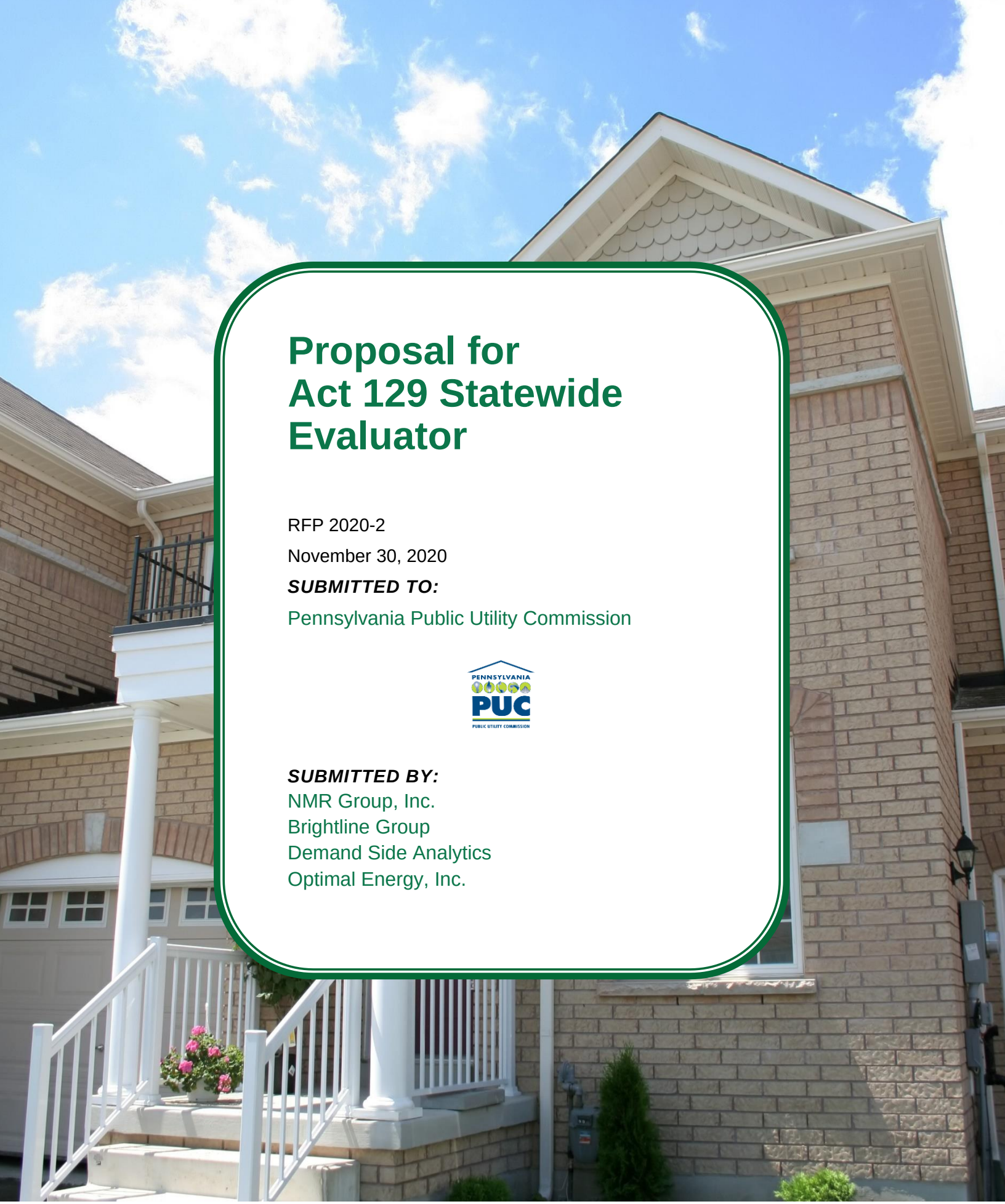

Proposal for Act 129 Statewide Evaluator

RFP 2020-2

November 30, 2020

SUBMITTED TO:

Pennsylvania Public Utility Commission

SUBMITTED BY:

NMR Group, Inc.
Brightline Group
Demand Side Analytics
Optimal Energy, Inc.

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Executive Summary

NMR Group, Inc. (NMR), Demand Side Analytics (DSA), BrightLine Group (BLG), and Optimal Energy – collectively referred to as "the NMR team" – are pleased to submit this proposal to the Pennsylvania Public Utility Commission (PUC), Bureau of Technical Utility Services (TUS) to serve as the Phase IV Statewide Evaluator (SWE). The NMR team understands the importance of the SWE to the PUC – that the SWE provides independent, rigorous, and timely monitoring and verification of the Pennsylvania Electric Distribution Companies' (EDCs') data collection, quality assurance processes, and performance of EDCs' Energy Efficiency and Conservation (EE&C) programs, while also conducting an assessment of potential future energy-efficiency savings and peak demand reductions.[1] The NMR team is ideally suited to serve as the Phase IV SWE. As the incumbent SWE, our experience with the processes, manuals, and studies adopted during Phase III will allow us to seamlessly transition from Phase III to Phase IV. Our experienced and dedicated staff have extensive knowledge from Phase III and previous Phases. The core staff from Phase III will remain committed to serving on the Phase IV SWE, as is evident from the hours dedicated to the SWE during Phase IV (see Table 19 in Section 2.11).

The key strengths of the NMR team are highlighted below:

Knowledge of Act 129 for efficient auditing. A fundamental role of the SWE is to audit EDC progress toward, and compliance with, existing conservation targets. Our familiarity with Act 129 and all of the guiding documents allow us to be very efficient with our audit activities. The staff who updated the Technical Reference Manual (TRM) and authored the Total Resource Cost (TRC) Order and Audit Plan/Evaluation Framework have a clear advantage when it comes to auditing evaluation procedures for consistency with the key requirements.

Familiarity with Act 129 stakeholder, goal setting, and regulatory environment. Another fundamental role of the SWE is to inform the PUC's proposed goals for cost-effective energy-efficiency and peak demand reductions for the following phase. We understand the important and significant interrelationships between the statewide baseline studies, the TRM updates and order, the TRC test updates and order, the market potential studies, and informing the PUC's proposed targets in subsequent phases. We have an excellent understanding of the regulatory procedures and schedules to provide support to TUS staff for the following critical tasks: writing tentative orders, reviewing stakeholder comments, and summarizing and drafting dispositions to stakeholder comments in final orders.

Expert advice and guidance. With our knowledge of industry trends and best practices, experience with providing evaluation oversight in other jurisdictions, and unmatched historical knowledge of evaluations in Pennsylvania, the NMR team will assist the PUC with insights regarding best practices in impact evaluation and program implementation;

[1] Act 129 directs EDCs with at least 100,000 customers to develop and file EE&C plans.

information and support for PUC discussions, meetings, and workshops; and expert testimony regarding the evaluation findings and results. The SWE will also provide the PUC with objective recommendations on the appropriate balance of evaluation rigor and cost and what evaluation, measurement, and verification (EM&V) approaches are reasonable given program budgets, contribution to savings, and uncertainty. Importantly, we have historically not pushed to mold Act 129 programs after what California and Massachusetts are doing because we understand the Commonwealth has its own policy priorities and those should always be the primary consideration.

Knowledge of industry trends. The needs of the Commonwealth with respect to energy conservation have evolved since 2008. In 2007-2008, wholesale energy prices had skyrocketed and reducing consumption was an important strategy to manage costs. Over a decade later, wholesale energy prices are at historic lows thanks to Act 129 successes, abundant natural gas supply, rapidly increasing renewables, and excessive reserve margins at PJM. This places significant pressure on TRC ratios for traditional energy efficiency. As we enter Phase IV of Act 129, issues such as managing the cost of capital upgrades to the T&D system and decarbonization are more likely to get the attention of legislators. As these issues emerge, the SWE can provide valuable insights on their relevance within Act 129 and how guiding documents might need modifications to address evolving priorities. Issues like beneficial electrification (e.g., electric vehicles [EVs], heat pumps) do not fit well within the current paradigm. We can (1) make TUS staff aware of what is coming before it appears in stakeholder comments, and (2) lay out the implications to all the various policies and procedures due to evolving priorities.

Accessible, reliable, and responsive staff. Key staff on the NMR team will be located on the East Coast, providing easy access to the Project Officer and the Bureau of TUS. These staff members will also be dedicating substantial amounts of their time to this work and will be readily available to the TUS staff to respond to any issues or questions.

Established and effective team. Our Phase III experience has demonstrated that our team successfully and efficiently coordinates across firms, leveraging our team's breadth and depth of Act 129 and industry knowledge for the benefit of the PUC and the Commonwealth.

Knowledge of the mature and well-established Act 129 Programs. Headed into its fourth phase and 13th program year, Act 129 has become a well-oiled machine. Compared to other states, Pennsylvania's reporting and data transfer protocols are timely, structured, and largely free of issues. The current state of program data delivery and reporting is due in no small part to detailed and structured evaluation protocols, data requests, and reporting templates developed by the SWE. Data delivery and reporting are so streamlined that the PUC was able to significantly compress the EDC and SWE annual reporting schedule. Furthermore, our team has spent hundreds of hours reviewing EDC program delivery and evaluation data and working with the EDCs and their contractors to refine processes. Our goal is to continue refining processes and monitoring all EDC data for inconsistencies – not to rebuild the machine.

Experience with early and ongoing reviews of EDC-verified savings. During Phase III, the NMR team began working with the EDCs to provide preliminary reviews of their verified savings calculations, ahead of the EDC Annual Report submission. This has resulted in a more efficient and less contentious review of EDC Annual Reports and EDC claimed verified savings. This will be an important practice to continue in Phase IV as the SWE will have approximately three weeks to submit the draft SWE Annual Report to the EDCs for review, compared to having almost eight weeks in Phase III.

Earned the respect of the EDCs and their evaluation contractors. We believe the EDCs generally view our experts as tough, but fair. They understand that we are incredibly hands-on. The NMR team is going to conduct a thorough review of the EDC evaluation reports and claimed savings. Knowing that their work must be replicable by a team of peers pushes the EDC evaluation contractors to implement better QA/QC procedures.

Quality reports. The NMR team will continue to produce high-quality reports for the PUC and the broader Act 129 stakeholder community. The NMR team will also continue to implement rigorous report development and QA/QC protocols to ensure that all deliverables are clear, concise, and free of technical, grammatical, and formatting errors. Conclusions and recommendations will be clearly stated with supporting documentation**.**

Data security. The NMR team will continue to successfully manage a secure SharePoint site to obtain, compile, consolidate, and disseminate the evaluation results. The SharePoint site will continue to use separate, siloed, password-protected folders for the EM&V data and results for the PUC and each EDC.

While maintaining continuity from Phase III SWE activities, the NMR team's proposed scope for Phase IV includes targeted changes and enhancements. Some changes are mandated by the PUC and some are suggestions by the NMR team, stemming from our experience in Phase III. Some of the key mandated and suggested changes are as follows:

Audit Plan, Auditing, and Verification:

- Fewer ride-along on-site verifications by the SWE, facilitated by greater access to trend data at the site level and the equipment level
- Adaptation to a changing residential measure mix. Lighting will be a much smaller portion of the residential portfolio in Phase IV, so the residential audit will encompass a more diverse set of measures, many of which will require EDC verification of TRM parameters.
- Additional Audit Plan guidance and enhanced review of peak demand savings since Phase IV of Act 129 has a compliance target for peak demand reduction from energy efficiency
- Exploration of additional meter-based savings verification methods for Act 129

TRM updates and TRM Order:

- Addition or modification of default values based on historic program tracking data or evaluation results. Providing deemed or default values for parameters that have been relatively stable over time can help streamline program delivery and evaluation.
- Increased focus on load shapes, which can be used to estimate summer and winter demand impacts and partition annual savings into costing periods for the TRC Test
- Transition of formerly custom measures to prescriptive measures if they are common enough and there is enough supporting data to develop a TRM characterization

TRC Order and TRC updates:

- Monitoring the need for more timely avoided cost estimates and the heat rate assumptions used to convert projected natural gas prices to electricity
- An overhaul of the approach to estimating the avoided cost of T&D capacity to reflect the reality of flat or declining peak demand at the zonal level
- Conducting a study to quantify potential reductions in arrearages as benefits in the TRC Test for low-income programs
- Assessment of Demand Reduction Reduced Price Effects (DRIPE) to assess how energy-efficiency and demand-response programs can impact wholesale prices

Baseline Studies and Market Potential Studies:

- Increased residential measure-level sample sizes and precision through use of a self-audit tool
- Enhanced Commercial and Industrial (C&I) segmentation via incorporation of publicly available building data
- Investigation of managed EV charging as a peak demand reduction strategy

Section 1 Leadership and Project Management

NMR will be the primary contractor and will coordinate resources for each evaluation activity and study. The NMR team is composed of known subject matter experts – including experts with years of experience with the SWE – for each task assignment and study under the SWE contract (Figure 1). NMR will be responsible for overall project management; residential, net, and process audit and verification activities; the residential baseline study; and the TRM updates and Order. DSA will lead the TRC audit and Order, the behavioral conservation audit, the statewide tracking database and associated dashboard, the C&I baseline study, and the peak demand reduction market potential study (MPS). BLG will lead the C&I audit and verification activities, and Optimal Energy will lead the energy-efficiency MPS.

The Overall Project Manager will be Greg Clendenning from NMR. He will be the central point of contact and will ensure that the SWE speaks with a unified voice and that all those involved in the project carry out their responsibilities properly and on time. Specifically, he will focus on contract oversight to ensure the following:

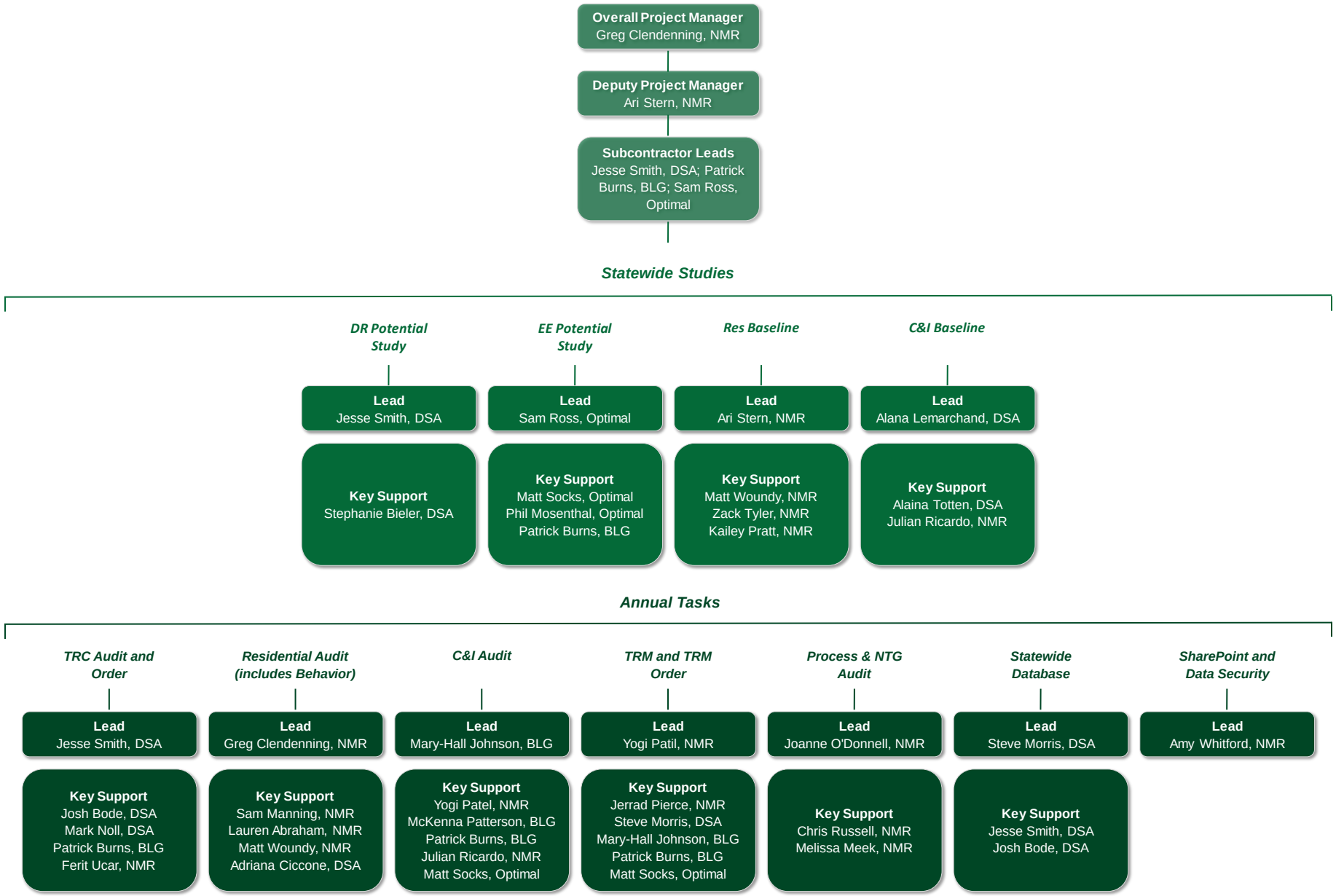
- Our interaction with the PUC is optimal and efficient
- We effectively manage our team
- We meet our commitments to the PUC
- We provide project deliverables on time
- We adhere to project budgets
- We identify, understand, and consider the value proposition for all projects

Greg will dedicate approximately 40% of his time to the project. Ari Stern of NMR will act as the deputy project manager, providing support for management and administrative issues across all tasks and studies. Jesse Smith of DSA, Patrick Burns of BLG, and Sam Ross of Optimal Energy will be the leads for their firms, provide management support to NMR, and will serve as task leads and key support staff on a number of tasks, as illustrated in Figure 1.

Project leads with relevant subject matter expertise will direct individual tasks and will be available to TUS staff to answer any questions or provide advice. Each of these task leads will be supported by experienced and knowledgeable support staff, including national experts in their fields. Our task leads have extensive Act 129 and other jurisdictional experience, which will allow them to establish sound technical protocols for the most accurate measurement, verification, and accounting of Act 129 impacts. Our experts are fully aware of the nuances of conducting the Phase IV baseline and market potential studies to recommend targets for the next phase, taking into consideration the appropriate determinants of projected Phase V acquisition costs. Finally, our Phase III experience has demonstrated that the NMR team successfully and efficiently coordinates across firms, leveraging our team's breadth and depth of Act 129 and industry knowledge for the benefit of the PUC and the Commonwealth.

In terms of reporting, in addition to the Task Leads, our Overall Project Manager (Greg Clendenning) and professional editor (Brittany Harris) will review all deliverables, including work plans, memos, and reports.

Figure 1: Team Structure



1.1 TEAM STRUCTURE AND ROLES

As mentioned above, we have assigned subject area and study leads (Figure 1). The subject area and study leads will coordinate research activities and will ensure that information is shared across all projects. Subject area leads will be supported by highly experienced personnel who will serve in various roles on individual projects and tasks. For example, additional personnel may serve as project managers, may lead or conduct significant portions of the work, or may serve in an advisory capacity. Such a flexible organizational structure allows us to bring the right skill set or level of experience to individual tasks and studies while allowing the subject area lead to maintain oversight and control over the portfolio of tasks and studies.

1.2 DEDICATED SENIOR STAFF

Our team has a proven track record of serving as the Phase III SWE and proven experience in providing extremely high-quality evaluations. Our commitment to quality starts with assigning knowledgeable, senior-level staff to oversee each project and task. Our dedicated subject area leads do not simply delegate responsibilities to other staff members, but rather are involved in all aspects of study design and execution. The senior staff members assigned to this project have extensive experience designing, implementing, and reporting on robust evaluation, baseline, and potential studies.

Greg Clendenning, NMR, Overall Project Manager. Greg has a great deal of experience managing large and complex projects, including serving as the project manager for the Phase III SWE team. Other recent projects include leading a team to conduct five-year process and impact evaluations of two Department of Energy (DOE) clean energy R&D programs – the Small Business Vouchers (SBV) and the Energy I-Corps (formerly Lab Corps) programs – and serving as project manager for a multi-year study developing monetized values for the health and safety non-energy impacts of low-income multifamily weatherization projects. Greg's evaluation research experience also includes residential and low-income programs, market effects, clean and renewable energy, residential lighting and appliance programs, commercial lighting, and branding issues. Prior to his employment at NMR, he evaluated the effectiveness of educational and cultural exchange programs of the U.S. State Department and served as a rural community development extension agent in Togo, West Africa, with the U.S. Peace Corps. He holds a Ph.D. in Sociology from Wisconsin.

Ari Stern, NMR, Deputy Project Manager. Ari is a building science and codes expert. Ari served as the day-to-day project manager and lead analyst for the 2018 Pennsylvania Residential Baseline study and provided support for the C&I Baseline study. Ari was a lead analyst for the annual verification and reporting for the Phase III savings and TRM update. Additionally, he summarized and drafted dispositions to public comments and reply comments to the TRM and Implementation Orders. Outside of Pennsylvania, Ari has been a lead on seven other residential baseline studies encompassing both new construction and existing single-family and multifamily homes across five states. Other projects Ari has managed include commercial code studies, residential and commercial attribution studies, and residential net-to-gross (NTG) studies. Ari has extensive experience with data collection instruments, web/phone surveys, in-depth interviews,

and focus groups. He received an MA in Energy and Environmental Analysis from Boston University.

Yogesh (Yogi) Patil, NMR, Overall Lead on the TRM and TRM Order, and Key Support on the C&I Audit. Yogi has been conducting and managing impact evaluations for C&I energy-efficiency programs since 2003. He has taken a leading role in every phase of the evaluation, from recruiting sites, to conducting savings analyses, to reporting. He has conducted multi-year impact evaluations for over 15 programs throughout the country targeting industrial process efficiency, new construction, demand response (DR) efforts, small business customers, and retro-commissioning. He also has experience working on the implementation side of C&I programs. He has conducted comprehensive and focused energy audits for over 200 C&I facilities, assessing potential savings for a wide variety of electric and natural gas measures. One of his most recent projects involved development of TRM measures and corresponding analysis tools for gas measures for Vermont Gas Systems. He holds an M.S. in Mechanical Engineering from the University of Dayton. He is a licensed Professional Engineer in the State of Massachusetts and a Certified Energy Manager.

Lauren Abraham, NMR, Key Support on the Residential Audit. Lauren has ten years of experience in the areas of impact evaluation, attribution estimation, and TRM savings algorithm reviews. She has been an integral member of the SWE team for the entirety of Phase III. Lauren has served as lead analyst for the annual verification of residential upstream lighting savings for the last four program years. She has conducted technical reviews of TRM savings algorithms for a wide range of energy-efficiency measures in multiple jurisdictions, including Pennsylvania. In addition to her work on the annual savings verification and the TRM, Lauren's role on the Phase III SWE team included reviewing EDCs' EM&V plans and survey instruments, providing technical guidance to the EDCs' EM&V contractors, gathering incremental costs for the incremental cost update, and summarizing and drafting dispositions to public comments to the Implementation Order. Lauren holds an MA in Energy and Environmental Analysis from Boston University.

Matt Woundy, NMR, Key Support on the Residential Baseline and the Residential Audit. Matt has extensive experience with SWE residential evaluation requirements from his work as part of the SWE team in Phase III and will be assisting Ari Stern in managing the residential baseline study. Matt has been a lead analyst for the SWE Phase III annual savings verification and reporting for residential and low-income programs. He also performed data collection, analysis, and reporting for the Phase III Residential Baseline Study and served as an analyst in the Phase III update to the residential portion of the 2021 PA TRM. In addition, Matt performed data collection for the Phase III C&I Baseline Study. Matt has extensive experience in all facets of residential baseline planning and execution covering new and existing single- and multifamily construction. In addition, he has evaluated savings attribution for residential and commercial new construction programs and has facilitated program planning studies to implement high efficiency construction pathways, including Passive House and Zero-Net Energy, into both residential and commercial new construction programs. He holds an M.S., Environmental Policy and Sustainability Management from the New School.

Sam Manning, NMR, Key Support on the Residential Audit. Sam is a building science expert and has extensive experience working on the SWE team in Phase III. He has served as an integral part of the SWE Phase III team as a lead for the residential annual savings verification and

reporting; performing data collection, analysis, and reporting for the Phase III Residential Baseline Study; and serving as an analyst in the Phase III update to the residential portion of the 2021 PA TRM. In addition, Sam performed data collection for the Phase III C&I Baseline Study. Sam has extensive experience in residential baseline execution, analysis, and reporting for both new and existing single- and multifamily construction. He has experience in evaluating incremental costs for new construction, renovation, and addition programs and characterizing HVAC markets. In addition, he has led program design evaluations that focus on construction that achieves Passive House levels of efficiency in high-rise multifamily buildings. He holds a Bachelors in Business Administration from Colorado Mesa University.

Jesse Smith, DSA, Overall Lead for the Peak Demand Reduction Potential Study and TRC Order. Jesse is an experienced energy consultant whose work is focused on estimating the impacts and economics of demand-side interventions to alter the way homes and businesses use energy, and on helping clients improve those offerings. He has been involved in the design and EM&V of a wide variety of DR, dynamic pricing, and energy-efficiency programs implemented by electric and gas utilities across North America. Jesse specializes in statistical analysis of energy usage data, sampling, matching, experimental design, and benefit cost modeling. Jesse has been a core member of the SWE team since 2011 and has hands-on experience with virtually all the SWE's Act 129 audit and planning responsibilities. Jesse has been a key contributor to multiple Implementation Orders, TRM Orders, and TRC Test Orders and helped PUC staff craft policy positions and author dispositions based on stakeholder comments. He received a BS in Psychology from the University of North Carolina at Chapel Hill and an MS in Applied Statistics from Kennesaw State University.

Steve Morris, DSA, Overall Lead on the Statewide Database. Steve is an applied statistician with wide exposure to energy-efficiency and DR impact evaluation and market potential studies. Steve has been a key member of the Phase III SWE team since joining DSA in 2016. During his tenure on the SWE team, he has worked on a wide range of Act 129 deliverables including Home Energy Report (HER) audits, DR audits, the 2021 TRM Update, and the Phase IV DR potential study. Steve also designed and maintains the Pennsylvania statewide tracking database, which archives measure-level tracking records from the seven EDCs subject to Act 129 and offers a variety of reports and visualizations in Tableau. Steve is an expert in developing regression-based estimates of energy-efficiency savings and recently led a study in Rhode Island comparing the results of billing analysis to TRM-based estimates for C&I program participants. Steve was a primary author of recent updates to Bonneville Power Administration's Regression Guide for M&V protocol. He holds an MS in statistics from the University of Georgia.

Josh Bode, DSA, Key Support on the TRC Audit and Order. Josh specializes in advanced applications of data analytics using large volumes of hourly and sub-hourly data for evaluation, valuation, planning and forecasting in the energy sector. He has led over 50 studies including some of the first innovations and largest applications of smart meter and SCADA data analytics in topics as varied as distributed energy resource valuation and cost-effectiveness, location-specific probabilistic forecasting and planning methods, location-specific T&D marginal costs, impact evaluations, market potential studies, and value-based targeting analytics. Josh has analyzed hourly or sub-hourly smart meter data for tens of millions of homes and businesses from numerous utilities. He also has applied experience with utility wide transmission level, substation,

and distribution circuit feeder hourly data from multiple utilities, including PG&E, Con Edison, Orange & Rockland, Central Hudson, NYSEG, RG&E, PSEG Long Island, and National Grid (Rhode Island). Most recently, he has worked on projects designed to align distributed energy resources with grid value and in developing location specific, probabilistic forecasts and T&D marginal costs. He received a Master's degree in Public Policy from the University of California, Berkeley.

Alana Lemarchand, DSA, Overall Lead on the C&I Baseline. Alana has worked on engagements ranging from impact and process evaluations, quantitative customer research, program design optimization, and valuation frameworks for distributed energy resources. She has also managed and advised market research projects for California utilities assessing the accuracy of EV sub-metering and customer enrollment in DR programs. Ms. Lemarchand led the segmentation, analysis, and reporting components of the 2018 Act 129 Non-Residential Baseline Study as well as the battery storage portion of the Phase IV DR Potential Study. Alana is the architect of DSA's benefit cost model and has assisted with TRC audit activities and development of the 2021 TRC Order. Alana has recently supported several clients with granular, probabilistic avoided T&D cost analysis for the purposes of benefit-cost modeling and T&D planning. She holds a BS in Environmental Economics and Policy from the University of California, Berkeley.

Mary-Hall Johnson, BLG, Overall Lead on the C&I Audit. Mary-Hall has 15 years of experience in the energy-efficiency industry. She focuses on providing technical expertise and insight to her projects. Mary-Hall excels at applying her background in energy engineering to evaluate the performance of energy-efficiency technologies, projects, and programs. She has extensive experience working at all levels and stages of DSM impact evaluations, from performing field measurements to managing at the portfolio level and has managed over 600 project site visits and energy audits including project sampling, M&V plan development, recruitment, auditor logistics, analysis, and quality control. She applies her start-to-finish understanding of the evaluation process to design evaluation plans that produce accurate and defensible results. Mary-Hall is a professional engineer, certified energy manager, and earned a bachelor's degree in mechanical engineering from Mississippi State University and a master's degree in civil engineering from the University of Colorado with a specialization in Building Systems Engineering.

Patrick Burns, BLG, Overall Brightline Lead and Key Support on the Energy Efficiency Potential Study, TRC Audit and Order, and C&I Audit. Patrick has over 20 years of engineering, planning, and analytic experience, with a focus on demand side management (DSM) consulting, evaluation, energy-efficiency analysis, and electrical systems. As a licensed electrical engineer, Patrick has a strong expertise in measurement and verification approaches for all energy-efficiency, DR, and distributed energy resource systems utilizing many different algorithms and data sources. He excels in delivering valued consultation, leading challenging and difficult projects, and using communication and problem-solving skills to facilitate coordination between technical teams and clients. Patrick is a Professional Engineer, Certified Energy Manager and Certified Demand Side Management Professional. He holds a BS in Civil Environmental and Architectural Engineering from the University of Colorado.

Sam Ross, Optimal Energy, Overall Lead for the Energy Efficiency Market Potential Study. Sam has held this role for the Phase IV Energy Efficiency and Peak Demand Reduction MPS since he joined Optimal in 2017. Sam's work at Optimal includes innovation in quantitative tool

development, automation, and quality assurance, and supporting clients in benefit-cost analysis, clean energy finance, quantification of non-energy impacts, and climate change and carbon pricing. Sam brings broad experience in energy-efficiency program design and implementation oversight from work supporting energy-efficiency management councils in Rhode Island, Massachusetts, and Delaware. His work in the energy industry, which began in 2012 at an electricity futures trading desk, is supplemented by several years working as a data scientist. Sam holds an MSc in Environmental Economics and Climate Change from the London School of Economics and BA in Economics, Environmental Studies from Dartmouth College.

Philip Mosenthal, Optimal Energy, Key Support on the Energy Efficiency Potential Study. Philip has over 30 years of experience in energy-efficiency consulting, including facility energy management, utility and state planning, regulatory policy, program design, implementation, evaluation, and research. He has particular expertise in efficiency regulatory policy, assessment and integrated analysis of demand-side energy resources, valuation of energy resources and cost-benefit analysis, and program planning, design, and evaluation. Philip has developed numerous utility, state, and regional integrated resource and DSM plans, and has designed and evaluated energy-efficiency programs throughout North America, Europe, and China. He has also led numerous efficiency and renewables potential studies and is a nationally recognized expert on efficiency resource assessment and valuation. Philip has played key roles in many utility-stakeholder processes and successfully worked to build consensus among diverse parties in various assignments. This work has included leading policy and planning initiatives related to goal setting, EM&V frameworks, cost recovery, and performance incentives. Philip has testified before numerous regulatory commissions, state legislatures, and the U.S. Nuclear Regulatory Commission. He has a B.A. in Environmental Design and a M.S. in Energy Management and Policy, both from the University of Pennsylvania.

Matthew Socks, Optimal Energy, Technical Lead on the Energy Efficiency Market Potential Study. Matt has served a leading role in efficiency program engineering, economic analysis, and implementation support for clients across North America since he joined the firm in 2007. He has both managed and served as a primary contributor to numerous energy-efficiency potential analyses and maintains Optimal Energy's suite of analytical tools. In the last three years alone, Matthew has led or contributed to market potential analyses for Pennsylvania, Massachusetts, Minnesota, New Jersey, and New York, all of which have directly led to efficiency savings targets. With expertise in the field of efficiency measure research and characterization, he has developed standard methodologies for determining savings from efficiency measures and programs in more than a dozen states, most recently supporting TRM development in Pennsylvania and the Mid-Atlantic. Having provided clients with efficiency program design and implementation support, he has both developed novel program approaches from the ground up, and provided strategic assessment of existing program portfolios. An experienced analyst, Matthew has also led targeted market research efforts on both building sectors and efficient technologies. Matthew holds a BS in Mechanical Engineering from the Massachusetts Institute of Technology. He is a licensed Professional Engineer in the State of Vermont and a Certified Energy Manager.

1.3 SERVICES AND DELIVERABLES

The SWE services and deliverables will encompass four primary activities: expert evaluation advice and guidance, oversight and review of EDC EM&V activities, development of statewide energy-efficiency information, and data management and delivery of commission reports.

Table 1 and Figure 2 show a summary of the services and deliverables that the NMR team will provide as the SWE evaluation contractor. More detailed descriptions of the services, deliverables, and technical approach are provided in Section 2.

Table 1: SWE Services and Deliverables

Task or Deliverable	Proposal Section
Oversight and Review of EDC Program and EM&V Activities	
Updated and revised Audit Plan	2.2
Audit and verification: EDC EM&V evaluation plan review	2.3.1
Audit and verification: Gross savings, energy efficiency	2.3.2
Audit and verification: Gross savings, behavioral conservation programs	2.3.2
Audit and verification: Gross savings, strategic load management	2.3.2
Audit and verification: Gross savings, TRC	2.3.2
Audit and verification: Net impacts	2.3.4
Audit and verification: Process evaluations	2.3.5
Audit and verification: Ad hoc activities	2.3.6
Statewide Energy-efficiency Information	
Updates to TRM and TRC order	2.4
Residential baseline study	2.6.2
C&I baseline study	2.6.3
Energy-efficiency MPS	2.7.2
Peak demand reduction MPS	2.7.3
Expert Evaluation Advice and Guidance	
Meetings and other requirements	2.8
Reports and program control	2.9
Testimony	2.10.1
Data Management and Commission Reports	
Data management and PUC reports	2.5
Disaster recovery and long-term storage of records	2.10.2

Figure 2: Primary SWE Activities

Section 2 Work Plan

The Phase IV SWE scope of work includes a variety of tasks that are designed to ensure continued success of the Act 129 EE&C programs. Table 2 of the RFP (Roles and Responsibilities) identified 19 tasks and/or deliverables for the SWE to fulfill. Many of these tasks occur in parallel with, or depend on, timely completion of a previous task. NMR has assembled a team with the technical expertise needed to deliver quality work across diverse subject areas and has developed a work plan that will accomplish all tasks in the scope of work within the necessary timeframes. The following sections provide additional detail on our proposed approach to provide the requested services.

2.1 Kickoff Meeting

The engagement will officially commence with a kickoff meeting with the TUS staff. If the PUC's offices in Harrisburg are open, the meeting will be held at the PUC's offices; however, if COVID-19 restrictions are still in place, the kickoff will be conducted via conference call and webinar. The purpose of this meeting will be to clarify and refine our proposed technical approach and the scope of work, identify priorities, discuss expectations, review the reporting schedule and deliverables, and discuss the scheduling of the weekly SWE team teleconferences with the TUS staff. As the incumbent SWE, we can efficiently schedule the Phase IV weekly call to immediately follow the Phase III weekly call, if desired by TUS staff, during the overlap between the Phase III and Phase IV SWE. The NMR team will prepare a draft agenda for the kickoff meeting for review by TUS staff, and will compile notes and action items during the meeting. Based on the issues discussed at the kickoff meeting, the NMR team will produce a final work plan that details the agreed-upon scope, schedule, and deliverables for the project. The plan will provide detailed task-by-task descriptions of the scope of work. After review and comment by the PUC, the NMR team will submit a final work plan for approval.

Below, we list the items that we recommend including on the kickoff meeting agenda:

1. Presentation of expected roles and responsibilities of key personnel from the NMR team for Phase IV. Nearly all of the key roles and responsibilities in Phase IV will be filled by the same staff from Phase III
2. Discussion of project objectives and required schedule
3. TUS comments on NMR team proposed scope of work and research approach
4. Project schedule by task
5. Project deliverables
6. Initial discussion for proposed updates to the Audit Plan
7. Communications plan
8. Other topics

In addition to a kickoff meeting with TUS staff, the NMR team will conduct kickoff meetings via conference call and webinar with the EDCs and their EM&V contractors. The purpose of the meetings are as follows:

- Introduce Phase IV SWE to the EDCs and their new EM&V contractors, including key staff of both teams and their respective roles.
- Review expected changes to the Audit Plan / Evaluation framework and generally review EM&V guidance for Phase IV.
- Review any updates to the SWE quarterly and annual data requests and procedures; to review changes to reporting requirements and schedules for Phase IV.
- Review procedures and schedules for providing SWE reviews of EDC claimed gross savings prior to the submission of the EDC Final Annual Reports.

2.2 UPDATE AND REVISE AUDIT PLAN

The Audit Plan/Evaluation Framework is an important early deliverable for the Phase IV SWE team because it establishes expectations and requirements of the EDC evaluation contractors. This upfront documentation provides valuable technical guidance to the EDC evaluation contractors as they develop their Phase IV EM&V plans. It also reduces the amount of back-and-forth required during the EM&V Plan Review task as the SWE reviews and approves the planned sample sizes, data collection techniques, and analysis methods. The Audit Plan/Evaluation Framework has been updated several times over the course of Phase I, Phase II, and Phase III. The NMR team does not believe a wholesale revision of the document is needed for Phase IV; instead, we propose targeted revisions based on policy changes and other developments since the last update in May 2018. We see the following items as priority updates:

- Update Section 2 (Policy Requirements) to reflect the directives of the PUC in the Phase IV Implementation Order, 2021 TRC Test Order, and 2021 TRM Order.
    - Phase IV compliance reduction targets for portfolio MWh, portfolio MW, and low-income MWh.
    - Revised EDC and SWE reporting schedule for Phase IV
    - A summary of how different cost and benefit elements are handled in the TRC Test
    - Use of the TRM to calculate reported gross and verified gross energy and peak demand savings.
    - Possible TRM updates during Phase IV to address changes to codes and standards.
    - Clarification of the purpose and appropriate use of the Interim Measure Protocol (IMP) process.
    - A new section regarding the requirement to nominate a portion of Phase IV peak demand reductions into PJM's forward capacity auctions.

- Modify Section 3.3 (Gross Impact Evaluation) to better address options for virtual, or remote, site inspections to manage administrative costs and ensure safety to the extent COVID-19 considerations are still in effect during Phase IV.
    - One issue that has created friction in Phase III is where the role of the Implementation Conservation Service Provider (ICSP) ends and that of the evaluation contractor begins. While the NMR team is supportive of having ICSPs gather data during program delivery, PPL and their evaluator have taken this approach to an extreme that we feel creates concerns about characterizing savings as "independently verified." We believe the Audit Plan/Evaluation Framework is the appropriate forum to address this issue and set clear delineations about appropriate and inappropriate levels of coordination between the ICSP and evaluation contractor.
- Review and update Section 3.4 (Net to Gross) and Section 3.5 (Process Evaluation) based on our Phase III experience and on recent updates to some Uniform Methods Project (UMP) guidelines for estimating program net savings, such as the refrigerator recycling protocol.[2] Section 3.4.1.5 (Approaches for Upstream Lighting) needs to be modified to address other upstream and midstream offerings since residential upstream lighting will not be a viable program option in Phase IV, but EDCs are expected to use upstream or midstream delivery models for other measures, such as midstream commercial lighting offerings.
- Provide additional guidance in Section 3.3 regarding best practices for calculating peak demand savings since Phase IV of Act 129 has a compliance target for peak demand reduction from energy efficiency. Historically, the approaches used by the EDC evaluation contractors for peak demand have been less rigorous than for energy savings.
- Update the sampling requirements in Section 3.6. Based on discussions with FirstEnergy and PECO during the Phase IV EE&C Plan template review period, we expect several EDCs will use a definition of "program" that is effectively sector, or customer class. This umbrella definition is not adequate for evaluation and reporting, so the Audit Plan/Evaluation Framework will need to set clear guidelines regarding organization of offerings into logical groupings for evaluation purposes.
- Modify Section 3.8 (Frequency of Evaluations) to encourage deeper dives into program performance with less frequency. A challenge in prior phases has been that evaluation contractors evaluate programs annually, a frequency that limits the ability for any "deep dives" within the allocated EM&V budget. Any changes to frequency in evaluation also need to take into account EM&V requirements of PJM's forward capacity auctions.
- Modify Section 4 (SWE Audit Activities) to reflect the NMR team's planned approach to audit activities for Phase IV. Our proposed approaches are discussed in Section 2.3. With peak demand targets for Phase IV, our audit activities will necessarily place additional emphasis of peak demand savings calculations.

[2] https://www.energy.gov/eere/about-us/ump-protocols

- We found that during Phase III, being able to point to detailed descriptions of our planned audit activities reduced resistance from the EDCs and their evaluation contractors compared to prior phases. Clear documentation of the data requirements and planned validation exercises limits the chances for contentious situations later between EDCs and the SWE when the SWE team implements its audit activities.

- Update Section 6.1 (Behavioral Conservation Programs) to address the new HER accounting protocol established in the 2021 TRM. This will require an overhaul of the current Section 6.1.1.9. The SWE and TUS will need to make a determination and socialize it with the EDCs through the Audit Plan/Evaluation Framework, whether the Business Energy Report (BER) programs are required to the follow the HER accounting protocol in the 2021 TRM. We also plan to expand the technical guidance regarding peak demand savings from HERs as several Phase III evaluation contractors have struggled with these calculations. We also plan to add a fifth regression model specification to Section 6.1.1.5 that uses the control group usage as an independent variable. NMR team member DSA has been utilizing this approach for recent evaluations and finds it outperforms the current roster of model specifications.
- Delete Section 6.2 (Demand Response Programs). The Phase IV Implementation Order did not established goals for dispatchable DR programs and clarified that that dispatchable DR impacts would not count towards Phase IV compliance. Given this development, the NMR team recommends deleting the section.

In parallel with implementation of these known updates, the NMR team will solicit input from TUS staff on items that would be beneficial to add or clarify in the document. We will work closely with TUS staff to determine the acceptable level of input from the EDCs and their Phase IV evaluation contractors. Greg Clendenning and Jesse Smith will lead the Audit Plan/Evaluation Framework update for the SWE team. The proposed deadline of May 31, 2021, provides ample time to implement the changes described above and any suggestions from TUS and the EDCs (if appropriate).

As noted in the RFP, the Audit Plan will be a living document that will be updated or modified as appropriate. Our goal in Phase IV will be to continue to segregate the technical and policy aspects of the Audit Plan as we encounter evaluation issues specific to the Act 129 programs and address them in a collaborative manner in order to continually improve based upon feedback from all parties involved.

2.3 AUDITING AND VERIFICATION

SWE audit and verification activities are designed to provide the PUC with certainty that the energy and peak demand savings values claimed by EDCs and their evaluation contractors accurately reflect the resources conserved by ratepayers across the Commonwealth. Audit results allow for straightforward determination of compliance with statutory goals and comparison of program benefits with the implementation costs according to the TRC Test. The NMR team's proposed approach is organized by the following categories:

- Review of EDC EM&V plans
- Gross energy and peak demand savings (organized by program type and ex-ante vs. ex-post)
- TRC audit
- NTG analysis
- Process evaluation
- Ad hoc auditing and research

2.3.1 EM&V Plan Review

The NMR team strongly believes that successful and useful evaluations begin with a well-thought-out and comprehensive EM&V plan that balances rigor with reducing administrative and overhead costs. The NMR team also recognizes that EM&V plans (and those implementing the plans) need to be adaptable to mid-course corrections due to EDC decisions and changes in program design, regulatory environment, and market trends. For example, during Phase III, the EDCs developed mid-stream offerings, such as mid-stream commercial lighting, that required modified EM&V practices to verify savings compared to traditional downstream commercial lighting programs.

In addition, the NMR team found that our practice in Phase III of providing detailed, upfront feedback on EDC EM&V plans by the EDC evaluators early in the phase resulted in a more efficient and less contentious auditing of EDC's claimed verified savings. SWE feedback on EM&V practices is much more actionable when it is provided before the EM&V research is conducted. As in Phase III, the NMR team expects we will need to conduct our most thorough review of EM&V plans in PY13 as the initial EDC EM&V plans will cover proposed EM&V practices for all of Phase IV. Once reviewed and approved, the subsequent annual reviews of EDC EM&V plans for PY14 through PY17 will likely require less intensive reviews of updates to agreed-upon EM&V approaches.

The issues that need to be taken into account when developing EM&V plans include the following:

- A program's estimated savings (MWh and MW) contribution to the sector and Act 129 portfolio
- A program's budget allocation relative to the sector and Act 129 portfolio
- The expected degree of uncertainty in a program's savings
- The status of measure attributes currently listed in the TRM
- Findings and recommendations made during the prior evaluation cycle

- Expected changes in the market and program delivery channels (such as new mid-stream delivery channels)
- Whether any special features of a program require extraordinary evaluation effort

The NMR team believes the general structure for the EDCs' annual EM&V plans should include the following seven sections:

- Introduction to Key Issues (guided by the Audit Plan)
- Approach to Estimating Verified Gross Energy and Peak Demand Savings (M&V approach)
- Net Savings Analysis
- Process Evaluations and Program Design Changes
- Phase IV Tracking & Reporting System
- Activity and Reporting Schedule Summary
- Roles and Responsibilities

The NMR team's responsibility for this task will be to guide the development of the EDCs' annual EM&V plans with clearly specified mandatory and discretionary requirements in the Audit Plan. Annually, this task will include the following activities:

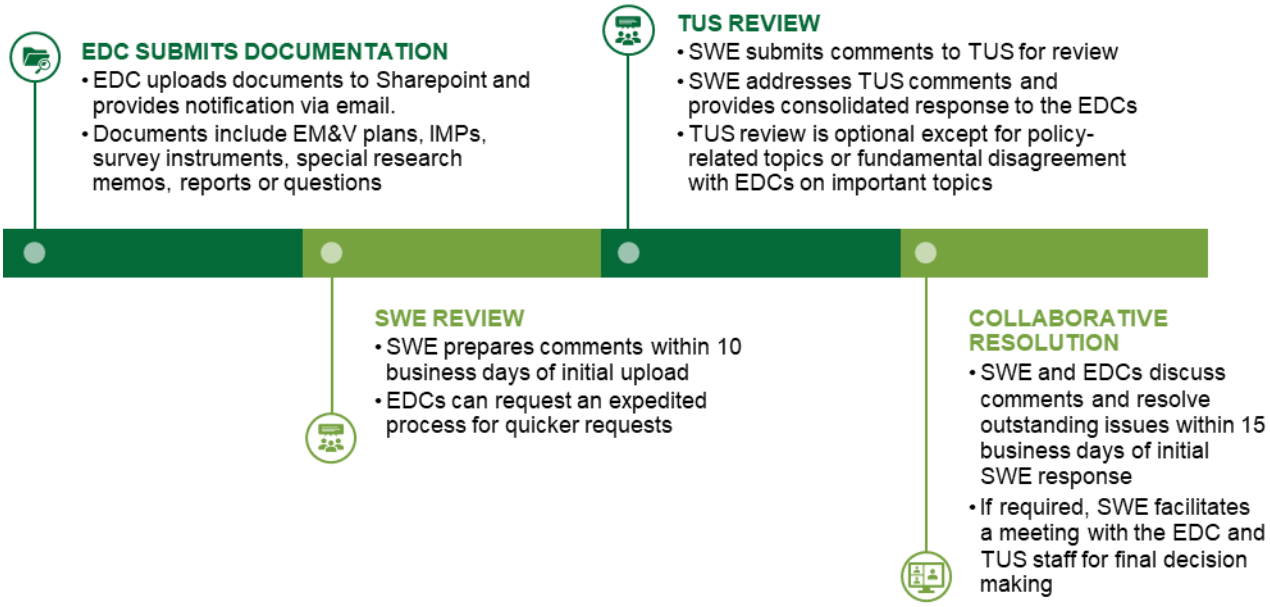
- Review the EDCs' plans to determine whether the EDCs are complying with the technical and policy requirements of the Audit Plan, the Implementation Order, the TRC and TRM Orders, and guidance memos or secretarial letters issued by the SWE and the PUC
- Review and monitor the annual revisions to the plans and ensure they meet the evolving needs of the Act 129 framework
- Review and approve the proposed sample sizes, stratification, and data collection techniques proposed for each initiative
- Audit the EDC survey instruments, on-site verification forms, M&V plan templates, and other documents associated with the EM&V plans

For Phase IV, we will continue to review all EDC evaluation plans to determine compliance with the Audit Plan, PUC Orders, and standard industry protocols for DSM program evaluations such as the UMP Protocols,[3] the SEE Action Protocols, and the International Performance Measurement & Verification Protocol (IPMVP). We also will provide qualitative feedback to the PUC regarding EE&C plans for Phase IV (if requested by TUS), especially with regard to measure and program offerings. During Phase III, we found that upfront communications with the EDC teams about program implementation, evaluation activities, and reporting helped to pre-emptively resolve issues and mitigate any disputes during the program cycle.

[3] https://www.energy.gov/eere/about-us/ump-protocols

Figure 3 shows the SWE's proposed review process for EDC document submission for Phase IV, which continues the successful review process from Phase III.

Figure 3: SWE Review Process for EDC Submissions



We will continue with our formal document review strategy to complete all first reviews within two weeks of receiving documents to ensure that review procedures do not impede progress of activities. We will continue to conduct some reviews within five business days, such as our review of EM&V survey instruments and annual updates to approved EM&V plans or sampling protocols. We note that we assume the initial Phase IV EDC EM&V plans will likely be lengthy, comprehensive EM&V plans that requires a longer review period. We will complete our initial review within four weeks of submission from the EDC EM&V evaluator. During Phase III, the review period from submitted draft EM&V plan to final, SWE-approved EM&V plan ranged from as short as six weeks to over eight months.

We will submit our comments to TUS staff for review and approval. We will complete any revisions resulting from these conversations within one additional week and provide a response to the EDCs. In addition, we will track all revisions to documents on the SharePoint site to manage version control and verify timeliness of all reviews. All SWE reviews will be accompanied by written comments and tracked on SharePoint. If needed, we will facilitate meetings with the EDCs and TUS staff to resolve disagreements, conflicting opinions, and other contentious topics. Resolutions will be made collaboratively with the EDCs to the best of our ability, but the final decision on any topic will be made by TUS staff under advisement of the SWE team.

2.3.2 Gross Savings Auditing & Verification Activities

Compliance with Act 129 consumption and peak demand reduction targets are assessed on a gross basis; therefore, the verification of gross MWh and MW savings claims is the central SWE audit task. Audit activities will vary by program type and sector. The following sections detail the proposed audit tasks by broad program types.

2.3.2.1 Overview of Gross Savings Audit

SWE audit activities are intended to give the PUC and the public confidence in the accuracy and reliability of the verified energy and peak demand savings reported by each of the Pennsylvania EDCs toward the mandated consumption and peak demand reduction targets. Moreover, the SWE audit activities ensure proper implementation and evaluation of EE&C programs in a manner consistent with the Phase IV Audit Plan.

The NMR team anticipates there will be several changes to the gross savings audit compared to Phase III. First, as noted in Section 2.2, historically, the approaches used by the EDC evaluation contractors for peak demand have been less rigorous than for energy savings. The SWE understands that the rigor of the audit of peak demand savings estimates during Phase IV should increase compared to previous phases given the Phase IV peak demand reduction target. The Audit Plan/Evaluation Framework will be providing more guidance on best practices for calculating peak demand savings to the EDCs. Second, residential lighting will be a much smaller portion of the residential portfolio. The NMR team anticipates the residential audit will encompass a more diverse set of measures, many of which will require EDC verification of TRM parameters. Examples include connected thermostats and HVAC measures. Third, the NMR team anticipates a reduced number of ride-along site inspections that are supplemented by detailed desk reviews (known as verified audit desk reviews [VADRs] in Phase III).

The NMR team will audit each step of the program implementation and evaluation process. Figure 4 presents a diagram of the C&I and residential audit process for ex-ante or reported savings. Figure 5 presents a diagram of the C&I and residential audit process for ex-post or verified savings.

Figure 4: Ex-ante SWE Audit Activities and EDC Program Activities

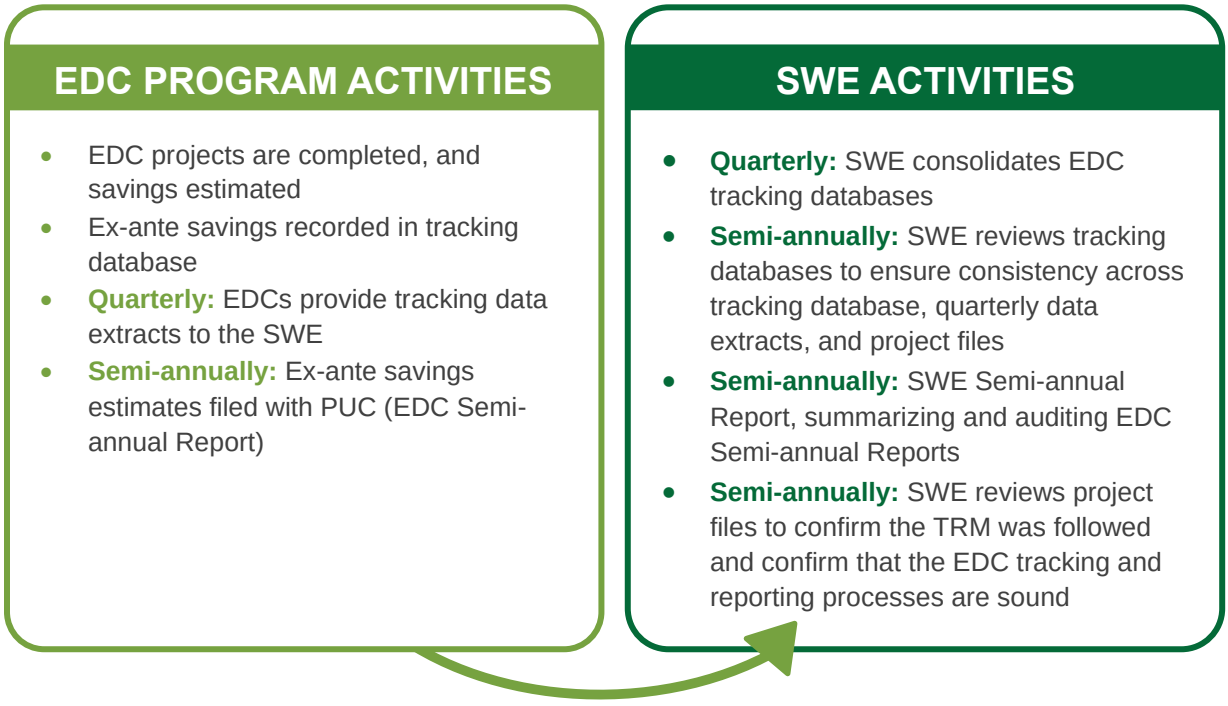


Figure 5: Ex-post SWE Audit Activities and EDC Evaluation Activities[4]

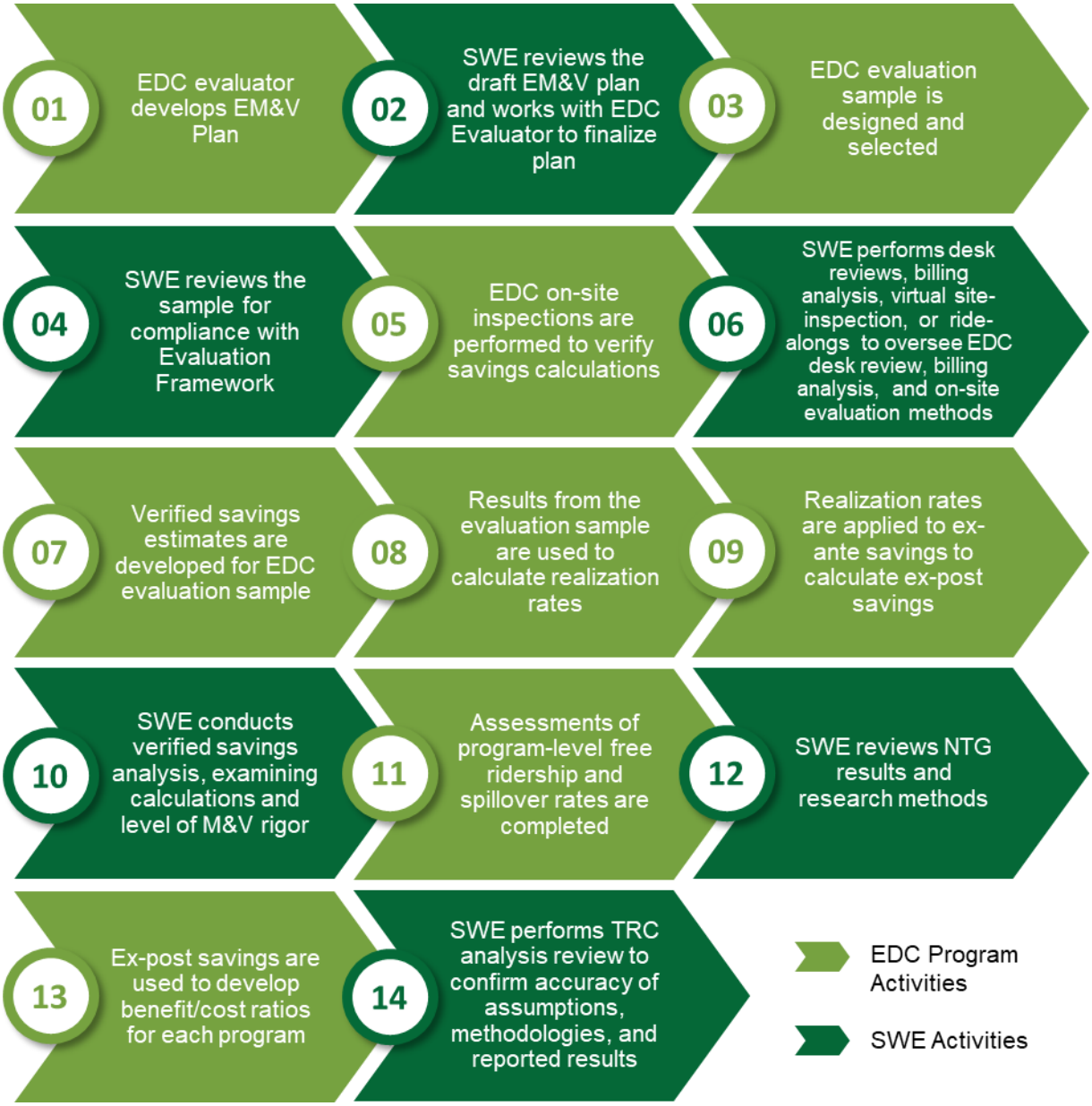


Table 2 presents the schedule of milestones and activities that the NMR team proposes to implement for the annual energy-efficiency audit, using PY13 as an example. During Phase III, the NMR team began working with the EDCs to provide preliminary reviews of their verified savings calculations, ahead of the EDC Annual Report submission. We found this practice allowed the EDC evaluators to incorporate corrections and clarify discrepancies prior to submitting annual EDC reports. This has resulted in a more efficient and less contentious review of EDC Annual Reports and EDC claimed verified savings. The NMR team proposes continuing this

[4] The figure shows both gross and net components of the proposed C&I and residential audit process, including the TRC audit approach. However, the narrative in this section is about auditing the gross savings. The NTG audit approach is explained in Section 2.3.4.

practice and encouraging the EDC evaluators to submit as much of their verified savings analysis as possible before submitting their Annual Reports. In Phase IV, the SWE will have approximately three weeks to submit the draft SWE Annual Report to the EDCs for review, compared to having almost eight weeks in Phase III. Therefore, the NMR team considers the early review of EDC verified savings a critical part of the Phase IV audits.

Table 2: Proposed Energy-efficiency Audit Timeline

Milestone	Estimated Date
EDC projects are completed and rebates paid	June 2021-May 2022
PY13Q1 Data Request is due to the SWE	October 15, 2021
SWE performs ex-ante audit on PY13Q1 tracking data and project files	October to November 2021
PY13Q2 Data Request is due to the SWE	January 14, 2022
SWE performs ex-ante audit on PY13Q2 tracking data and project files	January to February 2022
EDC issues Semi-annual Report with reported savings for PY13Q1 and PY13Q2	January 17, 2022
SWE submits PY13 Semi-annual Report, summarizing PY13 reported savings[1]	February 28, 2022
PY13Q3 Data Request is due to the SWE	April 14, 2022
SWE performs ex-ante audit on PY13Q3 tracking data and project files	April to May 2022
SWE performs desk reviews, virtual site-inspection, and ride-along site inspections	November 2021 to August 2022
PY13Q4 Data Request is due to the SWE	July 15, 2022
SWE performs ex-ante audit on PY13Q4 tracking data and project files	July to August 2022
SWE completes ex-post savings analysis for any EDC programs or initiatives submitted for early review	August to September 2022
EDCs report Final PY13 EDC verified savings in Annual Report	September 30, 2022
Annual Data Request is due to the SWE	September 30, 2022
Draft PY13 SWE Annual Report submitted to EDCs for factual review	October 19, 2022
SWE completes audit of ex-post savings analysis, NTG, process evaluation, and TRC models; SWE finalizes PY13 verified savings and submits final PY13 SWE Annual Report	November 30, 2022

[1] Beginning in PY14, SWE semi-annual reports will also include verified savings results from the previous program year(s).

2.3.2.2 Non-behavioral Energy-efficiency Programs

2.3.2.2.1 Ex-ante

The objective of the ex-ante audit is to verify that the kWh and kW savings reported/claimed by the EDCs and their ICSPs are calculated using the appropriate TRM protocol or custom measure protocol developed by the EDC and are stored correctly in the program tracking system. The ex-ante audit includes a review of the EDC program tracking system information and project files submitted as part of the data requests made by the SWE team.

Program Tracking Data and Semi-annual Report Review

The NMR team will develop updated quarterly data requests based on the Phase III quarterly data requests prepared by the NMR team. Each EDC will be expected to submit its up-to-date program tracking database on a quarterly basis, and, after two quarters, the EDCs will be expected to submit a Semi-annual report to the PUC. On a quarterly basis, the NMR team will consolidate the EDC tracking databases and prepare high-level, dashboard reporting on EDC progress toward energy savings and peak demand savings goals. We will also be prepared to answer questions from the PUC pertaining to program tracking data and EDC progress toward their mandated targets.

On a semi-annual basis, the NMR team will check for consistency between the project file documentation, tracking database, and ex-ante impacts claimed in the EDC semi-annual and annual reports. The NMR team will verify the consistency between the tracking system impacts and impacts noted in the semi-annual and annual reports for each EDC report using the following equation:

$$Reported\ Figure\ -\ Database\ Summary = Discrepancy$$

Discrepancies will be calculated within each program and at the portfolio level for participants, MWh, MW, and incentives. If we discover any discrepancies, we will investigate and discuss the root cause and, if applicable, provide recommendations for future database and report submissions. Audit results will be explicitly reported on in SWE Semi-annual Reports.

Project File Reviews

The NMR team will perform desk audits of a sample of project files that are submitted as part of the SWE quarterly data requests. During Phase III, the NMR team generally found the submitted project files to be adequate and generally provided the necessary supporting details. To reduce administrative and overhead costs while providing a faster feedback loop, the NMR team recommends reducing the number of project file reviews in Phase IV,[5] but conducting our reviews immediately following receipt of the quarterly data request response.

Project file reviews are designed to audit the accuracy of the savings values stored in the program tracking database and confirm that calculations are being performed in accordance with the applicable TRM protocol. In the case of custom measures installed in C&I facilities or residential

[5] The NMR team recommends reducing the selected sample from ten projects to five projects per quarter if the program or initiative has 50 or more participants in the quarter or a sample of two projects rather than five projects if the program or initiative has fewer than 50 participants in the quarter. The NMR team may increase this number for programs or EDCs for which consistent discrepancies are observed.

measures without an applicable TRM protocol, the project file review will focus on whether the methodology used to calculate savings was reasonable and well-documented. The uploaded project files are expected to include project-level savings calculation workbooks, specification sheets for equipment installed, invoices, customer incentive agreements, and post-inspection forms. The NMR team will review rebate forms, invoices, audit reports, and supporting documentation used to estimate reported gross savings.

We will verify key aspects of the reviewed project files, providing feedback and recommendations to the EDC and EDC ICSP when appropriate. These key points of interest will include the following:

- Was the appropriate version of the TRM used properly?
- Did the project measure(s) meet all eligibility requirements in the TRM?
- Were all assumptions reasonable and well-documented?
- Did quantities, measure characteristics, and values match across all documents (e.g., invoices, calculation workbooks, incentive agreements, and post-inspection forms)?
- Were appropriate energy and peak demand savings calculation methods and values used for custom measures?
- Did the energy savings, peak demand savings, and rebate amounts called out in the project files match what was stored in the program tracking database?

2.3.2.2.2 Ex-Post

The ex-post audit tasks are a critical piece of the process through which the PUC can observe and understand the EDC program evaluations. The NMR team will perform audit activities on an annual basis to oversee each EDC's evaluation activities. The NMR team's ex-post audit activities will focus on comprehensively assessing the quality of the independent evaluations conducted by EDC evaluation contractors and will include the following key areas:

- Provide reasonable assurance that the claimed measures are being properly verified by EDC evaluators and the claimed progress toward Phase IV targets has been achieved and quantified accurately
- Ensure evaluations conducted by the EDC evaluation contractors are compliant with the Audit Plan
- Confirm that evaluation activities are conducted at the level of rigor stipulated in each EDC's approved evaluation plan
- For prescriptive projects, assess verified savings for adherence to the TRM
- For custom programs and projects, assess accuracy and appropriateness of analytical approaches use
- Review and verify the EDCs' performance by having trained SWE personnel accompany EDC evaluators on site verification activities, including virtual site inspections and follow-up interviews

For Phase IV, the NMR team will use its extensive experience with these activities in previous phases to further streamline and target ex-post verification activities for each EDC program. For well-established programs that have been running for some time and for which we have already verified analytical approaches (such as established TRM protocols), and for low-impact programs, the requirements for audits may be reduced with little risk due to the confidence in savings estimates generated by the evaluators. However, we recognize that for projects and technologies with more uncertainty or higher impact on portfolio savings, the NMR team will likely need to provide increased attention on verification activities. And for new programs and measures for which it has been difficult to identify savings, such as new midstream programs, the NMR team will increase rigor commensurately.

The SWE's review will encompass all aspects of the EDC evaluation verified savings cycle. Proposed activities will include the following:

- Sampling and Stratification Review
- M&V Methods Review
- Verified Savings Review
- Extrapolation of sample findings to program population

After the review, the NMR team will develop recommendations concerning specific project comments and general M&V approaches. The NMR team's concurrent review of the evaluation samples as a whole and individual project analyses will enable our team to provide more relevant and useful recommendations to the EDC evaluation contractors concerning their M&V practices.

Sampling and M&V Methods Review

The NMR team will review each EDC evaluation contractor's evaluation rigor and achieved sample as a whole for adherence to the Audit Plan/Evaluation Framework and the approved EM&V plan. Key aspects of the verified savings analysis will include reviewing the types of M&V used (e.g., simple verification, Option A, Option B), the frequency with which each M&V approach was used, the achieved sample sizes and associated sampling error, and the frequency with which end-use metering was used.

Because the residential programs consist predominantly of TRM-based measures with established and well-tested technologies marketed to most or all households in a service area, the NMR team will typically apply basic levels of rigor will when verifying residential measures. However, some residential programs, such as weatherization or HVAC programs, include measures that require site-specific verification. These measures may require an enhanced level of rigor and corresponding M&V methods, depending on the type of measure and level of savings. For example, with the ENERGY STAR® Connected Thermostat measure, the site-specific heating fuel and installation scenario are major factors in determining the gross savings and will require an M&V method to validate these TRM inputs.

Assessment of EDC C&I Field Work

The NMR team will monitor and assess the EDC evaluators' on-site activities throughout Phase IV. Site inspections are considered the highest rigor EM&V activity, so the SWE audit seeks to ensure these activities are well-planned, conducted by experienced staff, and leveraged in the calculation of gross verified savings. While ride-along site inspections have provided a window into the effectiveness and reliability of the EDC evaluator's activities in prior Phases, for Phase IV, the NMR team proposes to continue with practices developed during Phase III and expand field work assessment practices to include desk reviews, virtual on-site inspections, and follow-up interviews with evaluator field personnel. The NMR team will continue conducting a reduced number of ride-along site inspections for projects of large size, high uncertainty, or other specific interest to Act 129. Supplementing these activities with virtual/remote alternatives will allow the NMR team to continue observing the evaluators' on-site M&V activities while streamlining our involvement, optimizing expenditure of the audit budget on projects and programs of highest interest, and reducing administrative and overhead costs.

EDC evaluation contractors will be expected to conduct field work for programs where the savings contribution to the overall portfolio warrants the additional level of rigor. The SWE audit of these activities ensures that the field work provides value by collecting high-quality data on large and complex projects. The NMR team proposes conducting oversight of this field work assessment according to the following guidelines:

- Desk reviews, inspections (on-site and virtual), and interviews will focus on the following types of projects and programs:
  - Programs for which EDC evaluators conduct site inspections
  - Programs with a significant number of projects above the TRM metering thresholds
  - Programs with populations that are positively skewed (i.e., a relatively small percentage of projects make up a large percentage of program savings)
  - Programs with custom measures (and therefore uncertain savings)
- SWE desk reviews, inspections, and interviews will be conducted based on the following statistical guidelines:
  - Desk reviews and inspections will be utilized for highest impact and high uncertainty projects
  - Desk reviews and inspections will be utilized following major program implementation changes
  - Desk reviews and interviews will be used for stable programs with medium impact and uncertainty projects

Verified Savings Review

The NMR team will assess the accuracy of the EDC evaluation contractors' verified savings calculations by reviewing calculations, regression models, and building energy simulations. For TRM-based measures, the NMR team will focus on verifying that the per-unit kWh and kW savings values are calculated in accordance with the 2021 PA TRM or approved IMP. For most custom measures, the NMR team will utilize a sampling approach to assess a representative portion of the EDC evaluator's process. Samples for this audit activity will include all Field Work Assessment projects, as well as additional desk review projects to achieve a 90/10 confidence/precision level at the sector-level statewide.

The NMR team will request data from EDC evaluation contractors to support this review, including both ex-ante and ex-post documentation, such as invoices, savings calculations, site-specific measurement and verification plans (SSMVPs), site inspection photos, and reports. The key elements to review will include the appropriate use of values and calculations, appropriate level of rigor, and administrative or calculation errors found. We will provide feedback on the effects these elements had on the project's ex-post savings and realization rate. Findings will be summarized in an individual report for each project assessed in the Verified Savings Review.

