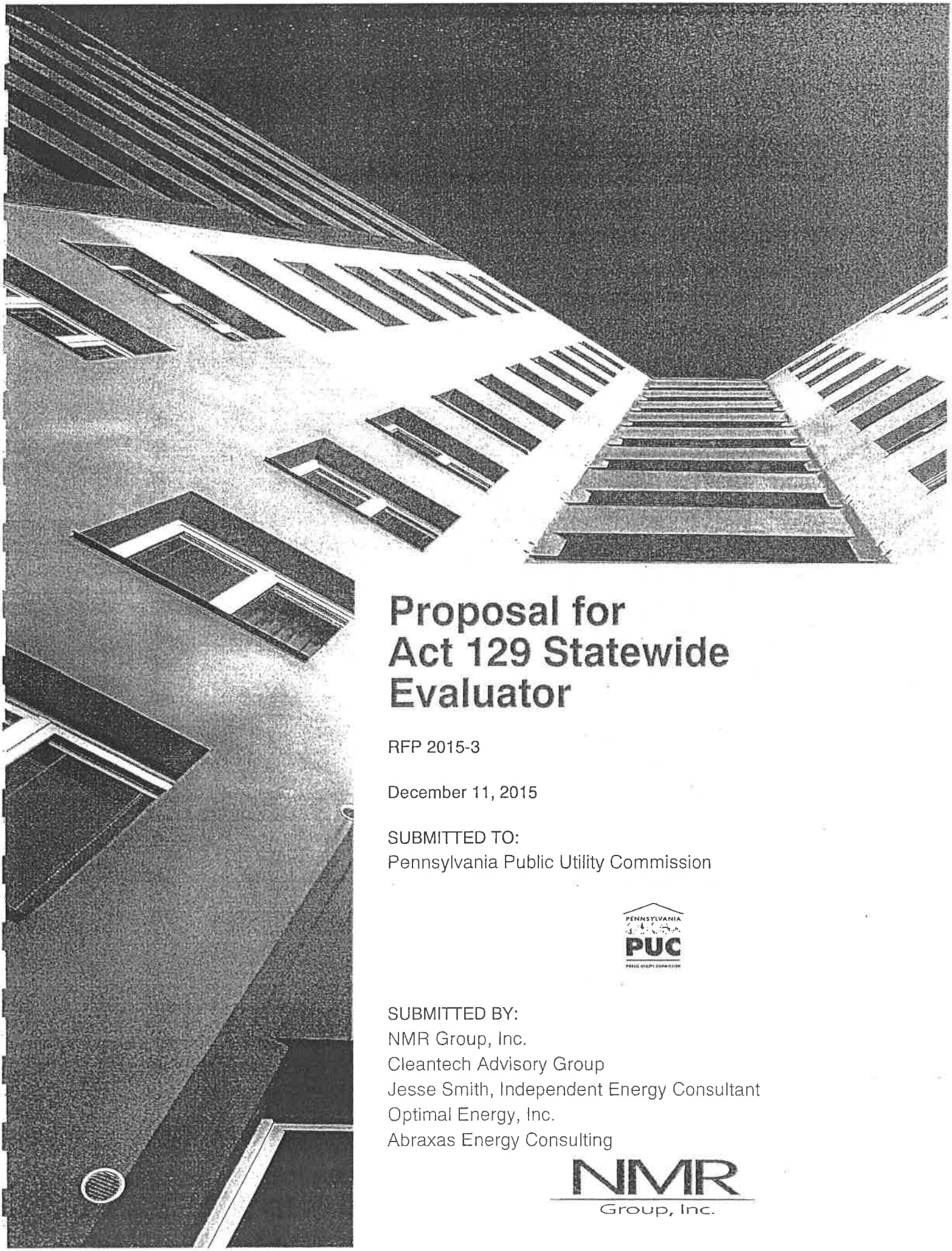

Proposal for Act 129 Statewide Evaluator

RFP 2015-3

December 11, 2015

SUBMITTED TO:
Pennsylvania Public Utility Commission

SUBMITTED BY:
NMR Group, Inc.
Cleantech Advisory Group
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NMR Group, Inc.

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Section 1 Executive Summary and Statement of the Problem

NMR Group, Inc. (NMR), Cleantech Advisory Group, LLC (Cleantech), Jesse Smith, Optimal Energy, and Abraxas Energy Consulting—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 Statewide Evaluator (SWE) for the Energy Efficiency and Conservation (EE&C) Programs of the large Pennsylvania Electric Distribution Companies (EDCs). The NMR team understands the importance of the SWE to the PUC—that the SWE provides independent, rigorous, and timely monitoring and verification of EDC data collection, quality assurance processes, and performance of EDCs' EE&C programs, while also conducting an assessment of potential future energy efficiency and demand response savings. The NMR team combines a fresh perspective with core incumbent knowledge and experience that will allow us to anticipate, instead of being reactive to, hurdles. We have extensive experience with numerous similar evaluations and audits, including the Statewide Evaluation in New York (NYSERDA) and Wisconsin (WI PSC).

Pursuant to Act 129 of 2008 ("Act 129"), the PUC has been charged by the Pennsylvania General Assembly with establishing an energy efficiency and conservation program. The energy efficiency and conservation program requires each EDC with at least 100,000 customers to adopt a plan to reduce energy demand and consumption within its service territory. Accordingly, the EDCs that must comply with the Act are Duquesne Light Company, Metropolitan Edison Company, PECO Energy Company, Pennsylvania Electric Company, Pennsylvania Power Company, PPL Electric Utilities Corporation, and West Penn Power Company. The broad customer class categories that are to be tracked are residential, low-income residential, commercial, industrial, governmental, educational, and non-profit entities. On June 19, 2015, the PUC entered a Final Phase III Implementation Order that established a timeline for each EDC to implement EE&C programs with targets for reducing both energy and demand consumption. The Final Implementation Order established a five-year Phase III term commencing on June 1, 2016, and ending on May 31, 2021. The statewide five-year reduction targets are 5,710 GWh/year of energy savings and 424 MW/year of demand response savings.

Highlights of the Proposed Approach

As part of the Implementation Order and Act 129, the PUC is seeking a SWE to evaluate the EDCs' Phase III EE&C programs. The high-level work scope outlined by the PUC for this work generally seeks to build upon the processes, manuals, and studies adopted during Phase I and Phase II that were designed to audit and verify the accuracy of the results provided by the EDCs and the Act 129 EE&C program as a whole. Very broadly, the PUC has the following two fundamental evaluation needs:

- **Retrospective**. Ensure the reliability and accuracy of estimates of energy and demand savings and cost-effectiveness of the EDC-implemented electric energy efficiency and demand response programs.

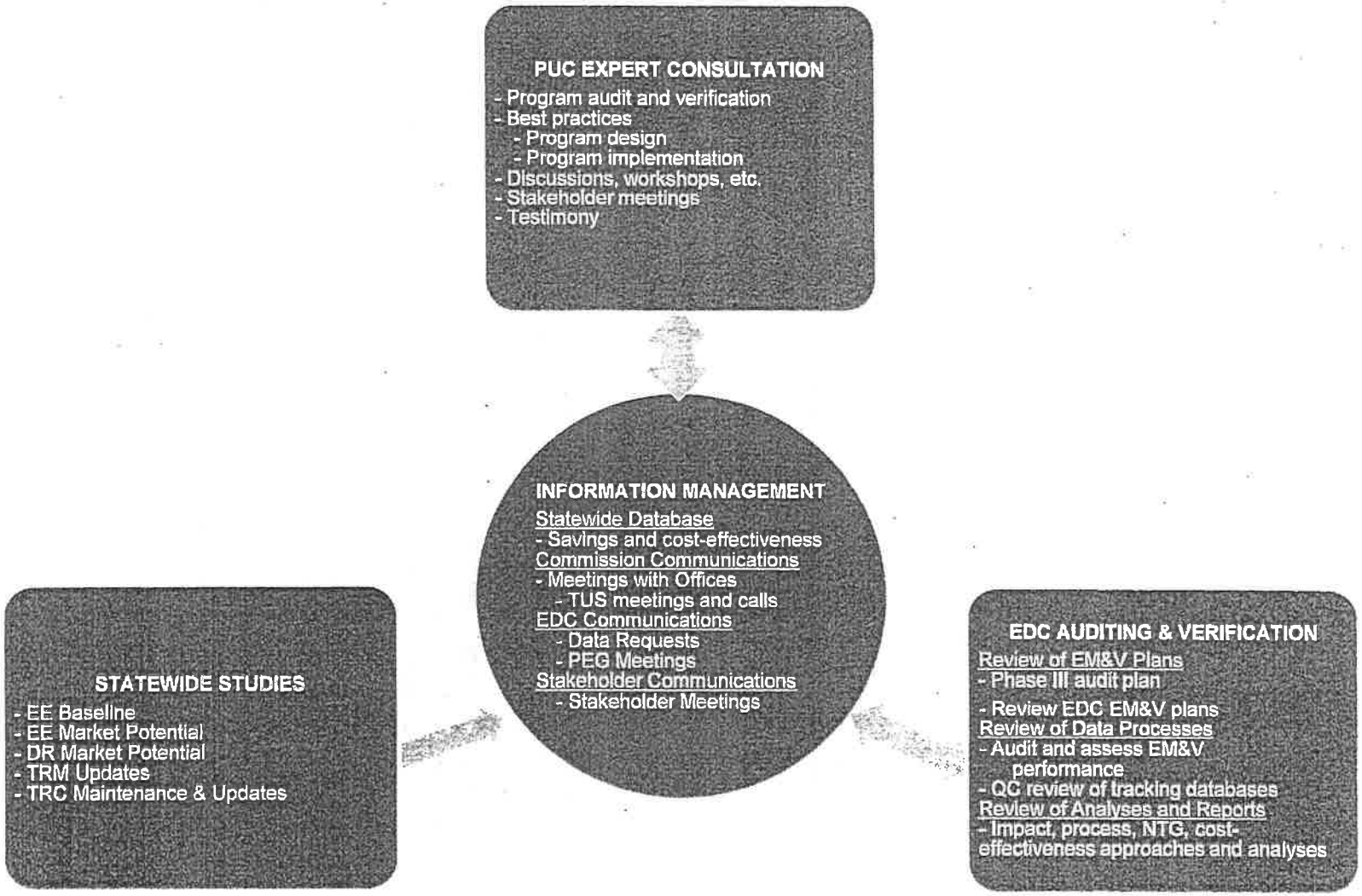
- **Prospective**. Establish targets and provide guidance for energy efficiency and demand response programs going forward.

The SWE is thereby expected to engage in four primary activities to support the PUC in satisfying the above two fundamental needs.

1. Provide expert evaluation advice and guidance to the PUC
2. Provide oversight and review of EDC program tracking, reporting, and EM&V activities
3. Provide information and guidance for statewide energy efficiency opportunities, targets, and standards.
4. Manage transmission of information between stakeholders for the above activities

These four primary activities and their associated tasks are depicted in Figure 1, following which we briefly discuss them.

Figure 1: Primary SWE Activities



Expert Advice and Guidance. The NMR team will serve the PUC as a reliable and trusted evaluation advisor, drawing upon a combination of historical knowledge of evaluations in Pennsylvania, knowledge of best practices, and experience with providing evaluation oversight in other jurisdictions. In this capacity, the NMR team will assist the PUC with insights regarding best practices in impact evaluation and program implementation; 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 EM&V approaches are reasonable given program budgets, contribution to savings, and uncertainty.

Oversight and Review of EDC Program and EM&V Activities. The NMR team will assist the PUC in ensuring the reliability and accuracy of the EDC EE&C program savings estimates. We will accomplish this through a comprehensive examination of four key aspects of EDC EM&V activities and performance. First, we will review EDC program implementation, tracking, reporting, and supporting documentation to ensure that EDC data and reports accurately calculate and report TRM savings. Second, we will scrutinize each EDC's EM&V plan to ensure that it meets industry standards for best practices and will cost-effectively provide credible and accurate results. Third, we will conduct a detailed review and audit of the EDCs' EM&V primary data collection processes and procedures to verify that they are generating accurate and verifiable measurements of program impacts. Fourth, we will review the EDCs' EM&V analyses and documentation of gross and net energy and demand savings for accuracy, consistency, and adherence to industry best practices and state standards such as the TRM and TRC test.

Statewide Energy Efficiency Opportunities and Goals. The NMR team will assist the PUC in assessing future opportunities for energy efficiency in Pennsylvania and providing guidance for a possible Phase IV of Act 129 EE&C programs in Pennsylvania. We will accomplish this through a range of different studies including residential and commercial baseline studies, energy efficiency and demand response market potential studies, and updates to the Technical Reference Manual (TRM) and Total Resource Cost (TRC) test.

Information Management. The NMR team considers information management a central and critical component of the SWE responsibilities. We recognize that even after ensuring the technical reliability and accuracy of evaluation results, if the information cannot be easily but securely accessed or is inadequately communicated, the evaluation findings may not be fully understood or utilized. There are two overall components to the information management function: establishing and maintaining a secure SharePoint statewide database for the exchange of non-public/confidential data and information; and communicating relevant information and data between and among the SWE, the EDCs, the PUC, and key stakeholders.

Risk Management

The NMR team realizes that to successfully execute the SWE activities, we will need to have a clear understanding of the major sources of uncertainties and risks that could limit the quality of the outcomes. Armed with such an understanding, we propose to

prospectively put in place methods to manage or mitigate their impact. In general, we view the sources of uncertainty and risk to be associated with either technical evaluation issues or evaluation management process issues. The technical evaluation uncertainties and risks are associated with either the retrospective evaluation activities or the prospective evaluation activities. The evaluation management process issues are primarily associated with barriers to or failures in communication between the various players engaged in the conduct of the evaluations. A discussion of the anticipated uncertainties and risks and our proposed approaches to addressing them is provided below.

Technical Risks. These risks and uncertainties relate to the reliability and validity of the evaluation findings.

Retrospective risks are associated with program savings and the EM&V results. These would include ineffective program implementations by EDCs, or limitations or flaws in the EDC EM&V approach, data collection, and analysis. The NMR team will seek to manage or mitigate these risks through a combination of detailed audit and review of results informed by knowledge of best practices in EM&V and updated values for the TRM and TRC test. In this regard, the NMR team will include consideration of the following factors and issues in its approach to managing or mitigating these risks.

- In its capacity as the SWE, the NMR team will be the technical arm of the PUC and must provide unbiased assessments that will withstand regulatory scrutiny. All studies, research investigations, and audits conducted under this contract will be the responsibility of the NMR team with directional guidance from TUS staff. Recognizing these critical requirements, the NMR team has selected known subject matter experts for the task assignment under the SWE contract. Our task leads have extensive Act 129 and other jurisdictional experience to establish sound technical protocols for the most accurate measurement, verification, and accounting of Act 129 impacts. Our planning experts are fully aware of the nuances of conducting the Phase III baseline and market potential studies to recommend targets for the next phase, taking into consideration the appropriate determinants of projected Phase IV acquisition costs.
- With Act 129 of 2008, the Pennsylvania Legislature implemented a punitive approach to DSM implementation. EDCs are required to meet energy (MWh) and peak demand (MW) savings targets or face fines of between $1 million and $20 million. Such a regulatory mechanism creates an environment in which progress toward and compliance with savings targets is of paramount importance to the seven EDCs subject to Act 129. Each EDC retains an EM&V contractor to estimate and report gross verified savings, but these firms are paid consultants of the EDCs, and this may compromise the independence desired by the PUC when assessing compliance with goals. The SWE, as contractor of the PUC, has no fiduciary relationship with the EDCs and offers a truly independent assessment of the savings achieved by each EDC. The NMR team will accordingly provide the necessary technical expertise in engineering, statistics, market research, planning, and benefit cost modeling to assess whether the EDC claimed savings were developed

according to industry best practices, and recommend to the PUC whether claimed savings should be accepted, rejected, or modified.

- Standardization across EDCs is important in Act 129, and the NMR team will facilitate the adoption of common methods of practice in key areas. We will identify best practice research methods for the EDCs and their contractors to follow. The development and maintenance of the Technical Reference Manual (TRM) establishes common ground rules for calculating and reporting savings from energy efficiency (EE) and demand response (DR) measures. The Audit Plan/Evaluation Framework provides technical guidance and sets expectations regarding acceptable verification methods for the EDC evaluation contractors.
- The NMR team will also have key auditing and reporting responsibilities. In addition to establishing ground rules up front, we will verify that established protocols were followed in audit activities. The sheer scope of Act 129 means that we will need to efficiently process and review large volumes of data. Data from all seven EDCs will need to be synthesized into statewide reports that provide the PUC with insight into each EDC's achievements and confidence that all savings numbers have been thoroughly vetted.
- The SWE is uniquely positioned to offer conclusions and strategic recommendations to the PUC because its consultants will be intimately involved in programs delivered by all seven EDCs. This will allow the NMR team to observe patterns and trends across EDCs that may be less apparent to a single EDC evaluation contractor. The SWE is also expected to inform Act 129 policies based on DSM trends in other jurisdictions. The ability to provide the PUC with a national perspective is a key service for which the NMR team offers the requisite experience and capabilities.

Prospective risks are associated primarily with the statewide studies that the SWE will conduct. We will seek to manage or mitigate these risks by conducting reliable and accurate baseline and market potential studies informed by experience with conducting such studies in other jurisdictions as well as a knowledge of the best practices in conducting them. In this regard, the NMR team will include consideration of the following factors and issues in its approach to managing or mitigating the risks.

- **Goal-setting given budget constraints.** Because of the financial penalties associated with missed compliance targets, the magnitude of EDC savings goals is always a contentious topic in Pennsylvania. Phase I goals were established by the legislation, but Phase II and Phase III goals were effectively determined by the SWE as an outcome of a market potential study. Program spending is fixed at 2% of 2006 revenues, so the key question that the SWE market potential study must answer is what quantity of savings should each EDC be able to achieve given their budget allocation, service territory characteristics, and split between EE and DR. It is critical that this analysis be unbiased, technically sound, and transparent to all Act 129 stakeholders.
- **Planning expertise.** An informed market potential study requires a significant amount of customer segmentation analysis and primary data collection on equipment saturations and building stock. The NMR team will provide the technical

expertise and staffing bandwidth to execute these baseline studies for the PUC. Our team has multifaceted experience conducting baseline and market potential studies to investigate the nuances of market transformation and develop programs of incremental benefit.

Process Risks. These risks and uncertainties stem from potential barriers to and failures in the processes associated with the transmission and communication of information between the various players engaged in doing the evaluations. The NMR team will seek to manage or mitigate these risks in a number of ways.

- **Accessible staff.** Key staff on the NMR team will be located in or near Pennsylvania, making them easily accessible to the Project Officer and the Bureau of Technical Utility Services (TUS). These staff members will also be dedicating the majority of their time to this work and will be readily available to the TUS staff to respond to any issues or questions.
- **Communications.** Upon start of the work, we will establish a process and structure for regular meetings and status updates. These will include both in-person and telephone meetings. Additionally, we will be available for ad hoc meetings as needed.
- **Quality reports.** Written reports to the PUC and the broader Act 129 stakeholder community are the primary deliverable for the SWE. The NMR Team will implement rigorous report development and QA/QC protocols to ensure all deliverables are written clearly in a single voice and are free of technical, grammatical, or formatting errors. Conclusions and recommendations will be clearly stated with supporting documentation.
- **Data security.** We will establish a secure SharePoint site to obtain, compile, consolidate, and disseminate the evaluation results. In addition to separate, siloed, password-protected folders for the EM&V results for the PUC and each EDC, we will provide the PUC with spreadsheets that provide consolidated summaries of the results.
- **EDC reporting templates.** To ensure consistency in the reporting formats for EM&V results from each of the EDCs, we will develop and provide the EDCs with data and reporting templates. This will also facilitate the consolidation and summarization of the results for reporting to the PUC.

The Act 129 framework is a dynamic environment that requires TUS staff and the SWE to be agile and adaptable to ongoing, sometimes conflicting, concerns raised by the stakeholders. This frequently results in ad-hoc and unforeseen task assignments for the SWE team—for example, supporting the development of special secretarial letters for policy directives, making changes to the Audit Plan for unforeseen technical issues, or supporting TUS staff in determining the PUC's dispositions to petitions and other regulatory comments made by stakeholders on implementation orders and other PUC documents. The experience of the incumbent partners on the NMR team has taught us that a portion of the SWE's scope of work and budget needs to be flexible in order to respond to this dynamic work environment. The NMR team will therefore ensure that it has the appropriate resources and funds available to respond to such ad-hoc tasks assigned by TUS staff.

Section 2 Management Summary

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 for each task assignment and study under the SWE contract (Figure 2). NMR will be responsible for overall project management; residential, net, and process audit and verification activities; as well as the residential baseline study. Cleantech will be responsible for the C&I audit and verification activities, the C&I baseline study, TRM and TRC updates, and leading the updates to the Phase III Audit Plan. Jesse Smith will lead the DR audit and verification activities and the DR potential study as well as audit activities pertaining to behavioral conservation and conservation voltage reduction programs. Optimal Energy will lead the energy efficiency potential studies, while Abraxas Energy will provide support to Cleantech on all C&I audit and verification activities and the C&I baseline study.

The Overall Project Manager will be Greg Clendenning from NMR. He will be the central point of contact and ensure that the SWE speaks with one 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:

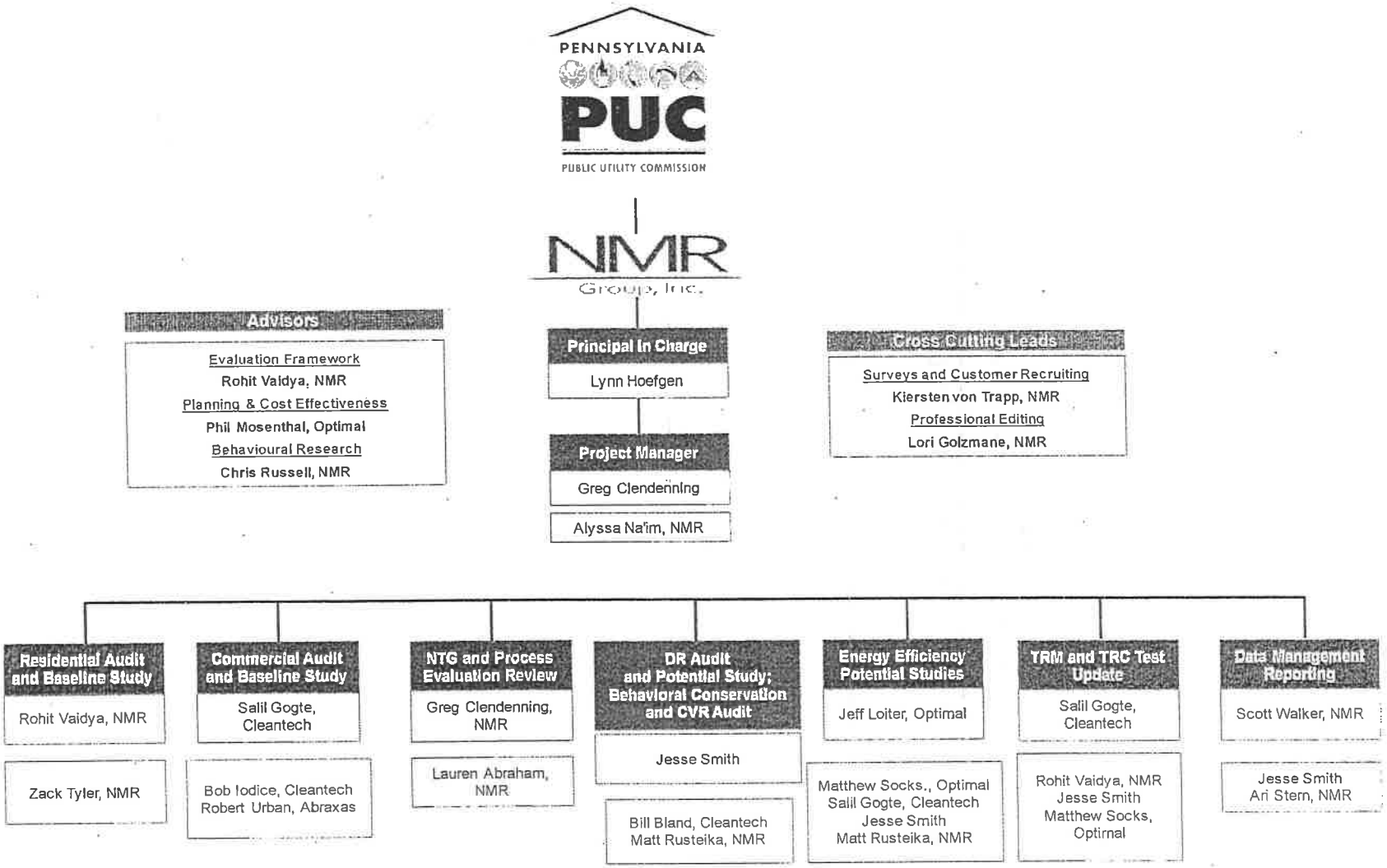
- Our interaction with the PUC is optimal and efficient
- We effectively manage our team
- We meet our commitments to the PUC
- We provide project deliverables on time
- We adhere to project budgets
- We identify, understand, and consider the value proposition for all projects

Greg will dedicate 50% of his time to the project and will be supported by Lynn Hoefgen as Principal-in-Charge in all of the above activities. Also as principal-in-charge, Lynn will actively participate in project planning, project management, research design, staff assignments, interpretation and presentation of results, and quality assurance. Alyssa Na'im will serve as the deputy project manager, providing support for management and administrative issues across all tasks and studies.

Project leads with relevant subject matter expertise will direct individual tasks and will also be directly accessible to TUS staff to answer any questions or provide advice. Each of these task leads will be supported by experienced and knowledgeable deputy task leads assembled from the team, a data manager who will be responsible for data requests and data warehousing, and highly experienced personnel who will work on individual projects and tasks in various roles. Our task leads have extensive Act 129 and other jurisdictional experience 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 III baseline and market potential studies to recommend targets for the next phase, taking into consideration the appropriate determinants of projected Phase IV acquisition costs.

In addition to the Task Leads, our Overall Project Manager (Greg Clendenning), Principal-in-Charge (Lynn Hoefgen), and professional editor (Lori Golzmane) will review all deliverables including work plans, memos, and reports. In addition, there is value in having parties who are not involved in the evaluation from start to finish review reports before they are delivered. Staff not directly involved in evaluation tasks are often able to see things that can be missed by someone who has been intensely focused on a project. We will draw upon a pool of potential advisors who are all nationally recognized experts in their fields. These key advisors will be responsible for approving methodological approaches and deliverables, as well as providing quality assurance and general advice and guidance as necessary throughout projects. The team has also identified cross-cutting leads—experienced staff who will lead and direct activities that reach across evaluation tasks, such as professional editing, regulatory reporting QA/QC, recruiting for site visits, and other data collection needs. Figure 2 presents our proposed team structure. Note that, for brevity, the organizational chart only shows the key personnel identified to work on the SWE project. Key personnel will be supported by a cadre of qualified engineers, statisticians, economists, sociologists, and coordinators carefully chosen for skills that align with the RFP requirements.

Figure 2: Team Structure



2.1 Team Structure and Roles

As mentioned above, we have assigned subject area and study leads (Figure 2). The subject area and study leads will coordinate research activities and ensure that information is shared across all projects. Subject area leads will be supported by highly experienced personnel who will serve individual projects and tasks in various roles. 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 projects, while allowing the subject area lead to maintain oversight and control over the portfolio of projects.

2.2 Dedicated Senior Staff

Our team has a philosophy and track record of 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.

Lynn Hoefgen, NMR, Principal-in-Charge. Dr. Hoefgen, the founder and president of NMR Group, Inc., has over 30 years' experience in energy-related evaluation and market research. He has moderated hundreds of focus groups, conducted hundreds of in-depth interviews, designed and analyzed results from hundreds of surveys, and designed and managed scores of complex multidisciplinary research projects. For the US EPA, for many years he was the Research Director for efforts in support of the ENERGY STAR label. He has been a key member of the team helping NYSERDA coordinate and supervise other evaluation contractors, helped write NYSERDA's annual program evaluation and status report for several years, and set up a system to track indicators of program success. For the sponsors of the Massachusetts programs, he led a team that developed long-term evaluation plans for three residential programs, and for years has led broad-ranging evaluations of their residential lighting, appliances, and new homes programs, including impact evaluations, process evaluations, market assessments, baseline studies, and market effects studies. He has conducted leading-edge work in assessing program effects on the market penetration of NEMA Premium motors, efficient appliances, and efficient lighting. He has conducted numerous market effects studies and has advised program administrators in California and Massachusetts on planning and executing market effects studies. Before forming NMR, Dr. Hoefgen established and headed the energy practice at Opinion Dynamics Corporation.

Greg Clendenning, NMR, Overall Project Manager, has a great deal of experience managing large and complex projects, including recent experience leading a market effects and market characterization study focused on California's Investor-Owned Utilities' (IOUs)

multifamily new construction (MFNC) programs and the MFNC market in California, as well as the market effects portion of the process and impact evaluation of the US Department of Energy's Better Buildings Neighborhood Program (BBNP). Dr. Clendenning has extensive experience evaluating the net impacts of efficiency programs, including a review and recommended methods to be used to estimate net program effects for residential programs in Massachusetts and a study to help ensure the understanding, transparency, and credibility of electric and gas energy efficiency resources implemented in the Northeast and mid-Atlantic region for the Northeast Energy Efficiency Partnerships (NEEP) Evaluation, Monitoring, and Verification (EM&V) Forum. Dr. Clendenning's evaluation research experience also includes residential housing programs, non-energy benefits, 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 US State Department and served as a rural community development extension agent in Togo, West Africa, with the US Peace Corps.

Rohit Vaidya, NMR, Vice President, has worked in the energy industry for more than two decades. Over the years, he has conducted process, market, and impact evaluations of the full spectrum of residential and commercial energy efficiency programs. Areas of expertise include program portfolio evaluation, process evaluation, market characterization, market transformation, product design and development, market segmentation, and customer satisfaction. He has also conducted studies focused on critical evaluation components such as net-to-gross measurement, market effects measurement, and economic impacts. Mr. Vaidya is currently on the General Evaluation Assistance Contractor team for NYSERDA, working with evaluation staff to oversee the activities of process and survey evaluation contractors for the full range of NYSERDA programs, including commercial/industrial, residential, low-income, and research and development programs. He has also led a multi-year process and impact evaluation of all of the residential and commercial/industrial DSM programs at Nova Scotia Power. Mr. Vaidya received his B.A. degree in Economics & Mathematics from the University of Delhi, India; he has also completed work toward an M.A. in Sociology at Columbia University.

Alyssa Na'im, NMR, Deputy Project Manager, has more than 10 years of experience conducting applied research and program evaluation, providing training and technical assistance, and coordinating multi-site, cross-project data collection and oversight. Ms. Na'im has managed and contributed to numerous process and impact evaluations. This work has involved developing and administering data collection instruments as well as synthesizing findings from document reviews, interviews, and surveys. Prior to joining NMR in 2013, she worked as Project Director and Senior Research Associate at Education Development Center (EDC), a non-profit organization addressing education, health, and economic development programs. At EDC she performed research, evaluation, and capacity-building for projects that engage populations underrepresented in science, technology, engineering, and mathematics fields. Ms. Na'im's areas of expertise include program and skill assessment, resource development, and policy analysis. She holds a Master's in Public Policy from the J.F.K. School of Government at Harvard University.

