodology.

Methodology Component	Description	Calculation Methodology/Value
+/- Avoided Energy	Increase/reduction in variable costs to the Utility from conventional energy sources, i.e. fuel use and power plant operations, associated with the adoption of NEM.	Component is the marginal value of energy derived from production simulation runs per the Utility's most recent Integrated Resource Planning ("IRP") study and/or Public Utility Regulatory Policy Act ("PURPA") Avoided Cost formulation.
+/- Energy Losses/Line Losses	Increase/reduction of electricity losses by the Utility from the points of generation to the points of delivery associated with the adoption of NEM.	Component is the generation, transmission, and distribution loss factors from either the Utility's most recent cost of service study or its approved Tariffs. Average loss factors are more readily available, but marginal loss data is more appropriate and should be used when available.
+/- Avoided Capacity	Increase/reduction in the fixed costs to the Utility of building and maintaining new conventional generation resources associated with the adoption of NEM.	Component is the forecast of marginal capacity costs derived from the Utility's most recent IRP and/or PURPA Avoided Cost formulation. These capacity costs should be adjusted for the appropriate energy losses.
+/- Ancillary Services	Increase/reduction of the costs of services for the Utility such as operating reserves, voltage control, and frequency regulation needed for grid stability associated with the adoption of NEM.	Component includes the increase/decrease in the cost of each Utility's providing or procurement of services, whether services are based on variable load requirements and/or based on a fixed/static requirement, i.e. determined by an N-1 contingency. It also includes the cost of future NEM technologies like "smart inverters" if such technologies can provide services like VAR support, etc.

Settlement Agreement Attachment A

Methodology Component	Description	Calculation Methodology/Value
+/- T&D Capacity	Increase/reduction of costs to the Utility associated with expanding, replacing and/or upgrading transmission and/or distribution capacity associated with the adoption of NEM.	Marginal T&D distribution costs will need to be determined to expand, replace, and/or upgrade capacity on each Utility's system. Due to the nature of NEM generation, this analysis will be highly locational as some distribution feeders may or may not be aligned with the NEM generation profile although they may be more aligned with the transmission system profile/peak. These capacity costs should be adjusted for the appropriate energy losses.
+/- Avoided Criteria Pollutants	Increase/reduction of SOx, NOx, and PM10 emission costs to the Utility due to increase/reduction in production from the Utility's marginal generating resources associated with the adoption of NEM generation if not already included in the Avoided Energy component.	The costs of these criteria pollutants are most likely already accounted for in the Avoided Energy Component, but, if not, they should be accounted for separately. The Avoided Energy component must specify if these are included.
+/- Avoided CO_2 Emissions Cost	Increase/reduction of CO_2 emissions due to increase/reduction in production from each Utility's marginal generating resources associated with the adoption of NEM generation.	The cost of CO_2 emissions may be included in the Avoided Energy Component, but, if not, they should be accounted for separately. A zero monetary value will be used until state or federal laws or regulations result in an avoidable cost on Utility systems for these emissions.
+/- Fuel Hedge	Increase/reduction in administrative costs to the Utility of locking in future price of fuel associated with the adoption of NEM.	Component includes the increases/decreases in administrative costs of any Utility's current fuel hedging program as a result of NEM adoption and the cost or benefit associated with serving a portion of its load with a resource that has less volatility due to fuel costs than certain fossil fuels. This value does not include commodity gains or losses and may currently be zero.
+/- Utility Integration & Interconnection Costs	Increase/reduction of costs borne by each Utility to interconnect and integrate NEM.	Costs can be determined most easily by detailed studies and/or literature reviews that have examined the costs of integration and interconnection associated with the adoption of NEM. Appropriate levels of photovoltaic penetration increases in South Carolina should be included.
+/- Utility Administration Costs	Increase/reduction of costs borne by each Utility to administer NEM.	Component includes the incremental costs associated with net metering, such as hand billing of net metering customers and other administrative costs.
+/- Environmental Costs	Increase/reduction of environmental compliance and/or system costs to the Utility.	The environmental compliance and/or Utility system costs might be accounted for in the Avoided Energy component, but, if not, should be accounted for separately. The Avoided Energy component must specify if these are included. These environmental compliance and/ or Utility system costs must be quantifiable and not based on estimates.