Approach by Program/Measure Type

This section presents the technical approach the NMR team will use to audit each program. Generally, the approach will be common across the state, although we will modify some activities for unique programs. We have elected to organize this section by measure category instead of program name or program type because the gross impact evaluation methods employed in each category will share many common features, despite the fact that the measures come from a variety of end-uses and programs. This high-level taxonomy for energy efficiency includes two primary measure types: TRM-based measures and custom measures. The NMR team notes that nearly all residential program measures are TRM-based measures. Table 3 shows the anticipated EDC evaluation activities and the proposed SWE audit activities by program/measure type.

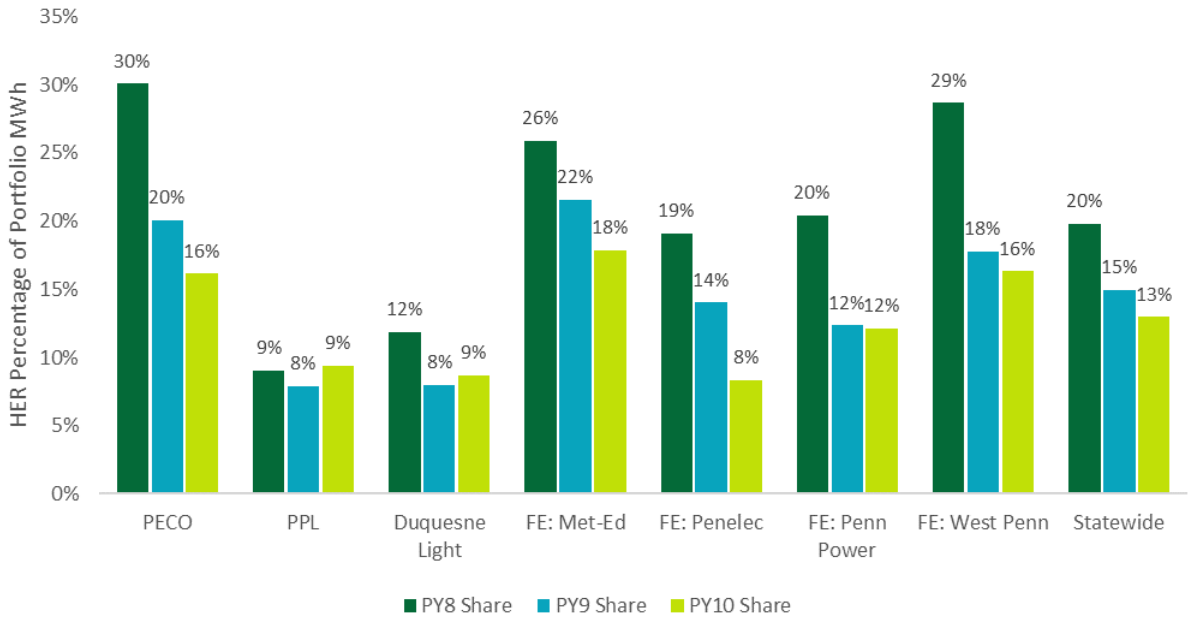
Table 3: SWE Audit Activities by Measure Type

Measure Type	Anticipated Evaluation Activities	SWE Audit Activities
TRM-based Measures	• Survey participants to verify installation • Verify installation, conduct audits • Collect nameplate info (type, efficiency, rating, size, etc.) • Collect data (house type, CAC/Furnace/Heater/AC model and efficiency [EER, COP, AFUE, R-value]) • Reconcile program database and invoices • Conduct metering activities (install hourly meter, collect billing data) for open variables, if required • Perform engineering calculations to calculate savings • Conduct measure-by-measure evaluation of installation, energy savings calculation, and reporting	• Review survey results • Verify the efficient technology meets the eligibility requirements outlined in the TRM • Verify the program delivery strategy is consistent with the measure vintage assumed in the baseline component of the TRM algorithm • Verify the per-unit kWh and kW savings values are calculated in accordance with the 2021 PA TRM or approved IMP • Verify measures are being mapped to the correct Pennsylvania reference cities for heating degree days, cooling degree days, equivalent full load hour (EFLH), and coincidence factor assumptions • Verify installation-rate results, energy savings calculations, and reporting • Verify methods and results of metering activities • Verify engineering calculations used to calculate savings • Review and verify model simulation savings estimates • Review site inspection and EM&V plans • Review logger and metered data • Field work assessment, if needed
Custom Measures	• Conduct on-site inspections • Conduct on-site metering and logging of end-use energy consumption parameters (kW, amperage, temperature, pressure, etc.) • Review project records/site audits/retro commissioning study • Obtain list of installed measures for visual inspection, review energy service company (ESCO) submittals • Develop metering plan/review existing metering records • Develop SSMVP, conduct site inspection: obtain nameplate equipment information (model, efficiency, etc.), conduct deemed savings review • Deploy metering equipment (if required) • Obtain energy savings calculation input parameters • Calculate savings (engineering approach/billing analysis/DOE2 simulations)	• Verify installation-rate results, energy savings calculations, and reporting • Verify methods and results of metering activities • Verify engineering calculations used to calculate savings • Review and verify building energy model simulation savings estimates • Field work assessment • Review site inspection and EM&V plans • Review logger and metered data • Review regression models used to calculate savings

2.3.2.3 Behavioral Conservation Programs

HER programs have become a staple of Act 129 residential programs and represent approximately 15% of all Phase III verified gross MWh savings to date. Figure 6, which is taken from the SWE PY10 Annual Report, shows HER energy savings as a share of compliance savings by EDC over time. HERs have also been a significant contributor to Phase III low-income compliance targets for Duquesne Light and the FirstEnergy EDCs.

Figure 6: HER Savings as a Percentage of the Portfolio, by EDC and Program Year



With the opportunity from residential lighting largely vanishing, the Phase IV Energy Efficiency and Peak Demand Reduction MPS estimated that approximately 45% of residential energy and demand savings would come from HERs. HERs are one of the most inexpensive measures from an EDC acquisition cost perspective, so inclusion of HERs affords EDCs with program design flexibility. FirstEnergy has also rolled out a BER offering in PY11 that utilizes similar principles to deliver savings from Small C&I customers. If this BER offering is successful in Phase III, we expect that FirstEnergy and the other EDCs will expand the role of BERs in Phase IV EE&C Plans.

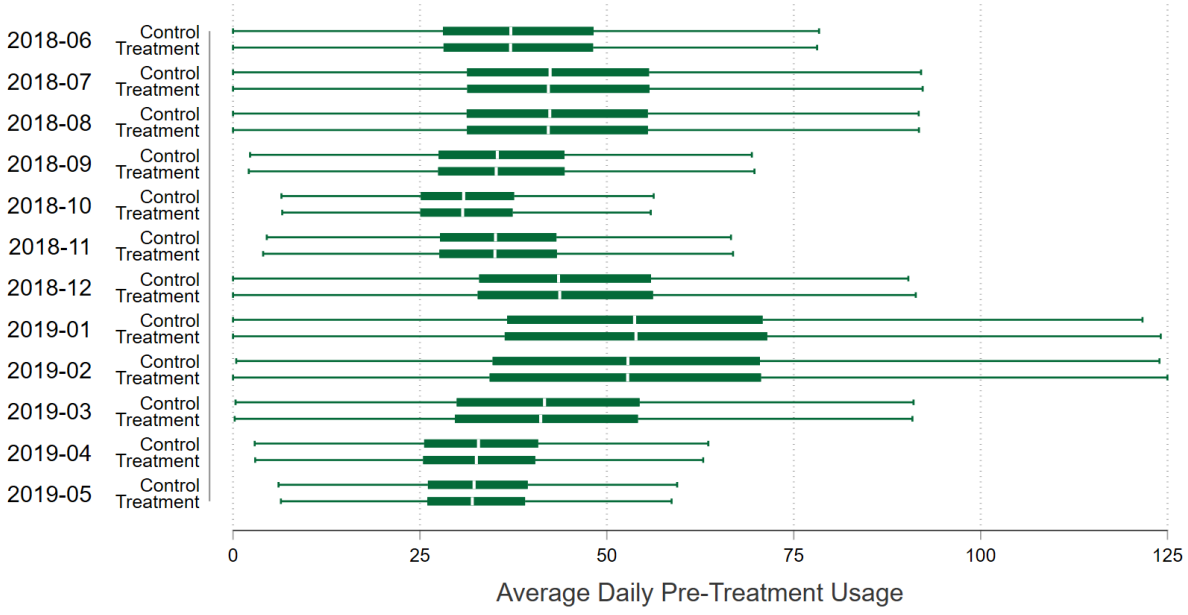
Early in Phase III, Jesse Smith of DSA authored the Behavioral Conservation Chapter of the Audit Plan/Evaluation Framework. Between the detailed protocol and extensive work with the EDCs and their evaluation contractors to standardize and improve their processes, the behavioral audit activities have become more efficient and identified fewer issues each year. As discussed in Section 2.2, two key modifications are needed to the behavioral protocol of the Audit Plan/Evaluation Framework to align with the HER protocol adopted in the 2021 TRM. Audit activities will need to investigate whether the EDC evaluation contractors have modified their processes appropriately.

1. The transition to a multi-year measure life and associated partitioning of measured savings into first-year compliance savings and persistent savings from prior years.
2. More strenuous expectations regarding the estimation of peak demand savings from HERs since EDCs have peak demand compliance targets for Phase IV of Act 129.

2.3.2.3.1 Ex-Ante

The ex-ante component of the SWE's audit activities for these programs will focus on confirming that the treatment and control groups are well-specified and do not show differences in consumption prior to energy reporting that could confound the savings estimates. If EDCs continue providing existing HER cohorts with behavioral messaging, it is not necessary to repeat this step because we have completed the checks as the Phase III SWE. However, the new HER accounting protocol makes it advantageous for EDCs to rotate HER exposure rather than continuing to treat the same homes year after year, so we expect new cohorts to be created. For each new HER/BER wave an EDC begins, the NMR team will request a minimum of one year of pre-treatment data for all treatment and control group customers as part of the EM&V plan review task. Figure 7 provides a graphical representation of a successful equivalence check. In each month, notice how the treatment and control groups have the same central tendency of energy usage. When pre-treatment usage is this well-aligned across seasons, estimating impacts from the energy reports is straightforward.

Figure 7: Successful HER Equivalence Check



With the creation of new HER cohorts and a finite number of residential accounts, it is likely that EDCs will create new HER cohorts that have received HERs previously. If the treatment group and control group contain equal proportions of prior HER recipients, this does not create any evaluation issues. In addition to checking for balance on the dependent variable (energy usage), the SWE will confirm that randomization is sound with respect to prior HER exposure.

2.3.2.3.2 Ex-post

SWE audit activities of behavioral program impacts after the savings are claimed by the EDCs in a Final Annual Report will be focused on replicability. Instead of spot-checking elements of the analysis, each year the SWE will independently estimate HER impacts using the same raw data as the evaluation contractor and the approved data preparation and analysis procedures. If the analysis is sound, the two efforts should return the same answer. The Phase IV audit steps can be placed into five main categories.

1. **Review of data cleaning and data management procedures.** Are EDC evaluators using appropriate methods to calendarize data? Are customers being excluded from the analysis who should not be? Are the evaluation contractors receiving a complete set of billing records from the EDC or are there gaps that distort the results? Are the pre-treatment and post-treatment periods correctly identified?
2. **Verification of the number of treated homes or businesses.** Analysis of this type of program will produce an average impact value that must be multiplied by the number of participants to calculate aggregate MWh and MW impacts. The SWE will verify the participant counts by month using the EDC billing records.
3. **Review of model selection and specification.** Are regression equations specified and interpreted correctly to calculate energy and demand savings? Did the evaluation contractor use the model specification approved in its EM&V plan? Is the data structured in the correct manner for the selected model specification?
4. **Verification that incremental participation in other Act 129 programs was handled in an appropriate way.** HERs will typically promote other energy-efficiency programs within the mailing, which leads to higher participation in those programs by the treatment group than the control group. Because the other Act 129 programs have already claimed the savings from this participation, a downward adjustment must be applied to the behavioral program to prevent double counting of savings.
5. **Partitioning of measured savings into incremental and persistent savings.** The accounting methodology developed by DSA during Phase III and codified in the 2021 TRM is more accurate than the legacy method, but also more complex. In the early years of Phase IV, the NMR team will carefully review each EDC's application of these new accounting rules to ensure compliance with the TRM.

The audit of the Behavioral Conservation Programs will follow the same schedule as the Energy Efficiency audit presented in Table 2.

2.3.2.4 Strategic Load Management

The NMR team believes that the new peak demand reduction goals for Phase IV will potentially lead to the inclusion of new programs and types of measures specifically designed to meet demand reduction goals. Complex measures like combined heat and power (CHP) and Conservation Voltage Reduction (CVR) may play a more prominent roll. Other examples could include expanded photovoltaic installations, specifically west-facing solar, thermal energy storage, and on-site battery storage. The NMR team has a deep bench of technical specialists who are prepared to review, audit, and provide verification oversight of the impacts for complex

measures and programs toward compliance. Our high-level approach to a sample of these types of measures is described in the following paragraphs.

2.3.2.4.1 Conservation Voltage Reduction (CVR)

For CVR implementations, the NMR team proposes in-depth involvement from the SWE in order to conduct a prospective analysis and ensure buy-in on CVR before the implementation phase. Gathering early consensus between the EDC, its evaluators, and the SWE makes the auditing and verification process more straightforward and limits the chances of a contentious situation surrounding compliance savings. Within the ex-ante phase, the NMR team recommends a false experiment analysis to assess the likely margin of error to be expected for the actual CVR experiment. The NMR team would also propose a thorough review of any analysis conducted by evaluation contractors, including the inputs, methodology, and, most importantly, the interpretation of results.

SWE audit activities of ex-post CVR impacts after the savings are claimed by the EDCs in a Final Annual Report will be focused on the following key areas:

- Validating the percent voltage reduction implemented across affected circuits on the distribution system
- Confirming that historic and normal weather conditions were gathered and applied correctly
- Independently estimating the statistical model used to determine the CVR factor (CVRF)
- Assessing the appropriateness of the annual loading estimates for each circuit. That is, if CVR is determined to produce a 1% reduction in energy usage, we will make sure that the 1% reduction value is applied to a reasonable estimate of annual kWh passing through each feeder.

2.3.2.4.2 Combined Heat and Power (CHP)

In recent years, CHP measures have been among the largest group of technologies used by the EDCs to meet their savings goals. The NMR team, acting as the Phase III SWE, has focused efforts each year towards ensuring these projects are accurately and appropriately characterized by the EDCs and their evaluators. Important aspects of the SWE audit activities for CHP projects include the following:

- Ensure that CHP projects are fully and accurately described through on-site assessments, considering CHP system operation and integration with other facility systems
- Review data collection activities, including data sources, metering intervals, and definitions of performance monitoring periods
- Confirm characterization of CHP system annual availability
- Assess regression analysis model inputs, assumptions, adjustments, and outputs

2.3.3 TRC Audit

The NMR team will audit the gross and net TRC ratios calculated by each EDC on an annual basis. If selected as the Phase IV SWE, we will develop an EDC annual report template that requires detailed TRC tables at the program level. We will also develop the template in such a way that EDCs who use a sector-based definition of *program* in their EE&C plan will need to present TRC Test results at the sub-program or solution/initiative level. We will also require more granular categorization of cost elements than the Phase III reporting tables. Like prior phases, we anticipate requiring EM&V contractors to provide a working TRC model as part of the annual data request response. If the EM&V contractor believes their TRC model to be proprietary, we will require all inputs to be provided so that the calculations can be independently replicated. Key elements of the TRC audit include the following:

- Consistency of input values with other reporting and EE&C plan. Do the kWh, kW, and dollar amount match the totals reported elsewhere? Are the avoided energy supply costs used in the TRC model consistent with the approved EE&C plan?
- Correctness of calculations. Are all quantities being multiplied and added together appropriately? Are unit conversions being handled appropriately?
- Adherence to the 2021 TRC Test Order, especially where the 2021 TRC Order guidance differs from prior phases. For example, are fossil fuel impacts being treated as negative impacts?
- Reasonableness of assumptions (e.g., incremental measure costs, timing of baseline shifts)

For each of the above factors, we will assess whether the EDC was successful in meeting expected standards or guidance. Where they have not, we will assess and report on the likely direction and magnitude of the error and how it may affect the cost-effectiveness outputs and any other components of the EDC's annual report. If differing assumptions are observed across EDCs, the NMR team may issue a guidance to memo to encourage standardization of practices across EDCs.

As with most audit activities, the selection of Phase IV EM&V contractors will influence the nature of the audit during the early years of Phase IV. NMR team members have audited the TRC tools used by the incumbent contractors repeatedly and are quite familiar with the model architecture. We have also developed parallel models for the EM&V contractors who do not share working TRC models (Cadmus and Guidehouse). If the EDCs maintain the same EM&V contractors from prior phases, the TRC audit will largely focus on continued refinement and confirming that all new Phase IV guidance and assumptions have been incorporated appropriately. If an EDC selects a new EM&V contractor for Phase IV, the TRC audit will require more attention to both understand the new vendor's model architecture and to educate that contractor on some of the nuances of the Pennsylvania TRC Test.

In the dispositions of the 2021 TRC Order, the PUC expressed its intention to direct the Phase IV to conduct several analyses as part of the TRC audit task. Several of these analyses are prospective in nature and are discussed in Section 2.4.2 (TRC Order). Two relatively straightforward tasks we plan to add to the annual TRC audit and reporting function are as follows:

1. **Avoided Cost of Electric Energy** – *While we maintain the position that a single forecast of avoided costs should be the foundation of Phase IV EE&C plans and annual reports, we agree with the Pennsylvania Energy Efficiency for All Coalition that there is value in periodically assessing the accuracy of the forecast. Consequently, we will direct the Phase IV SWE to include in its Final Annual Reports a comparison of forecasted avoided costs of electricity to load-weighted real-time LMPs for each EDC service area.*
2. **Alternative Energy Portfolio Standards Act** – *We will direct the Phase IV SWE to include a summary of the Alternative Energy Portfolio Standard costs with its Phase IV annual reports for comparison purposes.*

The SWE team's position is unique in that it has a detailed understanding of EE&C programs, can review high-level cost-effectiveness results across EDCs, and has access to the detailed inputs and assumptions that drive these results. As part of the SWE Annual Reports, the NMR team will compare and contrast TRC results for similar offerings across EDCs and provide context regarding the key drivers of differences. If differences in cost-effectiveness are driven by varying assumptions, the SWE's role should be to promote standardization. If differences are driven by efficient or inefficient program delivery practices by an EDC, the SWE should provide observations about what appears to be working well to promote sharing of best practices across EDCs.

2.3.4 Net Impacts

The PUC's Phase IV Implementation Order[6] maintained the practice used in prior phases, in that NTG research results will be used for modifications to existing programs and for planning purposes for future phases, while compliance in Phase IV will be determined using gross verified savings. In addition, the Phase IV Implementation Order directs the EDCs to report net TRC ratios in their annual reports and EE&C plans as the inclusion of NTG-based TRC ratios will provide all stakeholders with additional information regarding the effectiveness of EE&C measures and programs. However, compliance with the directive to offer a cost-effective portfolio will continue to be based on the gross TRC ratio.

In Phase IV, the NMR team will continue with the Phase III practices of providing streamlined approaches and methods for use by the EDCs in their NTG evaluations. During Phase III, the NMR team updated and enhanced the NTG approaches and *common method* guidance in the Audit Plan that are appropriate for nearly all downstream programs. The NTG guidance takes into consideration program design and budget, project savings, target population, the type of data that can realistically and consistently be collected or tracked by the EDCs, and study cost. The Audit Plan provides additional guidance to focus NTG research on measure categories or technologies of high importance, high-impact measures (HIM) in order to help program planners make decisions concerning measures responsible for the bulk of portfolio savings.

There are two key benefits to continuing with the *common method* guidance for EDC NTG research. First, consistent NTG measurement for a program across time allows for reliable and valid comparisons of the NTG metric across time. This helps program staff use the NTG metric to

[6] https://www.puc.pa.gov/PCDOCS/1666981.DOCX

inform their thinking about their program modifications and planning. Second, consistent methods across EDCs allows for comparisons across the EDCs. Just as programs change from year to year, it is clear that the programs offered by the EDCs vary from each other. When there are different NTG metrics, no one can discern whether different NTG values are due to program differences, external differences, or differences in the metric. By using a consistent metric, we can at least rule out differences in the metric. The *common method* maintains a consistent approach that allows for comparisons across time and EDC, while also allowing flexibility and customization to the EDCs.

In addition to reviewing and updating the Audit Plan, we anticipate two primary activities regarding NTG:

- **Review proposed NTG approaches in EDC EM&V Plans.** As noted in Section 2.2, the NMR team will continue to provide early, upfront feedback on NTG approaches, which will result in feedback that is much more actionable. The NMR team will review all NTG plans to determine if the studies follow the common method approach when appropriate and if they meet the appropriate rigor level from the Audit Plan, including proposed data collection, sample sizes, and analysis. If a program requires NTG evaluations that deviate from the guidance in the Audit Plan, the NMR team will closely review the alternative study plan to ensure that the methodology and sampling meets the appropriate rigor level.
- **Audit NTG results annually.** The NMR team will conduct a review of the NTG study results, including realized sample sizes, analysis (including the NTG algorithms), results, and reporting, to confirm that the study was carried out as planned. In addition, we will examine how the EDC and its evaluators are applying the NTG results to modify program design and implementation, as necessary.

Table 4 presents the general schedule of milestones and activities that the NMR team proposes to implement for the annual net impacts audit, using PY13 as an example.

Table 4: Proposed Net Impacts Timeline

Milestone	Estimated Date
EDC evaluator submits net impacts surveys to the SWE for review	February to April 2022
SWE reviews EDC evaluator net impacts surveys	February to May, 2022
Annual Data Request is due to the SWE	September 30, 2022
SWE audits net impacts	October 2022
SWE finalizes PY13 net impact findings in SWE Annual Report	November 30, 2022

2.3.5 Process Evaluation

The NMR team has industry-leading expertise in designing, conducting, and reporting on process evaluations. Our team reviewed and provided feedback on all Phase III EDC process evaluations and findings, and our team has conducted myriad process evaluations and market assessments for the full breadth of residential, low-income, and C&I programs for clients across the U.S. and Canada. We have fielded thousands of telephone and online surveys with participating and non-participating customers; performed hundreds of in-depth telephone interviews with program staff, implementers, contractors, and partners; and led dozens of focus groups. These process evaluation studies have been conducted for many of the leading energy-efficiency organizations, including program sponsors in Massachusetts, Connecticut, New York, Vermont, Ontario, and California, among others.

The NMR team will perform a comprehensive review of the current process evaluation guidance outlined in the SWE Audit Plan in order to assess whether any updates or revisions are required. Well designed and implemented process evaluations can help determine if there are ways to modify programs in order to improve cost-effectiveness or the program's efficiency in acquiring savings. For example, program managers and decision-makers can use the results of process evaluations to improve program performance with respect to internal administration and communications, promotional practices, program delivery, incentive levels, and data management, as well as to improve customer satisfaction and identify market threats and opportunities. Process findings can also provide information to regulators and stakeholders that programs are being implemented effectively and modified or refined as necessary.

In auditing EDC process evaluation studies, the NMR team will review the plans to ensure that the research objectives are clearly and appropriately defined and that the proposed research activities are sufficient to fully inform each of the research objectives. In addition, we will review the sampling plan to ensure that it is robust and addresses any known bias issues. Lastly, we will review the draft interview guides, surveys, and other data collection instruments to ensure that the questions are adequately mapped to the research objectives.

When reviewing the process evaluation reports, the NMR team will ensure that the methodology followed the approved study plan and SWE guidelines and that the analysis and reporting are clear, thorough, and reasonable. In particular, we will closely review any key findings of each program to ensure they accurately summarize the results of the study. We will also closely review any recommendations to confirm they are justified, specific, actionable, and supported by the key findings. Lastly, we will report on selected EDC responses to the recommendations and summarize the findings in our annual report to the PUC.

Table 5 presents the general schedule of milestones and activities that the NMR team proposes to implement for the annual process evaluation audit, using PY13 as an example.

Table 5: Proposed Process Evaluation Audit Timeline

Milestone	Estimated Date
EDC evaluator submits process evaluation surveys to the SWE for review	February to April 2022
SWE reviews EDC evaluator process evaluation surveys	February to May, 2022
Annual Data Request is due to the SWE	September 30, 2022
SWE audits process evaluation findings	October 2022
SWE finalizes PY13 process findings in SWE Annual Report	November 30, 2022
SWE conducts follow-up with EDC to review EDC application of process findings	Spring 2023

2.3.6 Ad Hoc Auditing Activities

In addition to the known audit activities described previously in this section, the SWE will be required to respond to ad hoc research tasks over the course of Phase IV. Although the exact nature of these tasks can be difficult to forecast, our experience on the prior SWE teams tells us that these ad hoc reporting tasks or analyses should be expected in Phase IV in response to technical inquiries raised by stakeholders. Several ad hoc analyses that were completed in Phase III, but were not explicitly called out in the SWE scope of work, include the following:

- PY8 updates to incremental measure costs database for LED lighting in the residential and non-residential sectors
- PY8 updates to incremental measure costs database for air-source and ductless heat pumps (residential and non-residential)
- PY8 EISA 2020 overview and implications memo summarizing two new rules issued by the U.S. DOE pertaining to EISA 2020 and ongoing EDC EISA inquiries for PY12 and Phase IV
- Guidance memo on the applicability of TRM Appendix E to clarify the eligibility requirements of lighting equipment, largely for non-residential applications
- Guidance memo on the inclusion of fossil fuel and water benefits in the TRC test
- Addendum to Act 129 Behavioral Persistence Study
- Guidance memo on dual baseline assumptions for screw-in LED lighting in the PY11 and PY12 TRC tests
- Guidance Memo on calculating savings from cross-sector sales under residential ENERGY STAR lighting programs
- Guidance memo Act 129 and PJM M&V Considerations for Phase IV
- Creation of a Tableau dashboard to view summary information from the statewide tracking database
- Guidance memo on PY11 EM&V and the Coronavirus outbreak and FAQ memo

We also know that these tasks typically require the attention of experienced team members with specialized skill sets and often have tight timelines. The NMR team has allocated a portion of our audit activity budget to these tasks, with hours concentrated among key senior staff to ensure the SWE will always have sufficient bandwidth to tackle ad hoc technical requests from staff in a timely fashion. This approach also prevents a situation in which TUS staff must consider contract modifications or re-allocate hours from other core audit activities in order to leverage the SWE for an unforeseen technical analysis.

If the volume of ad hoc research tasks in Phase IV proves to be lower than expected, staff hours allocated to ad hoc activities could be shifted elsewhere or simply reduced at a cost savings to the PUC.

One ad hoc task we recommend incorporating into the Phase IV SWE scope of work involves exploring the expansion of meter-based savings verification for Act 129. Meter-based savings is a concept gaining traction in the industry as an alternative to traditional M&V practices. This is sometimes referred to as "M&V 2.0," Advanced M&V, or Normalized Metered Energy Consumption (NMEC). Proponents of this approach cite the availability of high frequency advanced metering infrastructure (AMI) data and the ability to build more accurate regression models of home and business energy consumption. Not surprisingly, the purveyors of software products who provide these services cite the potential for increased accuracy at a fraction of the cost of traditional M&V techniques. The PUC will undoubtedly be lobbied during Phase IV to move away from TRM-based verification and towards the panacea of meter-based savings. The NMR team believes that these methods can be useful in certain cases, but the appropriate applications will be relatively limited under Act 129 for several reasons:

1. **Baseline Issues** – Most Act 129 measures utilize a code minimum baseline rather than the efficiency of the replaced equipment. Billing analysis methods are much better suited for retrofit measures where the replaced equipment is the baseline.
2. **Signal to Noise** – Small changes in energy consumption are difficult to measure with whole-building data. Therefore, traditional M&V practices often focus on the specific equipment or systems affected by the upgrade.
3. **EDC Risk** – The TRM provides a great deal of certainty in terms of the kWh savings per unit or program dollar spent. With meter-based methods, the level of savings would be far less certain, which would be perceived as risk by the EDCs. At a fundamental level, there is nothing new about billing analysis – evaluators have been performing regression analysis on utility bills since the 1970s. EDC evaluation contractors use these methods in certain cases, but generally rely on the safe harbor of the TRM when possible.

Reservations aside, the NMR team proposes to conduct some limited testing as part of Phase IV activities to determine if expansion of meter-based methods in Act 129 would be advantageous in certain applications from an accuracy or cost standpoint. Including a limited amount of this type of research in the Phase IV work plan gives the PUC something to point to when stakeholders or Commissioners invariably ask where Pennsylvania is on adopting meter-based savings methods. Potential advantages include the following:

- **Eliminates the need for sampling:** Analyzing a census of program participants using traditional M&V methods is cost-prohibitive, so statistical sampling is used to develop estimates of the parameters of interest. With meter-based methods, there is little to no incremental cost associated with analyzing additional premises.
- **Reduces the M&V burden on participants:** Sending technicians to homes and businesses to install and remove meters requires time and coordination. If M&V can be conducted remotely using the revenue meter, it creates less of an *ask* on program participants.
- **Enables EDCs to look beyond the average customer:** The use of average savings assumptions to set rebate levels and claim savings is standard industry practice but can create inefficiencies and misaligned incentives. In practice, some customers save more and some save less given the same measure. Additionally, the timing of savings can vary considerably, which has important implications for valuation. An M&V approach that can identify these differences and segment customers creates powerful opportunities for targeting high-value customers and *pay for performance* program designs.
- **The ability to embed M&V into program delivery:** Once the data transfer protocols, cleaning procedures, and methods are established, meter-based methods can be conducted on a rolling basis. Savings performance still needs to be observed over a range of conditions to develop a reliable estimate of normalized savings, but the analysis and reporting can be largely automated.
- **Granular impact estimates:** Time-differentiated savings estimates are useful for a wide range of planning and valuation functions.

We propose to identify a small number of TRM measures with high participation across multiple EDCs and expected savings large enough to observe with whole-building data and analyze the savings using AMI data. We would conduct the analysis using the Lawrence Berkeley National Lab (LBNL) Time of Week and Temperature (TOWT) piecewise linear regression model. This model has been adopted in California and elsewhere as the default NMEC method. We envision this analysis as a research effort and would not use the findings in any compliance determination for Phase IV. However, the outputs could inform future TRM updates, load shapes for TRC models, or recommended methods in the Pennsylvania Audit Plan/Evaluation Framework.

We may also see a return of the EPA's Clean Power Plan (111d) under the Biden administration during Phase IV, or similar proposed rules. If the Clean Power Plan is reinstated, or similar legislation enacted, the PUC will likely require ad hoc research tasks from the SWE in support of an implementation approach. Act 129 programs will likely be an important component of

Pennsylvania's implementation plan, and this will create complex technical and economic challenges that the SWE will be well-positioned to respond to.

2.4 UPDATES TO TRM AND TRC ORDER

After the Implementation Order, the PA TRM and TRC Order are the two most binding documents for EDCs subject to Act 129. They go through the formal PUC order process with a Tentative Order, comments, and reply comments prior to Final Order. Although these policy directives are issued by the PUC and written in its voice, the SWE team is leveraged extensively to provide technical analysis, develop algorithms and assumptions, and author cohesive sections that blend technical and policy issues seamlessly.

2.4.1 TRM Order Update

Members of the NMR team have extensive experience with, and involvement in, the development and updates of the prior versions of Pennsylvania TRMs used in Phase I, II, and III, along with the associated Tentative and Final TRM Orders. Our team excels in the execution of both the technical and administrative aspects of the TRM Order.

The NMR team has valuable experience developing, maintaining, and reviewing TRMs in many other jurisdictions, including Massachusetts, Connecticut, New York, Ohio, Illinois, Louisiana, New Jersey, Vermont, Maryland, Delaware, and the District of Columbia. Our team has successfully demonstrated the ability to coordinate and lead the update of the TRM in Phase III and proposes a similar process with a few enhancements. TRM updates focus on any pertinent new measures and the calculation of savings for standard energy-efficiency measures to ensure that the TRM accurately captures Act 129 program measure savings.

Regardless of the schedule ultimately determined by the PUC for the Phase V TRM, the NMR team recommends completing the bulk TRM update research during 2024 to leverage synergies with the potential study measure characterizations. From an administrative standpoint, it is best to avoid misalignments between the Phase V energy-efficiency MPS and Phase V TRM because EDCs will invariably use any misalignment to cast doubt on the proposed targets. Conducting TRM research this early does have a drawback – the assumptions and inputs can become *stale* before the phase ever begins. One option is to conduct the TRM research and develop updates in 2024 but hold off on issuing the Tentative TRM Order until closer to the beginning of Phase V so that new developments can be included.

The NMR team will seek direction from the PUC regarding the level of upfront input to solicit from the EDCs and their evaluation contractors. Our objectives for the TRM update activities will be to improve existing protocols based on primary research from evaluation and baseline studies, secondary research sources, and changes in technology and codes and standards.

2.4.1.1 TRM Update Topics

The NMR team will focus on new industry standards and technology updates for measures within the TRM and/or any measures that are impactful within EDC EE&C plans. NMR team members are industry leaders in technology innovation and regularly follow industry trends and research. Our consultants regularly publish work papers at leading energy industry conferences and seminars. Based on our experience with, and knowledge of, the TRM, we expect updates to include the following topics.

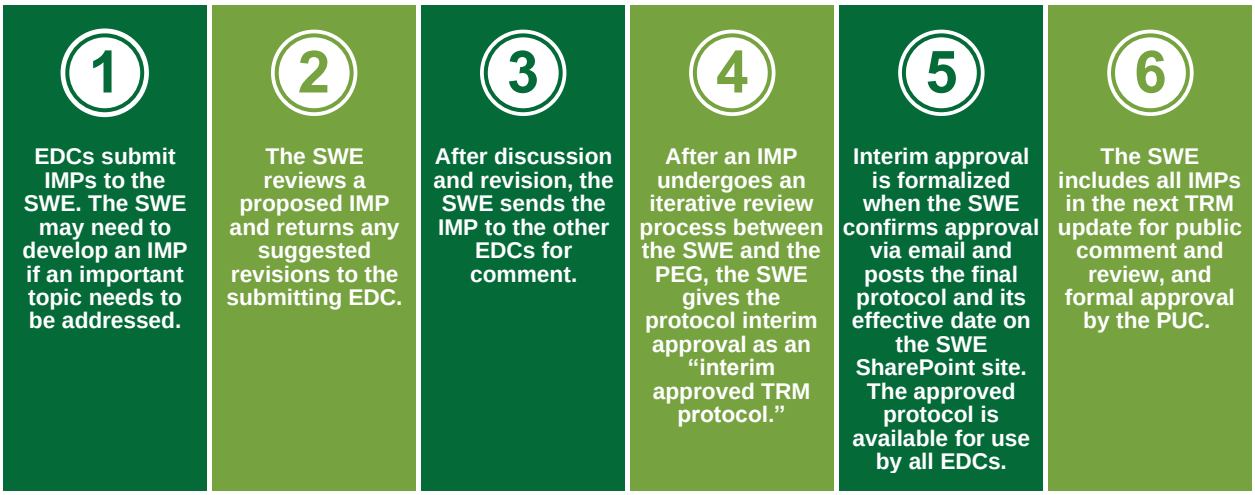
- Addition or modification of default values based on program tracking data or evaluation results. In certain cases, providing deemed or default values for parameters that have been relatively stable over time can reduce program delivery requirements without jeopardizing the rigor of savings.
- Increased rigor for summer capacity values as peak demand reduction targets are a new component of EDC EE&C goals. Where pertinent, winter capacity values to support EDC nomination of resources to the PJM Forward Capacity Market.
- Hourly load shapes based on prior PA TRM research studies, such as commercial lighting, and additional sources, such as the U.S. DOE's End-Use Load Profiles for the U.S. Building Stock project, which is scheduled for completion in 2021
- IMP for measures that are introduced at the end of Phase III and proposed by EDCs throughout Phase IV (refer to Section 2.4.1.2), such as cold weather heat pumps
- Treatment of formerly custom measures as prescriptive measures if they are common enough and there is enough supporting data in order to reduce EDC EM&V costs
- Increased industry prevalence of end-use equipment controls (occupancy sensors, economizers, CO_2 sensors, etc.)
- Potential changes for federal codes and standards that are a result of new federal administration and DOE priorities
- Increased prevalence of consumer electronics and *connected* equipment (Smart Devices), with growing research on the Internet of Things

Additionally, as part of the Phase IV EE&C Implementation Order (Section D.2), the SWE is to provide an annual recommendation to potential TRM updates based on any impacted parameters related to codes, standards, and ENERGY STAR specifications. As active industry experts, SWE members monitor proposed codes and standards. By March 15 of each year, the SWE will deliver a memorandum that highlights any pertinent codes and standards, along with identification of potential impacts on EDC goals. It is expected that by July 15 of that year, tentative TRM order and manual updates will be prepared for the public meeting agenda.

As noted above, one likely potential source for standards are from the DOE due to expected improvements in lighting and appliance standards with the Biden administration priorities.

2.4.1.2 IMP Process

The NMR team will continue to administer the IMP process established in prior phases, which is a means for EDCs to establish common assumptions and methods for a new measure or suggest modifications to an existing protocol. This provides an iterative and collaborative review process to vet measures in an orderly and manageable fashion. Because Phase IV is envisioned to be a fixed-TRM phase (other than the previously noted potential updates to codes, standards, and ENERGY STAR specifications), we anticipate that the EDCs will increasingly leverage the IMP process as programs evolve and market characteristics change with technological advancements. SWE approval of an IMP is intended to minimize risk for EDCs planning to offer measures that do not have a TRM protocol by developing savings protocols. The IMP review and approval process includes the following steps:



The NMR team will work closely with TUS staff during to the Audit Plan/Evaluation Framework to assess whether modifications to the IMP processes are necessary given the expected mechanism for mid-phase TRM updates to reflect changes to codes and standards.

2.4.2 TRC Order Update

In addition to auditing the cost-effectiveness results reported by each of the EDCs on an annual basis, the SWE team is expected to work closely with PUC staff on updates to the TRC Order for a potential Phase V of Act 129. Based on the timing in phases and the guidance set forth in the RFP, we anticipate a Tentative Order on the Act 129 TRC Test for Phase V during summer 2024. The Tentative Order will go through the standard comment and reply comment process and the 2026 TRC Test Final Order will be issued in fall 2024. The NMR team plans to begin technical work on the TRC Test Update in 2023.

When the first TRC Test Orders were issued during Phase I, the Act 129 TRC Test closely mirrored the TRC Test as described in the California Standard Practice Manual. Over time, the Act 129 TRC Test has evolved to reflect Pennsylvania-specific policy positions and perspectives on the avoided cost of energy supply and other economic issues. For example, in the 2021 TRC Order, the PUC took a new position on the discount rate used to calculate the present value of future benefits and transitioned away from the EDC weighted average cost of capital (WACC) to a 3% real discount rate statewide. Because the TRC Test puts policy into practice, it is critical that

the proposed guidance in the Tentative Order reflect the priorities of the Commission. While the Order will state that TRC Order directives are not binding in other regulatory matters, we believe it is important for the PUC to set forth positions that are reasonably consistent with other policy proceedings.

The 2026 TRC Order Update will be led by Jesse Smith and Patrick Burns. Jesse led both the 2016 TRC Order and 2021 TRC Order updates for the SWE team and understands the genesis of the Commission's position on almost every issue. He also possesses a strong understanding of which aspects are feasible to update and which ones are not. For example, the 15-year measure life limit for Act 129 measures is an often-criticized rule by stakeholders. While the SWE and PUC may agree with this viewpoint, the 15-year measure life limit is set by the original legislation (Act 129 of 2008) and it would be inappropriate to contradict the legislation in a PUC Order. Patrick developed the Avoided Cost Calculator (ACC), which accompanied the 2021 TRC Order to promote methodological consistency across EDCs when developing the avoided cost of energy supply used to compute TRC benefits.

The first step in the TRC Test Update will be to review the 2021 TRC Order with TUS Staff and other Commission staff, as appropriate, to identify areas where energy policy in the Commonwealth may have changed and merit an update to the TRC Test Order. For example, if Pennsylvania joins the Regional Greenhouse Gas Initiative (RGGI), the TRC Test will need to be modified to reflect avoided RGGI compliance costs as a benefit. In dispositions responding to stakeholder comments in the 2021 TRC Order and Phase IV Implementation Order, the PUC committed to monitoring and reviewing several issues during Phase IV to assess the need for a mid-phase update and in preparation for the 2026 TRC Order. These items include the following:

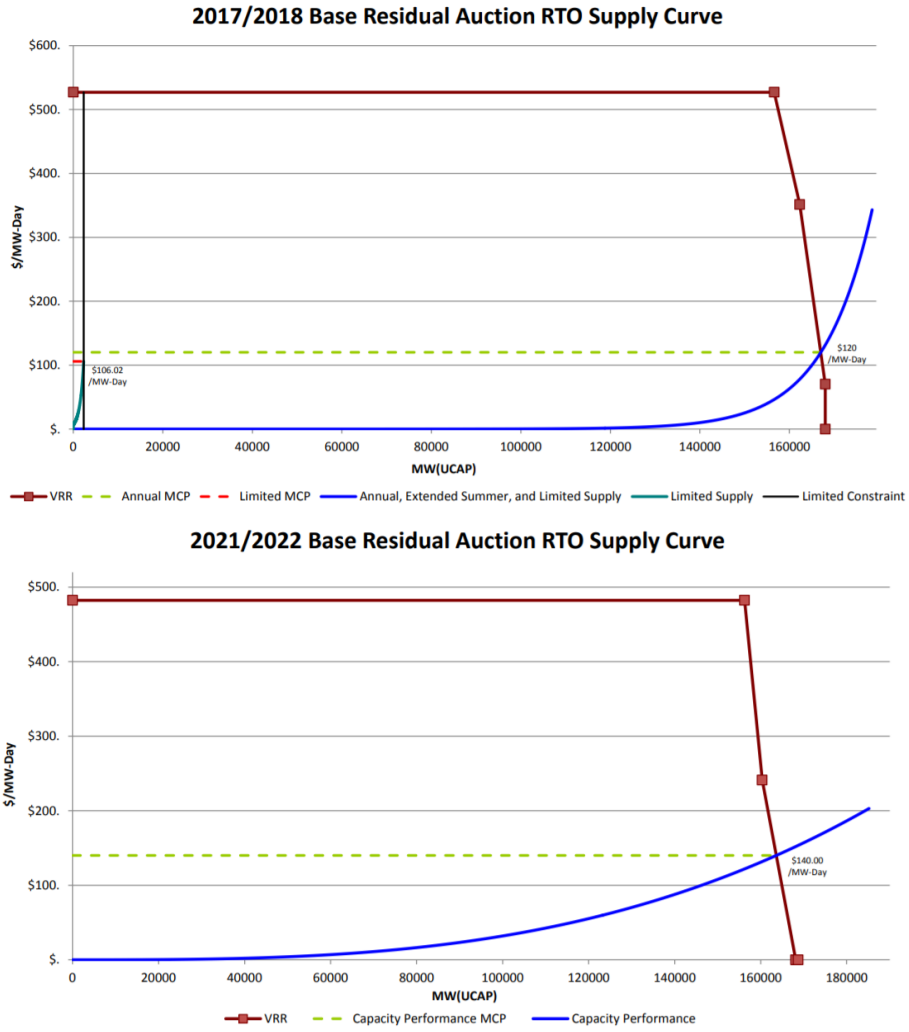
1. **Vintage of Avoided Cost Forecasts**: The status quo approach for Act 129 phases is to develop a set of avoided costs as part of the EE&C plan and use these for all TRC calculations in the phase. Stakeholders suggested this approach could lead to *stale* assumptions, so the PUC committed to directing the Phase IV SWE to monitor the issue.
2. **Avoided Cost of Electric Energy**: The status quo approach relies on short-, medium-, and long-term forecasts. The medium- and long-term portions assume a natural gas unit on the margin and convert projected natural gas prices to electricity via a heat rate assumption. The 2021 TRC Order states that the PUC will direct the Phase IV to monitor heat rates.
3. **Avoided Cost of T&D Capacity**: The status quo approach to these capacity benefit streams needs to be overhauled for a world of flat or declining peak demand at the zonal level. Section 2.4.2.1 describes the NMR teams approach to this component of the TRC Order Update.
4. **Beneficial Electrification**: Act 129 is designed to reduce consumption of electricity. Most progressive jurisdictions are pivoting their DSM programs to target a reduction in emissions, which includes electrification of heating, water heating, and transportation end-uses. In the Phase IV Implementation Order, stakeholders identified the limitations of the 2021 TRC Test Order with respect to electrification measures. The inclusion of beneficial electrification measures is a far-reaching policy discussion for goal setting and cost recovery and may require changes to the legislation itself. If the PUC wishes to consider

beneficial electrification in Phase V of Act 129, several significant modifications will be required to the TRC Test.

5. **Arrearages Study**: In the Phase IV Implementation Order, stakeholders pointed out that the arrearages and uncollected debt were a cost of supplying electricity and suggested the PUC quantify potential reductions of these costs as benefits in the TRC Test for low-income programs. In its disposition, the PUC stated, "*In preparation for the next TRC Test Order, we will direct the Phase IV SWE to study, in collaboration with the EDCs, to study the impact of Act 129 low-income programs on arrearages and collections. The results of this analysis will be used to determine whether such a benefit should be added to the Pennsylvania TRC Test."*[7] This analysis will be led by Ferit Ucar of NMR. Ferit is a Senior Economist at NMR with over ten years of experience in program evaluation, data analysis, survey methodology, sample design, and multivariate statistical techniques
6. **DRIPE or demand reduction induced pricing effects**: These are not included as a TRC benefit in the 2021 TRC Order. However, in the 2021 TRC Order, the PUC stated that it would direct the Phase IV SWE to monitor the issue and provide recommendations regarding the methodology, cost, and timeline of a study to re-examine capacity and/or energy DRIPE in the Commonwealth. NMR team member DSA has conducted this analysis previously using the scenario analysis that PJM publishes following each Base Residual Auction and will perform the analysis for the PUC in preparation for the TRC Order update. As shown in Figure 8, the supply curve in PJM has flattened in recent years, which suggests DRIPE benefits will be more modest than in prior analyses. The details of a Minimum-Offer Price Rule (MOPR) will undoubtedly affect any DRIPE estimates.

[7] PHASE IV implementation order at page 106.

Figure 8: Flattening of the Regional Transmission Organization (RTO) Supply Curve Over Time



The NMR team understands the importance of aligning the market potential studies with the accounting and cost-effectiveness guidelines that are expected to be in place during the upcoming Phase. All economic screening for the Phase V market potential studies will be conducted using the guidance contained in the 2026 TRC Test Order.

2.4.2.1 Avoided Cost of Transmission and Distribution Capacity Study

The value of avoided transmission and distribution (T&D) costs associated with an increment or decrement of peak load is a key component of benefit-cost analyses. In practice, T&D capital costs resources are concentrated in pockets that are experiencing growth but lack the capacity to accommodate additional growth. Most utilities have a mix of areas where loads are growing and areas where loads are declining, which may or may not overlap with highly loaded components. In locations with excess distribution capacity or where local peak demand is declining, the potential to avoid T&D costs is minimal. In areas where a large, growth-related investment is imminent, the avoided T&D costs from reducing peak demand are much higher.

The 2021 TRC order recognized that the approach used historically is a simplification. In prior years, the costs of growth-related T&D projects have been divided by the changes in the system (not local) peak demand to obtain an estimate of avoided T&D costs per kW. The limitation in this approach becomes evident when system loads are flat or declining. Even utilities with nearly flat or negative system load growth require T&D capital investments because a subset of areas in the territory is still growing. However, the historical approach yields extreme or negative avoided T&D costs whenever system loads are nearly flat or declining.

The 2021 TRC order directed the Phase IV SWE to develop a more granular alternative methodology for the avoided cost of T&D capacity in Pennsylvania. Staff from subcontractor DSA have worked extensively with utility T&D planning teams to produce location-specific estimates of avoided T&D costs. The staff proposed to lead this analysis (Josh Bode and Alana Lemarchand) have analyzed hourly data from tens of thousands of feeders, banks, substations, and transmission load pockets. Our team also has standardized processes and code for the following:

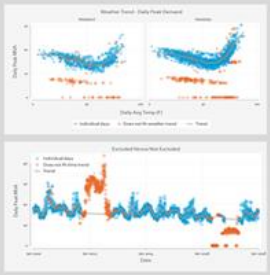
- Estimating location-specific growth
- Producing location specific, weather normalized forecasts
- Simulating load transfers (N-1)
- Calculating the magnitude of load relief needed to defer, avoid, or reduce T&D costs
- Estimating the avoided or deferred T&D costs due to reductions in local demand peaks

Figure 9 summarizes the process we employed for a recent study of location-specific T&D avoided costs on Long Island. However, the process is data-intensive and requires substantial collaboration with T&D planning teams.

Figure 9: Typical Process for Estimating Location-specific Avoided T&D Costs

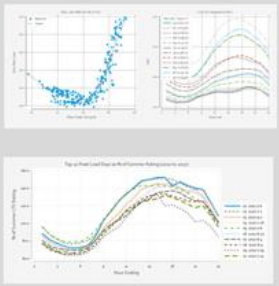
1. CLEAN SCADA DATA

- Identify load transfers
- Remove outages and meter recording issues
- Avoid mixing data issues such as load transfers with load growth/declines



2. ANALYZE HISTORICAL DATA

- Plot top 10 peak load days
- Plot load duration curves
- Sensitivity of loads to weather

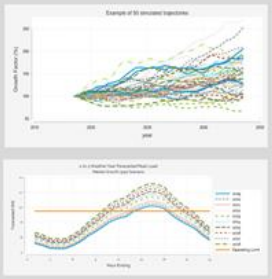


3. ESTIMATE LOCATION SPECIFIC GROWTH RATES

- Goal is to produce location specific peak growth rates absent incremental DER (otherwise DER is undervalued)
- Growth rates produced for 130 substations
- Add in solar production base on location specific installed resources
- Estimate models using 2014-2019 loads designed to isolate the annual % change in peak load (vs. weather, etc.)
- Use model to predict loads under planning conditions (normal weather years)

4. SIMULATE GROWTH TRAJECTORIES

- Use Monte Carlo simulation to reflect greater uncertainty in future years
- Factor in growth trend, uncertainty, and auto-correlation (random-walk)
- Add in lump loads (to simulate distribution planning process)

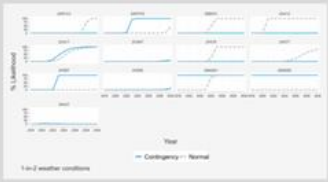


5. ANALYZE EMERGENCY CONDITIONS (N-1)

- Most of PSEG LI system is designed for N-1 planning criteria
- Most upgrades are due to expected overloads under emergency conditions
- If a feeder or bank trips, load can be supported by neighbors with tie points using 3 or fewer load transfers
- Simulated emergency transfers for all feeders and banks

6. ESTIMATE THE LIKELIHOOD OF OVERLOADS

- Estimate the likelihood of upgrades given uncertainty in growth and weather
- Record likelihood of upgrades due to normal and emergency overloads

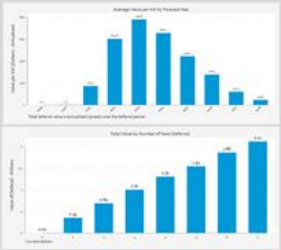


7. GATHER COST DATA FOR LOCATIONS WITH OVERLOAD RISK

- For locations with an overload risk due to load growth, gather data on:
  - T&D solution
  - Capital costs
- PSEG LI provided the cost data based on locations identified in the study

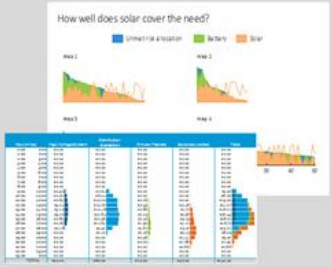
8. ESTIMATE VALUE OF INCREMENTAL RESOURCES

- For each simulated trajectory identify if an upgrade is needed, when it is needed, the magnitude of resource required, the deferral period, and the costs with and without deferral.



9. TIME-DIFFERENTIATE VALUE

- Allocate value by hour of day, weekday/weekend and season
- Assess how well different DERs align with value, given operating characteristics



Developing more granular T&D avoided costs for the seven EDCs subject to Act 129 within a reasonable budget requires some modifications. Specifically, it will be critical to meet five objectives:

1. **As much as possible, rely on EDC data and existing planning practices.** The goal is not to supplant existing practices but to use the planning data and existing planning standards to estimate the deferral value.
2. **Ensure a standardized and transparent process.** To accomplish this objective, we will create standardized tools with transparent inputs and rely on the EDCs to develop the initial estimates.
3. **Verify that project T&D costs align with historical expenditures, loading factors, and loads**. A key issue is identifying the growth-related projects. In practice, not all utility investments are due to load growth. Load growth typically occurs due to changes in existing loads (e.g., EV adoption), increases in the number of customers (e.g., a new housing sub-division), or new large loads (e.g., a new warehouse center). Utilities also need to install or replace equipment due to aging or failed equipment, storms, voltage violations, and grid modernization efforts. In practice, upgrades can serve multiple purposes. However, a key indicator of growth-related investments is the ratio between the peak load and the capacity rating, known as the loading factor. As peak loads near the capacity ratings, growth-driven T&D upgrades are required. Most utilities model the potential for overloads under both normal and emergency operations. The normal rating reflects the amount of demand, or load, the equipment can support in the absence of emergencies. However, when an emergency occurs, the feeder or bank may need to accommodate additional demand from a neighboring location for a short period while the repairs to restore normal operations occur. Thus, the emergency ratings are typically higher than normal ratings and used to assess the ability to produce the ability to deliver power even if a grid component – a circuit feeder or substation bank – is temporarily unavailable (an N-1 condition). While planning practices vary by utility, most growth-related T&D capital investments are due to violations of planning standards under emergency (N-1) conditions.
4. **Estimate the timing of overloads, the magnitude of load relief required for deferral, and the avoidable T&D costs**. The avoided T&D costs are tied to deferring, reducing, or avoiding capital costs for specific T&D projects. To realize the benefit, specific amounts of load relief are needed for specific project years and hours. Thus, the T&D ACC must factor in the magnitude of load relief required to defer, avoid, or reduce the project's cost.
5. **Produce location-specific time differentiated value**. We plan to estimate total deferral value, deferral value per kW, and deferral value per kW-year for each T&D project. We will then aggregate the value to different geographic units: feeder, substation, load pocket, utility planning area, and system. Finally, we plan to time-differentiate the value. This last step is critical because load relief in the wrong hours or days does not help alleviate T&D costs. The Pennsylvania PUC will ultimately decide the geographic and temporal

granularity used to report avoided T&D costs. However, we plan to produce bottom-up estimates, which allow for different levels of aggregation.

Table 6 summarizes the data requirements and analysis outputs. At a high level, we plan to produce two tools. The first tool will be a web-based tool to enable EDCs to estimate location-specific growth rates and use a standard process to weather-normalize loads. Many utilities do not have location-specific growth rates and location-specific weather normalization. If they do, they are welcome to use their internal estimates or Census Bureau location-specific population projections, in which case the NMR team will cross-check their growth estimates. The second tool will be an Excel-based tool to ingest standardized inputs, calculate the T&D deferral value associated with deferring or avoiding projects, and produce granular time-differentiated estimates of T&D avoided costs. We recommend an Excel-based tool to ensure transparency of inputs, calculations, and outputs for the EDCs, the Commission, and other stakeholders. The NMR team will also conduct a detailed assessment to ensure all the relevant growth-related projects are included and that T&D projected costs are consistent with historical patterns. Finally, the NMR team will implement detailed checks of the inputs and outputs produced by the utilities.

Table 6: Data Requirements and Analysis Outputs

Data Requirements	Analysis Outputs
▪ Database of feeders, banks, substations, and transmission load pockets with normal and emergency ratings ▪ For each feeder, bank, substation, and transmission load pocket, the following is required: ✓ Historical annual peak loads ✓ Historical loading factors (annual peak load/capacity) under normal and emergency conditions ✓ Historical peak day load profiles (for load cycle) ✓ Forecast peak loads under normal and emergency conditions ✓ Forecast loading factors (annual peak load/capacity) under normal and emergency conditions ✓ Cumulative installed distributed solar capacity ▪ Location-specific growth rates absent incremental DERs for highly loaded areas (85% or above) ▪ Historical and planned T&D infrastructure projects, including the following: ✓ Capital costs ✓ The amount of added capacity ✓ Age and expected useful life of the equipment being replaced ✓ Drivers of the project, such as new loads, growth rates, voltage violations, aging equipment, etc. ✓ Locations where load relief reduce loads on the limiting element(s) ✓ Projected lump loads ✓ The magnitude of projected overloads by forecast year and hour ▪ Financial inputs – carrying costs (either levelized annual carrying charge or revenue requirement multiplier), book life, discount rate, and inflation rate	▪ Comparison of historical and projected expenditures and capacity additions: ✓ What share of T&D capital cost historical and forecast T&D projects are growth related? ✓ Do projected growth-related expenditures align with historical expenditures? ✓ What is the relationship between the loading factor and capital investments? ▪ Check if proposed T&D projects have highly loaded component (and vice-versa) ▪ Website tool to help utilities estimate location-specific growth and weather normalized loads ▪ Publicly available calculator to estimate the deferral value. The model will be an Excel-based model designed to capture utility inputs and accomplish the following: ✓ Estimate revenue requirements with and without deferral of T&D project ✓ Estimate total deferral value, deferral value per kW, and deferral value per kW-year for each location ✓ Aggregate T&D deferral value to different units of analysis – feeder, substation, load pocket, EDC planning area, and system ✓ Time-differentiate the deferral value ▪ Validate and cross-check EDC inputs ▪ Assist EDCs with critical analysis, if needed (e.g., location-specific growth rates)

2.4.3 Pennsylvania Incremental Measure Cost Database

The SWE has historically maintained a database of incremental costs for efficiency measures that EDCs regulated under Act 129 can optionally use in developing their energy-efficiency plans and performing TRC calculations. In Phase III, this database was updated after the completion of the TRM update, TRC order, and Market Potential Studies, in time for EDCs to begin program planning for Phase IV. While this timing satisfies the primary applications of the incremental cost database, the NMR team proposes a modified approach to updating the incremental cost database for a potential Phase V of Act 129: updating the incremental cost database at the time the TRM is updated, in time for inclusion in the MPS.

In addition to the improved alignment among deliverables, this change will drive efficiency by allowing SWE team members working on TRM updates to simultaneously work on incremental cost updates for those same measures. It would also eliminate the process of merging incremental cost research from the measure characterization step of the MPS with the incremental cost update workstream since the cost updates would be completed in advance of the potential study, and therefore would constitute an input to measure characterizations rather than an output.

Data sources for the incremental cost database update process include case studies, incremental cost research and data repositories from other jurisdictions, RS means, industry research papers, systematic harvesting of equipment vendor data through web scraping and manual review, and the U.S. DOE, among others.

2.5 Data Management and Commission Reports

A staggering amount of data is collected in the administration of Act 129 EE&C programs: electric consumption records, sales data and specifications for efficient products, and all necessary (potentially sensitive) customer characteristics needed for rebate processing. One of the SWE's key duties is to organize data streams from the seven EDCs and synthesize them into digestible reports for the PUC and Act 129 stakeholders in an accurate and timely fashion without compromising data security agreements between the EDCs and their customers.

2.5.1 Statewide Repository of Program Tracking Data

Table 2 of the RFP states that one of the roles and responsibilities of the Statewide Evaluation Contractor is the "design, implementation and maintenance of statewide database of program, portfolio, EDC and statewide energy and peak demand savings and cost-effectiveness reporting." During Phase III, the NMR team developed such a database in our role as the SWE. Each quarter, EDCs submit measure-level tracking data to the SWE in a uniform format that enables the aggregation of records across EDCs. The beauty of storing data in a highly granular level is that virtually any question can be answered by analyzing the data at the appropriate level of aggregation. In addition to energy savings, peak demand savings, and incentive costs, the EDCs must provide a host of other variables in their data request responses, including program, sub-program, zip code (for downstream measures), and TRM measure number. With this additional detail, the NMR team can easily aggregate records by end-use, zip code, program, etc. This

aggregation plays a key role in our audits of reported gross savings values in the EDCs' Semi-annual and Annual reports.

The Phase III database is currently updated quarterly and stored on one of the NMR team's internal servers. If requested by TUS staff, we could also house the database in the partition of the current SWE SharePoint site that is only accessible to the SWE and TUS staff. As has been the case in Phase III, the SWE SharePoint site is secure and maintained by experienced staff. The site is hosted by Microsoft's Office 365 platform and all data are encrypted both in storage and in transit.

Because the number of records in the database makes it prohibitive to work with the raw dataset, TUS staff does not currently have direct access to the full database. That said, TUS staff does have access to a custom Tableau dashboard that summarizes the statewide database at higher levels of granularity. The NMR team developed this dashboard, with input from TUS stuff, in 2018 and has updated it throughout Phase III. Example screenshots from the dashboard are shown in Figure 10 and Figure 11. By quarter, Figure 10 shows statewide savings for residential and non-residential lighting measures. On the left side of the figure, note that users can toggle between EDCs, upstream and downstream measures, end uses, and the savings metric. Users can easily drill into PPL peak demand savings for HVAC measures with this dashboard, for example. Figure 11 shows a heat map of downstream savings by installation ZIP code. Like Figure 10, Figure 11 could be adjusted such that only certain EDCs, time periods, or end uses are represented. If TUS staff has a preference for another data visualizations software, such as Microsoft Power BI, our team could easily create similar visualizations within the preferred software.

Figure 10: End Use Dashboard

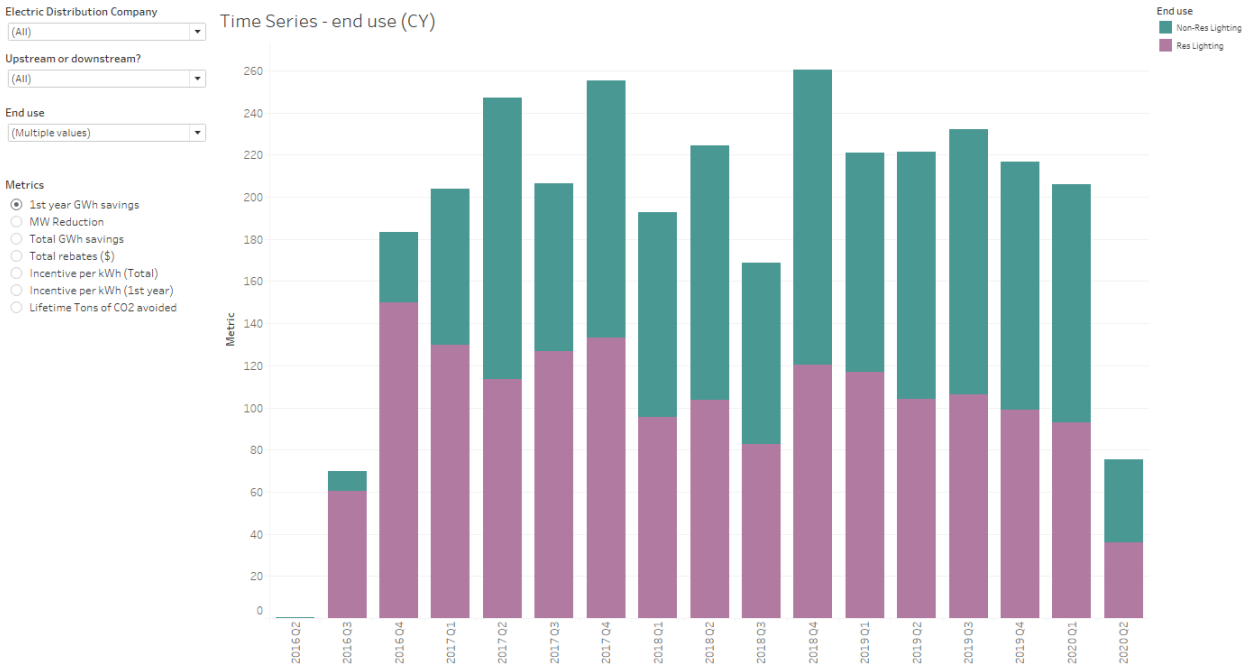
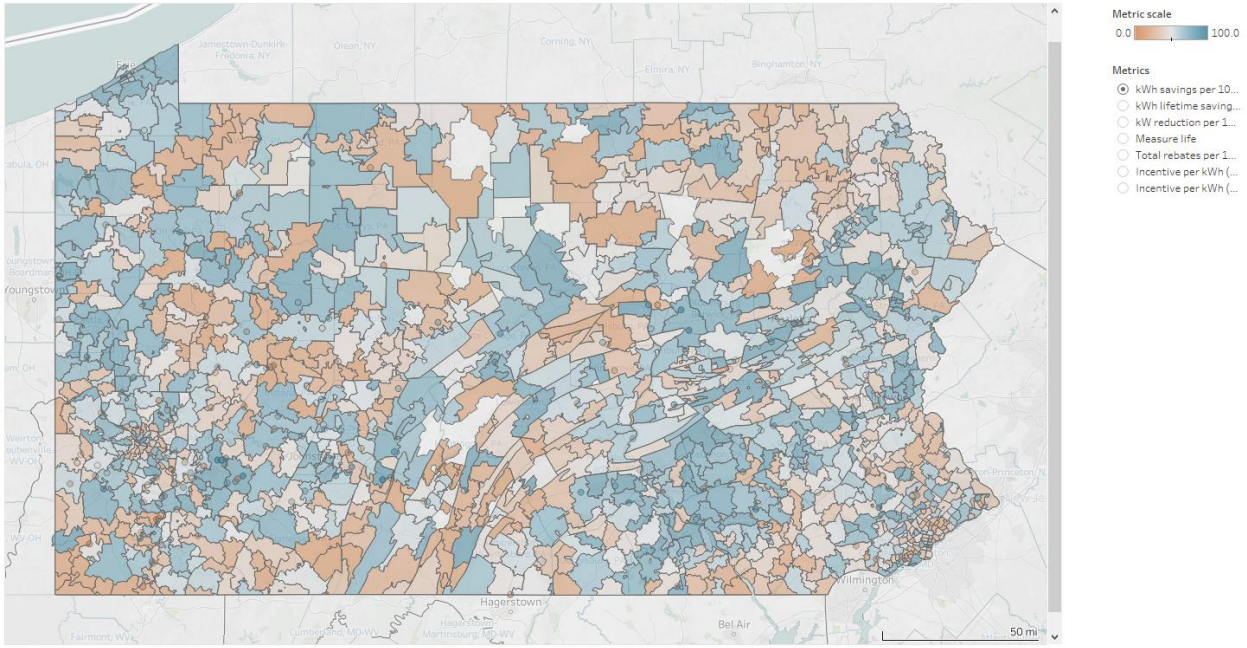


Figure 11: Downstream Energy Savings Heat Map



Though EDC tracking systems record the ex-ante savings values for completed projects, Act 129 compliance goals are based on gross verified savings (ex-post) that include adjustments resulting from EM&V. Gross verified savings are not currently in the statewide tracking database. Much of what the SWE compiles and shows in our Annual Report concerns gross verified savings, so it makes sense to include such data in the database. This can be accomplished by including energy and peak demand realization rates, by program or sub-program, in the database.

While granular measure-level information is useful for savings and incentive amounts, we believe including TRC costs and benefits is not advisable. For starters, it would require program administration costs to be allocated across thousands of transactions. We recommend storing and viewing this information at the program or sub-program level.

The NMR team believes that one of the key benefits of a central repository of all Act 129 performance data is to facilitate rapid insights into program performance. We anticipate working with TUS staff to develop additional Tableau dashboards that can provide these rapid insights. The NMR team has also developed automated quarterly reports for other clients that summarize savings and measure lives by program. We could easily repurpose these tools to develop EDC-specific or statewide quarterly reports using the statewide tracking database.

2.5.2 Data Management and Security

Our goals with data management and security are (1) to ensure the security and confidentiality of all sensitive program data and information (including non-public/confidential data and information), (2) to protect against any anticipated threats or hazards to the security or integrity of such information, and (3) to protect against unauthorized access to use of such information. We understand that data security is particularly important for this project because we will be handling a range of sensitive customer information.

Any and all customer data collected as part of the study will be considered completely confidential and will be maintained and archived using a secure SharePoint site. We absolutely will not use any data for additional analysis outside the scope of this project.

All project data will be stored on a secure SharePoint Online server and only accessed as necessary by staff working on the project. NMR team members will download copies of the data to their local encrypted computers or network servers for analysis. NMR team members will delete any local copies from their encrypted computers or network servers upon completion of the task for which those data were being stored. Data sharing between team members will also take place through a secure SharePoint site and data will never be emailed. The NMR team will ensure that all team members who handle or come in contact with sensitive client information (including end-use customer data) adhere to these policies.

For this contract, the NMR team has identified Amy Whitford of NMR as our SharePoint and Data Manager. Amy will be responsible for managing access of authorized team members to the secure SharePoint site.

2.5.2.1 General Data Security Policies and Procedures

NMR has a Written Information Security Policy (WISP) in place to ensure full protection of client, company, and personal information assets. Our objective in developing and maintaining the WISP is to create effective administrative, technical, and physical safeguards for the protection of all paper and electronic records containing Personally Identifiable Information (PII) either stored or transmitted by NMR. While compliance with the law and protection of PII is our primary goal, NMR considers any information our clients share with us to be private, so our WISP also covers the safeguard of any other data or information that a client has shared with NMR to be used solely for the purposes put forth in the contract governing our work. NMR's policies and procedures apply to both project and internal operations. NMR follows the Health Insurance Portability and Accountability Act (HIPAA), National Institute of Standards and Technology (NIST) Special Publication 800-122, and all other applicable laws and guidance.

NMR conducts all its work in a secure IT environment. All new employees receive formal training on NMR's WISP when they begin, and all current employees are retrained annually. NMR also requires its subcontractors to follow strict data security protocols. We assess our subcontractors' data security capabilities as part of the subcontracting process and we include data security expectations in the subcontract.

The NMR team's minimum security protocols cover the areas outlined in Table 7.

Table 7: Data Security Protocols

Security Protocol	Key Components of Protocol
Data handling	• Assigning a Data Manager • Data Manager ensures team-wide compliance with security protocols
System security	• Full-disk encryption, passwords updated every 180 days, and up-to-date antivirus and firewall security systems on company systems • Sensitive data never emailed or stored on unencrypted portable devices
Training	• Data security trainings for all new employees, and annually for all staff • Trainings updated annually to ensure compliance with new policies
Vulnerability response	• Systems handling PII regularly checked by third-party compliance vendor to identify and address vulnerabilities
Incident response	• Clear chain of command for responding to potential or detected security breaches, including pre-defined protocols for alerting clients or law enforcement • Incident response protocols include meeting post-incident to update policies and protocols based on lessons learned
Security assessment	• Annual risk assessment follows NIST 800-30, assessing security policies, systems configurations, and system vulnerabilities

2.5.3 Commission Reports

The NMR team will provide semi-annual and annual reports on EE&C Program performance, as well as a final five-year assessment report to the PUC. The schedules and summary of the contents of the reports are provided in detail in Section 2.9 of this proposal.