Salil Gogte, Cleantech Advisory Group (Cleantech), Principal. Mr. Gogte is an active proponent of economical energy production, transmission, and distribution. He has spent more than 10 years advising the energy industry on structuring policies and regulations that govern the economic management of demand-side resources. His expertise includes a variety of energy efficiency and demand response consulting services including policy planning, goal setting, program design, assessing market potential, market research and characterization, and evaluation, measurement and verification. Formerly a Principal Consultant in Nexant's Utility Services business unit, he directed DSM planning and evaluation studies for multi-sector utilities and regulators in North America and provided leadership to a team of over 30 engineers, statisticians, and economists. Mr. Gogte is a Certified M&V Professional and a co-author of the International Performance Measurement and Verification Protocol (IPMVP) 10000-1:2012 Volume I.

William (Bill) Bland, Cleantech, Senior Manager. Mr. Bland brings 30+ years of experience in load research, market research, savings estimation, EM&V, and forecasting to the Cleantech team. He has evaluated numerous load management and energy efficiency programs for Commonwealth Edison, East Kentucky Power, and Gulf Power Company and has conducted several hundred residential baseline saturation surveys and commercial audit projects for Savannah Electric, Oglethorpe Power Corporation, and Southern Company Services including Alabama Power, Georgia Power, Gulf Power, and Mississippi Power. Mr. Bland understands the importance of conducting quality commercial equipment audits to document equipment types and connected load for marketing, forecasting, and load research. He also has extensive experience in market characterization and assessment for programmatic improvements.

Robert (Bob) Iodice, Cleantech, Senior Engineer. Mr. Iodice's fifteen years of diverse technical experience in the energy efficiency industry has enabled him to establish a strong reputation for best-in-class demand-side management (DSM) program design and evaluation, technical study delivery, code compliance assurance, facility energy audits, energy efficiency analyses, and renewable energy generation assessments. He provides guidance and mentoring to the teams he leads in the form of technical knowledge, a practical applied skillset, and an ability to cultivate others' aptitudes.

Jesse Smith, Independent Energy Consultant, is an experienced utility analyst and 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 evaluation, measurement and verification (EM&V) of a wide variety of demand response, dynamic pricing, and energy efficiency programs implemented by electric and gas utilities across North America. Mr. Smith specializes in statistical analysis of energy usage data, sampling, matching, experimental design, and benefit cost modeling. While working as a consultant for Nexant, he analyzed a number of behavioral conservation programs, including the largest Home Energy Report deployment in the industry to date. Prior to joining Nexant, Mr. Smith worked as a load research analyst for GoodCents Solutions, where he performed statistical analyses of the energy and demand savings of a number of direct load control and energy efficiency projects for client utilities. 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. He is an experienced analyst and proficient with a variety of tools, including SAS, Stata, SQL, and Excel.

Jeff Loiter, Optimal Energy, has over 20 years of experience in energy, environmental, and economic consulting for both private- and public-sector clients. His energy experience includes policy, planning and program design, research on renewable and efficiency technologies, electricity transmission systems, integrated resource planning, and savings verification. Mr. Loiter became a partner in Optimal Energy in 2015 and focuses his firm management efforts in the areas of hiring and business development.

Phil Mosenthal, Optimal Energy, has 30 years of experience in energy efficiency consulting, including facility energy management, utility and state planning, program design, implementation, evaluation, and research. He has particular expertise in the commercial, industrial, and institutional sectors. Mr. Mosenthal has developed numerous utility, state and region integrated resource and DSM plans, and designed and evaluated residential, commercial, and industrial energy efficiency programs throughout North America and in Europe and China. He has also been the lead analyst on numerous energy efficiency potential assessments. He has played key roles in utility collaboratives and has successfully worked to build consensus among diverse parties in various assignments. Mr. Mosenthal has also designed program implementation procedures, managed implementation contracts, trained efficiency program and planning staff, and performed over 400 commercial and industrial facility energy efficiency analyses for end users.

Matthew Socks, Optimal Energy, has served a leading role in conducting efficiency program engineering, economic analysis, and implementation assessments for clients across North America. With a background in mechanical engineering, Mr. Socks possesses particular expertise in the fields of efficiency measure research methodology and characterization practices. He is currently involved with technical analyses, program design, and program assessment for the New York Power Authority, the Massachusetts Energy Efficiency Advisory Council, and Delaware Department of Natural Resources and Environmental Control. Mr. Socks has been a primary contributor in the development of energy efficiency savings estimation methodologies for clients in more than a dozen states including Massachusetts, New York, Connecticut, Vermont, Rhode Island, and Maryland. Mr. Socks holds a BS in Mechanical Engineering from the Massachusetts Institute of Technology. He is a licensed Professional Engineer in the State of Vermont, a Certified Energy Manager (CEM), and a Certified Building Energy Simulation Analyst (BESA).

2.3 Project Communications

Effective communication is central in assuring that high-quality projects are delivered on time and on budget. To this end, we propose establishing a set of protocols and mechanisms to ensure that the SWE, the PAs, the EDCs, and other stakeholders have regular, clear, and transparent communications. These communication protocols and mechanisms are described in Section 3.9.

2.4 Services and Deliverables

As noted in Section 1, the SWE services and deliverables will encompass four primary activities that include expert evaluation advice and guidance, oversight and review of EDC EM&V activities, development of statewide energy efficiency information, and transmission of information.

Table 1 shows a summary of these 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 3 of our proposal.

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	3.2
Audit and verification: EDC EM&V evaluation plan review	3.3.1
Audit and verification: Gross savings, energy efficiency	3.3.2
Audit and verification: Gross savings, demand response	3.3.2
Audit and verification: Gross savings, behavioral conservation programs	3.3.2
Audit and verification: Gross savings, conservation voltage programs	3.3.2
Audit and verification: Gross savings, TRC	3.3.2
Audit and verification: Net impacts	3.3.3
Audit and verification: Process evaluations	3.3.4
Audit and verification: Ad hoc activities	3.3.5
Statewide Energy Efficiency Information	
Updates to Technical Reference Manual and TRC order	3.4
C&I baseline study	3.6.1
Residential baseline study	3.6.2
Energy efficiency market potential study	3.7
Demand response market potential study	3.8
Expert Evaluation Advice and Guidance	
Meetings and other requirements	3.9
Testimony	3.10
Ongoing obligations	3.11
Information Transmission	
Data management and PUC reports	3.5

Section 3 Work Plan

The Phase III SWE scope of work includes a variety of different tasks 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 to deliver quality work across diverse subject areas and a work plan to 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.

3.1 Kickoff Meeting

The evaluation will commence with a kickoff meeting with the TUS staff at the PUC's offices in Harrisburg. 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 schedule and deliverables, discuss reporting schedules, and establish contract and communication protocols, including the scheduling of the bi-weekly SWE team teleconferences with the TUS staff. The NMR team will prepare a draft agenda for the kickoff meeting for review by TUS staff, and we will also prepare detailed notes and action items for the meeting. Based on the issues discussed at the kickoff meeting, the NMR team will produce a final work plan detailing 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 be included on the kickoff meeting agenda:

1. Introductions of the TUS staff and NMR team key personnel for the project
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. Roles and responsibilities for TUS, EDCs, and NMR team
7. Identification of roles and responsibilities, and communication protocols between the NMR team and Phase II SWE during the period when the contracts overlap
8. Initial discussion for proposed updates to the Audit Plan
9. Communications plan
10. Other topics

3.2 Update and Revise Audit Plan

The NMR team is confident that the EDCs will retain qualified evaluation contractors who have a good understanding of the intricacies of an EM&V plan compliant with the Act 129 Evaluation Framework/Audit Plan. In order to have the EDCs produce well-thought-out and

efficient evaluations, the Audit Plan needs to be well-written and crystal clear about mandatory and discretionary requirements. Significant groundwork has already been done by the Phase II SWE to improve the Phase I Audit Plan and incorporate the various pieces of guidance given to the EDCs since the inception of Act 129. Leveraging the knowledge of incumbents Salil Gogte and Jesse Smith on our team, NMR is able to develop a judicious and cost-effective approach to update the Phase II Audit plan and create a Phase III framework document. The Phase III Audit Plan will retain the majority of Phase II requirements except for revisions in a few areas like Demand Response, Conservation Voltage Reduction, Behavioral Programs (Home Energy Reports and Business Energy Reports), NTG and process evaluations, and EDC reporting.

During the development of the Phase III Audit Plan, we will work directly with TUS staff and the Program Evaluation Group (if PEG involvement is approved by TUS) to identify new subject areas and content that will be incorporated in Phase III. The Audit Plan update task will begin with a review of the existing Audit Plan revised by the SWE in PY7. Salil Gogte will lead this task with support from our evaluation framework experts Jesse Smith, Lynn Hoefgen, and Rohit Vaidya. All communications will be streamlined and will flow through our Project Manager, Greg Clendenning. In Phase III, our focus will be to build a more streamlined Audit Plan that combines the content of a technical evaluation framework with policy directives from TUS staff. The new Audit Plan will focus on mandatory versus discretionary protocols for the EDCs and their evaluators, while emphasizing the need to standardize protocols across the Commonwealth and between the Conservation Service Providers (CSP) and evaluators for each EDC. The audit plan will continue to provide two main sections—guidelines and requirements for EDC independent evaluations and audit activities conducted by the SWE team.

In order to establish expectations up front, we will engage with TUS staff in extensive discussions and will solicit PEG input (if deemed appropriate by TUS staff) into the Audit Plan development. An important mechanism that we will use to ensure transparency and provide direction for the audit plan update will be to leverage the Program Evaluation Group (PEG) meetings. The PEG discussions will be strictly technical and all policy discussions will be held in closed-door conferences with TUS staff and other PUC advisors.

In advance of all meetings, we will provide potential Framework topics to be included in the Phase III Audit Plan. Providing a selection of topics in advance of the collaborative meetings will allow sufficient time for attendees to review the topics and consider how these can or should fit into the Audit Plan.

During the Audit Plan update meetings, the NMR team will lead discussions focusing on the topics and issues that must be considered by TUS staff. The Audit Plan will be a SWE document and will prescribe requirements that the SWE believes are appropriate for unbiased and accurate EDC evaluations. We will solicit input from the PEG, if appropriate and approved by TUS staff, but the SWE team will own the document and will be responsible for ongoing updates. If we engage in technical or informational meetings with other external stakeholders, we will convey the importance, scope, and function of each topic to the Stakeholder Group using this information to facilitate a forum that ensures ample opportunity for both discussion and feedback. Final approval authority will rest with

TUS staff and other PUC Energy advisors. The Audit Plan update process will be carefully managed, with strict deadlines, consolidation of TUS comments, and proactive responses provided by the SWE team.

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 III 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.

Below is a minimum set of new/revised topics that we will cover in the Phase III Audit Plan. Note that the list below is not an outline of the Audit Plan. The new version of the Audit Plan will build on the previous version and will retain key areas for consistency and continuity.

- **Demand Response.** The current Audit Plan does not address Demand Response because Phase II did not have Demand Response goals. The PA TRM has two high-level protocols (Residential and Non-Residential) discussing acceptable methods, but does not offer a lot of technical guidance. The NMR team will provide technical guidance on the acceptable methods, outline what the SWE's DR audit activities will be, discuss DR reporting requirements, etc. We anticipate developing special requirements for auditing the dual participation allowed by the PUC with a 50% payment to Act 129 DR participants enrolled in multiple programs. One issue we anticipate that we may need to tackle is the CSPs' expected reluctance to disclose financial transactions with the customers, which will hinder the auditing of allowances in the Commissioner's motion on this topic.
- **Home Energy Reports (HERs).** The current Audit Plan has a protocol that was submitted by PPL in 2010 and augmented with some guidance provided by the Phase II SWE team pertaining to calculating a downward adjustment for incremental participation in other programs. The protocol is outdated and in need of an update. These programs will be an important component of Phase III considering the incremental annual accounting of savings and low acquisition cost allowances. The NMR team would like to address two critical topics in the treatment of HERs: (i) encouraging use of a lagged dependent variable (LDV) model over linear fixed effects; and (ii) a requirement for EDCs to submit all pre- and post-participation billing data to the SWE. The NMR team believes the SWE should be validating the randomization and confirming equivalence of the treatment and control groups prior to exposure. The definition of persistence for HER programs is an evolving issue for Act 129 programs. The NMR team will include recommended methods for the EDCs to measure savings persistence of HERs in Phase III.
- **Conservation Voltage Reduction (CVR).** The accuracy and precision of CVR impact estimates are a function of the testing protocol used to estimate the counterfactual, or what loads would have been if CVR were in the opposite state (e.g., on vs. off). The following four factors are the key drivers of the precision of the resulting CVR energy savings estimates.
  1. The number of feeders included in the study

2. The magnitude of the reduction. This parameter is limited by American National Standards Institute (ANSI) power quality standards.
3. The granularity of the data used for analysis (e.g., smart meter data vs. SCADA)
4. The number of days CVR is operated and included in the analysis. That is, more on/off cycles increases the ability to detect the CVR effect and reduces the chance of differences due to random chance.

The NMR team will combine the skills of our statistical expert, Jesse Smith, with the experience of electrical engineers at Abraxas and Optimal to improve the CVR custom measure protocol submitted by PECO in 2010 and develop the Phase III CVR requirements in the Audit Plan.

- **Net-to-Gross.** The NMR team believes that a disproportionate and unwarranted amount of effort was expended on measuring NTG in Phase II. Act 129 gives very little weight to NTG, and EDCs have voiced concern about the NTG research costs to programs when the results are not used to assess program performance. That said, NTG research, if optimally designed and conducted at a measure or end-use level, can provide simple and meaningful insights into market transformation. This enables the EDCs to make decisions on program modification to follow the market's naturally occurring or induced measure adoption, or retire programs if a market is saturated or fully transformed. This is one area where requirements of the EPA Clean Power Plan (CPP) may need to be considered. If the CPP requires compliance on a net savings basis, the NTG topics may need more attention.
- **Reporting.** Phase III will shift from quarterly to semi-annual reporting for the EDCs. This reduces the reporting burden for the EDCs but has implications for the SWE data requests and audit activities. Phase III is also moving from cumulative first-year to annual incremental accounting, and the Audit Plan will need to explain appropriate reporting changes and savings accounting mechanisms.
- **Cost-Effectiveness.** The NMR team has identified two important topics we need to address in this area, but we know there are several more. The two we have identified are as follows: (i) the 2016 TRC Order lays all of the ground rules for calculating TRC in Act 129, and the Audit Plan needs be updated to reflect changes implemented since the 2013 TRC Order; and (ii) the Audit Plan needs to include a mechanism to implement the PUC motion that allows monetizing water and fossil fuel savings for cost-effectiveness. This should be done consistently across the seven EDCs, and the SWE should develop a common methodology to calculate these avoided costs across the state. Water is particularly challenging because of well versus municipal water. The SWE team also needs to consider if EDCs can claim electric savings from reduced pumping. The PY7 TRM has equations for water savings only tangentially, as the water volume is generally part of the algorithm required to estimate electric savings.
- **On-Bill Financing.** Commissioner Powelson filed the motion with the Phase III Implementation Order that strongly advocates more On-Bill Financing (OBF) in Act 129. NMR is interested to see if OBF is proposed in Phase III EE&C plans, but this is one area that we have identified for special consideration in the Phase III Audit

Plan. OBF has policy implications, and we need to discuss how to separate technical and policy topics on OBF with TUS staff.

The Phase III Audit Plan will also include detailed descriptions of the audit activities the NMR team will conduct to verify EDC progress toward savings goals. Clear documentation of the data requirements and planned validation exercises will limit the chances for contentious situations later between EDCs and the SWE when the SWE team implements its audit activities.

3.3 Auditing and Verification

SWE audit and verification activities are designed to provide the PUC with certainty that the energy and 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 presented in sections as follows:

- Review of EDC EM&V plans
- Gross Savings (organized by program type and ex-ante vs. ex-post)
- Net-to-Gross analysis
- Process evaluation
- Ad hoc auditing and research

3.3.1 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. At the same time, various influences such as EDC decisions and changes in program design, regulatory environment, and market trends require that EM&V plans (and those implementing the plans) be adaptable to mid-course corrections. The issues that need to be taken into account when developing EM&V plans include:

- A program's estimated savings (kWh and kW) 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
- Whether any special features of a program require extraordinary evaluation effort

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

- Introduction to Key Issues (guided by the Audit Plan)
- Approach to Estimating Verified Gross Savings (M&V approach)

- Net Savings Analysis
- Process Evaluations and Program Design Changes
- Phase III 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
- Audit the EDC survey instruments, on-site verification forms, M&V plan templates, and other documents associated with the EM&V plans

Since there are many parties involved in Act 129, it is critical that rules and regulations are explicitly stated and followed. During Phase II of Act 129, incumbents on our team provided feedback to the PUC regarding various planning documents filed by the EDCs, including EDC program plans, TRC ratio calculations, and quarterly and annual reports. In addition, they reviewed and approved evaluation documents submitted by the EDCs such as EM&V plans, survey instruments, and sampling plans. They provided critical feedback and initiated conversations when EDCs were not adhering to agreed-upon protocols to ensure that savings claims were measured and reported accurately.

For Phase III, 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 like the Uniform Methods Protocols,[1] 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 III (if requested by TUS), especially with regard to measure and program offerings. We believe that upfront communications with the EDC teams about program implementation, evaluation activities, and reporting will help to pre-emptively resolve issues and mitigate any disputes during the program cycle.

During Phase III, the NMR team will review a number of EDC documents throughout the entirety of the program cycle. This may include, but is not limited to, the following:

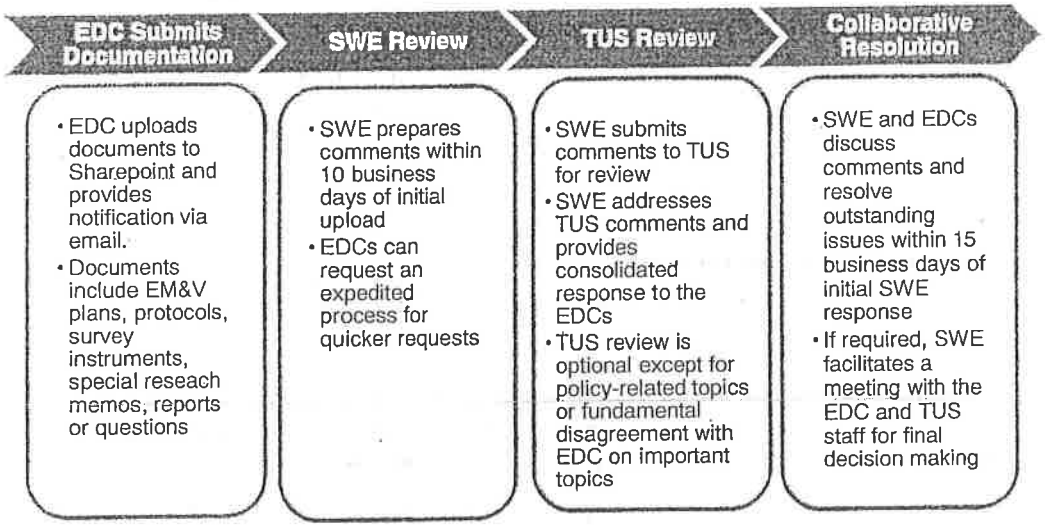
- EE&C Plans and Plan Revisions (if assigned by TUS)
- EM&V Plans and Annual Plan Updates, including the following:
  - Annual Sampling Plans
  - M&V Protocols

[1] http://energy.gov/eere/about-us/ump-protocols

- Survey Instruments
- Impact and Process Evaluation Reports
- Semi-annual and Annual Reports

Figure 3 below shows the SWE's proposed review process for EDC document submission.

Figure 3: SWE Review Process for EDC Submissions



As such, we will implement a 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 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.

3.3.2 Gross Savings Auditing & Verification Activities

Compliance with Act 129 energy efficiency and demand response goals are assessed on a gross basis, so verification of gross MWh and MW savings claims is the central SWE audit task. Audit activities will necessarily vary by program type and sector. The following sections detail the proposed audit tasks by broad program types.

3.3.2.1 Energy Efficiency

SWE audit activities are intended to give the PUC confidence in the accuracy and reliability of the verified energy and demand savings reported by each of the Pennsylvania EDCs toward the mandated consumption reduction targets. Moreover, the SWE audit activities

ensure proper implementation of EE&C programs and evaluation of such programs in a manner consistent with the Phase III Audit Plan. The Audit Plan will establish common metrics that are used to make accurate comparisons among EDC programs. 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, and 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

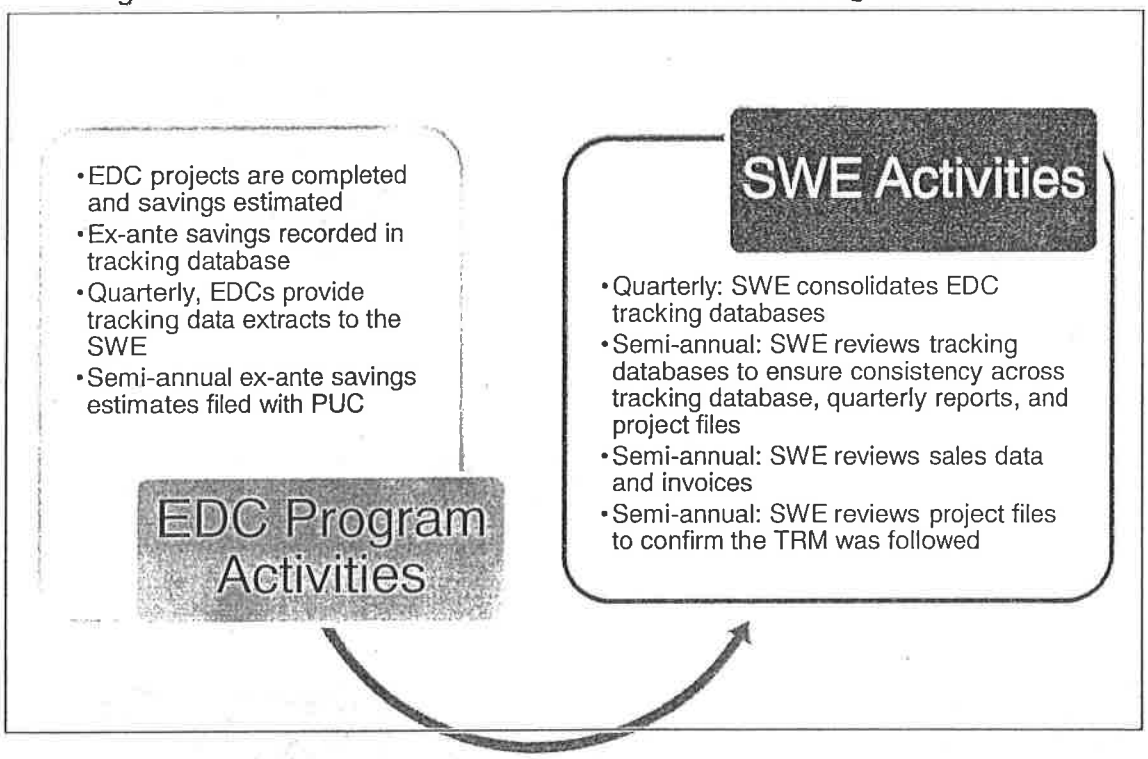
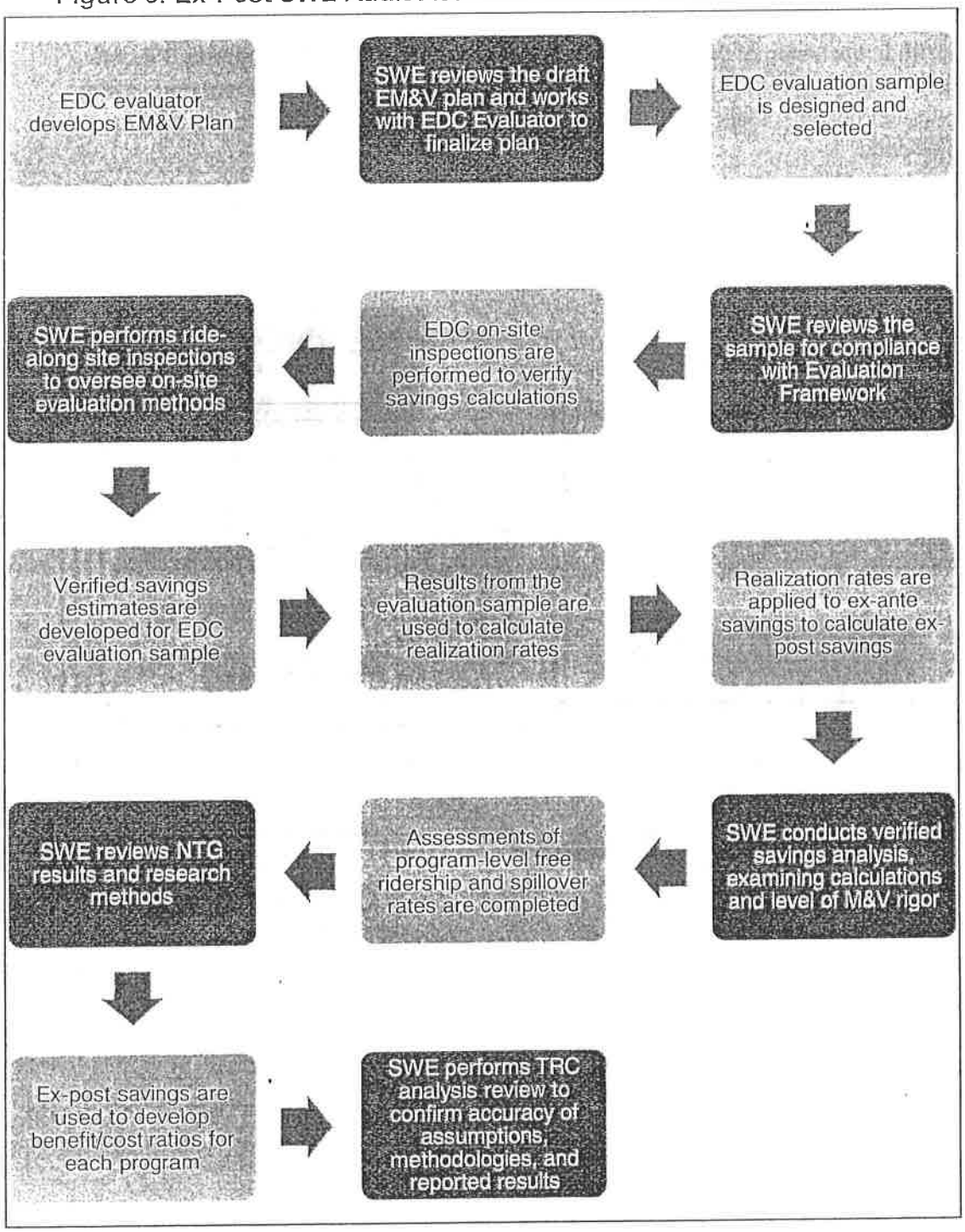


Figure 5: Ex-Post SWE Audit Activities and EDC Evaluation Activities[2]



[2] The figure shows both gross and net components of the proposed C&I and residential audit process, including the TRC audit approach. The narrative in this section, however, is about auditing the gross savings. The NTG audit approach is explained in Section 3.3.3.

Table 2 presents the schedule of milestones and activities that the NMR team proposes to implement for the annual energy efficiency audit.

Table 2: Proposed EE Audit Timeline

Milestone	Estimated Date
EDC Projects are Completed and Rebates Paid	June 2016-May 2017
PY8Q1 Data Request is Due to the SWE	October 15, 2016
SWE performs ex-ante audit on PY8Q1 tracking data and project files	November 2016
EDC Issues Semiannual Report with Reported Savings for PY8Q1 and PY8Q2	December 31, 2016
PY8Q2 Data Request is Due to the SWE	January 15, 2017
SWE performs ex-ante audit on PY8Q2 tracking data and project files	February 2017
PY8Q3 Data Request is Due to the SWE	April 15, 2017
SWE performs ex-ante audit on PY8Q3 tracking data and project files	May 2017
SWE Performs Ride-Along and Independent Site Inspections	January 2017-September 2017
PY8Q4 Data Request is Due to the SWE	July 15, 2017
EDC Issues Preliminary Annual Report with Reported Savings for PY8	July 15, 2017
SWE performs ex-ante audit on PY8Q4 tracking data and project files	August 2017
SWE Team Submits PY8 Update Report to the PUC summarizing PY8 reported savings and early indications of verified savings results	August 15, 2017
EDC Report Final PY8 Verified Savings in Annual Report	November 15, 2017
Annual Data Request is due to the SWE	November 30, 2017
SWE audits ex-post savings analysis, NTG, process evaluation, and TRC models	December 2017-January 2018
SWE Finalizes PY8 Verified Savings in SWE Annual Reporting Cycle	January 2018-February 2018

Ex-Ante

The objective of the ex-ante audit is to verify that the savings reported/claimed by the EDCs and their implementation contractors are calculated using the appropriate TRM protocol or custom measure protocol developed by the EDC. 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 quarterly data requests similar to the quarterly data requests prepared by the previous SWE team. Each EDC will be expected to submit its up-to-date program tracking database on a quarterly basis, and on a semi-annual basis the EDCs will be expected to submit progress reports 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 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 preliminary annual reports. For measures installed in C/I facilities or residential measures with mass market protocols (i.e., low-income programs) or partially deemed savings measures, the NMR team will check for consistency between individual project file documentation and tracking systems as part of the project file review discussed in the next section.

The NMR team will verify the consistency between the tracking system impacts and impacts noted in the semi-annual and preliminary 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 the following: 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.

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.[3] 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. In the case of custom measures installed in C/I facilities or residential measures with mass market protocols, for which there is no 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. Examples of residential programs that will undergo project file reviews similar to C&I include HVAC and HVAC tune-up programs, home performance and audit programs, weatherization programs, and new construction programs. The NMR team will review rebate forms, invoices, audit reports, and supporting

[3] The team anticipates selecting a sample of 10 projects per quarter if the program has 50 or more participants in the quarter or a sample of five projects if the program has fewer than 50 participants in the quarter.

documentation used to estimate programming tracking savings. For residential programs with fully deemed savings measures, the NMR team will supplement the tracking data review with reviews of sales and rebate invoices. Examples of residential programs with fully deemed measures include upstream lighting and residential retail product programs.

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

- Was the appropriate version of the TRM used properly?
- Were all assumptions reasonable and well-documented?
- Did quantities and values match across all documents (e.g., invoices, calculation workbooks, incentive agreements, and post-inspection forms)?
- Were appropriate energy 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?

Ex-Post

The NMR team's ex-post audit activities will focus on 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 installed and utilized
- Ensure evaluations conducted by the EDC evaluation contractors are compliant with the Audit Plan
- Review and verify the EDCs' performance by having trained SWE personnel accompany EDC evaluators on site verification activities
- Conduct random spot verification coordinated with the EDCs' independent evaluator of data measurement and savings calculations
- Spot verify or conduct metering activities utilizing the NMR team's logging equipment in coordination with the EDCs.

The ex-post verification tasks are a critical piece of the audit process through which the PUC is able to observe and understand the EDC program evaluations. The NMR team will perform annual audit activities for each program run by the EDCs to oversee evaluation activities conducted by the EDC evaluators. The audit activities will include database and documentation reviews for a sample of projects to provide reasonable assurance that claimed measures were being appropriately verified. If needed, we will conduct independent SWE spot verifications, gathering our own measurements to calculate verified savings.

For Phase III, we will improve current practices by streamlining and customizing impact verification activities for each EDC program. Increased attention will be given to high impact C&I projects above the measurement thresholds defined in the TRM. The NMR team is aware that the lack of adequate measurement is an ongoing problem with the EDC

evaluations. For low-impact programs that have been established and running for some time and for which we have already verified analytical approaches, the requirements for audit may be reduced with little risk due to the confidence in savings estimates generated by the evaluators. For new programs and programs for which it has been difficult to identify savings, the NMR team will increase rigor commensurately. The NMR team members on the previous SWE team have developed a level of reliance on the EDC evaluators which will likely enable a reduction in time and money invested in the audit activities. Major activities will include:

- On-site Inspections
  - On-site inspections with EDC evaluators (ride-along inspections)
  - On-site inspections without EDC evaluators (independent inspections)
- Verified Savings Analysis
  - Sampling and stratification review
  - Review of M&V methods and level of rigor used by the EDC evaluators by project/program type
  - Desk reviews of EDC evaluation contractor verified savings calculations, regression models, and building energy simulations
  - Extrapolation of sample findings to program population

SWE On-site Inspections

The NMR team will continue to conduct two types of site inspections—ride-along inspections and independent inspections. This combination will provide a window into the effectiveness and reliability of the EDC evaluator's activities.

Ride-along inspections will consist of random spot verifications coordinated with the EDC evaluator. The goal of these inspections will be to verify that claimed measures are properly installed and utilized, and to verify that the EDC evaluator is conducting evaluation activities effectively and reliably. Independent inspections will consist of site inspections not selected by the EDC evaluator to observe if evaluation visits are biasing on-site results from a quantitative and qualitative perspective. At the end of each program year, we will review all verification data collected by the EDC evaluators to ensure that ex-post savings values and realization rates are being calculated properly. Results will be used to identify potential updates to savings protocols.

Since on-site activities will make up a significant portion of our audit activities, we have developed initial criteria for conducting inspections. The NMR team will perform a combination of ride-along for both residential and C&I programs and independent site inspections for a sample of C&I projects for programs where the savings contribution to the overall portfolio warrants the additional level of rigor. The NMR team will conduct independent inspections for residential programs if there are residential programs with savings contributions to the overall portfolio that warrant the additional level of rigor and the savings estimates are highly variable and uncertain.

The NMR team proposes conducting inspections according to the following guidelines:

- Inspections will be conducted for the following programs

  - Programs for which EDC evaluators conduct site inspections
  - Programs with a significant number of projects above the TRM metering thresholds (C&I only)
  - 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)
- Inspections will be conducted at the following statistical level
  - Inspections will target 90/10 at the statewide level by sector (residential and non-residential).
  - Inspections will be allocated to each EDC by savings contribution.
  - Inspections will be allocated to each program by savings contribution.
  - Ride-along inspections will generally represent 80% of the SWE audit activities. Independent site inspections will be 20% or less.
- Value of Information approach
  - Balance auditing costs with the value of information received.
  - Focus on high impact (either size or case weight) and high uncertainty projects.
  - Focus on programs with measures of prospective value to Act 129.
  - Focus on programs with previously observed errors in analysis and reporting.

Verified Savings Analysis

In an effort to strengthen the M&V approaches used by the EDCs' evaluation contractors to determine verified savings estimates for sampled projects, the NMR team will review, analyze, and provide feedback on the verified savings methodologies used.

The NMR team will first review each EDC evaluation contractor's evaluation rigor and sample as a whole. 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, and the frequency with which end-use metering was used.

Because the residential programs are predominantly mass market programs with established and well-tested technologies marketed to most or all households in a service area, basic levels of rigor will typically be applied when verifying residential measures. However, some residential programs, such as weatherization or HVAC programs, include measures with partially deemed savings which 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.

If the EDC evaluation contractor used stratification for sampling, we will examine strata definitions and sample sizes and evaluate them for their impact on M&V type. We will also check the evaluation sample for adherence to the previously submitted EDC EM&V plans and the Audit Plan.

In addition to reviewing each evaluation sample as a whole, we will review 5 to 10 projects from each EDC that did not receive a ride-along or independent site inspection. Data requested for each specific project will include site-specific measurement and verification plans (SSMVPs), calculations, and site inspection photos and reports. From these

materials, we will validate each EDC evaluation contractor's savings verification approach. 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.

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.

Approach by Program/Measure Type

This section presents the technical approach the NMR team will use to audit each program. The approach generally 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 three primary measure types: TRM fully deemed measures, TRM partially deemed measures, custom measures. The NMR team notes that nearly all residential program measures are TRM fully deemed or partially deemed. 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

Program/Measure Type	Anticipated Evaluation Activities	SWE Audit Activities
TRM Fully Deemed 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	• 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 applicable PA TRM • Verify measures are being mapped to the correct Pennsylvania cities for heating degree days and cooling degree days. • Conduct ride-along inspections or independent survey, if needed
TRM Partially Deemed Measures	• Verify installation, conduct audits • 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, reporting	• Review survey results • 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 • Conduct ride-along and independent site inspections • Conduct independent surveys, if needed

Program/Measure Type	Anticipated Evaluation Activities	SWE Audit Activities
Custom Measures (including MMPs)	• 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 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 • Review site inspection and EM&V plans • Review logger and metered data • Review regression models used to calculate savings • Conduct ride-along and independent site inspections • Perform independent M&V (if required)

3.3.2.2 Demand Response

In its Phase III Implementation Order, the PUC established demand response (DR) reduction targets for six of the seven Pennsylvania EDCs subject to Act 129. Penelec does not have a Phase III demand response reduction goal. The Phase III DR design is different from the Phase I program in several key ways.

1) Phase III demand reduction goals must be achieved through demand response programs and measures only. Coincident demand reductions from energy efficiency measures do not count toward Phase III goals.
2) Phase III demand response programs will be active each summer in Program Years 9, 10, 11, and 12.
3) The number of hours over which Phase III performance is to be measured depends on system loads, which are highly dependent on weather. During a hot summer, there could be as many as six 4-hour events. During a cool summer, there may be no events. The event dispatch criterion is the PJM's Regional Transmission Organization RTO level day-ahead forecast (96% or greater).
4) While the Phase III demand response compliance target tied to the financial penalties outlined in the Act is determined by averaging performance across all DR

event hours, EDCs were also directed to obtain no less than 85% of the target in any one event.

5) C&I customers enrolled in the PJM's Emergency Load Response Program are allowed to participate in the Phase III DR program, but are subject to a "50% discount in Act 129 DR incentives."

The NMR team includes several members who were integral to the design and goal-setting process for Phase III demand response programs. Jesse Smith will lead the SWE's DR audit activities for the NMR team with support from demand response experts at NMR, Cleantech, and Optimal. The first component of the audit will include a simple verification that EDCs interpreted the PJM forecast correctly and initiated demand response events on the correct days and hours, as directed by the Implementation Order. Assuming that these dispatch instructions are followed, the majority of the SWE's efforts will be focused on assessing the accuracy of the load reduction estimates reported by the EDCs and their evaluation contractors.

The NMR team plans to issue a "DR Data Request" each January, assuming a DR event took place the previous summer, to gather all of the participation and load data necessary to perform an independent assessment of demand response load impacts for inclusion in the August Update Report. We expect to have any technical issues resolved with the EDCs in advance of their Final Annual Report for a program year. Table 4 outlines the sequence of events the NMR team proposes to implement for each program year when Act 129 demand response programs are active. For simplicity, we have chosen to use PY9 in the example.

Table 4: Proposed DR Audit Timeline

Milestone	Estimated Date
EDC Demand Response Events Occur	June – September 2017
EDC Issues Preliminary Load Impact Estimates in PY9 Semiannual Report	December 31, 2017
SWE Team Issues DR Data Request	January 15, 2018
DR Data Request Response Provided to the SWE	March 1, 2018
SWE Team Verifies Load Impact Estimates and/or Performs Independent Estimates	Spring 2018
SWE Team Submits PY9 Update Report to the PUC with Evaluated Savings for PY9 DR Events	August 15, 2018
EDC Report Final PY9 Verified Savings in Annual Report	November 15, 2018
SWE Finalizes PY9 Verified Savings in SWE Annual Reporting Cycle	January 15 – February 28, 2019

The following sections outline the NMR team's approach to auditing and verification of Phase III demand response programs. We organize the approach into two broad sections by sector.

Dispatchable DR for Residential and Small Business

There are a number of different technologies and customer motivation techniques EDCs may choose to implement in Phase III that qualify as dispatchable DR for residential and small business customers. While the mechanisms vary considerably, virtually all commercially viable options share a common characteristic: they target a reduction in air conditioning usage in the home or business. This means the expected load impacts from residential DR will vary based on outdoor air temperature and occupancy (time of day). The Phase III demand response dispatch mechanism is based on whether PJM's day-ahead forecast for the RTO is greater than 96% of the PJM RTO summer peak demand forecast for the delivery year. Because RTO peaking conditions are driven heavily by hot weather, Pennsylvania EDCs can expect high levels of AC usage (and DR potential) on event days.

Section 5.2 of the 2016 PA TRM establishes a clear hierarchy of approaches for the EDCs to use when estimating load reductions from this type of DR program. The NMR team will carefully examine the circumstances of each EDC program and assess whether TRM guidance is being followed during the review of EDC EM&V plans. We will also verify that the stated approach was utilized during the audit process. The primary driver of each EDC's evaluation approach will be the prevalence of interval (hourly or sub-hourly) revenue meters in the residential sector. EDCs like PECO and PPL that have close to 100% saturation of interval meters will be able to use a randomized control trial (RCT; TRM Option #1) or comparison group (TRM Option #2) approach to estimate impacts. For some of the FirstEnergy companies where Advanced Metering Infrastructure (AMI) deployment is still sparse, the EDC evaluation contractor will need to deploy loggers or rely on runtime data collected by load control switches or thermostats and perform within-subjects analysis (TRM Option #3).

Because participant loads during events are measured, the uncertainty in DR comes from the counterfactual estimates of what loads would have been in the absence of an event. The NMR team's audit will focus on verifying that the EDC estimation methods produce accurate estimates of loads on hot non-event days. The underlying premise of this analysis is that if the model or control group estimates participant electricity usage accurately for non-event days, we can be confident that the event day estimates are reasonable. Figure 6 shows what the result of this analysis should look like. The average hourly loads of the participant group (blue line) are virtually identical to the reference load on non-event weekdays.

Figure 6: Participant and Reference Load for a Non-Event Weekday

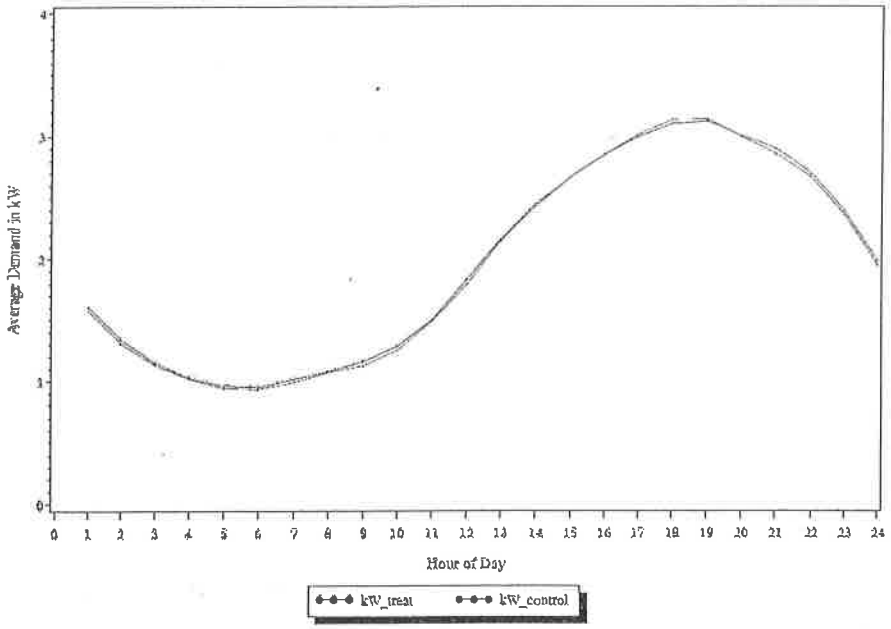
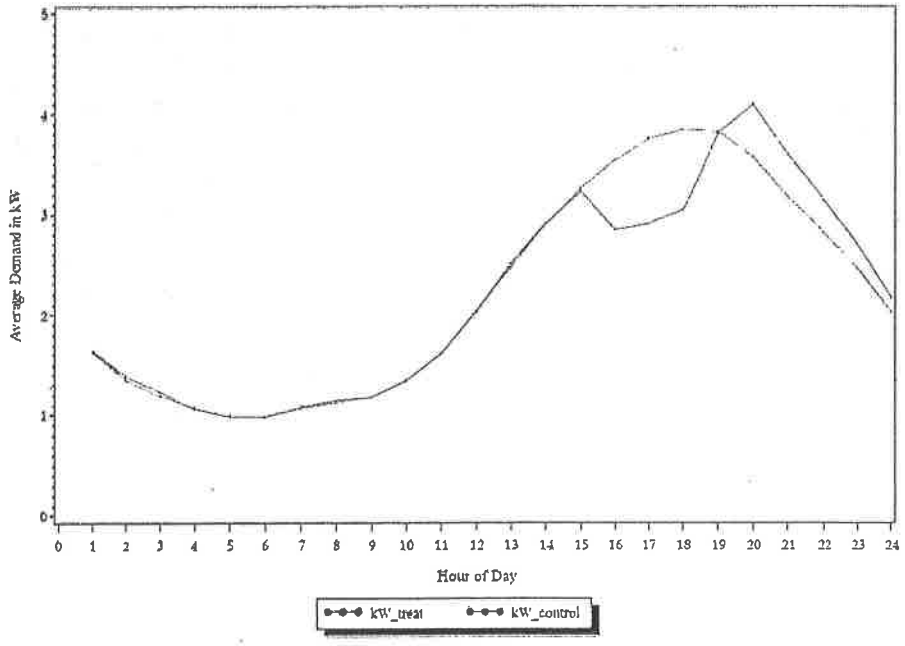


Figure 7 compares the same groups of homes on a DR event day. Notice how the hourly loads track nearly perfectly until 3:00 p.m., when the event begins. We can assume that the loads would have continued to show a high level of agreement for the remainder of the day if the event had not been called.

Figure 7: Participant and Reference Load for DLC Event Day



In addition to verifying that the average load reduction per participating home/business is calculated correctly, the SWE team will validate that the number of participants used to aggregate program savings is reasonable. This exercise will require program tracking data from the EDCs that includes the installation/enrollment date and removal date (if applicable) of each program participant. For each DR event, the NMR team will count the number of participating homes and businesses that were active during the event and verify that this value is correctly applied to the per-unit kW savings to estimate the MW impact from a curtailment event. Because Phase III demand response targets are at the system level, we will also confirm that the correct line loss factors are used and applied correctly.

For EDC programs in which loggers are deployed for a sample of program participants, the NMR team will ensure that device operability is not overstated by the logging sample. This can occur when the logger installation is skipped at homes or businesses where the load control equipment is found to be inoperable. Alternatively, the faulty equipment could be fixed, or scheduled for replacement during the logger installation visit. This scenario can result in an evaluation sample in which the load control equipment is 100% operational when this is not true for the program population. The NMR team will specify in the Evaluation Framework that one of the following protocols must be followed:

- If faulty equipment is replaced or loggers are not installed at sites with operability issues, load impact estimates from the sample must be de-rated by a switch operability percentage.
- Sites with faulty equipment remain in the sample where they presumably contribute no load impact and reduce aggregate load impacts accordingly.

Large C&I Load Curtailment

Similar to demand response for residential and small business customers, the uncertainty in load impact estimates for large C&I sites comes from the reference load—i.e., the estimate of how much electricity the site would have used if a DR event had not been called. Unlike smaller customers, load impact estimates for large C&I customers are generally performed on a site-by-site basis. Section 5.1 of the 2016 PA TRM provides a general hierarchy of estimation techniques for EDCs to use when calculating load reductions. The 2016 TRM is less reliant on PJM protocols than Phase I of Act 129 and discourages EDCs from using standard Customer Baselines (CBLs) for all customers. The NMR team recognizes that this issue has been contentious for EDCs and intends to clarify expectations and issue additional technical guidance in the Phase III Evaluation Framework.

The NMR team's top priority for Load Curtailment audit activities is to verify that the reference load method used to calculate load reductions is unbiased. Considering that Act 129 events will be called on high system load days, this means that we expect the method to predict accurately on these days. In order to test accuracy and certify that the baseline selection is reasonable, a series of out-of-sample validations will be conducted. Rather than running the model on all of the available load data, a group of three randomly selected high system load non-event days are withheld from the estimation. Although these three days are not included in the estimating sample, the model is used to predict load on those days. This process mirrors what the baseline technique will be asked to do on DR event days, so

performance on these "false event" days is a logical test of expected model performance on event days.

We believe that the iterative process between the SWE and EDCs outlined in Table 4 will limit contentious disagreements over baselines—or at least provide sufficient time to reach consensus before Final Annual Reports are filed.

In order to calculate load impacts for C&I demand response events, hourly (or sub-hourly) data is needed for each participant for the full summer. The NMR team plans to request this load data, in its entirety, from the EDCs and perform a census analysis. That is, the NMR team will produce independent load impact estimates for every customer, every event, and every hour. While this approach may seem onerous at first glance, we note the following:

- Load impact calculations will be programmed in a statistical package and run on a high-performance machine in bulk. The incremental labor cost to analyze 1,000 customers instead of 100 or ten is trivial.
- Requiring EDCs to provide the actual load data ensures that the necessary data is being gathered for all participants and EDCs are not relying on load reduction estimates supplied to them by CSPs who have a financial incentive to inflate performance.
- A census approach eliminates any sampling error from the results. This is beneficial because baseline estimation techniques carry an inherent level of uncertainty and it is helpful not to compound this with additional variability.
- A thorough analysis of every event will provide the PUC with solid information about compliance with its directive to achieve at least 85% of the goal in each event.
- The audit activities will provide the SWE with a rich and very granular data set of actual Act 129 load reductions that can be used to estimate Phase IV demand response potential.

The decision to allow PJM demand response participants to also enroll in Act 129 load curtailment programs adds a layer of complexity to load reduction calculations. This will be a key focus of the DR protocols in the Phase III Evaluation Framework. We will work collaboratively with TUS staff to establish policies that are clear and fair to all parties and enforce them through rigorous auditing. At a minimum, any day during which a site curtails load in exchange for a settlement from PJM will need to be excluded from the reference load calculation. To the extent that the PUC wishes to audit the "50% discount in Act 129 DR incentives" called for in the Implementation Order, the NMR team will establish reporting and data transfer protocols that will enable the SWE to calculate the average incentive amount (per kW) paid to dual participants and Act 129-only participants.

3.3.2.3 Behavioral Conservation Programs

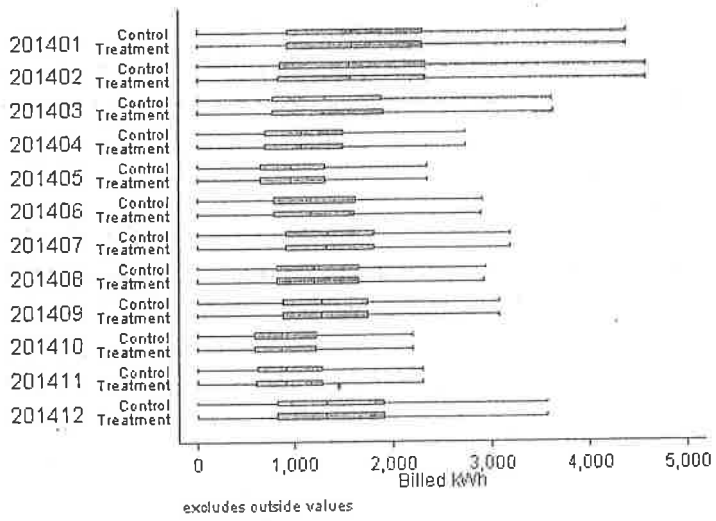
Behavioral conservation programs such as the Home Energy Report (HER) and Business Energy Report (BER) programs are generally implemented as an RCT in which eligible participants are randomly placed into a treatment group and a control group. Only the treatment group receives the reports, and they do so on an "opt-out" basis. This means that the program automatically enrolls participants (instead of the participant signing up) and will

send treatment households or businesses reports unless the participant formally indicates they want to leave the program, thus eliminating the self-selection bias inherent in many other program designs.[4] An RCT is generally considered to be the gold standard of evaluation protocols because the randomization process ensures that the energy reports are the only plausible explanation for the observed energy savings as long as the treatment and control groups used electricity in a nearly identical manner prior to the receipt of EDC energy reports.

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. 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 semi-annual data request. Figure 8 provides a graphical representation of a successful equivalence check. Notice how, in each month, 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 8: Successful HER Equivalence Check



One added benefit of requesting billing histories for SWE analysis as part of the SWE semi-annual data request is that it will provide early indication of any data storage, transmission, or management issues. The SWE will report back to the PUC whether EDC billing systems

[4] Program participants in "opt-in" designs tend to differ systematically from non-participants in ways that impact their energy use and savings and complicate billing and other types of analyses that compare participants and non-participants. Opt-out design eliminate this bias unless there are large numbers of people who take advantage of the opt-out option; this has not been an issue with most HER/BER type programs to date.

are able to produce the required data fields for analysis and whether EDC evaluators are processing the data for analysis in a manner that will produce unbiased results.

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 the following key areas:

- *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. Particular emphasis will be placed on treatment of closed accounts due to churn.
- *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?
- *Review of model selection and specification*. Are regression equations specified and interpreted correctly to calculate energy and demand savings? Have they adequately controlled for external factors such as weather?
- *Verification that incremental participation in other Act 129 programs was handled in an appropriate way*. EDC energy reports will typically promote other EE programs within the mailing and this 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. The SWE will independently perform the calculation for programs that are able to track participation and review the evaluation contractors' treatment of upstream programs for which participation is not tracked and cannot be connected to the HER\BER participant.

The jury is still out on how persistence of behavioral conservation programs will be treated for compliance savings and cost-effectiveness purposes. The NMR team plans to be heavily involved in the additional research needed to develop Act 129 policies about this issue and will review the design and interpretation of persistence analysis conducted by the EDCs and their evaluation contractors.

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

3.3.2.4 Conservation Voltage Reduction

The NMR team believes that several EDCs will elect to include CVR programs in their EE&C plan for Phase III. Furthermore, if an EDC is over budget or in jeopardy of missing compliance targets after two to three years of Phase III, it is likely that they would consider a plan change to pursue CVR toward the end of the phase because of the relatively low acquisition cost of the technology. The ability to estimate energy and demand reduction accurately from CVR is contingent upon a sound experimental design that systematically eliminates alternative explanations for changes in energy use besides CVR. After-the-fact

analysis relies heavily on econometric modeling of energy demand to develop a counterfactual of what energy demand would have been in the absence of using CVR technology. There is a very real risk that the analysis may not be able to distinguish the small energy savings from unexplained residual noise.

Ex-Ante

At the outset of Phase III, the NMR team will modify the Evaluation Framework to require a prospective analysis of any CVR implementation to assess the ability of the research design to detect energy savings. This prospective analysis will rely on a methodology known as a false experiment. In a false experiment, the load data from the proposed feeders are analyzed when the CVR equipment is not actually in place (pre-implementation). Days are randomly assigned to a fictional CVR state (on/off) and analyzed for impacts. Since there is no actual difference between the days, any answer other than 0 kWh savings is error introduced by unexplained noise in the data. When this analysis is repeated hundreds of times (with the same statistical model that will be used for the real experiment) the distribution of error can be analyzed to reveal the expected margin of error for the actual CVR experiment. Consider a false experiment that tells us that the margin of error at the 85% confidence level is ± 1% reduction. If the expected savings from the CVR deployment is in the typical industry range of 1%, this means that the verified savings analysis will tell us that there is an 85% chance that the actual reduction is between 0% and 2%. This is well outside the acceptable precision levels for compliance savings in Act 129, and the EDC would need to modify the research design so as to develop more rigorous savings estimates.

The NMR team is proposing to conduct this assessment for any EDC that proposes a CVR program in Phase III. If an EDC wishes to have its evaluation contractor perform the analysis, the SWE would review the inputs, methodology, and, most importantly, the interpretation of results. The beauty of this scoping analysis is that it ensures the EDCs have SWE buy-in on all CVR implementation and modeling decisions *before* the implementation phase of the project commences. This makes the actual auditing and verification process more straightforward and limits the chances of a contentious situation in which the SWE believes the EDC research design or estimation method lacked the rigor needed to claim compliance savings.

Ex-Post

SWE audit activities of 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 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.

The audit of the CVR programs will follow the same schedule as the Energy Efficiency audit, presented in Table 2.

3.3.2.5 TRC Audit

The NMR team's approach to auditing the EDC's reported program cost-effectiveness results will focus on the following key factors:

- Correctness of calculations
- Adherence to PUC TRC order and guidance
- Adherence to general best practices (where not in conflict with the PUC guidance)
- Reasonableness of assumptions (e.g., line losses, discount rates, incremental measure costs, baseline shifts)

For each of the above factors, we will assess whether or not 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.

Past audits have reported on inconsistencies in the assumptions used by EDCs (e.g., Tables 3-5 and 3-6 in the Program Year 5 report). For Phase III, the NMR team will continue to report these comparisons and take the additional step of assessing whether or not the differences in assumptions are warranted and defensible. Where necessary, we will request additional information from the EDCs that supports their assumptions, particularly in cases where a value diverges from the general range of all EDCs. This information will also be used in the TRC update process (section 3.4.2) as a starting point for discussion about needs for future PUC guidance.

One comparison that previous audits have not made is between the cost-effectiveness *results* for similar programs across EDCs. We believe such a comparison should be made, as it may reveal discrepancies that inform future program improvements, particularly those related to ensuring that all the EDCs' programs operate at a consistently high level of performance. The NMR team will identify EDC programs that are substantially similar and for which comparisons can be made. Where possible, differences in cost-effectiveness results will be explained first by known variances between utilities in areas such as avoided costs and measure costs (both equipment and labor). Unexplained differences may point to areas where one or more EDCs have developed more cost-efficient approaches to program delivery or are able to promote higher-benefit measures more successfully. These approaches could then benefit other EDC programs.

Because several years of program results from Phases I and II will be available as Phase III gets underway, we also believe it will be valuable to look at trends in cost-effectiveness results over time, for both individual EDCs and for the Act 129 portfolio as a whole. Again, where possible, we will control for known changes over time, particularly in avoided costs

and the rapid decline in the cost of efficient lighting technologies. Divergent trends over time may indicate important driving forces that should be considered in program delivery during the later years of Phase III and in planning for a potential Phase IV.

3.3.3 Net Impacts

The NMR team is a recognized industry leader in the measurement and interpretation of NTG for a diversity of programs, from upstream lighting to custom C&I programs. We have authored numerous papers outlining methodologies to conceptualize and measure NTG ratios, the reasons for the divergent estimates, and the strengths and weaknesses of efforts to "standardize" NTG in the Northeast and beyond.[5] The NMR team has extensive practical experience tackling the challenges inherent to measuring and applying NTG—we understand its potential usefulness to programs and regulators but are also keenly aware of the pitfalls that too often plague NTG data collection, calculation, and interpretation.

Given that the PUC has consistently decided over three Phases **not** to use NTG in determining EDC program compliance, the NMR team believes that prior NTG efforts may have expended more resources than necessary for the stated purposes of informing program modifications, planning, and cost-effectiveness. The NMR team will build upon the foundation established by the Phase II SWE to develop streamlined approaches and methods for use by the EDCs in their NTG evaluations.

We anticipate undertaking the following three primary activities regarding NTG.

- **Update and enhance the SWE framework NTG "common method" guidance.** The NMR team will perform a comprehensive review of the current NTG guidance outlined in the SWE Evaluation Framework[6] in order to assess whether the NTG approaches require updating based on industry standards and best practices. When developing new or revised NTG guidance, the NMR team will draw on our knowledge of and experience with "best practices" in NTG data collection and measurement, such as the Uniform Methods Protocols[7] as well as protocols developed in California, Massachusetts, and Oregon. In addition, we will work with TUS staff and the Program Evaluation Group (if PEG involvement is approved by TUS) to identify the approaches that match the level of effort appropriate to specific programs. In doing so, we will take into consideration the program design and

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[5] NMR and Research Into Action. 2010. *Net Savings Scoping Paper*. Submitted to Northeast Energy Efficiency Partnerships, Evaluation, Measurement, and Verification Forum;
NMR and Research Into Action. 2012. *Regional Net Savings Research, Phase 2: Definitions and Treatment of Net and Gross Savings in Energy and Environmental Policy*. Submitted to Northeast Energy Efficiency Partnerships, Evaluation, Measurement, and Verification Forum;
Rosenberg, M., and L. Hoefgen. 2009. *Market Effects and Market Transformation: Their Role in Energy Efficiency Program Design and Evaluation.* California Institute for Energy and Environment. Accessed July 10, 2013, from http://www.calmac.org/publications/Market_Effects_and_Market_Transformation_White_Paper.pdf
NMR, TetraTech and KEMA. 2011. *Cross-Cutting Net to Gross Methodology Study for Residential Programs – Suggested Approaches (Final)*. Prepared for: Massachusetts Program Administrators
http://ma-eeac.org/wordpress/wp-content/uploads/Cross-Cutting-Net-to-Gross-Methodology-Study-for-Residential-Programs-Suggested-Approaches-Final-Report.pdf

[6] Statewide Evaluation Team. 2015. *Evaluation Framework for Pennsylvania Act 129 Phase Ii Energy Efficiency and Conservation Programs.*

[7] http://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf

budget, its target population, and the type of data that can realistically and consistently be collected or tracked by the EDCs or made available via third-party data compilers. Critically, we will consider both the study cost, the projected savings, as well as the value of the NTG results in order to develop streamlined approaches that yield appropriate yet useful results. Some of the methods we anticipate incorporating in study designs include, but are not limited to, the following.

- Surveys of participants to gauge the role the program played in:
  - Free ridership: The influence of the program on measure and behavior adoption, ideally assessed within a few months of participation.
  - Take back: Use of the efficiency measure compared to what was in place before, assessed six months to a year after program participation.
  - Spillover: Adoption of additional measures or behaviors outside of the program but attributable to the program, assessed six months to a year after program participation.
- Surveys of non-participants or general customer surveys to gauge baseline adoption of program measures and behaviors.
- In-depth interviews with program partners (e.g., contractors, retailers, distributors) to assess the impact of the program on their stocking and sales of targeted measures. For some programs, these interviews may also be used to assess spillover.
- Benchmarking studies and literature reviews of similar programs in other states.
- Conjoint analysis, demand elasticity and other econometric modeling based on program- and market-level sales data or willingness-to-pay questions asked of EDC customers.