2.6 Baseline Studies

2.6.1 Introduction

Baseline studies serve as important DSM planning tools because they provide a snapshot of market conditions and answer key questions about the type, capacity, fuel, and efficiency of end-use equipment across the state. Baseline study findings serve as key inputs for the market potential studies and updates to the TRM. The residential and C&I baseline studies described below build on the successful methodologies we used in Phase III by incorporating new innovations that will increase the data points available to the potential study and will provide even more clarity about any differences between EDCs.

Below, we describe the key elements for conducting a successful baseline study, highlighting our ability to execute a carefully crafted and complex study.

A consistent approach for longitudinal tracking of change over time. A critical component of baseline studies is the ability to compare new results to those from prior studies to track changes over time. This longitudinal tracking helps identify how markets and building stocks are evolving and identifies the energy-saving opportunities that remain, helping to inform program planning and design. Because the NMR team conducted the Phase III baseline and potential studies, we are intimately familiar with the methodologies and assumptions made at the measure level in the

previous study. This will allow us to easily ensure "apples-to-apples" comparisons from the earliest stages of data collection through analysis and reporting. Our experienced team can leverage our past work to thoughtfully and carefully gather reliable data about how Pennsylvania building stocks and efficiency practices have changed. These results will allow the PUC and related stakeholders to build upon better and more up-to-date assumptions for program design, planning, and savings calculations.

Developing a Representative Sample. We recognize that financial incentives are needed to reduce bias in the types of homes and businesses included in the baseline study. For example, the site visits will require each participant to take hours out of their day and allow unfamiliar individuals to examine their home or business. Incentives acknowledge the time and effort that participants provide in support of the study. For the residential baseline online survey, we also suggest a flexible incentive structure that considers demographics in calculating potential incentives.

Rigorous quality control. The value of baseline studies is contingent upon the premise that data collected at one home or business are directly comparable to data collected at another. Our baseline study experience has led to an **internal structure and a set of evaluation protocols** that result in highly consistent data collection and analyses that can be used to develop representative baselines. Our processes begin at project planning and continue until all deliverables are provided. Below, we highlight some of the quality control procedures we have developed for our baseline studies.

- ✓ **Review of instruments and deliverables.** All draft versions of questionnaires or surveys will be double checked for wording, logic, and skip patterns by the responsible analyst and project manager. We test all instruments to ensure that questions are clear, skip patterns function as intended, and they take the expected amount of time to complete. For all surveys and on-site tools, we conduct multiple rounds of user testing with staff members from both building science and non-building science backgrounds. We monitor instruments while they are in the field and review preliminary data early in the data collection process to identify and correct any issues.
- ✓ **Data Validation.** For most numeric fields, our tools have data validation settings that restrict the input values to expected ranges. Figure 12 shows a simple example from the C&I system where a technician enters the efficiency value of a water heater on (0,1) scale instead of the expected convention of "95" for a 95% efficient unit. These simple checks help enforce training protocols and reduce the amount of data cleaning required for analysis.

Figure 12: Sample Data Validation Error

No record was Changed - errors

Domestic Hot Water Name:	HW tank
Number of Identical Units:	1
Heating Fuel Type	EL=Electric
Water Heater Type	SC=Self Contained (Tank)
Year Installed:	
Location	CD=Conditioned
Percent of Building Handled	100
Tank Wrap	N=No
Pipe Wrap	Y=Yes
Drain Water Heat Recovery	N=No
Circulation Pump	N=No
Continuously Circulating	N=No
Setpoint Degrees	130
Make/Line	Bradford White
Model Number	M120L6DS
Tank Capacity (Gallons)	120
Input Capacity (Btu/h)	80000
Efficiency (EF)	0.95 Range is 1 to 100

Save the Record | Undo changes (reset)

- ✓ **Staff training.** NMR team members who conduct surveys or interviews undergo project-specific training to ensure they can answer questions from customers accurately and communicate with a natural and neutral tone. All assigned field staff will undergo training specific to the Pennsylvania baseline to ensure consistent data collection across team members. This ensures consistency not only across homes and businesses in the same study, but also across studies. The NMR team has established systematic and comprehensive on-site inspection protocols, including an internal manual for on-site data collection. This manual focuses not only on high-quality data collection, but also includes other protocols that help ensure study participants are satisfied.
- ✓ **Monitoring customer contacts.** During recruitment for onsites or surveys, customers will be called back at least three times. We will provide a call disposition log in the draft and final report, including the number of calls made, refusals, ineligible customers, and other common call disposition categories. We will also provide customer response and recruitment rates for the recruitment surveys.
- ✓ **In-field data checks.** Our quality control process is enhanced by our mobile data collection forms that have built-in reminders and quality control checks. These collection forms allows technicians to upload their data to a secure server on a routine basis, resulting in a review process that is both quick and effective.
- ✓ **Post-visit data checks.** After on-site inspections are completed, the NMR team will review each data collection form. This review will be conducted by a staff member that

was not present during the site visit in order to remove bias in the review. This process will include reasonableness, consistency, and completeness checks. When errors or inconsistencies are found, the NMR team will contact the appropriate on-site technician to correct or verify any issues. This post-site visit review allows us to correct any data entry errors and ensure that different individuals collect data consistently in the field. On-site audits of homes where occupants have used the self-audit tool will also serve as verification audits for the self-audit tool results.

- ✓ **Review of data analysis.** All programming in data analysis software platforms, such as SPSS or R, will be double-checked by the responsible analyst and, as appropriate, reviewed by another analyst and NMR project manager. All spreadsheet-based analysis will include cross-verification calculations, when appropriate, and will be double-checked by the responsible analyst and then reviewed by the NMR project manager.

2.6.2 Residential Baseline Study

Below, the NMR team details our proposed plan for the Phase IV residential baseline study. We propose an **innovative web survey that includes a self-audit tool** for occupants to provide a level of detail about their homes previously only achievable via on-site inspections. We also propose **on-site inspections to verify and expand on the web survey results**. Our approach leverages our past work in Pennsylvania and elsewhere to deliver a comprehensive assessment of the residential market that will build on and provide continuity with our Phase III work.

2.6.2.1 Overall Approach and Research Goals

The NMR team understands that the primary goal of this residential housing assessment is to characterize the current baseline position of Pennsylvania's residential housing stock and to inform the market potential studies. The key objectives are to comprehensively document the current penetration, saturation, and efficiency levels of key energy features found in Pennsylvania homes.

This analysis will also provide data for subsequent market potential studies to inform a possible Phase V of Act 129 EE&C Programs for Pennsylvania. As discussed below, we have adjusted our proposed methodology from Phase III for the Phase IV baseline study to ensure more robust sample sizes for key technologies and end uses that feed into the potential study.

Primary research objectives. The primary objectives of the residential baseline study are as follows:

- Characterize measure-level efficiencies for the residential housing stock statewide and by EDC
- Determine the current saturation of energy-using equipment in the residential housing stock statewide and by EDC
- Determine the percent of energy-using equipment by end use that is high-efficiency equipment
- Estimate energy consumption by end-use and heating fuel for the residential housing stock statewide and by EDC

- Inform the TRM Update
- Inform the Phase IV Market Potential Studies

2.6.2.2 Key Study Elements and Enhancements to Past Study Approach

Prior to detailing our methodology, we highlight key elements of our proposed approach, focusing on enhancements that will build on and improve the reliability of our study relative to the Phase III study.

Increase measure-level sample sizes with a self-audit tool. The NMR team has developed a web-based self-audit tool that allows residents to use their mobile devices to provide pictures of mechanical equipment, appliances, and consumer electronics, including nameplates. The self-audit tool will be a new component of the online survey. By directing respondents to take pictures of equipment nameplates, the self-audit tool provides far more detail and certainty than a traditional telephone or web-survey. These nameplates will allow our team to document the efficiency and capacity of key equipment without conducting a site visit, and respondents will not need technical familiarity with their mechanical systems to provide valuable data. The tool will substantially increase sample sizes for key measures, capture data from respondents who are uncomfortable having people in their homes, and potentially reduce the time required for on-site inspections. Our study methodology includes on-site verification for a sample of self-audit tool responses, along with an incentive structure and implementation approach that will ensure equitable access and incentives to study participants.

Web-based Self-audit Tool

- Substantially increases measure-level sample size
- Generates high-quality photographic data
- Gathers data from residents uncomfortable with in-home inspections
- Reduces on-site inspection time
- Pairs with on-sites to verify accuracy

Perform diagnostic testing. Our baseline studies across the Northeast have confirmed that air leakage and duct leakage represent two of the most important factors in the energy performance of a home. Our 2018 residential baseline study[8] was the first in Pennsylvania to conduct actual air and duct leakage diagnostic testing as opposed to relying on less accurate qualitative assessments. We propose to have our RESNET-certified Home Energy Rating System (HERS)[9] raters conduct these same tests for the upcoming study.[10] Because the EDCs' home energy audit programs target air-sealing measures, including diagnostic tests in the baseline will let us track

[8] https://www.puc.pa.gov/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf

[9] The HERS index is a nationally recognized rating system through which a home's energy efficiency is measured. The index scores range from below zero to well above 100. A standard new home built at the time the index was created would have a rating of 100. A home with a score of 70 would be 30% more energy efficient than home with a score of 100, while a home with a score of 130 would be 30% less energy efficient.

[10] https://www.resnet.us/

any potential improvements over time and update data that inform TRM savings calculations for air-sealing and duct-sealing measures.

Clearly identify savings opportunities. We plan to analyze data collected during on-site inspections to identify and highlight savings opportunities in Pennsylvania homes. We propose to create full energy models and HERS ratings for 72 homes across the state. The energy models will allow us to identify energy consumption at the measure-level to highlight the greatest opportunities for electric savings. When paired with economic considerations, energy modeling will allow us to recommend key measures upon which future program efforts can focus. These results will also provide key metrics that can feed into this effort's energy-efficiency potential study.

Achieve high levels of precision. At the statewide level, our sampling approach will achieve at least ±10% precision at the 90% confidence level for single-family homes, multifamily housing units, and all homes collectively for the key parameters of interest in the study assuming a conservative coefficient of variation of 0.5. In addition, our plan will achieve ±13% precision at 90% confidence level across all homes in each EDC service territory. At the measure-level, the previous study typically estimated coefficients of variation well below 0.5 for HERS scores and mechanical equipment efficiencies regardless of whether the data was split by vintage or EDC, which means that the actual precision of the estimates for these parameters will likely be substantially better than stated above.

Minimize sampling error. Sampling error is a major concern in baseline studies because these studies rely on a relatively small group of customers to represent a much larger population. While it may be impossible to account for all potentially confounding variables in a sample design, it is important to learn from prior studies to account for the most significant variables and sources of variation in order to minimize their distorting influence and maximize the representativeness of the sample. For example, the previous Pennsylvania baseline found that newer homes are more energy efficient than older homes. Moreover, the variation in efficiency levels across homes was lower among newer homes than older homes. In order to minimize sampling error, our proposed sampling approach will ensure that the distribution of homes in our study reflects the distribution of vintage, heating fuel, and income in Pennsylvania per the U.S. Census. Since the mix of heating fuels varies across EDC territories, targeting the sample based on heating fuel will help achieve a more balanced distribution by vintage and EDC.

Assess multifamily buildings. The NMR team will inspect 70 units in multifamily buildings and ten multifamily *buildings*, including common areas.[11] This approach will allow us to develop a well-rounded baseline of multifamily housing throughout the state. We will report at the housing-unit level for in-unit technologies, such as lighting, appliances, and mechanical equipment. At the building level, we will collect data on common area lighting, appliances, building shell components (e.g., wall and ceiling insulation), and any centralized mechanical equipment in order to inform the C&I baseline study. The NMR team will leverage the results of the previous residential and commercial baseline studies from Phase III to inform the common area findings associated with the ten whole-building inspections being proposed for this study. This approach will provide the

[11] In addition to 60 units at separate buildings, the ten multifamily building inspections will each include an inspection of one housing unit, yielding 70 total unit inspections.

necessary detail required to accurately forecast the potential associated with energy upgrades in the common areas of multifamily buildings.

Continue enhanced projection of measure adoption curves. In order to track changes in customers' willingness-to-pay (WTP), the NMR team proposes to reprise the WTP survey analysis method used in the previous study. In the 2018 Residential Baseline study, we utilized WTP surveys conducted during on-site audits to gather insight on important decision factors for choosing between standard and high-efficiency options, likelihood to purchase high-efficiency options given different payback scenarios, and the importance of program assistance. Our experience with this research will reduce the cost associated with implementation.

2.6.2.3 Study Timeline

Table 8 presents our schedule for completing the residential baseline study.

Table 8: Schedule for Residential Baseline Study

Milestone	Estimated Date
Work plan development	Nov – Dec 2022
Web/Telephone survey recruitment and self-audit tool	Jan – Mar 2023
Scheduling	Feb – Jun 2023
Site visits	Mar – Jul 2023
Data review and QC	Mar – Aug 2023
Data analysis and reporting	Sep – Dec 2023

2.6.2.4 Online Survey with Self-Audit Tool

A new way to learn about people's homes. Below we describe our proposed approach for the online survey portion of the residential baseline study. This survey will not only recruit potential on-site participants, but will also ask people to provide information about their homes via a simple-to-use self-audit tool, providing a level of detail that only on-sites have been able to provide to date. The online survey will accomplish the following:

- Ask people to provide photos of key energy-consuming equipment
- Collect basic information about the homeowner and the home
- Assess interest and availability to support recruiting for on-sites

2.6.2.4.1 Sampling Plan and Recruitment for On-Sites

We plan to issue a data request to each EDC for a random sample of residential customer addresses, phone numbers, and email addresses. This will serve as the basis of the online survey, from which we will then recruit potential participants for the on-site portion of the study.

From that initial sample from the EDCs, we will randomly select roughly 11,500 single-family homes and 2,500 multifamily homes to mail an invitation to an online survey. These sample sizes are designed to result in 287 site visits and about 1,000 completed surveys. This would result in a statewide precision of ±2.6% at the 90% confidence level (±2.8% for single-family and ±6.3% for multifamily) for the online survey. Please note these values are different than those for the site visits, which can be found in Table 10. The survey will request demographic information to assist with on-site recruitment targets, contact information for on-site scheduling, and implementation of the self-audit tool.

The invitation letters will include a URL address for the survey and a QR code, as well as a phone number for those who cannot access the survey over the internet.[12] The letter will mention the incentive for participation in the on-site home energy audit and an incentive for completing the recruitment survey.

The previous study did not offer an incentive for the on-site recruitment survey and resulted in a response rate of 7.6%. For this iteration of the study, the NMR team believes an incentive is necessary to reap the full benefits of the self-audit tool, which will extend the length of the online survey.

Typically, multifamily properties are extremely challenging to recruit. This is due to the difficulty of coordinating with both property managers and tenants. To increase the recruitment rate of multifamily properties, in Phase IV, we plan to split the multifamily sample into two groups. Sixty multifamily site visits will focus on tenant recruitment and on the in-unit measures and common spaces accessible to the unit's occupant. Ten site visits will focus on property manager recruitment and will include inspections of all common space and utility rooms, as well as in-unit measures, yielding a total of 70 unit inspections.

To meet the sample size target for multifamily properties, the NMR team will use the following methods:

- Target a sample of multifamily properties in the survey. The survey in the previous study only targeted what were believed to be single-family homes.
- Conduct internet searches for eligible multifamily buildings via www.craigslist.org

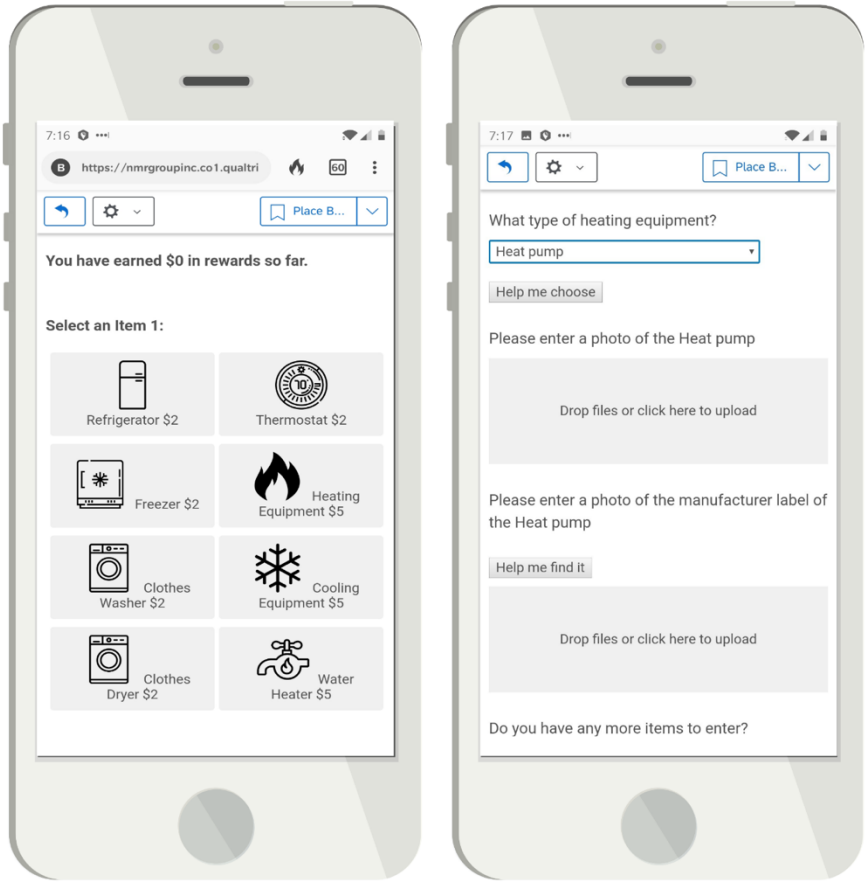
2.6.2.4.2 Implementing the Self-audit Tool

Rich data directly from customers. The self-audit tool will allow respondents to use their smartphone or another web-connected device to submit information and pictures of mechanical equipment, appliances, and consumer electronics found in their homes. We tested an early version of the tool with a small group of occupants and homeowners in the previous baseline and are preparing to implement versions of a similar tool in studies in Vermont and New Jersey.

Simple user interface with no technical knowledge required. The self-audit tool makes it easy for anyone to provide useful photos of equipment in their home, including model numbers, by guiding users through the photo-taking process and helping them identify the systems of interest and locate their nameplates. The photos provide a much higher quality of data than a typical telephone or web survey. With photos, our certified HERS raters can verify the accuracy of occupant-reported information and determine other characteristics that would be too technical to ask of occupants, such as detailed system specifications. Figure 13 presents an example of the self-audit tool.

[12] The self-audit tool will only be available over the internet; however, those who call in to complete the survey will be invited to use the self-audit tool with guidance from the NMR staff member over the phone.

Figure 13: Example of Self-audit Tool



Increased sample sizes for key equipment. The self-audit tool will allow us to substantially increase our sample sizes for mechanical equipment and appliances. Table 9 shows the potential statewide sample size increase for different types of equipment based on the estimated penetration for each type of equipment from the 2018 Residential Baseline Study. The 2018 Residential Baseline Study found a coefficient of variation of about 0.5 or less for the efficiency of each type of equipment whether the data was analyzed by vintage, EDC, or home type. Increasing the sample through the self-audit tool will further improve the precision of the data inputs for the potential study.

The self-audit tool is particularly effective at gathering data on measures with easy-to-access model numbers. These systems also happen to be large consumers of electricity and are thus of particular interest for this study. They include central air-conditioners, refrigerators, room air conditioners, ductless heat pumps, water heaters, clothes washers, and clothes dryers. The incentive structure of the tool can also be designed to encourage respondents to enter data on certain types of equipment, for example, by offering greater incentives for targeted equipment. To that end, we will work with TUS staff to identify any equipment that is of particular interest and consider adjusting our incentives to prioritize the collection of those data.

Table 9: Potential Equipment Statewide Sample Size Increases with Self-audit Tool

Equipment Type	Potential Sample Increase	Previous Sample Size
Furnace	430	128
Boiler	320	51
Air-source heat pump	100	35
Central air conditioner	350	108
Ductless heat pump	40	11
Room air conditioner	400	191
Fossil fuel storage water heater	530	148
Electric storage water heater	340	100
Instantaneous water heater	40	11
Refrigerator	715	352
Stand-alone freezer	340	92
Dishwasher	590	172
Clothes washer	715	233
Clothes dryer	715	231
Dehumidifier	280	90

2.6.2.4.3 Reducing Sample Bias and Increasing Equity

Our team will account for potential biases and equity issues while implementing the self-audit tool. Responses to the self-audit tool could be biased towards households that have smartphones and are comfortable interacting with smartphone applications. According to the 2019 Community Survey one-year estimates, 82% of households in Pennsylvania have at least one smartphone and 91% have at least one computing device. To help mitigate potential bias and increase response rates, the self-audit tool will provide a customer service number for any users who need technical assistance completing the survey. A version of the self-audit tool will be available online for those who do not have smartphones or tablets, though it may not be able to collect all the data that will be available from devices with cameras. Additionally, the survey will provide a call-in number for respondents who do not have the technology necessary to complete the survey online. These respondents will be instructed to call NMR, at which point one of our staff members will conduct the survey over the phone. In these cases, it will not be possible for respondents to participate in the self-audit component of the survey, but they will be able to complete the recruitment survey and will be eligible for an on-site inspection.

The incentive structure associated with the self-audit tool is flexible. For example, we can offer respondents a flat incentive for providing photographs of at least three different pieces of equipment. Alternatively, we can offer an incremental incentive depending on the number and types of equipment for which they provide photographs, with a maximum achievable incentive. However, some incentive structures may introduce inequities into the survey, which we will work to avoid. For example, if an incremental incentive is employed, higher-income households likely have a better opportunity to procure a larger incentive as they are more likely to have many types of equipment. The NMR team will work with TUS staff to determine the most appropriate incentive structure that balances incentives and equity among respondents and collects the most important data points. The self-audit tool will also include a location-based check to ensure that respondents

are providing information specifically about the home of interest, and not taking additional photos at other homes to increase their potential incentive.

The quality of the audit tool will be ensured through a verification process. In similar appliance saturation studies in Connecticut and Rhode Island, we have used site visits to calculate adjustment factors for homeowner-reported data. We propose using a similar approach to verify the accuracy of responses to the self-audit tool. We expect the self-reported entries to be highly accurate given the photographic details.

2.6.2.5 Site visits

In this section, we discuss our proposed methodology for conducting residential site visits. We will leverage our experience from prior baseline studies to inform our evaluation of Pennsylvania's housing stock and ensure high-quality on-site data collection, analysis, and reporting.

2.6.2.5.1 Sampling Plan

Table 10 shows the estimated statewide populations and on-site sample sizes by primary heating fuel for the single-family and multifamily markets.[13] In addition, we present precision estimates for the site visits, assuming a coefficient of variation of 0.5. This is a conservative assumption given that the previous Pennsylvania residential baseline study found coefficients of variation well below 0.5 for most measures. Statewide, the precision estimates are anticipated to be about ±5% at the 90% confidence level for the overall study, ±6% for single-family homes, and ±10% for multifamily housing units. In addition, we anticipate completing 41 site visits in each of the seven EDC service territories, which yields an estimated precision of ±13% at the 90% confidence level for each EDC across all housing types. However, note that the final achieved precisions will be dependent upon the actual coefficients of variation the study finds. In addition, because our self-audit tool will allow us to substantially increase the sample sizes for mechanical equipment and appliances, the EDC-level precision for these measures will be significantly better.

Table 10: Statewide Sample Sizes and Precision for Site Visits

Primary Heating Fuel	Single-family Homes		Multifamily Units		Statewide Total
	Population	Sample Size	Population	Sample Size	
Utility gas	53%	114	46%	32	146
Bottled, tank, or LP gas	5%	11	2%	1	12
Electricity	17%	38	46%	33	71
Fuel oil, kerosene, etc.	19%	42	4%	3	45
Other fuel	6%	12	2%	1	13
Total	**4,025,614**	**217**	**997,959**	**70**	**287**
Precision at 90% confidence level		*±5.6%*		*±9.9%*	*±4.9%*

[13] Source: ACS 5-year data set PUMS 2018. Single-family includes mobile homes and trailers.

Because of the diversity of the housing stock in Pennsylvania, there is potential for sampling bias. To mitigate this concern, we will track key housing and demographic characteristics that may affect energy efficiency – including house type, fuel type (as illustrated in Table 10), house age, and income level – to ensure that the on-site sample accurately represents the Pennsylvania population according to the most recent Census statistics. In addition, the 1,000 Web/Telephone Surveys are anticipated to yield about 400 on-site volunteers, which will offer a large enough pool of volunteers from which to select the on-site sample of 217 single-family homes and 70 multifamily units.

We will perform air leakage testing at 72 single-family homes. The homes selected for air leakage testing will be distributed equally amongst the EDCs and will reflect the heating fuel mix statewide. Because we know that the mix of heating fuels varies across the EDCs, this approach will achieve a representative sample by heating fuel across the state while also capturing the variation in heating fuels among the EDCs. At each of these homes, we will conduct a single-point blower door test at 50 Pascals' of pressure relative to the outdoors. In addition, we estimate that, based on the 2018 Residential Baseline Study, about 60 of these 72 homes will contain ducts and will receive a duct leakage test.

2.6.2.5.2 Recruitment and Scheduling

The objective of the recruitment process will be to visit homes that are representative of each market segment – either single-family or multifamily. The recruitment protocol that we will follow has been proven to maximize recruitment success and minimize bias in the selection of homes. Examples of these protocols include on-site recruitment via surveys, incentives for on-site participants, and flexibility in the scheduling of on-site assessments. The recruitment process will also be simple for any survey respondents who choose to complete the survey over the phone with NMR staff – they will be able to schedule their site visit at the end of the phone-survey.

In order to encourage participation in the site visits, we will offer a $150 incentive to occupants or property managers. This will be in addition to any incentive provided for the online survey that includes the self-audit component. Incentives are needed to reduce bias in the types of homes and demographic characteristics of the occupants included in the site visits. The site visits will require participants to take three-to-four hours out of their day to allow the NMR team to perform a detailed examination of their home. Incentives help acknowledge the time and effort that participants provide in support of the study.

In addition, the NMR team will mail each single-family on-site participant a letter printed on PUC letterhead that includes contact information so the resident can confirm the legitimacy of the study. We anticipate that these letters will help facilitate the scheduling process.

The NMR team will use internal staff to efficiently schedule and conduct site visits. Most visits will occur during weekdays, although weeknight options will also be available. In addition, weekend days will occasionally be offered in order to accommodate residents' schedules. The NMR team will conduct two site visits on most days in order to complete the on-site surveys in a timely fashion.

2.6.2.5.3 Data Collection Form

The evaluation team will develop an electronic data collection form for review by the PUC. The on-site data collection form will be an upgraded version of the electronic tool used in the previous study. It is designed with the ultimate objective of gathering the information of interest to the PUC, including such items as lighting, appliances, HVAC, and building shell characteristics. The form will include built-in quality control mechanisms that ensure all necessary data are gathered while auditors are on site. The electronic data collection tool securely uploads data to an NMR server, allowing for timely processing and quality control by in-office staff. The NMR team will draw upon experiences from previous baseline studies and will include in the data collection form all key data elements identified in the RFP. After receiving comments from the PUC, the NMR team will revise and finalize the data collection form. The data collection form will also streamline analysis since it will be integrated with internal automated analysis tools that allow analysts to spend less time compiling data and more time critically assessing the trends in the data.

2.6.2.5.4 On-site Data Collection

Single-family Homes. We anticipate that the on-site data collection will consist of a detailed physical inspection of all visited homes, including diagnostic testing at a sub-sample of single-family homes. Trained auditors will visit each home to conduct a thorough visual inspection of the construction features and equipment. Data will be collected for the following features:

- General information, including approximate total square footage; number of stories and rooms; size of conditioned space in main home (as defined by RESNET); and number of fireplaces, stoves, and space heaters
- Features of the thermal boundary of homes, including the following:
  - Wall, ceiling, floor, foundation, crawlspace, and slab insulation locations and types (from rated values on products, or else estimated from visual inspection)
  - Framing dimensions and spacing (via measurement)
  - Windows and skylights: location, dimensions, number of panes, presence of low-E coating, and U-value ratings (if available). We will also calculate the percent of glazing on each home.
  - Exterior door location, dimensions, type, and thickness
  - Basement wall height (or whether on-grade slab foundation)
- Heating and cooling equipment for primary systems and all supplemental units, including make and model, type, location, fuel, size, and rated efficiency based on model information
- Thermostats, including number, type, and usage
- Water heating equipment, including make and model, type, fuel, location, size, and efficiency rating based on model information, plus water heater and piping insulation R-values, and number of low-flow showerheads and faucet aerators
- Appliances present at the home, including dishwashers, clothes washers, primary and secondary refrigerators, freezers, room air conditioners, and dehumidifiers. Data

collected will include make and model, type, location, and approximate age; where available, we will also gather appliance size, efficiency, and ENERGY STAR status (based on visual inspection or model information).

- Survey of consumer electronics present at the home, including number and type of TVs, set top boxes, DVD/VCR players, DVR recorders, game consoles, computers, printers, and advanced power strips
- Duct type, location (conditioned vs. unconditioned space), insulation type and estimated R-value, and duct sealing material used, if any, for return and supply ducts
- Mechanical ventilation for homes, including energy recovery ventilators, make, model, type, location, type of control, rated cubic feet per minute (CFM), and efficiency based on model information
- Lighting inventory, including all hardwired and plug-in fixtures. This inventory will include information such as room location, bulb type, bulb shape, and control type.
- Renewables and whole-home battery storage, including output (kW) of solar photovoltaic (PV) system and wind turbine
- Air and duct leakage testing at all single-family homes that are electrically heated and a subset of single-family homes with central air conditioning

WTP Survey for Single-family Homes. To maintain consistency and track changes over time, we propose employing the same WTP methodology used in the previous study for single-family homes. On-site technicians will administer a WTP survey at the conclusion of each site visit. The survey will provide insights on the following topics that will be used to inform the energy-efficiency MPS: decision factors for choosing between standard and high-efficiency options, likelihood to purchase high-efficiency options given different payback scenarios, and the importance of program assistance. The survey will be designed to ask about specific measures relevant to the homeowner based on what was found during the on-site inspection and will prioritize measures with large impacts on electric loads.

Multifamily Buildings. The NMR team will visit 60 multifamily housing units to inspect the energy-efficiency related features of residential spaces in multifamily buildings.[14] In addition, the NMR team will visit ten multifamily buildings to inspect the common areas associated with multifamily properties. The ten site visits with common area inspections will also include an inspection of one housing unit within the property, bringing the total number of housing units inspected to 70. The data collected at multifamily buildings will be similar to the data collected in single-family homes, though the NMR team will not perform diagnostic tests. In addition, it will likely be more difficult to estimate insulation R-values, window areas, and other elements given the nature of larger multifamily buildings. Our team will assess these measures to the best of our ability within each housing unit. For the buildings that include detailed common area inspections, we will work with the property manager to obtain this information. For the common area inspections, we will collect

[14] The NMR team will collect as much common area data as possible during these inspections, but our recruitment will be at the tenant level and common area access could be limited.

information on interior and exterior lighting, HVAC and DHW systems, and clothes washers and dryers.

WTP Survey for Multifamily Homes. A targeted version of the WTP survey will be completed by occupants of multifamily housing units, focusing on those products they may purchase, such as lighting and appliances.

2.6.2.6 Data Preparation, Analysis, Reporting

2.6.2.6.1 Data Quality

As previously discussed, the NMR team will review all collected data for accuracy and completeness. We will follow all appropriate data quality control protocols, including the following:

- Thorough training of all technicians and analysts
- Automated checks on data entry in electronic data collection tools
- Granular review of all collected data and analysis

2.6.2.6.2 Analysis of On-site and Survey Data

Once the NMR team reviews the data files from the on-site inspections and corrects or verifies any questionable data entries, we will analyze the data and report findings. In addition, we will attempt to determine the energy efficiency of any equipment for which we have manufacturer and model information available, including AFUE, HSPF, and SEER for HVAC equipment; Energy Factors for hot water equipment; and ENERGY STAR for appliances. We will also match the on-site sample to the EDC customer databases to analyze and report on average annual and monthly electricity consumption.

Our goal will be to document the status of building features (including electricity consumption), appliances, and equipment and to characterize the current efficiency levels in the following sectors across Pennsylvania:

- Single-family detached homes
- Single-family attached homes
- Manufactured homes
- Multifamily buildings and units

In addition, for the purposes of the energy-efficiency MPS, we will characterize building features by low-income single-family homes, non-low-income single-family homes, low-income multifamily, and non-low-income multifamily.

In addition, we will present the baseline results for each of the seven EDCs across all housing types included in site visits for that EDC. Because we propose to oversample both multifamily homes and the smaller EDCs, we anticipate weighting the on-site data in order to estimate statewide results.

We will also compare key results from this study to the results of the prior baseline study. Additionally, we will identify opportunities for improving the efficiency of Pennsylvania homes. In particular, we propose to input the on-site data into the REM/Rate energy modeling software tool to estimate annual energy consumption for the 72 single-family homes that undergo diagnostic testing. After converting to an energy intensity figure, we will obtain a single parameter to

represent the efficiency level of each home. This will allow us to more clearly assess the degree and distribution of electric savings opportunities among single-family existing homes.

In addition to presenting mean and median values for key data points, we will estimate the percent of homes that are above or below reasonably achievable values in order to assess the presence and extent of savings opportunities. Building energy code requirements can provide a reasonable benchmark for insulation levels in certain spaces, such as open attics, where even older homes can typically accommodate high insulation R-values. However, in other spaces, such as walls with limited cavity depth, we will use technically feasible values as the comparison point. For most mechanical equipment and appliances, ENERGY STAR criteria provide a suitable benchmark.

We anticipate that the results of the baseline study will inform the baseline assumptions for a broad array of TRM residential measures, including air sealing, duct sealing, various types of insulation, electric HVAC equipment, hot water measures, room air conditioners, clothes washers, and dishwashers.

2.6.2.6.3 Reporting and Deliverables

Final data sets. In addition to submitting final reports, the NMR team will archive all final survey, on-site, and interview databases, including documentation as necessary. All data and documentation will be available upon request to stakeholders and approval from the PUC. We anticipate that the data will primarily be delivered as Excel files.

2.6.3 Commercial & Industrial Baseline Study

The NMR team is well-positioned to deliver a comprehensive, cost-effective, and statistically valid C&I baseline study for the PUC and its stakeholders. Below, we detail our proposed approach for the C&I baseline study, which includes an online pre-screening survey that will recruit participants for our site visits.

2.6.3.1 Overall Approach and Research Goals

As part of the NMR team, Jesse Smith of DSA has led the two prior C&I baseline studies for the PUC, and we propose to build on this foundation by keeping the research approach largely consistent with prior studies while adding key enhancements. The Phase IV baseline study will build on the previous studies. Up-to-date Pennsylvania-specific data will lend credibility to the potential studies and help to refine key TRM input assumptions, such as end-use saturations, technology baseline efficiencies, building stock, and measure parameters.

Introducing substantial changes in the research design (e.g., fielding approach or questionnaire) could result in differences that may be difficult to disentangle from actual changes in the market, thereby increasing uncertainty in the result. As such, we propose to conduct the study entirely with NMR-led site visits, using DSA's online data collection tool, which was customized especially for the Phase III study.

Primary research objectives. The primary objectives of the C&I baseline study are as follows:

- Profile customer groups at the sector, building type, and end-use level. Segment the sales and peak demand for electricity by group.

- Determine current saturation of energy-using equipment and practices in EDC customer buildings.
- Determine the current saturation of distributed generation and energy storage technologies and their operating parameters.
- Determine average baseline levels of energy use and energy efficiency for lighting, plug load, space heating, space cooling, and water heating by equipment type.
- Determine the percent of energy-using equipment by end use that is high-efficiency equipment.
- Establish market trends and derive information on standard market practices to inform program design, incentive structure, and program marketing methods.
- Gather data to inform adoption curves in the MPS.

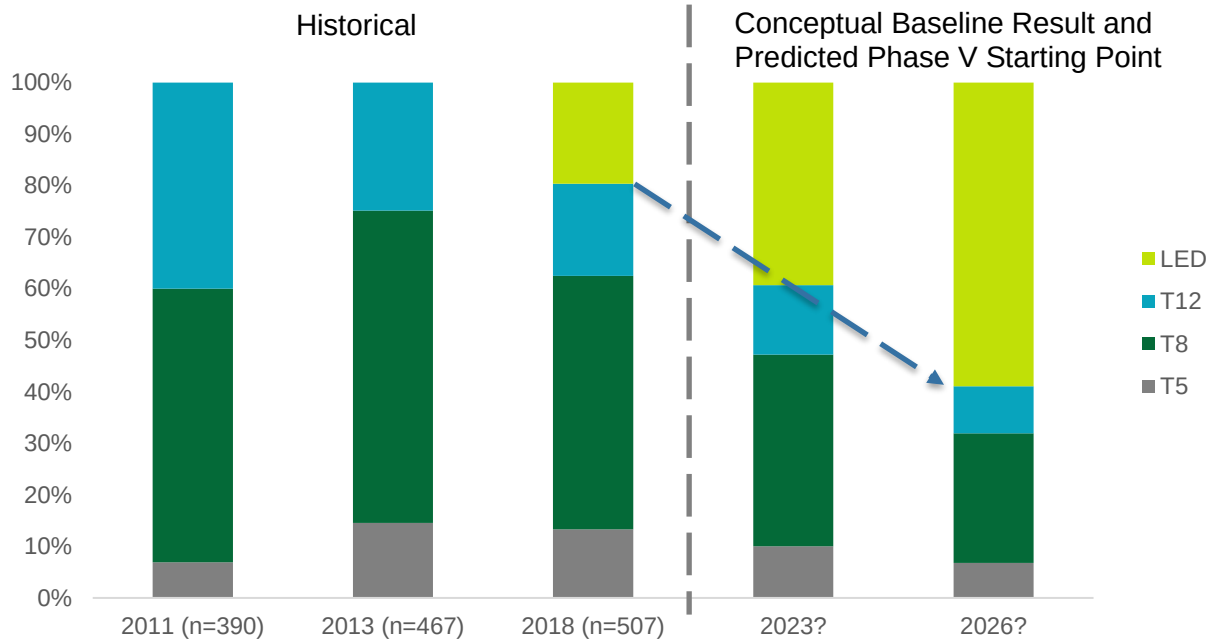
2.6.3.2 Key Study Elements and Enhancements to Past Study Approach

Prior to providing additional details about our baseline methodology, we highlight key elements of our proposed approach, including enhancements that we propose to the Phase III study approach.

Tracking changes across time. As previously discussed, baseline studies are most useful as time-series efforts, where each new study is designed to fit the framework and architecture of previous studies. Accordingly, the NMR team sees great value in using a similar data collection instrument as was used in the last three Act 129 baseline studies. This approach will allow us to conduct a time-series analysis and fit trend lines in equipment stock and saturation over time, particularly for key metrics, such as LED penetration in C&I facilities. This time-series will allow us to fit a trend line and deal with the time lag between data collection in 2023 and the beginning of Phase V.

To highlight the importance of making these longitudinal comparisons, we show the historical trends in linear lamp type distributions from the Phase III C&I baseline study in Figure 14. For conceptual purposes, we also show where linear lamp type distributions could possibly be in 2023 if LED penetration doubles to 40% and what a linear prediction for the beginning of Phase V in 2026 might look like. Reducing uncertainty in these estimates will be increasingly critical as LED penetration continues to grow at a rapid pace. Commercial lighting comprised a substantial portion of EDC program budgets and savings in Phase III. If inefficient lighting drops from 80% to 40% of total fixtures, there will be less opportunity to achieve substantial savings in this end use and it will be necessary to pursue increased energy savings elsewhere. Such substantial market shifts could have drastic implications for Phase V planning, and it is critical to have high confidence in the result.

Figure 14: Comparison of Linear Fluorescent Lamp Type Distribution (by Fixture Count), Historical vs Conceptual Future



An enhanced approach to market segmentation. The Phase I, II, and III C&I baseline studies revealed EDC customer segmentation data (i.e., identifying the type of business electric accounts are engaged in) to be quite poor. In the Phase III study, the NMR team worked to supplement known gaps in the market data specific to each EDC service territory by leveraging online research and string-matching algorithms to classify all EDC customers into the 12 core building types defined in the TRM and two sectors (Large C&I and Small C&I) based on business name, address, rate class, billed usage, and any available segment data provided by the EDC. The 12 core building types listed in the TRM include the following:

- Education
- Institutional / Public Service
- Health
- Grocery
- Retail
- Industrial Manufacturing
- Office
- Lodging
- Miscellaneous / Other
- Religious
- Restaurant
- Warehouse

For the Phase IV study, the NMR team will classify all customers into the 12 building types used for the Phase III study and will complete sampling within these core building types. We will leverage both the Phase III classification (for accounts that remain active) and any available

market data provided by EDCs (e.g., industry codes that can be mapped to the study building types). However, to the extent that gaps still need to be filled, the NMR team will use the same algorithmic approach to segmentation used for the Phase III study. Importantly, this enhanced, standardized, exhaustive approach to customer segmentation will be leveraged later in the market potential studies to ensure the accuracy of the forecast disaggregation and apply savings opportunities to customer accounts with confidence that the assumed building type is correct.

New data sources: incorporating publicly available building data. A key enhancement proposed for the Phase IV study is the incorporation of publicly available building characteristics data, such as square footage data available from county assessor websites, building footprint, age, and other characteristics from Google Places, or other public sources. This data can be validated for the sampled sites during the on-site data collection process. Collecting square footage data for all of the commercial building stock, rather than just for the sampled sites, will permit a more direct and robust assessment of the building stock across the Commonwealth.

Enhanced C&I recruiting: pre-screening potential on-site participants. Also proposed for Phase IV is an enhanced recruiting and data collection process that leverages a short online screening survey to efficiently identify interest in participating in the on-site data collection effort. This brief survey will ask about site visit interest and availability and will also include questions to investigate customers' propensity to upgrade equipment.

Online Screening Survey

- Effectively identifies interested participants
- Streamlines the first phase of recruiting
- Ensures the adoption propensity questions reach a wider & more relevant audience
- Provides EDCs with meaningful information on market responsiveness

Adoption propensity questions were included in Phase III as part of the in-person site visits. From our experience – both with Phase III and with other studies in the Northeast – detailed propensity questions are better suited to the online mode than as a supplement to the on-site survey. The person providing mechanical room or rooftop access during a site visit is often a facility manager, or other operations personnel, rather than the key decision maker for equipment purchases. The result is often that the person declines to answer the questions during the site visit or answers with less certainty. Using email and paper letter communications to drive sampled customers to a pre-screening survey will both streamline the first phase of recruiting and ensure the adoption propensity questions reach a wider, and likely more relevant, audience, resulting in more robust adoption propensity estimates.

There will be an incremental cost to this two-phase approach, but it will also maximize cost-effectiveness in recruiting, by producing "warm leads," and cost-effectiveness in the site visits since no time will be spent attempting to ask detailed adoption propensity questions. The propensity survey questions will enable the SWE team to develop more realistic and Pennsylvania-specific adoption curves for the MPS. The propensity research will also provide the EDCs with meaningful information on market responsiveness.

2.6.3.3 Study Timeline

Table 11 presents our schedule for completing the C&I baseline study.

Table 11: Schedule for C&I Baseline Study

Milestone	Estimated Date
Work plan development	Sep – Oct 2022
EDC data request response due	Dec 2022
Telephone/Web survey recruitment	Jan – Feb 2023
Scheduling	Feb – Jun 2023
Site visits	Mar – Jul 2023
Data review and QC	Mar – Aug 2023
Data analysis and reporting	Sep – Dec 2023

2.6.3.4 Online Pre-screening Survey

A brief tool to recruit on-site participants. We propose conducting online pre-screening surveys with a representative sample of C&I customers for each EDC, primarily to recruit potential on-site participants. The pre-screening survey will accomplish the following:

- Introduce the study to potential on-site participants
- Collect interest and availability to support recruiting for on-sites
- Validate building type classification
- Collect basic information, such as business name, and contact name, and other information
- Identify respondent business role
- Present equipment adoption propensity questions to equipment decision makers

We anticipate that the pre-screening portion will take fewer than five minutes and that the adoption propensity questions, only presented to purchase decision makers, will take fewer than ten minutes. No incentive will be presented for the pre-screening survey, but participants will be introduced to the on-site study and will be informed that site visit participants qualify for the full study incentive ($150) upon completion of the site visit. As an added incentive to complete the adoption propensity questions, a $20 donation to a Pennsylvania charity will be made for each equipment purchase decision maker that completes those supplemental questions. We propose designing adoption propensity questions around conjoint-based customer preference questions (which allow for measurement of non-price attributes on purchase decisions) rather than direct WTP questions (as in Phase III).

2.6.3.5 Site Visits

In this section, we discuss our proposed methodology for conducting C&I site visits. We intend to leverage our past baseline work to inform the next Pennsylvania's building stock assessment and ensure high-quality on-site data collection, analysis, and reporting.

The NMR team proposes that on-site surveys be used for all building data collection. The NMR team's Project Coordinators will handle all recruiting and scheduling of the site visits. Qualified NMR technicians will be deployed to the field to visit C&I buildings and collect building characteristics, end-use saturations, equipment efficiencies, and more. While a site visit approach is more expensive than telephone calls, it also produces higher quality, more complete data with less uncertainty because it enables trained building science engineers to directly observe and verify conditions at each customer site, thus resulting in a more accurate data set. While it is possible to collect accurate data over the phone, the quality of such data is contingent on the knowledge of the customer providing the phone interview. In our experience, phone surveys conducted with a person lacking knowledge about the building equipment may lead to large gaps in the data collection or even mischaracterization of equipment. In contrast, on-site data collection by a trained engineer enables collection of highly accurate, detailed data that is difficult to capture over the phone/web. If for any reason a site visit or visits are not possible, we can deploy a hybrid approach where the participant provides live video chat access to the engineer who can then guide the participant to enter certain rooms or look closely at certain equipment.

Ultimately, the key to ensuring data quality is for the engineer to guide the data collection and be able to see the premises being surveyed. If necessary, that view can be provided remotely thanks to the ubiquity of live video chat software. The NMR team will use the data collection portal deployed and thoroughly tested for the Phase III study and for multiple subsequent studies throughout the Northeast. The site engineers will receive data collection portal training well in advance of their first site visit, along with test data to ensure familiarity with the tool. This will ensure data is collected in a consistent and reliable manner – ready for direct input into the MPS models.

2.6.3.5.1 Sampling Plan

The distribution of premises and energy consumption by building type across the non-residential sectors is a fundamental research question for both the baseline study and the MPS. These population characteristics drive the sampling frame for the baseline study and represent one of the primary inputs in the MPS because different types of businesses utilize different types of equipment and therefore have quite different conservation opportunities. During the Phase II baseline and potential studies, the SWE team found that approximately 140,000 of PECO's 200,000 non-residential accounts had an *unclassified* building type, thus hindering the ability to extrapolate the findings and savings to this large group of buildings. Properly characterizing these large segments of unclassified buildings was a key achievement in Phase III and carrying the approach through Phase IV will be critical for Phase V planning. The NMR team proposes to leverage the same algorithmic classification approach deployed for Phase III, supplemented by any EDC data that might be available.

As discussed in the RFP, a final decision on the number and allocation of site visits will be decided once the project commences and specific gaps in market data are known. We anticipate following a similar sampling approach as undertaken for the Phase III C&I baseline study. At a high level, this means sampling evenly across EDCs (oversampling smaller EDCs) and sampling building

types roughly in line with share of sales, as summarized in Table 5 of the 2018 Non-Residential Baseline Study.[15]

Weights can be applied after the fact to better align sample shares with share of sales across EDCs and building types (see Section 2.6.3.5.2).

The NMR team is proposing conducting 70 site visits per EDC, like in previous phases, for a total of 490 sample points across EDCs in the C&I market segment. Though results will be reported for all 12 building types, sampling for smaller building types will be pooled within similar building activities. This approach will meet or exceed a margin of error of ±10% with 90% confidence for each EDC, while meeting or exceeding a margin of error of ±5% with 95% confidence across the entire C&I sector. Customers will be stratified by facility type (retail, office, restaurant, etc.) and customer sector (Small C&I and Large C&I). Table 12 summarizes the number of accounts and sales by sector. We will target 420 Small C&I sites and 70 Large C&I sites in the study sample. Essentially, we will *oversample* large customers relative to customer counts but *under sample* them with respect to share of sales. The sector targets will be overlaid on the planned building type sample sizes (Table 13) with a target of ten Large C&I sites and 60 Small C&I sites per EDC.

Table 12: Share of EDC Accounts and Electric Sales (by Sector) - From Phase III C&I Baseline Report

Sector	Accounts	Electric Sales, June 2016-May 2017 (MWh)
Large C&I	6,845	50,194,627
Small C&I	466,240	30,252,140

Table 13: Sample Premises Distribution across EDC Industry Segments

Segment	PECO	PPL	DLC	ME	PN	PP	WPP	State
Education	5	5	5	5	5	5	5	**35**
Institutional / Public Service	6	6	6	6	6	6	6	**42**
Health	5	5	5	5	5	5	5	**35**
Grocery	5	5	5	5	5	5	5	**35**
Retail	5	5	5	5	5	5	5	**35**
Industrial Manufacturing	10	10	10	10	10	10	10	**70**
Office	10	10	10	10	10	10	10	**70**
Lodging	2	2	2	2	2	2	2	**14**
Miscellaneous / Other	10	10	10	10	10	10	10	**70**
Religious	2	2	2	2	2	2	2	**14**
Restaurant	5	5	5	5	5	5	5	**35**
Warehouse	5	5	5	5	5	5	5	**35**
Total	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**490**

[15] https://www.puc.pa.gov/Electric/pdf/Act129/SWE-Phase3_NonRes_Baseline_Study_Rpt021219.pdf, Page 19.

2.6.3.5.2 Reducing Sample Bias and Uncertainty

Sample bias occurs if a sample is selected incorrectly and does not represent the true population due to non-random reasons. For example, the non-residential sample may be biased toward businesses more inclined to accept and participate in a survey. We will make every effort to minimize such potential bias. As discussed in the sampling plan, we will ensure that we define the target population properly and that the sample frame, through stratification procedures, matches the population as much as possible. Also, as discussed in the sampling plan, we will oversample large customers to ensure we have sufficient sample from which to draw inference for this population comprised of very few accounts but representing a large share of sales. This will help ensure the study sample is not composed of disproportionately small or large businesses whose equipment operating characteristics may not be representative.

Given the equitable 70 sample across EDCs and building types, we anticipate that we will need to develop weights to make the final sample more accurately represent the population. As in Phase II and Phase III, we will weight the sample to align with the building type distribution of share of sales in each EDC population and across EDCs. To rebalance the intentional oversampling of large customers, we will further apply a case weight based on the number of accounts in each sector and building type.

2.6.3.5.3 Recruitment and Scheduling

The NMR team will send recruitment letters to a stratified random sample of the population to inform potential participants that an energy survey is to be performed in their territory. The NMR team may also send emails to customers for which this information is available, after screening out role-based emails to non-applicable functions, such as “Accounts Payable.” Recruitment letters and emails will direct the recipient to the pre-screening survey via a simple link and access code and will note that a representative may also contact them to follow up. The initial recruitment letter should be sent out under the name and letterhead of each respective EDC to provide legitimacy to the recruitment effort.

Most of the Large C&I accounts in the sample will have key account managers at the EDC. Our data request template will include a field for EDCs to identify accounts with a key account manager, and Project Coordinators will work closely with key account managers on outreach and communications to these customers. We have found that the key account managers can often put the study team in contact with the best person in the organization to speak with regarding study participation.

We anticipate that site visit recruitment will occur through a combination of customer completion of the pre-screening survey and follow up calls made by the NMR team. Follow up calls will also utilize the pre-screening survey to ensure all information is collected consistently and in one place. Overall, the success rate during the Phase III C&I baseline study was approximately 5% of all businesses contacted.

To increase interest in the site visit for the Phase IV baseline studies, the NMR team proposes to provide businesses with a $150 incentive for participation in the site visits. This on-site incentive level worked well for the Phase III baseline study.

After determining eligible businesses for the baseline study, the NMR team will schedule the on-site assessments. Registered participants will be given a timeframe in which to complete the web survey, and the recruiting team will oversample to ensure that we meet targets set for each survey type. The scheduler will cluster site visits by EDC and in nearby cities and towns to minimize travel time and expenses.

2.6.3.5.4 On-site Data Collection

A trained NMR technician will arrive at each participant business at a time previously scheduled with the participant. The technician will have a picture name badge to identify him or her as an employee of the company, will introduce him- or herself, and ask for the contact person who had been identified when scheduling the visit. Based on previous experience, including the baseline studies conducted during Phase III, the NMR team estimates that comprehensive on-site surveys can take up to three hours of interview time, plus additional time for driving and preparation. During large site visits, technician often collect extensive notes, photos, building blueprints, mechanical drawings, equipment lists, and other items that require detailed post-visit processing and review. As such, we have budgeted five hours of travel and data collection per site for Small C&I sites and 12 hours per Large C&I site.

We anticipate that data collected during site visits may include the following:

- Business size (in square feet) and operating hours
- HVAC equipment characteristics (including type, age, and energy efficiency of existing equipment; type of thermostat and temperature settings, etc.)
- Water heating characteristics (including fuel type, age, and energy efficiency of existing equipment; and temperature settings)
- Building shell characteristics (including, but not limited to, insulation type, insulation levels, windows, roof color, and qualitative assessments of proper duct sealing and air infiltration)
- Type, characteristics, and energy-efficiency level of major commercial appliances, industrial machinery, and plug load systems
- Presence and efficiency of commercial cooking and refrigeration equipment, among others
- Type and quantity of consumer electronic equipment
- Type, quantity, controls, and location of lighting fixtures and bulbs in and around the business
- Type, size, number, operating characteristics, and efficiency of motor-driven equipment and associated efficiency measures installed (such as variable speed drives)
- Presence of envelope upgrades (e.g., weather stripping, insulated blinds, duct insulation)

2.6.3.6 Data Preparation, Analysis, Reporting

2.6.3.6.1 Data Quality

As previously discussed, the NMR team will review all collected data fields for validity and completeness to ensure data quality across all responses. The NMR team will scan all data points will for entry errors and outliers. In addition to data entry errors, the NMR team will also check for internal consistency in recorded responses across fields. Any significant errors will be rechecked and/or confirmed with a follow-up phone call to the participant, where possible. To facilitate this process, the NMR team developed an automated data quality check report that we will provide to site engineers once or twice per week during the data collection phase. Table 14 shows some sample data quality flags and the condition(s) that trigger them for engineer follow-up.

Table 14: Sample Data Quality Flags

Flag Level	Flag Name	Flag Description
building	flag_sqft	Lighting sqft, surveyed sqft are not all equal, excludes exterior spaces
building	flag_lighting	Total building interior lighting wattage per total interior sqft not in 0.2-3watts/sqft range OR there is no lighting space data
building	flag_ac	Disagreement between stated presence of AC and count of AC units
building	flag_heat	Disagreement between stated presence of heating and count of heating units
building	flag_hefuel	Disagreement between stated type of heating system (e.g., fossil boiler / furnace) and heating fuel (e.g., if fossil should be natural gas, fuel oil, or propane)
building	flag_heatpump	Disagreement between presence of heat pump heating and cooling; only applies if AC present.
building	flag_hotwater	Disagreement between stated presence of domestic hot water and hot water fixtures (e.g., in bathroom, shower, kitchen)
building	flag_process	Disagreement between presence of processes and motors
building	flag_process2	Process with zero capacity
building	flag_process3	Process where motor hp does not align with capacity (within 50kw)
site	flag_eui	Site EUI (annual usage / sqft) outside segment range (acceptable range is 10% to 200% of segment average from previous baseline report). Flag not applied to industrial segment)
site	flag_process_seg	Industrial processes noted at a non-industrial site.
site	flag_accapacity	Site AC capacity (total tonnage) outside of expected range based on conditioned square footage. Only applies if ac units present
site	flag_hecapacity	Site heat capacity (total btu) outside of expected range based on conditioned square footage.
site	flag_missingbldg	No building records for the site
site	flag_giftcard	For sites with complete status, gift card entry does not contain a 16-digit number

In the Phase III study, we found that following up with engineers in a timely, detailed manner while the visit was still fresh in the engineers' notes and memories was highly an effective means of ensuring data quality. We will deploy this same approach for Phase IV.

In addition, the NMR team will collect the make/model number of numerous equipment types during the on-site assessments. These recorded data allow for future verification of equipment efficiency and other important characteristics. While not all make/model numbers may be successfully located and verified through online databases, the accuracy regarding the saturation of efficient equipment will be significantly improved through this practice.

2.6.3.6.2 Analysis of On-site Data

Following the data preparation effort, the NMR team will analyze the final data set for all pre-determined building and end-use characteristics. Our team will record the total number of observations for each data field. Where appropriate, the NMR team will present data as penetration percentages, saturation percentages, or averages. At a minimum, our team will analyze data at the EDC level, building type level, and statewide level.

The NMR team recognizes that the findings of the Phase IV baseline study are expected to be key inputs to the Market Potential Analysis and possible Phase V planning. We believe our team is uniquely positioned, having conducted and analyzed the Phase II and Phase III baseline studies, to accurately and efficiently review both data sets and understand the trend impacts that Phases I, II, III, of Act 129 have had on building and equipment characteristics across Pennsylvania. The NMR team would then utilize this analysis in the market potential analysis to assess potential Phase V targets.

2.6.3.6.3 Customer Propensity Analysis

Traditional baseline studies are an inventory-gathering exercise that provide a good understanding of building stock and equipment saturations to inform program design. Even though opportunities may exist to upgrade building equipment, a building's decision maker may not have the ability, motivation, or access to capital to invest in upgrades or participate in energy-efficiency and DR programs. The NMR team is proposing an enhancement to the Phase III adoption propensity research design, which included WTP questions as supplemental questions during the site visit to determine propensity to invest in potential energy-saving opportunities. Specifically, we propose to use the short online screening survey, targeted at equipment purchase decision makers, to include questions to investigate customers' propensity to upgrade equipment. We also propose designing adoption propensity questions around conjoint-based customer preference questions (which allow for measurement of non-price attributes on purchase decisions) rather than direct WTP questions (as in Phase III). Propensity studies are meaningful for C&I customers due to the complex nature of their decision-making processes. The interview questions will reveal the barriers decision makers must overcome and will examine topic areas that include, but are not limited to, the following:

History

- Previous program participation
- Other efficient upgrades completed that were not incentivized

- Size/scope of projects

Motivation(s) – improved cash flow, lower energy bills, higher rents, environment, health benefits, etc.

Barriers

- Financial
  - ROI or payback requirements
  - Access to financing
- Awareness
- Tenant disruption during upgrade process (mainly office buildings) – noise, parking issues, closed building sections, etc.

Future

- Current plans to upgrade – when equipment burns out?
- WTP for upgrades

We propose a stated-preference approach for analyzing customer preferences. Stated-preference methods are a class of statistical methods used to study customer preferences. The goal of these methods is to quantitatively estimate the relative importance of different product characteristics using data collected from surveys or interviews. For our purposes, the product of interest is an EE&C program that includes any building equipment and operational features. The two most common types of stated preference methods are Conjoint Analysis and Discrete Choice Experiments (DCE). For both conjoint analysis and DCE, data are typically collected through customer surveys that enable the customer to visually compare the different combinations of attributes that make up a choice set and ask them to choose between different program offerings.

Data analysis is conducted using regression analysis in specialized statistical software. With an intelligently designed experiment and suitable sample size, estimation is generally straightforward. A common step in estimation is to anchor predicted probabilities to observed choices in the real world. This maintains the relative relationships between attributes and enrollment likelihood while removing some of the hypothetical nature of the stated preference approach.

The output of the analysis will be parameter estimates that capture the preferences of customers as defined by the relative importance of each attribute included in the study. These parameter estimates will indicate the program attributes expected to most influence propensity to participate and quantify that relationship. In addition, the parameter estimates can be used to estimate the adoption rates under several different program designs. The adoption rates will provide data-driven inputs for the MPS and limit the amount of professional judgement required. The NMR team will produce a memo that describes the detailed methods, results, and recommendations of the propensity study. This report may be either a standalone document or included in the larger baseline study report.

2.6.3.6.4 Reporting and Deliverables

The NMR team will produce a draft report organized to address the project objectives and the associated research questions. The report will provide results at both the statewide and EDC-specific level. All tables will provide both the total number of observations and the percentage characteristics. After revising the draft report based on comments from TUS staff, we will submit a final report. If the PUC wishes, we will provide the EDCs with a database with information specific to their territory.

2.7 Market Potential Studies

2.7.1 Introduction

Historically, Act 129 MPS results have been directly incorporated into Implementation Orders for subsequent phases of EE&C programming. For both Phase V potential studies, the NMR team anticipates support of the Tentative and Final Phase V Implementation Orders as the culmination of the MPS proposed approach. Many teams that conduct market potential studies build their work plans to produce a report, which is handed off to the client with little to no ongoing support. The NMR team understands the approach Pennsylvania has taken in the past with respect to utilizing potential study results to propose targets for subsequent phases of Act 129. While the energy-efficiency and peak demand reduction potential studies are separate efforts, they need to come together to inform cohesive recommendations for a potential Phase V. A successful pair of potential studies will answer the following questions:

1. How much remaining cost-effective conservation potential exists in each EDC service territory? Are there specific types of programs and customer segments that are more cost-effective than others? What type of measures and programs have the most potential or are most cost-effective to pursue?
2. What is the optimal design of dispatchable DR programs for Phase V of Act 129, if included? How much DR potential is there in each EDC service territory given the recommended Phase V program design? How do policy decisions about dual enrollment affect the amount of available DR potential?
3. What is the cost of acquiring energy-efficiency potential ($/MWh) by sector, including low-income? What is the estimated acquisition cost for dispatchable DR programs ($/kW-year), as considered, for each EDC? These values are used to convert fixed budget amounts to EDC targets.
4. What is the optimal budget split between energy-efficiency and DR for each EDC? Is it cost-effective to include dispatchable DR programs at the expense of energy efficiency? Because of the fixed 2% spending cap in Act 129, the question is not whether dispatchable DR is cost-effective, but whether DR options are more cost-effective than energy-efficiency offerings. We recommend examining the approach that maximizes the present value of net benefits (benefits minus costs).

In addition to the final synthesis of findings, the two studies share certain cross-cutting methodological steps, which we discuss prior to the detailed study descriptions. The NMR team understands that the potential studies share common inputs that should be collected in a single, streamlined process. After all, the studies focus on the same customers and ultimately determine how a single pool of EE&C program funding will be allocated to best serve those customers.

In order to develop accurate and realistic estimates of DR potential, a significant volume of data must be gathered and synthesized about customer characteristics, end-use saturations, system loading, current EE&C offerings, and customer response to technology and incentive offers. Much of the same data are needed for the baseline and potential studies. For example, the Baseline, Energy-Efficiency Potential, and DR Potential Study all require non-residential customer accounts to be classified by business type according to rate class, NAICS code, or other demographic data maintained by the EDCs. Based on our experience in previous phases, the EDC customer segmentation data are quite poor and will need to be supplemented by the SWE. The NMR team will issue a consolidated data request to the EDCs and coordinate common activities across studies. The largest data request will come at the outset of the Baseline Studies and a smaller data request focused on the EDC sales and customer count forecasts will follow.

Each potential study requires a long-term forecast of energy sales and peak demand by EDC. The sales forecast is most critical for the energy-efficiency potential study and the peak load forecast is most important for the Peak Demand Reduction Potential Study. Based on our experience performing the previous potential studies in Pennsylvania, we know that the EDCs, with the exception of PECO, do not develop their own peak load forecasts. Each January, the PJM Resource Adequacy Planning Department issues an updated 15-year forecast of peak loads, net energy, load management, and energy efficiency for each PJM zone, region, locational deliverability area, and the total RTO. The NMR team will use the January 2024 Load Forecast Report as the starting point for our estimates of the baseline peak demand forecast. Energy sales forecasts will be collected from each EDC through the data request.

2.7.2 Energy-efficiency Market Potential Study

The energy-efficiency MPS is critical to determining the opportunities for cost-effective electric energy-efficiency savings and to developing EDC-specific targets for a potential Phase V of Act 129 EE&C programs. The NMR team has extensive experience in performing energy-efficiency potential studies in many jurisdictions. These have ranged from extremely detailed, measure-level analyses with thousands of measure permutations, to relatively high-level assessments developed based on benchmarking and other more aggregated data. Our studies have been developed to support numerous purposes, including, but not limited to, informing and establishing energy-efficiency policies and regulations, determining the maximum possible achievable cost-effective efficiency opportunities, establishing efficiency plan goals, supporting integrated resource plans (IRP), and supporting detailed program planning and implementation. Additionally, the members of the NMR team who will be responsible for implementing the energy-efficiency MPS are the same as those who conducted the study during Phase III. Consequently, we will be well-positioned both in terms of experience and toolset to build on this success and deliver a high-quality study on time and within budget.

The remainder of this section describes the sequence of steps proposed for this study, beginning with establishing study parameters, collecting data, and establishing the model's approach and inputs. These initial steps will be followed by estimating economic and achievable potential to establish the pool of savings opportunities available in Pennsylvania, and subsequently by estimating program potential for each EDC accounting for the budget caps under Act 129. The final proposed steps are developing a report of the potential study results as a standalone document, after which the study's key results, likely from the program achievable scenario, can be incorporated into the implementation order for a potential Phase V of Act 129.

2.7.2.1 Define Study Parameters, Objectives, and Scenarios

The NMR team will conduct a statewide MPS to determine the opportunities for cost-effective electric energy-efficiency savings in each of the service territories of the seven EDCs in Pennsylvania subject to Act 129. The primary goal of this effort is to inform EDC-specific energy savings targets for a potential Phase V of Act 129 EE&C programs. The analysis of energy-efficiency potential and acquisition costs must be unbiased, technically sound, comprehensive, and transparent to all Act 129 stakeholders. It is important to note that the bulk of the energy-efficiency potential study development will not occur until 2024, several years from the date of proposal submission. Energy-efficiency programs and technologies continue to advance at a rapid pace. Given this, it will be of critical importance to work closely with the TUS and other stakeholders in the initial phases of the study to confirm the study parameters and objectives. This timing will allow the NMR team to fully leverage our prior work assessing baselines and developing the TRM.

Because the EE&C programs delivered under Act 129 are constrained by a budget cap, the NMR team believes that the potential study effort should be focused on developing defensible estimates of the savings that can be realized by each EDC within their budget cap. A potential study focused on this outcome may be structured differently than one designed to assess the absolute limits of efficiency over a longer time horizon and absent program budget limitations, or a study focused on the efficiency resource's ability to meet load requirements. For example, assumptions regarding incentive cost coverage, program administrative spending, equity, and customer responsiveness to this spending will warrant particular attention.

Our current assumption is that the achievable and program potential estimates are the most important outcomes of the study, and that the technical and economic potential scenarios are merely steps in the process to attain these outcomes. Because the current PUC order regarding cost-effectiveness requires the use of the TRC test at the program level, the NMR team believes that it is important to consider how cost-effectiveness is relevant at the measure level, and what the appropriate measure-level cost-effectiveness thresholds should be for inclusion in the achievable and program potentials. This may vary depending on customer segment (e.g., cost-effectiveness criteria may be relaxed for the low-income sector). In addition, while it is generally preferable to pursue cost-effective measures, there may be programmatic, customer service, or technical reasons to include some non-cost-effective measures in the program plan scenarios. The NMR team will work with the TUS and other stakeholders to address issues around cost-effectiveness tests and criteria, ascertain any necessary modifications to the cost-effectiveness approach used for the previous energy-efficiency MPS, and identify the key drivers of the cost of

savings to ensure that the potential study provides the data needed for a PUC order on Phase V targets.

Because there are numerous possible ways to allocate the available EDC program budgets to capture cost-effective energy efficiency, we will work closely with TUS to identify key objectives and criteria to apply in development of the program potential scenarios. We will be informed by the EDCs' current and past programs and actual achievements. We will also explore any issues of concern TUS may have regarding the overall focus of efforts in terms of customer targets, end uses, comprehensiveness and longevity of savings, breadth of coverage, allocations to low-income household, or other issues. This will ensure development of balanced portfolios that meet TUS's key policy objectives, are achievable by the EDCs, build on current EDC efforts, and ensure appropriate savings and net benefits will be captured in Phase V.

2.7.2.2 Collect Data

Having conducted numerous energy-efficiency potential studies and reviewed many others, the NMR team understands the value of data quality and transparency. To assure the quality and reliability of this study, we will conduct systematic research to identify and collect all relevant, current sources of data. All assumptions will be supported by data or information, whether gathered from the baseline studies, from the EDCs, or from other sources.

The primary tasks of any data collection effort are as follows:

- Identify the necessary data
- Determine data availability
- Collect existing data
- Verify the accuracy of the data

Recognizing that a study is only as reliable as the data at its foundation, we will create and maintain a transparent record of data sources referenced by the study and used for the analyses. As with the many past potential studies the NMR team has performed, we fully understand that clear documentation of data sources is essential to assure the defensibility of the study.

Data collection tasks will benefit tremendously from using an integrated team involved in the entire Phase V SWE effort and the timing of the various data collection and analysis efforts that will precede the MPS. Key MPS staff will be integrally involved in the scoping of the baseline studies and TRM work to ensure that appropriate data is captured, and will be in a form easily transferable to the MPS work. This will include, but not be limited to, input into market segmentation and sampling strategies, data instrument development, data sources, and identifying areas of particular need that may have received less attention in the past.

While much of the data will have been developed and collected during the earlier phases of the project, the remainder of this section addresses the data collection tasks specific to developing potential study inputs, which, in many cases, includes translation or transformation of baseline study findings. The primary types of data and steps related to data collection are as follows:

- Issuing Data Requests to EDCs to maximize usage of Pennsylvania specific data where possible
- Assembling Energy and Demand Sales Forecasts

- Developing the Sales Disaggregation to break forecasts down to the building type and end use level
- Gathering data on Baseline Equipment saturations, drawing on the baseline studies
- Assembling Measure Characterizations consistent with most up-to-date version of the TRM
- Incorporating insights related to Customer Behavior
- Capturing recent Program Performance Data
- Utilizing Avoided Costs and a Discount Rate consistent with Act 129
- Developing Load Shapes that reflect best estimates for Pennsylvania

2.7.2.2.1 Data Requests

For necessary inputs not captured through proposed project work like the baseline studies, TRM, evaluation oversight, and incremental cost database development, the NMR team will issue a consolidated data request to the EDCs and coordinate common activities across studies. The largest data request will come at the outset of the Baseline Studies and a smaller data request focused on potential study needs, such as EDC-specific sales and peak demand forecasts, will follow.

Though we expect to minimize the use of out-of-state data given the extensive prior tasks and our history of supporting the TUS in EDC evaluation, planning, and analysis, we recognize that it is sometimes necessary to supplement EDC or state-specific data. Where this *gap-filling* is required, we will use regional data calibrated to Pennsylvania. For example, the U.S. DOE's Residential Energy Consumption Survey (RECS) is a large and valuable data set that is segmented by census region, type of housing, rural vs. urban characteristics, climate, and other key factors in ways that allow for such calibration. DOE's Commercial Buildings Energy Consumption Survey (CBECS) and Manufacturing Energy Consumption Survey (MECS) provide similar information for commercial buildings and industrial facilities, respectively. We believe this approach of using the most relevant and geographically local data possible is preferable to relying on data sets from outside the region, such as the California Database for Energy Efficiency Resources (DEER), which is often looked to by other practitioners. Finally, in addition to data collected through the activities above, we will compile relevant program data, such as lists of promoted measures, recent program evaluations, recent and planned program performance (budgets and savings), participation rates, and estimates of free-ridership and spillover developed through statewide evaluation activities. These data will be especially useful as we calibrate the program potential scenario mix of measures to balance recent history alongside current and future-looking policy priorities.

2.7.2.2.2 Assemble Forecasts and Disaggregate Sales

The residential and C&I baseline studies will provide energy sales data for the baseline year by EDC, sector (residential, low-income, Large C&I, and Small C&I), customer class, building type (where government, non-profit, and institutional [GNI] utility customers will be captured), and end-use. The NMR team will couple these disaggregated energy sales with the EDC sales forecasts to estimate disaggregated energy sales for each year in the analysis period. Further, the NMR

team may use secondary sources, such as the Energy Information Administration's (EIA) Annual Energy Outlook, to forecast future trends in the relative distribution of energy sales by building type and end-use.

2.7.2.2.3 Baseline Equipment Data

Before the impacts of efficiency measures can be estimated, the characteristics of existing building systems and equipment must be understood. This is clearly acknowledged by the emphasis on baseline study data collection in support of the potential study. The residential and C&I baseline studies will provide the bulk of the necessary information on baseline equipment characteristics, such as equipment type, capacity, and efficiency. The baseline study will identify prevalence of different baselines to enable better estimates of the true potential as opposed to simple averages of baseline conditions. For example, when assessing the potential for early replacement of residential air conditioners, knowing that a certain percentage of existing units have a SEER rating of less than 9.0 is more relevant and useful than knowing that the average SEER rating of all such equipment is 10.5.

2.7.2.2.4 Measure Characteristics

Each measure included in the potential study must be characterized with respect to savings, costs, applicability, load shape, and effective useful life (EUL). Notably, the TRM will be a primary resource for the measure characterization effort as the EDC efficiency programs are required to use it to quantify savings, where applicable.

However, the NMR team recognizes that the TRM and other sources may not provide savings estimates for all measures. Many efficiency programs capture the majority of savings through so-called "custom" programs and projects. While the prescriptive savings algorithms presented in TRMs may be adequate to quantify the savings for some custom projects, they will certainly not cover all possible savings opportunities. Therefore, a robust set of measure characterizations must go beyond savings algorithms presented in TRMs, estimating savings potential from a variety of additional sources. We will draw from our team's existing library of measure characterizations, including those developed during the measure characterization process for the MPS conducted during Phase III, and other regional sources, as appropriate. Additionally, the NMR team will review savings information to ensure savings estimates are calibrated to current Pennsylvania energy codes, equipment standards, market trends, etc.

2.7.2.2.5 Program Performance Data (Participants, Conversion Rates, Realization Rates)

Because EE&C programs typically evolve over time, the program potential estimate should reflect relevant characteristics of the programs being delivered by the EDCs immediately prior to the beginning of the potential Phase V. From the several years of evaluation work leading up to the potential study, the NMR team will be familiar with, and have access to, detailed information regarding the programs being implemented by the EDCs; their key results and outcomes; trends in performance, participation, and cost; market penetrations, etc. As Phase IV comes to a close, we will work with the TUS and other stakeholders to assess likely or potential changes to program design for Phase V and the impact of these changes on all aspects of the cost and performance of the programs and savings achievable under the program potential scenario.

One area that we believe will be particularly important is how program dollars are being spent to achieve savings. This includes considering the relative spending on direct customer incentives, upstream market interventions, other implementation costs, and administrative spending. Data on the actual costs of program savings from other jurisdictions may also play a role in developing a defensible forecast of savings acquisition costs for Phase V.

2.7.2.2.6 Customer Behavior

Because the program potential and associated cost of savings is highly dependent on customer behavior and response to programs, this study will devote both survey resources (during the baseline studies) and analytical effort to developing defensible, transparent estimates of measure penetrations that are tied to clear assumptions regarding program delivery. This effort will be informed by data from the Pennsylvania baseline studies, TRM, and program results from other jurisdictions.

2.7.2.2.7 Avoided Costs, Discount Rates

Avoided electric supply costs are necessary for valuing the financial impacts of pursuing energy efficiency. These avoided costs are typically reported as both avoided energy costs and avoided transmission, distribution, and generation avoided capacity costs. Avoided energy costs are usually further divided into summer and winter (and, in some cases, shoulder seasons), and peak and off-peak costs to reflect the variation in electric supply costs over both the course of the year and any given day. Our toolset has the flexibility to treat avoided costs broken out across a range of different granularities, ensuring that we will be aligned with TRC Order guidance that will be developed as described in Section 2.4.2 of this proposal.

Since the cost-benefit analysis will assess the life-cycle cost of opportunities over an extended period of time, a discount rate must be used to estimate the present value of costs and benefits to enable meaningful comparison of alternatives. The NMR team understands and can apply the ACC.[16] If available, we can also collect appropriately calculated avoided costs from each EDC. Our team also understands the appropriate frameworks with which to establish a discount rate that accurately reflects the PUC's policy position, such as ensuring the consideration of all Act 129 stakeholders. This was reflected in Phase III discussions, where our team investigated the historical use of WACC as a discount rate and successfully recommended switching to a 3% real discount rate to reflect the PUC's point of view as a public regulatory entity.

2.7.2.2.8 Load Shapes

Load shapes, or load profiles, capture the timing of measure energy and demand savings over the course of a year. For cost-effectiveness screening purposes, load shapes are typically simplified to express the portion of total annual savings that occur in discrete energy or demand savings periods that coincide with the periods used to quantify avoided electric supply costs. This simplifies the process of estimating the financial benefits of reducing energy consumption and demand. The NMR team will develop appropriate load shapes in collaboration with the TUS and the EDCs, cataloging and improving upon the load shapes used in previous market assessments. As a preliminary recommendation, we propose adopting the load shapes currently being

[16] The current ACC can be found here: https://www.puc.pa.gov/pcdocs/1648144.xlsx

developed as part of the U.S. DOE's End-use Load Profiles for the U.S. Building Stock project.[17] This project, scheduled for completion in 2021, will produce a set of highly resolved end-use load profiles of the U.S. residential and commercial building stock. Because the project relies on extensive building energy models, a set of load shapes specific to Pennsylvania's climate and construction characteristics will be available. These load shapes will be vetted for reasonableness and reviewed for consistency with coincidence factor values embedded in the TRM.

2.7.2.3 Prepare the Cost-Benefit Model and Model Inputs

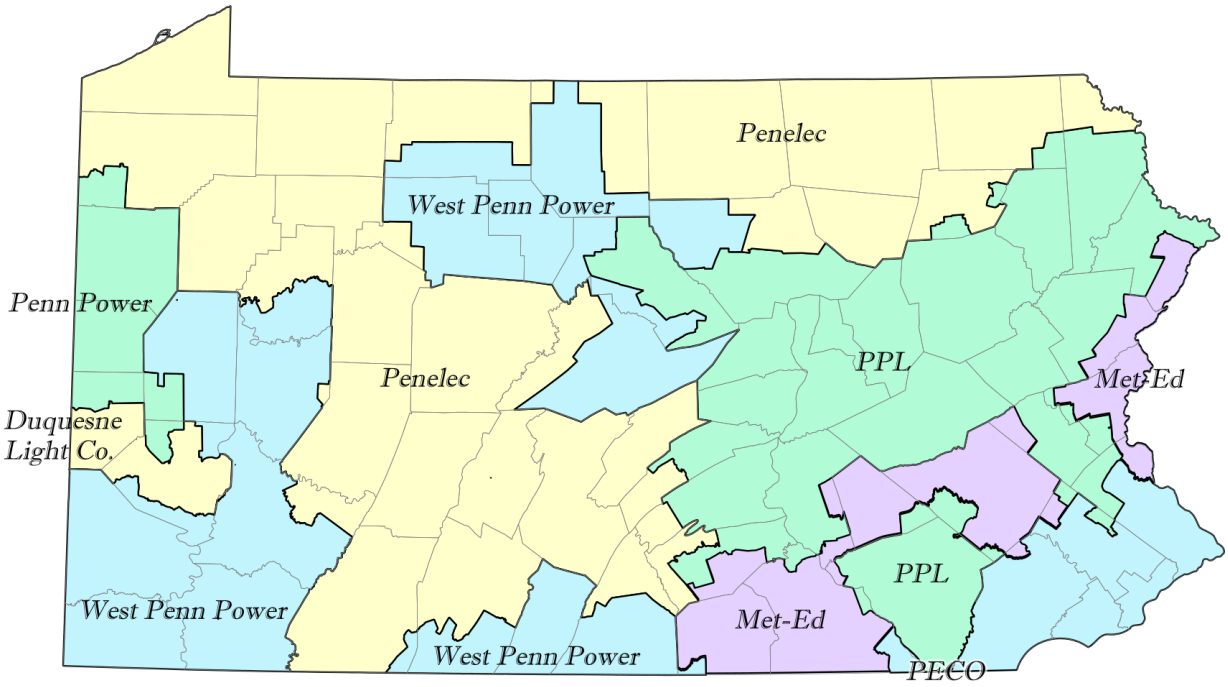
2.7.2.3.1 Establish Analysis Regions

The analysis regions will be based on the service territories of the seven EDCs in Pennsylvania subject to Act 129 (Figure 15). Each analysis region should have, to the degree feasible, consistent characteristics and assumptions for use in the potential analyses. In collaboration with the TUS, EDCs, and other stakeholders, we will determine the appropriate factors for each of the analysis regions. Where necessary, measure characterizations will take into consideration differences by EDC territory, including climate considerations, such as heating or cooling degree-days, regional equipment and labor costs, end-use fuel availability and use (i.e., share of gas, oil, propane, etc.), and regional trends in efficient equipment saturations. For example, as part of the research to inform the Pennsylvania Incremental Cost Database described in Section 2.4.3, the NMR team will review and update cost information, as appropriate, to reflect current market trends and the specific market conditions in Pennsylvania using sources RSMeans Cost Data books and equipment pricing catalogs.[18] In addition, all program costs will consider the actual experience of each EDC and be will customized, as appropriate.

[17] See the following website for additional information on this project: https://www.energy.gov/eere/buildings/downloads/end-use-load-profiles-us-building-stock

18 RSMEANS tracks labor and material costs in the construction industry. Http://www.rsmeans.com/cost-data/

Figure 15: Map of Pennsylvania EDC Service Territories



2.7.2.3.2 Establish the Baseline and Disaggregate the Forecast

A first step in any potential study is defining and forecasting "baseline" or naturally occurring practices and energy consumption, to which the energy-efficiency analysis will be compared. The starting point is the current and forecasted usage of electricity. The NMR team will use the PJM Resource Adequacy Planning Department's January 2024 Load Forecast Report and the energy sales forecasts provided by the EDCs as the starting point for our estimates of the baseline – or what EDC energy sales and peak loads would be absent Act 129 energy efficiency. Careful consideration will be given as to how the PJM peak load and EDC energy sales forecasts treat impacts from upcoming state energy-efficiency offerings, energy codes and standards, future electrification (e.g., due to increased use of EVs), and adoption of efficient technologies embedded in the forecasts. If deemed necessary, the NMR team will add back all or some of the expected energy reductions from implementation of Phase V Act 129 energy-efficiency programs to the forecast. This is an essential step to ensure that all estimates of equipment saturations and impacts are internally consistent between the forecasted energy sales and actual end-use equipment consuming that energy. All data and results will be calibrated to forecasts and adjusted for impacts from codes and standards and naturally occurring efficiency improvements.

PJM forecasts summer, winter, and monthly peak loads so the necessary data will be available to support an investigation of winter demand reduction potential (in addition to summer) if the PUC decides that this analysis is part of the desired scope.

In order to estimate energy-efficiency potential, the sales forecast must be segmented into a series of smaller, more homogenous pieces for analysis.

1. **By Sector/Sub-Sector** – How much of the EDC sales forecast is attributable to the residential; residential low-income; small and large commercial; industrial; and governmental, educational, and non-profit entities?
2. **By Building Type** – How much of the EDC sales are attributable to, for example, offices, retail, education, and warehouse facilities? The proposed approach for the C&I and residential baseline studies will include detailed investigations of this topic to inform the sampling plan that will then be leveraged in the potential study.
3. **By Market** – How much of the EDC sales are attributable to new construction vs. existing buildings?
4. **By End-Use** – Within a home or business, what equipment is using electricity?

Electricity sales disaggregation will be conducted in close coordination with the DR potential study to ensure that the results are comparable across market segments and end-uses.

The current sales disaggregation will have been characterized as part of the development of segmentation and samples for the baseline studies, based on billing and other customer information, as discussed in Section 2.6.3.2. We will then forecast this disaggregation for future years, ensuring to calibrate all totals with the forecasts net of efficiency we develop. In many cases we expect that we may assume constant proportional shares of load for each sector, building type and end use going forward. However, we will discuss with the TUS any expectations of significant shifts and the desire to modify the future disaggregation. For any shifts investigated, we will use available data sources such as new construction and C&I business-specific economic forecasts. We will also consider the end use trends that may result from things like improved lighting, increased plug loads, and electrification.

2.7.2.3.3 Develop Measure List

We will develop a comprehensive list of efficiency measures, including emerging technologies, for consideration. The NMR team has extensive experience in measure characterization, having led TRM development for numerous clients, including the Massachusetts Energy Efficiency Advisory Council, the Northeast Energy Efficiency Project's EM&V Forum (Mid-Atlantic TRM), and the Ohio PUC. In addition, we have performed critical reviews of other TRMs, including New York's Statewide TRM. The NMR team understands the importance of consistency with Pennsylvania's TRM, and plans to refer to the most up-to-date version wherever possible during measure characterization. In addition to this, our team has developed many potential studies and TRMs in other jurisdictions, and will come to this work equipped with a robust list of data sources and candidate measures with which to supplement measure data from the TRM, where appropriate. As discussed in Section 2.4.1, we propose conducting an update cycle of the TRM after the conclusion of the C&I and residential baseline studies but before – or in parallel with – the development of the energy-efficiency potential study to eliminate redundancy and ensure that the potential study reflects the most current measure savings and other assumptions. In addition to measure assumptions adopted from the TRM, the NMR team will endeavor to develop a comprehensive measure list reflecting opportunities that may not be included in the TRM. The measure list development will be supported by the data collection conducted in tasks described in Section 2.7.2.2.

2.7.2.3.4 Perform Qualitative Screening

Upon completing a robust initial measure list, we will perform a qualitative screening to identify any measures that should be removed from consideration in the early stages of analysis. This process will ensure that resources are not wasted investigating measures with negligible or indefensible savings potential. It will also serve to document decisions to omit certain technologies or practices. We anticipate that the vast majority of measures assessed will pass the qualitative screening and proceed to the full characterization process. We propose to qualitatively screen measures according to the following criteria:

- Market barriers
- Commercial availability
- Availability of superior competing measures
- Ability to make a meaningful contribution to overall potential
- Likely cost-effectiveness
- Likelihood of promotion through an efficiency program
- Data quality

Measures may be eliminated at this point if, for example, they have become standard practice because of market advances or new standards, or if our experience indicates that they will never provide a cost-effective efficiency resource. New technologies may be included that previously were not commercially available or excluded for other reasons. In addition, we may keep some emerging technologies on the list that have limited current commercial availability, but are expected to offer significant efficiency potential later in the study period. The specifics of the qualitative screening will be determined through collaboration with the TUS to ensure we are meeting project goals.

2.7.2.3.5 Develop Measure Parameters

Measures that pass the qualitative screening will be fully characterized. Typically, our potential studies include hundreds of different technologies and thousands of different efficiency measures representing combinations of technologies, building or customer type, and market event or program type. We will segment all efficiency opportunities by EDC territory, sector, building type, and market. Generally, markets are the arenas in which decisions are made that affect energy use. Broadly, there are two different markets: existing buildings and new construction. Owners of existing facilities are faced with different decisions than potential owners of new facilities, particularly when evaluating costs of different options that would affect energy use. The existing building market can be further divided into three *submarkets*: retrofit, purchase/replacement, or renovation. The NMR team's analysis methodology recognizes that the costs and savings for the same measure may be different among these markets. Further, the timing of the opportunities and the year-by-year tracking of building and equipment stocks require a full understanding of the replacement cycles and size of eligible markets in each year.

Retrofit markets refer to situations where no efficiency investment or building modification is planned and is only induced by an efficiency program. This could include early retirement of older inefficient equipment and additions of measures not currently in place, such as insulation and HVAC controls. In these instances, we will treat the existing building conditions as the baseline from which to estimate savings, and the full cost of materials and labor to install the measure. For

the other markets, often referred to as "lost opportunity" markets, a customer is already planning an investment in the building or energy-using equipment and systems. Here, the efficiency measure reflects incremental improvements over a baseline of what the customer is assumed to have done absent the programs, and the costs only reflect any incremental equipment and labor costs compared to that baseline investment.

Additionally, the NMR team will review savings information to ensure that, where applicable, savings estimates are calibrated to current energy codes, equipment standards, market trends, etc. For example, for planned or emergency replacements, we will typically assume baselines mandated by the energy code or typical standard practice anticipated to be in effect during the analysis period. Measure characteristics include the following:

- **Savings Factor** represents the percent savings (as compared to either existing stock or new baseline equipment for retrofit and non-retrofit markets, respectively) of the high efficiency technology. Savings factors are calculated based on individual measure data and assumptions about existing stock efficiency, standard practice for new purchases, and high efficiency options. For retrofit measures, a baseline adjustment factor may be applied to adjust the saving factor downward in future years to account for the fact that the customer would presumably otherwise have purchased newer, standard equipment efficiencies (that would naturally be installed at some point in the future even without program intervention) prior to the end of the measure life. Typically, standard efficiencies in the future are assumed to be higher than older, existing stock efficiencies. Savings factors will generally be estimated from the TRM, other regional TRMs and potential studies, and engineering analysis, as appropriate.
- **Measure Cost** is the estimated cost of the efficiency measure as compared to the base case alternative. For retrofit measures, the base case is no action, so the cost reflects both labor and full equipment costs. For all other markets where there is already a planned investment, costs are the *incremental* labor and equipment costs of the efficient product over and above the base case efficiency. The NMR team proposed a process improvement for measure cost data for the MPS, which will shift the work of developing the Incremental Cost Database forward in the Phase IV cycle so that the cost data are available for use in the MPS (see Section 2.4.3). As a result, to the degree possible, measure costs will be drawn from this database, and supplemented from recent incremental cost studies, EDC tracking data, and other regional studies if necessary.
- **Load Shapes**, as described in Section 2.7.2.2.8, capture the timing of energy savings over the course of a year. Energy savings may not occur evenly throughout the day, week, or year. Because avoided costs also vary hourly, we will develop load shapes for each measure that identify the portion of annual savings that is attributable to each avoided cost period (e.g., summer peak, summer off-peak, shoulder weekday, etc.) Further, the load shapes establish the estimated savings that are coincident with the expected timing of the overall electric system peak, which is important to value capacity savings.
- **Effective Useful Lifetime** (EUL) is the length of time that a given efficiency measure is expected to generate energy savings. EULs will generally be adopted from the TRM, limited to 15 years as per PUC order. The EUL is not always the same as the estimated

measure life. For example, some equipment may last a long time, but the expected baseline improvement in efficiency and/or lifetime is assumed to happen sooner because of transforming markets or other factors.

2.7.2.3.6 Develop Market Data

Both the residential and the C&I sector analyses will use a *top-down* approach, where potential savings are estimated by forecasting total electric energy sales over the analysis time horizon, and then determining what percentage of those sales may be offset by the installation of a given energy-efficiency measure in each year. Each portion of the disaggregated electric sales forecast (e.g., the energy consumed by water heating in restaurants and similar facilities) is multiplied by the savings attributable to measures that address that segment of energy usage, in addition to factors that compensate for the technology applicability, technical feasibility, rate of equipment turnover, and saturation of existing efficient equipment. These factors will generally be drawn from the baseline studies and the TRM.

2.7.2.4 Estimate Technical, Economic, and Achievable Potential

The technical and economic potential generally serve as stepping stones to the achievable and program potential estimates. In and of itself, the technical potential does not offer significant utility. It primarily serves as an initial, hypothetical investigation of the overall magnitude of energy-efficiency potential unbounded by any market or budget constraints, if all measures included in the study were adopted immediately. In contrast, the economic analysis limits the potential to only those measures or programs that pass some cost-effectiveness threshold (e.g., positive net benefits using a standard cost-effectiveness test methodology), and recognizes the timing of replacement and renovation cycles. As discussed above, the NMR team will work the TUS to determine a relevant cost-effectiveness threshold for use in the economic potential analysis. While the technical potential is a necessary internal step to screening the measures and quantifying economic potential, it does not reflect the full technical potential because it is limited to the measures included; therefore, we do not plan on reporting results from the technical potential.

2.7.2.4.1 Estimate Technical and Economic Potential

The results of the technical and economic potential analysis are theoretical in nature; these levels of savings cannot be achieved by efficiency programs. They serve as preliminary steps to performing the achievable and program potentials.

We will first estimate the technical potential, which assumes that all measures are implemented to their full potential without regard to market barriers. Where multiple measures *compete* for the same end-use energy or technology opportunity, we will generally prioritize the measures with the lowest cost of saved energy. We will take care to avoid double-counting and to account for the high level of interactions between measures. Again, because it really represents an interim step to economic potential, technical potential will not be reported.

While the economic potential analysis will essentially use the same methodology as the technical potential analysis, it will be limited to only those measures that pass the appropriate cost-effectiveness threshold. It is presently assumed that the TRC test will be used to develop the economic potential as was the case for the potential study conducted in Phase III. We note that

the 2021 TRC Test Order requires that the TRC test be performed at the program level, which implies that not all measures need to pass the cost-effectiveness threshold to be included in the program portfolio. Therefore, an economic potential estimate that eliminates measures based on individual measure cost-effectiveness may unnecessarily eliminate some measures that could be included in the achievable and program potential estimates. We will work with TUS to decide measure-, program-, or sector-specific criteria for what measures to include. For example, we may include all measures for low-income or include some specific measures in certain programs for specific programmatic reasons.

The economic potential modeling will also consider the timing for each eligible measure, as well as any interactions between them. For example, all available retrofit measures can be installed at any time, but replacing equipment at the time of failure is a function of the typical vintage of existing equipment and measure lives, and can only be captured during specific moments. Further, if a retrofit is completed, then it is assumed that equipment or system will not be eligible for a replacement on failure until the end of the measure life, and vice versa. Our model will track and account for replacement and retrofit activity and the timing of all eligible efficiency opportunities.

2.7.2.4.2 Estimate Achievable Potential

Develop Achievable Penetrations

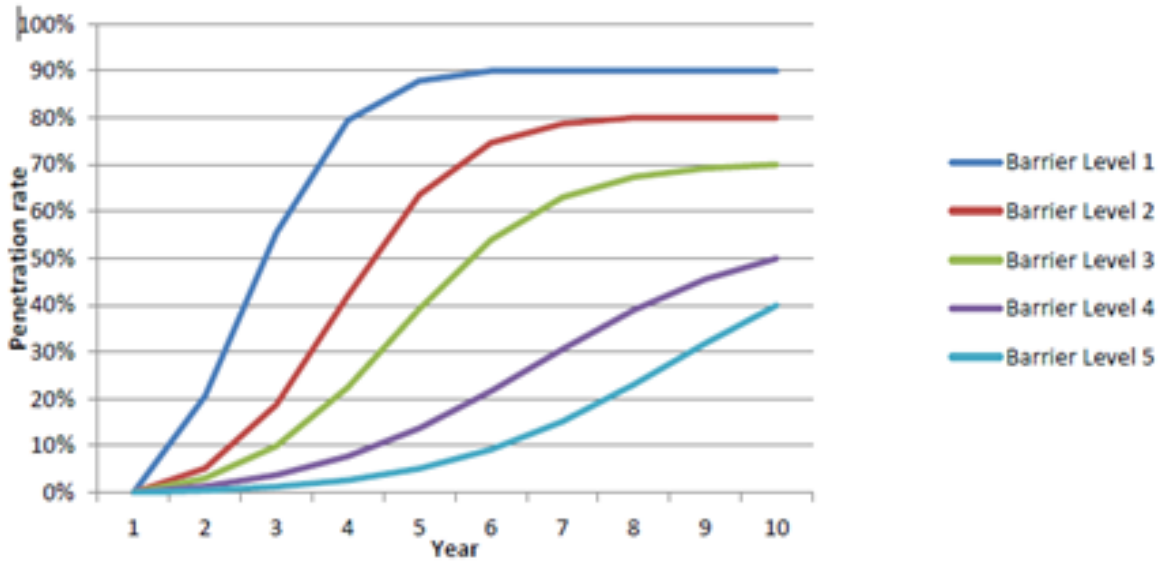
Significant emphasis will be placed on the achievable scenario, which provides the first realistic set of results, assuming no budget constraints and a goal of maximizing energy savings, but recognizing all the market barriers. One of our first tasks will be to define the parameters for the achievable study. The industry standard is to assume that programs offer incentives covering 100% of incremental measure costs and the most aggressive marketing and technical services possible. While this is useful to establish an upper bound *maximum* achievable estimate, it may be less useful to the TUS and EDCs for purposes of Act 129 and future program design activities, given budget constraints. We will work closely with the TUS to identify the most useful achievable scenario to explore, and clearly document these decisions prior to analysis.

Developing accurate measure adoption curves, or penetration rates, is one of the more challenging aspects of estimating energy-efficiency potential. We believe the best method for forecasting adoption rates for a given technology is to first understand its current market saturation, its technical potential, the market barriers to its implementation, and the strategies for promoting it. We also identify how measures have performed in actual efficiency programs, relying on program evaluations and related studies, while being cognizant of the level of maturity and market strategies employed by those programs, and adjusting for local conditions as appropriate. Further, the customer propensity analysis proposed as part of the baseline studies will provide crucial data on customer disposition regarding various efficiency investments, awareness of opportunities, and willingness to invest in improvements.

Many practitioners use a deterministic model that creates adoption curves as a function of a single variable – typically customer simple payback. The drawback to this approach is that it often underestimates the achievable efficiency potential as evidenced by the actual savings achieved in jurisdictions with the most aggressive programs. While simple payback is certainly one factor in customers' decisions to invest in efficient equipment and services, many other factors play a

role. We will use our expert judgment and the data sources described above to develop adoption curves and penetrations consistent with the latest and best knowledge of how programs actually perform. See Figure 16 for an example of illustrative penetration curves for measures with different levels of market barriers.

Figure 16: Illustrative Measure Penetration Curves



The NMR team will work with the TUS and other stakeholders to develop first-year penetration levels consistent with the most current data available on actual program activity (e.g., from current program and market evaluations). Anticipated baseline changes will reflect expectations about future implementation of codes and standards and technology advances (e.g., changing costs, higher efficiencies, more competing technologies). Estimation of penetrations due to program activity will be a function of the target market (new construction, retrofit, natural replacement), customer awareness and economics, incentives, and non-incentive-related program activity (marketing, education, technical assistance, etc.). The outputs of this process will consider the experience of leading programs across the country that have attempted to address the same or similar efficiency markets with similar budgetary resources.

Develop Achievable Potential Non-measure Costs

Unlike the technical and economic potential estimates, all achievable potential analyses must include the costs of delivering efficiency programs in addition to the costs of the measures themselves. These non-measure costs can include utility or other administrator staff and operating costs, program-wide marketing costs, training costs, audits and site visits, and other costs not attributable to a specific measure. In addition, the achievable analyses will account for free-ridership and spillover – that is, respectively, market effects that account for customers who would have installed measures even in the absence of the program, and those who install measures because of the program but do not actually participate by receiving a rebate or direct program services.

The NMR team has developed a model for scaling non-measure costs to measure costs in a way that acknowledges that some of these costs are fixed and some are variable with program activity. The model will be initially calibrated to the performance of the Phase IV programs, but will also incorporate actual cost data from a variety of best practices program types for a variety of leading jurisdictions.

2.7.2.5 Program Potential

The program scenario is arguably the most important outcome of the potential study. This should be a realistic scenario that reflects practical assumptions about the future in order to meet specific goals. Further, to be useful for setting goals in Pennsylvania, any program potential scenario must not exceed the available budgets set by Act 129. We will work closely with the TUS to identify and prioritize the modeling parameters, which will produce results of greatest value for a potential Phase V, within the constraints of the time and resources available.

For the program potential scenario design, it will be important to understand current and potential market strategies for Pennsylvania's efficiency programs. The strategies for promoting efficiency measures and programs will inform the process of prioritizing efficiency measures and estimating their adoption rates. We expect to work closely with the TUS and the EDCs to ensure the study provides the most useful results.

The NMR team's potential study toolset and seasoned modeling team are well-suited to utilizing Pennsylvania-specific data sources like baseline studies, the TRM, and recent EDC EE&C program performance data, while also understanding and incorporating PUC policy priorities, such as ensuring that the low-income sector is well served, balancing the acquisition cost of efficiency savings with depth and comprehensiveness, and optimizing the portfolio of measures to fall within budget constraints.

Our analysis will begin with establishing a strong foundation in current program offerings, which will be built upon by assessing measures for adherence to policy goals and prioritizing the best-fit measures appropriately. For example, our model allows for measure-specific incentive levels to account for enhanced support for some measure groups, such as replacing electric resistance heating with air source heat pumps. Critically, the model has the flexibility to retain these differential incentive levels among measures through the full budget optimization process, such that the final program potential results show a mix of measures that both retain enhanced support for priority areas while also meeting specified budget constraints.

Our team is fully versed in the process of translating policy priorities into model parameters. In past work, we have executed market potential studies that reflect priorities such as maximizing energy savings, achieving peak demand reduction, pursuing comprehensive efficiency, and ensuring balanced participation across customer and market types. We will develop measure prioritizations for this study in collaboration with the TUS to ensure that our model fully reflects the appropriate policy goals for efficiency programs in a potential Phase V of Act 129.

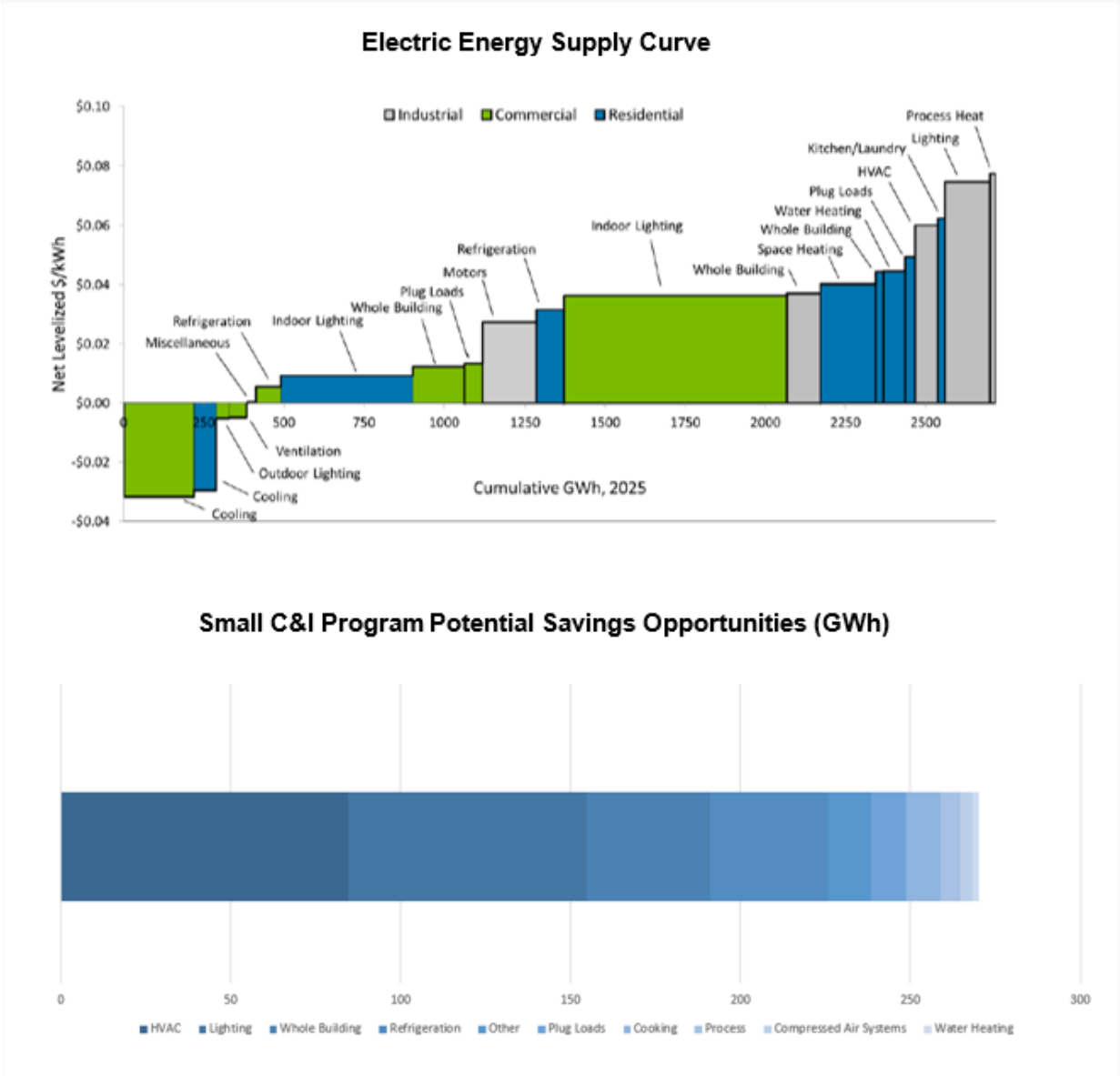
Finally, the measures will be passed through the prioritization process described earlier in this section before executing the budget-constrained program potential optimization routine. Beginning with the largest estimate of potential and successively paring that pool of savings down to the program potential scenario ensures that the TUS and the EDCs can be confident in the model results, which can thus be used to inform future program design.

2.7.2.6 Reporting

We assume that the final report will need to present the study findings and methodology to a variety of stakeholders. Therefore, the report must present both detailed and summary information to meet the different needs of those various stakeholders. We also recognize that transparency is essential to the process, so the report should include adequate detail to satisfy a deep level of scrutiny. From previous experience on the SWE team, NMR team members have learned the right level of detail to provide in presentations and reports. As a first step, we will prepare a table that lists all the figures we intend to include in the final report. This table will clearly describe the data points and dimensions of the data, the timeframe or other basis for inclusion or exclusion from the figure, and the type of presentation (e.g., table, line graph, pie chart). We plan to work closely with the TUS staff to confirm this aspect of the report before proceeding to develop a draft outline and format that is structured to provide clear and actionable insights for TUS staff.

All tables, graphs, and embedded values in the report will be linked to their source data in Excel files. This will facilitate tracing values to their source, as well as automating the process of updating the report when the analyses are refined, which avoids errors that are common with manual updates. Figure 17 provides two illustrative reporting outputs from past potential studies.

Figure 17: Sample Reporting Outputs



The RFP states that "the study methodology should be detailed enough to result in recommendations to be contained in the report to the Commission for EDC-specific MWh targets for a potential Phase V of Act 129 EE&C programs." These goals will guide the selection of data and the manner in which tables and charts are presented in the report. By comparing projected efficiency savings to the base-case sales forecasts – disaggregated by sector, end-use, and building type – we will be able to identify where the gaps are widest between the base case and the efficiency potential at different levels of segmentation. Measure-level results will be applied to determine the specific technologies and practices that account for the potential savings. In this way, the energy-efficiency potential study will provide critical insights to the EDCs on targeting energy-efficiency resources that will aid in cost-effective delivery of energy-efficiency programs in a potential phase V. Table 15 presents our schedule for completing the energy-efficiency potential study.

Table 15: Schedule for Energy-efficiency Potential Study

Milestone	Estimated Date
Define study and develop work plan	November 2023
Collect data	November 2023 – January 2024
Prepare model	January 2024 – March 2024
Estimate technical and economic potential	March – April 2024
Develop achievable potential	April – June 2024
Develop program potential	June – August 2024
Prepare report	September – December 2024
Phase V Implementation Order Support	January 2025 – June 2025

2.7.3 Peak Demand Reduction Market Potential Study

The characteristics of the "reductions in peak demand" called for in the Act 129 legislation have varied from phase to phase.

- **Phase I** – Peak demand reductions were measured during the "top 100 hours" of 2012 and could be delivered by either dispatchable DR programs or coincident demand reductions from energy efficiency. Energy-efficiency programs delivered 54% of the Phase I peak demand reductions statewide; dispatchable DR programs were responsible for the other 46%.[19]
- **Phase II** – Did not include peak demand reduction targets.
- **Phase III** – Peak demand reduction compliance targets had to be met exclusively through dispatchable DR programs. The Commission established a *trigger* based on the PJM day-ahead load forecast, which determined when events would be called and when EDC performance against compliance targets was measured.
- **Phase IV** – Peak demand reduction compliance targets must be met exclusively with coincident demand reductions from energy-efficiency programs. EDCs are also required to nominate a portion of their Phase IV peak demand reductions into PJM's forward capacity market for wholesale recognition.

This variation over time is a function of the language in the Act, which required the Commission to set additional incremental requirements for reduction in peak demand for the 100 hours of greatest demand, *or an alternative reduction approach approved by the Commission* – provided the benefits exceed the costs. The NMR team believes the Peak Demand Reduction Potential Study should consider the economics of dispatchable DR programs relative to coincident reductions in peak demand from energy efficiency and inform the Commission's proposed definition of Phase V peak demand reduction and associated targets. Under this construct, the first task of the peak demand reduction MPS is to consider the design of dispatchable offerings and select a recommended design for modeling.

[19] SWE Phase I report. https://www.puc.pa.gov/PCDOCS/1274547.PDF. Page 169. Table 3-25

2.7.3.1 Demand Response Program Design

Much more so than energy-efficiency potential, the quantity of achievable dispatchable DR potential and the cost required to acquire it are a function of the program design and grid application that DR resources are intended to fulfill. A critical upfront task is identifying the mechanism(s) for wholesale recognition at PJM. The avenues whereby retail programs can enter the wholesale markets operated by PJM are constantly evolving. The NMR team will need to monitor developments at PJM and form a clear recommendation about how the Phase V dispatchable DR programs we model will avoid capacity costs or receive capacity payments. If the proposed Phase V DR program requires integration with PJM, the rules and value streams set forth by PJM are important predictors of potential. Programmatic considerations that influence the amount of DR potential available and the cost to acquire it include the following:

- **Seasonality requirements** – Do resources need to able to perform year-round or just during the summer?
- **Event Frequency** – How many events are expected per year, on average?
- **Event Time and Duration** – What time of day are events called? How long do events last, on average?
- **Notification Time** – How far in advance are participants notified of events?

Dual participation between Act 129 and PJM will undoubtedly continue to be an issue for the Phase V DR potential study. In the Phase IV DR potential study, we excluded Act 129 potential from Large C&I accounts because many of these large, more savvy customers have existing PJM commitments. Time-varying pricing will be a key consideration for Phase V. With AMI penetration in the Commonwealth approaching 100%, PJM's Price Responsive Demand (PRD) offering may present a viable path for residential and Small C&I sectors.

Peak demand reduction potential studies in prior phases devoted considerable resources to examining the most cost-effective DR program design. The *optimal* or *most effective* program design is somewhat subjective, so it is useful to develop quantitative metrics. The Phase IV DR potential study considered a 5 Coincidental Peak (CP) metric and an Effective Load Carrying Capacity (ELCC) metric. The NMR team compared the performance of hundreds of possible design and dispatch combinations using these two metrics to develop a data-driven recommendation. We recommend a similar approach for the Phase V study once some initial scoping considerations are finalized with TUS staff.

At this point, we also want to establish a shared vision and common understanding of the definitions of technical, economic, achievable, and program potential. The assumptions and interpretation of these estimates are not as well defined for DR as they are for energy efficiency. While the technical potential for DR potential is driven by equipment saturations and loading, the meaningful outcome of a DR potential study – achievable DR potential – is fundamentally driven by customer behavior, particularly willingness to participate in a DR program given different incentive, marketing, and technology options made available by the EDC. One fundamental truth in the DSM industry is that all customers are not created equal. Certain types of homes and businesses are better candidates for DR than others, and a good DR potential study needs to understand and leverage these differences.

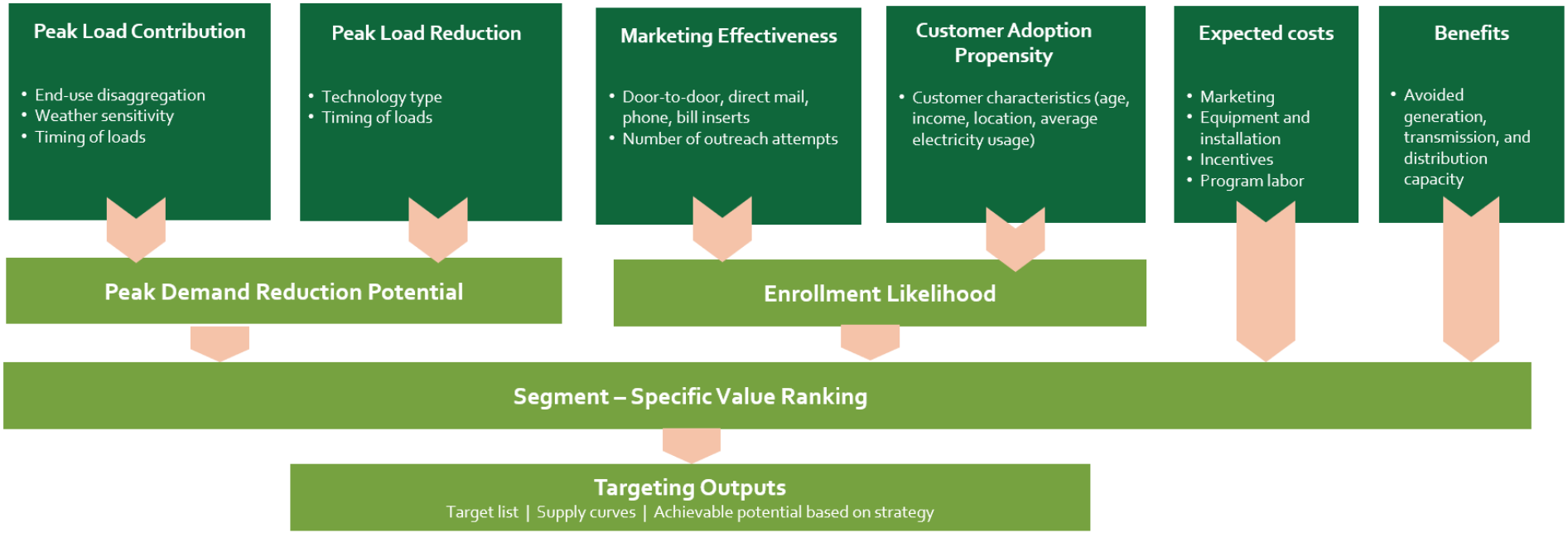
2.7.3.2 EDC Data Request and Independent Data Collection

In addition to the core data request elements discussed in Section 2.7, our proposed approach requires secondary data collection. Market adoption of DR technologies and rates under different incentive structures is the single most important driver of DR potential. Given the absence of dispatchable DR programs in Phase IV of Act 129, the NMR team will need to monitor the performance of peak demand reduction strategies in other jurisdictions to understand the latest market trends. For C&I customers, study lead DSA uses a price elasticity of supply approach and continually updates the elasticity coefficients based on the results of DR evaluations across North America. The type and number of internet-connected devices is growing exponentially in homes and businesses, which creates additional peak demand reduction opportunities. The NMR team will carefully inventory connected devices during the baseline studies and monitor the success of pilots and programs that control these devices in other jurisdictions.

2.7.3.3 Modeling Approach

Figure 18 provides a conceptual overview of the NMR team's approach to the study. We believe that robust estimates of potential need to be anchored in accurate customer segmentation and will leverage work completed as part of the baseline studies. With DR potential, it is important to look beyond the average customer and recognize that customers have different load shapes, peak load contributions, and end-use equipment that dictate their ability to shift load off-peak. Some customers are also more likely to participate in DR than others. Technical potential is not a terribly informative quantity for goal setting as most loads can be curtailed temporarily for enough money. The important question from a policy standpoint is how much demand reduction can be acquired via programs at a lower cost than traditional supply alternatives, representing the avoided costs.

Figure 18: Peak Demand Reduction Potential Study Conceptual Overview



2.7.3.3.1 Peak Load Contribution

The first step in analyzing the peak demand reduction is understanding where demand for electricity comes from at the time of the system peak. Peak demand reduction strategies can then be mapped to the applicable loads. Each January, the PJM Resource Adequacy Planning Department issues an updated 15-year forecast of peak loads, net energy, load management, and energy efficiency for each PJM zone, region, locational deliverability area, and the total RTO. The NMR team will use the January 2024 Load Forecast Report as the starting point for our estimates of the baseline – or what EDC peak loads would be in the absence of Act 129 DR. Subcontractor DSA is currently conducting a study for the Consumer Advocate of PJM States to better understand changes to PJM's load forecast process and diagnose why the projections at times seem contrary to trends in weather-normalized loads. This familiarity with the load forecast process and underlying data will help ensure that the potential study teams incorporate the peak demand forecasts appropriately into the Act 129 analysis. PJM forecasts summer, winter, and monthly peak loads so the necessary data will be available to support an investigation of winter DR potential if the PUC decides this analysis is part of the desired scope.

To estimate DR potential, the peak load forecast must be segmented into a series of smaller, more homogenous pieces for analysis.

1. **By Sector** – How much of the EDC peak load forecast is attributable to the residential, commercial, and industrial sectors?
2. **By Customer** – How much electricity does each customer typically consume during system-peaking conditions?
3. **By End-use** – Within a home or business, what equipment is using electricity during the peak?

Peak load disaggregation will be conducted in close coordination with the Baseline studies and energy-efficiency potential study. For the Phase IV DR potential study, this step required different approaches for PECO, PPL, Duquesne Light, and the FirstEnergy EDCs because of differences in data availability and practices across the EDCs to allocate capacity costs to rate classes and customers. The NMR team will be more deliberate in the way we request data regarding peak load contribution from the EDCs for the Phase V studies. The sure-fire remedy would be to collect one year of hourly load data from all customers, but this would be a massive data request. Instead, we recommend an approach where each EDC draws a random sample of 10,000 residential and 10,000 Small C&I accounts to provide hourly load data for. Since there are relatively few accounts in the Large C&I class, we would request a census of their interval meter data.

2.7.3.3.2 Identify Strategies and Associated Peak Load Reductions

Peak demand reduction programs can include a wide range of strategies. Coincident demand reductions from energy efficiency will be an output of the energy-efficiency MPS. The Peak Demand Reduction Potential study will consider dispatchable DR offerings and load shifting interventions that deliver *everyday* reductions in peak demand. To deliver a focused study, the NMR team will need to limit the technologies considered or collapse them into more manageable bins. Consider the air conditioning end-use within the residential and small commercial segments. There are dozens of products and strategies in the market from different vendors, including direct

load control switches, programmable communicating thermostats (PCTs), and smart thermostats, which are all designed to reduce AC usage temporarily on hot summer days. Most products are capable of controlling load with varying levels of aggression. Each product and control strategy has somewhat different load shed profiles and cost structures. This step of the DR potential will establish a short list of technologies for examination and estimate the expected peak load reduction on a per-unit basis.

Historically, the largest and most cost-effective pool of peak demand reduction potential lies in the C&I sector. Programmatically, these offerings can take the form of interruptible tariffs, reservation payments in exchange for committed reductions, or tariffs with a billing determinant that discourages on-peak usage. Ultimately, in an Act 129 setting, these details are decided by the EDC in an EE&C plan. At this stage in the study, the NMR team will determine the expected response to DR incentives for a generalized program model.

EVs are one of the most flexible electric loads in a home or business. In a residential setting, most EV owners plug their vehicle in after returning home from work and just want it to be fully charged by the following morning. The largest opportunity for managed charging may lie in commercial fleet vehicles. Table 16 shows the expected contribution to summer peak load, by year and zone, in PJM's 2020 Load Forecast Report.[20] This forecast projects a peak load contribution of 101 MW across Met-Ed, PECO, Penelec, and PPL zones in 2026 and 153 MW in these four EDC zones in 2030. While EVs represent a fraction of the total peak load in the Commonwealth, a significant amount of EV load can be shifted off-peak through program options like direct load control of chargers or vehicle timers.

Table 16: PJM 2020 Peak Load Forecast Adjustment for Electric Vehicles

PLUG IN ELECTRIC VEHICLE ADJUSTMENT TO SUMMER PEAK LOAD (MW) FOR EACH PJM ZONE AND RTO
2020 - 2035

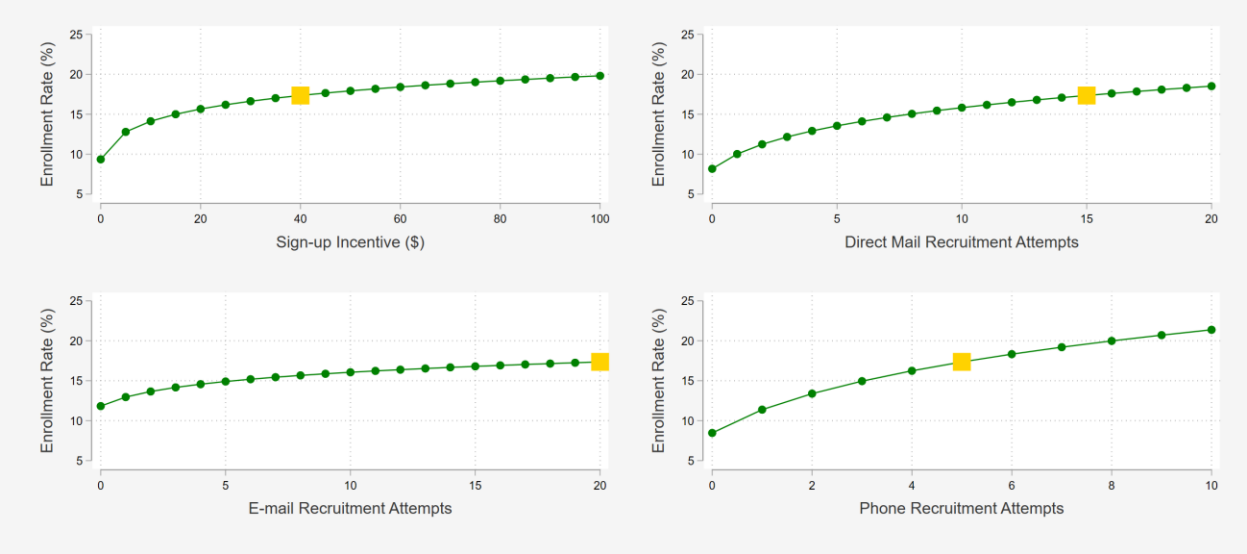
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
AE	5	8	11	15	18	21	24	27	30	33	36	37	39	40	41	42
BGE	12	18	25	33	41	49	55	62	68	75	82	86	90	93	95	97
DPL	5	7	10	13	16	19	21	24	26	29	32	33	34	36	37	37
JCPL	12	19	27	35	44	52	58	66	72	79	86	90	94	97	99	101
METED	3	4	6	8	10	12	14	16	17	19	21	22	23	24	24	25
PECO	8	13	18	24	30	36	41	46	51	56	62	65	67	70	72	73
PENLC	3	4	6	8	10	12	13	15	17	19	20	21	22	23	24	24
PEPCO	10	16	22	29	36	43	49	55	60	67	73	76	79	82	84	86
PL	7	11	15	20	25	29	33	38	41	46	50	53	55	57	59	60
PS	20	32	45	59	73	86	98	110	120	133	144	151	157	162	166	169
RECO	1	1	2	2	3	3	4	4	5	5	6	6	6	7	7	7
UGI	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2

[20] https://www.pjm.com/-/MEDIA/LIBRARY/REPORTS-NOTICES/LOAD-FORECAST/2020-LOAD-REPORT.ASHX?LA=EN

2.7.3.3.3 Estimate Enrollment Likelihood

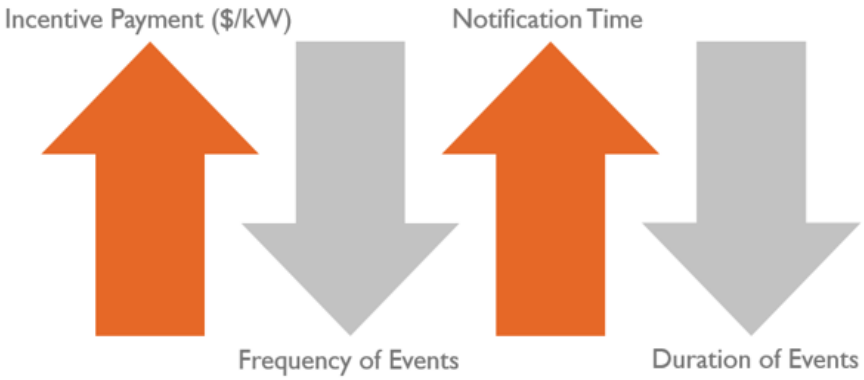
DR potential is effectively the number of customers who can be enrolled in a DR program multiplied by the kW impact that can be expected from their participation. Getting both components of this formula correct is critically important. It is also important to understand the relationship between marketing, enrollment rates, and cost. EDCs can increase the enrollment rates of peak demand reduction programs through various marketing tactics, but those marketing efforts have direct costs. For example, if we assume a 20% enrollment rate in a connected thermostat DR program, it is imperative that the costs to achieve that rate of enrollment are fully accounted for. Figure 19 illustrates this type of modeling from a different study. Each panel in the figure varies one dimension of the marketing tactics while holding all other aspects constant. In each case, the use of the tactic had diminishing returns. The gold square represents the levels selected for maximum achievable potential. A realistic achievable or program potential scenario would likely settle on the lower enrollment rate associated with less aggressive marketing tactics. Given the limited history of residential DR programs in Pennsylvania, these curves will need to be estimated using secondary data.

Figure 19: Enrollment Rate Sensitivity to Marketing Tactics



For large customers in particular, participation rates and percent demand reductions are related, vary by industry and customer size, and depend on how many events are called and the duration of events. The directional effect of each component is illustrated in Figure 20. Some customers have low or no start-up costs and can deliver demand reductions for a short time with little disruption by just delaying energy-intensive business processes until after the DR event is over. The more frequently DR events are called, the more disruptive DR participation becomes to the primary business line. This translates into lower participation rates and lower committed reductions from the sites that do enroll. Like the Large C&I analysis in prior phases, the NMR team will determine the mathematical relationship between these program attributes and the all-important incentive level.

Figure 20: Drivers of C&I Customer Enrollment



2.7.3.3.4 Benefit Cost Analysis

Once participation rates and estimated load impacts are applied to the eligible customers and end-uses, the next step is to monetize the calculated load reduction and compare these benefits to the costs of acquiring them. As discussed in the previous sections, we will take care to align the participation rate assumptions with the administrative and incentive costs required to achieve those levels of enrollment. Recurring software and application programming interface fees from connected device vendors represent a growing share of program costs in most jurisdictions. The NMR team evaluates and performs benefit-cost analysis on enough programs across the country that we are confident in our ability to quantify the full range of costs an EDC would incur to deliver these programs.

The NMR team will perform this cost-effectiveness analysis in accordance with the procedures set forth in the 2026 TRC Order. The handling of participant incentive payments is a key assumption for benefit-cost analysis of peak demand reduction programs. In prior phases, the PUC has directed EDCs to treat 75% of DR incentives as a TRC cost. We believe this is a sound policy assumption but will ask TUS staff to confirm for Phase V early in the modeling process.

The avoided cost of T&D capacity analysis described in Section 2.4.2.1 will play an important role in the value of peak demand reduction strategies for Phase V. If that analysis determines that avoided T&D value is concentrated in pockets where large capital projects can be avoided or deferred through peak demand reduction, we would suggest exploring whether the concept of “non-wire alternatives” fits in the Act 129 Framework. For example, could the Phase V Implementation Order direct each EDC to identify a planned capital upgrade and avoid or defer it through targeted peak demand reduction program(s)?

2.7.3.4 Reporting

The NMR team understands that transparency of assumptions, inputs, and methodology, along with clear presentation of results, are of paramount importance to TUS staff. With DR, there are several groups of active stakeholders who want to be kept abreast of study progress and dissect the study results once complete. From previous experience on the SWE team, the NMR team members have learned the right level of detail to provide in presentations and reports. We plan to work closely with the TUS staff to develop a draft report with an outline and format that is structured to provide clear and actionable insights for TUS staff. The Peak Demand Reduction Potential Study will also provide critical insights to the EDCs on targeting DR resources that will aid in cost-effective delivery of DR programs in a potential Phase V. Our intention is to produce a report that will be a valuable program planning tool for the EDCs and that will act as a technical guide for regulators.

The DR potential study report will include an executive summary with high-level findings and a detailed volume that lays out the methodology and results in a more technical and granular manner. Table 17 presents our schedule for completing the DR potential study.

Table 17: Schedule for DR Potential Study

Milestone	Estimated Date
Program design	October 2023 – December 2023
EDC data request and independent data collection	November 2023 – April 2024
Establish the baseline and disaggregate the forecast	January 2024 – April 2024
Define program dispatch rules and scenarios	October 2023 – April 2024
Identify technologies of interest	January 2024 – April 2024
Estimate participation rates and load impacts	March 2024 – May 2024
Benefit cost analysis	May 2024 – August 2024
Reporting	July 2024 – January 2025
Phase V Implementation Order Support	January 2025 – June 2025

2.8 MEETINGS AND OTHER REQUIREMENTS

The NMR team will participate in a variety of meetings needed to perform the SWE duties, meet the needs of the PUC, and perform other tasks required by the PUC. As an example, the NMR team will participate in the following meetings:

- Weekly or biweekly conference calls with SWE team leaders and TUS staff. Greg Clendenning and NMR staff will prepare the agenda and provide minutes and action items for each call. The NMR team proposes scheduling the Phase IV weekly call to immediately follow the Phase III weekly call, if desired by TUS staff, during the overlap between the Phase III and Phase IV SWE. We believe this would be the most efficient use of time for both TUS staff and the SWE.
- Occasional Act 129 stakeholder meetings in Harrisburg, or held virtually as necessary. The NMR team will be prepared to lead meetings that address study findings and updates, such as updates to the TRM or TRC, or findings from the baseline and market

potential studies. We will prepare PowerPoint presentations and be prepared to respond to PUC and stakeholder questions.

- Occasional PEG meetings with TUS staff and EDC representatives (in person or virtual if necessary). The NMR team will prepare an agenda for the meeting and prepare PowerPoint presentations as needed. In addition, the team will provide minutes and action items from the meetings.
- Annual in-person meeting (or virtual if necessary) with TUS staff, Commissioners' assistants, and perhaps Commissioners. The purpose of the annual meeting is to discuss the SWE's performance and prioritize activities for the upcoming year. The NMR team will prepare an agenda and PowerPoint presentation for the meeting.
- Occasional in-person or conference call meetings with TUS staff and/or the Project Officer. The NMR team will be prepared to discuss topics such as a project budget review and the status of special research projects.
- Occasional in-person or conference call meetings and special working group sessions with EDC Representatives and EM&V Consultants. The NMR team will be prepared to lead meetings to discuss topics such as the development of custom measure protocols, evaluation findings, audit planning, or feedback. The NMR team will prepare an agenda for the meetings and prepare PowerPoint presentations as needed. In addition, the team will provide minutes and action items from the meetings. During Phase III, the SWE incorporated quarterly check-in calls with the EDCs and their evaluators. These regular check-ins allowed the SWE and EDCs to efficiently coordinate on audit activities and address SWE questions and concerns on EDC EM&V activities. It also allowed the SWE and EDCs to coordinate on EDC data and inputs needed for the statewide SWE studies. The NMR team proposes continuing with these quarterly check-ins.

In addition to meetings, the NMR team will be prepared to perform other tasks required by the PUC. Examples of other possible tasks include the following:

- Design and develop materials needed for PUC discussions, workshops, and reports
- Provide Act 129 Phase IV data for use in analysis
- Provide Act 129 Phase IV data for use in coordinated state agency projects that may benefit Act 129
- Provide analysis of data from prior Act 129 phases.

2.9 REPORTS AND PROGRAM CONTROL

As noted in Section 2.5.3, the NMR team will provide semi-annual and annual reports on EE&C Program performance and a final five-year assessment report to the PUC, as detailed in Section III-5 of the RFP.

The annual reports and five-year report will provide a comprehensive review of the EDCs' programs. Because verified gross savings (e.g., ex-post) are the estimates used for compliance and cost-effectiveness calculations in Pennsylvania, the reports will focus on verified or ex-post savings achieved by the EDCs' programs. The reports will include a detailed review of the EDC independent evaluation contractors' findings, as well as evaluation methodologies and sampling strategies. In addition, the reports will include the following review and analyses:

- An analysis of each EDC's expenditures at the portfolio, sector, and program levels, including a comparison of actual expenditures to the projections in approved EE&C Plans
- An analysis of each EDC's protocol for measurement and verification of energy and peak demand savings attributable to its plan, in accordance with the PUC-adopted TRM and approved custom measures
- An analysis of the cost-effectiveness of each EDC's expenditures in accordance with the PUC-adopted TRC Test Order
- A review of the TRM information and savings values, with suggestions for possible revisions and additions
- A review of the TRC Test Order and suggestions for possible revisions and additions
- A review of any proposed revision and updates to EDC plans
- An analysis of the top offerings responsible for the majority of verified gross energy (MWh) and peak demand (MW) savings

The NMR team will provide annual reports for the years 2022 through 2025, and will provide the five-year report by November 30, 2026. For example, the SWE Annual Report that will be delivered November 30, 2022, will report on PY13 (which runs from June 1, 2021 through May 31, 2022). The five-year report will also include the content for the PY17 (the 2025/2026 program year). Table 18 provides a timeline of the key dates in the process of developing the annual and five-year reports. As noted in Section 2.3.2, the Phase IV annual reporting schedule is accelerated compared to Phase III. The NMR team recommends continuing with the Phase III practice of conducting reviews of as much of the EDC evaluator's verified savings calculations ahead of the submission of the EDC Annual Reports as possible. This will allow for an efficient review of the EDC Annual Reports and efficient writing of the draft SWE Annual Report in the allotted three-week period.

Table 18: Timeline for Annual Reports and Five-year Report

Milestone	Date
EDCs submit Final Annual Reports to PUC	September 30
SWE provides Draft Annual Report to EDCs	October 19
EDC review and factual corrections provided to SWE	October 26
SWE submits updated Annual Report to PUC	November 2
PUC provides comments on Annual Report to SWE	November 16
SWE provides Final Annual Report to PUC	November 30

The NMR team will provide semi-annual reports by February 28 of each year from 2022 through 2026. The SWE Semi-annual Report will be based on the EDCs' Semi-annual Reports, which will be submitted to the PUC on January 15 of each year from 2022 through 2026. For example, the SWE Semi-annual Report delivered February 28, 2022, will report on the first two quarters of PY13 (June 1, 2021 through November 30, 2021). The SWE Semi-annual Report will include a review of as much evaluated savings as possible for the program year. If evaluated savings are not available, the Update Report will include as much claimed savings to date as possible. The Update Reports will provide updates on energy (MWh) and demand (MW) savings, impact evaluations, and cost-effectiveness of EE&C programs by EDC. The reports will also contain an analysis of program year performance and phase-to-date information, as appropriate.

2.9.1 Professional Editing of Reports

The NMR team recognizes that professionally edited, cohesive, and concise reports are an important aspect of all SWE reporting activities. Our reports will be cohesive, with sections from multiple authors weaved together to speak in a unified voice and tone. The NMR team will deliver reports that focus on summary findings and recommendations, with detailed findings, methodological approaches, and technical discussions reported in appendices. Brittany Harris of NMR, a professional editor, will serve as the editor for all SWE reports and studies to ensure high-quality and professional reports.

2.9.2 EDC Report Templates

Developing the templates that the EDCs and their evaluation contractors will use to file the semi-annual and final annual reports is an important responsibility of the SWE team. The intent of standardized EDC report templates is simple: by requesting the exact same information in the same set of tables and report sections, they allow the SWE to compile data across EDCs in an efficient manner. A well-designed report template saves substantial time on the back end, obviating the need to assemble disparate information into a common set of metrics. It also minimizes the number of judgement calls and follow-up inquiries to the EDCs.

The NMR team's philosophy for this task is to put in the work upfront and issue a template that works for all five years of the phase so that the reports for each program year utilize a common outline. For example, in the PY13 reports, there will be no difference between "program year to date" and "phase to date" totals because PY13 is the first year of the phase. Even so, we believe a good template should anticipate all reporting quantities whether they are needed immediately or not. We have learned that a template needs to be specific and precise with respect to the definitions of requested elements. Specificity reduces the chances of EDCs interpreting template

components differently and providing inconsistent information. We believe the Phase III templates are a good starting point, but we offer some initial recommended changes for Phase IV. For example, DR content can be removed from both report templates.

The EDCs' semi-annual reports should be short and direct and provide readers with an easy to digest update on program delivery. Because these reports occur mid-year before evaluation findings are available, they should focus on the following:

- Documenting the amount of carryover from Phase III to Phase IV
- Clearly laying out the Phase IV compliance targets for the EDC and progress towards those targets:
  - Verified gross MWh and MW from previous program years plus the reported gross savings from the current program year
  - A breakdown of MWh and MW savings acquired by program
- Summarizing expenditures by program with the more detailed cost categories called for in the Phase IV EE&C Plan template[21]

The EDCs' final annual reports are far more detailed than the semi-annual reports. These reports are where all EM&V activities are described and the findings are summarized. These reports include tables for gross verified savings and net verified savings, as well as process evaluation and TRC reporting. We anticipate that several EDCs will utilize a sector-based definition of "program" in their Phase IV EE&C Plans. We will develop the template in such a way that evaluation results and TRC metrics are required at the sub-program level so that stakeholders have visibility into the performance of different offerings.

2.10 OTHER REQUIREMENTS

2.10.1 Testimony

The NMR team is prepared to support, orally and in writing, our professional findings and conclusions, both for internal discussions and for on-the-record proceedings. The NMR team has prepared and filed such testimony and provided testimony in other jurisdictions, such as Massachusetts, New York, Illinois, Vermont, and Michigan, and is prepared to do so on behalf of the TUS staff.

2.10.2 Disaster Recovery / Long Term Storage of Records

As detailed in Section 2.5.2, project data will be stored on a secure SharePoint Online server and accessed only as necessary by staff working on the project. NMR team members will download copies of the data to their local encrypted computers or network servers for analysis. Work files will be stored on a secure SharePoint Online server and on local encrypted computers. The secure SharePoint server is backed up continuously to secure, encrypted Azure storage

[21] https://www.puc.pa.gov/PCDOCS/1676672.DOCX

accounts. Locally encrypted computers are backed up continuously with Carbonite, a cloud based secure backup software and storage system.

The NMR team understands that the work on this project must be maintained in a secure manner for a period of at least ten years and be available within a reasonable timeframe if required by TUS. Prior to destruction of such materials, NMR will notify the Commission to allow the Commission to take custody of such materials, if it so chooses.

2.10.3 Disclosure of Potential Conflicts of Interest

NMR Group, Inc.

NMR conducted two future-oriented market research projects for ComEd in 2018 and 2019. ComEd is a subsidiary of Exelon, the parent company of PECO. Neither of these projects sought to assess ComEd's program performance, but rather sought to provide direction for future program design. The first was a study that sought to describe and map the residential and commercial lighting markets in Northern Illinois, identify market trends, and explore future program and market scenarios. The second was a study to map the HVAC supply chains in Northern Illinois, explore recent and anticipated changes to those chains, and identify technological or other developments that could affect program planning. The total value of NMR's work on these two projects was about $450,000. On November 19, 2020, in reviewing the conflict of interest requirements of the Phase IV RFP, NMR realized that, according to NMR's Phase III SWE contract with the PUC, it appears that we should have received permission before taking on this work; although, to be clear, it did not involve evaluating ComEd's programs. At the time we were engaged it had not occurred to us that there was a potential conflict because we considered ComEd and PECO to be separate unrelated companies. We regret this oversight, and confirm that, should the NMR team be selected for the Phase IV SWE work, NMR, DSA, BrightLine, and Optimal will review the affiliations of any entities whose RFPs any of us are considering responding to; if any of those parent companies are also affiliates of any of the Pennsylvania EDCs, we will of course ask permission from the PUC before bidding on the work. We will certainly not consider any work for any of the Pennsylvania EDCs, and never have considered such work since being awarded the SWE Phase III contract. Further, we confirm and warrant that the work for ComEd has not affected our objectivity in evaluating the performance of PECO's Phase III energy-efficiency programs.

Demand Side Analytics

Demand Side Analytics has not performed any evaluation or conservation services for the Pennsylvania EDCs or their affiliates since inception in 2016 and has no plans to bid on such services for Phase IV of Act 129.

Brightline Group

BrightLine Group, as a subcontractor to Apex Analytics, is developing efficiency measure parameters in ComEd's 2022 – 2025 energy-efficiency plan in 2020. ComEd is a subsidiary of Exelon, the parent company of PECO. Brightline's work includes research and gathering of pertinent measure data to align the plan with the Illinois TRM. Data sources include the Illinois TRM, program reporting assumptions, and emerging technology program. This support work for ComEd concludes in 2020. We will certainly not consider any work for any of the Pennsylvania

EDCs, and never have considered such work since being awarded the SWE Phase III contract. Further, we confirm and warrant that the work for ComEd has not affected our objectivity in evaluating the performance of PECO's Phase III energy-efficiency programs.

Optimal Energy, Inc.

Optimal Energy has no conflicts of interest to completing the scope of work issued by the Pennsylvania PUC Bureau of TUS in RFP Number PUC RFP 2020-2 for Act 129 SWE. Should Optimal Energy see any potential conflict of interest arise, it will disclose immediately to TUS staff.

2.10.4 Objections and Additions to Contract Terms and Conditions

NMR Group, Inc., respectfully submits the following edits upon award of the Contract in order to satisfy state law for our one of our subcontractors (Optimal Energy).

~~Deletions in blue and strikethrough~~

Additions in red and underlined

O. Insurance

> The insurance called for above is subject to the normal limitations and exclusions applying to each type of insurance; provided, however, that first dollar coverage shall be provided for each type. The Commission, the Contracting Entity, and all the EDCs (each listed individually by name) will be named as an additional insured on the policies referred to in 2, 3, 4, and 5 above and such insurance shall be endorsed to require the insurer to furnish the Commission, the Contracting Entity and the EDCs with ~~ten (10) days~~ *fifteen (15) days (30 days for nonpayment)* written notice prior to the effective date of any cancellation of insurance.

2.11 Time Estimates and Schedules

2.11.1 Time Estimates

Table 19 provides a summary for all staff for all years and a total for the Phase.