- **Audit NTG studies that meet the SWE framework "common method" guidance.** The NMR team will review all NTG plans to determine if the studies meet the appropriate rigor level for the "common method" guidance from the SWE framework. In particular, we will review the rationale for the selected methodology as well as the sampling and analysis plan. If the NTG plan meets common method guidance, we will review the report to ensure that the data collection, analysis, and interpretation of results is accurate and appropriate. In particular, we will review the full report as well as data collection instruments, raw data, and NTG algorithms 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.
- **Perform a detailed review of NTG studies that deviate from the SWE framework.** As described in the SWE Evaluation Framework, certain programs may require NTG evaluations that deviate from the approved SWE guidance. In these cases, the NMR team will closely review the alternative study plan to ensure that the methodology and sampling meets the appropriate rigor level and will provide robust and defensible results. Once the plan is approved, the NMR team will closely review the report, analysis, and data collection as outlined in the above bullet.

The NMR team notes that if the EPA Clean Power Plan (CPP) requires compliance on a net savings basis, the proposed approaches and resources devoted to NTG topics may need to be modified during Phase III to fulfill the requirements of the CPP.

Table 5 presents the general schedule of milestones and activities that the NMR team proposes to implement for the annual net impacts audit, using PY8 as an example.

Table 5: Proposed Net Impacts Timeline

Milestone	Estimated Date
EDC evaluator submits net impacts surveys to the SEW for review	March, 2017
SWE reviews EDC evaluator net impacts surveys	March to May, 2017
Annual Data Request is due to the SWE	November 30, 2017
SWE audits net impacts	December 2017-January 2018
SWE Finalizes PY8 net impacts SWE Annual Reporting Cycle	January 2018-February 2018

3.3.4 Process Evaluation

The NMR team has industry-leading expertise in designing, conducting, and reporting on process evaluations. Our team has conducted a myriad of process evaluations and market assessments for the full breadth of residential and C&I programs for clients across the US and Canada. We have fielded thousands of telephone surveys with participating and nonparticipating customers, performed hundreds of in-depth telephone interviews with program staff, 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, and California, among others.

The NMR team will perform a comprehensive review of the current process evaluation guidance outlined in the SWE framework in order to assess whether any updates or revisions are required. While most process evaluations justifiably rely on telephone interviews and surveys with staff, partners, and participants for the majority of data collection, in our experience, methods such as field staff ride-alongs and mystery shopping visits are under-utilized but can provide unique insight into program operations that may be otherwise inaccessible. For example, ride-alongs with residential energy audit and retrofit programs can assess auditing staff's adherence to on-site protocols and procedures, including installation and quality control practices, as well as auditing staff's effectiveness in helping customers understand the audit report. For lighting and appliance programs, in-person interviews and retail store visits with implementation staff can yield valuable insights on program facets such as in-store quality control and verification processes, trainings conducted by implementation staff, program delivery challenges, and opportunities for program enhancements. The SWE framework may therefore place greater emphasis on such process evaluation activities.

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 draft process evaluation reports, the NMR team will ensure that the methodology followed the approved study plan and that the analysis and reporting are clear, thorough, and reasonable. In particular, we will closely review any recommendations to confirm they are justified, specific, and actionable. Lastly, we will contact the EDCs to assess their planned response to each of the recommendations and summarize the findings in our annual report to the PUC.

Table 6 presents the general schedule of milestones and activities that the NMR team proposes to implement for the annual process evaluation audit, using PY8 as an example

Table 6: Proposed Process Evaluation Audit Timeline

Milestone	Estimated Date
EDC evaluator submits process evaluation surveys to the SWE for review	March, 2017
SWE reviews EDC evaluator process evaluation surveys	March to May, 2017
Annual Data Request is due to the SWE	November 30, 2017
SWE audits process evaluation findings	December 2017-January 2018
SWE Finalizes PY8 process findings in SWE Annual Reporting Cycle	January 2018-February 2018
SWE conducts follow-up with EDC to review EDC application of process findings	Spring 2018

3.3.5 Ad Hoc Auditing Activities

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

- Development of an incremental measure cost database
- Analysis of the decay rate of behavioral savings once Home Energy Report mailings stop

- Quantitative comparison of low-income contractor performance across Act 129 and the Low-Income Usage Reduction Program (LIURP)
- Estimation of wholesale capacity price suppression effects from Act 129 demand reductions
- Completing an ACEEE scorecard of statewide impacts

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 have to 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 III 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 key area in which the PUC will likely require ad hoc research tasks from the SWE is in support of an implementation approach in response to the EPA's Clean Power Plan (111d). 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.

3.4 Updates to Technical Reference Manual 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.

3.4.1 TRM Order Update

During Phase II, incumbents on our team had significant involvement in the development and update of the 2014, 2015, and 2016 Pennsylvania Technical Reference Manuals (TRM) and the associated Tentative and Final TRM Orders. The Phase II SWE team expanded the Phase I TRMs by adding over 50 new measures and refining the assumptions for existing measures by conducting end-use metering studies, eQUEST modeling, and secondary research investigations. The data output of the EDC evaluations and baseline studies also informed the TRM updates.

The NMR team has valuable experience developing, maintaining, or reviewing TRMs in many other jurisdictions, including Massachusetts, Connecticut, New York, Ohio, Illinois, Louisiana, Pennsylvania, New Jersey, Vermont, and the Mid-Atlantic (Maryland, Delaware, and the District of Columbia). Incumbents on our team have demonstrated the ability to coordinate and participate in the annual update of the Pennsylvania TRM regarding the calculation of savings for standard energy efficiency measures to ensure that the TRM

accurately captures Act 129 program measure savings. Significant effort was expended in previous phases on the annual TRM update process. This investment was necessary to make the TRM a best-in-class product. The TRM has made long strides since 2009 and is now on par with the latest industry standards. We understand Pennsylvania is now moving to a fixed TRM for the five-year Phase III. That being said, we expect TRM changes will come up through EDC evaluations, SWE audit activities, or other changes in federal, state and regional codes and standards during Phase III. The Phase III Implementation Order stated, "In our (PUC) Tentative Implementation Order, this Commission proposed that the 2016 TRM be applicable for the entirety of Phase III. We (PUC), however, reserved the right to implement a mid-phase TRM update if we deem it necessary." Absent an annual TRM update process, we expect the EDCs will propose Interim Measure Protocols (IMPs) to add new measures more frequently than in previous phases. The NMR team recommends that the PUC consider a detailed mid-cycle review of the TRM in 2018 before the Phase IV potential studies are initiated. This could be a formal TRM update with the associated Tentative and Final Orders or simply a mechanism to memorialize the Baseline study findings and the considerable amount of measure research needed for the potential study. The mid-cycle update will inform the potential studies that need to incorporate the latest available information for the next phase goal setting. A final TRM update will be required in 2020 to establish a Phase IV TRM, but this final update will build on the 2018 update.

The NMR team will work with the PUC, EDCs, and their evaluators as well as other stakeholders through a collaborative process to provide guidance on TRM updates. Our objectives for all TRM update activities will be to (i) improve existing protocols based on primary research from evaluation and baseline studies, secondary research sources, as well as changes in technology and codes and standards; and (ii) update TRM formatting to ensure consistency and ease of use.

3.4.1.1 TRM Update Topics

The NMR team will focus on new industry standards and technology updates to take the Act 129 TRM to the next generation. NMR team members are industry leaders in technology innovation and regularly follow industry trends and research. Our consultants regularly publish TRM work papers at leading energy industry conferences and seminars. Based on our experience with and knowledge of the 2016 TRM, we recommend the two proposed Phase III updates (mid-cycle and final year) focus on the following topics.

- Changes in building codes and equipment standards. Pennsylvania's current code is the 2009 IECC with reference to ASHRAE 90.1-2007. Presumably, the Commonwealth will adopt 2015 IECC at some point in Phase III.
- Increased industry prevalence of end-use equipment controls (occupancy sensors, economizers, CO_2 sensors etc.)
- Increased prevalence of consumer electronics and "Connected" equipment (Smart Devices) with growing research on the Internet of Things

- Efficient heating and cooling equipment with variable speed drives (current equivalent full load hours [EFLH] assumptions in the TRM assume single-speed units)
- The 2020 lighting baseline shift to CFLs and how it is enforced. Sell-through, stock piling, and grey market availability of non-compliant equipment will be major considerations for the timing of TRM baseline changes. For example, the linear fluorescent T12s were an allowed baseline in the PA TRM for four years after federal regulations discontinued their manufacture and sale in the United States.
- Impacts of energy displays, home energy reports, customer engagement portals and other behavioral modification interventions
- Standardization of non-electric resource savings (water and fossil fuel) so that these benefits can be consistently monetized in the TRC Test
- Requirements of the EPA Clean Power Plan (CO_2 savings)
- Addition of protocols for rooftop solar and other distributed energy technologies

3.4.1.2 Interim Measure Protocol Process

The NMR team will continue to administer the interim measure protocol (IMP) process setup by the previous SWE team, which is a means for EDCs to introduce new measures into the TRM 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 III is envisioned to be a fixed-TRM phase, 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 through a collaborative review process in the PEG. The IMP review and approval process includes the following steps:

1. EDCs submit IMPs to the SWE. *The SWE may need to develop an IMP if an important topic needs to be addressed.*
2. The SWE reviews a proposed IMP and returns any suggested revisions to the submitting EDC.
3. After discussion and revision, the SWE sends the IMP to the other EDCs for comment.
4. After an IMP undergoes an iterative review process between the SWE and the PEG, the SWE gives the protocol interim approval as an "interim approved TRM protocol."
5. Interim approval is formalized when the SWE confirms approval via email and posts the final protocol and its effective date on the SWE SharePoint site. The approved protocol is available for use by all EDCs.
6. The SWE includes all IMPs in the next TRM update for public comment and review, and formal approval by the PUC.

The NMR team will work closely with TUS staff during the 2016 update the Audit Plan/Evaluation Framework to assess whether modifications to the IMP processes are necessary given the static Phase III TRM.

3.4.2 TRC Order Update

In addition to auditing the cost-effectiveness results reported by each of the EDCs, the SWE is relied upon to support the PUC's technical and legal staff in a periodic update of the TRC Test Order. The TRC Order was last updated in spring 2015 with significant contributions from NMR team members Jesse Smith and Salil Gogte. The 2016 TRC Test Order[8] establishes the ground rules that Pennsylvania EDCs are expected to follow when determining the cost-effectiveness of energy efficiency and demand response programs. Technical areas where staff have leveraged the SWE in previous TRC Test updates include:

- Presentation of all formulae required to calculate TRC ratios and the interim steps
- Avoided cost of supplying energy. Because generation is decoupled from transmission and distribution in Pennsylvania, the marginal cost of electricity is estimated using market signals from PJM or NYMEX.
- Differences between energy efficiency and demand response programs
- Avoided transmission and distribution costs. In Phase II, the SWE advised staff that this benefit stream was best captured as a capacity benefit ($/kW) rather than energy benefit ($/kWh).
- Treatment of costs in the TRC Test; proper accounting of participant costs, program administration costs, and incentive costs.
- Gross vs. Net. There are subtle differences in the TRC Test depending on whether a gross or net perspective is desired.
- Treatment of non-electric resource savings (water, fossil fuel, etc.)

The NMR team includes members with direct experience with the Pennsylvania TRC Test (Jesse Smith and Salil Gogte) as well as experienced cost-effectiveness experts who have performed benefit-cost calculations and established cost-effectiveness protocols in other states, such as Maine and Connecticut. Team members have been responsible for developing cost-effectiveness protocols in Vermont, Massachusetts, Illinois, and New York, and have critiqued and commented on protocols in other jurisdictions including Pennsylvania. In addition, all of the potential studies conducted by the NMR team include cost-effectiveness analyses from multiple perspectives and with a range of components and details, depending on the jurisdiction. Our team understands that responsiveness from SWE consultants is critical when PUC orders are in the development phase, and we will make sure to have several qualified consultants available to work through questions or technical issues with TUS or Law Bureau staff at any point in the TRC update process.

The general process of the TRC Order, like other PUC Orders, is to issue a Tentative Order for public review and comment. Several months later, a Final Order is released which includes the three sections for each topic. The "Summary of Issue and Proposed Resolution" is the content from the Tentative Order. The "Comments and Reply Comments" section lists or paraphrases the input provided by stakeholders on the issue, and the "Final Resolution" section provides the PUC's final ruling on the matter. Many of the comments on

[8] http://www.puc.pa.gov/pcdocs/1367195.docx

the TRC Order are highly technical in nature so the SWE is required to work closely with PUC staff to interpret and inform the ultimate policy decisions set forth in the Order.

The NMR team understands the importance of aligning the market potential study with the accounting and cost-effectiveness guidelines that are expected to be in place during the upcoming Phase. Although the actual Phase IV TRC Order will not be due until 2020, we believe it will be important to have a mid-phase check-in between the SWE and TUS staff prior to developing estimates of economic potential in 2019. If there are known or expected changes to the TRC Test in Pennsylvania, our team will address them in the economic screening of measures. The changes could either become the base scenario or be considered as a sensitivity analysis.

3.5 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 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.

3.5.1 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 demand savings and cost-effectiveness reporting." The SWE and TUS will need to determine the appropriate level at which to construct the database. The NMR team believes that there are three potential options, listed below in order from least to most robust.

- **Program Level**: A program-level tracking database is essentially an extension of the information provided by the EDCs in their semiannual and annual reports. Table 7 illustrates what this type of tracking system would look like. Essentially, the data are stored in a very high-level summary fashion.

Table 7: Data Structure for Program-Level Tracking

EDC	Program Name	Program Year	Quarter	Number of Participants	MWh Savings	MW Savings	Incentive Costs
Met-Ed	Appliance Recycling	8	3	1,200	1320	0.151	$42,000

- **Project Level**: A project-level tracking system would contain a more granular version of the same information. In our example of the Met-Ed Appliance Recycling program, rather than having a single record showing that there were 1,200 participants in PY8Q3, a project-level tracking approach would have 1,200

records—one for each participant. When aggregated, the sum of the kWh and kWh values in Table 8 would equal the MWh and MW impacts shown in Table 7.

Table 8: Data Structure for More Detailed, Project-Level Tracking

EDC	Program Name	Program Year	Quarter	Unique ID	Measure Qty.	kWh Savings	kW Savings	Incentive
Met-Ed	Appliance Recycling	8	3	987654321	1	1075	0.123	$35
Met-Ed	Appliance Recycling	8	3	784115443	1	935	0.107	$35
Met-Ed	Appliance Recycling	8	3	549843415	2	2090	0.239	$70

- **Measure Level**: In many cases, EE&C program participants will implement more than one conservation measure at the same time and apply for incentives in batches. This is most prevalent in non-residential programs, but happens in the residential sector as well. Consider the third row of Table 8 where Measure Qty. = 2. This could be because the homeowner recycled two refrigerators, one refrigerator and one freezer, or maybe a freezer and a room air conditioner. Tracking data at the project level does not have the ability to nimbly capture the underlying technologies of the project's measure-level data. Table 9 shows a simplified example[9] of what measure-level tracking would look like for the participant (ID=549843415) who implemented more than one measure in the program.

Table 9: Data Structure for Measure-Level Tracking

EDC	Program Name	Program Year	Quarter	Unique ID	Measure	kWh Savings	kW Savings	Incentive
Met-Ed	Appliance Recycling	8	3	549843415	Freezer	1180	0.135	$35
Met-Ed	Appliance Recycling	8	3	549843415	Refrigerator	910	0.104	$35

One important fact about tracking systems is that data can always be aggregated to a less granular level, but cannot be disaggregated to a more granular state than it was originally entered. So measure-level data can be converted to project-level or program-level easily, but program-level and project-level data cannot be separated into component measures. The NMR team believes that measure-level tracking is the logical choice for the PUC because it considers implementing a statewide tracking system in Phase III. Measure-level information is capable of answering a host of more detailed questions than project or program-level data. It is also the level at which data are captured by the EDCs in their tracking systems.

[9] The sample tables in this section are abridged for simplicity and size. Actual tracking data would include additional relevant fields about the participant, installation date, and efficient technologies

In addition to the raw (ex-ante) tracking data discussed above, a statewide data repository would need to include additional tables in order to accurately reflect verified energy and demand savings and cost-effectiveness.

- Energy and demand realization rates by program or sub-program. 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.
- Non-Incentive costs. Incentive payments cancel out of the TRC test (cost to the EDC, benefit to the participant). The cost data that matter for TRC purposes are EDC program costs (marketing, administration, etc.) and participant cost (incremental cost of efficient technology).
- Avoided Costs. These are the benefits generated by the EE&C program in the form of avoided electricity production and avoided generation capacity.

The NMR team proposes to develop a dynamic and granular relational database for the PUC and host it on the SWE SharePoint site. We will construct the database in Microsoft SQL Server Express 2014 and house it in the partition of the SharePoint site that is only accessible to the SWE and TUS staff. The residential portion of the current EDC data request will be modified to require a more standardized data structure to facilitate bulk uploads. This transition was made for C&I programs in PY3Q1, but may require some modification depending on the PUC's desired tracking level. The NMR team will update the tracking database five times each year as updated data become available:

1) Following EDC submission of Q1 data as part of the quarterly data request response (~ November)
2) Following EDC submission of Q2 data as part of the quarterly data request response (~ February)
3) Following EDC submission of Q3 data as part of the quarterly data request response (~ May)
4) Following EDC submission of Q4 data as part of the quarterly data request response (~ August)
5) Following EDC submission of Final Annual Reports and annual data request response (~ December)

NMR's 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. Each user has his or her own individual login credentials, regulated by individual Microsoft accounts. All files for this project will be hosted on a site workspace dedicated only to this project. Within that site, individual document libraries will be used to organize files. Clients will be given access only to the document library space to which they should have access and to all the files therein. The site is maintained by internal NMR SharePoint administrators and the ability to grant permission to users for accessing specific areas on the site will be limited to those administrators and other project managers who have completed extensive training in this tool.

Our 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 a series of queries to produce "one-click" views into the data. If a Commissioner or other Act 129 stakeholder requests information that is not included in the pre-defined queries, TUS staff would just need to reach out to the SWE team, and one of our team members would quickly develop and validate the query. 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. For example, the NMR team will be able to produce a table reporting participation and impacts by zip code, city, EDC program, or other desired level or aggregation.

3.5.2 Data Management and Security

Our goals with data management and security are (i) to ensure the security and confidentiality of all sensitive program data and information (including non-public/ confidential data and information), (ii) to protect against any anticipated threats or hazards to the security or integrity of such information, and (iii) 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. Team members will download copies of the data to their local encrypted computers or network servers for analysis. 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. NMR 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 team has identified Scott Walker as our Data Manager. He will be responsible for all data requests. Scott will warehouse all data and ensure that only staff members who need client information have access to them. He will strip all data of identifiers prior to storage and create a key file, accessible only to authorized team members, and store that key file separately from the confidential data.

3.5.2.1 General Data Security Policies and Procedures

NMR has in place a Written Information Security Policy (WISP) 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), 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 team's minimum security protocols cover the following areas.

Data Handling Procedures

The Data Manager for the team is responsible for helping the team adhere to secure data handling procedures. The Project Manager, with assistance from the team's Data Manager, will submit data requests and facilitate data exchanges between the team and the EDCs. When we receive program and other project data, we will follow a procedure to first identify the type of data we receive and assess what level of risk is associated with them. Based on that assessment, the Data Manager will process the data so that team members handle the minimum PII needed to complete their work. When distributing data to team members for audit activities, we will substitute customer utility account numbers with our own unique identifiers. All data will be transmitted and stored on an encrypted SharePoint server and only users needing to access the data will be provided access to them. SharePoint access will be logged and reviewed. Users will download PII data to their computers or network servers when necessary for processing or analyzing the data for a given task, and then users will delete data from their individual computers when they are no longer needed or when the task is complete. The Data Manager will be responsible for making sure everyone on the team removes PII from their computers or network servers when data are no longer needed.

System Security

System security encompasses PII data storage on online systems, email, computers, cell phones, and other portable devices. The team uses two-factor authentication for online systems. When data are stored outside of the secure SharePoint site, they will be stored either on password-protected computers with whole-disk encryption or secure network servers with access by individual user authentication. Systems are protected by anti-virus and firewall security software, with definitions updated regularly, to prevent viruses and other potential data breaches through internet connections or user error. Passwords to all systems must be complex and must be changed every 90 days. Company-owned tablets containing PII must be encrypted and password-protected. PII data will not be permitted on personal cell phones or devices, and if personal devices are used to connect to company email, that device must be encrypted and password-protected. The team will never send PII over email unless the email and the document are encrypted. If a user receives an unencrypted email containing PII, then the user will save the data appropriately and delete

the email immediately. PII will never be stored or transported on unencrypted portable devices such as USB flash drives.

Training

All team members must attend security awareness training upon hire, and at least annually thereafter. Trainings are updated at least annually to reflect any new policies and procedures. Team members must certify in writing that they have completed trainings.

Vulnerability Response

Systems that handle PII are regularly checked for known security vulnerabilities. Detected vulnerabilities are assigned a severity level of High/Medium/Low. High-severity vulnerabilities are to be mitigated as soon as possible—no more than one week after detection. Medium-severity vulnerabilities are to be mitigated within thirty days of detection. Low-severity vulnerabilities will be addressed as appropriate.

PII Incident Response and Data Breach Notification

NMR has an incident response team that should be contacted whenever there is a suspicion of a data breach, as detected by log analysis, loss of physical hardware, or malware detection. The incident response team will determine what information may have been affected and will then determine who else needs to be notified, including the appropriate clients and law enforcement. At the conclusion of any data breach incident, the incident response team will meet for a post-incident review to determine lessons learned and update any policies or protocols, as needed.

Security Assessment

Changes to the systems and procedures must be accompanied by a risk assessment appropriate to the changes. Risk assessment procedures follow general guidance from NIST 800-30. A risk assessment is to be performed no less than annually, or accompanying any material change of procedures or systems. Assessments must include a review of security policies, system configurations, and system vulnerabilities.

The NMR team recognizes that risk management is a holistic, ongoing, organization-wide process of framing, assessing, responding to, and monitoring information system-related risks. Team members conduct risk assessments annually for our general operations and at the start of each new contract, assessing risks specific to that contract and updating protocols as necessary.

3.5.3 Commission Reports

The NMR team will provide annual, final five-year phase, and semi-annual update Reports for the PUC.

The annual and five-year reports 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 contractor's findings as well as

evaluation methodologies and sampling strategies. In addition, the reports will include the following review and analyses.

- An analysis of each EDCs' plan expenditures and an assessment of the programs' expenditures.
- An analysis of each EDC's protocol for measurement and verification of energy 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 Total Resource Cost Test Manual.

The NMR team will provide annual reports by the end of February for the years 2018 through 2021, and the five-year report by the end of February 2022. The five-year report will also include the content for the 2020/2021 program. Table 10 provides a timeline of the key dates in the process of developing the annual and five-year reports.

Table 10: Timeline for Annual Reports and Five-year Report

Milestone	Date
EDCs submit Final Annual Reports to PUC	November 15
SWE provides Draft Annual Report to EDCs	January 15
EDC review and factual corrections provided to SWE	January 22
SWE submits updated Annual Report to PUC	January 29
PUC provides comments on Annual Report to SWE	February 13
SWE provides Final Annual Report to PUC	February 28

The semi-annual SWE Update Reports, based on the EDCs' July 15 semi-annual reports, will include a review of as much evaluated savings as possible for the program year. If 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.

The team will provide Update Reports by August 15 of each year from 2017 through 2021.

3.5.3.1 Professional Editing of Reports

The NMR team recognizes that professionally edited, cohesive, and concise reports are an important aspect of all SWE reporting activities. We know the quality of previous SWE reports has not met PUC's expectations, and the knowledge of incumbents on our team is useful in this regard. The NMR team will address the feedback provided by TUS staff on previous SWE reports. Our reports will be cohesive, with sections from multiple authors weaved together to speak in a single voice and tone. The writing style and formatting will match the style guide provided by the PUC. The NMR team will deliver reports that focus on summary findings and recommendations with detailed findings, methodological approaches, and technical discussions reported in appendices. Lori Golzmane of NMR, a

professional editor, will serve as the editor for all SWE reports and ensure high-quality and professional reports.

3.6 Baseline Studies

Baseline studies are important DSM planning tools because they provide a snapshot of the market conditions and answer key questions about the type, fuel type, 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 Technical Reference Manual.

3.6.1 Residential Baseline Study

The NMR team understands that the primary goal of this project is to characterize the current baseline position of Pennsylvania's residential housing stock. The key objectives are to comprehensively document the current penetration, saturation, and efficiency levels of key energy features of homes. A critical component of baseline studies is the ability to compare results to prior studies in order to track changes in the residential markets over time. This comparison helps illustrate how the residential market is evolving and identifies the energy-saving opportunities that still remain in order to inform program planning and design. In particular, this analysis will also help inform a subsequent market potential study for a possible Phase IV of Act 129 EE&C Programs for Pennsylvania.

Designing a robust baseline study begins with asking basic questions: How will the results be used? What data are needed? How should the sample be drawn? What level of precision is appropriate? We anticipate working collaboratively with the PUC and EDCs to address these questions and ensure the baseline study provides insightful data that provide the greatest value to the Commonwealth.

The key aspects of designing and conducting a robust baseline study include the following: taking proactive steps to avoid problems encountered in prior studies; concentrating on collecting the information program planners, implementers, and evaluators need; and addressing any known bias issues in applying the results. By taking these steps, a baseline study can provide valuable information on how markets and practices have changed that could update assumptions used in program design, planning, and savings calculations.

In this section, we describe in detail the individual tasks we propose to undertake in order to assess the residential housing market in Pennsylvania. Prior to providing the details of our plan, we first begin by outlining the key elements of our proposed approach.

- **Perform diagnostic testing**. Our recent baseline study in Maine[10] confirmed that the primary source of heat loss in single-family homes is air leakage. In addition, the EDCs' home energy audit programs target air-sealing measures. However, the prior baseline study in Pennsylvania did not measure air leakage; instead, auditors qualitatively assessed leakage via visual inspection. Our experience indicates that such visual assessments do not correspond well with actual measurements of air

[10] http://www.efficiencymaine.com/docs/2015-Maine-Residential-Baseline-Study-Report-NMR.pdf

leakage. Therefore, we propose to conduct air and duct leakage testing at all single-family homes that are electrically heated and a subset of single-family homes that are centrally air conditioned in order to provide more accurate data to inform the TRM electric savings calculations for air-sealing and duct-sealing measures.

- **Clearly identify savings opportunities.** We plan to analyze the on-site data to identify and highlight savings opportunities in Pennsylvania homes. In particular, we propose to model the annual energy usage using the Department of Energy's Home Energy Score tool for the electrically heated or centrally air conditioned homes that undergo diagnostic testing. We will calculate an energy intensity value to represent the efficiency level of each modeled home, allowing us to more clearly assess the degree and distribution of electric savings opportunities. In addition, the HES tool provides savings recommendations; when aggregated across the study, these recommendations will provide further insight into the electric savings opportunities in Pennsylvania.
- **Rigorous quality assurance.** Our experience with conducting numerous baseline studies has led to the development of an organizational structure and a set of evaluation protocols that result in highly consistent and accurate data collection and analysis and provide reliable baselines. In particular, the value of baseline studies is contingent upon the premise that data collected at one home are directly comparable to data collected at another home. Therefore, all assigned field staff receive project-specific training to ensure consistent data collection practices. In addition, the NMR team has established systematic and comprehensive on-site inspection protocols, including an internal manual for on-site data collection.[11] Lastly, all of the on-site data will be subject to a continuous quality review to ensure that they are accurate, consistent, and high quality.
- **Achieve high levels of precision.** At the statewide level, our sampling approach will achieve at least 90% ± 10% precision for single-family homes, multifamily buildings, and all homes collectively. In addition, our plan will achieve 80% ± 10% precision across all homes in each EDC service territory.
- **Minimize sampling bias.** Because baseline studies rely on a relatively small group of customers who are willing to volunteer for the study to represent a much larger population, sampling bias is a major concern. 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 in order to minimize their distorting influence and maximize the validity of the results. Our recent baseline studies in Connecticut[12] and Maine found that homes of a more recent vintage and those with households earning higher incomes are more energy efficient. In order to minimize sampling bias, our proposed sampling approach will ensure that the

[11] The internal NMR manual is available for viewing at the following link: http://www.nmrgroupinc.com/wp-content/uploads/2015/12/NMR-HERS-Field-Guide.pdf

[12] http://www.energizect.com/sites/default/files/R5-Connecticut%20Weatherization%20Baseline%20Assessment-FINAL%2006-04-14.pdf

distribution of homes in our study reflects the distribution of these key characteristics in Pennsylvania per the US Census.

- **Comprehensively assess multifamily buildings.** The NMR team will visit 70 multifamily buildings to inspect the common areas and one housing unit in one building at each property. Using this approach will allow us to develop a well-rounded baseline of multifamily buildings throughout the state. We will report at the unit level for technologies that are typically found within multifamily units such as in-unit 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.
- **Enhanced projection of measure adoption curves.** In order to improve upon the Willingness-to-Pay research conducted for the prior Baseline study, the NMR team proposes a conjoint survey analysis. The conjoint analysis utilizes a stated preference approach that statistically determines which combination of features is most influential in decision-making, which can then be used to estimate measure adoption curves.

Table 11 presents our schedule for completing the residential baseline study.

Table 11: Schedule for Residential Baseline Study

Milestone	Estimated Date
Work plan development	Nov – Dec 2017
Telephone survey recruitment	Jan – Feb 2018
Scheduling	Feb – Jun 2018
On-site visits	Mar – Jul 2018
Data review and QC	Mar – Aug 2018
Data analysis and reporting	Sep – Dec 2018

3.6.1.1 Task 1: Single-family Telephone Surveys

We plan to conduct telephone surveys among occupants of single-family homes[13] in order to recruit a representative sample of volunteers for the on-site visits. We propose calling respondents from the general population using a random-digit-dial sample of landlines supplemented by a cell phone sample in order to reach those homes that rely exclusively on cell phones. Recent data indicate that about 28% of Pennsylvania households only use cell phones; therefore, we will complete at least 28% of the surveys using the cell phone sample.[14]

Telephone surveys will be conducted with a sample of 868 occupants of single-family homes from across Pennsylvania, providing a statewide sampling error of ±2.8% at the 90% confidence level. This sample size is designed to ensure a sufficient number of volunteers to achieve the sample size targets for the on-site visits.

Because we will need to access a housing unit as well as the common areas of multifamily buildings, we will recruit property managers rather than tenants for the multifamily[15] site visits. In order to identify a representative sample of multifamily buildings in Pennsylvania, we plan to utilize the following approaches:

- Respondents who screen out of the single-family telephone survey because they reside in a multifamily building will be asked to provide the name and phone number of their property manager.
- Internet searches for eligible multifamily buildings via www.craigslist.org

Deliverables

For the occupant telephone surveys, we will provide the following deliverables:

- Draft and final survey
- Draft and final survey sampling plan

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[13] In order to be consistent with the prior baseline study, single-family homes are defined as single-family detached, single-family attached, and mobile homes.

[14] http://www.m-s-g.com/Web/genesys/resources.aspx

[15] In order to be consistent with the prior baseline study, multi-family homes are defined as any residential building with two or more housing units (excluding single-family attached buildings).

3.6.1.2 Task 2: On-site visits

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

Sampling Plan

Table 12 shows the estimated statewide populations and on-site sample sizes by primary heating fuel for the single-family and multifamily markets. In addition, we present sampling error estimates assuming the maximum coefficient of variation (CV) found in similar baseline studies (0.50). 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 homes. In addition, we anticipate completing 41 site visits in each of the seven EDC service territories, which yields an estimated precision of ±10% at the 80% confidence level for each EDC across all housing types. However, note that the final achieved precisions will be dependent upon the actual CV for the study results.