Table 19: Staff Hours by Year and Total

Firm	Category	Name	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
NMR	Director	Clendenning	662	578	638	642	467	256	3,243
NMR	Director	Patil	214	228	262	252	168	78	1,202
NMR	Director	Tyler	20	132	54	4	4	2	216
NMR	Snr Quant Analyst / Snr Proj. Mgr	Ucar	26	30	278	18	5	0	357
NMR	Snr Quant Analyst / Snr Proj. Mgr	O'Donnell	50	85	85	85	85	60	450
NMR	Snr Quant Analyst / Snr Proj. Mgr	Russell	50	90	90	90	90	50	460
NMR	Project Manager, NMR	Stern	222	523	424	165	135	65	1,534
NMR	Project Manager, NMR	Pon	0	15	15	15	15	8	68
NMR	Project Manager, NMR	Meek	30	120	120	120	120	95	605
NMR	Project Manager, NMR	von Trapp	0	40	0	0	0	0	40
NMR	Research Analyst II	Abraham	110	225	225	175	135	40	910
NMR	Research Analyst I	Manning	90	333	342	190	150	90	1,195
NMR	Research Analyst I	Woundy	80	345	632	150	120	80	1,407
NMR	Research Analyst I	Ricardo	130	360	280	200	205	108	1,283
NMR	Research Analyst I	Pierce	100	400	290	130	110	70	1,100
NMR	Research Associate II	Steis	80	482	540	180	175	100	1,557
NMR	Research Associate II	McGowan	20	392	120	40	30	20	622
NMR	Research Associate II	Smaglia	30	40	40	40	30	20	200
NMR	Research Associate I	Pratt	50	276	110	80	60	40	616
NMR	Research Associate I	Kodua	100	1230	390	210	220	140	2,290
NMR	Research Associate I	Nathin	60	1130	190	100	120	60	1,660
NMR	Research Associate I	NMR-Associate I	60	1305	220	220	220	100	2,125
NMR	Editor and Administrative Assistant	Harris	30	76	162	120	66	20	474
NMR	Editor and Administrative Assistant	Whitford	132	132	112	104	60	30	570
NMR	Editor and Administrative Assistant	Hoefgen-Harvey	40	30	30	30	30	10	170
NMR	Field Technician / Baseline Recruiter	TBD	0	2,614	198	0	0	0	2,812

Firm	Category	Name	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
DSA	Partner	Smith	496	563	996	566	351	151	3,123
DSA	Partner	Bode	66	35	313	84	10	0	508
DSA	Partner	Lemarchand	20	332	968	82	34	24	1,460
DSA	Principal, DSA	Ciccone	80	112	176	96	96	56	616
DSA	Consultant, DSA	Bieler	0	0	416	80	0	0	496
DSA	Consultant, DSA	Morris	356	323	723	486	265	120	2,273
DSA	Senior Quantitative Analyst	Noll	10	95	423	183	63	58	832
DSA	Senior Quantitative Analyst	Totten	65	366	576	288	134	89	1,518
DSA	Senior Quantitative Analyst	Hylant	0	0	160	0	0	0	160
DSA	Quantitative Analyst	Burley	35	340	280	144	114	89	1,002
DSA	Quantitative Analyst	McBride	20	40	40	35	35	20	190
DSA	Quantitative Analyst	Horner	140	100	80	80	80	40	520
DSA	Web Developer / Admin Assist.	Klos	0	80	0	0	0	0	80
DSA	Web Developer / Admin Assist.	Jones	0	30	12.51	0	0	0	43
BLG	Principal	Burns	282	320	601	359	170	75	1,807
BLG	Principal	Roy	5	8	8	8	8	4	41
BLG	Managing Consultant	Johnson	292	364	537	447	299	168	2,107
BLG	Managing Consultant	Hodgson	56	96	160	160	84	50	606
BLG	Managing Consultant	Wobus	42	116	196	116	112	50	632
BLG	Project Analyst	Penzkover	80	168	168	168	140	60	784
BLG	Engineer	Patterson	206	386	466	444	340	130	1,972
Optimal	Partner / Managing Consultant	Mosenthal	9	40	192	134	20	0	395
Optimal	Partner / Managing Consultant	Schuur	0	0	50	60	10	0	120
Optimal	Project Mgr / Snr Consultant	Ross	88	126	616	326	101	27	1,284
Optimal	Project Mgr / Snr Consultant	Socks	60	148	558	308	103	25	1,202
Optimal	Project Mgr / Snr Consultant	McDonald	0	0	150	100	10	0	260
Optimal	Consultant	Johnson	0	0	300	170	0	0	470
Optimal	Consultant	Jacobs	0	0	300	170	0	0	470
Optimal	Analyst	Keating	0	0	100	25	0	0	125
Optimal	Analyst	Caesar	20	90	275	180	90	40	695
Total Hours			**4,814**	**15,489**	**15,688**	**8,569**	**5,489**	**2,818**	**52,957**

2.11.2 Project Schedules

In this section, we present an overview of the proposed schedules for the annual audit activities, the statewide studies, and for major activities for Phase IV (such as PUC orders and stakeholder meetings).

Figure 21 presents the schedule for audit activities, using PY13 as an example.

Figure 21: Schedule of Audit Activities, PY13

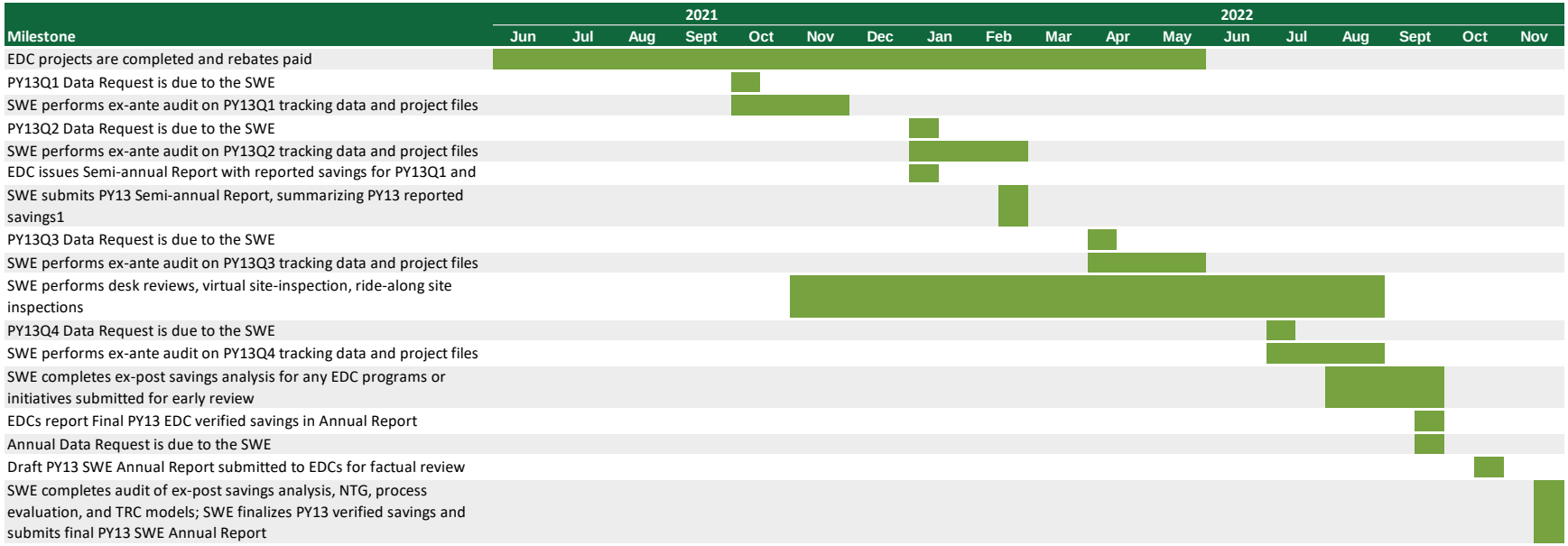


Figure 22 presents the schedule for the residential and C&I baseline studies.

Figure 22: Baseline Studies Schedule

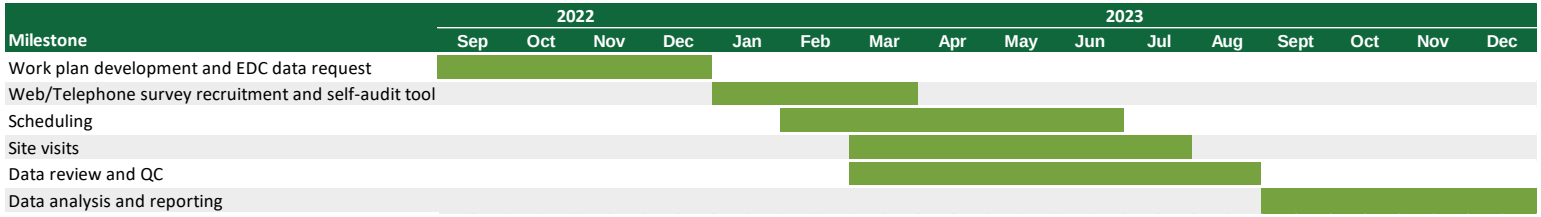


Figure 23 presents the schedule for the energy-efficiency and DR potential studies.

Figure 23: Potential Studies Schedule

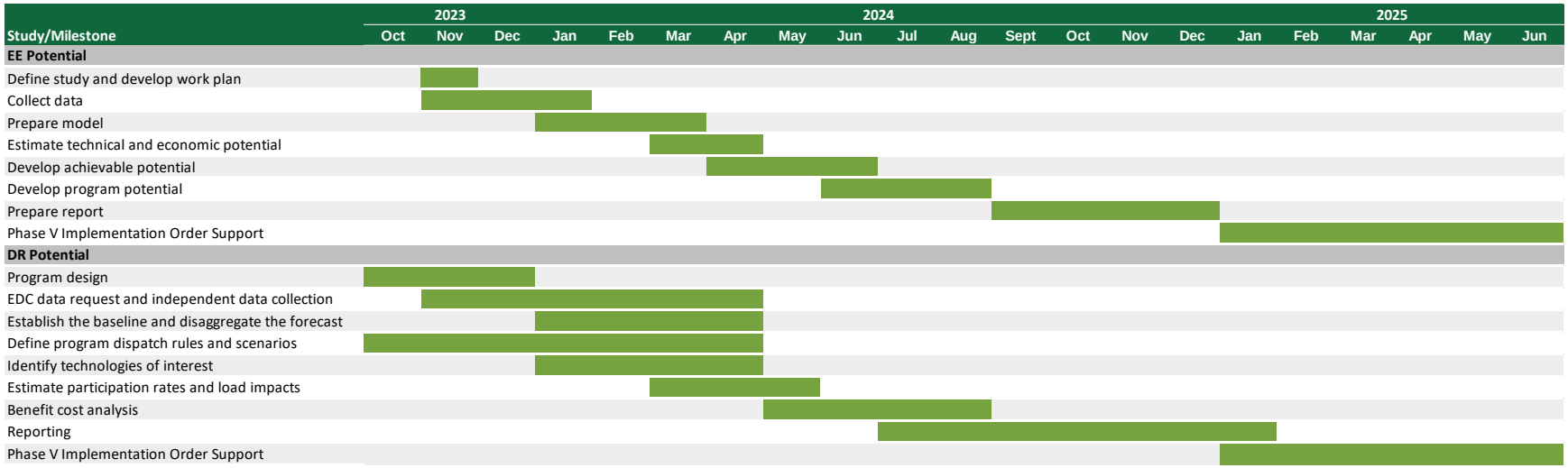
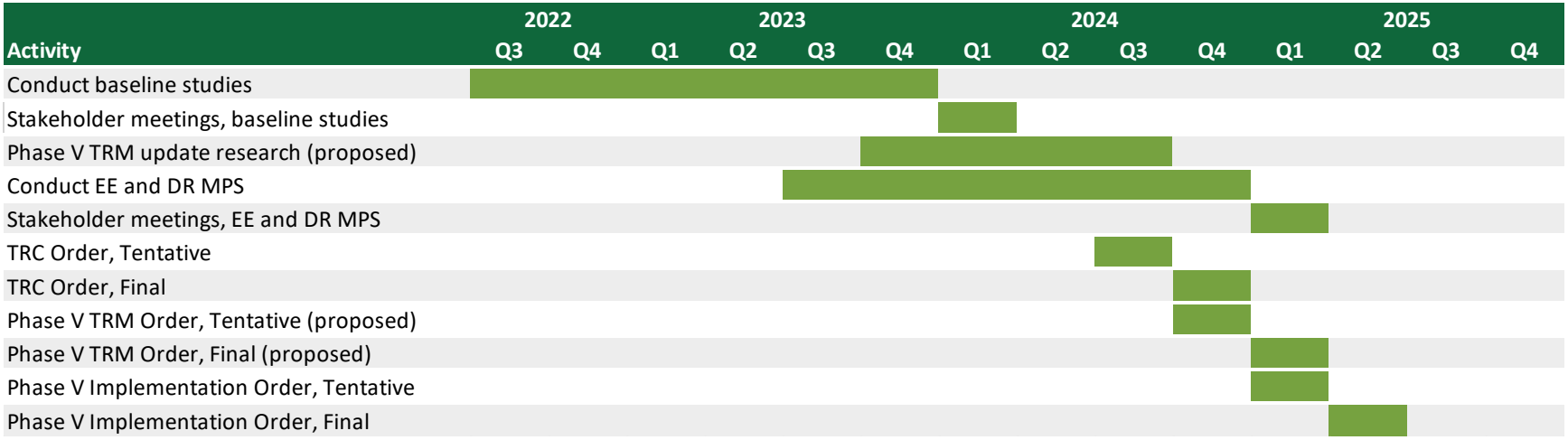
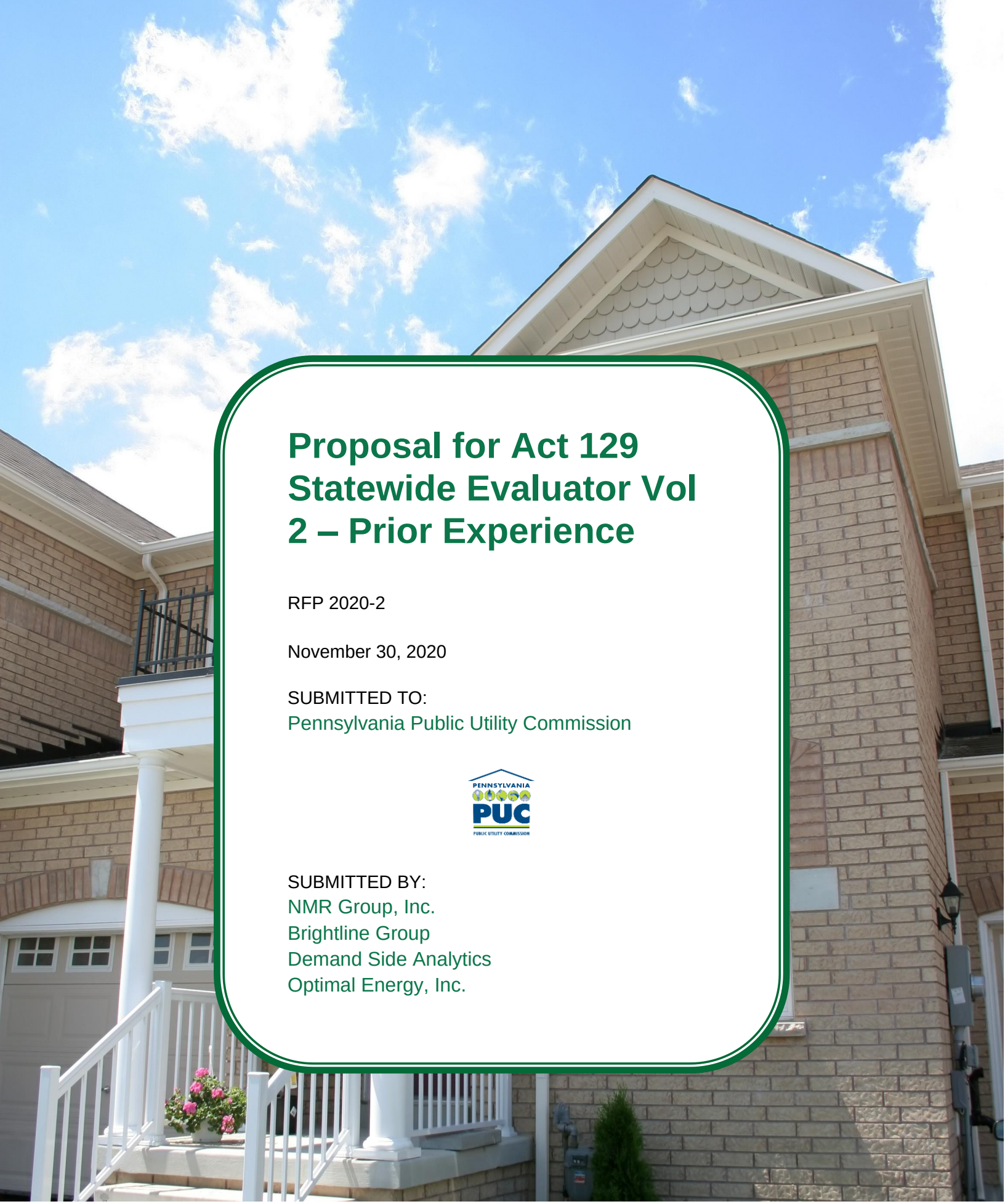


Figure 24 presents the tentative schedule for some of the major activities – outside of the annual auditing and reporting – during Phase IV, including stakeholder meetings and Commission orders. The NMR team understands that the schedule for the Phase V TRM update will be determined by the Commission at a later date, but that the Commission anticipates the Phase V TRM will be finalized at least one year in advance of June 1, 2026 (so that the EDCs can prepare Phase V plans based on known Phase V TRM values). The schedule for the Phase V TRM activities in Figure 24 are tentative and will be adjusted to the schedule the Commission determines.

Figure 24: Tentative Schedule of Major Phase IV Activities





Proposal for Act 129 Statewide Evaluator Vol 2 – Prior Experience

RFP 2020-2

November 30, 2020

SUBMITTED TO:
Pennsylvania Public Utility Commission

SUBMITTED BY:
NMR Group, Inc.
Brightline Group
Demand Side Analytics
Optimal Energy, Inc.

Table of Contents

Section 1 Prior Experience

NMR is the prime contractor and will be responsible for overall management of the project. NMR's subcontractors on this project are Demand Side Analytics, BrightLine Group, and Optimal Energy. The NMR team is uniquely qualified to undertake the Act 129 Statewide Evaluator project for the Pennsylvania Public Utility Commission (PUC). In this role during Phase III, the NMR team has conducted multiple residential and commercial baseline studies, market assessment studies, Pennsylvania Technical Reference Manual (TRM) development and updates, cost-effectiveness testing, and information management, as well as other types of activities required of the Act 129 Statewide Evaluator.

1.1 NMR Group, Inc.

NMR was founded in 2001 with a mission of providing independent, high-quality evaluation and market assessment services to administrators and regulators of energy-efficiency and renewable energy programs. NMR measures the impacts of energy-efficiency and renewable energy programs and delivers strategic guidance for improving program design and delivery. We provide clients with research-based information and insights to help them focus program efforts based on prevailing market structures and conditions.

NMR has led the Statewide Evaluator Team (SWE) for the Pennsylvania PUC since 2016. In addition, since 2018, we have led the team conducting annual impact, process, and net-to-gross (NTG) evaluations of the DC Sustainable Energy Utility's (DCSEU) portfolio of energy-efficiency and renewable energy programs.

NMR also serves as the prime contractor for multiple long-term impact and process evaluation studies. For example, NMR has worked extensively for the Massachusetts Program Administrators (PAs). This work includes serving as lead evaluator for NTG, market effects, codes and standards, non-energy impacts, and top-down modeling for cross-cutting programs and measures; serving as lead evaluator for comprehensive residential new construction (RNC) and residential lighting evaluations; serving as the lead evaluator for commercial & industrial process evaluations; and serving as a subcontractor (to DNV GL) for commercial & industrial impact evaluations. Other examples of NMR's work include serving as the prime contractor for multiple National Grid impact and process studies in New York, including an impact and process evaluation of the Small Business Service (SBS) Program.

NMR has led three residential baseline studies (both existing and new homes) for the Public Service Department in Vermont, and in 2020 began working on a fourth. In addition, the NMR team has led six new construction baseline studies in Massachusetts, two in Connecticut, and two in Rhode Island over the past ten years. We have also undertaken existing residential baseline studies in Connecticut, Maine, Rhode Island, and New Hampshire in recent years. NMR has recently begun work on a baseline study of existing homes for the New Jersey Board of Public Utilities. The current Vermont and New Jersey baseline studies both involve the use of self-audit tools that either supplement or replace site visits for collecting data.

Numerous NMR staff members hold one or more building science certifications, as outlined in the bullets below. The knowledge, skills, and experience we have gained through our prior work and training provide the NMR team with the experience necessary to accurately and efficiently characterize Pennsylvania's residential housing stock.

- 9 RESNET Certified Home Energy Rating System (HERS) raters
- 2 PHIUS Certified Passive House Consultants (CPHC)
- 1 Professional Engineer
- 1 DOE Pumping System Assessment Tool Specialist
- 1 Certified Energy Manager (CEM)

1.1.1 Representative Projects

Statewide Evaluator, Pennsylvania PUC (2016-present). NMR is the prime contractor leading the SWE team for Pennsylvania's energy-efficiency and demand response programs for Phase III of Act 129 Demand Side Management (DSM) programs (2016-2021). In the role, NMR focuses on evaluating the performance of the Energy Efficiency and Conservation (EE&C) program portfolios of the seven largest Electric Distribution Companies (EDCs). Core responsibilities of the SWE include conducting annual evaluations of the EDC's EE&C portfolios, which involves auditing and reviewing the evaluation methods and findings of each program. The SWE then advises the PUC on whether to adopt the claimed savings toward each EDC's statutory reduction targets or request revisions to the impact estimates. Another core SWE responsibility is an analysis of the cost-effectiveness of the EE&C portfolios. NMR is the technical lead for auditing the residential and low-income programs as well as all process and NTG evaluations across all sectors. To meet critical reporting deadlines, the SWE team conducts as many verification activities in parallel with the EDC evaluator as possible, including ride-along site visits of selected commercial and industrial (C&I) sites; engineering desk reviews of complex sites; and analysis and reviews of residential programs.

Another responsibility of the SWE team is to create an Evaluation Framework to guide the utility evaluation, measurement, and verification (EM&V) contractors in the development of data collection and sampling protocols and the proper use of TRM. As part of the framework, the SWE team created a menu of approaches, depending on size and type of program, for verifying gross and net impacts and producing process recommendations. The SWE also develops and maintains the TRM.

The SWE also conducts independent studies for the PUC. These have included statewide baseline studies (residential and non-residential), which inform the statewide market potential study (MPS) and updates to the Pennsylvania TRM. NMR was the technical lead for the residential statewide baseline study, which characterized the market and assessed equipment saturation and energy-efficiency levels. The study objectives required a complex sample design

that considered different types of dwellings and equipment arrangements and allowed for diagnostic testing. With experience conducting baseline studies in multiple states, NMR developed sampling, recruiting, site-visit, analysis, and reporting protocols to successfully complete the study.

Other work of the SWE includes providing technical support to the PUC in developing the Total Resource Cost (TRC) test order, which provides guidance to the EDCs and EDC evaluators in analyzing the costs and benefits of the EDC EE&C plans, conducting independent statewide MPS for both energy-efficiency and demand response, and providing technical support to the PUC in developing the Phase IV Implementation Order.

Evaluation of the DC Sustainable Energy Utility Portfolio (DCSEU), DC Department of Energy and Environment (2018-present). NMR is leading a team to conduct a multi-year impact and process evaluation of the full portfolio of energy-efficiency and renewable energy programs offered by the DCSEU. These programs target both the commercial sector and the multifamily sector with an emphasis on the low-income market. The annual impact evaluation entails desk reviews and on-site visits to verify gross savings as well as telephone surveys with participating customers to estimate net savings. The annual process evaluation includes in-depth telephone interviews with program managers and trade allies as well as telephone surveys with participating customers. The annual evaluation also calculates cost-effectiveness at the program level and portfolio level and documents DCSEU progress towards pre-established performance benchmarks. In addition, NMR estimates both annual and lifetime reductions in greenhouse gas emissions resulting from the DCSEU programs. The results of the evaluations also inform updates to the TRM.

Report: Evaluation of DC Sustainable Energy Utility FY2017 Programs.

Baseline Studies – Single- and Multifamily Existing and New Homes, Various Clients (2009-present). NMR has led residential baseline studies throughout New England for well over a decade. These studies have encompassed new and existing homes as well as single-family and multifamily homes. NMR completed the most recent RNC baseline study in Massachusetts in 2019, assessing baseline characteristics and code compliance rates for new homes built under the 2015 IECC and the updated Massachusetts stretch code. NMR is currently conducting a baseline study in Vermont of new and existing single-family and multifamily homes that uses a virtual audit tool designed to improve the accuracy of web-based survey data collection on the characteristics of homes and household equipment. We recently started on an additional baseline study in New Jersey that will also make use of a virtual audit tool.

Report: 2019 MA Single-Family New Construction Compliance/Baseline Study

Report: 2018 VT Multifamily Baseline Study – New and Existing Homes

Report: 2018 VT Single-Family Existing Homes Baseline Study

Report: 2017 MA Multifamily High-Rise New Construction Baseline Study

Residential Appliance Saturation Studies (RASS), Connecticut Energy Efficiency Board (EEB) (2019) and National Grid Rhode Island (2018). NMR has conducted numerous RASS studies, which set baselines for appliances, consumer electronics, and heating, ventilation, and air conditioning (HVAC) and other mechanical in homes. NMR recently completed a RASS study in Connecticut that involved a web survey of 2,000 households to learn about the equipment in their homes. NMR followed the web surveys with 200+ onsite verification visits to confirm the accuracy of web survey responses. The study also included a lighting socket saturation study, a lighting NTG study, and a heat pump water heater technical feasibility study.

Similarly, NMR led a RASS study in Rhode Island that dovetailed with the Connecticut study. The Rhode Island RASS included about 500 customer web surveys and 75 on-site verification visits. The study also included a mini-split heat pump technical feasibility study. NMR has also led multiple baseline studies of new homes in Rhode Island (the most recent in 2018), using its team of certified HERS raters to develop HERS ratings for each home and perform detailed analyses of homes' performance relative to the requirements of the energy code.

Report: 2018 CT Single- and Multifamily RASS

Report: 2018 RI Single- and Multifamily RASS

Business Programs NTG and Process Evaluation, Independent Electric System Operator (IESO) (2017-present). Under both the Conservation First Framework (2017-2019) and Interim Framework (2019-2021), NMR, as a subcontractor, led the NTG and process evaluations for the Independent Electric System Operator's (Ontario) portfolio of business programs. For all programs, NMR conducted in-depth interviews with program staff and program partners/contractors, as well as surveys of participants, local distribution companies, and other relevant groups. Evaluation tasks include designing survey instruments and NTG algorithms, fielding process surveys and data collection activities, and analyzing and reporting on process and NTG components of each program-specific evaluation. NMR has provided direction and recommendations for improving program design and delivery.

Small Business Direct Install Impact Evaluation, National Grid New York (2015-present). NMR has conducted impact evaluations of the National Grid New York Small Business Service Program since 2015. NMR conducted impact evaluations of the 2016 and 2017 program years and is currently engaged in a real-time impact of the 2018 program. The 2018 impact evaluation is being conducted in coordination with program vendors to further reduce the lag between implementation and evaluation results, and to provide an opportunity to review current vendor practices. As a test case for this approach, NMR worked with a 2017 vendor to conduct an impact methods evaluation that included a comparison of several methods of estimating savings: lighting loggers, advanced sub-circuit metering, disaggregation advanced metering infrastructure (AMI) data, and billing analysis. NMR worked closely with the program vendor to test measurement and verification (M&V) 2.0 techniques and identify opportunities for coordination between implementation and evaluation.

Paper: Into the Great Wide Open: A Comparison of M&V 2.0

Appliance Recycling Impact, NTG, and Process Evaluation, Massachusetts PAs (2018, present). NMR completed an impact, NTG, and process evaluation of the 2017 Massachusetts Appliance Recycling program, which pays participants incentives to remove secondary refrigerators and stand-alone freezers. The impact evaluation drew from a combination of program tracking data and web surveys of 365 program participants to provide estimates of gross, adjusted gross, and net energy savings. NMR used the program tracking data to describe the characteristics of units recycled in the program, including their age, year of manufacture, size, and door configuration. The web survey provided estimates of partial-use and free-ridership, confirmed the primary or secondary status of refrigerators, and determined whether the unit had been used in unconditioned spaces. NMR applied these data to algorithms developed by the Uniform Methods Protocol to estimate gross and net savings. The results were used to update the Massachusetts TRM. The surveys also asked about customer satisfaction with the program and explored participation by key demographics, including age and income. NMR updated gross and net savings by applying the 2017 study results to units recycled in 2018. NMR is currently conducting a survey to establish NTG estimates for dehumidifiers and update them for refrigerators and freezers.

Report: Appliance Recycling Report

Residential New Construction Incremental Cost Study, Massachusetts PAs (2018). NMR conducted a study to assess the incremental costs associated with participating in the Massachusetts PAs' RNC program. The study assessed incremental costs at the measure level on a dollar-per-square-foot basis for single-family, low-rise multifamily, and high-rise multifamily new construction. NMR created measure-level templates that compared baseline new construction practices to those typically seen in housing units that participated in the RNC program. NMR recruited contractors who were actively engaged in the RNC market to assess the costs of baseline measure-level efficiencies and the measure-level efficiencies typically seen in RNC program participant housing units. The contractor assessments were used to calculate the incremental costs associated with participating in the RNC program.

Report: Massachusetts Residential New Construction Incremental Cost Study

TRM & Tools Development, Vermont Gas Systems (VGS) (Present). NMR is in the process of developing TRM measures for VGS that include wood stoves, commercial and residential thermostats, low infrared heaters, pipe wraps, and demand control ventilation. NMR is also modifying algorithms for existing TRM measures to reflect findings from recent evaluations. The approach involves researching similar TRMs in other jurisdictions, reviewing the inputs to the algorithms that are specific to Vermont, and mining VGS' data to supplement the inputs to the TRM algorithms. NMR is additionally developing analysis tools for the new TRM measures and modifying analysis tools for four existing measures. The tools will provide a standardized layout, transparent calculations, peak savings calculations, and appropriate information that will aid future evaluations.

Products Evaluation of In-Service and Short-Term Retention Rates, Massachusetts PAs (2018, present). To assist the PAs in updating their TRMs and benefit cost ratio models, NMR fielded a web survey of program participants to establish current estimates of in-service rates (ISR) and short-term retention rates for a variety of products distributed by the Massachusetts PAs. Products included advanced power strips (APS) and various home appliances and showerheads. The results were based on two different populations of program participants: (1) those who purchased products via a program-sponsored online store or using a mail-in (or online-submitted) rebate, and (2) those who received Tier 1 APS through a direct install program. NMR benchmarked the survey results to ISRs in other jurisdictions. NMR is currently updating the ISR and short-term persistence estimates for APS and various retail products.

Report: Products Impact Evaluation of In-Service and Short-Term Retention Rates

Renovations and Additions Market Characterization, Massachusetts PAs (2020). NMR recently completed a study to estimate the size and scope of single-family renovation and addition projects in Massachusetts. These estimates were used to develop savings potential estimates for the PAs' new renovations and additions program offering. NMR used a variety of data sources to triangulate the size of this market and to determine the scope of the projects. Specifically, the study used a combination of publicly available secondary sources (e.g., census data or regional construction activity indicators), a web survey of local contractors and handymen, and a detailed review of building permits to estimate the market size. The study then included a series of focus groups with contractors and handymen, a web survey of homeowners who have recently completed renovations or additions, in-depth interviews with HVAC contractors, and a web survey with code officials to characterize the scope of these projects. NMR used the information from the various tasks to create models that estimated the potential savings for this market.

Report: Massachusetts Renovations and Additions Study

Table 1 presents examples of NMR's prior studies, including those described above and numerous others. The table demonstrates the breadth of NMR's evaluation experience across clients, program types, and sectors.

Table 1: Examples of Prior NMR Studies

Study Name	Timing	Impact Evaluation	TRC / Cost-effectiveness	TRM	Baseline Studies	Potential Studies	Process & NTG	Portfolio & Regulatory Support
Pennsylania PUC: Act 129 Statewide Evaluator	2016-2021	●	●	●	●	●	●	●
Various Clients (CT, MA, ME, PA PUC, RI, VT): Residential Baseline Studies, Existing/New & Single/Multifamily	2009-present				●			
Connecticut EEB: Home Energy Solutions and Home Energy Solutions Income Eligible Program Impact and Process Evaluation	2016, Present	●		●			●	●
Connecticut EEB and National Grid RI: Residential Appliance Saturation Studies, Heat Pump Technical Feasility Studies	2018-2019			●	●	●	●	
Delaware DNREC: Process Evaluation of the Weatherization Assistance Program	2018-present						●	
District of Columbia DEE: Evaluation of the DC Sustainable Energy Utility Portfolio	2018-present	●	●				●	●
Independent Electric System Operator (IESO): Business Program NTG and Process Evaluation	2017-present						●	
Independent Electric System Operator (IESO): Residential and Low-Income Programs Impact and Process Evaluation	Present	●					●	
Massachusetts Program Administrators and National Grid RI: Appliance Recycling Process, Impact, and NTG Studies	2018, present	●		●			●	●
Massachusetts Program Administrators: Retail Products ISR, Short-term Persistence, and NTG Study	2018, present	●		●			●	●
Massachusetts Program Administrators: Residential New Construction Incremental Cost Study	2018		●					
Massachusetts Program Administrators: Residential New Construction NTG Study	2018			●			●	●
Massachusetts Program Administrators: Residential HVAC NTG and Market Effects Study	2018			●			●	●
Massachusetts Program Administrators: Renovations and Additions Study	2020					●	●	
National Grid NY: Behavioral Program Process and Impact Assessment	2017-present	●					●	
National Grid NY: Small Business Direct Install Impact and Process Evaluations	2015-present	●					●	
National Grid NY: Multifamily Process and Impact Evaluation	2019-present	●					●	
Vermont DPS: Commercial Building Baseline Study - Process Evaluation and Market Research	2016						●	
Vermont Gas Systems: Technical Support of Annual Savings Claims (2019-2020)	2019-2020	●						
Vermont Gas Systems: TRM Tools and Development	Present			●				

1.2 Demand Side Analytics

Demand Side Analytics (DSA) was formed in 2016 to help utilities and regulatory agencies navigate the technical, economic, and policy challenges of building a smarter and cleaner energy future. Our research focuses on impact analysis as well as predictive and causal analytics. We deliver data-driven insights into how various technologies and interventions affect the way homes and businesses use energy and how those in turn affect grid and system planning. We have a proven record for conducting high-quality, accurate, and unbiased analysis and are meticulous about ensuring that research is useful for policy decisions, operations, and implementation. Our team includes data scientists, applied statisticians, economists, public policy experts, and engineers.

1.2.1 Representative Projects

Statewide Evaluator, Pennsylvania PUC (2016-present). Since 2016, DSA has been part of the NMR-led SWE team for Pennsylvania's energy-efficiency and demand response programs for Phase III of Act 129 DSM programs (2016-2021). DSA is the technical lead for behavioral and demand response programs for the Phase III team and is responsible for development and maintenance of a statewide tracking system of program activity and savings. In 2016, DSA developed a detailed evaluation protocol for behavioral conservation programs, which is included as Section 6.1 of the Pennsylvania Evaluation Framework. This protocol details the procedures that each of the EDCs in the state is required to follow when evaluating Home Energy Report (HER) and Business Energy Report (BER) programs. In 2018, DSA performed an HER persistence study for approximately 82,000 FirstEnergy residential customers to model savings decay after HER exposure ended. The results of this persistence analysis were used to develop a TRM protocol for HERs for Phase IV.

In addition to developing HER and connected thermostat measures in the residential sector, DSA developed new residential Equivalent Full Load Hour assumptions for residential HVAC measures and led the 2021 TRM updates for the non-residential sector. In 2019, DSA led the Phase IV Demand Response Potential Study. The study included EDC-specific estimates of demand response potential and examined the costs and benefits of statewide policies to encourage the development and deployment of demand response resources. DSA staff were instrumental in developing the 2021 TRC Order and Phase IV Implementation Order.

C&I Baseline Study, Pennsylvania PUC (2018). As part of the Phase III SWE team, DSA led the analysis and reporting phases of the 2018 statewide C&I baseline study. DSA's online data collection tool was used in the field by the team for site inspections of 500 non-residential businesses across the state. DSA also set up and managed weekly data cleaning processes for follow up with site inspectors to ensure data quality across dozens of complex and interrelated data fields. While on site, inspectors also gathered willingness-to-pay data via survey questions in the data collection tool. The rich data set enabled detailed, bottom up analysis of end use, energy use intensity, and efficiency purchase behaviors across several end uses. In addition, results were provided by sector (large versus small), EDC (seven total), and about a dozen industry segments. Results of the C&I baseline study served as key inputs to the 2019 TRM update and market potential study.

Demand Response Potential Study and Integrated Resource Planning (IRP) Support, Consumers Energy (Present). DSA conducted a demand response market potential study for Consumers Energy to inform the expansion of existing program offerings and examine opportunities for new program offerings. The results of the potential study formed key inputs for Consumers Energy's 2021 IRP. Demand response potential was modeled at a granular level and expressed in a supply curve to facilitate modeling by the Consumers Energy IRP team alongside supply resources. DSA staff assessed the potential from eight program types across all customer sectors. Options included direct load control, connected thermostats, time-varying rates, and curtailment agreements. The study involved extensive analysis of peak load forecast data, hourly electricity use data, customer characteristics data, demand response marketing campaign data, program evaluation data, and weather data. DSA also developed detailed cost, marketing, and operational assumptions for each program based on Consumers Energy's historical experience and internal planning for demand response programs. In addition to developing levelized cost blocks, DSA compared the cost of achieving load reduction in each program to static benefits assumptions regarding the avoided cost of generation capacity and the avoided cost of energy.

Locational Avoided T&D Cost Study, PSEG Long Island (PSEG-LI) (2019-present). DSA prepared a locational avoided T&D cost study for PSEG-LI based on analysis of five years of 8,760 hourly supervisory control and data acquisition (SCADA) data for about 1500 distribution assets (~150 substations, ~350 substation banks, ~1000 feeders). The study quantified the value associated with an increase or decrease of kW coincident with location specific peaks. It employed methodologies that have been applied and approved by other New York utilities, namely granular, probabilistic load forecasting and deferral value estimation which quantifies the option value of reducing peak demand in specific locations in the PSEG-LI system. The study focuses on distribution and transmission avoided costs and was designed to meet numerous objectives, including, but not limited to analyzing load patterns, excess capacity, load growth rates, and the magnitude of expected infrastructure investments at a local feeder level; quantify the probability of potential need for infrastructure upgrades at specific locations; and calculate local avoided T&D costs by year and location using probabilistic methods.

Independent System Operator of New England (ISO-NE) Forward Capacity Market (FCM) Compliance Review, Efficiency Maine (2018-2020). For the last three years DSA has conducted the required annual third-party compliance review of Efficiency Maine's Measurement and Verification (M&V) plan for delivering capacity to the ISO-NE FCM. The compliance review centers on the calculation of Efficiency Maine's summer and winter demand reduction value (DRV), which exceeds 100 MW. The compliance review includes a *top-down* task which assesses the data exchange process between Efficiency Maine's tracking system and ISO-NE's system of record. DSA also conducts a *bottom-up review* which seeks to determine if the summer and winter kW impacts stored in Efficiency Maine's tracking system are calculated consistently with the applicable TRM as called for the approved M&V plan. To implement the bottom-up review DSA independently calculates demand impacts for the full catalog of prescriptive measures and compares the independent calculations with the values stored in the tracking system and passed to ISO-NE. Demand impacts from custom measures are also reviewed for reasonableness and to confirm that the appropriate realization rate applied. ISO-NE's *Manual for Measurement and*

Verification of Demand Reduction Value from Demand Resources (M-MVDR) requires that all demand resources have no more than ± 10% sampling error at the 80% confidence level so DSA computes and reports the aggregate uncertainty based on the relative precision values reported in each independent program evaluation. Efficiency Maine also has a number of cogeneration assets with metered output. Each year DSA reviews the instrumentation and data to confirm that each asset is compliant with metering guidelines in Section 10 of the M-MVDR, which require true RMS power measured across all three phases in no more than 15-minute intervals.

DSM Portfolio Evaluation, Central Hudson Gas & Electric (Central Hudson) (2019-present). DSA is the impact evaluation lead for Central Hudson's portfolio of DSM programs. The programs evaluated include the following:

- **Residential Behavioral** – DSA produces both quarterly updates and an annual report. The savings are estimated using a randomized control trial with approximately 110,000 electric participants and 35,000 electric controls and 30,000 gas participants with 8,000 controls.
- **Point-of-Sale Lighting** – The programs works with retailers to reduce the customer-facing price of efficient lighting. DSA verified the electric savings and conducted a price-elasticity analysis to quantify the relationship between uptake of energy-efficient lighting and discounts.
- **Small Business Direct Install** – The program delivers efficient lighting to small and medium businesses free of charge. The analysis included three components: verification of saving calculations, billing analysis with matched controls to quantify the impact, and verification of installations at sites.
- **C&I Prescriptive and Custom** – The program is designed for larger customers, and the evaluation includes onsite visits for verification of electric savings.
- **CenHud Online Store** – The online store allows Central Hudson customers to purchase energy-efficient products at a discount. The evaluation includes verification of the savings calculation and estimating the relationship between discounts and customer uptake of different products.
- **Targeted Demand Management Support** – DSA is also providing support for Central Hudson's targeted demand management programs, including conducting settlement baseline accuracy analysis, design of operations strategies, and design of non-wire and non-pipe alternatives.

Non-Residential Baseline Study, Central Hudson (2019). DSA designed, implemented, and analyzed Central Hudson 2019 C&I baseline study. The study consisted of on-site and phone surveys to businesses across Central Hudson's territory and utilized an in-house data collection platform. Primary research was supplemented with data recently collected for the New York State Energy Research and Development Authority's (NYSERDA) commercial market assessment study. Analysis of this end use and saturation study provided baseline energy-use characteristics by business type and for the non-residential customer class as a whole. Findings from the baseline study were used to inform the Commercial and Industrial Potential Study, led by the Cadmus Group. Ten end uses including lighting, HVAC, water heating, and others were

analyzed in-depth and in-conjunction to form an energy use intensity evaluation at the segment, or business-type, level. Additionally, the report included detailed analysis of historical and hypothetical program participation as well as motivators of energy-efficiency decision making.

Cost Effectiveness Evaluation of the DCSEU, DC Department of Energy and Environment (2018-present). As a subcontractor to NMR, DSA is responsible for the benefit-cost modeling portion of this portfolio evaluation. To conduct the annual cost-effectiveness assessment, DSA built a detailed and flexible benefit-cost model for assessing the project-, program-, portfolio-level cost-effectiveness for DCSEU energy-efficiency, and renewable energy programs. Modeling and assessment included functionality for dynamically assessing four cost-effectiveness tests[1] and a variety of cost-effectiveness scenarios, including a base scenario replicating DCSEU cost-effectiveness plus scenarios for layering in updated avoided cost assumptions, realization rates, NTG yield, and environmental benefits. The study incorporated key cost-effectiveness considerations including an adjusted baseline. DSA also developed updated time-differentiated avoided energy and capacity costs using historic data from the PJM markets and EIA long-term cost projections.

C&I Energy Efficiency Programs Evaluation, Rhode Island Office of Energy Resources (RIOER) (2019-present). DSA was part of the team selected to evaluate National Grid's energy-efficiency programs (gas and electric). DSA's role in the evaluation was to perform a billing analysis for any premise that installed an incented retrofit measure between 2015 and 2019. Example retrofit measures offered by the program include lighting measures, steam traps, and variable speed drives (VSDs) on HVAC systems. The billing analysis included over 250 electric customers and nearly 40 gas customers. For each customer, estimates of weather-normalized savings and avoided energy use were produced. Billing analysis savings estimates were then compared to gross savings estimates stored in the tracking data, as well as adjusted gross savings estimates that accounted for in-service rates and realization rates. In each step of the project, the DSA team sought feedback from the Working Group, a group of stakeholders representing different interests.

Demand Response Evaluations, Southern California Edison (SCE) (2019-present). Since 2019, DSA has evaluated SCE's Demand Response programs, including:

- **The Summer Discount Program** – The program uses air conditioning load switches to reduce peak demand. In 2019, the program had over 220,000 and 9,000 residential and commercial, respectively, and controlled over 320,000 air conditioner units with three control options – 100% cycling, 50% cycling, and 30% cycling. DSA used AMI data for the full population, a matched control group, and differences-in-difference panel regressions to evaluate the impacts.
- **The Smart Energy Program** – The program utilizes Wi-Fi connected smart thermostats to reduce air conditioning load in participating residential households during peak hours. DSA used AMI data, a matched control group, and difference-in-difference panel

[1] These include the Total Resource Cost/Societal Cost Test (TRC/SCT), Program Administrator Cost Test (PACT), Utility Cost Test (UCT), and the Ratepayer Impact Test (RIM).

regressions to evaluate the 50,000 homes and 23 demand response events for the Summer of 2019.

- **Agricultural Pumping Interruptible** – The program controls agricultural pumps across SCE's territory during system emergencies. The analysis relies on developing individual customer regressions for approximately 1,200 customers in a unique customer segment. In the process of the evaluation, DSA assessed how impacts varied by location, crop type, and pump size, the switch signal success rates, and how changes in the program affected ex-ante impacts used for planning.
- **Real-Time Pricing program** – The program includes large customers with varying hourly pricing tied to weather in Downtown Los Angeles. SCE had implemented a shift in the prices to target the shift of peak load from mid-afternoon to late afternoon and evening hours. The modeling for this program involves quantifying how customer loads change in response to change in price and determining what a customer would have done had they been metered under the otherwise applicable tariff.

As part of the study, DSA developed weather standardized impacts of system planning and estimates for individual substations banks to incorporate into T&D planning.

M&V Protocols Revision and Update, Bonneville Power Administration (BPA) (2017-2019). DSA was part of the kW Engineering team selected to update BPA's measurement and verification protocols. These M&V protocols provide BPA engineers, staff at BPA partner utilities, and third party implementation contractors with comprehensive guidance for developing ex-ante savings estimates for custom non-residential energy-efficiency projects. The suite of protocols consists of eight standalone guidance documents on different M&V approaches and a Selection Guide to help staff select the appropriate protocol for a given project. DSA's role on the team was to update the protocols that rely of regression and statistical methods.

Key areas of focus for the update included non-routine events, model coverage of independent variables, normalized savings versus avoided energy use, use of indicator variables in energy models, and uncertainty considerations when working with high-frequency data.

In 2019 DSA authored a new protocol containing guidance on estimation of peak demand, or capacity, savings from energy efficiency. The Peak Demand Impact Application Guide reviewed the system load characteristics of the BPA system and included examples of how to calculate capacity savings using methods from several energy savings protocols. The protocol includes references where users can access end-use and premise load shapes and provides guidance on how to use those load shapes to estimate capacity savings.

Table 2 presents a wide range of examples of DSA's prior studies, including some of the studies highlighted above and numerous others.

Table 2: Examples of Prior DSA Studies

Study Name	Timing	Impact Evaluation	TRC / Cost-effectiveness	TRM	Baseline Studies	Potential Studies	Process & NTG	Portfolio & Regulatory Support
Pennsylvania PUC: Act 129 Statewide Evaluator	2016-2021	●	●	●	●	●	●	●
Bonneville Power Administration: M&V Protocols Revision and Update	2017-2019	●						
CEPC: Residential Appliance Saturation Survey, MPS, and IRP Support	2018-2020		●	●	●	●		●
CPUC: Integrated Resource Plan - Electric Vehicle Forecast	2019-present					●		●
Central Hudson Gas and Electric: Non-Residential Baseline Study	2019				●			
Central Hudson Gas and Electric: EM&V of Electric and Gas DSM Portfolio	2019-present	●	●	●	●	●	●	●
Con Edison: Smart Home Rate Demonstration and Innovative Pricing Pilot support	2016-2018		●			●		●
Consumers Energy: Demand Response Potential Study and IRP Support	Present	●	●			●		
DCSEU: Cost Effectiveness Evaluation and Nest Seasonal Savings Evaluation	2018-present		●					
Ecobee: Eco+ Evaluation	2019-2020	●		●				●
Efficiency Maine: LED and Heat Pump Water Heater Pricing Trials	2016-2019			●			●	
Efficiency Maine: Retail, Small Business, and Distributor Lighting Impact Evaluations	2019-present	●		●			●	
Georgia Power: Home Energy Improvement and Specialty Lighting Program EM&V	2019-present		●	●		●	●	●
HECO: Hawaii DR Evaluations	2019-present	●						
IESO: Forward Capacity Market Compliance Review	2018-2020	●		●				●
IESO: EM&V of Industrial Programs	2017-2019	●	●	●				
IPMVP Uncertainty Assessment – Option C: Whole Building	2017-2019	●						●
Public Service New Mexico: Power Saver and Peak Saver Impact Evaluations	2017-2021	●	●					●
PSEG Long Island: Locational Avoided T&D Cost Study	2019-present		●			●		
RIOER: C&I Energy Efficiency Programs Evaluations	2019-present	●						
Southern California Edison: Demand Response Evaluations	2019-present			●				
SDG&E: Small Commercial TOU, CPP, & Smart Thermostat Evaluation	2016-present	●	●			●		
WA UTC: Assessment of Utility T&D Planning Capabilities and DER integration Practices	2017		●			●		●

1.3 BRIGHTLINE GROUP

BrightLine Group is a certified woman-owned small business made up of industry experts in DSM program planning and evaluation based in Boulder, Colorado. We are dedicated to meeting our clients' needs with best-in-industry services, capable and efficient project management, and clear communication. We are also committed to applying our skills and experience in clean energy engineering, programs, and policy to address climate change and build a more sustainable future.

BrightLine's combined experience is both broad and deep in the DSM industry, including all phases of the program cycle from planning to implementation to evaluation. Collectively, our team has led or supported more than two dozen evaluation studies and nearly a dozen planning studies for utilities and public agencies across North America. Our expertise in project management, engineering, planning and consulting allows us to provide clients with the information and insight to develop and offer more successful energy-efficiency and demand response programs.

1.3.1 Representative Projects

Statewide Evaluator, Pennsylvania PUC (2018-present). BrightLine staff is part of the NMR-led SWE team for Pennsylvania's energy-efficiency and demand response programs for Phase III of Act 129 DSM programs. In this role, BrightLine has reviewed project documentation and files for accuracy, conducted cost-effectiveness analysis for nonresidential programs, updated the state's TRM, and developed portion of the Annual Report that summarize the energy-efficiency and demand response savings for each utility in the program year.

BrightLine staff are currently acting in an advisory capacity for the energy-efficiency potential study and baseline study as part of Phase III. This state-wide DSM energy-efficiency market potential study for the seven EDCs will help inform the planning and implementation of Phase IV of Pennsylvania's Act 129 energy-efficiency goals. The potential study includes the determination of technical, economic, achievable and program potential for the C&I sectors.

Commercial and Industrial Impact and Process Evaluations, Georgia Power Company (2019-present). The BrightLine Group is leading the process and impact evaluations of Georgia Power Company's certified commercial DSM programs, including Small Business Direct Installation; HVAC and Kitchen Midstream; and Commercial Behavioral, Commercial Prescriptive, and Commercial Custom programs for the 2020 through 2023 program years. The evaluation project includes the formation of key program questions; planning; interviews with program staff and implementers; surveys with trade allies, distributors, contractors, participants, and non-participants; measure review; on-site inspections; measurement and verifications; and cost-effectiveness analysis. Each program is being evaluated independently, with results reported at measure, program, and portfolio levels. Measurement and verification approaches are customized to each specific energy-efficiency measure, considering expected uncertainty, and impact magnitude.

Energy Efficiency Potential Assessment, California Municipal Utilities Association (CMUA) (Present). BrightLine is supporting GDS Associates to estimate the technical, economic, and market potential for energy-efficiency and complementary resources for California municipal electric utilities. Resource potential will be based on CMUA member's customer characterization, climate zone, economic conditions, and other relevant factors over a forecast period of at least

ten years. As part of this project, multiple scenarios and range assessments will be analyzed, in particular differentiating between utility investments and improving compliance and implementation of the Title 24 Building Energy Efficiency Standards. All potential forecasts and assumptions will be developed in compliance with AB 2227 and by member request. In addition to the assessment of energy-efficiency resource potential, BrightLine will assess the resource potential for transportation electrification, energy storage, and self-generation.

Portfolio Planning and Evaluation Support, Mississippi Power Company (MPC) (2019-present). BrightLine Group is working with MPC on the development of a new portfolio of energy-efficiency and load growth programs for their 2020-2023 DSM cycle. BrightLine is applying a three-phased approach to the planning activity: (1) analyzing program performance history, (2) assessing opportunities for expansion, and (3) applying these findings into a new portfolio plan. The portfolio plan includes the creation of a program manual, the development of incentive levels and expected participation, and the performing of a cost-effectiveness analysis for each measure and program as well as the portfolio as a whole. This work builds on the BrightLine team's extensive experience providing impact evaluation, process evaluation, and cost effectiveness services for MPC over the past several years. In addition, BrightLine Group will support MPC in the impact and process evaluation efforts for the programs offered in their 2020-2023 DSM cycle.

Energy Efficiency Programs Evaluation Study, RIOER (2019-present). BrightLine Group is leading a team to conduct an energy savings verification study of National Grid's energy-efficiency programs. The objectives of the study are to examine implemented program and planned conservation measures, review and confirm the claimed energy savings, and review and summarize National Grid's process for incorporating results from completed evaluation studies into on-going energy efficiency program reporting and implementation. The BrightLine Team is conducting three main tasks as part of the study: (1) describe and evaluate the general EM&V process and report on how the EM&V results are applied, (2) independently review all current estimates of savings and verify the use of EM&V industry standards, and (3) conduct an analysis of utility bills and a customer experience evaluation to help guide future recommendations on the use of billing analysis for future reporting of savings. The study will include interviews with National Grid and RIOER program staff and their consultants; a review of up to 20 completed evaluation reports to assess the accuracy of reported savings, the EM&V methods employed, and the use of deemed savings and engineering algorithms; and a billing analysis on all commercial participants from 2015 thru 2018 program years to compare project-level energy savings with the energy savings reported by National Grid.

Distributed Energy Resources Market Potential Study, Ameren Missouri (2019-present). BrightLine Group is leading the distributed energy resource (DER) market potential for Ameren Missouri's service territory for future opportunities in 2021 – 2040. The study is conducted in partnership with GDS Associates, who is assessing the potential for synergistic energy efficiency and demand response. Considered DERs include Combined Heat Power, Photovoltaic Solar, Electric Vehicles, Batteries, and Microgrids. Project tasks include a detailed technology assessment, technology applicability review, market characterization, cost effectiveness, and applicability review.

Report: 2020 DSM Market Potential Study

Building Operator Certification Assessment; Top Tier Trade Ally Program Assessment; Commercial Building Stock Assessment Engineering Support, Northwest Energy Efficiency Alliance (NEEA) (2019-2020). BrightLine Group recently supported NEEA by conducting an assessment of three NEEA offerings: (1) the Top Tier Trade Ally Program, (2) the Building Operator Certification Program, and (3) the Commercial Building Stock Assessment. BrightLine Group conducted an assessment of the Northwest Energy Efficiency Council (NEEC) Building Operator Certification (BOC) program dataset for 2019. The BOC program educates, trains, and certifies facility operators to perform energy-efficient operations and maintenance. The focus of the assessment was to describe the 2019 new BOC certificants and update the count of active BOC certificants in the four Northwest states as of December 31, 2019. Brightline's assessment of NEEA's Top Tier Trade Ally (TTTA) Program was conducted to gauge the impact of TTTA trainings on the market activity of participants and progress to date towards Program objectives. As part of the assessment, BrightLine Group and subcontractor, Evergreen Economics, designed and implemented an assessment using a two-pronged approach which utilized both an online survey and in-depth phone interviews to collect both quantitative and qualitative data from NXT Level designees. The assessment focused on understanding participant experience and building NEEA's understanding of the market. Lastly, BrightLine provided technical expertise, review, and recommendations on NEEA's preliminary Commercial Building Stock Assessment (CBSA) datasets. Activities included: review of the data dictionary and data collection tool, review of data sets resulting from data collected via site visits, and identification of variables where values are not *reasonable* for the equipment or component to which they are linked.

Technical Support of Annual Savings Claims, VGS (2019-2020). BrightLine Group, as a subcontractor to NMR Group, led the impact evaluation of VGS commercial and residential energy-efficiency programs with the objective of calculating the annual and peak day energy impacts at the program and sector levels and suggesting process improvements to streamline program implementation and savings verification efforts. The programs included in the evaluation are Commercial Equipment Replacement (CER); Commercial Retrofit (CSR); Commercial New Construction (CNC); Custom RNC; Custom Residential Retrofit (RIR); and Residential Equipment Retrofit (RER). Brightline's tasks included project document review, engineering desk review, telephone surveys, and billing analysis.

Table 3 outlines the evaluation areas addressed in each of BrightLine's prior studies described above.

Table 3: Examples of Prior BrightLine Studies

Study Name	Timing	Impact Evaluation	TRC / Cost-effectiveness	TRM	Baseline Studies	Potential Studies	Process & NTG	Portfolio & Regulatory Support
Georgia Power Company – Commercial and Industrial Impact and Process Evaluations	2019-present	●	●				●	●
California Municipal Utilities Association – Energy Efficiency Potential Assessment	Present					●		●
Mississippi Power Company – 2020 Portfolio Planning and Evaluation Support	2019-present	●	●				●	●
Pennsylvania PUC – Statewide Evaluator: Verification of DSM Programs	2018-present	●		●				●
Pennsylvania PUC – Act 129 Statewide Evaluator: Energy Efficiency and Demand Response Potential Study and Baseline Study	2018-present				●	●		●
ComEd – 2020 – 2025 Energy Efficiency Portfolio and Program Planning	2019-present			●	●	●		●
Rhode Island Office of Energy Resources – Energy-efficiency Programs Evaluation Study	2019-present	●		●			●	●
Ameren Missouri – Distributed Energy Resources Market Potential Study	2019-present					●		
Northwest Energy Efficiency Alliance – Building Operator Certification Assessment; Top Tier Trade Ally Program Assessment; Commercial Building Stock Assessment Engineering Support	2019-2020	●					●	
Vermont Gas Systems – Technical Support of Annual Savings Claims	2019-2020	●						

1.4 Optimal Energy, Inc.

Founded in 1996, Optimal Energy provides a full range of energy-efficiency consulting services to investor and municipally owned utilities, PAs, state and federal energy offices, regulatory commissions, advisory councils, and advocacy groups. We specialize in assessing, developing, designing, planning, and launching efficiency programs and policies that effectively address the needs of all stakeholders in a cost-effective, balanced fashion. These efforts are supported by broad experience gathering both quantitative and qualitative data from a variety of sources and synthesizing it into meaningful, defensible, and actionable conclusions and recommendations. Our primary objective is to help our clients recognize opportunities and be leaders in their industry.

Optimal Energy offers unparalleled expertise and technical support in all aspects of energy efficiency. We help our clients develop the organizational capacity and expertise needed to define and acquire all cost effective energy efficiency. Our technical analyses are regarded by the industry as comprehensive and accurate. We are nationally recognized for our assistance to policy-makers and program providers at all levels.

Optimal Energy's subject matter experts work on a range of energy-related challenges.

- Conducting in-depth market assessments to characterize various technologies or market segments and identify opportunities for market transformation, intervention or promotion.
- Performing comprehensive studies to determine the technical, economic, and achievable potential for energy efficiency, demand response, fuel switching and renewable energy measures or programs
- Analyzing the costs and benefits of demand-side management energy resources, including the treatment of many ancillary and non-energy costs and benefits that are often overlooked by others in the industry
- Designing, developing and supporting long range, forward-looking energy-efficiency program plans, implementation strategies and goals, including management and administrative protocols and processes
- Developing TRMs and other support for monitoring and verification with algorithms for estimating the energy savings and non-energy benefits of electric and gas efficiency measures, and documenting associated costs, impact factors, and data sources
- Developing policies and procedures on legislative and regulatory issues ranging from public benefits charges to decoupling and utility incentives to establishment of statewide energy resource standards to development of State energy and climate goals and plans.

1.4.1 Representative Projects

New York State Commercial Potential Study, NYSERDA (2019-2020). Optimal Energy estimated the ten-year potential for energy efficiency in the commercial sector in New York State for electricity, natural gas, fuel oil, and propane. This analysis was built around significant primary baseline data. It also included an investigation of potential for gas peak demand reduction, as well as beneficial electrification through emerging heat pump technology.

Strategy Advising, New Jersey Board of Public Utilities (BPU) (2019-2020). Optimal Energy was retained to provide technical advising as the BPU structured program implementation to align with legislative goals and the market potential study. Optimal advised on program administrative structure, performance targets, incentives and penalties, stakeholder engagement, and measurement and verification.

Energy Efficiency Potential Study, New Jersey BPU (2019). New Jersey's 2018 Clean Energy Act mandated completion of an energy-efficiency potential study to inform the Board as it established targets. Optimal Energy was selected in a competitive bidding process to complete the work, which had to meet a very tight legislative deadline. The project included estimation of ten-year (2020-2029) energy-efficiency potential, demand response potential, and potential for

savings from combined heat and power. The potential then needed to be allocated to the electric and gas public utilities. Optimal also completed a literature review on setting targets and establishing performance incentives and penalties. Finally, Optimal provided recommendations on five-year efficiency targets, allocated to each public electric or gas utility, and on a structure for performance incentives and penalties that complied with legislative mandates.

Energy Efficiency Market Potential Study, New Orleans City Council (2018-2019). Optimal Energy performed a demand-side management potential study on behalf of the New Orleans City Council to inform the 2018 Triennial Integrated Resource Plan (IRP) by Entergy New Orleans (ENO). The potential study was used to help power procurement planning, as well as to assess the most viable paths to achieving ENO's energy savings goals as set by the City Council.

Statewide Energy Efficiency Potential Study, Minnesota Department of Commerce (2018). Optimal Energy and partner Center for Energy and Environment (CEE) collaborated to prepare a statewide natural gas and electric energy-efficiency and carbon saving potential study on behalf of the State of Minnesota. This study was commissioned to inform decision-makers with Minnesota's Conservation Improvement Program (CIP) about the market sectors, geographic areas, utility service territories, end uses, measures and programs that should be targeted to help realize demand-side management potential in Minnesota. This study required separate analyses and reporting for seven regions in Minnesota.

Evaluation Audit, Enbridge Gas Distribution (EGD) (2013-2015). Optimal Energy conducted comprehensive audits of EGD's DSM evaluation reports and associated DSM activities to provide independent opinions to DSM stakeholders, including the Ontario Energy Board, on whether or not the magnitude of established financial recovery mechanisms were correct. In support of this effort, Optimal reviewed and validated findings presented in a series of custom project savings verification (CPSV) reports developed by third-party Technical Evaluators (TEs) and assessed the reasonableness of deemed savings estimates for prescriptive measures. Optimal provided detailed feedback on the quality, reasonableness, and accuracy of project savings estimates and ensured that the TEs satisfied their contractual duties. By reviewing key project and measure savings assumptions using industry best-practices, Optimal developed revised project savings estimates, as appropriate. The result of this work was a set of modified realization rates used to quantify the recommended financial mechanisms.

Mid-Atlantic TRM, Northeast Energy Efficiency Partnerships (NEEP) (2016-present). Optimal Energy, with Shelter Analytics and Vermont Energy Investment Corporation, developed efficiency measure costs and savings estimation protocols for a novel, multi-state TRM for use by utilities in the Mid-Atlantic region. The project required comparative analyses between regional energy-efficiency savings estimation methodologies and working with stakeholders to reach consensus on the characterizations. Optimal Energy was also in charge of the review and update of the manual, working with the stakeholders each year to prioritize measures that need update, to identify specific additional needs, and to characterize the savings, costs, baseline shifts, and other aspects of each measure.

Energy Efficiency Advisory Council Program Development and Support, Delaware Department of Natural Resources and Environmental Control (DNREC) (2015-present). Optimal Energy provides broad program planning, analysis, and strategic guidance to the DNREC as it

begins developing a new model for joint utility and public-sector delivery of energy-efficiency services, with the objective of dramatically increasing energy savings and demand reductions in that state. Optimal leads a ten-member team of experts. Optimal provides program design review and economic analysis; EM&V regulation promulgation; TRM development, database development, and stakeholder engagement.

Potential Study for Energy Savings in Affordable Multifamily Housing, Energy Efficiency for All (2014-present). In support of Energy Efficiency for All, a joint initiative of the Natural Resources Defense Council, the National Housing Trust, and others, Optimal Energy developed a study of energy-efficiency potential in affordable multifamily housing covering electricity, natural gas, and fuel oil potential in nine states. Optimal developed a novel method of parameterizing the potential analysis to provide justifiable results across disparate regions. Optimal has continued to support these efforts through educational outreach and additional focused analyses.

Policy and Program Planning Consulting, Rhode Island Energy Efficiency and Resource Management Council (EERMC) (2008-present).

Optimal Energy leads the consultant team that provides support to the EERMC on topics ranging from policy and legislative issues to oversight of program implementation and infrastructure development. The team provides research, budget analysis, cost-effectiveness modeling, data tracking, and general oversight to the Council as well as strategy and general support to the RIOER. Optimal's role includes representing the EERMC on all aspects of negotiating efficiency programs, plans, goals and budgets with National Grid, the PA. Optimal provides oversight of all program implementation and evaluation, monitoring and verification activities.

Technical Consulting Services, Massachusetts Energy Efficiency Advisory Council (EEAC) (2006-present). Optimal Energy has served as the lead technical consultant to the EEAC since its inception. Optimal's role includes representing the EEAC on all aspects of negotiating efficiency programs, plans, goals and budgets with the PAs, and oversight of all program implementation and evaluation, monitoring and verification activities. Optimal manages all aspects of the 20-member consultant team's interactions with the Council, PAs, and myriad stakeholders in advising, designing, and supporting implementation of the Mass Save® programs. The Team is tasked with overseeing the planning and implementation of Massachusetts's $2.4 billion Three-Year Plan. The Optimal team oversees and advises on the 25 C&I, residential, multifamily, low-income programs and initiatives, leads the $70 million EM&V effort (approximately 45 studies ongoing at any one time), and advises and analyzes demand response efforts.

Table 4 presents Optimal Energy's prior study examples and the types of evaluation activities addressed in each study.

Table 4: Examples of Prior Optimal Energy Studies

Study Name	Timing	Impact Evaluation	TRC / Cost-effectiveness	TRM	Baseline Studies	Potential Studies	Process & NTG	Portfolio & Regulatory Support
NYSERDA: New York State Commercial Market Potential Study	2019-2020		●	●	●	●		
New Jersey BPU: Strategy Advising	2019-2020		●				●	
New Jersey BPU: Market Potential Study	2019		●	●	●	●		
New Orleans City Council: Market Potential Study	2018-2019		●			●		
MN Dept. of Commerce: Market Potential Study	2018		●	●	●	●		
Enbridge Gas Distribution: Portfolio Evaluation	2013-2015	●	●	●				
NEEP: Mid-Atlantic TRM	2016-present			●				
DNREC: Delaware Energy Efficiency Advisory Council Technical Consultant*	2015-present	●	●	●	●	●	●	●
Energy Efficiency for All: Affordable Multifamily Market Potential Study (selected states),	2014-present		●			●		
Rhode Island Energy Efficiency and Resource Management Council: Technical Consultant*	2008-present	●	●	●	●	●	●	●
Massachusetts Energy Efficiency Advisory Council: Technical Consultant*	2006-present	●	●	●	●	●	●	●

*As technical advisors to state councils, Optimal Energy provides direct oversight for portfolio cost-effectiveness, including all EM&V functions.

Section 2 References

The tables below provide references for each of the NMR team members.

Table 5: NMR

Name	Organization	Phone	Email
Brian Greenfield, Analyst	Eversource Energy	(781) 441-8734	Brian.Greenfield@eversource.com
Lance Loncke, Ph.D., Economists/Senior Program Analyst	Energy Administration, Department of Energy and Environment, Government of the District of Columbia	(202) 671-3306	Lancelot.Loncke@dc.gov
Jessei Kanagarajan, Senior Manager, Portfolio Operations	Independent Electricity System Operator (IESO)	(416) 969-6314	Jessei.kanagarajan@ieso.ca

Table 6: DSA

Name	Organization	Phone	Email
Laura Martel, Research and Evaluation Manager	Efficiency Maine Trust	207-213-4143	laura.martel@efficiencymaine.com
Scott Hammond, Director of Member Programs	Central Electric Power Cooperative	803-779-4975	shammond@cepci.org
Marc Sclafani, Director of Demand Side Management	Central Hudson Gas & Electric	845-486-5979	Msclafani@cenhud.com

Table 7: Brightline

Name	Organization	Phone	Email
Jeff K. Smith, Energy Efficiency Strategy Manager	Georgia Power Company	404-506-3817	JKSMITH@southernco.com
Craig Aubuchon, Manager, Energy Analytics	Ameren	(314) 554-2688	caubuchon@ameren.com

Table 8: Optimal Energy

Name	Organization	Phone	Email
Maggie McCarey, Manager of Energy Resources	Massachusetts Department of Energy Resources	617-626-1036	maggie.mccarey@state.ma.use
Anthony Fryer, Conservation Improvement Program Supervisor	Minnesota Department of Commerce	651-539-1858	anthony.fryer@state.mn.us
Becca Trietch, Administrator, Energy Efficiency Programs	Rhode Island Office of Energy Resources	401-574-9106	becca.trietch@energy.ri.gov

GREG CLENDENNING

Director | Employee Owner

Overall Lead

Fourteen years' experience

Ph.D., Environmental Sociology, University of Wisconsin-Madison

WORK EXPERIENCE

2006 – Present	**Director, NMR Group, Inc.,** Somerville, MA
2005 – 2006	**Evaluation Officer, U.S. Department of State,** Washington, DC
1998 – 2004	**Research Assistant and Research Fellow, University of WI-Madison, Depart. of Forest Ecology & Mgt,** Madison, WI

ILLUSTRATIVE PROJECTS

Project Manager. Statewide Evaluator. For the Pennsylvania Public Utility Commission (PUC), leading the Statewide Evaluation Team (SWE) for Phase III. Greg has been the overall lead for the SWE and his responsibilities have included the following:

- Day to day project management for the team and primary contact between the SWE and TUS staff and between the SWE, the EDC, and EDC evaluator teams
- Managed and led the development of the SWE Annual Reports and Update Reports
- Managed the residential and low-income programs audit and the process and NTG audit for all residential, low-income, and non-residential programs
- Managed and contributed to the updates to the EM&V Audit Framework
- Managed and contributed to the updates to the 2021 TRM and TRM Order, as well as the interim measurement protocols (IMPs) during Phase III
- Oversaw the 2018 Residential Baseline study, the Energy Efficiency and Demand Response Potential Studies, the TRC Order, and the incremental cost database updates
- Managed and contributed to the Phase IV Implementation Order
- Managed and contributed to Phase III guidance memos

Project Manager. Clean Energy R&D. For the US Department of Energy (US DOE), led a team conducting five-year process and impact evaluations of two DOE clean energy R&D programs: the Small Business Vouchers (SBV) and the Energy I-Corps (formerly Lab Corps) programs. Both programs seek to improve collaboration between national laboratories and businesses and by doing so move new clean energy technologies to commercialization and adoption more quickly. Both evaluations examined processes and impacts, as well as the conditions in which these pilots can be improved and/or successfully implemented in other organizations.

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Project Manager. Non-Energy Impacts (NEIs), Low-Income Multifamily Weatherization. For the Massachusetts program administrators (MA PAs), serving as project manager for a multi-year study developing monetized values for the health and safety NEIs of low-income multifamily weatherization projects. The monetized NEIs will be used in cost-effectiveness testing. The study is being conducted in conjunction with a larger, national evaluation managed by Three[3] and their business partner Slipstream through a grant awarded by the JPB Foundation (JPB). The study includes cooperation with low-income housing agencies and partners in multiple states. The team developed a quasi-experimental research design to conduct a preliminary, qualitative assessment of NEIs (phase 1), and to quantify the NEIs (phase 2).

Subject Matter Expert – NEIs. For the Delaware Department of Natural Resources and Environmental Control (DNREC), designed an evaluation to assess and quantify the comfort, noise, and health NEIs associated with Weatherization Assistance Program (WAP). Designed follow-up research, which included interviews with program participants to provide a better understanding of the NEIs they experienced.

Project Manager, Non-Energy Impacts Framework. For the MA PAs with DNV GL, developed a framework that assessed the comprehensiveness of existing NEIs across the portfolio of commercial and industrial, residential, and low-income/multifamily programs offered by the MA PAs. The study identified gaps between the existing body of NEI research in MA and NEI research in the available literature and made recommendations for prioritizing future NEI research.

Project Manager. Non-Energy Impacts Study, Solar and Home Energy Services Safety Remediation. For the MA PAs, led a team that conducted a Solar and Home Energy Services Safety Remediation Non-Energy Impacts Study. Using a literature review and other secondary research, the team identified and, when possible, quantified NEIs associated with the installation of solar photovoltaic (PV) panels, energy-storage batteries, and the remediation of knob and tube (K&T) wiring and asbestos. The MA PAs have proposed or are considering solar PV or energy-storage battery incentives as new components of the energy services offering in the 2019-2021 program cycle, including a low-income program component.

SELECTED PRESENTATIONS AND PUBLICATIONS

"Accounting for Health and Safety Benefits of Energy Efficiency" with Noel Stevens, DNV GL, Beth Delahaij National Grid and Bruce Tonn, Three3. Public Webinar for Association of Energy Services Professionals (AESP). March 21, 2019.

"Cost Effectiveness and Non-Energy Impacts," NEEP EM&V Forum, May 8, 2018. Nashua, NH.

"Challenging Topics in Cost-Effectiveness – Health and Safety Impacts of Low-Income Weatherization." NEEP EM&V Forum, June 15, 2017. Hartford, CT.

"Gaining a Better Understanding of Energy Efficiency in California's Multifamily New Construction Market" AESP National Conference, February 2016. Phoenix, AZ.

"Evaluating the Market Effects of the Better Buildings Neighborhood Program" presented at the 2015 International Energy Program Evaluation Conference (Long Beach, CA, August 2015).

ARI STERN

Project Manager | Employee Owner

Assistant Project Manager

Five years' experience

M.A. Energy and Environmental Analysis

WORK EXPERIENCE

2015 – Present **Project Manager, NMR Group, Inc.,** Somerville, MA

2013 – 2015 **Research Fellow, Boston University Dept. of Earth and Enviro.,** Boston, MA

CERTIFICATIONS

Certified HERS Rater (HERS) – RESNET 2015 - Present

Home Energy Score Assessor – U.S. Department of Energy 2016 - 2018

ILLUSTRATIVE PROJECTS

Day-to-day Manager. Residential – Pennsylvania Residential Baseline. For the Pennsylvania Public Utilities Commission, provided day-to-day management for a study of 289 single-family and multifamily homes in Pennsylvania, including data collection tool development, sample recruitment, on-site inspections, analysis, and reporting. The study served to update the technical reference manual used to determine electric distribution company achieved savings, inform a potential study, and characterize the energy-efficiency levels of the housing stock.

Day-to-day Manager. Residential – Massachusetts Residential Baseline/Code Compliance. For the Massachusetts program administrators (MA PAs), provided day-to-day management for a study of non-program residential new construction (RNC) across Massachusetts in 2019, including data collection tool development, sample recruitment, on-site inspections, energy modeling, analysis, and reporting. The study characterized the non-program RNC market, compared the market to previous studies, assessed the difference in measure level efficiencies between non-program and program homes, and measured code compliance. Additionally, the study included facilitating conference calls with stakeholders to update the User Defined Reference Home (UDRH) that serves as the baseline for the RNC program.

Lead Analyst. Residential and Commercial – Act 129 Annual Reporting and Verification. For the Pennsylvania Public Utilities Commission, annually analyzed and summarized reported savings from the Electric Distribution Companies to determine compliance. Additional tasks included conducting measure-level implementor project file reviews and conducting analysis to ensure compliance with measure-level low-income offering requirements.

(617) 544-2004 astern@nmrgroupinc.com nmrgroupinc.com

Analyst. Residential and Commercial – TRM Update. For the Pennsylvania Public Utilities Commission, provided research and analysis to update the Act 129 Phase III Technical Resource Manual for Phase IV. Additional tasks included summarizing and responding to public comments and reply comments on the tentative order.

Day-to-day Manager. Residential and Commercial – Code Promulgation Attribution. For the MA PAs, provided day-to-day management for a study to estimate gross-technical-potential savings for proposed amendments to the 2018 International Energy Conservation Code. Additionally, managed detailed document reviews, in-depth interviews, and stakeholder conversations to determine an attribution factor.

Project Manager. Residential – Net-to-gross. For the MA PAs, currently leading project to estimate net-savings and net-to-gross rations for RNC offerings in the single-family and low-rise multifamily new construction markets. The study uses a Delphi panel and energy modeling to estimate measure-level counterfactual efficiencies and consumption in the absence of the RNC offerings.

Lead Analyst. Residential – Single-Family Baseline/Compliance. For the Vermont Department of Public Service, served as a lead auditor and analyst for a new construction and existing home baseline and code compliance study. Additional tasks included modeling homes using DOE HES tool and REScheck software.

Lead Analyst. Residential – Multifamily Baseline. For the Vermont Department of Public Service, served as a lead auditor and analyst for multifamily baseline. Tasks included designing a collaborative data collection tool, conducting energy audits with blower door tests, and analyzing program and audit data.

Lead Analyst. Residential – Single-Family Baseline/Compliance/Attribution. For National Grid Rhode Island, served as a lead analyst and auditor to update a new construction program UDRH, assess code compliance, and determine attribution. The attribution study leveraged baseline results and comparison state baseline results to assess natural market adoption.

Lead Analyst. Residential – Single-Family Baseline/Compliance. For the Connecticut program administrators, designed a data collection tool, inspected homes, analyzed program and audit data, generated energy models, and consulted with stakeholders to update the UDRH used in determining program savings. Additionally, the study evaluated statewide code compliance.

Lead Analyst. Commercial – Market Research. For the Northwest Energy Efficiency Alliance (NEEA), examined and reported on differences in commercial building energy codes across four states and additional municipalities in the NEEA territory to estimate potential for a NEEA program to increase code compliance. Additional tasks included conducting in-depth interviews with market actors.

Lead Analyst. Residential – Single-Family Mini-Baseline/Compliance. For the MA PAs, worked as a lead auditor and analyst for a study to characterize new construction efficiency levels and assess code compliance of homes built at the end of a code cycle in 2017. The study supported a net-to-gross evaluation and a UDRH update.

Analyst. Behavioral Intervention – Billing Analysis. For the Pennsylvania utilities, contributed to an evaluation of savings derived from Opower behavioral intervention. Tasks included cleaning, analyzing, and reporting on large billing record datasets.

YOGESH PATIL, PE

Director of Engineering | Employee Owner

- TRM and TRM Order Lead
- Eighteen years' experience
- M.S. Mechanical Engineering, University of Dayton

WORK EXPERIENCE

2019 – Present	**Director of Engineering, NMR Group, Inc.,** Somerville, MA
2017 – 2019	**Director, World Institute of Sustainable Energy (WISE),** Pune, India
2002 – 2017	**Associate Director, Energy & Resource Solutions, Inc. (ERS),** North Andover, MA

CERTIFICATIONS

Professional Engineer (PE-MA) – Commonwealth of Massachusetts - License #51505

DOE Pumping System Assessment Tool Specialist – Department of Energy

Certified Energy Manager (CEM) – Association of Energy Engineers (AEE)

ILLUSTRATIVE PROJECTS

Project Manager. Existing Facilities and New Construction – Impact Analysis. For NYSERDA, managed the impact evaluations for Existing Facilities and New Construction Programs. Developed net-to-gross (NTG) instruments for the enhanced self-report method to use in the field. Developed demand response persistence assessment instrument and conducted the aggregate analysis. Led multiple site visits for data collection and verification and prepared measurement and verification (M&V) plans that included detailed descriptions of the installed measures, proposed metering plan, analysis approach, and possible non-energy benefits (NEBs). Performed comprehensive engineering analysis, which included desk reviews, detailed M&V data analysis, and billing analysis. The overall level of engineering rigor was high, with inspection and verification site visits for all the sampled sites that adhered to IPMVP standards.

Project Manager. Small Business Direct Install – Impact Evaluation. For the Consolidated Edison Company of New York, led multiple site visits for data collection and verification and prepared M&V plans that included detailed descriptions of the installed measures, proposed metering plan, and analysis approach. Performed comprehensive engineering analysis to obtain the savings impacts from the installation of measures.

Project Manager. Retrofit and New Construction – Impact Evaluation. For Eversource (NSTAR), managed the C&I impact evaluation, which involved both retrofit and new construction tracks. Led multiple site visits for data collection and verification and prepared M&V plans that included detailed descriptions of the installed measures, proposed metering plan, analysis approach, and possible NEBs. Performed comprehensive engineering analysis to obtain the savings impacts from the installation of measures.

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Project Manager. Investor-Owned Utility – Impact Evaluation. For the Maryland Energy Administration (BGE, PEPCO, and SEMCO), provided guidance to the field teams in preparing M&V plans and reports and setting up the spreadsheets for savings analyses. Monitored the overall project progress and mentored junior engineers. In addition, conducted desk reviews of technical assistance studies for 12 large commercial and industrial projects.

Project Engineer. Commercial and Industrial – Impact Evaluation. For the California Public Utilities Commission, prepared M&V plans that included detailed descriptions of the installed measures, proposed metering plan, and analysis approach. Conducted verification site visits to interview the site staff to assess the system operating characteristics and to deploy metering equipment. Performed comprehensive engineering analysis to obtain the savings impacts from installation of large complex measures.

Project Manager. Residential, Commercial & Industrial – Impact Evaluation. For Vermont Department of Public Service (PSD) and Vermont Gas Systems (VGS), currently managing impact evaluation of VGS' gas programs. The evaluation involves a combination of desk reviews, billing analyses, and telephone surveys, for sites with complex gas measures, across three residential and three commercial programs. In addition, developing a measure-level evaluation database to aid future evaluations and support natural gas TRM.

Project Manager – Residential, Commercial and Industrial – TRM and Analysis Tools Development. Currently managing the team to develop TRM for six measures for VGS to use in their programs. In addition, modifying the existing TRM measures for which algorithm related issues were identified through recent evaluation. Modifying existing analysis tools for four measures and developing new analysis tools for six measures.

Senior Technical Advisor. Industrial – Program Outreach. For NYSERDA, conducted outreach to industrial customers in New York's downstate region. Outreach activities included locating and contacting eligible customers; performing site visits/audits to identify industrial and process related energy-efficiency measures that are eligible for NYSERDA incentives; and helping customers apply for incentives, estimate energy savings, and implement projects. Over six years, the outreach team contacted over 1,000 customers and performed hundreds of site visits, contributing over 1 million MMBtu in energy savings.

SELECTED PRESENTATIONS AND PUBLICATIONS

"Industrial Process Efficiency: A Vital Part of Sustainable Operation in Industry," Indian Institution of Plant Engineers, 2017. Hyderabad, India.

"Taking Engineering Savings to the Next Level," IEPEC Conference, 2009. Portland, OR.

"Case Studies from Industrial Demand Response Audits Integrated with Renewable Energy Assessments," ACEEE Summer Study, 2007. White Plains, NY.

"Application of Commercial Sector Energy Code Compliance Documents for Assessing Baseline Practice: Assessing Whether Compliance Documents Can Be Used for Developing Lighting Baseline Data," IEPEC Conference, 2005. Brooklyn, NY.

"NSTAR Business Solutions Program Evaluation: Noteworthy Approaches and Findings From a C&I Retrofit Program," IEPEC Conference, 2005. Brooklyn, NY.

JOANNE O'DONNELL

Sr Project Mgr | Employee Owner

- Process Lead
- Fourteen years' experience
- M.A. in Energy and Environmental Analysis, Boston University

WORK EXPERIENCE

2013 – Present	**Project Analyst - Senior Project Manager, NMR Group, Inc.,** New York, NY
2012 – 2013	**Project Analyst, Opinion Dynamics Corporation,** Waltham, MA
2006 – 2012	**Program Assoc. – Manager, Consortium for Energy Efficiency,** Boston MA

ILLUSTRATIVE PROJECTS

Analyst. Task Lead. Residential, Multifamily, C&I – Process Evaluation. For the Pennsylvania Public Utility Commission and as part of the Statewide Evaluator team (SWE), performed an audit of process evaluation reports for a wide range of programs, including residential, multifamily, low-income, combined heat and power (CHP), demand response, and small and large C&I programs.

Project Manager. Residential, Low-Income, Small Business, C&I – Process and Net-to-Gross Evaluations. As part of a multi-year contract with the Ontario Independent Electric System Operator (IESO), was the project manager for the process and net-to-gross (NTG) activities for IESO's portfolio of residential, low-income, and business programs and pilots. Responsibilities included providing project oversite and management, developing evaluation study scopes, writing interview guides and survey instruments, reviewing program documentation, building samples, and overseeing the implementation of all telephone and web survey fielding, in-depth interviews, and other data collection activities. Oversaw all report development, led the process and NTG analysis and reporting, developed key findings and recommendations to enhance the programs, and presented results to the client.

Analyst. Residential and Low-Income – Home Energy Solutions Process Evaluation. For the Connecticut Energy Efficiency Board, performed process, NTG, and non-energy impacts (NEI) evaluation activities for both low-income and market rate aspects of the program. Oversaw telephone survey real-time data collection and analysis of results, and performed assessments of program processes, NEIs, financing and decision-making, and NTG analysis.

Project Manager. Residential – National Grid New York Behavioral Evaluations. As the day-to-day program manager on this multi-year contract, oversaw all process and impact evaluation activities and led all process-related activities. Developed interview guides and survey instruments and reviewed all program data and documentation. Designed samples, coordinated with a CATI firm to implement treatment and control group process surveys, and performed in-depth interviews with program staff and implementers. Led the team in performing all analysis and reporting activities and presented findings and recommendations to the client.

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Analyst. Task Lead. Multifamily and Residential – Process Evaluation. For Nevada Energy, led a participant survey with multifamily and residential customers as part of a process evaluation for the NV Energy Residential High-Efficiency AC Program. Conducted data analysis and reporting with a focus on issues related to program design and implementation, as well as customer satisfaction.

Analyst. Residential – Retail Products Process Evaluation. As part of a process evaluation for the Ohio FirstEnergy Lighting Rebate and Markdown Program, developed interview guides and conducted in-depth interviews with program staff, implementers, and residential lighting retailers in Ohio. Conducted data analysis and reporting with a focus on issues related to program design, implementation, marketing, sales volume, and customer satisfaction.

Analyst. Residential – Low-Income Multifamily Weatherization Evaluations. For Efficiency Maine, conducted a process evaluation of a low-income weatherization program for multifamily homes. Interviewed program staff and property managers, and surveyed tenants to assess their experiences with the program. Collected billing data from participants for use in a gas and fuel oil billing analysis to estimate energy savings and cost-effectiveness.

Analyst. Residential – Massachusetts Residential Products. For the Massachusetts Program Administrators (MA PAs), served as a project analyst for a residential products and appliance recycling study. Contributed to a participant survey to estimate in-service rates, short-term persistence, and NTG ratios for numerous consumer products purchased online or with mail-in rebates. Performed a literature review to help benchmark results and provided additional information for products that could be added to the program in the future.

Task Lead. Commercial – Gas Kitchens Process Evaluation. For National Grid New York, conducted in-person interviews with participants who received incentives toward purchase of energy-efficient cooking equipment. Supported the development of final report, which offered insights into program administration and delivery challenges and successes, and customer and vendor satisfaction.

Task Lead. Residential and Commercial – Code Compliance Trainings. For MA PAs, analyzed survey data for the Code Compliance Support Initiative trainings over a multi-year period. Conducted in-depth interviews with market actors who utilized the Mass Save Energy Code Technical Support Initiative to understand their perspectives and satisfaction with the trainings. Analyzed results of the interviews and reported on findings and program recommendations.

SELECTED PRESENTATIONS AND PUBLICATIONS

"Boiling Down Complexity: Innovative Program Approaches to Optimize Efficient Commercial Boiler Systems." ACEEE Summer Study, August 2012. Asilomar, CA.

"CEE High-Efficiency Commercial Gas Water Heating Initiative Description." Consortium for Energy Efficiency. 2011. Link to the current version of this description.

"Working Together to Transform the Market for Water Heating." ACEEE Summer Study, August 2010. Asilomar, CA.

"A Market Transformation Strategy for Gas-Fired Domestic Hot Water Heaters." ACEEE Summer Study, August 2008. Asilomar, CA.

AMY WHITFORD

Associate Administrative Manager | Employee Owner

- SharePoint and Data Security Point Person
- Six years' experience
- B.A. English, University of Vermont

WORK EXPERIENCE

2017 – Present	**Associate Administrative Manager, NMR Group, Inc.,** Somerville, MA
2015 – 2016	**Project Manager/Bookkeeper/HR, Janine Dowling Design, Inc.,** Boston, MA

RESPONSIBILITIES

Invoicing – pull billable hours from employee timesheets; get project manager approval; create invoice, including any backup documentation; incorporate subs' invoices into main invoice.

Incentive Management – order, issue, and track incentives for all projects.

SharePoint Management – assign and manage permissions to project sites, including troubleshooting access issues.

Contract Organization – file all versions of client contracts from initial draft to final execution.

Budget Tracking – enter invoice amounts, including expenses, into database and track budget each month.

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MATTHEW WOUNDY

Research Analyst | Employee Owner

Analyst

Five years' experience

M.S. Environmental Policy and Sustainability Management

WORK EXPERIENCE

2015 – **Present** **Research Analyst, NMR Group, Inc.,** Somerville, MA

CERTIFICATIONS

Certified HERS Rater – Residential Energy Services Network (RESNET)

ILLUSTRATIVE PROJECTS

Field Technician, Analyst, QC Reviewer. Residential – New Construction Baseline. For the Massachusetts Program Administrators (MA PAs), Connecticut Companies and EEB, and National Grid Rhode Island, performed HERS energy audits, data analysis, reporting, training, and data QA/QC for five baseline studies in MA, CT, and RI. Assessed code compliance of new, non-program construction and analyzed data to characterize the non-program RNC market and update the savings baselines used by each program.

Analyst, Field Technician. Residential – New and Existing Homes Baseline. For Efficiency Vermont, performed home energy audits and data analysis to establish baseline understanding of energy characteristics in both new and existing single- and multifamily housing units in Vermont. Data were used to assess opportunities for energy savings, levels of code compliance, and market baselines.

Analyst, Field Technician, and QC Reviewer. Residential – Existing Homes Baseline. For the Pennsylvania Utility Commission, performed home energy audits, data QA/QC, and data analysis. On-sites were performed to establish a baseline understanding of energy characteristics in single- and multifamily housing units in Pennsylvania and provide values to inform an update to the PA TRM.

Analyst, interviewer. Residential – Passive House Assessment. For the MA PAs, evaluated implications of creating a Passive House (PH) offering within the high-rise and low-rise residential new construction programs. Conducted in-depth interviews with PH experts, performed a savings comparison between PH projects and new construction program participants, and assessed modeling performance of various PH and HERS rating software in assessing baseline and as-built energy savings.

Analyst. Residential – Utility Portfolio Evaluation. For the Pennsylvania Public Utility Commission, conducted engineering desk reviews and data analysis to verify the reported electric and demand savings of residential programs operated by the seven largest Pennsylvania Electric Distribution Companies (EDCs).

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Field Technician. Commercial – C&I End Use and Saturation Study. For the Pennsylvania Public Utility Commission, collected data at commercial and industrial sites across PA to categorize a wide variety of end-uses and their efficiency and to better understand the sources of energy consumption among commercial customers to inform a future market potential study.

Analyst, Commercial and Industrial – Luminaire Level Lighting Control Market Assessment. For NEEA, performed 30 in-depth interviews with commercial lighting market actors to learn more about the market for advanced networked lighting controls in the Pacific Northwest – including market barriers and opportunities – and develop recommendations for the NEEA LLLC Program.

Analyst. Residential – Technical Reference Manual (TRM) Update. For the Pennsylvania Public Utilities Commission, assisted in updating residential savings measures included in the TRM. Helped to develop updated TRM measure inputs with data from new baseline study. Verified updated sources and algorithms for accuracy and assisted in drafting TRM Order to detail changes for public review and comment.

Analyst. Residential – New Construction Net-to-Gross Study. For the Connecticut Companies and EEB, analyzed qualitative and quantitative responses from a panel of experts (Delphi Panel) convened to estimate alternate scenarios for home energy efficiency in the absence of the RNC program and to generate a net-to-gross value reflecting the impact of the Connecticut RNC Program on participants and non-participants.

Analyst, Field Technician, and QC Reviewer. Residential – Residential Appliance Saturation Survey (RASS). For National Grid Rhode Island, performed on-site measure verification of survey respondents and collected data on home efficiency to inform a heat pump feasibility study. Utilized Manual J software to assess heating loads and the feasibility of heat pump installation in homes. Analyzed on-site verification data to characterize the efficiency of HVAC and building shell measures in existing homes.

Analyst. Residential – Additions and Renovations. For the MA PAs, assisted in fielding and managing web surveys with contractors that performed additions and renovations work in Massachusetts in order to characterize the size and efficiency baselines of a market in the state with little available information.

Field Technician. Commercial – C&I Lighting Impact and Market Characterization. For the MA PAs and NGRID New York, performed field data collection, including logging commercial lighting installations, in support of two impact evaluations of C&I lighting retrofit programs. For National Grid Rhode Island, conducted site visits to inventory lighting and HVAC equipment as part of a statewide market characterization study.

SELECTED PRESENTATIONS AND PUBLICATIONS

Urban Transport Solutions, Lead Author, with Coordinating Lead Authors, Mehrotra, S., Zusman, E. and Lead Authors, J. N. Bajpai, K. Jacob, M. Replogle, L. Fedirko, & S. Yoon in C. Rosenzweig, W. Solecki, S. Dhakal, and P. Romero-Lankao, S. Ali-Ibrahim, Eds., *Climate Change and Cities: Second Assessment Report (ARC3–2),* London: Cambridge University Press.

Zack Tyler

Director | Employee Owner

Analyst

Eleven years' experience

M.A., Energy and Environmental Analysis, Boston University

WORK EXPERIENCE

2009 – Present **Director, NMR Group, Inc.,** Somerville, MA

CERTIFICATIONS

Certified Passive House Consultant (2019 – Present) – Passive House Institute U.S.

HERS Rater (2010 – Present) – Residential Energy Services Network

BPI Multifamily Building Analyst (2014 – 2017) – Building Performance Institute

Level I Certified Building Investigations Infrared Thermographer (2012 – 2017) – FLIR

ILLUSTRATIVE PROJECTS

Project Manager. Residential – Low-Income Impact Evaluation. Led an impact evaluation for the Independent Electricity System Operator (IESO) for their low-income Home Assistance Program. Tasks included client interaction, impact calculation QA/QC, reporting, and advising on key deliverables.

Project Manager. Residential – Vermont Residential Baseline Study. For the Vermont PSD, led the on-site component and RBES compliance assessment of the 2016 residential market characterization study covering both new and existing construction. Task included on-site staff management, leading the RBES compliance analysis, overall review of all on-site reporting, and advising on other key deliverables.

Project Manager. Market Characterization – Renovations and Additions Market Characterization Study. For the Massachusetts Program Administrators (MA PAs), managing a study that is assessing the size of the renovations and additions market and the scope of projects taking place in Massachusetts. This study is using web surveys with contractors and homeowners, focus groups with contractors, and in-depth interviews with HVAC contractors to estimate these factors. Tasks include overall management, client interaction, critical review, and reporting.

Project Manager. Residential – Single-Family Code Compliance/Baseline Study. For the MA PAs, oversaw a baseline study of 200 new non-program single-family homes throughout Massachusetts. The study included comprehensive Home Energy Rating System (HERS) ratings, including full diagnostic testing and energy modeling for each home. The study updated the RNC program user-defined reference home and assessed compliance with homes built under various codes. Tasks included overall project management, field work, analysis, and reporting.

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Project Manager. Residential – Code Compliance and Potential Savings Assessment. For the Connecticut Energy Efficiency Fund, managed an evaluation that measured code compliance and assessed the potential savings associated with increasing compliance within single-family homes in Connecticut. The study was used to help the state determine how to target compliance trainings. Tasks included overall management, analysis, and reporting.

Project Manager. Residential Multifamily – Multifamily High-Rise New Construction Baseline Study. For the MA PAs, managed a baseline study of Multifamily High-rise New Construction in Massachusetts. The study leveraged mixed methods to develop baseline estimates, including on-site visits, detailed plan reviews, and building department visits. The study was used to update the baseline for program savings calculations. Tasks included overall management, analyzing efficiency characteristics, and reporting on study results.

Project Manager. Program Design – Passive House Program Design Assistance. For the MA PAs, managed a study that was designed to provide detailed information to inform a new Passive House initiative. This study gathered information from market actors regarding incremental costs, incentive structure options, and barriers and opportunities associated with building to Passive House design principles. This study also provided feedback on the appropriate modeling tools to use for program savings calculations. Tasks include overall management, client interaction, quality control, and reporting.

Project Manager. Residential – Weatherization. Conducted a baseline study for the Connecticut Energy Efficiency Fund to assess the energy related characteristics of the single-family housing stock in the state of Connecticut. Tasks included, but were not limited to, interacting with clients on a weekly basis, managing field work, managing analysis, conducting energy audits, modeling energy usage in REM/Rate, and reporting/presenting on study results.

SELECTED PRESENTATIONS AND PUBLICATIONS

“Pushing the Market: Measure Market Effects in Residential New Construction.” IEPEC, August 2019. Denver, CO.

“Giving Credit Where Credit is Due: Assessing Attribution and Savings from a Building Energy Code Compliance Enhancement Program.” IEPEC, August 2019. Denver, CO.

“Polishing a Hidden Gem: A Novel Evaluation Method for Energy Codes & Standards Programs.” ACEEE Summer Study, August 2018. Asilomar, CA.

“How’s That for Performance? Changes in New Construction Practices Over Time.” IEPEC, August 2017. Baltimore, MD.

“How do Enhanced Code Requirements Influence Compliance and Building Efficiency: A Massachusetts Case Study.” ACEEE Summer Study, August 2016. Asilomar, CA.

“New Construction Multifamily Building Recruitment – A ‘Full Contact’ Game!” IEPEC, August 2015. Long Beach, CA.

“Just What do you Mean by ‘Weatherized’? Assessing and Achieving a Statewide Weatherization Target.” Department of Energy Building Technologies Office Peer Review Conference, April 2015. Tysons, VA.

Kailey Pratt

Research Associate I | Employee Owner

Analyst

Six years' experience

B.A. Policy and Management in Environmental Science

WORK EXPERIENCE

2014 – Present **Research Associate I, NMR Group, Inc.,** Somerville, MA

ILLUSTRATIVE PROJECTS

Onsite Management. Retail – Lighting. Worked with the Consortium for Retail Energy Efficiency Data (CREED) and Demand Side Analytics to conduct shelf-stocking and sales data analysis in non-program states in the fall of 2020. The goals of the study were to assess the availability and sales of LEDs vs. incandescent and halogen alternatives. Responsibilities included leading field and data collections training, managing data collections and oversee all visits.

Analyst. Code Implementation – Commercial Building Designers. For Northwest Energy Efficiency Alliance (NEEA), created survey instrument and formula to develop commercial energy code implementation practices. Conducted both mail and email outreach to 1,089 participant sample.

Onsite Management. Residential – Lighting. Massachusetts Sponsors. This was an on-site saturation study and a lighting stagnation study to observe saturation over time with a comparison to New York. Onsite visits were conducted throughout Massachusetts and New York. Responsibilities included recruiting and scheduling over 570 onsite visits for 11 technicians in Massachusetts and New York, and conducting onsite visits.

Analyst Appliances – Consumer Satisfaction Survey. For the Michigan utilities, analyzed and reported on monthly and quarterly customer satisfaction for appliance and thermostat rebate program, including multiple choice and open-ended questions**.**

Lead Technician/Onsite Management. Residential – RASS. Connecticut and Rhode Island Sponsors. Acted as a lead technician and assisted with coordinating 165 visits and managing technicians. Responsibilities included conducting basic energy audits by collecting data on home characteristics, lighting, appliances, water fixtures, and ventilation equipment.

Onsite Management/Technician – Single-Family New Construction Energy Efficiency. Massachusetts Sponsors. Acting as the lead recruiter, scheduler, and assistant technician. Responsibilities include recruiting and scheduling 200 hundred single-family homes with complex sample targets, conducting online research, and visiting building departments to gather code compliance information. Onsite responsibilities include collecting information on lighting, appliances, water fixtures, and ventilation equipment.

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Management. Residential – Market Transformation Effective Practices. Missouri Sponsors. This study consisted of reaching out to store program participants and conducting customer surveys on site to learn behaviors of residential lighting purchasing patterns. Responsibilities included recruiting and scheduling visits with store managers to 16 stores and conducting 131 of 218 the interviews with the customers.

Onsite Technician. Residential – Single-Family and Multifamily Baseline Study. Vermont Sponsors. This study consisted of 275 on site visits with a mix of new construction and existing multifamily and single-family homes. Responsibilities included the collecting of all fuel data usage from participating Vermont vendors for data analysis, recruiting and scheduling the onsite visits, and conducting the audits for both single family and multifamily.

Residential – Air Sealing and Duct Sealing Evaluation. Connecticut Energy Efficiency Fund. Responsibilities included recruitment and scheduling of 70 onsite inspections, coordinating with field staff, and conducting in-depth interviews with homeowners.

Residential – Lighting. Connecticut Energy Efficiency Fund. Responsibilities included recruiting and scheduling 75 to 100 site visits for three technicians, conducting on-site visits, and completing follow up quality control visits and calls.

Residential – Energy Efficiency. Efficiency Maine. This study consisted of onsite visits to assess the energy-related characteristics of Maine's residential housing stock. Responsibilities included recruiting 41 homes with specific sampling targets and scheduling them by either phone or email.

Residential – Multifamily High-Rise Baseline Study. Massachusetts Sponsors. This study consists of onsite visits at newly constructed multifamily high-rise buildings in Massachusetts to develop a baseline for the Massachusetts Multifamily High-Rise New Construction Program. Responsibilities included online research and screening, recruitment via telephone and email, and scheduling site visits.

JULIAN RICARDO

Engineer III | Employee Owner

Analyst

Three years' experience

M.S. Earth and Environmental Engineering

WORK EXPERIENCE

2020 – Present	**Engineer III, NMR Group, Inc.,** Somerville, MA
2017 – 2019	**Engineer II, NMR Group, Inc.,** Somerville, MA
2015 – 2016	**Solar Research Fellow, American Solar Partners,** Mt. Vernon, NY

ILLUSTRATIVE PROJECTS

Analyst. Residential – EDC Audits. For the Pennsylvania Public Utilities Commission, ensured the reliability and accuracy of the EDC EE&C program savings estimates by checking that EDC data and reports are accurately calculated and show the correct TRM savings. The measures audited for savings accuracy included HVAC equipment, water heaters, appliances, and lighting.

Field Technician. Commercial and Industrial – Baseline Study. For the Pennsylvania Public Utilities Commission, conducted site audits and on-site interviews as part of a baseline study of commercial and industrial facilities across multiple utility territories.

Analyst, Field Technician. Commercial – Impact and Process Evaluation. For National Grid New York, developed analysis for measurement and verification of lighting savings, comparing methods that employ advanced metering infrastructure (AMI) against photocell logger data. Built dashboard to track logger deployments and customer survey response rates. Conducted site visits, trained technicians to conduct visits, and coordinated with vendors to capture logger and HVAC information.

Analyst. Commercial and Residential – Impact and Process Evaluation. For the Independent Electricity System Operator (IESO), developed sample frames, audited savings calculations, analyzed data, and contributed to both process and impact reporting. Verified accuracy and consistency of savings calculations in project files. Developed samples and analyzed results from web and phone surveys of program participants, non-participants, contractors, and program staff. Assisted with in-depth interviews, net-to-gross (NTG) calculations, and a literature review of peer programs.

Analyst and Field Technician. Commercial – Custom Electric Impact Evaluation. For the Massachusetts Program Administrators (MA PAs), conducted site audits and on-site interviews to collect information on custom electric equipment. Reviewed measurement and verification (M&V) plan documents and conducted independent analysis to verify savings.

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Analyst. Commercial – TRM Development. For Vermont Gas, conducted research into updates for applicable measures listed in the utility technical reference manual (TRM) based on existing TRMs, Federal standards, ENERGY STAR® specifications, and IECC requirements. Researched new sources for outdated references. Verified and reconfigured savings algorithms to improve accuracy and ease of use. Trained utility staff on using TRM-based calculators for deriving energy savings.

Analyst. Commercial – Luminaire-Level Lighting Controls (LLLC) Study. For the Northwest Energy Efficiency Alliance, reviewed secondary datasets to estimate distribution of sales and installations of LLLC fixtures across different building types and states. Estimated floor space subject to different commercial codes in Northwest region to quantify energy savings potential of LLLC fixtures. Developed interactive visualizations and reporting of this secondary data review.

Analyst. NTG, Residential – High-Efficiency Heating Equipment NTG. For National Grid New York, assisted with creating and fielding survey instrument, as well as formula to develop residential heating equipment NTG ratios. Conducted analysis and contributed to reporting of survey results.

Analyst. Residential – Smart Power Strip Metering Study. For the MA PAs, developing customer survey and NTG instruments for evaluating energy savings opportunities for Smart Power Strips in MA homes. Analyzing data and contributing to report sections detailing program participants' responses to survey questions evaluating the program process, as well in-service rates and NTG.

Analyst. Commercial and Residential – Code Compliance Process Study. For the MA PAs, analyzed survey data for the Code Compliance Support Initiative trainings for code official and builders that spanned several years. Analyzed geographic distribution of training attendees. Reported findings of most recent trainings and put them in context of past trainings.

SELECTED PRESENTATIONS AND PUBLICATIONS

"Hard Times for an Honest Logger? Optimizing a Small Business Direct Install Logger Study in an M&V 2.0 Landscape," IEPEC, August 2019. Denver, CO.

"Into the Great Wide Open: A Comparison of M&V 2.0 and Traditional Evaluation Methods for a Small Business Direct Install Program," ACEEE Summer Study, August 2018. Asilomar, CA.

"Time to Move On: An Examination of Metering Periods for Small Business Direct Install Participants," ACEEE Summer Study, August 2018. Asilomar, CA.

"A Framework for Comparing the Economic Performance and Associated Emissions of Grid-Connected Battery Storage Systems in Existing Building Stock: a NYISO Case Study," IEEE Photovoltaic Specialists Conference, June 2017. Baltimore, MD.

FERIT UCAR

Senior Economist | Employee Owner

Analyst

Twelve years' experience

PhD Economics, Princeton University

WORK EXPERIENCE

2020 – Present	**Senior Economist, NMR Group, Inc.,** Brooklyn, NY
2020 – 2020	**Senior Advisor, New York State Department of Public Service,** New York, NY
2015 – 2019	**Senior Economist, Environmental Defense Fund,** New York, NY
2014 – 2015	**Senior Quantitative Analyst, NMR Group, Inc.,** Princeton, NJ
2008 – 2013	**Senior Project Director, APPRISE,** Princeton, NJ

ILLUSTRATIVE PROJECTS

Lead Analyst. Residential – Low-Income Program. For PECO, served as the lead analyst for the annual evaluation for several years, which provided energy-efficiency services to low-income customers in Pennsylvania. Reviewed and analyzed data from the program tracking database. Analyzed billing data and developed estimates of energy and cost savings of the program. Developed regression models to estimate measure-level savings and to assess cost-effectiveness at program and measure levels. Analyzed survey data from the energy education survey to measure the extent to which the energy education provided as part of the program was effective.

Statistician. Residential Baseline. For the Vermont Department of Public Service (PSD), led the sample design for the existing home and new construction baseline studies. These studies included web surveys and extensive on-site data collection to provide the PSD with the current baseline conditions for both new and existing structures, in both single-family and multifamily housing units, in the residential sector by assessing saturation and efficiency levels associated with building equipment and features.

Policy Advisor. Buildings and Transportation. For New York State, served as a policy advisor on the development of a carbon-neutral buildings roadmap and a clean transportation roadmap, which provided a blueprint of actions and policies to support decarbonizing the state's building stock and transportation sector by 2050.

Lead Analyst. Clean Energy Programs. For the Vermont Clean Energy Development Fund (CEDF), led the impact assessment of the CEDF programs since its inception. The impact assessment consisted of an analysis of CEDF project-level data to estimate energy, environmental, and economic impacts, as well as a qualitative estimate of net impacts through a review of recent evaluations of renewable energy programs and interviews with program participants, market actors, and contractors.

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Project Manager. Residential – Low-Income Program. For the Department of Energy's Weatherization Assistance Program (WAP), led a multi-year, national process and impact evaluation of WAP. Managed the development and maintenance of the databases for data collection from 50 states and the District of Columbia, 400 local agencies, and over 1,000 gas and electric utility companies. Oversaw the migration of data from the state program tracking databases, contributed to billing data analysis to estimate energy and cost savings, and developed information on the eligible population for weatherization services and the targeting of program services to the priority groups. Designed the sample frames, selected the samples of agencies, utility companies, and clients.

Lead Analyst. Residential – Low-Income Program. For Efficiency Maine, led the impact evaluation of this program, which was administered by the Efficiency Maine Trust and installed energy-efficiency measures, including ductless heat pumps, air sealing, and insulation in qualified electrically- and gas-heated multifamily properties in Maine over several years. The impact evaluation included the measurement and verification of gross and net program energy and demand savings, and an assessment of cost-effectiveness at the measure, building, and program level.

Lead Analyst. Residential and Commercial – Economic Modeling. For the Massachusetts PAs, developed a macro-economic (top-down) modeling approach to estimate the total, net impact of energy-efficiency programs administered by the Massachusetts utilities in the state for both residential and non-residential sectors. This top-down technique uses a holistic approach by estimating program impacts across all energy-efficiency programs in a geographical region or service territory rather than running separate studies for each program (or measure/end-use within a program).

Project Director. Power System Modeling. For Environmental Defense Fund, directed a power system modeling study for the Eastern Interconnection using Wisdom optimization model, which is a blended production cost and capacity expansion model that simulates electric system and wholesale market behavior under security-constrained economic dispatch and examines how the system evolves over time. The study also explored the impact of electrification of buildings and transportation sector on the grid and identified ways to most efficiently integrate this new load into the grid.

SELECTED PRESENTATIONS AND PUBLICATIONS

"Driving Environmental Outcomes Through Utility Reform: Lessons from New York REV." 2018. *EDF Whitepaper*. E. Stein and F. Ucar.

"The View from the Top: Top-down Estimation of Program Savings in Massachusetts." 2015. *International Energy Program Evaluation Conference*. C. Russell, et al.

"Evaluation of the Weatherization Assistance Program During Program Years 2009-2011 (American Recovery and Reinvestment Act Period): Energy Impacts for Single Family Homes." 2014. *Oak Ridge National Laboratory*, ORNL/TM-2014/582. M. Blasnik, et al.

"National Weatherization Assistance Program Impact Evaluation: Energy Impacts for Single Family Homes." 2014. *Oak Ridge National Laboratory*, ORNL/TM-2015/13. M. Blasnik, et al.

"Comparison of Pooled and Household Level Usage Impact Analysis." 2013. *International Energy Program Evaluation Conference*. J. Berger and F. Ucar.

Samuel Manning

Research Analyst

Analyst

Four years' experience

B.B.A, Business Management, Colorado Mesa University

WORK EXPERIENCE

2016 – Present **Research Analyst, NMR Group, Inc.,** Somerville, MA

CERTIFICATIONS

Certified Passive House Consultant (CPHC) – Passive House Institute US (PHIUS)

Home Energy Rater (HERS Rater) – Residential Energy Services Network (RESNET)

ILLUSTRATIVE PROJECTS

Field Technician, Analysist, and QC Reviewer. Residential and Commercial – Baseline Study. For the Pennsylvania Utility Commission, conducted HERS audits on existing homes and performed data collection on large multifamily and commercial buildings. Developed REM/Rate energy models, and conducted HVAC data analysis for baseline report. On-sites were performed to update baseline energy characteristics for existing single- and multifamily units and to inform an update to the PA technical reference manual (TRM).

Analyst. Residential and Commercial – Statewide Utility Portfolio Evaluation. For the Pennsylvania Public Utility Commission, conducted engineering desk reviews and program-level audits of verified savings calculations for energy-efficiency program measures of the seven major Electric Distribution Companies in Pennsylvania. Reported on discrepancies between the Pennsylvania TRM and EDC-specific EM&V plans for reported and verified savings. Reviewed program documents to ensure consistency in reported savings and data collection practices. Developed automated TRM savings calculation worksheets.

Lead Analyst. Residential – Low-Income Direct Install Impact Evaluation. For the Independent Electricity System Operator (IESO), conducted engineering desk reviews, TRM reviews, engineering calculation updates, and calculated verified savings for a low-income residential direct installation program. Reviewed project documentation to ensure consistency and accuracy of reported savings, identified systematic issues, and reviewed data collection practices and procedures. Developed automated TRM savings calculation worksheets based on engineering algorithms.

Project Manager. Residential – Passive House Assessment. For the Massachusetts Program Administrators (MA PAs), conducted literature review, in-depth interviews, model comparisons between five different energy modeling software, and savings assessments for Passive House construction. The results of the evaluation were used to identify opportunities and barriers for Passive House construction in Massachusetts, recommendations for calculating savings and appropriate modeling tools, and guidance on baseline model assumptions for initial program design.

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Field Technician, Analyst, QC Reviewer. Residential – New Construction Baseline. For the MA PAs, Connecticut Companies and EEB, and National Grid Rhode Island, conducted HERS energy audits; developed REM/Rate and Ekotrope energy models; and performed data analysis, reporting, and QA/QC for four baseline studies in MA, RI, and CT. Drafted and participated in conversations to update the user-defined reference home. The studies were used to assess trends in new construction, assess code compliance rates among new homes, and update the baseline against which to quantify RNC program savings.

Lead Analyst, Interviewer. Residential and Commercial – HVAC Equipment and Supply Chain Characterization. For ComEd, conducted literature review, market size assessment, in-depth interviews, and overall market characterization for residential and commercial HVAC equipment in Northern Illinois. Characterized supply chains, market segments, and market actor involvement for various types of HVAC equipment. This market characterization was used to inform who are major and minor influencers on customer purchase decisions, quantify equipment sales for HVAC equipment in Northern Illinois, map out how equipment flows through the market, and identify best practices for moving HVAC programs midstream.

Lead Analyst. Residential – New Construction and CCSI Attribution. For the MA PAS, conducted analysis of efficiency levels for building shell components, HVAC, leakage, and lighting based on code (stretch and 2012 IECC). Managed outreach and recruitment process for Delphi Panel. Developed survey instruments for three rounds of Delphi Panels, which included results from analysis, historical code requirements, program activities, and Delphi Panelist responses. Developed analysis tool for survey responses. Generated and conducted QA/QC on hundreds of REM/Rate energy models. Reported on methods and various results from the multi-method study. The Delphi Panel responses were used to inform gross savings estimates and net-to-gross ratios for the RNC program.

Lead Analyst. Residential – New Construction Incremental Cost. For the MA PAs, performed analysis of RNC program home REM/Rate models. Developed measure level databases for building shell components, HVAC, leakage, and lighting. Developed survey instruments to collect data from local contractors to assess the cost difference between non-program and program home building components. Conducted contractor recruitment for both low-rise and high-rise multifamily buildings. Reported on findings from data collection, secondary research, and analysis. The study was used to inform the total incremental cost per square foot for increasing efficiency levels from the baseline to the current program levels.

Field Technician and QC reviewer. Residential and Commercial – Lighting Saturation Study. For the MA PAs and Kansas City Power and Light, conducted on-site lighting saturation assessments for two commercial and three residential studies. Commercial building types include hospitals, universities, multifamily complexes, office buildings, and manufacturing sites. Installed, collected, and input lighting logger data into site specific data collection forms. Conducted training and QA/QC visits with local data collection technicians.

Project Manager. Residential – Incremental Cost Update. For the MA PAs, updated the incremental cost associated with participating in the residential new construction program. Applied cost estimates from primary and secondary sources to estimate the cost difference between non-program and program building components. Conducted data analysis and constructed cost estimates using a variety of regression techniques. The study was used to inform the total incremental cost per square foot for increasing efficiency levels from the baseline to the current program levels.

LAUREN ABRAHAM

Research Analyst II | Employee Owner

Analyst

Ten years' experience

M.A., Energy and Environmental Analysis, Boston University

WORK EXPERIENCE

2010 – Present	**Research Analyst II, NMR Group, Inc.,** Somerville, MA
2004 – 2010	**Senior Research Analyst, Dalbar,** Boston, MA

ILLUSTRATIVE PROJECTS

Task Lead. Residential – Impact Evaluation. For the Pennsylvania Public Utility Commission, leading an audit of the residential impact evaluations of the seven largest electric distribution companies in PA. The audit entails reviewing impact evaluation methods, assumptions, and calculations, and making final adjustments to ensure that savings reported by the electric distribution companies follow the guidelines set forth in the PA technical reference manual. Reviewing evaluation plans and survey instruments, and contributing to memos providing technical guidance to the electric distribution companies' evaluation, measurement, and verification contractors. Assisted in updating the technical reference manual and incremental cost database.

Task Lead. Residential and Low-Income Multifamily – Impact Evaluation. For the DC Department of Energy and Environment, leading an impact evaluation of the residential and low-income multifamily energy-efficiency and renewable energy projects implemented by the DC Sustainable Energy Utility. Periodically conduct comprehensive reviews of technical reference manual measure characterizations in an ongoing technical advisory process. Assisted in developing a logic model for a midstream program that provides instant rebates to customers purchasing lighting equipment through qualified distributors. Conducted a literature review of net-to-gross values from other jurisdictions for each of the programs offered by the DC Sustainable Energy Utility.

Lead Analyst. Residential – Impact and Process Evaluation. For the Independent Electricity System Operator (IESO, formerly Ontario Power Authority), conducted an impact evaluation of the IESO's consumer products initiatives. The impact evaluation included an engineering review of savings calculations, an input assumptions review, incremental cost updates, and estimation of net-to-gross savings factors. Analyzed survey results for participants and delivery agents in the IESO's low-income audit initiative. Summarized survey findings on participant motivations, barriers, behavior changes, satisfaction, and measure in-service rates and hours of use. Developed recommendations for program improvement based on these findings.

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Analyst. Residential – New Construction Baseline Studies. For various sponsors, performed data cleaning, analysis, and reporting for five separate residential new construction baseline studies in four states (MA, RI, CT, and VT). Calculated average R-values for attic, wall, floor, and duct insulation; average air changes per hour; average annual fuel utilization efficiency for heating equipment; average seasonal energy-efficiency ratio for cooling equipment; and the percentage of appliances that were ENERGY STAR® certified. Developed thematic maps displaying the towns in which sampled homes were located. Analyzed survey results from participating homeowners to assess decision-making processes for home features affecting energy use.

Analyst. Residential – Existing Homes Baseline Study. For the Vermont Public Service Department, identified trends and opportunities for energy efficiency within the existing single-family housing stock in Vermont based on findings from three consecutive baseline studies (conducted in 2008, 2011, and 2016). The baseline studies included on-sites to assess the energy characteristics of homes, and homeowner surveys to assess homeowners' awareness of energy efficiency and emerging technologies.

Analyst. Residential – Impact Evaluation. For Oak Ridge National Labs and US Department of Energy, conducted in-depth interviews with building owners and contractors to verify the installation of energy-efficiency measures and gather additional inputs for an impact evaluation of residential retrofit programs in multiple states (VT, MD, DE, GA, NE, MN, and LA). Entered the inputs into engineering algorithms to estimate gross and net energy savings.

Analyst. Residential – Market Progress Evaluation. For the Northwest Energy Efficiency Alliance, developed an in-depth interview guide for water heater distributors. Information gathered from the interviews was used to update market size estimates for the heat pump water heater market in the Northwest.

Field Technician. Residential – New Construction Baseline Study. For the Massachusetts program administrators, conducted site visits at new multifamily homes to gather data on lighting, appliances, insulation, and heating, cooling, and water heating equipment.

Lead Analyst. Residential and Low-Income – Non-Energy Impacts. For the Massachusetts program administrators, conducted extensive literature review of the non-energy impacts of residential and low-income energy-efficiency programs. Recommended non-energy impact estimation methods and values based on this review.

SELECTED PRESENTATIONS AND PUBLICATIONS

"Deep Dish: In-Depth Interviews Across Diverse Populations," IEPEC Conference, August 2017. Baltimore, MD.

JERRAD PIERCE

Senior Data Scientist | Employee Owner

- Analyst
- Six years' experience
- M.A. Urban and Environmental Policy & Planning

WORK EXPERIENCE

2016 – Present **Research Analyst, NMR Group, Inc.,** Somerville, MA

2015 – 2015 **Energy Conservation specialist, Boston Public Schools,** Boston, MA

CERTIFICATIONS

HERS Rater – RESNET ID #0134188

ILLUSTRATIVE PROJECTS

Analyst, Residential – Pennsylvania Statewide Evaluator. Review annual utility program savings reports. Develop new climate region system with GIS based on NOAA and IECC classifications. Revise multiple measures for the 2021 TRM, including some supported by numerous models of prototypical homes in various climate regions. Conduct energy audits for 2018 baseline.

Analyst, Residential – Massachusetts Code Promulgation Attribution. Estimate gross technical potential savings from increased mechanical equipment efficiency and insulation installation code quality amendments to the second revision of Massachusetts building code 9th edition.

Analyst, Residential – Massachusetts New Construction Baseline. Develop data collection form. Conduct energy audits. Assess energy-model derived code compliance for program and non-program homes, using conventional measure-level checklists for non-program homes. Compare REM/Rate and Ekotrope modelling outputs.

Analyst, Residential – New York Market Measure Evaluation. Estimate costs, market size, and savings potential of conventional and emerging efficiency measures (such as dual-fuel heat pumps) for multiple market segments (single-family, multifamily, low-income) and regions.

Analyst, Residential – NYSERDA Net-Zero Segmentation. Generated least-cost deep energy retrofit packages using baseline results, TRM defaults, and other data sources for more than a dozen prototype home profiles in climate zones across New York State. Created density maps showing areas of the state with the greatest concentration of households and housing stock most amenable to achieving net zero energy use through deep retrofits.

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Analyst. Residential – National Grid Rhode Island Residential Appliance Saturation Survey (RI2311). Develop data collection form and produce Manual J models for a ductless mini-split heat pump feasibility study.

Analyst. Residential – Vermont Residential Baseline Study. Conduct energy audits and analyze properties of multiple building components. Assess duct insulation and basement wall insulation compliance with Vermont Residential Building Energy Code, plus Manual J HVAC sizing requirements.

Analyst. Residential – Connecticut Codes and Standards Assessment. Use program data and results from the recent new construction baseline to assess code compliance and the gross technical savings potential of increased compliance. Conduct literature review of best practices for code compliance promotion activities in other jurisdictions.

Analyst. Residential – 2015 Massachusetts Stretch Code Update Compliance and Potential. Model average new construction gross technical savings potential for program and non-program homes in the early stages of the revised Stretch Code deployment, including code compliance statistics.

Analyst. Residential – MidAmerican Residential New Construction Program. Review program data and model energy savings to develop revised user-defined reference home used as the basis for future program energy savings calculations in MidAmerican's Iowa service territory.

Analyst. Lighting Residential Lighting Upstream Distribution Model (TXC 40). Model drive times to various classes of retail outlet across Massachusetts and New York to support analysis of efficient light bulb availability.

Project Lead. Appliances – Device Efficiency Database. Develop an internal, central repository to simplify look-up of equipment efficiency details. This project requires the harmonization of data structures from disparate resources to permit the merging and deduplication of tens of thousands of records.

SELECTED PRESENTATIONS AND PUBLICATIONS

"EF, MEF, and IMEF Oh My!" Poster on conversion of older equipment efficiency ratings in energy modeling, to be presented at International Energy Program Evaluation Conference (IEPEC), August 2019

"Five Stars—Would Totally Buy Again!!!! A Novel Method and Data Source to Study Consumer Lighting Decision-Making" Poster presented at International Energy Program Evaluation Conference (IEPEC), August 2017

"How do Enhanced Code Requirements Influence Compliance and Building Efficiency? A Massachusetts Case Study" Paper presented by Zack Tyler at American Council for and Energy-Efficient Economy (ACEEE) Summer Study, August 2016.

CHRIS RUSSELL

Senior Quantitative Analyst | Employee Owner

Analyst

Eleven years' experience

Ph.D., Demography, Texas A&M

WORK EXPERIENCE

2009 – Present	**Senior Quantitative Analyst, NMR Group, Inc.,** Somerville, MA
2007 – 2008	**Demographer, Population and Survey Analysts,** College Station, TX

ILLUSTRATIVE PROJECTS

Analyst – Statewide Evaluator. For the Pennsylvania Public Utility Commission (PUC), leading the Statewide Evaluation Team (SWE), focusing on evaluating the performance of the Energy Efficiency and Conservation (EE&C) program portfolios of the seven largest Electric Distribution Companies (EDCs). Reviewed residential and commercial NTG methodologies and results to determine their appropriateness and accuracy.

Lead Analyst. Residential – Behavioral Intervention. For Pennsylvania FirstEnergy, led an impact evaluation of electric energy savings derived from a home energy report behavioral intervention. Duties included dataset management and testing data for imbalances and bias. Oversaw the analysis and reporting of the analysis. The primary analytic tool was a panel fixed-effects multivariate regression with clustered standard errors.

Lead Analyst. Residential and Commercial – Top-Down Macro Econometric Modeling. For the Massachusetts program administrators (MA PAs), developed an econometric model that measured the impact energy-efficiency programs have had (at the utility level) on energy consumption over the past 23 years. Responsibilities included data gathering, modeling, and project management.

Project Manager. Residential – Single-Family Retrofit Programs Impact Evaluation. For the New York State Energy Research and Development Authority, serving as lead analyst to estimate electric savings in an impact evaluation of single-family households that have taken part in retrofit programs from 2012 to 2017. Households include low- and moderate-income households and market-rate households. The study will employ a billing analysis to estimate whole-house and measure-specific savings by program, funding source, and income group. Will be responsible for the electric billing analysis for all participants.

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Lead Analyst. Commercial – Small Business Direct Install Impact Evaluation. For National Grid New York, served as a lead analyst in a study designed to compare analysis methods for determining program savings from the Small Business Direct Install (SBDI). Performed a billing analysis using fixed-effects linear regression and whole-home seasonal degree day adjustment modeling on the 2016 SBDI participant population. Compared results to those produced by another vendor, and assessed which approach most accurately described program impacts.

Lead Analyst. Residential – Lighting Market Adoption Model. For the MA PAs, developed and revised a spreadsheet-based tool to analyze lighting technology market adoption in the face of increased federal lighting standards and the introduction of new lighting technologies. The tool establishes a lighting market baseline and utilizes multiple scenarios to predict delta watts given varying assumptions about the future market share of various bulb technologies. The tool also allows the client to manipulate adoption assumptions for program planning purposes.

Lead Analyst. Residential – Home Energy Reports Process and Impact Studies. For Eversource Connecticut and the Connecticut Energy Efficiency Board, led the analysis of the impact portion of a multi-year process and impact evaluation of a pilot behavioral home energy reports program. Duties included data management, conducting a billing analysis, and reporting the results. Estimated savings for various sub-groups of participants (e.g., pre-program energy use, home heating fuel, and frequency and duration of reports). The billing analyses used a fixed-effects linear regression, compressed ordinary least squares, and difference-in-differences on all pre-selected 35,000 participants and 35,000 non-participants to estimate energy savings.

SELECTED PRESENTATIONS AND PUBLICATIONS

"A Clarification Please: Comparing the Different Meanings of Persistence in Home Energy Report Programs and the Implications for Program Designs." BECC, October 2017. Sacramento, CA

"America's Next Top Model: Prediction of Lighting Market Change in Response to Laws and Consumer Adoption Since 2012." IEPEC, August 2017. Baltimore, MD.

"The View from the Top: top-Down Estimation of Program Savings Using Utility-Level Data in Massachusetts". IEPEC, August 2015. Long Beach, CA.

"What's the Point (of Sale)? Program Activity Impacts Efficient Bulb Sales – Proof Across 44 States and Five Years." IEPEC, August 2015. Long Beach, CA.

"Behavioral Effects: How Big, How Long, From Whom, How Best?" ACEEE Summer Study, August 2014, Asilomar, CA.

"Sure They Work, but for How Long?" IEPEC, August 2013, Chicago, IL.

"Net Impacts from Upstream Lighting Programs." IEPPEC, August 2012. Rome, Italy.

Melissa Meek

Project Manager | Employee Owner

- Analyst
- Four years' experience
- M.A. International Relations

WORK EXPERIENCE

2016 – Present	**Project Manager, NMR Group, Inc.,** Somerville, MA
2013 – 2016	**Research Associate, Massachusetts Institute of Technology,** Cambridge, MA

ILLUSTRATIVE PROJECTS

Analyst. Commercial/Residential – Process Evaluation Audit. Reviewed process evaluations for rigor and adherence to evaluation plans as part of a statewide audit of evaluation activities in Pennsylvania. Contributed to the 2018 and 2019 Annual Report.

Lead Analyst. Commercial/Residential – Process Evaluation. For DCSEU, conducted in-depth interviews with program staff and partners. Developed a participant sample and oversaw the distribution of surveys. Contributed to survey analysis and reporting.

Lead Analyst. Commercial – Process Evaluation. For the Independent Electric System Operators (IESO), conducted process evaluation and NTG analysis of business refrigeration and retrofit programs. Contributed to survey fielding, data analysis, and reporting.

Analyst. Commercial – Process and Impact Lighting Evaluation. For Xcel Energy, interviewed trade allies about their experience with small business lighting programs in Colorado and Minnesota. Estimated net-to-gross ratios and used the results of program participant and non-participant end-user, trade ally, and vendor telephone surveys to determine free-ridership and spillover values for commercial lighting programs.

Project Manager. Residential – Marketplace Products Update. For National Grid New York, used web-scraping tools to systematically collect data on pricing and features for appliances available at major retailers and energy-efficient products available through the National Grid Marketplace. Utilized the data to develop a snapshot of the market and study trends in pricing, features, and ENERGY STAR® status.

Project Manager. Residential – Potential Study. For the New York sponsors, managed the residential data collection and reporting for a technical and economic potential study. Researched service territory-specific data across all residential end-uses and weighted findings by home type and geographic location. Utilized baseline data and lighting saturation data from prior studies to provide data points according to climate zone, home type, and end use.

Analyst. Residential – Market Characterization. Conducted in-depth interviews with HVAC contractors to assess the single-family renovations and additions market in Massachusetts.

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Analyst. Residential – Market Progress Evaluation. For the Northwest Energy Efficiency Alliance (NEEA), fielded and analyzed survey of water heater installers. Compared market progress indicators against previous studies for a heat pump water heater program in the Northwest.

Analyst. Commercial – Outcomes and Impact Evaluation. For the Department of Energy, analyzed survey results measuring the experiences and outcomes of awardees and non-participants in a small business voucher program.

Analyst. Commercial and Industrial – Business Program Evaluation. For the IESO, conducted in-depth interviews with business owners to evaluate the Small Business Lighting and Retrofit programs.

Analyst. Commercial – Lighting Evaluation. For Vermont sponsors, interviewed lighting market actors, including distributors, architects, retailers and designers, about their experience with LEDs and lighting controls and analyzed survey data from commercial business owners. Utilized data from responses to analyze support for market transformation.

Lead Analyst. Residential – Appliance Saturation Survey. For the Connecticut Program Administrators, served as lead analyst on a project establishing a statewide baseline of appliance saturation and usage behavior, with a sample of follow-up on-site visits to confirm survey responses. Prepared customer survey sample, contributed to survey design and execution, analyzed survey responses, and used on-site verification data to calculate and apply adjustment factors to survey responses. Used lighting data collected on-site to conduct a residential lighting market assessment. Served in the same capacity on a related study for National Grid Rhode Island. For the Connecticut Program Administrators, maintains and updates a database of survey data, billing data, summary statistics, and average efficiency ratings.

Lead Analyst. Residential – Lighting Evaluation. For the Massachusetts program administrators, contributed extensively to the 2015-16, 2016-17, 2017-18, 2018-19, and 2019-20 Lighting Market Assessment Consumer Survey and On-site Saturation studies, including conducting site visits, verifying on-site data, and analyzing panel data. Analyzed trends in replacement bulb behavior by demographic factors.

SELECTED PRESENTATIONS AND PUBLICATIONS

“Anything They Can Do We Can Do Better: Examining Major Retailer’s Pricing Trends to Optimize an Efficiency Marketplace,” International Energy Professionals Evaluation Conference (IEPEC), August 2019, Denver, CO. (Poster presentation)

“How the Other Half Lights: An Analysis of Purchase and Installation Demographic Patterns,” International Energy Professionals Evaluation Conference (IEPEC), August 2017. Baltimore, MD. (Poster presentation)

“Best Frenemies: A Comparison of Shelf Stocking and Web Scraping,” International Energy Professionals Evaluation Conference (IEPEC), August 2017. Baltimore, MD. (Poster presentation)

SHIRLEY PON

Project Manager | Employee Owner

Analyst

Five years' experience

Ph.D. Agricultural and Resource Economics, University of Maryland

WORK EXPERIENCE

2020 – Present **Project Manager / Quantitative Specialist, NMR Group, Inc.,** Somerville, MA

2016 – 2020 **Quantitative Analyst, NMR Group, Inc.,** Somerville, MA

ILLUSTRATIVE PROJECTS

Auditor – PA Statewide Evaluator. For the Pennsylvania Public Utilities Commission, served as an auditor of the Total Resource Cost (TRC) Models for utilities in PA. Tasks included reporting discrepancies between the TRC models and the PA Technical Reference Manual and providing recommendations for future program reporting.

Analyst. Residential – Single-family Retrofit Programs Impact Evaluation. For the New York State Energy Research and Development Authority, serving as analyst to estimate electric and natural gas savings in an impact evaluation of single-family households that have taken part in retrofit programs from 2012 to 2017. Households include low- and moderate-income households and market-rate households. The study will employ a billing analysis to estimate whole-house and measure-specific savings by program, funding source, and income group. Will be responsible for the program and billing data cleaning, providing electric and natural gas billing analysis support.

Lead Analyst. Residential – Top-Down Macro Econometric Modeling. For the Massachusetts Electric Program Administrators (MA PAs), explored possible enhancements to PA-data and PA-Municipal Top-Down econometric models for measuring net energy impacts, such as accounting for program dollar leakage, testing the validity of town-level Top Down modeling and model sensitivity to program lighting dollar distribution. Other responsibilities included data gathering, modeling, and reporting.

Lead Analyst. Residential – Appliance Recycling Impact, Process, and Net Savings Survey. For the MA PAs, conducted analysis of appliance recycling survey, which was designed to measure free-ridership and net of free-ridership and explore customer satisfaction and drivers of program participation for refrigerator and freezer recycling. Duties included survey testing, analysis, quality control, and reporting.

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Lead Analyst. Residential – Estimating Energy Use for Single-Family New Construction. For the Connecticut Energy Efficiency Board, conducted billing analysis of single-family homes in a residential new construction project, and compared billing estimated use with engineering estimated use. Duties included data cleaning, merging, and management; data assessment; conducting billing analysis; and reporting.

Task Lead. Residential – Products Consumer Impact, Process, and Net Savings Survey. For the MA PAs, served as research manager for two surveys designed to measure in-service, retention, free-ridership, and spillover rates and to explore customer satisfaction and installation practices for participants who had purchased advanced power strips, temperature sensitive showerheads, dehumidifiers, room air cleaners, and dryers through a residential products program. Other duties included facilitating survey data collection and reporting.

Analyst. Commercial, Residential – Program and Pilot Impact Evaluation. For the Independent Electricity System Operator (IESO), served as survey conductor and analyst to evaluate the programs and pilots and assess the energy savings that resulted from the programs implemented by the Ontario utilities and IESO. Tasks included survey programming, conducting in-depth interviews with small business program participants and program assessors/installers, analysis, and reporting.

Analyst. Residential – Lighting Sales Data Analysis. For the National Grid in Rhode Island, conducted sales, market share, and incremental cost analysis for LEDs in Rhode Island, Massachusetts, program and non-program areas, and the entire United States.

Lead Analyst. Residential – New Construction Net Impacts. For the Connecticut Energy Efficiency Board, conducted net impacts analysis of single-family and multifamily homes in a residential new construction project by comparing as-built engineering estimated use with counterfactual engineering estimated use based on responses from a Delphi Panel. Duties included developing counterfactual building component efficiency values to program and non-program homes, and developing and reporting free-ridership, non-participant spillover, and net-to-gross ratios for homes by end use and fuel type.

Lead Analyst. Residential – New Construction Net Impacts. For the MA PAs, conducted net impacts analysis of single-family homes in a residential new construction project by comparing as-built engineering estimated use with counterfactual engineering estimated use based on responses from a Delphi Panel. Duties included drawing sampling distributions to assign counterfactual efficiencies to program and non-program homes, and developing and reporting free-ridership, non-participant spillover, and net-to-gross ratios for homes under 2012 IECC and MA Stretch Energy Code.

SELECTED PUBLICATIONS

Pon, Shirley. (2017). “The Effect of Information on TOU Electricity Use: An Irish Residential Study.” Energy Journal, 38(6), 55-79.

KIERSTEN VON TRAPP

Project Manager | Employee Owner

Analyst

Ten years' experience

M.A. Urban and Environmental Policy and Planning

WORK EXPERIENCE

2010 – Present **Project Manager, NMR Group, Inc.,** Somerville, MA

ILLUSTRATIVE PROJECTS

Principal-in-Charge. Residential – Connecticut Residential Studies. For the Connecticut Energy Efficiency Board (EEB), serve as principal-in-charge for all NMR-led residential studies conducted in Connecticut. Works closely with evaluation consultants to the EEB and NMR team members to plan and implement evaluation studies.

Project Manager. Commercial & Industrial – Lighting, Impact Evaluation. For the Massachusetts Program Administrators (MA PAs), led multi-year on-site data collection to support the impact evaluation and NTG assessment of upstream lighting program for both participants and non-participants across the state.

Project Manager. Residential – Lighting and Appliances. For the Rhode Island Energy-Efficiency Program Administrators and Connecticut EEB, managed two on-site lighting and appliance saturation studies. Hired, trained, and managed on-site technicians, collected data, and analyzed residential on-site data.

Project Manager. Residential – Lighting. For the MA PAs, hired, trained, and managed on-site technicians for panel study in Massachusetts and a comparison area, compiled and wrote training handbooks and on-site data collection documents, collected and cleaned data, and analyzed on-site data.

Project Manager. Residential – Lighting. For the Connecticut EEB, collaborated with client on work plan, coordinated with CATI firm, hired and managed on-site technicians, collected and cleaned data, and performed data analysis as part of an on-site study focused on the LED lighting market.

Project Manager. Residential – Lighting, Hours of Use Study. For the Massachusetts, Rhode Island, Connecticut, and New York Program Administrators, hired and managed on-site technicians, compiled and wrote training handbooks and on-site data collection documents, and cleaned and analyzed data for on-site saturation study and estimation of the hours of use of light bulbs in homes.

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Project Manager. Residential – Lighting. For the MA PAs, transcribed interviews, analyzed data in SPSS, and managed and analyzed Delphi panel for annual market progress and evaluation reporting. Study involved consumer and retailer surveys, shelf space and model counts, interviews with manufacturers, assessment of incremental prices, estimating market share, calculating net-to-gross ratios, conducting on-site studies of CFL saturation, assessing cost-effectiveness, identifying new opportunities for assessing market effects, and making recommendations for program improvements.

Lead Analyst. Residential – Appliances. For Efficiency Maine, analyzed on-site and telephone survey data for impact evaluation of the New York Residential Refrigerator-Freezer Recycling Program. Scheduled on-site visits, reviewed technician forms, and performed data entry.

Lead Analyst. Residential – Appliances. For the New York Program Administrators, analyzed on-site and telephone survey data for impact evaluation of the New York Residential Refrigerator-Freezer Recycling Program.

SELECTED PRESENTATIONS AND PUBLICATIONS

"Buy all the Shiny Things: Understanding Consumers' Lighting Decision-Making in a Transforming Market," ACEEE Summer Study, August 2018. Pacific Grove, CA.

"Déjà vu All Over Again: More Revelations of a Lighting Panel Study," IEPEC Conference, August 2017. Baltimore, MD.

"A lighting Study to Stand the Test of Time: Exploring the Results of a Residential Lighting Study designed to Produce Lasting Data," IEPEC Conference, August 2015. Long Beach, CA.

"We Know What you Did Last Summer: Revelations of a Lighting Panel Study," IEPEC Conference, August 2015. Long Beach, CA.

"Are You Turned On? A Hierarchical Modeling Approach for Estimating Lighting Hours of Use," IEPEC Conference, August 2015. Long Beach, CA.

"Fifteen Secret Tips That Will Change Everything You Think You Know About On-site Data Collection (Poster)," IEPEC Conference, August 2015. Long Beach, CA.

CHRISTINE SMAGLIA

Research Associate II | Employee Owner

Analyst

Eight years' experience

M.P.H., Epidemiology and Biostatistics
M.S., Food Policy and Economics

WORK EXPERIENCE

2017 – Present	**Research Associate II, NMR Group, Inc.,** Somerville, MA
2015 – 2017	**Environmental Consultant, Green Restaurant Association,** Boston, MA
2013 – 2014	**Program Evaluator, Independent Consultant,** Chicago, IL
2011 – 2012	**Program Evaluation Intern, MA Department of Public Health,** Boston, MA

ILLUSTRATIVE PROJECTS

Analyst. Residential – HVAC Net-to-Gross and Market Effects Evaluation. For the Massachusetts Program Administrators (MA PAs), assisted with the development of an online survey instrument and conducted in-depth interviews (IDIs) with HVAC contractors to assess program free-ridership, spillover, market effects, and prospective NTG ratios for incented equipment types, including central heat pumps, central air conditioning systems, ductless mini-split heat pumps, heat pump water heaters, and gas heating equipment.