Table 12: Statewide Sample Sizes and Sampling Errors for On-site Visits

Primary Heating Fuel	Single-Family Homes		Multi-family Units		Statewide Total
	Population	Sample Size	Population	Sample Size	
Utility gas	52%	112	49%	35	147
Bottled, tank, or LP gas	4%	9	1%	1	10
Electricity	16%	34	41%	29	63
Fuel Oil, Kerosene, Etc.	23%	49	6%	4	53
Other Fuel	6%	13	2%	1	14
Total	**3,982,818**	**217**	**974,376**	**70**	**287**
Sampling Error at 90% Confidence Level		*±5.6%*		*±9.8%*	*±4.9%*

Because of the diversity of the housing stock in Pennsylvania, sample bias is of particular concern. Therefore, we will track key housing and demographic characteristics that may affect energy efficiency—including house type and fuel type (as illustrated in Table 12) as well as house age and income level—to ensure that the on-site sample accurately reflects the Pennsylvania market according to the most recent Census statistics. In addition, the 868 telephone surveys are anticipated to yield about 434 on-site volunteers, which will offer a relatively large pool of volunteers from which to select the on-site sample of 217 single-family homes.

We will perform air leakage testing at 72 single-family homes, including all homes that are electrically heated plus a random sample of homes that are centrally air conditioned. At each of these homes, we will conduct a single-point blower door test at 50 Pascals' pressure. In addition, we estimate that, based on the 2014 baseline study, about 63 of

these 72 homes will contain ducts, and we will conduct duct leakage testing at those homes with ducts located in unconditioned space.

Scheduling and Recruitment

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 pre-recruitment via telephone surveys, incentives for on-site participants, and flexibility in the scheduling of on-site assessments.

In order to encourage participation in the on-site visit, we will offer a $150 incentive to occupants or property managers. Incentives are needed to reduce bias in the types of homes and demographic characteristics of the occupants included in the on-site visits. The on-site visit 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 will help acknowledge the time and effort that participants provide in support of the study.

In addition, each single-family occupant volunteering for an on-site visit will be mailed 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 the on-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 team will conduct two site visits on most days in order to complete the on-site surveys in a timely fashion.

Data Collection Form

The on-site data collection form and protocol will be 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 evaluation team will develop an electronic data collection form for review by the PUC. The form will include built-in quality control mechanisms that ensure all of the necessary data are gathered while auditors are on site. Additionally, using an electronic data collection form will allow the team to upload data to a server in order to perform quality control in a timely manner. The team will draw upon experiences from previous baseline studies and will include in the data collection form all of the key data elements identified in the RFP. After receiving comments from the PUC, the team will revise and finalize the data collection form.

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. Specifically, trained auditors will visit each home to conduct a thorough visual inspection of

the construction features and equipment. Data will be collected for all of 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[16]); number of fireplaces, stoves, and space heaters
- Envelope features on the thermal boundary of homes including:
  - Wall, ceiling, floor, foundation, crawlspace, and slab insulation locations and types (from rated values on product, or else estimated from visual inspection)
  - Stud framing information (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; also number, type, and usage of thermostats
- 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, insulation, and sealing, including whether it is on the supply or return ducting, its location (conditioned vs. unconditioned space), insulation type and estimated R-value, and duct sealing material used, if any
- 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.
- Presence and size (kW) of photovoltaic system array and wind turbine
- Air and duct leakage testing at all single-family homes that are electrically heated and a subset of single-family homes that are centrally air conditioned

[16] http://www.resnet.us/

Conjoint Survey Analysis

In order to improve upon the Willingness-to-Pay (WTP) research conducted for the prior Baseline study, the NMR team proposes a conjoint survey analysis. The prior WTP approach asked a series of questions to gauge the likelihood of respondents to purchase a program measure given constant energy cost savings and measure lifetimes combined with declining incremental costs. This simplistic WTP approach provides purely hypothetical scenarios that do not adequately reflect real-world conditions. In contrast, the conjoint analysis utilizes a stated preference approach that statistically determines the importance of different features, such as price and efficiency level, that comprise each program measure. The implicit valuation of the individual features comprising each measure can be determined by analyzing how the respondents choose between a controlled set of measures and features. The objective is to determine which combination of features is most influential in decision-making, which can then be used to estimate measure adoption curves.

During the on-site visits, the NMR team will provide occupants with a tablet computer that contains a self-administered questionnaire composed of several questions about selected program measures, including LEDs, appliances, HVAC and DHW equipment, and insulation. To the extent that sample sizes are sufficient, the results will be analyzed by measure type, EDC, as well as key homeowner characteristics such as house type and income level in order to provide more nuanced insights into the Pennsylvania market.

Multifamily Buildings

The NMR team will visit 70 multifamily buildings to inspect the common areas and one housing unit in one building at each property. The data collected at the multifamily buildings will be similar to the data collected in single-family homes, with the exception of the performance of diagnostic tests (which will not be performed at multifamily buildings). 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. In order to inform those elements that might not be otherwise observable during our visit, the NMR team will do our best to obtain this information from the property manager and/or building plans (if available). For the common areas, we will collect information on interior and exterior lighting, HVAC and DHW systems, and clothes washers and dryers.

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

3.6.1.3 Task 3: Analysis and Reporting

Once the data files from the on-site inspections are reviewed and any questionable data entries corrected or verified, the NMR team 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 so that we can 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, 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 the current study to the results of the prior baseline study. In addition, we will identify the opportunities for improving the efficiency of Pennsylvania homes. In particular, we propose to input the on-site data into the Department of Energy's Home Energy Score tool in order to estimate the annual energy usage as well as the DOE 1 to 10 score for the 72 electrically heated or centrally air conditioned 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, the HES tool provides savings recommendations; when aggregated across the study, these recommendations will provide further insight into the electric savings opportunities in Pennsylvania.

In addition to presenting average and median values for each of the key data points, we will also estimate the percent of homes that are above or below reasonably achievable values in order to assess the presence and extent of any savings opportunities. Building energy code requirements can provide a reasonable benchmark for insulation levels in certain spaces, such as open attics; however, in other spaces, such as walls where space is constrained, we will use technically feasible values. For most mechanical equipment and appliances, the ENERGY STAR criteria provide a suitable benchmark. This information will provide valuable data to inform the TRM, as the prior baseline studies' reliance on simple averages masks important underlying information.

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.

3.6.1.4 Database and Data Quality Procedures

Because this project involves the collection and analysis of a large quantity of data, in this section we present our data quality procedures for the following four types of databases with which we anticipate working:

- CATI survey data
- On-site inspection data
- DOE Home Energy Score data

CATI Survey Data Review

Data Collection Review. Each draft version of a questionnaire or survey form is double checked for wording, logic, and skip patterns by the responsible NMR analyst and then similarly reviewed by the designated NMR project manager. NMR tests programming with the CATI software before pretesting begins. The NMR project manager assists with interviewer training in order to provide project background and maintain continuity of interviewing techniques. We recommend survey pretests to identify and correct unclear questions, problems with skip patterns, and issues with instrument length. NMR staff members monitor surveys during the pretest and also during the first day of interviewing. NMR also reviews preliminary data early in the data collection process to identify and correct any issues.

Data Set Review. NMR reviews CATI data sets by employing completeness, range, and consistency checks. Any questionable values are discussed and resolved with the CATI firm. The NMR project manager reviews all codes and coding schemes.

Data Analysis Review. All programming in SPSS or Stata is double-checked by the responsible analyst and then reviewed by the NMR project manager; all spreadsheet-based analysis includes cross-verification calculations, when possible, and is also double-checked by the responsible analyst and then reviewed by the NMR project manager.

On-site Inspection Data Review

Data Set Review. After on-site inspections are completed, the NMR team will review each data collection form. This process will include reviewing each data field for reasonableness and consistency with other fields as well as making sure that all data are reported in consistent units. When errors or inconsistencies are found, the NMR team will contact the person in charge of conducting the on-site inspections and ask that the data entries in question be corrected or verified, as appropriate. Experience leads us to expect that revisions will need to be made—not only to correct data entry errors, but also to make sure that different individuals collecting data in the field describe similar situations in a consistent manner and are using consistent definitions.

NMR has extensive experience cleaning data from residential baseline studies and will use this experience to inform our work on this study. One of the benefits of using internal staff for the on-site surveys is that we have previous experience training our staff and cleaning their on-site data, which should result in a high level of accuracy and consistency in the on-site data collection for this study.

Data Analysis Review. All programming in SPSS is double-checked by the responsible analyst and then reviewed by the NMR project manager; all spreadsheet-based analysis includes cross-verification calculations when possible, and is also double-checked by the responsible analyst and then reviewed by the NMR project manager.

Data Delivery

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, although the telephone survey data could also be delivered as SPSS files.

3.6.2 Commercial & Industrial Baseline Study

The NMR team is well-positioned to deliver a comprehensive, cost-effective, and statistically valid Commercial & Industrial (C&I) baseline saturation study for the PUC and its stakeholders. Up-to-date Pennsylvania-specific data will lend credibility to the energy efficiency (EE) and DR potential studies and help to refine key inputs such as end-use saturations, technology baseline efficiencies, building stock, and measure parameters. Local presence of the NMR team partners, Cleantech and Jesse Smith, will save ratepayers money in travel costs, and instead reallocate those costs toward collecting additional data points to provide greater statistical validity to our findings. The primary objectives of the C&I baseline study are as follows:

- Profile customer groups at the sector, building type, and end-use level
- 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 market potential study

The NMR team will work to supplement known gaps in the market data specific to each EDC service territory and develop a plan fill in those gaps. Specifically, the Phase I and Phase II C&I baseline studies have revealed EDC customer segmentation data (i.e., identifying the type of business electric accounts are engaged in) to be quite poor. Supplementing EDC data with third-party segmentation data from a source such as Dun & Bradstreet, InfoUSA, or CoStar will allow the NMR team to develop a more representative

sampling plan for the C&I Baseline Study.[17] More importantly, this enhanced approach to customer segmentation will be leveraged later in the market potential study to improve the accuracy of the forecast disaggregation and apply savings opportunities to customer accounts with confidence that the assumed building type is correct.

The Phase III baseline study will build on and add information to the previous studies. Baseline studies are time-series efforts that need to be designed to fit the framework and architecture of previous studies. The NMR team sees great value in using a similar data collection instrument as the last two Act 129 baseline studies. It will allow us to conduct a time-series analysis and fit trend lines in equipment stock and saturation over time. Compared to the previous baseline studies, the NMR team is proposing a few enhancements for Phase III.

- Add mixed-mode surveys (phone and web-based) to on-site inspections and bolster sample sizes
- Incorporate customer propensity research to inform energy efficiency adoption curves in the potential study
- Investigate the effects of allowing dual participation in the load management programs and other unique aspects of the Phase III DR program design

The NMR team is proposing a modest increase in budget compared to the previous study, with the benefit of adding a great deal more value with additional data collection to ensure that the various pieces fit together and provide a complete picture of changes in end-use saturation over time. We propose to conduct a combination of phone/web surveys and on-site visits to investigate customers' propensity to upgrade equipment in addition to characterizing the building equipment stock. This approach maximizes cost-effectiveness by collecting the more straightforward data via affordable phone/web surveys while utilizing local building engineering talent to collect complex C&I building data via more comprehensive on-site visits. The propensity survey questions will enable the SWE team to develop more realistic and Pennsylvania-specific adoption curves for the market potential study. The propensity research also will provide the EDCs with meaningful information on market responsiveness.

Some of the data that may be collected during phone interviews or on-site visits include the following:

- 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)

[17] Dun & Bradstreet, InfoUSA, and CoStar provide business and consumer data, including contact information, for marketing and research purposes. See their respective websites for more information: http://www.dnb.com/ https://www.infousa.com/ http://www.costargroup.com/

- 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 energy efficiency upgrades (e.g., weather stripping, insulated blinds, duct insulation)
- Business size (in square feet) and operating hours

Table 13 presents our schedule for completing the C&I baseline study.

Table 13: Schedule for C&I Baseline Study

Milestone	Estimated Date
Work plan development	Nov – Dec 2017
Telephone/Web survey recruitment	Jan – Feb 2018
Scheduling	Feb – Jun 2018
On-site visits	Mar – Jul 2018
Data review and QC	Mar – Aug 2018
Data analysis and reporting	Sep – Dec 2018

3.6.2.1 Sampling

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 market potential study. These assumptions drive the sampling frame for the baseline study and represent one of the primary inputs in the market potential study because different types of businesses utilize different types of equipment and therefore have very 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 of the PECO and other EDC service territories is critical to informing Phase IV planning. The NMR team proposes to purchase secondary market data to supplement EDC customer segmentation information. This data will be merged with EDC sales records to produce a far more accurate service territory taxonomy than previous studies.

As discussed in the RFP, a final decision on the number and type of customer phone/web surveys and site visits will be decided once the project commences and specific gaps in market data are known. With this in mind, Table 14 presents our initial sampling plan. Instead of conducting 70 on-site visits per EDC, like in previous phases, the NMR team is proposing a nested sample with 70 phone/web surveys and 50 on-site surveys for a total of 120 sample points for each EDC in the C&I market segment. The nested sample allows for a mixed-mode approach tailored to the type of facility. For example, small businesses can provide meaningful data with a phone or web-based survey, saving costs that can be applied to more complex large commercial or industrial businesses. 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/or size (small and large). The industrial sub-segment sample will exceed a margin of error of ±10% with 90% confidence at the statewide level with greater sample points than the previous study.

Table 14 shows a preliminary sample for the customer surveys. The final sample will be determined based on the following additional considerations.

- Mapping the building types to customer segmentation in EDC sales data and third-party marketing data (D&B, InfoUSA, CoStar) purchased by the SWE
- Cluster sampling of buildings with similar load characteristics for EDCs that can provide access to AMI data
- Considering mapping study building types to the building types defined in the TRM, especially the lighting metering study completed in Phase II[18]

[18] The non-residential lighting protocol in the PA TRM lists the following building types: Education, Grocery, Health Care, Industrial, Institutional & Public Service, Lodging, Miscellaneous, Office, Restaurant, Retail, Warehouse Facilities

Table 14: Sample Premises Distribution across EDC Subsectors

	Retail & Grocery	Restaurant	Warehouse	Government/ Institutional	Office	Industrial	Misc	Phone/Web Surveys	On-Site Inspections	EDC Total
Duquesne	20	10	10	20	25	20	15	70	50	120
Met Ed	20	10	10	20	25	20	15	70	50	120
Penn Power	20	10	10	20	25	20	15	70	50	120
Penelec	20	10	10	20	25	20	15	70	50	120
PECO	20	10	10	20	25	20	15	70	50	120
PPL	20	10	10	20	25	20	15	70	50	120
WPP	20	10	10	20	25	20	15	70	50	120
Subtotals	**140**	**70**	**70**	**140**	**175**	**140**	**105**	**490**	**350**	**840**

3.6.2.2 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. One key check will be to ensure that electricity consumption is distributed similarly across the sample compared to the population it was selected from. This will help ensure the study sample is not composed of disproportionately small or large businesses whose equipment operating characteristics may not be representative.

We also will attempt to address other forms of uncertainty throughout the study process. For example, field technicians will receive training to ensure that they follow proper protocols and data entry procedures consistently across all EDCs to limit the possibility that inconsistent collection or measurement methods might cause observed differences.

Although we will attempt to minimize sample bias, the final sample selection may require a weight variable to make generalizations to the population. We will compare selected demographic data collected through the on-site surveys to available data from recently completed results from the EIA's Commercial Building Energy Consumption Survey (CBECS) and Manufacturing Energy Consumption Survey (MECS).[19] Where differences between the sample and the population as a whole exist, we will develop a weighting variable to correct for any sample bias.

Furthermore, given the equitable 120 sample points per EDC in the sample, we will apply the appropriate weights to each EDC's findings when rolling up the data to the statewide level. Similar to the approach taken in the Phase II study, we will base these weights on the energy consumption share of each EDC in the state.

3.6.2.3 Phone/Web Surveys

We propose conducting phone or web surveys with a representative sample of C&I customers for each EDC to collect basic building characteristics, end-use saturations, technology efficiency data, and more. We anticipate that these surveys will take approximately 45 minutes to one hour to complete. Participants will receive an incentive gift card for their time spent on the survey. Surveys are a cost-effective method of data collection for low-rise office buildings, restaurants, and other small businesses. Surveys can be completed over the phone or they can be web-based. Phone and web surveys will allow the NMR team to use a nested sample and conduct more meaningful data collection at higher precision with more sample points.

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[19] CBECS and MBECS provide detailed data on energy-related characteristics and consumption for commercial buildings and the manufacturing sector, respectively. For more information, see: http://www.eia.gov/consumption/commercial/ and https://www.eia.gov/consumption/manufacturing/

3.6.2.4 C&I On-site Visits

In addition to phone/web surveys, the NMR team proposes that on-site surveys be focused on the more complex C&I buildings. The NMR team's Project Coordinators will handle all recruiting and scheduling of the site visits. Qualified engineers will be deployed to the field to visit C&I buildings and collect building characteristics, end-use saturations, equipment efficiencies, and more. While an on-site visit approach is more expensive than telephone calls, it is appropriate for the larger and more complex building types 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. On-site data collection also enables collection of more detailed data since larger C&I buildings are more complex and heterogeneous—information that is difficult to capture over the phone/web. The survey instruments will be pre-tested with the on-site engineers to ensure data is collected in a consistent and reliable manner—ready for direct input into the market potential study models.

3.6.2.5 Secondary Research

The data collection and data mining effort begins with a search of available secondary sources in an effort to inform and streamline primary research efforts and identify gaps—in either the presence or the quality of data. We propose reviewing any recent baseline and potential studies that have been completed for regions similar to Pennsylvania, including those completed during Phase II, to (i) help inform the focus of the study and provide direction on which residential and nonresidential subsectors have the largest potential energy savings, and (ii) fill in gaps in data in which budgetary constraints will not permit a primary investigation.

3.6.2.6 Survey Instrument Development

Using an on-site survey instrument and trained staff to review end-use equipment within the business will ensure a high level of accuracy. The phone/web survey design will need to carefully consider participant fatigue in answering the questions. The questions will be designed differently than the on-site survey instrument to make the survey more interactive and easy to complete for the participant. We will modify the survey instruments from Phase II as necessary to be as comprehensive as possible without being overly intrusive to the business owner. We will design the survey instrument to capture data similar to the Phase II baseline study effort to allow us to draw comparisons between the two efforts. We will provide a draft survey instrument to EDC personnel, the EDC evaluation teams, and TUS staff for review and comment.

The phone-based surveys will be scripted with prompts for a telephone interviewer, and web surveys will be customized for a cloud-based web portal. We will continue to use hard copies for the commercial on-site survey instrument. We are proposing to continue to use paper-based surveys for on-site data collection. On-site surveys are designed for larger facilities and contain complex pieces of information that do not work well with tablet-based data collection applications. We have found that the complex and heterogeneous nature of large commercial and industrial facilities requires a flexibility in recording data that only a pencil and paper can provide. All C&I surveys will include open-ended questions that

require additional post-processing by a qualified engineer before they are entered in the central database to calculate equipment saturations. A knowledgeable engineer will conduct the proper data QA/QC of the completed surveys to maintain consistent data entry across all EDCs.

3.6.2.7 Recruiting and Scheduling

Recruitment letters will be sent to a stratified random sample of the population to inform potential participants that an energy survey is to be performed in their respective territory and that a representative may contact them to request participation. The initial recruitment letter should be sent out under the name and letterhead of each respective EDC to provide legitimacy to the recruitment effort. Web-based survey participants will receive a web link in the recruitment letter with a login/sign-up page for registration. Phone survey participants will receive a recruitment call to identify a date and time for the survey.

In order to identify the businesses where on-site surveys will take place, the NMR team will field a telephone recruitment survey to enlist interested and eligible participants and to gather basic information. In cases of answering machines or no answers, customers will be called back at least 3 times before moving on to the next name. 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. Overall, the success rate during the Phase II baseline studies was approximately 10% of all businesses contacted.

In order to increase interest in the on-site visit for the Phase II baseline studies, the NMR team proposes to provide businesses with a $50 incentive for participation in the phone/web survey and a $150 incentive for participation in the on-site visits. The on-site incentive levels are an increase over the Phase II baseline studies ($100 per visit) considering the difficulties the Phase II SWE team faces in recruiting business customers.

Incentives are also needed to reduce bias in the types of businesses and characteristics assessed. The on-site visits will require each participant to take two or more hours out of their day and to allow unfamiliar individuals to examine their home or business. Incentives acknowledge the time and effort that participants give in support of the study.

After determining eligible businesses for the baseline study, the NMR team will schedule the phone surveys and 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. A trained engineer will arrive at the business at a time previously scheduled with the participant. The engineer 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 II, the NMR team estimates that comprehensive surveys can take up to three hours for on-site customers and about an hour for phone/web surveys.

3.6.2.8 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 or motivation to invest in upgrades or participate in energy efficiency and demand response programs. The NMR team is proposing an enhancement to the previous baseline study efforts to interview decision makers to determine their propensity to invest in potential energy-saving opportunities. 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?
  - Willingness to pay for upgrades

Since the propensity research conducted in Phase II was narrowly focused on lighting and the nature of the investigation is forward-looking, 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 energy efficiency (EE) or Demand Response (DR) 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 a properly 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 inputs for the market potential study. Previous adoption rates used by the SWE team were based solely on professional judgment. 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.

3.6.2.9 Data Preparation, Analysis, and Reporting

Data Preparation

The NMR team will review all collected data fields for validity and completeness to ensure data quality across all responses. All data points will be scanned for entry errors as well as outliers. In addition to data entry errors, the 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.

In addition, the make/model number of numerous equipment types will be collected 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 upgraded through this practice.

Analysis

Following the data preparation effort, the final data set will be analyzed for all pre-determined building and end-use characteristics. The total number of observations for each data field will be recorded. Where appropriate, data will be presented as penetration percentages, saturation percentages, or averages. At a minimum, data will be analyzed at the EDC level, building type level, and statewide level.

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

Reporting

The 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 as well as the percentage characteristics. After revising the draft report based on comments from the EDCs and the TUS staff, we will submit a final report. In addition, the EDCs will receive a database with information specific to their territory.

3.7 Energy Efficiency Market Potential Study

The energy efficiency market potential study is critical to determining the remaining opportunities for cost-effective electric energy efficiency savings and to developing recommended EDC-specific targets for a potential Phase IV of Act 129 EE&C programs.

3.7.1 Define Study Parameters, Objectives, and Scenarios

The NMR team will conduct a statewide market potential study to determine the remaining opportunities for cost-effective electric energy efficiency savings in 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 IV of Act 129 EE&C programs. The analysis of energy efficiency potential and acquisition costs must be unbiased, technically sound, and transparent to all Act 129 stakeholders. It is important to note that the bulk of the EE potential study development will not occur until late 2018, three 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.

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, and customer responsiveness to this spending may warrant more attention than those regarding avoided costs and energy savings load shapes, or efforts to include as many efficiency measures as possible.

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 potentials are merely steps in the process to 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 threshold should be for inclusion in the achievable and program potentials. The NMR team will work with the TUS and other stakeholders to confirm this and to 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 IV targets.

3.7.2 Collect Data

Having conducted numerous EE 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 an annotated bibliography of documents referenced by the study and used for the analyses. We will save a date-stamped version of any data retrieved from dynamic internet resources. Citations will include page numbers, and we will provide a systematic cross-referencing between citations in the reports and the corresponding digital documents so that source information can be easily located. Full documentation of data sources is essential to assure the defensibility of the study.

3.7.2.1 Data Request

The NMR team proposes conducting a targeted data request. This effort would reach out to the TUS, EDCs, and other relevant sources to collect information on customer and billing data, energy forecasts, discount rates, avoided energy costs, and load shapes. In addition, many of the required analysis inputs will be developed through the residential and commercial & industrial baseline studies (e.g., end-use sales disaggregations, sales by fuel, customer class and building type, and equipment saturation data). For additional inputs not covered by the baseline studies, a survey instrument will be designed and distributed to all stakeholders. Where state-specific data are not available, we will use regional data calibrated to Pennsylvania. For example, the US Department of Energy'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. CBECS and 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 national data sets such as the California DEER database, 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.

3.7.2.2 Energy and Demand Sales Forecasts

Based on our experience performing the previous EE potential study 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 2019 Load Forecast Report as the starting point for our estimates of the baseline sales forecast. Energy sales forecasts will be collected from each EDC through the data request.

3.7.2.3 Sales Disaggregation

The residential and C&I baseline studies will provide energy sales data for the baseline year by EDC, customer class, building type, and end-use. These disaggregated energy sales will be coupled with the forecasts described above to estimate disaggregated energy sales for each year in the analysis period. Further, secondary sources such as the EIA's Annual Energy Outlook will be used to forecast future trends in the relative distribution of energy sales by building type and end-use.

3.7.2.4 Baseline Equipment Data

Before the impacts of efficiency measures can be estimated, the characteristics of existing building systems and equipment must be understood. 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.

3.7.2.5 Measure Characteristics

Each measure included in the potential study must be characterized with respect to savings, costs, applicability, load shape, and effective useful life. We will draw from our team's existing library of measure characterizations and other sources. Notably, the Pennsylvania TRM will be a vital resource for the measure characterization effort as the EDC efficiency programs are required to use it to quantify savings, where applicable. The Pennsylvania 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. Additionally, savings information will be reviewed to ensure 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 anticipated to be in effect during the analysis period.

3.7.2.6 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 IV. 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 III comes to a close, we will work with the TUS and other stakeholders to assess likely or potential changes to program design for Phase IV 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 prominent role in developing a defensible forecast of savings acquisition costs for Phase IV.

3.7.2.7 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 both the Pennsylvania baseline studies and program results from other jurisdictions.

3.7.2.8 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), peak and off-peak costs to reflect the variation in electric supply costs over both the course of the year and any given day.

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 will determine the appropriate avoided costs and discount rates through the EDC data request described above.

3.7.2.9 Load Shapes

Load shapes 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. Where possible, Pennsylvania-specific load shapes will be used (such as those published in the recently completed 2014 Commercial & Residential Light Metering Study). Where Pennsylvania data are not available, other regional sources will be leveraged to develop defensible estimates.[20]

3.7.3 Prepare the Cost-Benefit Model and Model Inputs

3.7.3.1 Establish Analysis Regions

The analysis regions will be based on the service territories of the seven EDCs in Pennsylvania subject to Act 129. 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, cost information will be reviewed and updated, as appropriate, to reflect current market trends and the specific market conditions in Pennsylvania using sources such as the RSMeans Cost Data books and equipment pricing catalogs.[21]

3.7.3.2 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 EE 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 2019 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 electric

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[20] For example, numerous regional resources are compiled in the Northeast Energy Efficiency Partnership's Loadshape Catalog Phase 1 Metering Studies Table, October 2015. http://www.neep.org/sites/default/files/resources/Loadshape%20Catalog%20Phase%201%20Metering%20Studies%20Table%20October%2014%202015.pdf

[21] RSMeans tracks labor and material costs in the construction industry. http://www.rsmeans.com/Cost-Data/

vehicles), and adoption of efficient technologies embedded in the forecasts. If deemed necessary, the NMR team will deduct the expected energy reductions from implementation of Phase IV Act 129 energy efficiency programs from 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 other 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 if the PUC decides that this analysis is part of the desired scope.

In order to estimate EE 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; 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 baseline study includes a detailed investigation 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.

3.7.3.3 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 Technical Reference Manual (TRM) development for numerous clients, including the Massachusetts Energy Efficiency Advisory Council, the Northeast Energy Efficiency Project's EM&V Forum, and the Ohio PUC. In addition, we have performed critical reviews of other TRMs, including New York's Statewide TRM. Through development of many potential studies and TRMs, we have developed a robust list of data sources and candidate measures with which to supplement measure data from the Pennsylvania TRM. As discussed in Section 3.4.1 of this proposal, we propose conducting an update cycle of the Pennsylvania TRM after the conclusion of the commercial & industrial and residential baseline studies but before, or in tandem with, the development of the energy efficiency potential study to eliminate redundancy and ensure that the potential study reflects the most current measure savings assumptions. In addition to measure assumptions adopted from the Pennsylvania 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 3.7.2.

3.7.3.4 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
- 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. The specifics of the qualitative screening will be determined through collaboration with the TUS to ensure we are meeting project goals.

3.7.3.5 Develop Measure Parameters

Those 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. We will segment all efficiency opportunities not only by EDC territory, sector, and building type, but also by market. Generally, markets are the arenas in which decisions are made affecting 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 subdivided 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. Furthermore, the timing of the opportunities and the year-by-year tracking of building and equipment stocks requires a full understanding of the replacement cycles and size of eligible markets in each year.

Additionally, savings information will be reviewed to ensure 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 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 is applied to adjust the saving factor downward in future years to account for the fact that newer, standard equipment efficiencies (that would naturally be installed at some point in the future even without program intervention) are higher than older, existing stock efficiencies. Savings factors will generally be estimated from the Pennsylvania 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. Measure costs will generally be estimated from recent incremental cost studies, EDC tracking data, and other regional studies.

Load Shapes capture the timing of energy savings over the course of a year. Energy savings may not necessarily occur in direct proportion to when equipment uses energy. 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. For example, these periods may coincide with the system peak and off-peak periods such that the proper avoided energy costs may be applied to produce a monetized estimate of measure savings.

Effective Useful Lifetime is the length of time that a given efficiency measure is expected to generate energy savings. Measure lives will generally be adopted from the Pennsylvania TRM, limited to 15 years as per PUC order.

3.7.3.6 Develop Market Data

The analysis will employ two different methodologies for estimating the energy efficiency potential. Each approach requires the development of a separate set of market factors.

The residential sector analysis will use a "bottom-up" approach. Potential savings are estimated by developing savings information for a specific measure (e.g., the installation of one screw-base omnidirectional LED lamp) and then multiplying those costs and savings by the projected number of measures installed through the analysis time horizon. Estimating the number of installed measures must take into account the total available market for the measure. For example, for the LED lamp example, this would be based on the total number of screw-base light sockets per home, the number of homes, and any technical constraints on installation of the measure, such as operating environment. An important aspect of developing bottom-up potential estimates is to ensure that opportunities for energy savings are not double-counted and that the assumptions regarding the number of available opportunities for efficiency measures represent a reasonable disaggregation of the total sector energy use—and, further, that the resulting savings do not exceed the actual energy use for a particular end-use or customer segment.

In contrast, the commercial and industrial sector analysis 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 existing efficiency equipment. These factors will generally be drawn from the commercial and industrial baseline studies and the Pennsylvania TRM.

3.7.4 Estimate Technical, Economic, and Achievable Potential

The technical and economic potential generally serve as stepping stones to the achievable and program potential estimates. The technical potential, in and of itself, does not offer significant utility. It primarily serves as an initial investigation of the overall magnitude of energy efficiency potential unbounded by any market or budget constraints. 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). As discussed above, the NMR team will work the TUS to determine a relevant cost-effectiveness threshold for use in the economic potential analysis.

3.7.4.1 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.

The technical potential will be estimated first and 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, generally the measures with the lowest cost of saved energy are prioritized. Care is taken to avoid double-counting and to account for the high level of interactions between measures.