Analyst. Commercial, Industrial – New Buildings and Major Renovations Net-to-Gross Evaluation. For the MA PAs, conducting secondary data review and developing Delphi instruments to evaluate prospective NTG ratios for various program pathways. Facilitating Delphi Panels to assess free-ridership and spillover and develop NTG ratios.

Analyst. Commercial, Industrial – Upstream LED Net-to-Gross Evaluation. For the MA PAs, conducted on-site inspections of commercial and industrial businesses to understand the market for light bulbs in these facilities.

Lead Analyst. Residential, Commercial – Process Evaluation. For National Grid in New York, assessed program processes and estimated program impacts. Topic areas included marketing and outreach, financing and decision making, program satisfaction, NEIs, measure installation verification, opportunities for collaboration, and researching peer program incentives and benefits. Developed survey and interview instruments; managed data collection activities; and conducted interviews with program staff, program vendors, counterpart utilities, and peer program managers.

Lead Analyst. Residential – Process Evaluation. For the Delaware Department of Natural Resources and Environmental Control (DNREC), developed a phone survey and interview script to assess the NEIs associated with Weatherization Assistance Program (WAP). Conducted participant interviews and analyzed data to quantify the value of changes to household comfort, noise, and health.

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Analyst. Commercial – Business Program Process Evaluation. For the Independent Electric System Operator (IESO), developed and programmed web-based surveys, conducted IDIs with utility program administrators, and analyzed data as part of the process evaluation for the Conservation First Framework Business Programs in Ontario, Canada. Synthesized findings and developed final report sections.

Lead Analyst. Residential – Health- and Safety-Related Non-Energy Impacts (NEIs). For the MA PAs and the EEAC, led sample management, recruitment, and on-site data collection for an evaluation of the NEIs attributable to the low-income, multifamily weatherization assistance program.

Lead Analyst. Residential, Commercial, Industrial – NEI Reference Tables. For the MA PAs, provided guidance and clarification on the correct application of NEIs at the measure-level and across individual initiatives in their benefit-cost models. Developed fully updated and verified NEI look-up tables for electric and gas benefit-cost plan models.

Lead Analyst. Commercial – Gas Kitchens. For National Grid New York, developed IDI instruments and designed a collaborative data collection system for commercial customers who received rebates for efficient equipment purchases and for the program-approved vendors. Conducted IDIs with customers and vendors, analyzed data, and incorporated results into the final report.

Analyst. Residential – Code Compliance Support Initiative. For the MA PAs, conducted IDIs with attendees of Mass Save trainings on changes in energy code, synthesized findings, and prepared final report chapters. Interviewed a variety of builders, code officials, HERS raters, and architects to find out the effects of the trainings on their compliance with the new code.

Analyst. Residential – Smart Power Strip Metering Study. For the MA PAs and the Energy Efficiency Advisory Council, assisted with sample design and management for an evaluation of the energy savings potential for smart power strips in Massachusetts homes.

Analyst. Residential – New Construction Passive House Assessment. For the MA PAs and the EEAC, conducting IDIs with Passive House contractors, builders, developers, engineers, and occupants and synthesizing results into the report as an assessment of the appropriate processes and methodologies by which whole building performance-based savings for Passive House multifamily buildings are quantified and claimed.

Analyst. Residential, Commercial, Industrial – Potential Study. For National Grid New York, New York State Electric & Gas, and Rochester Gas & Electric, in conjunction with DNV GL, conducted baseline measure research to determine appropriate cost measures and inputs to apply to the model.

Analyst. Residential – New Construction Baseline Study. For the Connecticut Energy Efficiency Board, contributed to the analysis and reporting of findings from on-site assessments of new homes in Connecticut to evaluate building practices with regards to energy efficiency.

Analyst. Residential – Lighting Saturation Study. For the MA PAs, conducted on-site visits to catalog lighting inventories at homes across MA to observe saturation change over time. Analyzed in LED satisfaction and contributed to various report sections.

EUGENE MCGOWAN

Research Associate II | Employee Owner

Analyst

Four years' experience

B.S. Environmental Geoscience, Boston College

WORK EXPERIENCE

2016 – Present **Research Associate, NMR Group, Inc.,** Somerville, MA

2014 – 2016 **Account Manager, Next Step Living,** Boston, MA

CERTIFICATIONS

Certified Home Energy Rater (HERS) – RESNET

ILLUSTRATIVE PROJECTS

Field Technician. Residential – Baseline Study. On behalf of the Pennsylvania Public Utility Commission, conducted site visits in residential homes to assess energy efficiency. This included obtaining information on insulation levels, efficiency of lighting, appliances and HVAC equipment, as well as conducting diagnostic blower door and duct blaster tests. This data was used by the PUC to update assumptions about the current level of efficiency of different measures within homes.

Field Technician. Commercial, Industrial – Baseline Study. On behalf of the Pennsylvania Public Utility Commission, conducted site visits to commercial and industrial locations to assess energy efficiency. This included obtaining information on heating and cooling equipment, lighting, compressed air applications, as well as other specific process equipment. This data was used by the PUC to update assumptions about the current level of efficiency of different measures within businesses.

Analyst. Residential – Impact Evaluation. For the Pennsylvania Public Utility Commission, conducted engineering desk reviews to verify savings for residential programs, including downstream, direct install, and low-income programs. This involved checking data and calculations for accuracy, as well as ensuring the proper use of the Technical Reference Manual for calculating savings for all measures and programs.

Field Technician. Commercial, Industrial – Upstream Lighting. For the Massachusetts program administrators (MA PAs), conducted onsite lighting inventories at a variety of commercial and industrial locations. This data was used to calculate a net to gross ratio for the Commercial and Industrial Upstream Lighting program, and to estimate LED saturation in non-participant sites.

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Analyst. Commercial, Industrial – Impact Evaluation. For Kansas City Power & Light, conducted a process and impact evaluation for the Small Business Lighting Program. This included interviews with program staff and implementers, and verifying program savings using algorithms from the Technical Reference Manual.

Field Technician. Commercial, Industrial – Market Characterization. For National Grid Rhode Island, conducted site visits to a variety of commercial and industrial locations to inventory lighting and HVAC equipment as part of a market characterization study.

Analyst. Residential – Impact Evaluation. For the Independent Electricity System Operator in Ontario, conducted engineering desk reviews to verify savings for a residential low-income direct install program. This involved a review and update of the current Technical Reference Manual assumptions and comparison to other jurisdictions. It also involved reviewing and recalculating savings based on the TRM algorithms.

Analyst. Residential – Market Characterization and Potential Savings Study. For the MA PAs, characterized the size and scope of the single-family renovations and additions market in Massachusetts. This included surveys with homeowners and contractors, focus groups, permit analysis, and creating energy models to estimate savings associated with these projects.

Field Technician. Residential – Residential Baseline Study. On behalf of the MA PAs, conducted site visits in newly constructed residential homes to assess energy efficiency. This included obtaining information on insulation levels, efficiency of lighting, appliances and HVAC equipment. It also involved conducting diagnostic blower door and duct blaster tests. This data was used to update assumptions about the current level of efficiency of new homes and create the User Defined Reference Home that program homes are compared against.

Field Technician. Residential – Low-Income Multifamily Non-Energy Impacts. For the MA PAs, created the data collection form and conducted site visits to multifamily buildings to collect data from the property managers and distribute surveys to residents. This study was used to evaluate the impact of the low-income weatherization program, specifically on non-energy impacts such as health and safety benefits.

Field Technician. Commercial, Industrial – NY SBDI Lighting On Sites. For National Grid New York, conducted on site lighting inventories at a variety of commercial and industrial locations as part of an evaluation of their Small Business Direct Install program. This included verifying program lighting installations, collecting data on non-program lighting, and installing lighting loggers to calculate hours of use.

QC Reviewer. Residential – Rhode Island RASS. For National Grid Rhode Island, conducted on site visits and performed QC on collected in home data for the Residential Appliance Saturation Survey. Also created Sketch Up Models detailing heat pump eligibility by room.

TIM STEIS

Engineer II | Employee Owner

Analyst

Four years' experience

B.S. Environmental Engineering

WORK EXPERIENCE

2016 – Present **Engineer II, NMR Group, Inc.,** Somerville, MA

2013 – 2015 **Data Analyst, Natural Gas Intelligence,** Sterling, VA

CERTIFICATIONS

Certified Home Energy Systems (HERS) Rater – RESNET

ILLUSTRATIVE PROJECTS

Analyst. Residential – Impact Evaluation. For the Pennsylvania Public Utility Commission, conducted desk reviews to ensure the reliability and accuracy of the EDC EE&C program savings estimates by checking that EDC data and reports are accurately calculated and show the correct PA technical reference manual savings.

Lead Analyst. C&I and Residential – Gas Savings Verification. For Vermont Gas Systems (VGS), conducted documentation reviews, engineering desk reviews, and supplementary billing analysis to verify the reported gas savings for VGS. The measures audited included boiler and hot water heater replacements, gas heating equipment, heat recovery equipment, building shell improvements, and heating control improvements.

Lead Engineer. C&I and Residential – TRM and Tool Development. For VGS, led the development of a VGS TRM for six different residential and commercial measures to be used to calculate gas and electric savings. In addition, led the development of the savings calculation tools for ten different residential and commercial measures.

Analyst, Field Data Collection. Residential – Existing Home and New Construction Baseline and Code Compliance Studies. For Massachusetts, Rhode Island, Connecticut, Vermont, and Pennsylvania Sponsors, conducted energy audits on new homes following HERS standards, including diagnostic blower door and duct blaster tests to assess the homes' energy efficiency. Analyzed results to illustrate characteristics of newly constructed residential homes, and wrote sections of the final report.

Lead Analyst. Residential – New Construction. For Consumers Energy, conducted peer program review of similar RNC programs. Tasks included web research and in-depth interviews with program managers.

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Engineer. C&I – Engineering Processes and Practices Review. For Eversource, assessed their engineering review process for custom C&I projects in Massachusetts. The study involved an in-depth process evaluation, which included a review of Eversource's engineering practices, staff skills, and training needs. The project also involved an evaluation of Eversource's application review process and recommendations on improvements to the realization rates of impact evaluations.

Field Engineer. C&I – Impact Evaluation. For the Massachusetts Program Administrators (MA PAs), conducted site visits to collect information regarding installation, performance, and operational characteristics of custom energy-efficiency measures through observation and direct measurement using "logger" instruments. Data collected is used in evaluating the performance of energy-efficiency measures of program participants.

Analyst. Residential – New Construction Attribution Study. For the MA PAs, assessed the net savings attributable to the RNC and CCSI programs. This study used a Delphi approach to estimate what would have happened in the absence of the programs. Tasks include client interaction, data analysis, and reporting.

Analyst. Residential – NEEA HPWH Market Characterization. For the Northwest Energy Efficiency Alliance, estimated the size of the HPWH market in the Northwest region using numerous manufacturer and distributor data sources.

Analyst. Residential – New Construction Impact and Process. For MidAmerican Energy, Iowa, conducted impact and process evaluation of a residential new construction program. Tasks including conducting interviews with construction industry experts and identifying opportunities for improving the MidAmerican Residential Energy program.

Analyst. Residential – Portfolio Evaluation. For the DC Department of Energy and Environment, conducting desk reviews to verify gross savings for various residential measures.

Analyst. Residential – Market Characterization and Potential Savings Study. For the MA PAs, characterized the size and scope of the single-family renovation and additions market in Massachusetts. Activities included survey analysis, focus groups with contractors, and using online building permit databases to estimate the size of the renovations and additions market.

Analyst. C&I – New Construction EUI Baseline. For the MA PAs, helped develop EUI baseline recommendations for newly constructed non-residential buildings.

Field Analyst, QC Reviewer. Residential – RASS Study. For National Grid Rhode Island, conducted site visits and performed QC on collected home data for the Residential Appliance Saturation Survey. Tasks also included training field technicians to conduct onsite visits and creating Sketch Up Models detailing ductless mini-split eligibility by room type.

Field Data Collection. Residential – Lighting Saturation Study. For the MA PAs, conducted on-site assessments of installed and stored lighting in order to assess the saturation of various types of efficient lighting in Massachusetts.

Field Data Collection. C&I – Massachusetts Upstream Lighting. For the MA PAs, conducted on-site lighting inspections of commercial and industrial building to track usage of LED lamps purchased through an upstream discount program.

SAM KODUA

Engineer I | Employee Owner

Analyst

One-year of experience

B.S. Integrated Science and Technology, James Madison University

WORK EXPERIENCE

2020 – **Present** **Engineer I, NMR Group, Inc.,** Somerville, MA

CERTIFICATIONS

Provisional Certified HERS Rater (HERS) – RESNET

ILLUSTRATIVE PROJECTS

Analyst. Residential – NTG. For the Massachusetts utilities, currently conducting an evaluation of the utilities efforts in the RNC market. The study will estimate net savings and a net-to-gross ratio for single-family and low-rise multifamily homes. The study leverages a Delphi panel to create counterfactual distributions of measure-level efficiencies if the RNC programs did not exist. Then, by adjusting as-built energy models with counterfactual efficiencies, the study estimates counterfactual consumption. The savings are then compared to program claimed savings to determine a net-to-gross ratio. Tasks include data gathering and analysis, coordinating with panelists, and reporting.

Analyst. Residential – Process Evaluation. For Consumers Energy, currently conducting in-depth interviews with builders and HERS raters who have participated in the New Home Construction program. The project seeks to gain insights that will increase the amount of projects that pursue ENERGY STAR® certification in addition to HERS ratings. Tasks include conducting interviews, analyzing interviews, and reporting.

Analyst. Products – Shelf-stocking. For Light Tracker, working with the Consortium for Retail Energy Efficiency Data (CREED) and Demand Side Analytics to conduct shelf-stocking and sales data analysis in non-program states in the summer of 2020. The goals of the study are to assess the availability and sales of LEDs vs. incandescent and halogen alternatives

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MARK NATHIN

Research Associate I | Employee Owner

Analyst

One year of experience

B.A. Statistics and Psychology, Amherst College

WORK EXPERIENCE

2020 – Present	**Research Associate, NMR Group, Inc.,** Somerville, MA
2018 – 2020	**Statistics Intern, Amherst College,** Amherst, MA

CERTIFICATIONS

Certified Home Energy Systems (HERS) Rater – RESNET (certificate expected January 2021)

ILLUSTRATIVE PROJECTS

Analyst. Commercial & Industrial – Massachusetts Upstream Lighting. Sponsored by the Massachusetts electric Program Administrators. This study consists of lighting inspections of commercial and industrial buildings to track usage of LED lamps purchased through an upstream discount program. Responsibilities include scheduling site visits with business owners via telephone and email and coordinating onsite and virtual visits with technicians.

Analyst. CREED Non-Program Shelf Stocking Visits. This study involves working with the Consortium for Retail Energy Efficiency Data (CREED) to conduct shelf-stocking and sales data analysis in order to assess the availability and sales of LEDs vs. incandescent and halogen alternatives. Responsibilities include downloading and reviewing footage from onsite technicians, entering all information for each store and product into FileMaker, and adding products to a database.

Institutional – Senior Thesis Project, Amherst College. Researched the paradox of choice and different decision-making styles through psychology database research. Fully developed Qualtrics survey and measurement scales, recruited participants, and analyzed resulting data in SPSS to determine the relationship between personality factors and satisfaction with the Amherst College curriculum.

Institutional – Census API Capstone Project, Amherst College. Used R to extract variables from the US Census API (which came from the American Community Survey administered by the US Census). Utilized various packages in order to perform binary, ordinal, and multinomial logistic regression analyses predicting median household income in the United States. Was responsible for explaining and comparing each of the techniques step-by-step within a comprehensive R markdown report.

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BRITTANY HARRIS

Senior Communications Manager | Employee Owner

Technical Editor

Five years' experience

MASc Environmental Applied Science and Management, Ryerson University, Toronto

WORK EXPERIENCE

2017 – Present	**Senior Communications Manager, NMR Group, Inc.,** San Francisco, CA
2015 – 2017	**Communications Coordinator, Mass Audubon Habitat,** Belmont, MA
2015 – 2017	**Contributing Editor, Harvard University's "The Harbus,"** Cambridge, MA

RESPONSIBILITIES

Editing and formatting. Brittany is actively involved with the development of reports and proposals and thoroughly reviews all NMR materials before they are published or distributed to clients, ensuring clear organization, concise language, and consistent formatting. She has reviewed, edited, and formatted over 300 documents since starting with the company in 2017. These documents include reports, proposals, papers, and presentations.

Data visualization. Brittany leads the Data Visualization Team at NMR. The goals of the team are to (1) ensure consistency in the quality of graphics in reports, (2) provide training to all employees to expand data visualization skills, and (3) create a process for NMR to continuously improve data visualization capabilities.

Marketing. Brittany leads NMR's ongoing marketing initiatives, collaborating with a multidisciplinary leadership team to identify new opportunities. As part of this initiative, Brittany develops and manages all of NMR's marketing materials, including newsletters, brochures, infographics, business cards, and resumes. She also manages NMR's participation in conferences and events by engaging external stakeholders, preparing marketing materials, and coordinating logistics. Brittany also coordinated the launch of NMR's new website by collecting user requirements from the leadership team, writing content, sourcing contract developers, and supervising the design and launch. She actively manages the website and all social media accounts.

Proposal coordination. Brittany reviews RFP requirements and ensures that proposals contain all necessary documents, follow formatting guidelines, and address all RFP questions. She also reviews proposals to ensure clear, concise language and consistent formatting.

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Rachel Hoefgen-Harvey

Administrative Manager | Employee Owner

- Administrative Support
- Over ten years' experience
- B.A. Liberal Arts

WORK EXPERIENCE

2009 – Present **Administrative Manager, NMR Group, Inc.,** Somerville, MA

ILLUSTRATIVE PROJECTS

Massachusetts Residential Portfolio Evaluation. In charge of invoicing for multi-sponsor project, including employee hours and expense tracking.

Connecticut Clean Energy Fund Monitoring and Evaluation. Maintained and updated community participation database for the Connecticut Clean Energy Fund's (CCEF) programs to increase voluntary demand for clean energy by creating model, sustainable communities.

Multi-State CFL Modeling Effort, Various Sponsors. Researched and compiled data for collaborative CFL-bulb program evaluation project among many utilities across the country.

Multiple Projects. Edited and formatted reports and other documents.

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Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

JESSE SMITH
PARTNER

Pennsylvania Act 129 Experience

- **Statewide Evaluator Behavioral Evaluation Lead (2016-2021)**
  Demand Side Analytics is the technical lead for behavioral and demand response programs for the Phase III team. In 2016, Jesse developed a detailed evaluation protocol for behavioral conservation programs which is included as Section 6.1 of the Pennsylvania Evaluation Framework. This protocol details the procedures that each of the EDCs in the state are required to follow when evaluating Home Energy Report and Business Energy Report programs.
- **C&I Baseline Study (2016 to 2021)** DSA's online data collection tool was used in the field by the Phase III SWE team for site inspections of 500 non-residential businesses across the state. Jesse led a team of DSA analysts who completed the analysis and reporting components of the Phase III study. Results of the C&I baseline study will serve as key inputs to the 2019 TRM update and market potential study.
- **Technical Reference Manual Updates and TRM Orders (2011-2021)** As a member of Phase I, Phase II, and Phase III SWE teams, Jesse Smith has worked on seven different TRM updates. In each update, he contributed to the measure characterizations in the manual itself as well as drafted comment summaries and dispositions for the associated Tentative and Final Orders.
- **Commercial Lighting Metering Study (2013-2014)** While employed at Nexant, Jesse Smith led a statewide commercial lighting metering study for Pennsylvania. The study included deployment of over 2,500 lighting loggers in 500 commercial businesses. The site visits included a full inventory of lighting equipment in a tablet-based data collection system. Mr. Smith processed and analyzed the logger data to create annual hours-of-use and coincidence factor assumptions by business type. Screw-based and general service lighting were analyzed separately and given separate default tables in the 2016 Pennsylvania TRM. The logger data was also used to develop 8760 load shapes for use in benefit cost models and other applications.
- **Incremental Cost Database Update- LED Lighting Update (2017-present)** In 2017, Jesse Smith's team completed a partial update of the incremental cost database focused on LED lighting in the residential and non-residential sectors. DSA developed a high-level taxonomy of LED lighting equipment and organized the cost assumptions accordingly. The program information provided

Education

MS, Applied Statistics
Kennesaw State University, 2010

BS, Psychology
University of NC, Chapel Hill, 2001

Work History

Demand Side Analytics, LLC - Atlanta, GA
Partner and Principal Consultant 2016-now

Nexant – Malvern, PA
Managing Consultant 2015-2016
Project Manager 2013-2015
Senior Analyst 2011-2013

GoodCents Solutions, Inc. – Atlanta, GA
Load Research Analyst 2010-2011

information on the cost of LED equipment and the web-scraping data was used to develop cost estimates for baseline lighting equipment which are not supported by energy efficiency programs. In addition to these participant cost assumptions, the SWE developed estimates of the operation and maintenance (O&M) benefits associated with installation of LED lighting equipment. In 2020, the cost assumptions were updated with a similar process but a new taxonomy.

Other Relevant Experience

- **DCSEU: Cost Effectiveness and Nest Seasonal Savings Evaluation (2017-present)** As a member of the NMR team, Jesse leads the annual benefit-cost modeling effort. DSA has also evaluated the Nest thermostat optimization program (Seasonal Savings) for two summers and one winter.
- **Rhode Island Office of Energy Resources: National Grid Energy Efficiency Programs Evaluation (2019-present)** National Grid's energy efficiency programs (gas and electric) were evaluated by performing a billing analysis for any premise that installed an incented retrofit measure between 2015 and 2019. Example retrofit measures offered by the program include lighting measures, steam traps, and VSDs on HVAC systems.
- **Unitil Energy Systems: ISO-NE Forward Capacity Market Review (2020)** Led the annual M&V compliance review for Unitil capacity commitments in New Hampshire and Massachusetts.
- **Efficiency Maine: ISO-NE Forward Capacity Market Review (2018-2020)** For the last three years, led DSA's contract to conduct the required annual third-party compliance review of Efficiency Maine's Measurement and Verification (M&V) plan for delivering capacity to the ISO-NE Forward Capacity Market.
- **Southern California Edison: Smart Energy Program Evaluation (SEP) (2019-present)** Southern California Edison's (SCE) Smart Energy Program (SEP) is a residential demand response program that utilizes Wi-Fi connected smart thermostats to reduce air conditioning load in participating households during peak hours. Jesse used matched control group and billing data to evaluate annual load impact of 35 MW residential demand response program for 52,000 participants.
- **Public Service New Mexico Power Saver residential AC Cycling and Peak Saver C&I curtailment evaluations (2017-2020)** Led the annual load impact evaluation of PNM's 60 MW demand response portfolio.
- **Consumers Energy (2020)** Jesse led the non-residential demand response potential study and provided Integrated Resource Plan support.
- **NIPSCO (2020-2021)** Led the demand response market potential study and provided IRP Support. Demand responses measures included connected thermostats, C&I load curtailment, and time-varying rates.
- **Union Gas – Home Energy Report Program (2017-2018)** Impact and process evaluation of a large randomized control trial implemented by Oracle. Included a dual participation and cost-effectiveness analysis.

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

ALANA LEMARCHAND
PARTNER & PRINCIPAL

Pennsylvania Act 129 Experience

- **Act 129 C&I Baseline Study (2017-2018)** Led the Evaluation Team to conduct the 2018 statewide C&I baseline study including site inspections of 500 non-residential businesses across the state. Set up and managed weekly data cleaning processes for follow up with site inspectors to ensure data quality across dozens of complex and interrelated data fields. Led, structured, and partially automated analysis of the rich data set including bottom up analysis of end use, energy use intensity, and efficiency purchase behaviors across several end uses. In addition, results were provided by sector (large versus small), EDC (seven total), and about a dozen industry segments. Results of the C&I baseline study served as key inputs to the 2019 TRM update and market potential study.
- **PECO Portfolio TRC Cost-effectiveness Audit (2018-2020)** Independently audited portfolio TRC results for PECO's Act 129 programs. To thoroughly verify PECO results, built a separate model using the same inputs as PECO and compared results overall, by program, and by cost test element. Identified, communicated, and validated key assumption and modeling modifications needed to ensure alignment between PECO model and independent model.

Education

BS, Environmental Economics 2010
University of California, Berkeley

Work History

Demand Side Analytics, LLC
Partner & Principal 2019-now
Principal Consultant 2017-2018

Nexant, Inc.
Senior Consultant 2014-2017

Simon-Kucher and Partners
Senior Consultant 2010-2014

- **Act 129 Phase IV Demand Response Study (2019-2020)** The study included EDC specific estimates for DR Potential and examined the costs and benefits of statewide policies to encourage the development and deployment of DR resources. Ms. Lemarchand led assessment of demand response potential specific to distribution connected battery storage for each EDC by incorporating commercial load shapes and retail distribution rates and battery cost curves into a battery cost-effectiveness model.

Other Selected Experience

- **DC SEU Portfolio Cost-effectiveness (2018-2020)** Built detailed, flexible benefit cost model for assessing project, program, portfolio level cost-effectiveness for DC SEU energy efficiency and renewable energy programs. Modeling and assessment included functionality for dynamically assessing all four cost effectiveness tests (TRC/SCT, PACT, UCT, and RIM) and a variety of cost effectiveness scenarios—a base scenario replicating DC SEU cost-effectiveness plus scenarios for layering in updated avoided cost assumptions, realization rates, net to gross yield, and environmental benefits. Incorporated key cost-effectiveness considerations including adjusted

baseline. Managed and guided analyst in rapid updating of cost-effectiveness calculations for subsequent years, facilitated by the flexible model architecture.

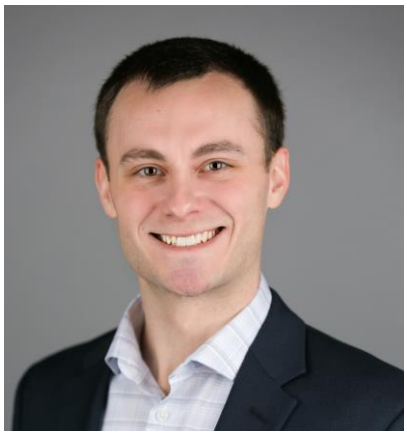
- **Central Electric Power Cooperative DSM Portfolio Cost-effectiveness and Forecasting for Integrated Resource Plan (2020)** Built detailed, flexible benefit cost model for assessing project, program, portfolio level cost-effectiveness across program categories (EE, DR, Electrification). Overlaid top down budget forecasts on bottom up cost benefit model to develop granular 20-year enrollment and resource forecasts for incorporation into IRP. Modeling and assessment included functionality for dynamically assessing all four cost effectiveness tests (TRC/SCT, PACT, UCT, and RIM) and a variety of assumption input levers and cost effectiveness scenarios—a business as usual investment scenario and an aggressive scenario including caps for achievable potential.
- **Central Hudson Gas & Electric Cost-effectiveness Modeling for Locational Non-Pipes Alternative and for Portfolio Earnings Adjustment Mechanisms (2020)** Built detailed, flexible benefit cost model for assessing measure and program level cost-effectiveness for a locational non-pipes program including detailed electrification module. Also adapted model for purposes of assessing cost effectiveness of client's Earnings Adjustment Mechanism (EAM) incentives including incorporation of module for assessing hourly (8760) benefits and avoided costs.
- **Central Hudson Gas & Electric Distribution System Implementation Plan and Locational Avoided T&D Cost Study (2016-2020)** Led preparation of Distribution System Implementation Plan (DSIP) filings in 2016, 2018, 2020, in compliance with Renewing the Energy Vision (REV) proceeding. Included development of granular (circuit level) forecasts of penetration and system and local peak impacts of various distributed energy resources (DERs) and incorporated granular, stochastic load and DER forecasts, and development of locational avoided T&D avoided costs for each substation and transmission area.
- **PSEG Long Island Locational Avoided T&D Cost Study (2019-2020)** Prepared a locational avoided T&D cost study for PSEG-LI based quantifying the value associated with an increase or decrease of kW coincident with location specific peaks. Modularized and scaled DSA's granular, probabilistic load forecasting model to support analysis of analysis of 6 years of 8760 hourly SCADA data for about 1500 distribution assets (~150 substations, ~350 substation banks, ~1000 feeders).
- **Central Hudson Gas & Electric C&I Baseline Study (2019)** Led segmentation and managed recruiting for over 100 phone and on-site visits, customized DSA's in-house baseline data collection platform, and led reporting for Central Hudson Gas & Electric's 2019 baseline study.
- **Efficiency Maine Trust Distributor Lighting Impact Evaluation (2019)** Customized and configured DSA baseline data collection portal to support site visits and light logging at 90 participation Maine businesses.

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

STEVE MORRIS
CONSULTANT

Pennsylvania Act 129 Experience

- **Audit of Demand Response Program Evaluations (2017-2021)** Reviewed baseline calculations and demand response load impacts for several EDCs. DR program types include C&I load curtailment, AC load control, and behavioral DR.
- **Audit of Home Energy Report Program Evaluation (2017-2021)** Reviewed participant counts, HER impacts, uplift calculations, calendarization procedures, and analysis code for several EDCs. Also reviewed the experimental design for FirstEnergy's Business Energy Report program launched in PY11.
- **Demand Response Market Potential Study (2018-2020)** Used Pennsylvania-specific C&I DR impacts to develop price elasticities used in estimating C&I demand response potential. Created the C&I DR potential Excel model. Primary author of the C&I potential content in the study report.
- **2020 Technical Reference Manual Update and TRM Order (2019-2020)** Managed the team updating the Commercial and Agricultural sections of the Pennsylvania TRM. Updated the battery of Commercial Refrigeration measures. Summarized EDC and stakeholder comments and drafted Commission dispositions in the TRM Order.
- **Statewide Tracking Database (2017-2021)** Reviews and cleans EDC tracking data on a quarterly basis. Consolidates and maintains a statewide tracking database with all Phase III tracking data records. Performs Annual and Semi-Annual audits of claimed savings using said database.



Education

MS, Statistics
University of Georgia, Athens 2014

BS, Statistics
University of Georgia, Athens 2010

BS, Sociology
University of Georgia, Athens 2010

Work History

Demand Side Analytics, LLC – Atlanta, GA

Consultant	**2020-now**
Senior Analyst	**2018-2019**
Quantitative Analyst	**2016-2018**

Kennesaw State University – Kennesaw, GA

Part-Time Faculty	**2016-now**

University of Georgia – Athens, GA

Instructor	**2014-2016**
Graduate Teaching Assistant	**2012-2014**

Other Relevant Experience

- **Southern California Edison: Demand Response Evaluations (2019-2021)** The evaluations included analysis of AMI data from over 280,000 sites, and five programs including residential load control, non-residential load control, smart thermostat, large, interruptible agricultural pumps, and non-residential real time pricing. Steve implemented the analysis of commercial load control.

- **Public Service New Mexico: Power Saver residential AC Cycling and Peak Saver C&I curtailment evaluations (2017-2020)** Annual load impact evaluation of PNM's 60 MW demand response portfolio. Also performed a weather sensitivity analysis to determine which sites are candidates for a day-of baseline adjustment and managed a field study to estimate operability rate of Power Saver AC load control devices.
- **Central Electric Power Cooperative: Smart Thermostat Pilot (2017) and DR Management System (2018-2021)** Used thermostat runtime data to assess group equivalency and estimate summer and winter demand response impacts. Helped develop an automated reporting tool that provides the client with rapid feedback concerning DR performance and participation levels.
- **Rhode Island Office of Energy Resources: National Grid Energy Efficiency Programs Evaluation (2019-2020)** National Grid's energy efficiency programs (gas and electric) were evaluated by performing a billing analysis for any premise that installed an incented retrofit measure between 2015 and 2019. Example retrofit measures offered by the program include lighting measures, steam traps, and VSDs on HVAC systems.
- **Georgia Power PowerCredit AC cycling switch operability assessment (2017)** Managed a field study of a random sample of 140 participating households to estimate the operability rate of the program's 50,000 load control switches.
- **Union Gas Home Energy Report Program (2017-2018)** Ran the impact evaluation of a large randomized control trial implemented by Oracle. Primary author of the impact evaluation report for the first heating season HERs were delivered.
- **CREED National Lighting Analysis of LED Costs (2017-2021)** Processed and cleaned large volumes of light bulb point-of-sale data purchased through Nielsen. Helped develop an incremental cost report, which compared the average price of different light bulb types and styles across the U.S. Helped develop a regression model that was used to predict the market share of LED light bulbs in each state. This model was the basis for NTG research in several states.
- **Independent Electricity System Operator of Ontario Industrial Energy Manager Program Evaluation (2017-2018)** Audited ex-ante energy and demand savings values for a variety of projects, including LED lighting upgrades, facility-wide operational changes, HVAC schedule optimization, and the reconfiguration of heat pump systems.
- **Efficiency Maine: TRM Review (2019-2020)** Efficiency Maine performs virtually all program tracking and reporting through its effRT system. The purpose of the TRM review was to verify that savings formulas and values stored in effRT reflect the TRM and that effRT schedule effective dates are consistent with the TRM effective dates. As part of the review, we also confirmed that measure lives, coincidence factors, energy period factors, in-service rates, realization rates, and free-ridership and spillover factors stored in effRT reflect the TRM.
- **IPMVP: Option C Uncertainty Protocol (2017)** Helped develop the uncertainty guidance for regression-based whole building analysis methods. Contributions included content related to: omitted variable bias and misspecification, diagnosing and understanding the impacts of autocorrelation, and methods for correcting for autocorrelation.

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

STEPHANIE BIELER
SENIOR CONSULTANT

Relevant Experience

- **Indiana Utility Regulatory Commission (IURC) – Emerging Technologies on the Electricity Distribution System (2019-2020)** As a lead analyst for the study, Stephanie worked to help develop six distributed energy resource (DER) adoption scenarios that combined deployment levels of rooftop solar (PV), electric vehicle charging (EV), and battery storage in residential and commercial customers connected to Indiana IOU feeders. She also helped develop and employ an empirical framework to measure the impact of DERs on the power system for the six scenarios. The framework measured both the economic value and the reliability impact of DER. To measure reliability impacts, Ms. Bieler used a pioneering method first developed for this study with a data set of over half a million of historical outages across the five Indiana IOUs and simulated the impact of different levels of behind-the-meter battery storage adoption, with several operational strategies, to reduce the frequency and duration of outages from the customer's perspective.
- **Duke Energy – Market Potential Study (2018–2020)** As a Consultant at Nexant, Stephanie led the analysis of market potential for demand response in three Duke Energy service jurisdictions. The study presented Duke Energy with an integrated picture of demand response technical options, economic analysis, and estimates of achievable potential for various scenarios. Stephanie's work included customer segmentation, system load analysis, measure impact estimates, program design, and forecasts of program participation.
- **State of Florida – Market Potential Study of DSM (2017–2019)** As a part of this study, Stephanie assessed the available technical, economic, and achievable potential for demand response in service territories of seven Florida utilities. She held regular meetings with a multi-utility client stakeholder group and worked with them collaboratively to better understand customer load, model load profiles, and produce deliverables. Additionally, Stephanie provided regulatory support for the utilities as a part of their rate case.
- **Southern California Edison (SCE) – Load Impact Evaluation of Demand Response Contracts (2020)** Stephanie was the lead analyst for the evaluation of SCE's Local Capacity Resource (LCR) demand response (DR) contracts. The bilateral contracts were between SCE and three different demand response aggregators (DRAs). Most of the contracts were for DR with battery storage and roughly 400 non-residential service accounts were enrolled with the three DRAs in 2019. Ms. Bieler used individual customer regressions to perform the analysis.

EDUCATION

MS, Earth Systems
Stanford University

BAH, Human Biology
Stanford University

WORK HISTORY

Demand Side Analytics, LLC
Senior Consultant 2020

Nexant
Consultant and Project Analyst 2017-2020

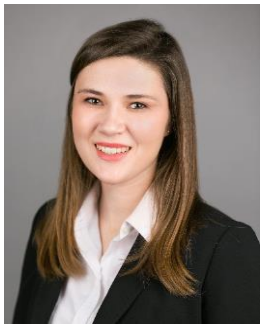
- **Southern California Edison (SCE) – Agricultural and Pumping Interruptible (API) Demand Response Load Impact Evaluation (2018–2019)** API is a direct load control program that targets agricultural pumping equipment. Stephanie led the load impact evaluation for API in program year (PY) 2018. There are currently 1,100 participants in the API program and the program is capable of delivering up to 34 MW in 2019.
- **Southern California Edison (SCE) – Real Time Pricing Demand Response Load Impact Evaluation (2017–2019)** Real Time Pricing (RTP) is a dynamic pricing tariff with hourly prices that vary according to day-type and temperature. The analysis performs individual customer regressions in order to estimate the reference loads for participating customers, as well as the ex-ante and ex-post impacts for the program. Stephanie was the lead analyst for the PY 2017 load impact evaluation for RTP and led the load impact evaluation for RTP in PY 2018.
- **Southern California Gas Company (SoCal Gas) – Smart Thermostat Demand Response Load Impact Evaluation (2018–2019)** Stephanie was the lead analyst for the 2018 load impact evaluation for the SoCal Gas Demand Response program and led the load impact evaluation for the Smart Therm program in 2019. She estimated ex post load impacts using difference-in-differences regression analysis. This is one of the first natural gas DR programs in the United States and one of the first evaluations of such a program. The program currently has 44,000 smart thermostats enrolled and is being evaluated for demand reductions during the event window, daily savings, and the impact of event implementation strategies on program performance.
- **Large Western Utility – Value of Service Study (2018–2019)** As a lead analyst for the study, Stephanie helped design and implement a customer interruption cost study of more than 3,500 surveys of residential and small to medium business customers, in addition to 75 in-person interviews of large business customers. This included designing a sample of utility customers to recruit for the study. Stephanie analyzed survey data to estimate customer interruption costs, assess customer satisfaction, and help the utility better understand customer attitudes toward acceptable levels of utility spending to improve resilience.
- **California IOUs – California Statewide Permanent Load Shifting (PLS) Program Evaluation (2017–2018)** Stephanie conducted analysis as part of Nexant's impact evaluation of SCE's Permanent Load Shifting program. She estimated ex post load impacts using a pre-post analysis and forecasted ex ante load impacts through an analysis of historic load performance. She also conducted building simulation models for customers who were expected to enroll but did not have any ex post data available. Due to the nature of the program and the low number of participants, the analysis for each participant was conducted separately.

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

ALAINA TOTTEN
SENIOR QUANTITATIVE ANALYST

Pennsylvania Act 129 Experience

- **PA PUC: Statewide Audit of HER Performance (2018-2020)** Lead analyst responsible for auditing the HER savings methods and calculations for PECO and Duquesne during the PY9 and PY10. Evaluated multiple waves of distributions including both residential and low income residential customers.
- **Incremental Cost Database Update- LED Lighting Update (2020)** Lead analyst for the 2020 update of cost assumptions and taxonomy using project files and scraped data from Graybar and Granger.
- **Phase IV Implementation Order (2020)** Assisted with the organization and summarization of stakeholder comments.
- **2021 TRM Update (2019)** Updated Water Heating savings protocols for the 2021 Technical Reference Manual, providing savings estimates for efficient systems based on fuel type and expected use. She created 8760 load shapes for water heating based on business type using secondary data.
- **C&I Baseline Study (2018)** Alaina completed the end use analysis for Commercial Cooking, Refrigeration, Lighting, Plug Load, Processes, and Water Heating. She also performed analysis for the participation component as well as general and building level statistics. She wrote the report for these sections and supported the reporting for the remaining components of the Phase III study. The study surveyed 500 non-residential businesses across the state and Alaina assisted in compiling relevant inputs from the baseline study to support the 2019 TRM update and market potential study.
- **Residential HVAC EFLH Update (2018)** Lead analyst in charge of calculating the baseline Equivalent Full Load Hours (EFLH) for central cooling systems and EFLH heating for gas furnaces and air source heat pumps. Proposed EFLH and Coincidence Factor (CF) values were created for 9 cities and adopted as inputs for the next phase of the Pennsylvania TRM for all residential HVAC measures.
- **Statewide Audit of C&I DR Performance (2018-2020)** Lead analyst responsible for auditing the DR savings methods and calculations and assessing EDC progress towards performance goals for multiple EDCs during the PY9 and PY10 Demand Response seasons. Supported the lead analyst for the PY11 evaluations. Worked with the EDCs to recreate program impacts, and independently evaluate savings estimates following Pennsylvania Evaluation Framework. Uncovered evaluation errors and worked with the EDCs to correct issues in time for annual reporting.



Education

MS, Economics
Georgia Institute of Technology 2019

BS, Economics
Georgia College & State University, Honor's College 2015

Work History

Demand Side Analytics, LLC

Senior Quantitative Analyst	**2020-now**
Quantitative Analyst	**2018-2020**

Other Relevant Experience

- **ecobee eco+ Demand Response (2019-2020)** Lead analyst for the two-year pilot which was a Randomized Encouragement Design. She led the data preparation for the suite of savings features and estimated impacts for six geographical regions across the United States and Canada and over 80 DR events.
- **Southern California Edison: Demand Response Evaluations (2019-2020)** Alaina was the lead analyst for the SEP program under the SCE portfolio of DR programs. The Smart Energy Program (SEP), which utilizes Wi-Fi connected smart thermostats to reduce air conditioning load in participating residential households during peak hours. Ex-post and ex-ante impacts were evaluated at various levels of segmentation including geographical region and thermostat manufacturer.
- **SDG&E: CPP and Smart Thermostat Demand Response Programs (2018-2020)** Ms. Totten has supported the commercial and residential DR program evaluations since 2018. Now the lead analyst, Alaina plays a larger role in data preparation, impact evaluation, and report writing in adherence to the California Load Impact Protocols.
- **Central Hudson Gas and Electric – Home Energy Reports Evaluation (2019-2020)** Assisted with the 2019 gas and electric HER evaluations. Created automated reporting to run quick, quarterly updates for 2020 evaluations.
- **Union Gas and Enbridge Gas Home Energy Reports Evaluation (2019)** Lead analyst for print and email distribution streams of both firms' HER programs. Also completed the uplift analysis using tracking data to compare impacts between participants and nonparticipants to net out any dual participation effects.

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

JOSH BODE
PARTNER

Pennsylvania Act 129 Experience

- **Statewide Tracking Database Visualizations (2019-present)** Developed dashboards and maps in Tableau to allow TUS and SWE to quickly view Phase III performance across various performance metrics.
- **Review of FirstEnergy Business Energy Report Experimental Design (2019)** Ran a series of equivalence checks and worked with FirstEnergy's EM&V contractor to ensure customers with multiple accounts were not placed in both the treatment and control group.
- **Phase IV Demand Response Study (2019-2020)** Provided oversight of the battery storage modeling and synthesis of industry cost curve projections.

Other Relevant Experience

- **Central Hudson Distributed System Implementation Plan Support (2014-present)** Location specific probabilistic forecasting for all substations producing 8760 forecasts. Develop locational value estimates for all substations, planning areas, and transmission projects using probabilistic modeling. Granular substation and feeder DER forecasts - Analyze historical adoption, estimate diffusion curves with uncertainty, adoption propensity modeling, and produce hourly (8760) forecasts. The granular forecasts were developed for: residential, non-residential, and community solar; electric vehicles, BTM battery storage, heat pump and heat pump water heater, energy efficiency. Estimated the location specific T&D deferral value for each substation (62) and sub-transmission area (10) in 2016 and 2018. This required identifying the timing of the infrastructure investments, modeling infrastructure costs with and without load management, calculating the avoided costs (if the simulated growth triggered an investment), estimating the expected avoided T&D cost for each location and year.
- **PSEG Long Island DER potential, NWA assessment, DER optimization tool (2020)** Developed a tool to allow planners to estimate DER potential and costs for specific locations and develop optimal DER portfolios.
- **PSEG Long Island Locational Value Study (2020)** Led analysis to develop granular load forecasts and quantify the locational value of avoided T&D costs.
- **Central Hudson probabilistic T&D planning tool (2017)**
- Location specific same day and day ahead forecasting models for all substations, transmission areas, and non-wire alternative projects (Central Hudson 2017). Development of tools for modeling 8760 customer and end use load,

EDUCATION

Master of Public Policy
University of California, Berkeley 2005

Bachelor of Science in Economics
Willamette University 1999

WORK HISTORY

Demand Side Analytics, LLC
Partner 2017-now

Nexant – San Francisco, CA
Vice President, Strategy & Planning 2016-2017
Principal Consultant 2014-2015

Freeman, Sullivan & Co – San Francisco, CA
Principal Consultant 2013
Senior Consultant 2010–2012
Consultant 2008–2009
Senior Analyst 2005–2007

U.S. Federal Energy Regulatory Commission – Washington D.C.
Energy Industry Analyst 2005

including solar and EV's, for all PG&E's 2900 circuits and 800 substations (PG&E 2014). Development of a tool for assessing non-wires alternatives to transmission and distribution investments (National Grid 2010)

- **Central Hudson 2019 Location Specific Avoided Gas Distribution Costs** Developed forecast models gas demand and pressure drops for 37 gas systems, estimated locational value, developed online tool.
- **Energy Trust Oregon: Nest Seasonal Savings Pilot Evaluation (2016-2017)** Evaluation of seasonal savings RCT with thermostat runtime data for 6K units.
- **Fortis BC: Smart Learning Thermostat Pilot (2018-2019)** Explored the potential for a new cost-effective residential electric and gas savings measure.
- **Questar Gas: Dominion Energy West- Peak Moment Valuation Frameworks (2017-present)** Questar Gas commissioned Demand Side Analytics to develop a peak moment valuation framework and apply it to instantaneous versus storage water heaters (in response to a regulatory order). The study included analysis of the historical hourly loads for the Dominion gas system, including system loads and loads for all its city gates in order to assess growth rates, the timing of peak loads, and whether specific energy efficiency measures contributed to the peak, lowered it, or did not align with peaking conditions. As part of the study, DSA also analyzed 5-minute data from 7,000 water heaters and used the data to simulate end use level loads with storage-type and instantaneous water heaters. The purpose was to assess if exchanging storage water heater with instantaneous ones led to increases, reductions, or no impacts on the peak moment. DSA also developed a technology agnostic analytical framework for valuing the contribution of energy efficiency to peak moment demand decreases and increases and presented to the regulators for the State of Utah.
- **Central Hudson Gas & Electric Behavioral Program Evaluation (2019-present)** Over 110,000 electric customers and 30,000 gas customers were sent energy reports designed to encourage energy conservation in both gas and electricity.
- **SDG&E DR and DER Analytics Tool (2020)** Developed a tool to allow SDG&E to simulate battery storage, solar, DR enrollment, and rate changes for any of its approximately 120,000 non-residential customers using AMI data. Apply analysis to full non-residential population and run models to identify customer who benefit most from DR or DR plus battery storage.
- **PSEG LI DER Locational Value tool (2020)** Tool to assess value of DER portfolios and individual DERs for feeders, substations, load pockets selected by user.
- **Central Hudson Battery Storage Model (2019-2020**) Developed a model to simulate market revenue and assess battery storage bids.
- **Consumers Energy and Sunverge (2019)** Identifying high value locations for battery storage.
- **State of Washington Distributed Energy Resource Planning Assessment (2017)** Worked with planners at each of the electric utilities in the state to assess current planning practices for distribution system upgrades and how distributed energy resources were accounted for, if at all.
- **Large Western Utility (2015-2016)** Battery Storage Pricing, Payback Periods, and Bill Impacts. Interval data analysis for all 1,500 largest customers.
- **ConEd: Brooklyn Queen Demand Management Project Framework and Model (2014)** for assessing bids and from demand and supply side resources with different operating characteristics.
- **ConEd (2015)** REV Market design support – Designing and Unlocking Markets for Distributed Energy Resources.
- **Central Hudson** Non-Wire Alternatives (NWA) assessments (6 projects), including analysis of load patterns, modeling of DERs, optimization of resource mix, and benefit costs analysis

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

MARK NOLL
SENIOR QUANTITATIVE ANALYST

Pennsylvania Act 129 Experience

- **Phase IV TRC Final Order (2019)** Was part of the team that summarized stakeholder comments in response to the Phase IV TRC Tentative Order and drafted the Phase IV TRC Final Order, with characterizations of stakeholder comments and PUC dispositions on various issues related to the Total Resource Cost Test.
- **Phase IV Demand Response Potential Study (2019)** Calculated the electric and gas energy efficiency savings for connected thermostats, and collected third-party forecasts of battery storage costs to inform the DR potential study and documented
- **FirstEnergy TRC Audit (2019)** Audited the PY10 TRC calculations for the four FirstEnergy EDCs.

Other Relevant Experience

- **Consumers Energy Demand Response Market Potential Study (2020)** Helped conduct a demand response market potential study for Consumers Energy in support of the company's 2021 Integrated Resource Plan. Mr. Noll focused on the residential sector and used hourly smart meter data for a sample of 20,000 customers to estimate the costs of peak load savings from residential HVAC programs (smart thermostats and AC switches) as well as for residential dynamic pricing
- **Central Electric Power Cooperative Generac Pilot (2019)** Led cost-benefit analysis for a demand response pilot for in South Carolina in which the company controlled customer-sited generators for reducing system peak demand during summer and winter months
- **San Diego Gas and Electric Baseline Accuracy Study (2019)** Conducted a demand response baseline accuracy study for San Diego Gas and Electric residential customers to inform future program implementation rules, testing different aggregation methods and sample sizes.
- **El Paso Electric School Summer Demand Response (2019)** Independently calculated verified demand response savings for 6 schools for the summer of 2019 and produced report with key findings and figures.
- **Southern California Gas Multifamily Central Hot Water (MFCHW) Program (2019-2020)** Led automated analysis and reporting for natural gas savings associated with upgrades to water heaters at over twenty sites, including methodological adjustments for COVID-19.

Education

BA, Economics
Georgetown University 2017

Work History

Demand Side Analytics, LLC
Senior Quantitative Analyst 2020-now
Quantitative Analyst 2019-2020

Charles River Associates – Washington, DC
Associate 2018-2019
Analyst 2017-2018

Georgetown University – Washington, DC
Research Assistant 2015-2017
Teaching Assistant 2016

- **ecobee Summer Impact Evaluation (2019-2020)** Assisted with summer 2019 impact evaluation for ecobee via randomized control trail, and created an Excel-based tool to estimate the impact of smart thermostats on customers' average energy usage and cooling bills under various TOU rates for ecobee. Built from scratch, the tool can take in custom TOU rate structures (2-part or 3-part) and different geographic areas to estimate energy and bill savings.
- **Central Hudson Distribution System Implementation Plan (2019-2020)** Assessed the potential for load relief at over three hundred feeders and sixty substations and calculated locational value for distributed resources (EE, DR, solar, storage) installed at these locations.
- **NIPSCO Demand Response Market Potential Study and IRP Support (2020-2021)** Developed the residential connected thermostat and time-varying rates models for 20-year assessment of demand response potential.

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

ADRIANA CICCONE
PRINCIPAL CONSULTANT

Pennsylvania Act 129 Experience

- **Phase IV Demand Response Potential Study (2019)** Led the residential modeling of dispatchable demand response potential for each of the seven EDCs. The study considered direct install and "bring your own" thermostat programs as well as a behavioral demand response program type for the residential sector.
- **Home Energy Report Persistence Study (2018)** Analyzed the persistence of savings in residential households that stopped receiving HERs. Collaborated on methods to account for first year and lifetime savings for HER programs that take in to account the persistence of impacts.
- **2021 TRM Update (2019-2020)** Assisted in developing a Home Energy Report measure for Phase IV of Act 129. This measure characterization implements a multi-year measure life perspective on HER impacts.

Other Relevant Experience

- **Southern California Edison Demand Response Portfolio (2019-2020)** Project manager of complex, four-program load impact evaluation for SCE's utility-specific demand response programs. Performed impact evaluations for their Agricultural & Pumping Interruptible and Large Commercial Real Time Pricing programs.
- **Tendril – Orchestrated Energy Evaluation of demand response (2018)** Orchestrated Energy is a thermostat optimization algorithm implemented by Tendril for several investor-owned utilities including Xcel Energy. The algorithm includes both an EE and DR component. Ms. Ciccone evaluated the demand response component for four utilities in the program.
- **California Statewide Baseline Interruptible Program (2016)** Performed three demand response evaluations of large industrial customers (at PG&E, SCE and SDG&E) using individual customer regressions. This analysis had extensive focus on model specification development and out-of-sample testing.
- **SDG&E Small Commercial Technology Deployment (2016)** Performed an analysis of demand response capabilities for small commercial customers with programmable communicating thermostats. This evaluation used a triple-differences method to develop ex post and ex ante impacts.
- **San Diego Gas & Electric DER Targeting Analysis (2020)** Performed a large-scale analysis of the bill savings associated with commercial customer adoption of batteries and solar PV in conjunction with demand response enrollment. All commercial customers in the territory had simulated bill impacts for over 1,000 scenarios of different rate, DER size, DR program and operating strategy.

Education

MS, Environmental Science and Public Policy
University of Chicago, 2015

BS, Materials Science, MIT, 2009

BS, Management Science/Operations Research
MIT, 2009

Work History

Demand Side Analytics, LLC
Principal Consultant 2020-now
Senior Consultant 2018-2019

Nexant, Inc.
Senior Consultant 2015-2018

Proctor & Gamble
Competitive Intelligence Analyst 2009-2013

- **Public Service Electric & Gas –Long Island Locational Value Study & DER Valuation Tool (2020)** Develop an Excel-based Location specific DER valuation model that relied on inputs from a DSA-generated locational value study. The tool will be used to identify and quantify the level of load relief required at the feeder, bank, or substation level in PSEG-LI territory.
- **Enbridge, Union Gas: Home Energy Report Evaluation (2017 to 2019)** Demand Side Analytics performed an impact and process evaluation of behavioral Home Energy Report programs offered by the two largest natural gas utilities in Ontario, Union Gas, and Enbridge Gas. The HER programs were implemented by Oracle and included approximately 350,000 treatment group homes and 100,000 control group homes. DSA performed a validation of the RCT once it was completed by Oracle and an annual impact and cost-effectiveness analysis for each year of the program. The evaluation also included a process evaluation with surveys conducted with households in both the treatment and control groups to understand how HERs affect customer attitudes and awareness of energy conservation.
- **Seattle City Light Home Energy Reports Evaluation (2016-2018)** Performed an evaluation of behavioral conservation program, including measuring differences in savings between vendors, report delivery frequency, and sub-population treatment arms. Analyzed customer satisfaction and conservation perception surveys to assess the effects of report delivery on qualitative measures.
- **Georgia Power Residential Thermostat Energy Savings Evaluation (2018**) Performed an assessment of energy savings associated with a thermostat rebate program and exploration of the incremental benefits of using large scale AMI data (over 1 billion rows) for energy efficiency program evaluation compared to traditional billing data methods.
- **Con Edison Innovate Pricing Pilot Design, implementation support, and evaluation (2017-2018)** The pilot is focused of assessing innovative delivery rates and assessing customer acceptance, load impacts, and bill impacts of rates with time-of-use demand charges and demand subscription rates. Both opt-in and default enrollment were being tested for residential and non-residential customers. Ms. Ciccone analyzed hundreds of potential revenue-neutral rates for customer bill volatility and revenue stability.
- **Con Edison and O&R SmartHome Pilot Design, implementation Support, and evaluation (2016 to 2019)** A prices-to-devices pilot designed to assess the ability of customers to respond through technology (battery storage, thermostats, EV's and home energy management systems) to location specific and time varying prices that better reflect all costs components. Ms. Ciccone analyzed hundreds of potential revenue-neutral rates for customer bill volatility and revenue stability.
- **California Statewide Demand Response Potential Study Support (2016)** Ms. Ciccone quantified the DR impacts of default or opt-in TOU rates in California as part of the statewide DR potential study conducted by LBNL.
- **Efficiency Maine Trust Lighting Impact Evaluations (2019-2020)** Designed an online data collection system for a residential socket saturation and hours of use study. Utilized lighting load shapes and HVAC system characteristics gathered onsite to update the interactive effect assumptions in the Maine TRM.

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

ANDREA HYLANT
SENIOR QUANTITATIVE ANALYST

Pennsylvania Act 129 Experience

- **Audit of HER Performance (2020)** Responsible for auditing the HER savings methods and calculations for Duquesne Light during PY11. Evaluated multiple waves of distributions including both residential and low-income residential customers.

Representative Project Experience

- **Central Hudson Residential HVAC TRM Gas Measures Review (2020)** Calculated both baseline and efficient Equivalent Full Load Hours (EFLH) for gas furnaces and boilers to estimate efficiency rebate program savings. Outcomes advised which TRM measures to use in savings calculations for more accurate program savings estimates.
- **SDG&E DER Analytics (2020)** Developed specialized bill calculator using AMI data to estimate bill impacts of solar, battery storage, DR and rate changes on customer bills. Develop propensity models to identify which customers were most likely to participate in solar, DR, and battery storage. The models were applied to all 150,000 non-residential customers to improve targeting and better understand customer bill impacts. She also developed the user dashboard to allow program managers and account representatives access to the analytics.
- **CPUC Integrated Resource Planning (2020)** Produce the granular geographic allocation for electric vehicles and plug-in-hybrids for each year through 2050 to assess impacts of electrification on distribution grid costs. Developed Tableau dashboard to visualize EV clustering in CA over time.
- **Central Hudson Electric Vehicle Data (2020)** Automated collection of EV vehicle registration data to provide up to date information on EV penetration and adoption for each municipality.
- **DCSEU Winter Seasonal Savings Analysis (2020)** Evaluated smart thermostat 5-minute interval data for 10,000 sites to estimate savings for Winter 2019-2020 and provide recommendations to TRM measures for Nest Thermostat seasonal savings analysis.
- **CEPC and PG&E Water Heater Pilots (2020)** Analyze the ability to use three new smart water heater technologies to provide thermal storage and demand reductions. The analysis includes automating API calls to download thermostat inform and 5-minute interval data, assessing load impacts of the devices, and automating reporting.

EDUCATION

BS, Earth & Environmental Sciences
University of Michigan, 2016

WORK HISTORY

Demand Side Analytics, LLC
Senior Quantitative Analyst 2020-now

Metis
Teaching Assistant 2020
Data Science Boot Camp 2019

Solar United Neighbors
Solar Program Specialist 2018-2019
Solar Program Coordinator 2017-2018

USGS, Branch of Hydrogeophysics
Geologist 2016

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

DANIEL KLOS
WEB DEVELOPER

Web-Enabled Survey Management Systems

Prepare, merge and clean large population datasets to support sample design and sample list creation. Develop web-enabled systems for tracking outbound recruiting calls, scheduling site-visits, and collecting field data. Real-time optimization of call lists to meet multi-dimensional quotas as quickly as possible. Link mapping software to facilitate for ease of use for schedulers and field technicians. Real-time access to tracking systems for monitoring purposes.

EDUCATION

BS, Mathematics,
Beloit College

WORK HISTORY

Demand Side Analytics, LLC
Web Design **2018-now**

Klos Energy Consulting
Owner **2010-2018**

- **Phase III SWE C&I Baseline Study**
- **Central Hudson C&I Baseline Study**
- **Efficiency Maine Commercial Lighting**
- **Pepco Holdings Direct Load Control Study**
- **Commonwealth Edison Residential CFL Study of Illinois and Kansas**- Created automatic individual cover sheets for field use.
- **Puget Sound Energy Residential HVAC Duct System Evaluation**
- **California Public Utility Commission High Impact Measure C&I Lighting Study**- Developed a centralized inventory system for loggers.
- **Palm Desert HVAC Study, including commercial refrigerant charge and airflow (RCA) sites**
- **Tucson Electric Power Residential and Commercial DSM Baseline and Potential Study**
- **Arizona Public Service Residential Lighting Study-** Developed access code to raw logger hexadecimal data and extract internal logger settings.
- **AEP-Ohio DSM Baseline Study**
- **Progress Energy- Carolinas Energy Efficiency Benchmarking**
- **California Public Utilities Commission Residential Gas Study**
- **Minnesota Office of Energy Security DSM Potential Study**
- **Northwestern Energy Home Energy Audit Evaluation**
- **Union/Enbridge Commercial Free-rider and Spillover Survey**
- **Natural Resources Canada Net to Gross Study**- Analyzed results using logit and probit models.

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

KATHERINE BURLEY
SENIOR QUANTITATIVE ANALYST

Pennsylvania Act 129 Experience

- **PY11 Demand Response Audit (2020)** Replicated verified demand response impacts for PPL's PY11 demand response programs. Worked with PPL's EM&V contractor to identify the cause of differing estimates for selected sites.
- **PY11 HER Audit (2020)** Verified reported savings for Home Energy Report **programs** for the four FirstEnergy utilities.
- **Phase IV Implementation Order (2020**) Assisted in review, organization, and summarization of stakeholder comments for the Phase IV Tentative Order and Final Implementation Order.

Other Relevant Experience

- **ecobee eco+ Evaluation (2020)** Analyzed ecobee's eco+ energy efficiency features during Winter 2019-2020 and the TOU rate feature in Summer 2020, using a nationwide randomized encouragement design of 250,000 thermostats.
- **PG&E WattSaver Pilot Evaluation (2020)** Evaluated daily and peak demand impacts of smart hybrid water heaters in the final phase of the pilot evaluation.
- **CEPC Generac Pilot Evaluation (2020)** Estimated demand impacts for pilot customers during winter demand response events.
- **San Diego Gas & Electric: DR and DER Analytics (2020**) Estimated demand response propensity score and nominated kW recommendations for all non-residential customers.
- **Southern California Edison: Demand Response Evaluation (2020)** Determined busbar-level portfolio impacts for four SCE demand response programs, and aggregate hourly impacts for two programs.
- **Unitil Energy Systems: Forward Capacity Market Compliance Review (2020)** Collected precision factors for over 300 energy efficiency measures across Massachusetts and New Hampshire and estimated statistical uncertainty of Unitil's demand reduction value for New Hampshire.
- **Central Hudson Gas & Electric: C&I Lighting Audit (2020)** Verified reported energy and demand savings for commercial lighting projects under Central Hudson's Business Incentives Program.

Education

Master of Arts, Economics
University of Texas – Austin 2019

BS, Economics
Louisiana State University 2017

Work History

Demand Side Analytics, LLC - Atlanta, GA
Quantitative Analyst 2020-now

Mather Economics – Atlanta, GA
Associate Consultant 2019-2020

TXP, Inc – Austin, TX
Research Analyst 2018

Capitol Market Research – Austin, TX
Market Analysis Intern 2017-2018

LSU AgCenter
Research Assistant 2016-2017

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

MOLLY JONES
RESEARCH COORDINATOR

Professional Experience

- **Research Coordinator, Demand Side Analytics, 2019-present** Coordinate customer outreach and recruiting for a variety of research activities including surveys, site inspections, and stakeholder interviews. Organize and maintain registrations with utility supply chain and procurement departments. Write qualifications and detailed project summaries for documentation and record-keeping.
- **Associate Executive Director, Academic Partnerships, 2018-present** Market the online advanced degree programs offered by the University of Alabama at Huntsville's College of Nursing to drive potential students to enroll. Conduct presentations to nurses at career fairs, hospitals and medical centers.
- **FIVE STAR Exclusive Instructor, LifeTime Fitness, 2014-present** Create and teach group fitness classes, including barre, Pilates, strength, cardio and yoga fusion formats.

Representative Project Experience

- **Efficiency Maine Trust Retail and Distributor Lighting Impact Evaluation (2019 to Present)** Recruited 80 residential customers to participate in a nine month lighting logger program through consistent communication and outreach. Maintain customer relationships and follow-up by phone, email, text and post. Responsible for project logger data tracking and input.
- **Central Hudson Gas and Electric (2019)** Recruited 110 commercial customers for participation in an energy efficiency baseline study. Maintained program status updates and target orientation through database management.

EDUCATION

BA, Spanish/Marketing
University of Alabama, 1997

WORK HISTORY

Demand Side Analytics, LLC
Research Coordinator 2019-now

Academic Partnerships
Associate Executive Director 2018-now

LifeTime Fitness
Group Fitness Instructor 2014-now

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

PETER MCBRIDE
ENGINEER

Areas of Expertise

- **Measurement & Verification**: Defining baseline scenarios, performing metering studies, calculating energy and demand savings for measures and systems, quality assurance review, and deemed savings estimation.
- **Energy Analysis:** Analyzing and estimating building and industrial process loads, and conducting cost-benefit analyses of energy conservation measures.
- **Baseline Market Characterization:** Establishing baseline energy usage characteristics of sectors, segments, end-uses, and equipment type; market research; conducting on-site audits and site visits; and ensuring data integrity through established QA/QC protocols.
- **Program Design & Implementation:** Designing, implementing, and managing programs focused on electric and gas energy efficiency measures; developing program materials and manuals; ensuring compliance with program rules; and providing technical advice to service providers.
- **Energy Audits:** Performing energy audits in commercial and industrial facilities to identify energy efficiency measures and estimate savings, mentoring staff engineers in auditing processes, and providing quality review of audit reports.

Representative Project Experience

- **IESO – Evaluation of Business Programs (2009–2010, 2012–2019)** Peter has developed measurement & verification protocols, performed on-site inspections and data collection, and/or calculated gross impacts for over one hundred and fifty projects since 2009. The projects involved a wide range of energy efficiency measures installed at commercial, industrial, agricultural, and multi-family residential facilities in Ontario.
- **Duke Energy – Custom Impact Evaluation (2017-18)** Peter performed on-site measurement and verification activities for twenty-eight commercial and industrial projects in three states.

EDUCATION

MS, Mechanical Engineering
Arizona State University, Tempe AZ

BS, Mechanical Engineering
University of Massachusetts, Amherst MA

Professional Engineer (PE) MA - 37188

WORK HISTORY

Demand Side Analytics, LLC
Engineer 2019-now

Nexant – Belfast, ME
Consulting Engineer 2003-2019

Alstom Power, Ltd. – Sydney, Australia
Design Engineer 2000-2002

Rolls-Royce Australia, Ltd. – Sydney, Australia
Design Engineer 1996-1999

Babcock Power, Inc. – Worcester, MA
Engineer 1988-1996

- **Hannaford Supermarkets - Refrigerated Case Lighting Controls Savings Study (2017)** Peter collected data to quantify the savings impact of changes to occupancy sensor delay settings for refrigerated case lighting in ten supermarkets.
- **Efficiency Maine – Evaluation of Business Incentive, Large Customer, and Boothbay Harbor Programs (2015-2016)** Peter performed on-site measurement and verification activities for seventy projects in three Efficiency Maine business programs.
- **IESO – Evaluation of Consumer Products and Capacity Building Programs (2014-2015)** Peter performed on-site measurement and verification activities at more than ninety homes for the evaluation of two residential HVAC programs. The measurements included power, flow, and temperatures for central air-conditioning systems.
- **Wisconsin Public Service Commission – Impact Evaluation of Focus on Energy Portfolio (2012–2015)** Peter developed measurement & verification plans, performed on-site inspections and data collection, and determined the savings impacts for various commercial and industrial projects.
- **Efficiency Maine – Evaluation of Residential Retail Products Programs (2013)** Peter performed on-site measurement and verification activities at seventy homes for the impact evaluation of Efficiency Maine's Residential Appliance program.
- **Pennsylvania Public Utility Commission (PA PUC) – PA Act 129 Statewide Evaluator - Evaluation of Pennsylvania Electric Distribution Companies' Energy Efficiency and Conservation Programs (2009–2012)** Peter provided engineering support to the PA PUC as it implemented Act 129 of 2008, with the overall goal of reducing energy consumption and demand throughout the state of Pennsylvania. Peter established and reviewed evaluation procedures and protocols, conducted project inspections to assess savings, and helped oversee M&V activities of the electric distribution companies.
- **New York State Energy Research and Development Authority (NYSERDA) – Technical Assistance (2003–2011)** Peter provided technical assistance for NYSERDA's commercial & industrial programs (CIPP, ECIPP, PLRP, and EFP), reviewing submittals for accuracy of engineering savings estimates, adherence to program goals, and ability to deliver savings. All reviews included site inspections to verify baseline and post-installation conditions, equipment configuration, and performance. In 2011, Peter reviewed reports submitted to NYSERDA's FlexTech Benchmarking Pilot program, which included commercial and multi-family residential projects.
- **Apartment Investment Management Company (AIMCO) – Multi-Family Residential Energy Audits (2005–2007)** Peter performed eight energy audits of multi-family apartment buildings for AIMCO, the nation's largest owner and operator of apartment communities. After completing on-site assessments, energy efficiency measures were identified, analyzed, and presented in written reports.
- **New York State Energy Research and Development Authority – Measurement & Verification Evaluation of New York Energy $mart Program (2003–2006)** Peter reviewed savings calculation methods and results for the New York Energy $mart program portfolio. Activities included conducting field inspections to verify equipment installation, taking power measurements to support engineering savings calculations, monitoring energy use, and reviewing energy savings calculation algorithms.
- **New York Power Authority – Energy Conservation Market Assessment (2005)** Peter provided technical support for an energy conservation market assessment of New York Power Authority's municipal and cooperative electric customers. As part of the assessment, Peter performed energy audits of more than forty residential, commercial, industrial, and institutional facilities.

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

SAVANNAH HORNER
QUANTITATIVE ANALYST

Education

- **Master of Science, Economics**, Georgia Institute of Technology, December 2020
- **Bachelor of Science**, Economics/Minor in International Affairs, Georgia Institute of Technology, 2019
- **European Union Study Abroad**, Brussels, Paris, Berlin, 2018

Work Experience

- **Quantitative Analyst**, Demand Side Analytics, 2020
- **Graduate Research Assistant**, Georgia Tech School of Public Policy, May 2020 Coordinated and conducted special activities related to energy and environmental policy analysis. Implemented the use of APIs to collect big data samples from government and private databases. Performed data extraction, manipulation, and statistical analysis using R.
- **Student Assistant**, Georgia Tech Office of Undergraduate Admission, 2019-2020 Counseled and instructed prospective students on college admission procedures and processes. Responded to prospective student inquiries through written and oral communication.
- **Business Intern**, FSC Securities Corporation, 2019 Supported advisor acquisition and retention through the development of Salesforce reporting. Worked with the Head of Business Management to maintain business figures and pipelines. Provided research and administrative assistance for special projects as assigned.
- **Director of Member Engagement**, Georgia Tech Residence Hall Association,2018-2019 Planned an overnight semester training retreat for 115 members to teach them the fundamentals of RHA. Charged with maintaining Leadership Development Track and planned six guest leadership presentations.

Project

- **Simulation Programming for Learning Economics Through Board Games**, 2017-2018 Researched the economic principles behind board games. Collaborated with computer science majors on the adaptability of board games. Analyzed the use of programming to convey overarching economic themes.

EDUCATION

MS, Economics
Georgia Institute of Technology **2020**

BS, Economics/International Affairs
Georgia Institute of Technology **2019**

WORK HISTORY

Demand Side Analytics, LLC
Quantitative Analyst **2020**

Georgia Tech School of Public Policy
Graduate Research Assistant **2020**

PATRICK BURNS, PE, CEM
PRINCIPAL CONSULTANT

Patrick has over 20 years of engineering, planning, and analytic experience with a focus on energy efficiency, distribution energy resources, and electrical systems.

brightline GROUP

CONTACT:

✉ Patrick@BrightLineGroup.com
✆ (303) 792-8669

WORK EXPERIENCE:

BrightLine Group
Principal Consultant and Co-Founder
2018 – Current

Nexant, Inc.
Sr. Vice President
2009 – 2018

BG BuildingWorks
Senior Associate
2000 – 2009

EDUCATION & CERTIFICATIONS:

Professional Electrical Engineer (PE)
CO 35370, CA 15948, FL 57217,
ID 10286, NV 171651

Certified Energy Manager (CEM)

Certified Demand Side Management Professional (CDSM)

BS Architectural Engineering
Illumination and Building Systems
University of Colorado – Boulder

INDUSTRY AFFILIATIONS:

Patrick is a corresponding member of the Regional Technical Forum (RTF) and an active member of AESP and SEPA.

SUMMARY

As a licensed engineer, Patrick has a strong expertise in measurement and verification approaches for all energy efficiency, demand response, and distributed energy resource systems utilizing different analytic methods and data sources. Patrick excels in delivering valued consultation, leading challenging and difficult projects, and using communication and problem-solving skills to facilitate coordination between technical teams and clients.

EXPERTISE

Impact Evaluation | Market Research | Market Potential Studies | Measurement & Verification | Emerging Tech | Planning | Regulatory Support | Strategic Consulting | Electrical Systems

WORK EXPERIENCE HIGHLIGHTS

- Lead consultant on dozens of market resource potential assessments for energy efficiency, demand response, and distributed energy resources; along with complementary efforts including Integrated Resource Planning (IRP) support, load profile analysis, program planning and regulatory support.
- Key investigator for hundreds of DSM program evaluations utilizing a wide toolkit including statistical sampling and probability analysis; measurement and verification (M&V); emissions benefits; cost-benefit analysis; impact savings; performing metering studies; and customer consumption data analytics.
- Executive-level client management and leadership, developing collaborative relationships with multiple investor owned utilities
- Providing regulatory and policy support, including expert witness depositions and detailed technical and contractual evaluation for energy projects, presentation of evaluation plans and findings to Utility Commission staff and Advisory Groups, in multiple jurisdictions.

REPRESENTATIVE PROJECT EXPERIENCE

PENNSYLVANIA PUBLIC UTILITIES COMMISSION – Evaluation, Measurement and Verification of Statewide Programs (2018 – Current)

Patrick is currently acting in an advisory capacity on the statewide evaluator (SWE) as part of the Phase III of Pennsylvania's Act 129 Programs. Patrick's advisory capacity includes support for the non-residential baseline study, the 2019 TRC Order, and the market potential of energy efficiency and combined heat and power for the Phase IV of Act 129. Additional activities include development of an avoided cost calculator and annual evaluation and audit reports for non-residential DSM programs.

GEORGIA POWER COMPANY – DSM Portfolio Evaluation (2011 - Current)

Patrick is currently the project manager for the impact and process evaluation of GPC's 2020-2022 certified commercial DSM programs. The evaluation includes the research of key program questions, planning, stakeholder interviews, hundreds of customer surveys, on-site inspections, utility bill analysis, measurement of key measure parameters, net-to-gross and cost-effectiveness analysis. Patrick has been involved in multiple roles with evaluation and planning projects for Georgia Power since 2011.

MISSISSIPPI POWER COMPANY – 2020 Portfolio Planning Support (Current)

Patrick is leading Mississippi Power's DSM program plan development from 2020 through 2023. This planning activity builds on the BrightLine team's experience providing evaluation and annual reporting for Mississippi Power. BrightLine is using a multi-phased approach: analyzing program performance history, assessing opportunities for evolution and expansion, and incorporating these findings into a new portfolio plan.

AMEREN MISSOURI – Distributed Energy Resources Potential Study (2018 - Current)

Patrick is leading BrightLine's role at assess the market potential for distributed energy resources for Ameren-Missouri for the Company's service area. This study is part of the GDS Team that will provide estimates of the technical, economic and achievable potential for electric energy efficiency, demand response, and distributed energy resources. Resources considered include combined heat and power, roof-top solar photovoltaic, and electric vehicles.

VERMONT PUBLIC SERVICE DEPARTMENT – Technical Support of Annual Savings Claims (Current)

Patrick is leading the impact evaluation of Vermont Gas's commercial and residential energy efficiency programs with the objective of calculating the annual and peak day energy impacts at the program and sector levels and recommending process improvements to streamline program implementation and savings verification efforts. The programs included in the evaluation include a variety of residential and commercial sector focused natural gas technology and construction approaches.

CALIFORNIA MUNICIPAL UTILITIES ASSOCIATION (CMUA) – Energy Efficiency Potential Assessment (2020)

Patrick is leading BrightLine's role to estimate the technical, economic, and market potential for energy efficiency and complementary resources for California electric municipal electric utilities. As a subcontractor to GDS Associates, the team will estimate the resource potential based on CMUA member's customer characterization, climate zone, economic conditions, and other relevant factors over a forecast period of at least ten years. In addition to the assessment of energy efficiency resource potential, BrightLine will assess the resource potential for transportation electrification, energy storage, and self-generation.

MARY-HALL JOHNSON, PE, CEM
MANAGING CONSULTANT

15+ years exploring, quantifying, and communicating energy efficiency.

brightline GROUP

CONTACT:

✉ Mary-Hall@BrightLineGroup.com
✆ (601) 622-8993

WORK EXPERIENCE:

BrightLine Group
Managing Consultant and Co-Founder
2018 – Current

Nexant, Inc.
Sr. Consultant
2010 – 2018

Siemens Building Technologies
Energy Engineer
2005 – 2010

EDUCATION & CERTIFICATIONS:

Professional Engineer (PE)
CO #45967

Certified Energy Manager (CEM)

MS Architectural Engineering
University of Colorado – Boulder

BS Mechanical Engineering
Mississippi State University

REPRESENTATIVE PUBLICATIONS:

"Review of Natural Ventilation Models", International Journal of Ventilation, August 2016.

"Performance Evaluation of Network Airflow Models for Natural Ventilation", HVAC&R Research, May 2012.

SUMMARY

Mary-Hall focuses on providing technical expertise and insight to her projects. She excels at applying her background in energy engineering to evaluate the performance of energy efficiency technologies, projects, and programs. She has experience evaluating and quantifying energy efficiency and building system performance from a variety of viewpoints including building owners and operators, utility program administrators, regulatory authorities, and more broad reaching policy perspectives.

EXPERTISE

Impact Evaluation	Measurement & Verification	Energy Audits
Building Science	VOI-Focused Study Design	Emerging Tech
Billing Data Analysis	Statistical Sampling	Energy Simulation

WORK EXPERIENCE HIGHLIGHTS

- Couples continuous learning with attention to detail to create valuable and creative solutions.
- Contributions to **30+** DSM program planning and evaluation studies for clients in 17 states.
- Managed **600+** project site visits and energy audits including project sampling, M&V plan development, recruitment, auditor logistics, analysis, and quality control.
- Developed and maintained multiple long-term collaborative client relationships.

INDUSTRY AFFILIATIONS

Mary-Hall is an active member of the Association of Energy Services Professionals (AESP). She is also an active member of the American Society of Heating, Refrigeration, and Air conditioning Engineers (ASHRAE) and has served multiple terms on the chapter leadership team.

REPRESENTATIVE PROJECT EXPERIENCE

GEORGIA POWER COMPANY – DSM Portfolio Evaluation (2011 - Current)

Mary-Hall is leading the impaction evaluation for Georgia Power's commercial programs in the years 2020 through 2022. She has been involved with project and client in multiple roles since 2011. During the 2017 – 2019 evaluation cycle, she managed evaluation planning, sampling, site visit coordination, engineering analysis, and results reporting for the Commercial Prescriptive, Custom, SCDI, and Midstream programs.

PENNSYLVANIA PUBLIC UTILITIES COMMISSION – Evaluation, Measurement and Verification of Statewide Programs (2018 – Current)

Mary-Hall is supporting the statewide, third-party evaluation of the residential and nonresidential energy efficiency and demand response programs offered by each Utility in Pennsylvania. Tasks include reviewing evaluated ex-post savings for accuracy, updating and maintaining the state's Technical Reference Manual (TRM), and developing an Annual Report summarizing savings achieved for each utility in the program year.

SOUTHERN CALIFORNIA EDISON – Commercial Sector Decarbonization Market Characterization Study (2019 - 2020)

Mary-Hall investigated the level of decarbonization that could be achieved through beneficial electrification in commercial sector buildings through EnergyPlus whole building simulation modeling. This study encompassed the adoption of electrification technologies like heat pump water heaters, heat pump-based HVAC systems, and induction cooking and considered the relative impacts of building vintage and climate zone. Study outputs focused on quantifying the impacts on customer load profiles, customer bills, and greenhouse gas emissions.

MISSISSIPPI POWER COMPANY – Energy Efficiency and Beneficial Electrification Portfolio Planning Support (Current)

Mary-Hall is supporting Mississippi Power's development of a new portfolio of programs, including traditional energy efficiency programs, electric vehicle incentives, and other beneficial electrification technologies. This activity builds on the BrightLine team's extensive experience providing impact evaluation, process evaluation, and cost effectiveness services for this client. BrightLine is applying a three-phased approach to the planning activity: analyzing program performance history, assessing opportunities for expansion, and applying these findings into a new portfolio plan.

VERMONT PUBLIC SERVICE DEPARTMENT – Technical Support of Annual Savings Claims (Current)

Mary-Hall is supporting the impact evaluation of Vermont Gas's commercial and residential energy efficiency programs with the objective of calculating the annual and peak day energy impacts at the program and sector levels and recommending process improvements to streamline program implementation and savings verification efforts.

TRI-STATE GENERATION & TRANSMISSION – DSM and Energy Efficiency Potential Study (2019 - 2020)

Mary-Hall is the task lead for the demand response portion of this system-level potential study, focusing on estimating summer and winter load curtailment potential for four sectors – residential, agricultural, commercial, and industrial customers – across Tri-State's 200,000 sq. mi. territory in four states. This study includes quantification of technical, economic, and achievable potential scenarios over a twenty-year study term.

MCKENNA PATTERSON
ENGINEER

Bringing enthusiasm and excellence to the nuts and bolts of energy efficiency

brightline GROUP

CONTACT:

McKenna@BrightLineGroup.com
(662)660-4934

WORK EXPERIENCE:

BrightLine Group
Engineer
2020 – Current

Institute for Clean Energy Technology
Research Assistant
2019 – 2020

EDUCATION & CERTIFICATIONS:

BS Mechanical Engineering
Mississippi State University

PUBLICATIONS:

"Proposed Analytical Methods for Determining Filter Media Properties", Waste Management Symposia, March 2020.

INDUSTRY AFFILIATIONS:

Society of Women Engineers (SWE)

Association of Energy Services Professionals (AESP)

SUMMARY

McKenna Patterson is an engineer with BrightLine Group with experience in renewable energy and environmental industry research. McKenna applies her technical training as an engineer to assess and analyze energy efficiency and sustainability measures and practices. During her time at the Institute for Clean Energy Technology, she researched methods to analytically determine filter media properties of nuclear grade HEPA filters. She also demonstrated knowledge of relevant NQA-1 and ASME industry standards.

EXPERTISE

Engineering | Efficient Problem Solving | Detail-Oriented | Technical Writing | Statistical Data Analytics | Data Collection

REPRESENTATIVE PROJECT EXPERIENCE

COMMONWEALTH EDISON – Energy Efficiency Portfolio and Program Planning (Current)

McKenna is developing energy efficiency measure workbooks to define ComEd's extensive incentive offerings as planned for the years 2022 through 2025. Data sources incorporated in this activity include the Illinois Technical Reference Manual, implementation contractor practices, prior year tracking databases, evaluation findings and reports, and assessments of new and emerging technologies.

MISSISSIPPI POWER – Load Growth and Energy Efficiency Portfolio and Program Planning (Current)

McKenna is supporting Mississippi Power's development of a new portfolio of energy efficiency and load growth programs. This activity builds on the BrightLine team's extensive experience providing impact evaluation, process evaluation, and cost effectiveness services for this client. BrightLine applying a three-phased approach to the planning activity: analyzing program performance history, assessing opportunities for expansion, and applying these findings into a new portfolio plan.

REPRESENTATIVE PROJECT EXPERIENCE CONT..

GEORGIA POWER COMPANY – Commercial and Industrial Impact and Process Evaluations (Current)

McKenna is contributing to the evaluation process for GPC's Commercial Prescriptive and Commercial Custom programs. Her supporting tasks include reviewing project files, performing engineering analysis of measure savings, and providing overall assistance in supplemental activities for both commercial programs over the program year.

CALIFORNIA MUNICIPAL UTILITIES ASSOCIATION – Energy Efficiency Potential Assessment (Current)

McKenna is supporting the research and analysis for the California clean energy policy landscape and historic utility program data to inform a study of technical, economic and market potential for energy efficiency and distributed energy resources for California's publicly owned utilities.

PENNSYLVANIA PUBLIC UTILITIES COMMISSION – Statewide Evaluation, Measurement, and Verification of DSM Programs (Current)

McKenna is supporting the statewide, third-party evaluation of the nonresidential energy efficiency and demand response programs offered by each Utility in Pennsylvania. Tasks include utilizing the Pennsylvania Technical Reference Manual in reviewing evaluated ex-post savings for accuracy, assessing project files, and developing an Annual Report summarizing savings achieved for each utility in the program year.

RHODE ISLAND OFFICE OF ENERGY RESOURCES – Rhode Island Energy Efficiency Programs Evaluation Study (Current)

McKenna is supporting the energy savings verification study for National Grid's energy efficiency programs in the State of Rhode Island, assessing evaluation rigor with respect to industry-standard practice. McKenna's role includes reviewing project documentation of commercial projects implemented through National Grid in the state of Rhode Island for accuracy and alignment with the Technical Reference Manual.

LYNN ROY, CEM
CEO & PRINCIPAL CONSULTANT

Providing clients with information and insight to offer more successful programs.

brightline GROUP

CONTACT:

Lynn@BrightLineGroup.com

(303) 792-8668

WORK EXPERIENCE:

BrightLine Group
CEO, Principal Consultant, & Co-Founder
2018 – Current

Nexant, Inc.
Vice President
2001 – 2018

EDUCATION & CERTIFICATIONS:

Certified Energy Manager (CEM)

MS Mechanical Engineering
University of Colorado – Boulder

BS Engineering Physics
University of Nebraska

REPRESENTATIVE PUBLICATIONS:

"The Evolution of Evaluation: Revolution or Resolution? EM&V 2.0 New Approaches vs. Traditional Methods", NEEA Efficiency Exchange Conference, May 2016.

"Federal Funds Spur Local Action – The Findings and Lessons Learned from the Preliminary Impact Evaluation of the Better Buildings Neighborhood Program", ACEEE Summer Study 2014.

SUMMARY

Lynn is an accomplished energy efficiency expert, actively engaged in the industry since 2001. Lynn has managed the design and implementation of large scale utility demand side management (DSM) programs; led evaluations and compliance reviews of government and utility-funded energy efficiency programs; conducted market research in support of DSM programs; and has overseen the measurement and verification (M&V) of building performance projects.

EXPERTISE

Program Management | **Market Research** | **Program Design**
Regulatory & Policy Support | **Process Evaluation** | **Survey Design**
Impact Evaluation | **Portfolio Planning** | **Market Assessments**

WORK EXPERIENCE HIGHLIGHTS

- **19 years** industry tenure with experience at every stage of the program lifecycle including planning, implementation, and evaluation.
- Executive-level program management of large-scale portfolio evaluations including maintaining client relationships, subcontractor management, and reporting findings to internal, stakeholder, and regulatory audiences.
- Contributions to **50+** DSM program planning and evaluation studies for more than 32 clients ranging from electric co-ops to governmental agencies.
- Internal leadership encompassing revenue oversight, business direction and development, and staff hiring and mentorship.

INDUSTRY AFFILIATIONS

Lynn is an active member of the Association of Energy Services Professionals (AESP) and regularly contributes leadership to industry events including the International Energy Program Evaluation Conference (IEPEC).

REPRESENTATIVE PROJECT EXPERIENCE

RHODE ISLAND OFFICE OF ENERGY RESOURCES – Rhode Island Energy Efficiency Programs Evaluation Study (Current)

Lynn is managing the energy savings verification study for National Grid's energy efficiency programs in the State of Rhode Island, assessing evaluation rigor with respect to industry-standard practice. This study is an overarching review of EE program implementation, reporting, and evaluation practices covering years 2014 through 2018.

GEORGIA POWER COMPANY – DSM Portfolio Evaluation (2014 - current)

Lynn currently leads key aspects of the evaluation of Georgia Power Company's commercial DSM programs for their 2020-2022 cycle. The evaluation includes the formation of key program questions, planning, stakeholder interviews, customer surveys, on-site inspections, measurement of key measure parameters, net-to-gross and cost-effectiveness analysis. Lynn is responsible for supporting overall project management tasks, managing the net-to-gross analysis, process evaluation sampling, survey development, net-to-gross, survey fielding, and reporting results. Lynn was in a similar role for the evaluation of Georgia Power's programs during their 2014 – 2016 and 2017 – 2019 cycles.

NORTHWEST ENERGY EFFICIENCY ALLIANCE (NEEA) – Commercial Building Stock Assessment Support, Top Tier Trade Ally Assessment, Building Operator Certification Program Assessment (2019-2020)

Lynn managed BrightLine's role in assessing three NEEA offerings; the Top Tier Trade Ally Program (TTTA), the Building Operator Certification (BOC) Program, and the CBSA. This work included characterizing the population of BOC program participants, gauging the impact of TTTA trainings on market activity to assess progress towards program objectives, and providing technical expertise and review on CBSA datasets and data collection tool.

PENNSYLVANIA PUBLIC UTILITIES COMMISSION – Evaluation, Measurement and Verification of Statewide Programs (2018 – Current)

Lynn is supporting the statewide, third-party evaluation of the residential and nonresidential energy efficiency and demand response programs offered by each Utility in Pennsylvania. Tasks include reviewing evaluated ex-post savings for accuracy, updating and maintaining the state's Technical Reference Manual (TRM), and developing an Annual Report summarizing savings achieved for each utility in the program year.

SOUTHERN CALIFORNIA EDISON – Commercial Sector Decarbonization Market Characterization (2019)

Lynn provided overall project management for BrightLine Group in investigating commercial sector buildings decarbonization through EnergyPlus whole building simulation modeling. This study encompassed the adoption of electrification technologies like heat pump water heaters, heat pump-based HVAC systems, and induction cooking and the relative impacts of building vintage and climate zone.

MISSISSIPPI POWER COMPANY – 2020 Portfolio Planning Support (Current)

Lynn is helping Mississippi Power develop of a new portfolio of programs. This activity builds on the BrightLine team's extensive experience providing impact evaluation, process evaluation, and cost effectiveness services for this client. BrightLine applying a three-phased approach to the planning activity: analyzing program performance history, assessing opportunities for expansion, and applying these findings into a new portfolio plan.

NICOLE WOBUS, AICP
MANAGING CONSULTANT

20+ years in environmental policy, planning and markets, with areas of focus including land use, energy efficiency and renewable energy.

brightline GROUP

CONTACT:

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(303) 766-1113

WORK EXPERIENCE:

BrightLine Group
Managing Consultant; 2020 – Current

Boulder County
Long Range Planning and Policy Manager, Land Use; 2016 – 2019

Navigant Consulting
Associate Director; 2005 – 2015

Mass. Energy Consumers Alliance
Clean Energy Program Director; 2000 – 2004

Tufts University Climate Initiative
Technology Director; 1999

EDUCATION & CERTIFICATIONS:

American Institute of Certified Planners (AICP) CP #32156

MA Urban & Environmental Policy & Planning
Tufts University

BA Government & Environmental Studies
Bowdoin College

AFFILIATIONS & AWARDS

American Planning Association, CO Renewable Energy Society, Women of Renewable Industries and Sustainability Energy, Switzer Fellow

SUMMARY

Nicole leads climate action, sustainability and resilience-focused planning for local governments and other organizations, as well as clean energy program evaluation, policy and market studies for utilities and state agencies. Her work helps guide program resource and policy decisions aimed at tackling climate change and building more sustainable communities. Prior to joining BrightLine Group, Nicole led Boulder County's Long Range Planning and Policy Team for 4 years. She managed policy and regulatory updates that involved extensive stakeholder collaboration and engagement, and included numerous climate, sustainability, equity and resilience-related efforts. For ten years prior to joining Boulder County, Nicole played integral research, analytic and management roles in energy program evaluation, policy and market research for clients nationwide.

EXPERTISE

Process Evaluation | Market Characterization | Land Use Planning | Climate & Energy Policy | Interviews & Focus Groups | Regulatory Support | Strategic & Program Planning | Project Management

WORK EXPERIENCE HIGHLIGHTS

- Diverse professional experience includes employment with local government, institutional, non-profit and consulting organizations.
- Capable of combining land use planning and local government experience with deep energy industry knowledge to develop EV, renewable energy and other climate solutions.
- Experienced in coordinating and managing successful stakeholder collaborations and public engagement efforts.
- Played a management role in over 20 energy efficiency and renewable energy program planning and evaluation studies for clients nationwide.

REPRESENTATIVE EXPERIENCE

GEORGIA POWER COMPANY – DSM Portfolio Evaluation (Current)

Nicole is supporting the process evaluation of Georgia Power Company's commercial DSM programs for their 2020-2022 cycle. The process evaluation includes the formation of key program questions, planning, stakeholder interviews, customer surveys, trade ally surveys, nonparticipant surveys, and net-to-gross analysis.

CALIFORNIA MUNICIPAL UTILITIES ASSOCIATION (CMUA) – Energy Efficiency Potential Assessment (2020)

Nicole is supporting the research and analysis for the California clean energy policy landscape and historic utility program data to inform a study of technical, economic and market potential for energy efficiency and distributed energy resources for California's publicly owned utilities.

RHODE ISLAND OFFICE OF ENERGY RESOURCES – Rhode Island Energy Efficiency Programs Evaluation Study (Current)

Nicole is conducting in-depth-interviews to explore efficacy of savings estimates and reviewed prior evaluations of National Grid's Rhode Island energy efficiency programs as part of an overarching review of EE program implementation, reporting, and evaluation practices for program years 2014 through 2018.

TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION – Energy Efficiency, DER, DR and BE Potential Study (Current)

Nicole contributed to a potential study addressing energy efficiency, demand response and distributed energy resource potential in residential, agricultural, commercial, and industrial sectors across Tri-State's four-state service territory. The study quantified technical, economic, and achievable potential scenarios over a 20-year study term.

CLIMATE, SUSTAINABILITY & RESILIENCE PLANNNING AND POLICY DEVELOPMENT (2016-2019)

Nicole played a lead role in a comprehensive update to the Boulder Valley Comprehensive Plan as well as numerous topic-focused updates to the Boulder County Comprehensive Plan (e.g., Sustainable Materials Management and Public Health). Oversaw Floodplain Buyout Program, Wildfire Partners Program, and policy integration of updated geologic hazard mapping. Much of this work involved extensive public engagement and collaboration with internal and external stakeholders and subject matter experts. The work included innovative policy development in the areas of climate action, sustainability and resiliency.

ELECTRIC VEHICLE (EV) AND SOLAR REGULATIONS (2017-2018)

As a land use planner for Boulder County, Nicole led updates to parking lot and solar provisions within the Boulder County Land Use Code to better align with the county's sustainability goals and values. Introduced creative strategies to balance key stakeholder interests. Examples include: 1) creating an EV Charging Fund as a funding mechanism for publicly located charging infrastructure and an alternative compliance path for applicants whose parking areas trigger a required investment in EV charging infrastructure; 2) limiting the acreage of disturbance for solar projects on prime agricultural land and encouraging co-location of PV with agricultural production.

WYLEY HODGSON
MANAGING CONSULTANT

For more than 14 years Wyley has delivered innovative solutions to clients across DSM and clean energy technologies.

brightline GROUP

CONTACT:

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✆ (303) 557-2106

WORK EXPERIENCE:

BrightLine Group
Managing Consultant & Co-Founder
2018 – Current

Nexant, Inc.
Principal Consultant
2011 – 2018

EDUCATION & CERTIFICATIONS:

MBA
The Fuqua School of Business,
Duke University

Master of Environmental Management
Nicholas School of the Environment,
Duke University

BA Earth Sciences & Environmental Studies
University of California, Santa Cruz

BA Philosophy
University of California, Santa Cruz

INDUSTRY AFFILIATIONS:

Wyley is an active member of AESP and SEPA.

SUMMARY

Wyley supports his clients through devising solutions to problems and bringing clarity to questions that allow clients to progress their endeavors and achieve their goals. Wyley designs and implements program evaluations for a wide range of DSM programs that have brought insight to clients' programs resulting in program modifications that ultimately drive more cost-effective energy savings for program portfolios. Additionally, Wyley leads planning studies to forecast potential for reduced energy consumption via energy efficiency and/or adoption of distributed energy resources. In previous roles, Wyley has led diverse sustainability initiatives and efforts such as corporate sustainability policy design and implementation as well as environmental life cycle analysis.

EXPERTISE

Market Potential Studies | Program Design and Evaluation | Market Characterization | DER Assessments | Energy Efficiency Potential | Climate & Energy Policy | Carbon Markets | Survey Design

WORK EXPERIENCE HIGHLIGHTS

- Strategically working with clients to actively amend program design midstream based on data collected from EM&V process to better achieve program goals and ultimately acquire energy savings.
- Leading large-scale data collection efforts including on-site data collection comprised of samples over **200** sites per study and survey data consisting of data collection from over **1000** individuals per study.
- Developing client strategies to address regional carbon reduction policies.
- Leading and managing internal teams and client management across the value chain.

REPRESENTATIVE PROJECT EXPERIENCE

PENNSYLVANIA PUBLIC UTILITIES COMMISSION – Evaluation, Measurement and Verification of Statewide Programs (2018 – Current)

Wyley is supporting the statewide, third-party evaluation of the residential and nonresidential energy efficiency and demand response programs offered by each Utility in Pennsylvania. Wyley's role includes reviewing evaluated ex-post savings for accuracy, updating and maintaining the state's Technical Reference Manual (TRM), developing an Annual Report for each utility in the program year, and supporting the non-residential baseline study, the 2019 TRC Order, and the market potential of energy efficiency and combined heat and power for the Phase IV of Act 129.

CALIFORNIA MUNICIPAL UTILITIES ASSOCIATION (CMUA) – Energy Efficiency Potential Assessment (2020)

Wyley is supporting BrightLine's role to estimate the technical, economic, and market potential for energy efficiency and complementary resources for California electric municipal electric utilities. As a subcontractor to GDS Associates, the team will estimate the resource potential based on CMUA member's customer characterization, climate zone, economic conditions, and other relevant factors over a forecast period of at least ten years. In addition to the assessment of energy efficiency resource potential, BrightLine will assess the resource potential for transportation electrification, energy storage, and self-generation.

TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION – Energy Efficiency, DER, DR and BE Potential Study (Current)

Wyley is leading components of a comprehensive potential study for Tri-State with specific focus on residential energy efficiency, distributed energy resources (solar photovoltaics), and electric vehicles. The potential study forecasts opportunities to reduce energy consumption through implementation of energy efficiency and DERs and DR within Tri-State's service territory as well as opportunities to reduce emissions through installation of beneficial electrification technologies. Results of the studies will be used to inform Tri-State's energy resource plan as well as assist member cooperatives in local planning efforts.

AMEREN MISSOURI – Energy Efficiency, Demand Response, Distributed Generation, Combined Heat and Power Potential Studies (2018 - Current)

Wyley is supporting BrightLine's role as part of the GDS Team developing potential studies for Ameren Missouri's service area. BrightLine is contributing the combined heat and power and distributed generation potential studies; Wyley's focus is on solar photovoltaic opportunities. The results of these studies will provide detailed information on measures that are the most cost effective and have the greatest potential for Ameren's service area.

RHODE ISLAND OFFICE OF ENERGY RESOURCES – Rhode Island Energy Efficiency Programs Evaluation Study (Current)

Wyley is supporting BrightLine's tasks in the energy savings verification study for National Grid's energy efficiency programs in the State of Rhode Island, assessing evaluation rigor with respect to industry-standard practice. This study is an overarching review of EE program implementation, reporting, and evaluation practices covering years 2014 through 2018.

SAMUEL C. ROSS, CONSULTANT

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PROFESSIONAL EXPERIENCE

Optimal Energy, Hinesburg, VT. *Consultant*, 2018 – Present; *Senior Analyst*, 2017 – 2018.

At Optimal Energy, Mr. Ross provides analytical services on a range of projects and technical writing for business development in addition to ongoing contracts. He provides subject matter expertise on data analysis tools, benefit-cost analysis, energy efficiency finance, and environmental economics. His project work includes conducting energy efficiency market potential studies, policy analysis and design for statewide energy efficiency programs, and developing energy efficiency finance solutions which are tailored to clients' specific needs and context. Though he concentrates on electric and gas energy efficiency, Mr. Ross continues to expand his expertise to include integrating energy efficiency with clean energy and storage, quantifying non-energy impacts, and other emerging trends in the energy sector.

The London School of Economics & Political Science, London, UK. *Overseas Consultant,* 2017 – Present

Following completion of his Master of Environmental Economics and Climate Change at the London School of Economics, Mr. Ross was hired to conduct research under Dr. Charles Palmer, Professor of Environment & Development, and Dr. Luca Taschini of the Grantham Research Institute on Climate Change and the Environment. His research focuses on quantifying agricultural carbon emissions through high-resolution GIS analysis, and developing novel market and policy mechanisms to minimize carbon emissions at least-cost. This research has been funded in part by the Norwegian Agency for Development Cooperation.

Data Consultant, London, UK. 2016 – 2017.

While pursuing his MSc, Mr. Ross transitioned to an independent consulting role with his prior employer, the National Investment Center for Seniors Housing and Care (NIC). In this position, he supported mission-critical data quality and analytical work for NIC's data and analytics team.

National Investment Center for Seniors Housing and Care (NIC), Annapolis, MD. *Data and Analytics Team Manager*, 2015 – 2016; *Quality Assurance Analyst*, 2014 – 2015.

As the Data and Analytics Team Manager at NIC, Mr. Ross managed a four-person team in charge of the firm's core research and analysis work, and he led all hiring and managed all personnel for the data and analytics team. Mr. Ross developed, implemented, and automated systems in R, MySQL, and Excel to ensure data quality both on import and analysis. Further, he led the firm's data quality, analysis, and quarterly reporting for their subscription website and data service, which was responsible for nearly 50% of firm revenue. He also initiated and led efforts to document key roles, processes and responsibilities across NIC to build institutional knowledge and reduce operational risk.

DC Energy, LLC, Vienna, VA. *Analyst*, 2012 – 2014.

At DC Energy, Mr. Ross developed software to facilitate robust automated process infrastructure and data acquisition, parsing, normalization and storage in MySQL databases. He developed metadata acquisition systems to ensure efficient debugging and error reporting, and supported OTC and auction-based electricity futures trading through software development and automated tracking systems.

EDUCATION

London School of Economics, London, UK
Master of Science with Distinction in Environmental Economics and Climate Change, 2017

Dartmouth College, Hanover, NH
Bachelor of Arts in Economics, Environmental Studies, Magna Cum Laude, 2012

REPRESENTATIVE PROJECT EXPERIENCE

Pennsylvania Statewide Evaluator Team Member, Market Potential Study Lead (2019)
Optimal Energy is a member of the Pennsylvania Statewide Evaluator team for Phase IV of Act 129. Optimal led the Energy Efficiency Market Potential Study, and has supported a wide range of other activities, including updating Pennsylvania's Technical Reference Manual, supporting the Demand Response and Combined Heat and Power Potential Studies, and significant contributions to a detailed efficiency measure cost analysis widely utilized by PA utilities in program planning. In addition, Optimal provides methodological guidance and written memos covering a range of topics including cost-benefit analysis, discount rates, avoided cost calculations, the application of baseline data to developing actionable policy insights, and participates in regular meetings with Public Utility Commission Technical Utility Staff.

Rhode Island Energy Efficiency and Resources Management Council, Policy and Program Planning Consulting
Optimal Energy manages a team of consultants providing support to the Rhode Island Energy Efficiency and Resource Management Council (EERMC) on topics ranging from high-level policy and legislative issues down to the oversight of program implementation and infrastructure development. Mr. Ross supports Optimal Energy's work for the EERMC in a range of areas related to ongoing program design, measurement and verification, in addition to key contributions to energy efficiency and clean energy finance tools developed in collaboration with EERMC and other Rhode Island energy sector stakeholders. Mr. Ross oversaw the completion of a market potential study for the state of Rhode Island in 2020. He is also leading the process of translating this key quantitative information into actionable policy options.

New Jersey Board of Public Utilities, New Jersey Potential Study with Recommended Targets (2019)
Optimal Energy completed an Energy Efficiency Market Potential Study for the State of New Jersey, with estimates of 20-year achievable potential for electricity and natural gas. The Clean Energy Act of 2018 specified minimum levels of efficiency targets for New Jersey's public utilities, and the potential study determined whether targets should be at the minimum level specified by legislation or higher. Mr. Ross contributed to the analysis underlying Optimal Energy's recommended targets, quantitative performance indicators, and performance incentives to meet or exceed the goals established by the Legislature.

Minnesota Statewide Energy Efficiency Potential Study (2018)
Optimal Energy and partner Center for Energy and Environment (CEE) collaborated to prepare a statewide natural gas and electric energy efficiency and carbon saving potential study on behalf of the State of Minnesota. This study was commissioned to inform decision-makers with Minnesota's Conservation Improvement Program (CIP) about the market sectors, geographic areas, utility service territories, end uses, measures and programs that should be targeted to help realize demand-side management potential in Minnesota. Mr. Ross provided technical expertise in the collection, aggregation, and integration of industrial-sector data and avoided costs data across all sectors, in addition to developing a suite of customized tools to meet client needs to iterate over a large number of input data sets and to report resulting data in a variety of ways.

PHILIP H. MOSENTHAL, PARTNER

Optimal Energy|10600 Route 116, Suite 3|Hinesburg, VT 05401|802-482-5607|mosenthal@optenergy.com

PROFESSIONAL EXPERIENCE

Optimal Energy, Hinesburg, Vermont. *Founding Partner*, 1996-present

As the Founding Partner Mr. Mosenthal is responsible for business development as well as direct consulting and analysis for numerous electric and gas utilities, government entities and other non-utility parties on energy efficiency, resource planning, regulatory issues, program design, and evaluation and market assessments. Mr. Mosenthal has over 30 years' experience in energy efficiency consulting, including facility energy management, utility and state planning, regulatory policy, program design, implementation, evaluation, and research. He has particular expertise in efficiency regulatory policy, assessment and integrated analysis of demand-side energy resources, valuation of energy resources and cost-benefit analysis, and program planning, design, and evaluation. Mr. Mosenthal has developed numerous utility, state, and regional integrated resource and DSM plans, and has designed and evaluated energy efficiency programs throughout North America, Europe, and China. He has also led numerous efficiency and renewables potential studies and is a nationally recognized expert on efficiency resource assessment and valuation. Mr. Mosenthal has played key roles in many utility-stakeholder processes and successfully worked to build consensus among diverse parties in various assignments. This work has included leading policy and planning initiatives related to goal setting, EM&V frameworks, cost recovery, and performance incentives. Mr. Mosenthal has testified before numerous regulatory commissions, state legislatures, and the U.S. Nuclear Regulatory Commission. Mr. Mosenthal also has designed program implementation procedures, managed implementation contracts, trained efficiency program and planning staff, and performed numerous commercial and industrial facility energy efficiency analyses for end users.

Resource Insight, Middlebury, Vermont. *Senior Research Associate*, 1995-1996

Xenergy, Incorporated (now DNV-GL), Allendale, New Jersey. *Chief Consultant*, 1990-1995

EDUCATION

University of Pennsylvania, Philadelphia, Pennsylvania
Master of Science, Energy Management and Policy, 1990

University of Pennsylvania, Philadelphia, Pennsylvania
Bachelor of Arts, Design of the Environment, 1982

REPRESENTATIVE PROJECT EXPERIENCE

New Hampshire Office of Consumer Advocate, Technical Consulting Services Related to Policy, Program Planning, and Stakeholder Engagement (2015 - present)
Since 2015 Optimal Energy has supported the NH OCA in its engagement with a utility stakeholder process. Mr. Mosenthal serves as the project manager. Through this engagement, Optimal has played a leadership role in the development of all gas and electric DSM efforts in New Hampshire, and has

participated in numerous working groups including ones related to cost recovery and lost revenue policy and estimation, performance incentive design, DSM potential assessment and baselines, plan development and program design, and EM&V.

Illinois Office of the Attorney General, Advisor on Energy Efficiency Policy, Planning, Design, Implementation and Evaluation (2007 – present)
Mr. Mosenthal has served as the project manager and lead advisor to the Illinois Office of the Attorney General on all aspects relating to development and on-going participation in a statewide utility collaborative process, establishment of statewide energy efficiency policies and frameworks, development of statewide legislation, efficiency potential assessment, program planning, design, implementation, evaluation, and general oversight of utility electric and gas efficiency programs throughout Illinois.

Massachusetts Energy Efficiency Advisory Council, Technical Consulting Services (1998 – present)
Optimal Energy has led the Technical Consultant team for the Massachusetts Energy Efficiency Advisory Council (EEAC) since its inception in 2006. Mr. Mosenthal has served in various roles on this team, including overall Team Manager, Team lead for the commercial and industrial sector, and senior advisor on efficiency policy, planning, programs, and EM&V. Optimal's role includes representing the EEAC on all aspects of negotiating efficiency policies, programs, plans, goals and budgets with the program administrators, and oversight of all program implementation and evaluation, monitoring and verification activities.

New Jersey Board of Public Utilities, Potential Study and Consulting Services (2019-present)
New Jersey's 2018 Clean Energy Act mandates delivery of aggressive efficiency efforts, the development of all policies and administrative and EM&V frameworks to guide efficiency, and the completion of an energy efficiency potential study to inform the Board as it establishes savings goals and other metrics. Mr. Mosenthal is an integral part of the team, working on the assessment of potential, and leading work on the establishment of targets and performance incentives / penalties, EM&V framework, and cost-effectiveness policies.

New York State Energy Research and Development Authority, Statewide Efficiency and Renewable Potential Studies (2003 – 2019)
Optimal has led numerous studies for NYSERDA to assess the energy efficiency and renewable potential throughout New York, as well as commercial baselines. Mr. Mosenthal has managed a number of these studies, as well as served as the lead investigator for the commercial and industrial segments, and overall senior advisor. Studies have assessed the efficiency potential from electricity, natural gas, and petroleum fuels, as well as the electric and thermal potential from renewable energy resources. Numerous studies have considered the potential statewide, as well as by utility region and load control zone. Many of these studies have directly led to establishment of New York State energy resource requirements as promulgated by various NY governmental administrations.

Rhode Island Energy Resource Management Council, Technical Consulting for the Energy Resource Management Council (2006 – present)
Optimal Energy has led the Technical Consultant team for the Rhode Island Energy Resource Management Council (ERMC) since its inception in 2006. Mr. Mosenthal has served in various roles on this team, including as the team lead for the commercial and industrial sector, and senior advisor on policy, planning, programs, and EM&V. Optimal's role includes representing the ERMC on all aspects of negotiating efficiency policies, plans, programs, goals and budgets with National Grid, the program administrator.

MATTHEW T. SOCKS, PE, CEM, SENIOR CONSULTANT

Optimal Energy|10600 Route 116, Suite 3|Hinesburg, VT 05401|802-482-5614|socks@optenergy.com

Matthew Socks, PE, CEM, Senior Consultant, joined Optimal Energy in 2007 and serves a leading role in efficiency program engineering, economic analysis, and implementation support for clients across North America. With expertise in the field of efficiency measure research and characterization, he has developed standardized methodologies for determining savings from efficiency measures and programs in more than a dozen states. Mr. Socks has served as a primary contributor to numerous energy efficiency potential analyses, many of which have formed the foundation for jurisdictional efficiency savings targets. Having provided clients with efficiency program design and implementation support, he has both developed novel program approaches from the ground up, and provided strategic assessment of existing program portfolios. An experienced analyst, Mr. Socks has led targeted market research efforts on both building sectors and efficient technologies. Finally, in addition to managing Optimal Energy's suite of analytical tools, Mr. Socks has developed customer-facing tools for project-level cost-benefit analysis and data collection management.

PROFESSIONAL EXPERIENCE

Optimal Energy, Hinesburg VT. *Senior Consultant*, 2007–present

NSK Corporation, Ann Arbor, MI. *Engineering Intern*, 2000–2003

EDUCATION, LICENSING, AND CERTIFICATIONS

Massachusetts Institute of Technology, Cambridge, MA
Bachelor of Science, Mechanical Engineering, 2006

Professional Engineer (PE), State of Vermont, 2013-present
Certified Energy Manager (CEM), Association of Energy Engineers, 2010-present
Certified Building Energy Simulation Analyst (BESA), Association of Energy Engineers, 2012-2015
Lighting Certified (LC), National Council on Qualifications for the Lighting Professions, 2011-2015

REPRESENTATIVE PROJECT EXPERIENCE

Pennsylvania Statewide Evaluator, Pennsylvania Public Utility Commission (2016-2020)
Optimal Energy served as a member of the Pennsylvania Statewide Evaluator team for Phase IV of Act 129. Optimal lead the Energy Efficiency Market Potential Study, and supported a wide range of other activities, including updating Pennsylvania's Technical Reference Manual (TRM), supporting the Demand Response and Combined Heat and Power Potential Studies, and made significant contributions to a detailed efficiency measure cost analysis widely utilized by PA utilities in program planning. Mr. Socks served as technical lead on the Energy Efficiency Market Potential Study development and authored numerous TRM entries and associated calculators.

New Jersey Board of Public Utilities, Energy Efficiency Potential Study (2019)
New Jersey's 2018 Clean Energy Act mandated completion of an energy efficiency potential study to inform the Board as it establishes targets. Optimal Energy was selected in a competitive bidding process to complete the work, which had to meet a very tight legislative deadline. The project included estimation of ten-year (2020 – 2029) energy efficiency potential, demand response potential, and potential for savings from combined heat and power. The potential then needed to be allocated to the electric and gas public utilities. Mr. Socks led the potential study team.

Northeast Energy Efficiency Partnerships, Mid-Atlantic Technical Reference Manual (2010-2017)
Optimal Energy, with Shelter Analytics and Vermont Energy Investment Corporation, developed efficiency measure costs and savings estimation protocols for a novel, multi-state Technical Reference Manual for use by utilities in the Mid-Atlantic region. The project required comparative analyses between regional energy efficiency savings estimation methodologies and working with stakeholders to reach consensus on the characterizations. Optimal Energy led the review and update of the manual, worked with the stakeholders each year to prioritize measures in need of update, and identified specific additional needs. From 2016 on, Optimal led the development of both residential and commercial & industrial measure entries. On this project, Mr. Socks led the development of the commercial and industrial measures and facilitated stakeholder engagement.

New York Power Authority and New York Governor's Office, New York State Government Facilities Energy Efficiency Study (2011-2012)
Optimal Energy conducted a study of the energy efficiency and renewable energy potential for New York State government facilities. Building upon previous analyses conducted by Optimal Energy for the State of New York, Optimal developed energy efficiency potential estimates for the ten largest state agencies, which together account for over 96% of statewide governmental energy consumption. A parallel analysis of the renewable energy potential for solar photovoltaic, solar thermal hot water, and biomass space heating and hot water technologies was also competed. Initiated and completed within an extremely demanding timeframe of only two months, this project required effective management and streamlined communication. The study led directly to Executive Order 88 and BuildSmart NY, an initiative by Governor Cuomo to release $450 million in state financing with the goal of reducing energy consumption in State buildings by 20%. Mr. Socks served as overall project manager and technical lead of the energy efficiency potential development.

REPRESENTATIVE PUBLICATIONS

"Leveraging Financing for Comprehensive Efficiency in the Public Sector," with P. Mosenthal and E. Alemany, *2014 ACEEE Summer Study on Energy Efficiency in Buildings*.

"Non-Transmission Alternatives: The Emerging Importance of Regional Planning to the Clean Energy Industry under FERC 1000," with T. Lyle and B. Chatt, *2012 ACEEE Summer Study on Energy Efficiency in Buildings*.

"Streamlining the Small Commercial New Construction Market: A Prescriptive Approach to Comprehensive Savings with Core Performance," with J. Kleinman, J. Pilliod, and M. Frankel, *2008 ACEEE Summer Study on Energy Efficiency in Buildings*.

ARAH SCHUUR, MANAGING CONSULTANT

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PROFESSIONAL EXPERIENCE

Optimal Energy, Hinesburg, VT. *Managing Consultant*, 2020-present

Ms. Schuur provides project management and client support for a project portfolio that includes development and management of comprehensive energy plans, implementation of large-scale energy efficiency programs, and support for state and local energy policies. She provides expertise in energy policy, utility and program administrator program design and execution, energy efficiency finance and contracting, and greenhouse gas mitigation and climate resilience planning.

Acadia Center, Boston MA. *Vice President, Climate and Energy,* 2019-2020

Ms. Schuur led program staff across New England in executing complex projects to advance research and policy advocacy work in clean energy, low-carbon transportation, grid modernization, and energy systems planning.

Massachusetts Dept. of Energy Resources (DOER), Boston, MA. *Director, Energy Efficiency,* 2015-2018

Ms. Schuur led the Commonwealth's energy efficiency policy and program portfolio, overseeing work with the stakeholder body responsible for planning and implementation of the state's nation-leading energy efficiency investment plans. During her tenure, Massachusetts incorporated fuel switching into its energy efficiency plans for the first time and expanded its focus on demand response and peak energy reduction. Ms. Schuur oversaw a team that planned and executed a portfolio of clean energy projects across Massachusetts, including DOER's first grant program for active demand response. She directed the team responsible for the development and implementation of key energy efficiency policies and regulations such as a new commercial PACE program, home energy scorecards, and energy efficiency regulations for new industries. She led the development of partnerships with other agencies and contributed her expertise to DOER's responses to utility rate cases, state policy formation, low-income clean energy initiative, and comprehensive energy planning.

U.S. Dept. of Housing and Urban Development, Washington, DC. *Senior Advisor for Energy,* 2014–2015

Ms. Schuur managed a team responsible for implementing clean energy initiatives and executing President Obama's Climate Action Plan goals at HUD, including energy efficiency projects, building energy codes, and solar energy targets. She advised Secretary Julián Castro on energy issues and completed the expedited development of a new HUD clean energy finance policy.

U.S. Department of Energy, Office of Energy Efficiency, Washington, DC.
Director, Commercial Buildings Integration, Building Technologies Office, 2012-2014
Senior Advisor to the Deputy Assistant Secretary of Energy Efficiency, 2011-2012

Ms. Schuur led DOE's work to deploy energy efficient technologies in commercial and multifamily buildings, leading a team that managed a $35 million portfolio of projects involving national laboratories, private sector companies, and other governmental, private, and nonprofit partners. She helped establish the Better Buildings Challenge, forging partnerships with real estate organizations to advance best practices in energy efficiency planning, finance, contracting, and implementation. Ms.

Schuur developed successful partnerships across the federal government to increase DOE's impact. As an authority on buildings and energy efficiency, she provided input on energy efficiency finance, labeling, and utility data-sharing policies.

C40 Program, Clinton Climate Initiative, New York, NY. *Director, Energy Efficiency Building Retrofit Program,* 2007-2011

Ms. Schuur joined the Clinton Foundation to build a new program to accelerate the planning, development, and implementation of large-scale energy efficiency retrofit projects. In this role, she oversaw a global team that built partnerships with governments, global real estate organizations, and financial and technical companies to execute energy efficiency projects. The team developed and disseminated new contracting and financing mechanisms for energy efficiency retrofits. Ms. Schuur provided subject matter expertise to President Clinton, Foundation leadership, the Clinton Global Initiative, and Bloomberg Philanthropies.

EDUCATION

Massachusetts Institute of Technology, Cambridge, MA

Masters of City Planning, Department of Urban Studies and Planning, 2005

Masters of Science in Real Estate Development, Center for Real Estate, 2005

Yale University, New Haven, CT

Bachelor of Sciences in Biology, 1993

PROFESSIONAL ACTIVITIES AND MEMBERSHIPS

New England Women in Energy and the Environment (NEWIEE)

Northeast Sustainable Energy Association (NESEA)

REPRESENTATIVE PRESENTATIONS AND PUBLICATIONS

Schuur, A., Farnsworth, D., Markowitz, P., Miziolek, C., and Musher, D., 2017. "Next Generation Energy Efficiency," *Proceedings of the New England Sustainable Energy Association (NESEA) Annual Conference.*

Schuur, A., Rodrigues, G., Hepp, R., Kiddie, and R., Nouel, C., 2016. "Infrastructure Modernization Affects Us All," *Proceedings of the Association of Energy Services Professionals (AESP) and the Northeast Energy Efficiency Council (NEEC) Annual Join Conference.*

Schuur, A. and Phillips, G., 2016. "Massachusetts' New Three-Year Energy Efficiency Plan, an Overview," *Proceedings of the Association of Energy Engineers, New England Chapter.*

Schuur, A. and Counihan, R. 2016. "Massachusetts Energy Efficiency: Demand Reduction, Technology & Innovation," *Proceedings of the National Association of State Energy Offices (NASEO) Energy Policy Outlook Conference.*

Walraven, B., Wilson, S., Schuur, A., Greener, C. and Fedrizzi, R. 2008, "The Business Case for Going Green," *BOMA International Conference General Session.*

CLIFFORD S. MCDONALD, SENIOR CONSULTANT

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PROFESSIONAL EXPERIENCE

Optimal Energy, Hinesburg, Vermont. *Analyst*, 2006-2007; *Senior Analyst*, 2009-2011; *Consultant*, 2012-19; *Senior Consultant,* 2019-present.

Mr. McDonald provides project management services, performs and reviews analyses, contributes to technology and policy white papers, performs program impact and process evaluations, provides testimony, and creates guidance documents. His project work includes developing and submitting testimony, supporting the design of statewide and utility specific energy efficiency programs for both the residential and commercial sector, and developing and critiquing analyses examining the potential for energy savings for specific programs and technologies. Mr. McDonald works largely in commercial and industrial sector electric and gas efficiency, but his expertise and project work expands to encompass the residential sector, utility ratemaking, demand response, clean energy, and biofuels.

Viridian Energy and Environmental, New York, New York. *Energy Analyst*, 2008–09.

At Viridian, Mr. McDonald used DOE2 to create energy models to analyze the energy use in existing and new construction buildings. He developed specific recommendations on the implementation of energy efficiency measures. He also worked with architects and developers to get LEED certification on new construction projects and building renovations.

University of Pennsylvania Medical Center, Philadelphia, Pennsylvania. *Medical Physics Researcher,* Summers 2004 and 2005, April-August 2008.

As a medical physics researcher, Mr. McDonald used computer simulations and Monte Carlo algorithms to support the development of new, state-of-the-art proton therapy for cancer treatment. He also developed recommendations on materials and dimensions to be used in multi-leaf collimator as well as created micro-dosimetry simulations to investigate neutron doses at a molecular level.

EDUCATION

Middlebury College, Middlebury, Vermont
Bachelor of Science, Physics, 2006

REPRESENTATIVE PROJECT EXPERIENCE

New York State Energy Research and Development Authority, Potential Study, 2019

Mr. McDonald led the effort to estimate the ten-year potential for energy efficiency in New York State in the Commercial Sector for electricity, natural gas, fuel oil, and propane. This analysis was built around significant primary baseline data. It also included an investigation of reduction potential for gas peak demand reduction, as well as beneficial electrification through emerging heat pump technology.

New Orleans Energy Efficiency Market Potential Study, 2018

Mr. McDonald led the project team for a demand-side management potential study for the New Orleans City Council to inform the 2018 Triennial Integrated Resource Plan (IRP) by Entergy New Orleans (ENO). The potential study was used to help power procurement planning, as well as to assess the most viable paths to achieving ENO's energy savings goals as set by the City Council.

Technical Resource Manual Development, 2015-2020

Mr. McDonald provides ongoing review and support for all modifications and additions to the technical resource manuals in Pennsylvania, mid-Atlantic, and New York State. This process involves examining draft measure protocol to ensure that all algorithms and input assumptions are well sourced, based off of engineering best practices, and result in a clear and accurate savings estimate.

Orange and Rockland Support, 2015-2020

Mr. McDonald provides ongoing analysis, policy, and program support to Orange & Rockland Utilities in New York State. Specific tasks include custom project analysis and cost-effectiveness screening, program design and planning, efficiency and clean energy forecasting, and support on filing to the department of public service.

Demand Response Potential Study, Michigan, 2016

Mr. McDonald worked on a team examining the potential for demand response activity in Michigan. In addition to other contributions, Mr. McDonald was the lead analyst and author for the section on potential contributions from time of use rates, critical peak pricing, and peak time rebates.

Forward Capacity Market Audit, AMERESCO, 2014-2020

Mr. McDonald provides an annual audit for AMERESCO's efficiency programs in Connecticut, to allow the demand savings to be bid into New England ISO's forward capacity market. The audit includes verifying that measures have been installed as described in the database, and that all applicable FCM mandated procedures and safeguards have been followed.

Pennsylvania Statewide Evaluator Team Member, Market Potential Study, 2019

Mr. McDonald played a significant role supporting the 2019 market potential study for Pennsylvania. Activities included measure characterization, global input development, and overall guidance and quality control.

ADAM JACOBS, CONSULTANT

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PROFESSIONAL EXPERIENCE

Optimal Energy, Hinesburg, VT. *Consultant*, 2019-present

Mr. Jacobs provides research, analysis, and writing and presentation support on a range of projects including advisory council technical services, potential studies, white papers, and policy reports for state and local governments. He has expertise in energy data management, measurement and verification, strategic planning, consensus building for groups of diverse stakeholders, and developing workforce training initiatives.

City of Boston, Boston, MA. *Energy Manager,* 2015-2019

Mr. Jacobs was responsible for tracking the City's $45M annual municipal energy budget and completing all relevant annual reporting obligations including the Municipal GHG inventory, U.S. Department of Energy Better Buildings Challenge, Green Communities Annual Report. Mr. Jacobs overhauled the entire monthly utility bill auditing and payment process for the City of Boston leading to the recovery of over $1.4M credits. He developed in-house capabilities to monitor performance of 5.7 megawatts of combined heat and power generators across Boston Public Schools in real-time, proving over $1.2M in annual utility savings. Mr. Jacobs also organized and delivered a 74-hour utility-funded Building Operator Certification training for 28 facilities managers from the City of Boston and neighboring municipalities. His leading efforts helped Boston maintain the #1 ranking in ACEEE's City Energy Efficiency Scorecard in 2017 and 2019.

Johnson Controls, Falls Church, VA. *Energy Analyst,* 2012-2015

Mr. Jacobs performed annual M&V to prove $1.5 million in savings under an Energy Savings Performance Contract. Mr. Jacobs completed ASHRAE Level 2 energy audits for client's data centers, and modeled energy performance using Power Usage Effectiveness (PUE) across 21 data centers globally. He presented quarterly sustainability updates to the client's executive staff. Mr. Jacobs also managed compliance with the UK Environment Agency under CRC Energy Efficiency Scheme and served as energy manager for ISO14001 and ISO50001 certification project team.

American Wind Energy Association, Washington, DC. *Media Specialist*, 2014-2015

As a part-time contractor, Mr. Jacobs created and distributed a daily newsletter of national wind energy media coverage to AWEA members and staff.

EnerNOC, Boston, MA. *Energy Markets Intern*, 2012

Mr. Jacobs performed legal review of demand response contracts before counter-signing for C&I demand response customers. During demand response dispatches, Mr. Jacobs contacted customers to review their energy reduction plan, coached facilities personnel through said plans, and monitored their electric load curtailment using real-time interval trend data.

Ceres, Boston, MA. *Electric Power Sector Intern,* 2011-2012

Mr. Jacobs researched and composed profiles of electric utilities outlining characteristics of projected growth and compliance with EPA emissions rules and state RPS and efficiency standards. He wrote persuasive memos to shareholders of investor-owned utilities to vote for a shareholder resolution requesting disclosure on emissions, renewable, and energy efficiency compliance strategies. Mr. Jacobs also analyzed EIA 861 data to calculate utility company's energy efficiency program savings.

EDUCATION

Northeastern University, Boston, MA
Master of Science, Energy Systems, 2016
Certificate in Engineering Leadership, 2016

Boston University, Boston, MA
Bachelor of Arts, Environmental Analysis and Policy, Minor in Economics, 2012

REPRESENTATIVE PROJECT EXPERIENCE

Massachusetts Energy Efficiency Advisory Council, Technical Consulting Services (2019-present)
Optimal Energy serves as the lead technical consultant to the Massachusetts Energy Efficiency Advisory Council (EEAC) and has since its inception in 2006. Optimal's role includes representing the EEAC on all aspects of negotiating efficiency programs, plans, goals, and budgets with the program administrators, and oversight of all program implementation and evaluation, monitoring and verification activities. To support the EEAC, Mr. Jacobs provides ongoing support for commercial and industrial efficiency program planning and analysis by tracking and analyzing quantitative and qualitative data as well as developing memos, presentations, and other work products.

Pennsylvania Statewide Evaluator Team Member, Market Potential Study Lead (2019)
Optimal Energy is a member of the Pennsylvania Statewide Evaluator team for Phase IV of Act 129. Optimal leads the Energy Efficiency Market Potential Study, and has supported a wide range of other activities, including updating Pennsylvania's Technical Reference Manual, supporting the Demand Response and Combined Heat and Power Potential Studies, and significant contributions to a detailed efficiency measure cost analysis widely utilized by PA utilities in program planning. In addition, Optimal provides methodological guidance and written memos covering a range of topics including cost-benefit analysis, discount rates, avoided cost calculations, the application of baseline data to developing actionable policy insights, and regular meetings with Public Utility Commission Technical Utility Staff.

PUBLICATIONS

"Energy Data Optimization: Dashboards, Utility Bill Verification and Open Data," with A. Guzzo, *U.S. Department of Energy Better Buildings Challenge – Solutions at a* Glance, Washington, D.C., May 2017.

CRAIG JOHNSON, CONSULTANT

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PROFESSIONAL EXPERIENCE

Optimal Energy, Providence, RI. *Consultant,* 2020-present; *Senior Analyst,* 2019-2020; *Analyst,* 2014-2018.

Mr. Johnson is responsible for providing technical services in support of Optimal Energy's efforts to promote energy efficiency and renewable energy. He researches energy efficient and renewable energy technologies, programs, and evaluations to support strategic planning and implementation. Project work includes analytical support in the development, review, and implementation oversight of energy efficiency programs for the Rhode Island Energy Efficiency and Resource Management Council, Massachusetts Energy Efficiency Advisory Council, and Connecticut Municipal Electric Energy Cooperative. Mr. Johnson also provides technical and analytical support in the form of screening projects for cost-effectiveness, drafting communications pieces for a variety of public and private sector clients, and characterizing measures for energy efficiency potential studies.

Acadia Center (formerly Environment Northeast), Providence, RI. *Climate Change and Policy Intern,* 2013.

Mr. Johnson performed quantitative and qualitative analysis to support core initiatives, with a primary focus on sustainable transportation. His research areas included conversion of freight shipping fuel from diesel to natural gas, electric vehicle incentives and polices, and alternative options for funding transportation projects. Mr. Johnson also participated in collaborative processes with stakeholders during the development and implementation of Rhode Island's Energy Efficiency Program Plans.

Bard Center for Environmental Policy, Annandale-on-Hudson, NY. *Teaching Assistant, Dr. Jennifer Philips*, 2012-2013.

Mr. Johnson researched and led discussions on sustainable farming practices and GHG emissions associated with agricultural systems.

Lyndon State College Atmospheric Department, Lyndonville, VT. *Research Assistant, Dr. Nolan Atkins* 2010-2012.

Mr. Johnson collected and photogrammetrically analyzed data of severe thunderstorms during the Verification on the Origins of Rotation in Tornadoes Experiment (VORTEX2). He also produced graphics for peer reviewed research publications and presented results at national and regional conferences.

EDUCATION

Bard Center for Environmental Policy, Annandale-on-Hudson, NY
Master of Science, Climate Science & Policy, 2014
Master's Thesis: *Driving Sustainability: Estimating Lifecycle Private Costs of Electric Vehicles*

Lyndon State College, Lyndonville, VT
Bachelor of Science, Atmospheric Sciences, 2012

REPRESENTATIVE PROJECT EXPERIENCE

Pennsylvania Statewide Evaluator – Market Potential Study (2019-Present)
Optimal Energy is a member of the Pennsylvania Statewide Evaluator team for Phase IV of Act 129. Optimal leads the Energy Efficiency Market Potential Study, and has supported a wide range of other activities, including updating Pennsylvania's Technical Reference Manual, and supporting the Demand Response and Combined Heat and Power Potential Studies. In addition, Optimal provides methodological guidance and written memos covering a range of topics including cost-benefit analysis, discount rates, avoided cost calculations, the application of baseline data to developing actionable policy insights, and regular meetings with Public Utility Commission Technical Utility Staff. Mr. Johnson has provided technical expertise and support in the form of measure characterizations and research associated with updates to the Technical Reference Manual and Incremental Cost Database.

Rhode Island Energy Efficiency and Resource Management Council, Technical Consulting Services (2014-present)
Optimal Energy leads the Consultant team for the Rhode Island Energy Efficiency and Resource Management Council (EERMC). Mr. Johnson contributes to this project by supporting the development, review, and implementation oversight of energy efficiency programs, participating in proceedings of the public utilities commission, and providing ongoing analytical support for Council activities and interests. These efforts have included setting targets of energy efficiency program potential, reviewing energy efficiency potential assessments, tracking and analyzing current and historical program performance, and assessing cost-effectiveness and total cost to achieve energy savings. Mr. Johnson has also spent time coordinating residential sector and evaluation, measurement, and verification (EM&V) teams.

New Jersey Board of Public Utilities, Potential Study and Consulting Services (2019-Present)
New Jersey's 2018 Clean Energy Act mandated completion of an energy efficiency potential study to inform the Board as it establishes targets. Optimal Energy was selected in a competitive bidding process to complete the work, which had to meet a very tight legislative deadline. During the potential study, Mr. Johnson was a key team member in the development of measure characterizations used in the analysis for both the residential and commercial and industrial sectors. Upon completion of the potential study, Optimal was retained to provide expert services as the BPU structured program implementation. In this phase of the project, Mr. Johnson has provided key technical and analytical support in the development of program budgets and savings targets.

Connecticut Municipal Electric Energy Cooperative, Conservation and Load Management Consulting (2015-present)
Optimal Energy has provided energy efficiency consulting services to the Connecticut Municipal Electric Energy Cooperative (CMEEC). Mr. Johnson contributes to the full range of these services, including program planning, program savings analysis and reporting, reviewing projects for cost-effectiveness on an as needed basis, and managing the collection and processing of CMEEC's program data. The latter has included the development of an online technical reference library and savings calculation engine database. As part of its annual reporting requirements to the Connecticut Energy Efficiency Board, Mr. Johnson also quantifies the GHG impacts of CMEEC's programs. Since 2019, Mr. Johnson has also managed CMEEC's participation in the ISO-NE Forward Capacity Market.

ADRIAN CAESAR, ANALYST

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PROFESSIONAL EXPERIENCE

Optimal Energy, Hinesburg, VT. *Analyst*, 2019-present

At Optimal, Mr. Caesar provides research, analysis, and writing and presentation support on a range of projects including advisory council technical services, potential studies, white papers, and policy reports for state and local governments. His expertise lies in economic analysis, statistical programming, and energy efficiency program evaluation.

Fortitude Systems, Denver, CO. Junior Account Executive/Hiring Consultant, 2018-2019

While working at Fortitude, Mr. Caesar collaborated with Senior Consultants to produce technical labor market insights for dozens of Fortune 500 clients in industries including oil and gas, telecommunications, healthcare, and e-Commerce. He provided consultation based on both primary and secondary research which aided in the fulfillment of over 12 projects and onboarding of over 25 functional/technical staff members.

Brown University, CareerLAB, Providence, RI. *Strategy Consultant,* 2017-2018

During his time at Brown's CareerLAB, Mr. Caesar worked in concert with four student team members to devise metrics of user engagement and satisfaction with BrownConnect, a networking, internship search, and career development web application for Brown University undergraduate students, graduate students, and alumni. His work entailed mediating three focus groups, administering website evaluation surveys to 14 participants, and modeling data on over 2,000 users using Excel and MySQL databases to aid in optimizing the survey designs and providing suggestions for improving BrownConnect to the CareerLAB Directors.

Northwestern Mutual, Providence, RI. Financial Representative Intern, 2017

At Northwestern Mutual, Mr. Caesar worked alongside life, disability income, long-term care, investment, accident, and health insurance specialists to prepare comprehensive financial planning analyses for clients. His primary focus was the development of Personal Planning Analyses based on financial risk management, wealth accumulation, and wealth distribution strategies using financial modeling and forecasting tools.

EDUCATION

Brown University, Providence, RI

Bachelor of Arts, Business, Entrepreneurship & Organizations, Economics Track (2018)

REPRESENTATIVE PROJECT EXPERIENCE

Pennsylvania Statewide Evaluator Team Member, Market Potential Study Support (2019-Present)
Optimal Energy has been actively involved with the Pennsylvania Statewide Evaluator team for Phase IV of Act 129 as the Energy Efficiency Market Potential Study Lead. In addition, Optimal provides methodological guidance and written memos covering a range of topics including cost-benefit analysis, discount rates, avoided cost calculations, the application of baseline data to developing actionable policy insights, and regular meetings with Public Utility Commission Technical Utility Staff. Mr. Caesar has been responsible for an array of activities which includes Potential Study Scenario Analysis, Potential Study Report drafting, and Combined Heat and Power Potential Study support.

Rhode Island Energy Efficiency and Resources Management Council, Policy and Program Planning Consulting (2019-Present)
Optimal Energy manages a team of consultants providing support to the Rhode Island Energy Efficiency and Resource Management Council (EERMC) on topics ranging from high-level policy and legislative issues down to the oversight of program implementation and infrastructure development. Mr. Caesar leads monthly and quarterly utility data reporting for the consultant team, as well as design and maintenance of the public EERMC. In addition, Mr. Caesar supports Optimal Energy's work for the EERMC in a range of areas related to ongoing program design, annual planning, measurement and verification, and research of emerging trends in the energy efficiency and clean energy space.

Massachusetts Energy Efficiency Advisory Council, Technical Consulting Services (2019-present)
Optimal Energy serves as the lead technical consultant to the Massachusetts Energy Efficiency Advisory Council (MA EEAC) since its inception in 2006. Optimal's role includes representing the EEAC on all aspects of negotiating efficiency programs, plans, goals and budgets with the program administrators, and oversight of all program implementation and evaluation, monitoring and verification activities. As a technical services core member, Mr. Caesar provides technical services including recording and production of meeting minutes for full Council and executive committee meetings, as well as subcommittee or other meetings on an ad hoc basis. Mr. Caesar also provides analytical support for a variety of Council activities, including development, review, and implementation oversight of energy efficiency programs.

Delaware Department of Natural Resources and Environmental Control, Energy Efficiency Advisory Council Program Development and Support (2019-Present)
Optimal Energy provides broad program planning, analysis, and strategic guidance to the Delaware Energy Efficiency Advisory Council as it begins developing a new model for joint utility and public-sector delivery of energy efficiency services, with the objective of dramatically increasing energy savings and demand reductions in that state. In support of the Council, Mr. Caesar conducts research and analysis in a range of areas related to ongoing program design, measurement and verification, and emerging trends in the energy efficiency and clean energy space. Mr. Caesar also supports data analysis and reporting requirements for the Regional Greenhouse Gas Initiative (RGGI).

GRIFFITH KEATING, ANALYST

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PROFESSIONAL EXPERIENCE

Optimal Energy, Hinesburg, VT. *Analyst*, 2020-present

Mr. Keating provides research, analysis, and writing and presentation support on a range of projects including advisory council technical services, potential studies, white papers, and policy reports for state and local governments. His expertise lies in quantitative and statistical analysis, policy research, and data management.

New York State Energy Research and Development Authority, Albany, NY. *Data and Markets Intern,* 2018-2019

Mr. Keating supported New York State energy programs by providing data analysis and data management. He contributed to major state publications such as the State Energy Plan, Patterns and Trends, and weekly fuel reports. He aided in data preparation for the State Greenhouse Gas Inventory. He collaborated on a framework to track and model natural gas deliveries in New York State using a combination of Excel, Access, and SAS.

TREES Project, Puerto Viejo de Sarapiqui, Costa Rica. *Field Assistant,* 2016

Mr. Keating collected and analyzed data for two projects centered around tree communities in the neo-tropical rainforest. The first project sought to determine how planting trees can alter the genetic diversity of tree communities that were regenerating from agricultural use. The second project was a resurvey of a section of old-growth forest to detect any uphill migration of tree species due to climate change. In both projects Mr. Keating used a combination of GIS, R, and Excel to facilitate the collection, management, and analysis of data.

McLaren Engineering, West Nyack, NY. *Draftsman*, 2015

Mr. Keating served as primary draftsperson for the land surveying department. He led survey drafting for the rehabilitation of 11 minor bridges in the greater New York Metropolitan area using AutoCAD and MicroStation. He worked on surveys for projects ranging from stadium roof construction to wetland delineations.

EDUCATION

University at Albany, Albany, NY

Master of Public Administration, Environmental Policy and Politics, 2019

Purchase College, Purchase, NY

Bachelor of Arts, Environmental Studies, Ecology Track, 2018

REPRESENTATIVE PROJECT EXPERIENCE

Massachusetts Energy Efficiency Advisory Council, Planning and Analysis (2020-present)
Optimal Energy serves as the lead technical consultant to the Massachusetts Energy Efficiency Advisory Council (MA EEAC) since its inception in 2006. Optimal's role includes representing the EEAC on all aspects of negotiating efficiency programs, plans, goals and budgets with the program administrators, and oversight of all program implementation and evaluation, monitoring and verification activities. As a planning and analysis core member, Mr. Keating provides data services including data collection, data preparation and data analysis. Mr. Keating also provides support for a variety of Council activities, including development, review, and implementation oversight of energy efficiency programs. Mr. Keating has conducted analyses into the customer economics and cost effectiveness of heat pumps, and how changes to the valuations of carbon and energy may impact them.

Delaware Department of Natural Resources and Environmental Control, Energy Efficiency Advisory Council, Technical Consulting Services (2020-present)
Optimal Energy provides broad program planning, analysis, and strategic guidance to the Delaware Energy Efficiency Advisory Council (EEAC) as it develops a new model for joint utility and public-sector delivery of energy efficiency services, with the objective of dramatically increasing energy savings and demand reductions. In support of the council Mr. Keating provides analytical services including data analysis, tool preparation, and policy research. Mr. Keating also provides support to Department staff in a variety of ways, including technical assessments, strategic planning, and topical research.