The economic potential will use essentially the same methodology as the technical potential, but will be limited to only those measures that pass the appropriate cost-effectiveness threshold. It is presently assumed that the Total Resources Cost (TRC) test will be used to develop the economic potential, but the NMR team will collaborate with the TUS to determine the appropriate test and application thereof prior to beginning work on the study. We note that the 2016 Total Resource Cost (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 potential that could be included in the achievable and program potential estimates.

3.7.4.2 Estimate Achievable Potential

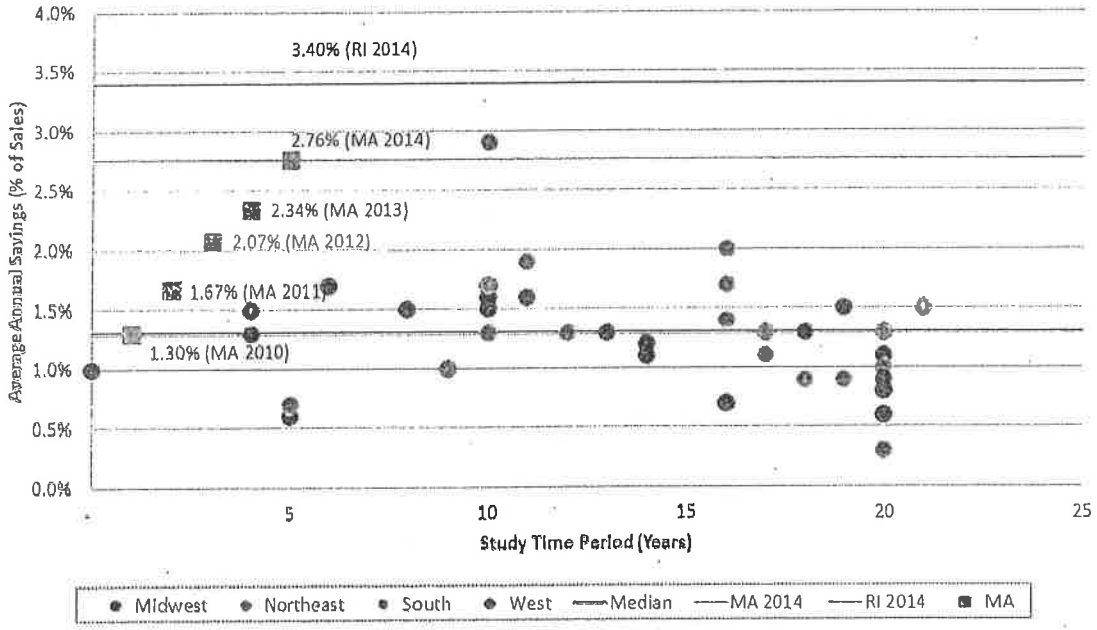
Develop Achievable Penetrations

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. 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. 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. 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 EE 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 generates achievable efficiency potential estimates that are lower than actual savings levels achieved in leading jurisdictions. For example, Figure 9 presents the annual maximum achievable potential from numerous recent potential studies from across the US (circles), the median annual savings projected by all studies (black line), and the actual evaluated savings from MA and RI in 2014 (green and purple lines, respectively). As shown, almost every potential study projects maximum achievable potential at rates lower than the leading jurisdictions are currently achieving.

Figure 9: Electric Savings Maximum Achievable Potential (% of Sales)



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.

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 take into account 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, the achievable potential analysis includes the costs of delivering an efficiency program 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, and other costs not attributable to a specific measure. In addition, it accounts for free ridership and spillover—respectively, market effects that account for customers who would have installed measures

even in the absence of the program, and those that 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 is based on actual cost data from a variety of program types and locations, to which we will add current data from Phase III, as available.

3.7.5 Program Potential

The program scenario is arguably the most useful outcome of the potential study. This should be a realistic scenario that reflects practical assumptions about the future in order to meet specific goals. We will work closely with the TUS to identify and prioritize the scenario that will be of greatest value, 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.

To establish the program potential scenario for each EDC, each measure will be rated or scored based on a variety of factors. This scoring will prioritize measures for inclusion in a program potential estimate that meets the budget constraints of Act 129. The scoring will be developed to balance several factors, including maximizing energy savings, achieving peak demand reduction, pursuing comprehensive efficiency, and ensuring balanced participation across customer and market types. We will develop the scoring process in collaboration with the TUS and will submit the criteria and methodology to TUS for approval.

Much of this will build on the qualitative screening described below in task 3.8.2.4. While the measure scoring process is useful for optimizing the measure mix needed to meet scenario goals, we acknowledge that other considerations come into play, such as filling the spectrum of energy end-uses, customer class and intra-class equity, and making the best use of marketing and delivery strategies.

We also note that the quantitative measure scoring will necessarily be done in several steps. First, all measures that pass the qualitative screening and get included in the technical potential will be screened for cost-effectiveness to inform the economic potential, which is the subset of technical potential removing non-cost-effective measures. We propose that the final scoring add other objectives such as total potential savings and ease of promotion in programs. This way, it can be used by the TUS and the EDCs to inform future program design. Based on this final scoring, measures can be bundled into programs for the purpose of informing Phase IV savings targets pursuant to budget constraints.

3.7.6 Reporting

We assume the final report will need to present the study findings and methodology to a variety of stakeholders. As such, 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. Our team members have learned from previous experience on the SWE team the right level of detail to provide in presentations and reports. As a first step, we will prepare a table that lists all of 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 to automating the process of updating the report when the analyses are refined, which avoids errors that are common with manual updates.

The RFP requires 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 IV 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. As such, the EE potential study will also provide critical insights to the EDCs on targeting EE resources that will aid in cost-effective delivery of EE programs in a potential phase IV.

Table 15 presents our schedule for completing the EE potential study.

Table 15: Schedule for Energy Efficiency Potential Study

Milestone	Estimated Date
Define study and develop work plan	November 2018
Collect data	Nov 2018 – Jan 2019
Prepare model	Jan 2019 – Mar 2019
Estimate technical and economic potential	Mar – Apr 2019
Develop achievable potential	Apr – Jun 2019
Develop program potential	Jun – Aug 2019
Prepare report	Sep – Dec 2019

3.8 Demand Response Market Potential Study

The NMR team understands that the DR and EE potential studies share common inputs and need to come together to form a cohesive result that the PUC can use as the basis for Phase IV policy decisions. The DR and EE potential study teams will work together closely to leverage shared tasks and address dynamic measures that need to be accounted for in both studies (e.g., smart thermostats).

3.8.1 DR Program Design

Much more so than energy efficiency potential, the quantity of achievable 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. Key drivers include the following:

- The expected frequency and duration of DR events. In general, the greater the number of hours that participants are expected to curtail load, the more expensive the resource is on a per-kW basis.
- The amount of notice participants are given in advance of dispatch. This parameter is heavily connected to grid application. For example, DR can be used for ancillary services (voltage regulation, spinning reserve) and command a premium price, but dispatch lead times for ancillary services must be extremely short, and the amount of DR resources with the potential to perform is limited. For an energy or generation capacity product, longer lead times are possible, and this significantly increases the amount of available potential. However, the price of these products is much lower on a per-KW basis.
- Seasonality requirements. Will DR events be called in the summer only or will winter performance be required? This element has significant implications for air conditioning load control potential, since air conditioning load is essentially non-existent on cold winter days.

There are also key policy decisions that impact the DR potential estimates. In the DR potential study for Phase III, the treatment of C&I customers enrolled in PJM DR programs was examined in detail. Dual participation will undoubtedly continue to be an issue for the Phase IV DR potential study. Our team believes that another significant policy issue for Phase IV will be time-varying pricing. With AMI penetration in the Commonwealth approaching 100% by June 1, 2021, time-varying pricing options such Critical Peak Pricing, Peak Time Rebate, and Time-of-Use Rates will become important considerations. The policy decision to date has been that these dynamic pricing options be handled outside of Act 129 through the Electric Generation Suppliers (EGSs). Even if dynamic pricing is excluded from the DR potential study as a measure, we believe it will be critical to account for the growing share of customers on time-varying rates and the impacts this has on the loads available for traditional dispatchable DR resources.

A carefully designed DR potential study is useful for answering several important policy and design questions, including the following.

- How much untapped DR potential is there in each EDC service territory given the Phase III program designs and budgets? How do policy decisions about dual enrollment affect the amount of available DR potential?
- Are there DR measures, programs, or pricing options not currently offered by the EDC that are capable of producing cost-effective peak demand reductions?
- Is it cost-effective to expand existing DR programs at the expense of energy efficiency? Because of the fixed 2% spending cap in Act 129, the question is not whether DR is cost-effective, but whether DR options are more cost-effective than EE offerings.

- What is the optimal budget split between EE and DR for each EDC? Is there a certain minimum size that a DR program needs to achieve to be effective and overcome the fixed program costs?
- Are there specific types of programs and customer segments that are more or less cost-effective than others? What type of customer or sector is most cost-effective to pursue?
- What is the supply cost curve for DR?

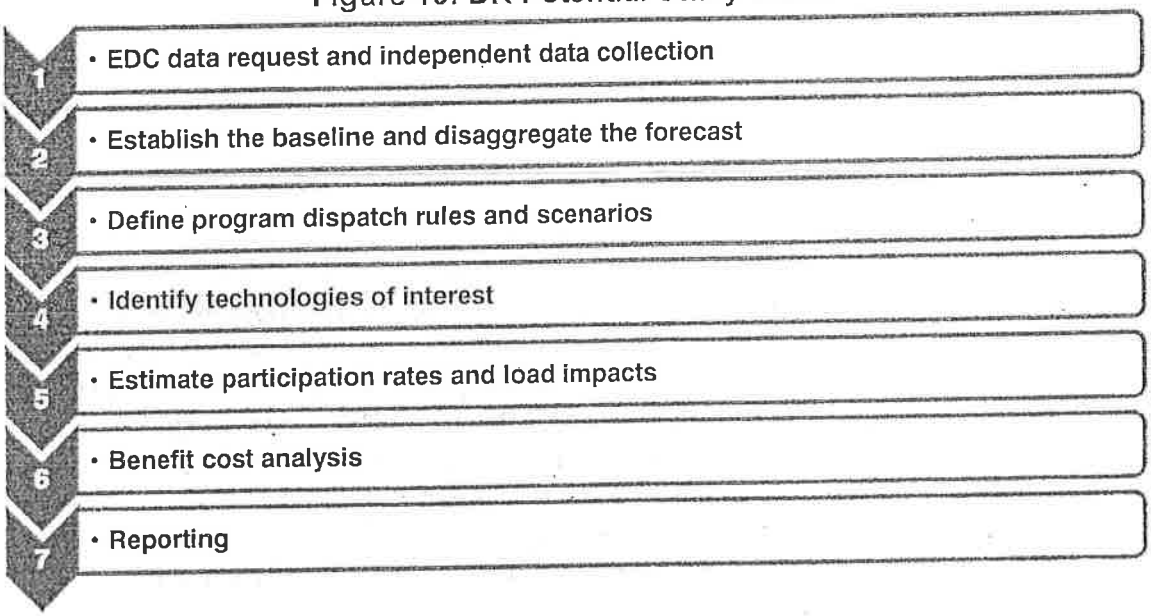
The DR potential study completed by the Phase II SWE team devoted considerable resources to examining the most cost-effective DR program design. A supply-side concept called Effective Load Carrying Capacity was used to compare hundreds of possible design and dispatch combinations and recommend an alternative to the "Top 100 Hours" construct that was utilized in Phase I of Act 129. The timing of the DR potential study for Phase IV will allow the NMR team to evaluate the performance of the Phase III DR program design for two summers (2017 and 2018) before beginning the heavy analytical portion of the study. Our team will carefully examine the performance and cost-effectiveness of EDC DR programs in PY9 and PY10 and work closely with the Project Officer and TUS staff to determine if design modifications should be considered as part of the DR potential study.

3.8.2 Analytical Approach

DR potential studies are effectively an exercise in customer segmentation. While the technical potential for DR potential is driven by equipment saturations and loading, the meaningful outcome of a DR potential study, achievable demand response 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.

Figure 10 lists the key research tasks in the NMR Team's proposed approach. Additional detail on each task is provided in the following sub-sections.

Figure 10: DR Potential Study Tasks



3.8.2.1 EDC Data Request and Independent Data Collection

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 DR offerings, and customer response to technology and incentive offers. Fortunately, the DR potential study is not an isolated study, and much of the same data are needed for the Baseline Studies and Energy Efficiency Potential Study. For example, the Baseline, EE 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 Phase I and Phase II, the EDC customer segmentation data are quite poor and will need to be supplemented by the SWE. To the extent possible, the NMR team will issue a consolidated data request to the EDCs and coordinate common activities across studies. The recently completed (at the time of the DR potential study) Baseline Studies will serve as a key input on end-use equipment types and efficiencies. The added focus of the Phase III Baseline Studies on the presence of controls will help the SWE to understand what DR-enabled technologies are in the market that can potentially be leveraged by a Phase IV Act 129 DR program.

The proposed approach also requires secondary data collection. Market adoption of DR technologies and rates under different incentive structures is the single most important driver of DR potential. In addition to cataloging historical program data from Act 129, the NMR team will rely on the results of studies and pilots focused on new and emerging DR technologies. The Phase II DR potential study for Large C&I customers relied on price elasticity values determined from empirical data on California programs. For this potential study, the NMR team will develop updated assumptions using publicly available bid data from PJM states. Depending on the grid applications under investigation, the NMR team will mine the available PJM RPM (generation capacity), day-ahead (energy), and ancillary

services offers to estimate the price elasticity of DR supply and model the DR supply curve in the Commonwealth.

3.8.2.2 Establish the Baseline and Disaggregate the Forecast

Based on our experience performing the previous DR potential study 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 2019 Load Forecast Report as the starting point for our estimates of the baseline—or what EDC peak loads would be absent Act 129 demand response. Careful consideration will be given to how PJM treats impacts from upcoming state energy efficiency offerings in its forecast. If deemed necessary, the NMR team will deduct the expected peak MW reductions from implementation of Phase IV Act 129 energy efficiency programs from the forecast. 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.

In order 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 EE potential study. After all, the two studies share a common set of customers. One key distinction is that the supply curve for DR is built by understanding coincident loads for different *customers*, calculating their cost-effectiveness, and stacking customer segments based on marginal cost-effectiveness. For the EE potential study, the supply curve is built by ordering *measures* from most to least cost-effective.

The increasing penetration of AMI in Pennsylvania will make all three stages of peak load disaggregation far more accurate than would be possible with monthly billing data. With AMI data on every customer, there is essentially no uncertainty in Step #1 or Step #2 (sector and customer, respectively). Merging hourly loads with outdoor air temperature can provide significant insight into the level of air conditioning use across customers. In a DR program that relies on AC control, this is half of the equation for potential (the other half being likelihood of enrollment).

3.8.2.3 Define Program Dispatch Rules and Scenarios

The importance of establishing program design and dispatch guidelines was discussed in Section 3.8.1. At this point in the study, these program attributes must be established, or at least limited to a small number of possibilities under consideration. 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 demand response as they are for energy efficiency. The concepts of technical, economic, achievable, and program potential are particularly troublesome for behavioral DR or "pay for performance" offerings. For enough money, most homes or business will forego electric service completely for a short period of time. While technically feasible, understanding this outcome is not particularly useful. Economic potential has similar issues because customers do not benefit from "doing DR" absent some incentive from the grid operator. We recommend the focus be placed on achievable potential and establishing appropriate assumptions about policy, incentive levels, and grid application of Act 129 demand response. Our budget estimate is sufficient to consider multiple achievable potential scenarios because we believe Act 129 stakeholders will be critical of a study that fails to consider multiple viewpoints on what is achievable in Phase IV.

3.8.2.4 Identify Technologies of Interest

Demand response is a broad term that encompasses a number of different technologies and strategies. In order 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 DLC switches, programmable communicating thermostats (PCTs), and smart thermostats—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 structure. This step of the DR potential will establish a short list of technologies for examination.

During this phase of the study, we will screen out end-uses that do not coincide with grid service or are too small. Loads that are very small, generally not coincident with system peak, or are required for normal home/business operation are not technologies available to modify loads. Consumer electronics have historically been considered in this category, but this may change by Phase IV with the proliferation of the Internet of Things (IoT).[22]

3.8.2.5 Estimate Participation Rates and Load Impacts

Demand response potential is effectively the number of customers that 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. The NMR team plans to rely first on Pennsylvania-specific data (both Act 129 and PJM) and, secondly, to supplement or benchmark with empirical data from other jurisdictions. By 2019, when the DR potential study is in full swing, several years of Phase III participation and impact data will be available.

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[22] Cisco estimates the IoT will consist of 50 billion devices connected to the Internet by 2020. http://www.cisco.com/web/solutions/trends/iot/overview.html

For large customers, 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. Some businesses' customers have low or no start-up costs and can deliver demand reductions for a short time period with little disruption by just delating energy-intense 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 to lower participation rates and lower committed reductions from the sites that do enroll. Similar to the Large C&I analysis in Phase II, the NMR team will determine the mathematical relationship between these program attributes and the all-important incentive level.

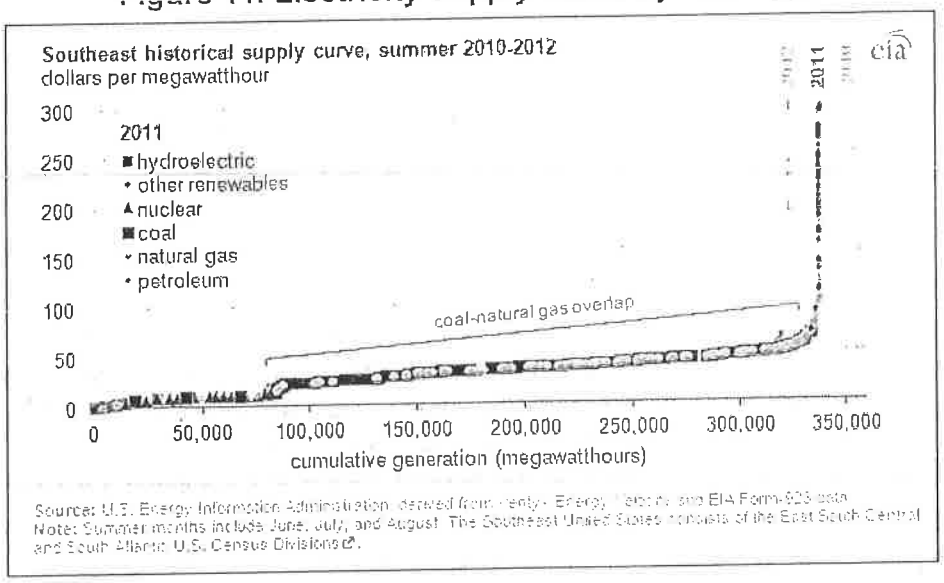
For residential and small commercial DR, enough mass market programs have been offered in North America that the relationship between incentive levels, marketing strategy, and technology offerings can be estimated with reasonable accuracy. However, we have observed enough regional variation that Pennsylvania-specific research is warranted. The NMR team will include in the Baseline Studies a battery of questions sufficient to develop an econometric customer choice model to estimate achievable participation rates. This data set, along with Phase III demand response participation data, and the customer segmentation research discussed previously, will provide a rich set of information about how specific tactics and incentive levels might influence DR enrollment rates in the Commonwealth.

3.8.2.6 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. The NMR team will perform this cost effectiveness analysis in accordance with the 2016 TRC Test with any modifications that the SWE and TUS staff determine are appropriate. Avoided cost values will be gathered from publicly available data sources, where possible, and supplemented with data requested from the EDCs as necessary. The avoided cost of generation capacity will be taken from zonal clearing prices in PJM's Base Residual Auction.

Because the NMR analysis approach is based on dividing customers and DR options into a large number of small pieces and analyzing them separating, it becomes easy to construct a supply curve with the results. Figure 11 shows an example of a supply curve for the generation side of the electric power system. Resources with little or no marginal fuel cost like hydroelectric, wind, solar, and nuclear are the cheapest forms of power generation, so they are always the first out of the stack. As demand increases, additional resources are used, but the lowest cost option is always used first.

Figure 11: Electricity Supply Curve by Fuel Type



The exact same concept applies to demand response. Some customers can be recruited with little effort and will provide large load reductions for small incentive payment. As you move up the supply curve, customers become increasingly difficult (expensive) to enroll and produce lower load impacts per incentive dollar. At a certain point, the levelized cost to acquire a kW of DR begins to outweigh the benefits, the TRC ratio drops below 1.0, and economic potential is exhausted. The supply cost curve is a useful tool because it allows DR resources to be compared with supply-side alternatives.

The ability to develop insightful supply curves requires estimating cost-effectiveness for multiple customer segments within a rate class. Our approach intentionally includes segmentation and cost-effectiveness analysis of customers and end-uses within each rate class to look beyond estimates for the average customer and develop more realistic estimates of DR potential.

3.8.2.7 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 in particular, there are a number of active stakeholders who want to be kept abreast of study progress and dissect the study results once complete. Our team members have learned from previous experience on the SWE team 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 DR 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 IV. Our intention is to produce a report that will be a valuable program planning tool for the EDCs as well as a technical guide for regulators.

We have budgeted for several in-person meetings during which stakeholders such as the EDCs, CSPs, environmental lobbyists, and customer advocate groups can provide input on

the study design prior to the public release of the report. Prior to submitting a Final Report, we will submit a Draft Final Report for TUS staff review and comments. 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 16 presents our schedule for completing the DR potential study.

Table 16: Schedule for DR Potential Study

Milestone	Estimated Date
Program design	October – December 2018
EDC data request and independent data collection	November 2018 – April 2019
Establish the baseline and disaggregate the forecast	January 2019 – April 2019
Define program dispatch rules and scenarios	October 2018 – April 2019
Identify technologies of interest	January 2019 – April 2019
Estimate participation rates and load impacts	March 2019 – May 2019
Benefit cost analysis	May 2019 – August 2019
Reporting	July 2019 – December 2019

3.9 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. Examples of meetings in which the NMR team will participate include the following:

- 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.
- Occasional Act 129 stakeholder meetings in Harrisburg. 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.
- Four PEG meetings with TUS staff and EDC representatives per year. 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 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 project budget review and status of special research projects.
- Occasional 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 development of custom measure protocols, evaluation findings, audit planning or feedback. The 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.

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 III data for use in analysis
- Provide Act 129 Phase III data for use in coordinated state agency projects that may benefit Act 129

3.10 Testimony

The NMR team is prepared to stand behind its conclusions and recommendations by testifying and aiding in the preparation of testimony by TUS staff, if necessary, in any future rate case or other proceeding before the PUC or for proceedings in other venues. The team understands that these proceedings may include, but are not limited to, hearings before Administrative Law Judges addressing EDC compliance with Phase III EE & DR targets or to support any potential Phase IV EE & DR targets. The NMR team will provide factual support for its conclusions and recommendations in such testimony. The NMR team has prepared and filed such testimony and provided testimony in other jurisdictions, such as Massachusetts, New York, Pennsylvania, Georgia, and Wisconsin, and is prepared to do so on behalf of the TUS staff.

3.11 Ongoing Obligations

The NMR team understands that the data, records, and other materials collected or created by our team regarding the evaluation of the conservation plans is the property of the PUC and will be maintained for a period of no less than 10 years. NMR will notify the PUC and provide access to all materials prior to any destruction or deletion of such materials.

3.12 Time Estimates and Schedules

3.12.1 Time Estimates

This section provides the estimated hours by staff for the proposed activities and studies. In addition, we provide a summary of the known existing commitments for leadership staff (Table 27).

Table 17 provides a summary for all staff for all audit activities and statewide studies.

Table 17: Total Hours by Audit Year and Statewide Study

Firm	Name	Category	Audit, Year 1	Audit, Year 2	Audit, Year 3	Audit, Year 4	Audit, Year 5	Res. Baseline Study	C&I Baseline Study	EE Potent. Study	DR Potent. Study	Total Hours
NMR	Hoefgen	President	183	135	134	133	133	5	5	75	-	803
NMR	Vaidya	Vice President	372	264	254	264	269	-	5	70	-	1,498
NMR	Clendenning	Senior Project Manager	688	570	562	583	560	30	30	110	-	3,133
NMR	Tyler	Senior Project Manager	-	-	-	-	-	205	-	20	-	225
NMR	Russell	Senior Quantitative Analyst	75	75	70	70	75	10	-	-	-	375
NMR	Na'im	Project Manager	395	338	315	345	315	-	25	-	-	1,733
NMR	Walker	Research Analyst I	240	160	160	160	175	290	-	-	-	1,185
NMR	Powell	Research Analyst I	-	-	-	-	-	260	-	-	-	260
NMR	von Trapp	Research Analyst I	50	50	40	40	40	-	-	-	-	220
NMR	Abraham	Research Analyst I	150	150	150	140	140	-	-	-	-	730
NMR	Rusteika	Research Analyst I	210	255	240	305	240	-	-	15	150	1,415
NMR	Stern	Research Associate II	285	280	265	200	270	1,245	-	-	80	2,625
NMR	Baker	Research Associate I	150	160	150	120	130	1,540	-	-	-	2,250
NMR	Pratt	Research Associate I	25	15	15	15	20	680	-	-	-	770

Firm	Name	Category	Audit, Year 1	Audit, Year 2	Audit, Year 3	Audit, Year 4	Audit, Year 5	Res. Baseline Study	C&I Baseline Study	EE Potent. Study	DR Potent. Study	Total Hours
NMR	Golzmane	Editor and Administrative Assistant	159	115	110	105	105	20	-	-	-	614
NMR	Coates-Connor	Editor and Administrative Assistant	160	80	80	80	80	-	-	-	-	480
Jesse Smith	Jesse Smith	Independent Contractor	1,196	1,545	1,418	1,510	1,498	-	430	147	835	8,579
Clean-tech	Gogte	Principal	509	504	483	494	442	-	105	130	-	2,667
Clean-tech	Muchrikar	Quantitative Analyst	760	875	805	835	783	-	367	65	100	4,590
Clean-tech	Iodice	Senior Engineer	560	645	650	680	655	-	310	-	-	3,500
Clean-tech	Bland	Senior Manager	410	525	460	465	475	-	104	16	180	2,635
Clean-tech	Rosenbaum	Engineer II	658	743	698	683	699	-	530	-	40	4,051
Clean-tech	T.Walker	Project Coordinator	820	825	815	820	840	-	689	25	-	4,834
Optimal	Belliveau	Partner	-	-	-	-	-	-	-	164	-	164
Optimal	Mosenthal	Partner	10	10	10	10	10	-	-	186	-	236
Optimal	Loiter	Partner	55	45	45	45	45	18	-	412	-	665
Optimal	Guerard	Managing Consultant	-	-	-	-	-	-	-	120	-	120
Optimal	Socks	Senior Consultant	15	15	15	15	15	30	-	803	100	1,008
Optimal	Lawrence	Senior Consultant	10	5	5	5	5	-	-	120	-	150
Optimal	McDonald	Consultant	33	54	50	50	50	-	-	454	-	691
Optimal	Johnson	Analyst	-	-	-	-	-	-	-	730	-	730
Abraxas	Urban	Project Manager	400	375	330	300	325	-	-	-	-	1,730
Abraxas	Rottmayer	Energy Engineer	475	375	375	330	450	-	1,184	-	-	3,189
Abraxas	McLaughlin	Junior Engineer	645	630	580	520	600	-	929	-	-	3,904
Abraxas	Barkley	Junior Engineer	700	650	475	325	600	-	855	-	-	3,605
Abraxas	Orsi	Junior Engineer	750	500	350	350	710	-	200	-	-	2,860

Firm	Name	Category	Audit, Year 1	Audit, Year 2	Audit, Year 3	Audit, Year 4	Audit, Year 5	Res. Baseline Study	C&I Baseline Study	EE Potent. Study	DR Potent. Study	Total Hours
Total			11,148	10,968	10,109	9,997	10,754	4,333	5,768	3,662	1,485	68,224

Table 18 through Table 26 provide detailed estimated hours by task for each year of audit activities and for each of the four statewide studies.

Table 18: Year 1 Audit Activity Hours

	NMR									Abraxas			Jesse Smith	Cleantech						Optimal			
Name	President	Vice President	Senior Project Manager	Senior Quantitative Analyst	Project Manager	Research Analyst I	Research Associate II	Research Associate I	Editor and Administrative Assistant	Project Manager (Abraxas)	Energy Engineer	Junior Engineer	Independent Contractor	Principal	Quantitative Analyst	Senior Engineer	Senior Manager	Engineer II	Project Coordinator	Partner	Senior Consultant	Consultant	Total Hours
1.Kickoff	12	12	35	0	15	0	0	0	0	0	0	0	30	40	0	0	0	0	0	10	0	0	154
2.Audit Plan Upate	20	45	40	0	20	0	0	0	8	0	0	0	65	50	60	35	0	0	10	0	0	0	353
3.EM&V Plan Review	10	20	15	0	15	15	15	0	10	0	0	0	35	10	40	0	15	25	30	0	0	0	255
4.Ex-ante, EDC Audit	0	0	10	0	20	50	0	0	0	0	0	0	75	20	20	0	0	20	20	0	0	0	235
4.Ex-ante, EE Residential	35	75	140	0	60	60	90	0	15	0	0	30	50	0	0	0	0	0	0	0	0	0	555
4.Ex-ante, EE Non-residential	0	0	0	0	0	0	0	0	0	150	125	615	0	49	100	100	60	180	200	0	0	0	1579
4.Ex-ante, DR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.Ex-ante, Behavioral	0	0	10	15	0	0	0	0	0	0	0	0	30	0	10	0	0	10	0	0	0	0	75
4.Ex-ante, CVR	0	0	0	0	0	0	0	0	0	0	0	0	38	0	0	0	0	8	0	0	0	0	46
5.Ex post, EE Residential	35	90	110	50	95	155	180	150	95	0	0	50	90	0	0	0	0	0	0	0	0	0	1100
5.Ex post, EE Non-residential	0	0	25	0	0	0	0	0	0	200	350	1400	75	70	220	300	200	200	250	0	0	0	3290
5.Ex post, DR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.Ex post, Behavioral	0	0	45	0	0	30	0	0	0	0	0	0	180	35	40	40	40	85	0	0	0	0	495
5.Ex post, CVR	0	0	0	0	10	0	0	0	0	0	0	0	38	0	0	0	20	0	0	0	10	13	91
5.Ex post, Process	10	20	35	0	35	110	0	0	4	0	0	0	40	5	40	0	0	0	60	0	0	0	359
5.Ex post, NTG	10	20	40	0	25	40	0	0	4	0	0	0	30	5	70	0	0	0	55	0	0	0	299
6.TRM Order update	10	10	15	0	5	10	0	0	4	0	0	0	40	15	25	20	0	0	20	15	15	0	204
7.TRC Order update	0	0	8	0	5	0	0	0	4	0	0	0	15	20	15	25	0	20	10	10	0	0	132
8.TRC Audit update	0	0	8	0	0	0	0	0	0	0	0	0	25	15	10	0	25	15	20	0	0	20	138
9.SharePoint	0	0	5	0	0	40	0	0	120	0	0	0	0	0	0	0	0	0	0	0	0	0	165
9.Data Tracking	0	5	25	0	0	100	0	0	0	0	0	0	100	0	0	0	0	0	65	0	0	0	295
10.Reporting	20	30	30	10	40	40	0	25	15	0	0	0	80	40	40	40	50	60	80	0	0	0	600
11.Project Management	15	45	80	0	50	0	0	0	40	50	0	0	80	80	5	0	0	0	0	30	0	0	475
12.AdHoc	6	0	12	0	0	0	0	0	0	0	0	0	80	55	65	0	0	35	0	0	0	0	253
Total, hours	183	372	688	75	395	650	285	175	319	400	475	2,095	1,196	509	760	560	410	658	820	65	25	33	11,148

Table 19: Year 2 Audit Activity Hours

	NMR									Abraxas			Jesse Smith	Cleantech						Optimal			
Name	President	Vice President	Senior Project Manager	Senior Quantitative Analyst	Project Manager	Research Analyst I	Research Associate II	Research Associate I	Editor and Administrative Assistant	Project Manager (Abraxas)	Energy Engineer	Junior Engineer	Independent Contractor	Principal	Quantitative Analyst	Senior Engineer	Senior Manager	Engineer II	Project Coordinator	Partner	Senior Consultant	Consultant	Total Hours
1.Kickoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.Audit Plan Upate	4	8	8	0	5	0	0	0	4	0	0	0	15	50	30	25	0	10	0	0	0	0	159
3.EM&V Plan Review	5	10	5	0	5	15	10	0	5	0	0	0	30	5	35	0	15	25	30	0	0	0	195
4.Ex-ante, EDC Audit	0	0	10	0	20	30	0	0	0	0	0	0	50	20	20	0	0	20	20	0	0	0	190
4.Ex-ante, EE Residential	25	63	130	0	60	55	90	0	15	0	0	30	50	0	0	0	0	0	0	0	0	0	518
4.Ex-ante, EE Non-residential	0	0	0	0	0	0	0	0	0	125	125	500	0	49	100	100	60	180	200	0	0	0	1439
4.Ex-ante, DR	0	0	0	0	0	0	0	0	0	0	0	0	130	10	15	0	15	30	0	0	0	0	200
4.Ex-ante, Behavioral	0	0	10	15	0	0	0	0	0	0	0	0	30	0	10	0	0	10	0	0	0	0	75
4.Ex-ante, CVR	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	5	0	0	0	0	25
5.Ex post, EE Residential	30	75	95	50	90	150	180	160	60	0	0	50	85	0	0	0	0	0	0	0	0	0	1025
5.Ex post, EE Non-residential	0	0	25	0	0	0	0	0	0	200	250	1200	75	70	220	300	200	200	250	0	0	0	2990
5.Ex post, DR	0	0	0	0	0	40	0	0	0	0	0	0	380	0	95	50	110	48	0	0	0	25	748
5.Ex post, Behavioroal	0	0	45	0	0	30	0	0	0	0	0	0	180	25	40	40	40	85	0	0	0	0	485
5.Ex post, CVR	0	0	0	0	5	0	0	0	0	0	0	0	20	0	0	0	15	0	0	0	5	9	54
5.Ex post, Process	10	15	35	0	35	110	0	0	4	0	0	0	40	5	40	0	0	0	60	0	0	0	354
5.Ex post, NTG	10	18	40	0	25	40	0	0	4	0	0	0	30	5	55	0	0	0	45	0	0	0	272
6.TRM Order update	10	10	18	0	10	25	0	0	4	0	0	0	80	55	65	60	0	0	50	15	15	0	417
7.TRC Order update	0	0	5	0	3	0	0	0	4	0	0	0	20	20	30	30	0	25	5	10	0	0	152
8.TRC Audit update	0	0	8	0	0	0	0	0	0	0	0	0	25	15	10	0	20	10	20	0	0	20	128
9.SharePoint	0	0	4	0	0	20	0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	79
9.Data Tracking	0	0	10	0	0	70	0	0	0	0	0	0	45	0	0	0	0	0	65	0	0	0	190
10.Reporting	20	20	30	10	30	30	0	15	15	0	0	0	80	40	40	40	50	60	80	0	0	0	560
11.Project Management	15	45	80	0	50	0	0	0	25	50	0	0	80	80	5	0	0	0	0	30	0	0	460
12.AdHoc	6	0	12	0	0	0	0	0	0	0	0	0	80	55	65	0	0	35	0	0	0	0	253
Total, hours	135	264	570	75	338	615	280	175	195	375	375	1,780	1,545	504	875	645	525	743	825	55	20	54	10,968

Table 20: Year 3 Audit Activity Hours

	NMR									Abraxas			Jesse Smith	Cleantech						Optimal			
Name	President	Vice President	Senior Project Manager	Senior Quantitative Analyst	Project Manager	Research Analyst I	Research Associate II	Research Associate I	Editor and Administrative Assistant	Project Manager (Abraxas)	Energy Engineer	Junior Engineer	Independent Contractor	Principal	Quantitative Analyst	Senior Engineer	Senior Manager	Engineer II	Project Coordinator	Partner	Senior Consultant	Consultant	Total Hours
1.Kickoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.Audit Plan Upate	4	8	5	0	5	0	0	0	4	0	0	0	20	50	50	0	0	10	0	0	0	0	156
3.EM&V Plan Review	5	10	5	0	5	5	5	0	5	0	0	0	20	5	10	0	5	10	30	0	0	0	120
4.Ex-ante, EDC Audit	0	0	10	0	20	30	0	0	0	0	0	0	40	20	20	0	0	20	20	0	0	0	180
4.Ex-ante, EE Residential	24	63	130	0	50	55	80	0	15	0	0	30	50	0	0	0	0	0	0	0	0	0	497
4.Ex-ante, EE Non-residential	0	0	0	0	0	0	0	0	0	80	125	425	0	49	100	100	60	180	200	0	0	0	1319
4.Ex-ante, DR	0	0	0	0	0	0	0	0	0	0	0	0	110	10	16	0	15	30	0	0	0	0	181
4.Ex-ante, Behavioral	0	0	12	15	0	0	0	0	0	0	0	0	25	0	10	0	0	10	0	0	0	0	72
4.Ex-ante, CVR	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	5	0	0	0	0	20
5.Ex post, EE Residential	30	65	95	50	80	140	180	150	55	0	0	50	90	0	0	0	0	0	0	0	0	0	985
5.Ex post, EE Non-residential	0	0	25	0	0	0	0	0	0	200	250	900	75	70	220	300	200	200	250	0	0	0	2690
5.Ex post, DR	0	0	0	0	0	40	0	0	0	0	0	0	320	0	54	90	60	28	0	0	0	25	617
5.Ex post, Behavioriaal	0	0	45	0	0	30	0	0	0	0	0	0	180	30	20	40	40	80	0	0	0	0	465
5.Ex post, CVR	0	0	0	0	5	0	0	0	0	0	0	0	15	0	0	0	10	0	0	0	5	5	40
5.Ex post, Process	10	15	35	0	35	110	0	0	4	0	0	0	40	5	40	0	0	0	60	0	0	0	354
5.Ex post, NTG	10	18	40	0	25	40	0	0	4	0	0	0	30	5	55	0	0	0	45	0	0	0	272
6.TRM Order update	10	10	18	0	10	25	0	0	4	0	0	0	83	55	65	55	0	0	40	15	15	0	405
7.TRC Order update	0	0	4	0	0	0	0	0	4	0	0	0	15	15	25	25	0	25	5	10	0	0	128
8.TRC Audit update	0	0	8	0	0	0	0	0	0	0	0	0	25	15	10	0	20	10	20	0	0	20	128
9.SharePoint	0	0	3	0	0	20	0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	78
9.Data Tracking	0	0	10	0	0	70	0	0	0	0	0	0	45	0	0	0	0	0	65	0	0	0	190
10.Reporting	20	20	20	5	30	25	0	15	15	0	0	0	80	40	40	40	50	55	80	0	0	0	535
11.Project Management	15	45	85	0	50	0	0	0	25	50	0	0	65	65	5	0	0	0	0	30	0	0	435
12.AdHoc	6	0	12	0	0	0	0	0	0	0	0	0	75	49	65	0	0	35	0	0	0	0	242
Total, hours	134	254	562	70	315	590	265	165	190	330	375	1,405	1,418	483	805	650	460	698	815	55	20	50	10,109

Table 21: Year 4 Audit Activity Hours

	NMR									Abraxas			Jesse Smith	Cleantech						Optimal			
Name	President	Vice President	Senior Project Manager	Senior Quantitative Analyst	Project Manager	Research Analyst I	Research Associate II	Research Associate I	Editor and Administrative Assistant	Project Manager (Abraxas)	Energy Engineer	Junior Engineer	Independent Contractor	Principal	Quantitative Analyst	Senior Engineer	Senior Manager	Engineer II	Project Coordinator	Partner	Senior Consultant	Consultant	Total Hours
1.Kickoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.Audit Plan Upate	4	8	5	0	5	0	0	0	4	0	0	0	20	50	70	0	0	10	0	0	0	0	176
3.EM&V Plan Revlew	5	10	5	0	5	5	5	0	5	0	0	0	20	5	10	0	5	10	30	0	0	0	120
4.Ex-ante, EDC Audit	0	0	10	0	20	30	0	0	0	0	0	0	40	20	20	0	0	20	20	0	0	0	180
4.Ex-ante, EE Residential	24	63	130	0	50	55	80	0	15	0	0	30	50	0	0	0	0	0	0	0	0	0	497
4.Ex-ante, EE Non-residential	0	0	0	0	0	0	0	0	0	50	130	415	0	49	100	100	60	180	200	0	0	0	1284
4.Ex-ante, DR	0	0	0	0	0	0	0	0	0	0	0	0	110	10	16	0	15	30	0	0	0	0	181
4.Ex-ante, Behavioral	0	0	10	15	0	0	0	0	0	0	0	0	25	0	10	0	0	10	0	0	0	0	70
4.Ex-ante, CVR	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	5	0	0	0	0	20
5.Ex post, EE Residential	30	65	95	50	80	130	115	120	50	0	0	50	90	0	0	0	0	0	0	0	0	0	875
5.Ex post, EE Non-residential	0	0	25	0	0	0	0	0	0	200	200	700	75	70	220	300	200	200	250	0	0	0	2440
5.Ex post, DR	0	0	0	0	0	40	0	0	0	0	0	0	320	0	54	100	60	28	0	0	0	25	627
5.Ex post, Behaviorloal	0	0	45	0	0	30	0	0	0	0	0	0	200	25	20	40	40	80	0	0	0	0	480
5.Ex post, CVR	0	0	0	0	5	0	0	0	0	0	0	0	15	0	0	0	15	0	0	0	5	5	45
5.Ex post, Process	10	15	35	0	35	100	0	0	4	0	0	0	40	5	40	0	0	0	60	0	0	0	344
5.Ex post, NTG	10	18	40	0	25	40	0	0	4	0	0	0	30	5	55	0	0	0	45	0	0	0	272
6.TRM Order update	10	20	45	0	40	100	0	0	4	0	0	0	170	90	90	80	0	0	40	15	15	0	719
7.TRC Order update	0	0	6	0	0	0	0	0	4	0	0	0	15	10	10	20	0	20	10	10	0	0	105
8.TRC Audit update	0	0	8	0	0	0	0	0	0	0	0	0	25	15	10	0	20	10	20	0	0	20	128
9.SharePoint	0	0	4	0	0	20	0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	79
9.Data Tracking	0	0	10	0	0	70	0	0	0	0	0	0	45	0	0	0	0	0	65	0	0	0	190
10.Reporting	20	20	15	5	30	25	0	15	15	0	0	0	80	40	40	40	50	50	80	0	0	0	525
11.Project Management	15	45	85	0	50	0	0	0	25	50	0	0	50	52	5	0	0	0	0	30	0	0	407
12.AdHoc	5	0	10	0	0	0	0	0	0	0	0	0	75	48	65	0	0	30	0	0	0	0	233
Total, hours	133	264	583	70	345	645	200	135	185	300	330	1,195	1,510	494	835	680	465	683	820	55	20	50	9,997

Table 22: Year 5 Audit Activity Hours

	NMR									Abraxas			Jessa Smith	Cleantech						Optimal			
Name	President	Vice President	Senior Project Manager	Senior Quantitative Analyst	Project Manager	Research Analyst I	Research Associate II	Research Associate I	Editor and Administrative Assistant	Project Manager (Abraxas)	Energy Engineer	Junior Engineer	Independent Contractor	Principal	Quantitative Analyst	Senior Engineer	Senior Manager	Engineer II	Project Coordinator	Partner	Senior Consultant	Consultant	Total Hours
1.Kickoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.Audit Plan Upate	4	6	5	0	5	0	0	0	4	0	0	0	20	50	70	0	0	10	0	0	0	0	174
3.EM&V Plan Review	5	10	5	0	5	5	5	0	5	0	0	0	18	5	10	0	5	10	30	0	0	0	118
4.Ex-ante, EDC Audit	0	0	10	0	20	35	0	0	0	0	0	0	50	20	20	0	0	20	20	0	0	0	195
4.Ex-ante, EE Residential	24	70	140	0	50	65	90	0	15	0	0	30	50	0	0	0	0	0	0	0	0	0	534
4.Ex-ante, EE Non-residential	0	0	0	0	0	0	0	0	0	75	150	580	0	49	100	100	60	180	200	0	0	0	1494
4.Ex-ante, DR	0	0	0	0	0	0	0	0	0	0	0	0	110	10	20	0	15	30	0	0	0	0	185
4.Ex-ante, Behavioral	0	0	10	15	0	0	0	0	0	0	0	0	25	0	10	0	0	10	0	0	0	0	70
4.Ex-ante, CVR	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	4	0	0	0	0	19
5.Ex post, EE Residential	30	75	95	50	90	150	175	130	50	0	0	50	90	0	0	0	0	0	0	0	0	0	985
5.Ex post, EE Non-residential	0	0	25	0	0	0	0	0	0	200	300	1250	75	70	220	300	200	200	250	0	0	0	3090
5.Ex post, DR	0	0	0	0	0	40	0	0	0	0	0	0	405	0	68	125	70	35	0	0	0	25	768
5.Ex post, Behavioricol	0	0	45	0	0	30	0	0	0	0	0	0	210	25	20	40	40	80	0	0	0	0	490
5.Ex post, CVR	0	0	0	0	5	0	0	0	0	0	0	0	15	0	0	0	15	0	0	0	5	5	45
5.Ex post, Process	10	15	35	0	35	100	0	0	4	0	0	0	40	5	40	0	0	0	60	0	0	0	344
5.Ex post, NTG	10	18	40	0	25	40	0	0	4	0	0	0	30	5	55	0	0	0	45	0	0	0	272
6.TRM Order update	10	10	10	0	5	10	0	0	4	0	0	0	30	15	20	30	0	0	60	15	15	0	234
7.TRC Order update	0	0	6	0	0	0	0	0	4	0	0	0	15	10	10	20	0	20	10	10	0	0	105
8.TRC Audit update	0	0	8	0	0	0	0	0	0	0	0	0	25	15	10	0	20	10	20	0	0	20	128
9.SharePoint	0	0	1	0	0	20	0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	76
9.Data Tracking	0	0	10	0	0	70	0	0	0	0	0	0	50	0	0	0	0	0	65	0	0	0	195
10.Reporting	20	20	20	10	25	30	0	20	15	0	0	0	80	40	40	40	50	60	80	0	0	0	550
11.Project Management	15	45	85	0	50	0	0	0	25	50	0	0	70	75	5	0	0	0	0	30	0	0	450
12.AdHoc	5	0	10	0	0	0	0	0	0	0	0	0	75	48	65	0	0	30	0	0	0	0	233
Total, hours	133	269	560	75	315	595	270	150	185	325	450	1,910	1,498	442	783	655	475	699	840	55	20	50	10,754

Table 23: Residential Baseline Study Hours

	NMR							Optimal		
Name	President	Senior Project Manager	Senior Quantitative Analyst	Research Analyst I	Research Associate II	Research Associate I	Editor and Administrative Assistant	Partner	Senior Consultant	Total Hours
Study design and recruitment	0	35	10	270	145	240	0	10	15	**725**
Site visits	0	0	0	0	400	1,250	0	0	0	**1,650**
Project management	0	135	0	0	0	0	0	0	0	**135**
Data entry	0	5	0	60	140	460	0	0	0	**665**
Analysis	0	20	0	100	280	100	0	0	0	**500**
Reporting	5	30	0	120	280	60	20	8	15	**538**
HES Score analysis	0	10	0	0	0	110	0	0	0	**120**
Total	**5**	**235**	**10**	**550**	**1,245**	**2,220**	**20**	**18**	**30**	**4,333**

Table 24: C&I Baseline Study Hours

	NMR				Abraxas		Jesse Smith	Cleantech						
Name	President	Vice President	Senior Project Manager	Project Manager	Energy Engineer	Junior Engineer	Independent Contractor	Principal	Quantitative Analyst	Senior Engineer	Senior Manager	Engineer II	Project Coordinator	Total Hours
Develop Work Plan	0	0	5	10	0	0	15	25	15	0	0	20	0	90
Sampling	0	0	0	0	0	0	25	20	23	0	20	0	0	88
Survey Development	0	0	0	0	0	0	10	10	15	0	0	20	0	55
Recruit on-sites	0	0	0	0	0	0	0	0	0	0	0	0	299	299
Phone/Web survey	0	0	0	0	50	100	0	0	74	105	0	45	0	374
On-sites	0	0	0	0	960	1600	230	0	0	130	0	260	320	3500
Secondary data analysis	0	0	0	0	0	0	0	0	45	50	0	75	0	170
Propensity score analysis	0	0	0	0	44	164	60	15	45	0	29	0	0	357
Data Preparation	0	0	0	0	65	85	20	0	40	25	0	20	45	300
Analysis	0	0	15	5	65	35	30	10	65	0	45	55	0	325
Reporting	5	5	10	10	0	0	40	25	45	0	10	35	25	210
Total, hours	**5**	**5**	**30**	**25**	**1,184**	**1,984**	**430**	**105**	**367**	**310**	**104**	**530**	**689**	**5,768**

Table 25: Energy Efficiency Market Potential Study Hours

	NMR				Jesse Smith	Cleantech				Optimal					
Name	President	Vice President	Senior Project Manager	Research Analyst I	Independent Contractor	Principal	Quantitative Analyst	Senior Manager	Project Coordinator	Partner	Managing Consultant	Senior Consultant	Consultant	Analyst	Total Hours
Define Study	10	10	30	0	40	25	25	0	0	70	0	50	40	20	320
Collect Data	0	0	0	0	15	0	0	0	0	40	0	80	120	150	405
Prepare Model	0	0	0	0	10	0	0	0	0	110	20	140	100	100	480
Tech and Economic Potential	0	0	0	0	10	0	0	0	0	74	0	70	50	50	254
Achievable Potential	0	0	0	0	10	0	0	0	0	84	30	100	30	80	334
Program Potential	0	0	0	0	10	0	0	0	0	172	70	210	70	180	712
Reporting	30	20	30	15	20	45	40	16	25	112	0	120	0	150	623
Project Management	35	40	70	0	32	60	0	0	0	100	0	153	44	0	534
Total	**75**	**70**	**130**	**15**	**147**	**130**	**65**	**16**	**25**	**762**	**120**	**923**	**454**	**730**	**3,662**

Table 26: Demand Response Market Potential Study Hours

	NMR		Jesse Smith	Cleantech			Optimal	
Name	Research Analyst I	Research Associate II	Independent Contractor	Quantitative Analyst	Senior Manager	Engineer II	Senior Consultant	Total Hours
Program Design	30	0	70	0	0	0	20	120
EDC data request and independent data collection	0	20	90	30	0	0	30	170
Establish the baseline and disaggregate the forecast	40	0	80	40	0	0	20	180
Define program dispatch rules and scenarios	30	0	80	0	30	0	0	140
Identify technologies of interest	0	30	75	0	30	40	0	175
Estimate participation rates and load impacts	0	30	150	20	30	0	0	230
Benefit cost analysis	30	0	130	0	60	0	30	250
Reporting	20	0	160	10	30	0	0	220
Total, hours	**150**	**80**	**835**	**100**	**180**	**40**	**100**	1,485

Table 27: Known Existing Commitments for Leadership Staff of the NMR Team, 2016 to 2022

Leadership Staff	Firm	Title	Clients with whom Personnel Have Existing Projects	Annual Hours of Labor Commitments for Existing Projects						
				2016	2017	2018	2019	2020	2021	2022
Lynn Hoefgen	NMR	President	Massachusetts Energy Efficiency Program Administrators, NYSERDA	1,000	700	300	0	0	0	0
Greg Clendenning	NMR	Senior Project Manager	U.S. Department of Energy, Connecticut Green Bank, Massachusetts Energy Efficiency Program Administrators	350	150	50	50	50	150	0
Rohit Vaidya	NMR	Vice President	NYSERDA, IESO Ontario, Consolidated Edison	750	400	400	0	0	0	0
Alyssa Na'im	NMR	Project Manager	Massachusetts Energy Efficiency Program Administrators	400	400	400	0	0	0	0
Salil Gogte	Cleantech	Principal	None	0	0	0	0	0	0	0
Jesse Smith	Indep. Energy Consultant	Principal	None	0	0	0	0	0	0	0
Phil Mosenthal	Optimal	Partner	NYSERDA, NRDC, Massachusetts Department of Energy Resources, New York Power Authority, Illinois Office of the Attorney General	575	500	0	0	0	0	0
Jeff Loiter	Optimal	Partner	Connecticut Municipal Electric Energy Cooperative, NYSERDA, Delaware Department of Natural Resources and Environmental Control, Wallingford Electric	550	400	0	0	0	0	0

Leadership Staff	Firm	Title	Clients with whom Personnel Have Existing Projects	Annual Hours of Labor Commitments for Existing Projects						
				2016	2017	2018	2019	2020	2021	2022
			Division, New Hampshire Sustainable Energy Association							
Matt Socks	Optimal	Senior Consultant	NYSERDA, New York Power Authority, Shelter Analytics	400	300	0	0	0	0	0

3.12.2 Project Schedules

In this section, we present an overview of the schedules for the annual audit activities and the statewide studies.

Figure 12 presents the schedule for audit activities in PY9 through PY12, which include DR audit activities. The audit activities for PY8 will follow the same schedule except that there will not be any DR audit activities.

Figure 12: Schedule of Audit Activities for PY9-12

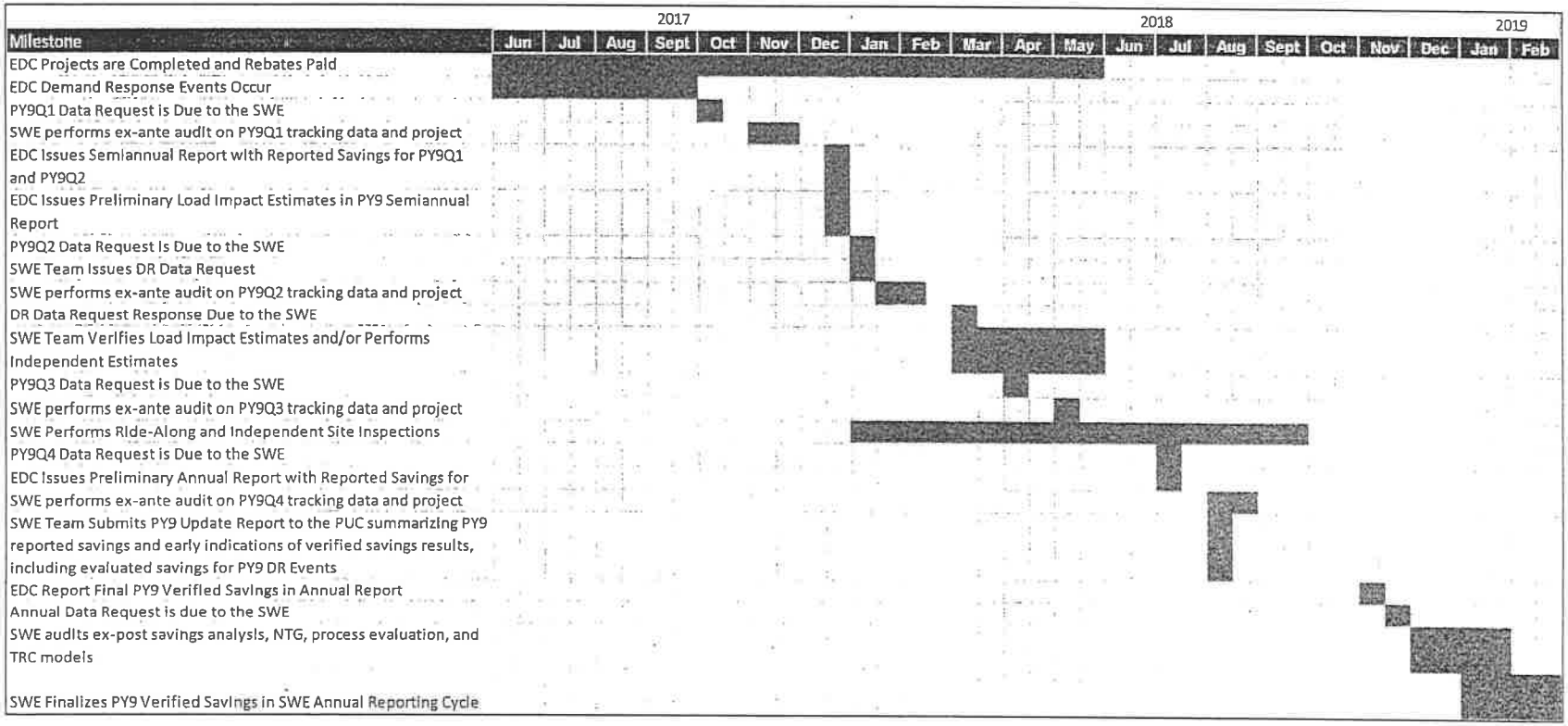


Figure 13 presents the schedule for the residential and C&I baseline studies.

Figure 13: Baseline Studies Schedule

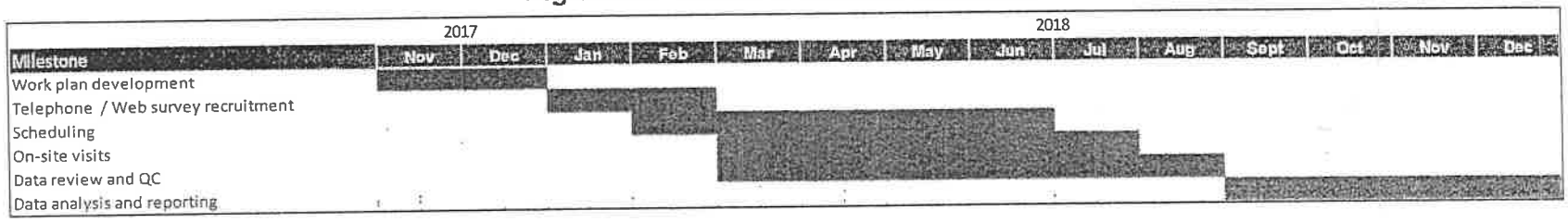
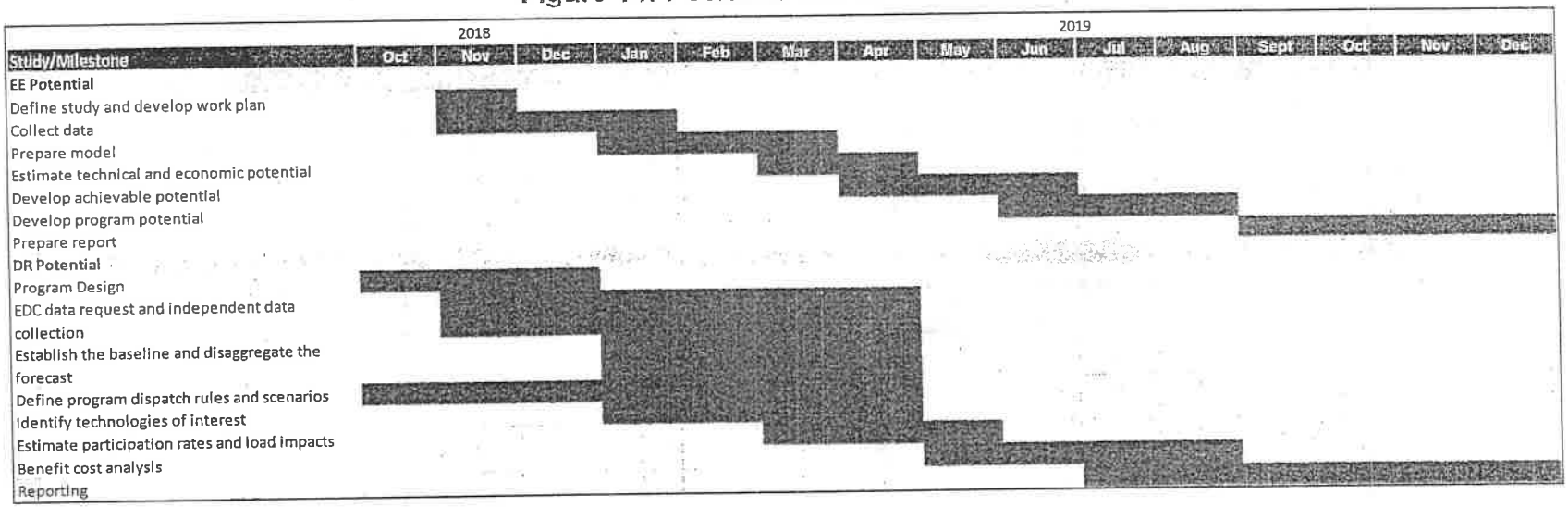


Figure 14 presents the schedule for the energy efficiency and DR potential studies.

Figure 14: Potential Studies Schedule



Section 4 Prior Experience

The NMR team is uniquely qualified to undertake the Act 129 Statewide Evaluator project for the Pennsylvania Public Utility Commission (PUC). NMR is the prime contractor and will be responsible for overall management of the project. NMR's subcontractors on this project are Cleantech Advisory Group (Cleantech), Jesse Smith, Optimal Energy, and Abraxas Energy Consulting. The team has extensive experience with all facets of evaluation, monitoring, and verification, including previous work carrying out key aspects of the Act 129 Statewide Evaluator project, as well as multiple residential and commercial baseline studies, market assessment studies, TRM development and updates, cost-effectiveness testing, information management, and all the other types of activities required of the Act 129 Statewide Evaluator.

4.1 NMR Group, Inc.

NMR provides evaluation and market research services for energy efficiency and renewable energy programs. We help clients evaluate these programs and assess the complex markets in which they operate. Our services include planning evaluations, developing program theory and logic models, and conducting market, process, and impact evaluations. We provide clients with research-based information and insights to help them focus program efforts based on prevailing market structure and conditions, measure the impacts of energy efficiency and renewable energy programs, and provide strategic guidance for improving program design and delivery.

NMR is qualified to lead this effort because of our experience and expertise in energy efficiency evaluation and because of a commitment to quality and on-time delivery. Over the years, work conducted by NMR's staff has addressed a wide range of energy use applications and related issues, including residential lighting, HVAC, energy audit programs, new construction, and appliances, among others. Below is a representative list.

- Commercial lighting
- Commercial HVAC (DX, chillers, boilers)
- Residential new construction
- Commercial new construction
- Residential HVAC
- Commercial refrigeration
- Residential lighting
- Commercial HVAC (DX, chillers, boilers)
- Photovoltaics
- Motors
- Residential appliances
- Office equipment
- Residential windows
- Building operator management
- Whole-house efficiency
- Motors

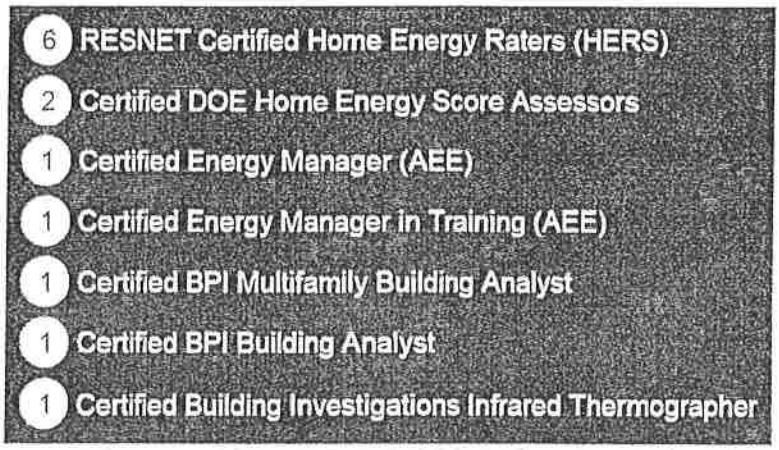
The populations researched by NMR staff have encompassed the spectrum of energy users and trade allies, including:

- Residential, commercial and industrial customers
- Refrigeration manufacturers and contractors
- Retail chain decision makers
- Motor manufacturers and contractors
- Building and facility managers
- Window manufacturers and contractors
- HVAC manufacturers, distributors and contractors
- Photovoltaic manufacturers, distributors and contractors
- Lighting manufacturers, distributors and contractors
- Builders, architects and engineers

A key aspect of the Act 129 Statewide Evaluator project is providing expert advice and assistance to the PUC, including review of EM&V plans, data processes, and reports. Since 2003, NMR has filled this role for NYSERDA as part of the evaluation assistance team, and has been the lead contractor since 2011. This work has included serving as liaisons to specialty evaluation contractors, reviewing evaluation plans and reports, helping to synthesize evaluation results in annual reports, organizing the development of key progress metrics and indicators for energy efficiency programs, developing evaluation plans, identifying program opportunities for NYSERDA, and providing strategic input for all aspects of the program evaluation effort.

NMR, the lead firm for the residential baseline study for the Commission, has conducted numerous residential baseline studies, including one existing construction and one new construction baseline study in Connecticut, three existing and three new construction baseline studies in Vermont, five residential new construction baseline studies in Massachusetts, one existing construction baseline study in Maine, and one new construction baseline study in Rhode Island. NMR's building science group is composed of staff members with extensive certifications, as detailed in Figure 15. The fact that these same individuals are also able to perform analysis and reporting provides consistency from the point of data collection to reporting, which leads to the highest quality evaluations. We have a written set of on-site protocols for our HERS raters to ensure consistency across our field staff and across studies.

Figure 15: NMR Building Science Certifications



4.1.1 Representative Projects

Evaluation Assistance, NYSERDA (2003-present). Since 2003, NMR has been part of NYSERDA's evaluation assistance team, and since 2011 has been the lead contractor. This work has included serving as liaisons to specialty evaluation contractors, helping to synthesize evaluation results in annual reports, organizing the development of key progress metrics and indicators for energy efficiency programs, developing evaluation plans, identifying program opportunities for NYSERDA, and providing strategic input for all aspects of the program evaluation effort. Contact: Jennifer Meissner, NYSERDA, 17 Columbia Circle, Albany, NY 12203-6399, 518-862-1090 x3367, jennifer.meissner@nyserda.ny.gov.

Commercial/Industrial & Residential Programs Impact and Process Evaluation, Nova Scotia Power (2009-2011). NMR led three years of impact and process evaluations of Nova Scotia Power's portfolio of commercial, industrial, and residential programs. NMR and DNV GL evaluated the following C&I programs: Custom incentives for large C&I customers; Business Energy Rebates for lighting, motors and drives, HVAC, refrigeration, and compressed air equipment; Smart Lighting Choices, which provided financial incentives to distributors for qualifying equipment sold for installation in non-residential facilities; Small Business Lighting Solutions, which offered lighting retrofits and recycling of old lamps and fixtures to eligible participants at a discounted price; and Efficient Lighting Products Direct Install, which provided CFL and LED exit light retrofits to small businesses. Contact: Nicole Cadek, Nova Scotia Power, P.O. Box 910, Halifax, NS B3J2W5, 902-428-6735, Nicole.Cadek@nspower.ca.

Residential Portfolio Evaluation, Connecticut Energy Efficiency Advisory Board (2011-present). Since 2011, NMR has been leading the evaluation of residential energy efficiency programs in Connecticut. Selected projects include: a baseline study to assess the extent of weatherization of existing single-family homes; a comprehensive evaluation of the Home Energy Services Program, including impact, process, net-to-gross, end-of-useful life, and non-energy-impact evaluations; a potential study; several impact studies of the OPower program; a study to assess how to improve the utilities' databases; an air sealing/duct sealing/insulation study; a multifamily process evaluation; lighting saturation studies; an

assessment of the Heat Loan (financing) program; and more. Contact: Lisa Skumatz, Evaluation consultant to Connecticut Energy Efficiency Board, 762 Eldorado Drive, Superior, CO 80027, 303-494-1178, skumatz@serainc.com.

Residential New Construction, Massachusetts PAs, (2002-present). NMR has been leading evaluations of the MA RNC program since 2002. This has included several baseline studies of both single-family and multifamily new construction, a net savings study, codes and standards assessments, incremental cost studies, assessment of the potential for net zero energy homes, and more. Contact: Bill Blake, National Grid, 40 Sylvan Road, Waltham, MA 02451, 781-907-1583, William.Blake@nationalgrid.com.

Residential Lighting Program Evaluation, Massachusetts PAs (2005-present). NMR has been evaluating residential lighting programs in Massachusetts since 2005. The fruits of this effort have included the most comprehensive series of saturation studies available in the US; an ongoing on-site panel study showing which bulb types are replacing other bulbs; multi-method net-to-gross studies; incremental cost studies; market studies conducted among manufacturers, high-level retail buyers, and store managers; a market adoption model based on current saturation and market trends that projects likely socket share by bulb type into the future; and more. Contact: Matt Nelson, Eversource, One NSTAR Way SW360 (Southwest 3039), Westwood, MA 02090, 781-441-3456, matthew.nelson@eversource.com.

Northeast Residential Lighting Hours-Of-Use Study, CT, MA, NY, and RI (2013-2014). NMR led a team that recently completed a study to measure residential lighting hours of use in 848 homes across four states in the Northeast—one of the largest studies of its kind ever undertaken. The purpose of this study was to provide updated information to assist in the calculations of demand and energy savings for residential lighting programs—specifically, load shapes, coincidence factors, and daily hours of use (HOU). Based on the data collected from 4,462 loggers, NMR developed a series of regression models to estimate HOU. Due to the vast amount of data collected for this study, NMR was able to analyze and present HOU data in many different ways. In total, the team created and analyzed over 1,700 data breakdowns. The report also provides detailed HOU estimates by room type, home type (i.e., single-family or multifamily), and income level for the region overall and for each individual area included in the analysis. Additionally, the report presents load shapes as well as coincidence factors for winter and summer peak periods to aid in load planning and the calculation of peak demand savings. Contact: Ralph Prahl, Evaluation Consultant to the Massachusetts Energy Efficiency Advisory Board, 7613 Whitebridge Glen, University Park, FL, 34201, 608-238-9942, ralph.prahl@gmail.com.

Residential Baseline Studies for MA, RI, CT, ME, and VT, (2010-present). NMR has led several baseline studies of single-family and multifamily new construction in Massachusetts, which were used to update the User Defined Reference Home (UDRH) used in calculating program savings and to assess code compliance at the beginning and end of different code cycles. NMR also conducted residential new construction baseline studies in Connecticut, Rhode Island, and Vermont. In Maine, NMR conducted a baseline study of existing single-family homes, and in Vermont, NMR has conducted two baseline studies of existing multifamily

homes. Contacts: Bill Blake, National Grid, 40 Sylvan Road, Waltham, MA 02451, 781-907-1583, William.Blake@nationalgrid.com; Laura Martel, Efficiency Maine Trust, 151 Capitol Street, Suite 1, Augusta, Maine 04330, 207-213-4143, laura.martel@efficiencymaine.com; Brian Cotterill, Department of Public Service, 112 State Street, Montpelier, VT 05602, 802-828-3212, Brian.Cotterill@vermont.gov.

Net Savings Scoping Study and Study on the Definitions and Treatment of Net and Gross Savings in Energy and Environmental Policy, Northeast Energy Efficiency Partnerships Evaluation, Monitoring, and Verification Forum (2012). Conducted a study to increase understanding of how net energy savings is defined and how stakeholders use net savings estimates, and to identify opportunities and barriers to increasing the consistency of and quality in net savings definitions and measurement in the region; and a follow-up study to help ensuring the understanding, transparency, and credibility of electric and gas energy efficiency resources implemented in the Northeast and mid-Atlantic region. Contact: Elizabeth Titus, Northeast Energy Efficiency Partnerships, Inc., 91 Hartwell Avenue, Lexington, MA 02421, 781-860-9177 x111, etitus@neep.org.

Non-Energy Impacts (NEI), Residential and Low-income Programs, Massachusetts Program Administrators (PAs) (2011-present). NMR conducted an evaluation identifying and estimating values of the NEIs associated with all of Massachusetts PAs' residential and low-income energy efficiency programs. Evaluation tasks include a review of the literature, in-depth interviews, surveys of program participants and quantification of NEIs. After concluding the evaluation, Dr. Clendenning appeared at a Massachusetts Department of Public Utilities (DPU) hearing along with program administrator evaluation staff and provided testimony about the NEI study. As a follow-up to the NEI study, NMR developed adjusted NEI values for residential heating, cooling, and water heating equipment that is early replacement compared to equipment that is replaced on failure, and is now assessing low-income NEIs. Contact: Monica Cohen, Nisource, 4 Technology Drive, Westborough, MA 01581, 508-836-7321, mcohen@nisource.com.

Residential Net to Gross Methodology, Massachusetts PAs (2011). NMR conducted a review and provided recommendations of methods that can be used to estimate net program effects for residential programs in Massachusetts. Contact: Monica Cohen, Columbia Gas of Massachusetts, 4 Technology Drive, Westborough, MA 01581, 508-836-7321, mcohen@nisource.com.

Job Impacts from Green Jobs/Green New York Program, NYSERDA (2013). NMR conducted survey research and analysis to support assessment of economic impacts of the Green Jobs Green New York Program (GJGNY). GJGNY program components have been integrated into many NYSERDA efforts, including the residential Home Performance with ENERGY STAR (HPwES) and Multifamily Performance programs. The primary purpose of the research was to estimate the number of direct jobs generated as a result of GJGNY-funded program activities and determine other job-related impacts, particularly on wage levels and worker skills, as well as challenges in recruiting skilled workers. This information served as inputs to an economic impact analysis to be performed by others. The survey research included in-depth interviews with program staff, analysis of secondary data, integration of jobs questions into previously planned data collection efforts by other program

evaluations, and original surveys with program partners and trade allies. Contact: Carley Murray, NYSERDA, NYSERDA, 17 Columbia Circle, Albany, NY 12203-6399, 518-862-1090 x3277, carley.murray@nyserda.ny.gov.

Better Buildings Program Net Savings and Market Effects Assessment, DOE (2012-2015). NMR led the market effects portion of the process and impact evaluation of the US Department of Energy's Better Buildings Neighborhood Program (BBNP) targeting commercial and residential end-users. The evaluation includes in-depth interviews with program staff and market informants, surveys of participating contractors, non-participating contractors, suppliers and distributors, and program participants as well as coordination with the process and impact evaluation teams to quantify any observed market effects. Contact: Ed Vine, Lawrence Berkeley National Laboratory, 974 Regal Road, Berkeley, CA 94780, 510-527-9933, elvine@lbl.gov.

Market Transformation Effective Practices Study, California Investor-Owned Utilities (2013-2014). This study identified effective program planning, design, implementation, and evaluation practices as described in the market transformation (MT) literature, and examined practices that have been used to support MT outside California. This study had a practical, hands-on focus, specifying *what to do* for effective market transformation. Contact: Brian Smith, Pacific Gas & Electric, 245 Market Street, Mail Code N4Q, San Francisco, CA 94105, 415-973-1180, b2sg@pge.com.

Multifamily New Construction Market Effects Baseline Study, California Public Utilities Commission (2013-2015). Under a subcontract to KEMA, NMR led an integrated study, with the dual objectives of establishing baseline measures for market effects of the California Investor Owned Utilities' (IOU) MFNC programs and characterizing the MFNC market in California. The study was conducted in two phases. In Phase I the team completed a market characterization and segmentation analysis of the California MFNC market during the 2010 to 2012 time period. Phase I included a preliminary analysis of the program and market theory linking program elements to potential market effects. Phase II included baseline measurements of MFNC projects built under the 2008 Title 24 standards during the 2010 to 2012 time period as well as case studies of a subset of projects included in the baseline. The case study approach allowed the evaluation team to develop a detailed understanding of the role of energy efficiency in MF buildings and the impact of the program on the energy efficiency of MF buildings. Contact: Ken Keating, Evaluation Advisor to the CPUC, 6902 SW 14th Avenue, Portland, OR 97219, 503-244-7204, keatingk2@msn.com.

Small Commercial & Residential HVAC Market Effects Baseline Study, California Public Utilities Commission (2012-2014). Under a subcontract to KEMA, NMR conducted a baseline characterization of current HVAC maintenance and installation practices among contractors who work in the small commercial and residential and sectors. In addition to primary data collection with customers, this study coordinated with and leveraged on-site field assessments being performed by numerous other CPUC evaluations. Key outcomes included developing a baseline estimate of market share, sales, installation, penetration, and saturation of energy-efficient HVAC systems, as well as developing a system for tracking market share and sales of energy-efficient HVAC equipment in the future. Contact:

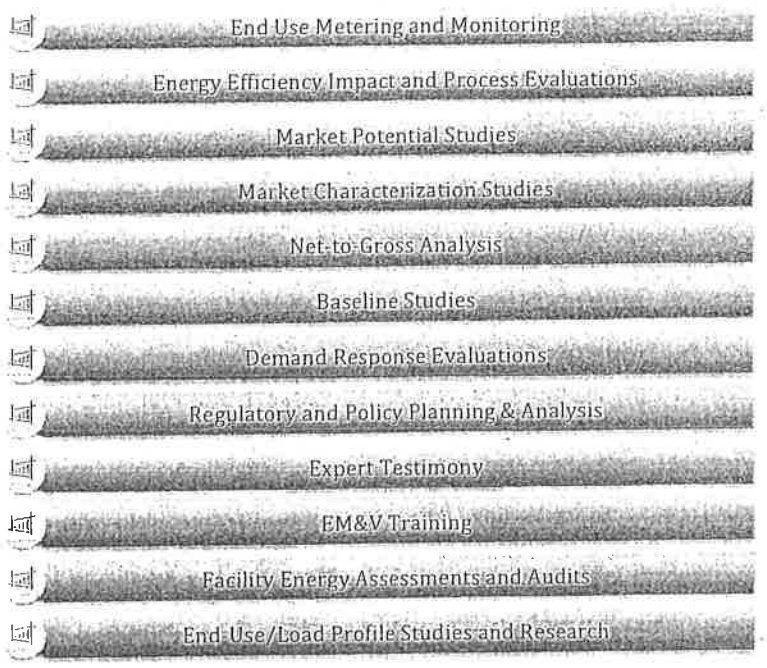
Ken Keating, Evaluation Advisor to the CPUC, 6902 SW 14th Avenue, Portland, OR 97219, 503-244-7204, keatingk2@msn.com.

4.2 CLEANTECH ADVISORY GROUP

Cleantech Advisory Group LLC (Cleantech) delivers a comprehensive range of DSM advisory services to utilities and governing agencies for the residential, commercial, industrial, institutional, and government market segments. Cleantech's Principal Consultants are industry leaders in the field of utility energy efficiency program Measurement and Verification (M&V) practices, having authored or assisted in the development of many of the industry's leading references, including the International Performance Measurement and Verification Protocol (IPMVP) and Statewide Evaluation Frameworks.

With a dedicated, experienced staff of energy professionals, Cleantech possesses extensive real-world experience implementing M&V practices to quantify program savings impacts, conducting complex portfolio evaluation studies, determining accuracy in program-reported savings, and evaluating lost revenue and cost-effectiveness analyses for investor-owned and public-owned utilities throughout the United States and Canada. Cleantech's senior staff have successfully designed, managed, and completed more than 25 evaluations of energy efficiency and demand response programs for utilities and regulators over the last decade. These qualifications allow Cleantech to approach work from multiple perspectives, ensuring that our findings are not only accurate, but also help inform utilities, regulators, and their stakeholders to make decisions on rate-payer funded investments.

Cleantech consultants have evaluated programs totaling hundreds of millions of dollars in funding and involving thousands of individual energy efficiency and demand response projects. Our core services include:



4.2.1 Representative Projects

PA ACT 129 Statewide Evaluator – Evaluation of Pennsylvania Electric Distribution Companies' Energy Efficiency and Conservation Programs, Pennsylvania Public Utility Commission (2009-2015). While working as a Principal Consultant at Nexant Inc., Salil Gogte was a member of the Statewide Evaluation (SWE) Team for the Pennsylvania Public Utilities Commission (PUC) from 2009 to 2015. This contract had a number of components which focus on evaluating the performance of the Energy Efficiency and Conservation (EE&C) programs of the seven large Pennsylvania Electric Distribution Companies (EDCs). Under the direction of the PUC, an evaluation process has been established that guides and monitors the sampling, data collection, savings estimation, reporting, and cost-effectiveness calculations of the evaluation contractors hired by each EDC.

The SWE team has created an Evaluation Framework (found at http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_PhaseII-Evaluation_Framework060114.pdf) to guide the utility EM&V contractors in the development of data collection and sampling protocols and the proper use of the Technical Reference Manual. They also created a menu of approaches, depending on size and type of program, for verifying gross and net impacts and producing process recommendations. After each program year, the SWE reviews the evaluation methods and findings of each program and advises the PUC on whether to adopt the claimed savings toward the EDC's statutory reduction targets or request revisions to the impact estimates.

TRM development and maintenance is another core task for the Pennsylvania SWE. The goal of the statewide TRM is to unify planning and verification processes and methodologies across the seven EDCs and ensure that program savings and benefits are

calculated and reported accurately. For each new measure our team adds, we develop corresponding EM&V guidelines to be followed as the measure is integrated into various utility programs throughout the state. As part of our TRM support, we developed MS Excel calculators to help the utilities and their contractors easily implement the TRM algorithms and calculate savings.

The PA SWE contract includes a number of primary research tasks in addition to the oversight and review duties. Since 2009, Salil has led two end-use saturation studies, two energy efficiency potential studies, a demand response potential study, a distributed generation potential study, and a commercial lighting metering study.

The reports for each of these studies can be found on the PA PUC's website (http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/act_129_statewide_evaluator_swe_.aspx) or furnished upon request.

One recent ad hoc task from the PA SWE contract was a quantitative assessment of weatherization contractor performance across the state's low-income program delivery streams. Using propensity score matching, a group of customers from each of the major contractors with similar observable characteristics was selected for analysis. Once our team was satisfied that a comparable group of 300-500 jobs from each contractor had been selected, a panel regression was performed to estimate the average daily kWh savings per $1,000 of program funds achieved by each contractor. Confidence intervals were presented for all estimates using robust standard errors. This analysis identified significant differences in contractor performance, and the PUC is considering additional research to determine the issues that drive these differences. Contact: Darren D. Gill| Deputy Director, Technical Utility Services, Pennsylvania Public Utility Commission, 400 North Street, 3rd Floor West |Commonwealth Keystone Building, Harrisburg, PA 17120, 717-783-5244, dgill@pa.gov.

New York State Energy Research And Development Authority (NYSERDA) – EM&V Contractor of New York Energy $Mart Program (2003-2007), NYSERDA-Con Edison Gas Efficiency (2007-2009) and System Wide Demand Reduction Program (2007-2010). While working as a Principal Consultant at Nexant, Inc., Salil led the evaluation, measurement and verification (EM&V) for NYSERDA's New York Energy $mart portfolio of 43 energy efficiency, market transformation and research programs, all funded through the State's system benefit charge. His primary responsibility under this multi-year contract was to independently verify the gross energy (kWh) and demand (kW) impacts that result from the operation of the Program. Using the evaluation team's broad engineering experience with energy-using systems found in commercial, residential, and industrial sectors, Salil reviewed project files to check that accepted savings calculation methodologies are used and correctly applied. The basic approach was to draw a random sample of representative projects and to calculate program realization rates that adjust NYSERDA's reported savings to match actual conditions found in the field. For each project in our sample, the team inspected installations to ensure that energy-efficient equipment that has received incentive money from NYSERDA was operating as designed. On-site activities included interviews with facility managers, witnessing equipment operation, collecting systems information, and taking spot measurements of power, temperature, flow, or other parameters. Based on the findings, the team determined the verified project savings and applied the results to the

sponsoring program. The EM&V results were used to quantify benefits that were credited to the operation of the New York Energy $mart, NYSERDA-Con Edison Gas Efficiency and the System Wide Demand Reduction Program. Contact: Judeen Byrne, Project Manager, NYSERDA, 17 Columbia Circle, Albany, NY, 12203-6399, phone: 518-862-1090 x3514, fax: 518-862-1091, email: judeen.byrne@nyserda.ny.gov

EM&V of Delaware Energy Efficiency and Demand Response Programs, Delaware Department of Natural Resources and Environmental Control (2011-2012). While working as a Principal Consultant at Nexant, Inc., Salil Gogte led the portfolio evaluation for the Delaware Department of Natural Resources and Environmental Control (DNREC), where the evaluation team developed an EM&V Framework and a Delaware-specific TRM, as well as provided impact and process evaluation services for Delaware's Sustainable Energy Utility's (SEU) statewide energy efficiency programs. Salil helped facilitate the stakeholder process for developing the EM&V Framework and played a central role in educating DNREC and informing the Framework on PJM Capacity Market participation. Salil led the efforts to adapt the Mid-Atlantic TRM to a Delaware-specific TRM through review of commercial measures and commercial baseline assumptions relevant to Delaware. Both the Framework and TRM informed future program EM&V throughout the state. The evaluation team also conducted program evaluations of ARRA-funded residential and non-residential statewide programs administered by Delaware's SEU. Specifically, the team conducted an impact and process evaluation of the commercial prescriptive and custom rebate programs, which focused largely on lighting and HVAC measures. The evaluation team also evaluated the new residential "green" construction program to assess the energy impacts, isolating market effects to understand common building practices. In addition to EM&V efforts, the team implemented baseline studies for both the residential and the commercial & industrial sectors. The project involved a considerable amount of stakeholder engagement and regulatory scrutiny from the Delaware Public Service Commission (PSC). A key aspect of Salil's role was to manage the interface between DNREC, outside interveners, PJM, the utilities, the SEU, and the Delaware PSC. Contact: Bahareh van Boekhold, LEED AP, Sustainable Communities Planner, Department of Natural Resources and Environmental Control, Division of Energy and Climate, 1203 College Park Drive, Suite 101, Dover, DE 19904, Phone 302-735-3495 (ext. 3495), Bahareh.vanBoekhold@state.de.us

4.3 Jesse Smith, Independent Energy Consultant

Jesse Smith is an experienced utility analyst and 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 helping clients improve those offerings. He has been involved in the design and evaluation, measurement, and verification (EM&V) of a wide variety of demand response, 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. While working as a consultant for Nexant, Jesse analyzed a number of behavioral conservation programs, including the largest Home Energy Report deployment in the

industry to date. Prior to joining Nexant, Jesse worked as a load research analyst for GoodCents Solutions, where he performed statistical analyses of the energy and demand savings of a number of direct load control and energy efficiency projects for client utilities. 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. Jesse is an experienced analyst and proficient with a variety of tools including SAS, Stata, SQL, and Excel.

4.3.1 Representative Projects

PA Act 129 Statewide Evaluator – Evaluation of Pennsylvania Electric Distribution Companies' Energy Efficiency and Conservation Programs, Pennsylvania Public Utility Commission (PA PUC) (2011-2015). Jesse was the Project Manager for Nexant's contract as the Statewide Evaluator of PA's energy efficiency and demand response programs. The Statewide Evaluator's role is to provide guidance and oversight to each of the seven electric distribution companies (EDCs) in the state and to audit the energy and peak demand savings values reported to the PA PUC. Jesse led a team of analysts and engineers responsible for maintaining the Pennsylvania Technical Reference Manual (TRM), compiling tracking data supplied by each of the seven EDCs on their commercial & industrial energy efficiency and demand response programs, and verifying that this information is being calculated and reported correctly. Jesse was a lead author of the Pennsylvania Evaluation Framework, and his team recently completed a statewide Commercial Lighting Metering Study and a Commercial and Industrial Baseline Study. These studies include over 1,000 site inspections and will inform future TRM updates and savings targets in the state. Jesse also led an assessment of non-residential demand response potential for the PAPUC that was completed in 2015. The seven EDCs have a combined summer peak of load of nearly 30,000 MW and $244 million in annual DSM program budgets. Previous ratepayer-funded demand response offerings in the state failed to pass the TRC test, so the first task in the study scope was to consider program design characteristics and recommend a more effective model given the various technical and policy constraints in place. The study classified residential and small commercial accounts by building type, demand magnitude, and weather sensitivity. Large commercial and industrial accounts were assigned to one of fourteen distinct business types. Jesse calculated price elasticity values for each business type using actual demand response program data in California, PJM, and previous offerings in Pennsylvania. These estimates of electricity price sensitivity provided data-driven intelligence on how large commercial and industrial accounts can be expected to respond to DR offerings. The study also considered the interplay between a potential state DR program and the PJM DR markets, which many large C&I customers already actively participate in. The study presents both full potential and potential net of existing DR commitments in wholesale markets. Contact: Darren D. Gill| Deputy Director, Technical Utility Services, Pennsylvania Public Utility Commission, 400 North Street, 3rd Floor West, Commonwealth Keystone Building, Harrisburg, PA 17120, 717-783-5244, dgill@pa.gov

MyHER Impact Evaluation, Duke Energy (2014-2015). Jesse was the lead analyst for the evaluation of Duke Energy's residential behavioral conservation initiative, MyHER. The program provides neighbor comparison reports to over two million residential customers in

Duke's service territory spanning Ohio, Indiana, Kentucky, North Carolina, and South Carolina. MyHER is a flagship program in Duke's DSM portfolio, generating nearly 500 GWh of savings annually. Jesse's responsibilities include requesting, processing, and analyzing in Stata the significant volume of data from Duke's data warehouse that is required to estimate the effect of the MyHER treatment. Because of the staggered deployment of MyHER across Duke's service territories, the impact evaluation of the program requires a careful consideration of impacts on a cohort basis to ensure that impact estimates are not confounded by cohort imbalances in the treatment and control groups. Once the total change in energy consumption is estimated via regression analysis, Jesse performs an "overlap analysis" using program tracking records from all other Duke DSM offerings to determine the quantity of savings which must be subtracted from the MyHER effect to prevent double-counting of savings. Jesse and his team also recently completed a bootstrapping simulation to provide Duke with strategic intelligence regarding the optimal size and composition of the control groups for each state.

Home Manager and Smart Thermostat Program Evaluations, CPS Energy (2011-2014). Jesse was the primary analyst for the evaluation of CPS Energy's Home Manager and Smart Thermostat demand response programs. These programs control residential and small commercial HVAC units, hot water heaters, and pool pumps allowing CPS Energy to curtail the energy use of these devices during peak periods. Nexant was tasked with quantifying system demand reduction resulting from curtailment events throughout the summers of 2012, 2013, and 2014. Jesse authored the statistical sample design portion of the M&V plans for the programs and led the data analysis portion of the evaluation. He wrote numerous SAS programs to import, manipulate, graph, and analyze the consumption data collected within the M&V plan. Jesse also developed time-series weather regression models to estimate program performance under both observed weather conditions and possible system emergency conditions. Contact: Keith Kaysing, 210-834-6020, KMKaysing@CPSEnergy.com

Nest Thermostat and ThinkEco Pilot Evaluations, CPS Energy (2014). Jesse managed the evaluation of two demand response pilot programs offered by CPS Energy in the summer of 2014. The Nest Rush Hour Rewards program offers existing Nest thermostat owners in CPS service territory an incentive to allow CPS to modify their set points on hot summer days. A randomized control trial (RCT) experimental design was developed and implemented for the pilot to accurately estimate load impacts and inform CPS's decision making about expanding the pilot into a full program within its portfolio. The ThinkEco pilot attempts to reach the 17% of CPS customers with room air conditioning. Participants are provided with a control device that allows them to operate their room AC unit like a programmable thermostat and control it from their smart phone. During DR events, the device will increase the thermostat setting in the room to reduce cooling load. Nexant used a within-subjects regression model to estimate impacts for the program.

Impact Evaluation of Residential Retail Products Program, Efficiency Maine Trust (2013-2014). As a subcontractor to NMR, Jesse contributed to the impact evaluation team for Efficiency Maine's Residential Retail Products program, which includes the Appliance program and the Lighting program. Through designing the evaluation and M&V approaches

to comply with ISO-NE requirements for M&V, set forth in the M-MVDR document to support the client's bid of resources into the Forward Capacity Market, he developed a comprehensive metering study to investigate energy consumption patterns of clothes washers, electric water heaters, refrigerators, and dehumidifiers. He coordinated and executed data collection efforts on the field with engineering staff to deploy and retrieve over 400 data loggers across nearly 100 homes. He developed SAS code to import and analyze all logger data in order to estimate ex-post energy and peak demand savings as well as develop 8,760 load shapes for each appliance. Jesse also led an analysis of free ridership within the upstream component of the Efficiency Maine's Residential Lighting Program. Using two years of sales data at various rebate levels, his team modeled the price elasticity of demand for various efficient lighting technologies and used these values to estimate the sales that would have occurred at the sales prices absent any program rebates. This modeling approach relies on the same founding principle as the program—a reduction in price will lead to increased adoption of efficient lighting options.

4.4 Optimal Energy, Inc.

Founded in 1996, Optimal Energy provides a full range of energy efficiency consulting services to investor and municipally owned utilities, program administrators, state and federal energy offices, regulatory commissions, advisory councils, and advocacy groups. We specialize in assessing, developing, designing, planning and launching efficiency programs 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 support their efforts to be a leading organization 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 acquire all cost-effective energy efficiency resources. Using our proprietary tools, our consultants provide in-depth technical analysis that is well regarded by the industry for its comprehensiveness and accuracy. We are nationally recognized for our assistance to policy-makers at all levels.

Our subject matter experts work on a range of energy-related challenges.

- Conducting in-depth market assessments to characterize the potential for electric, natural gas and fossil fuel efficiency
- Performing comprehensive studies to determine the technical, economic, and achievable potential for energy efficiency, demand response, and renewable energy programs
- Analyzing the costs and benefits of energy efficiency, 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
- Assisting program managers with business development, marketing campaigns, channel management, and oversight of implementation contractors
- Developing Technical Reference Manuals 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
- Managing collaborative processes with a wide variety of stakeholders to maximize the societal benefits from public and private investment
- Collaborating with interested stakeholders in the development of multi-year strategic evaluation plans to determine program-induced impacts
- Developing policies and procedures on regulatory issues ranging from public benefits charges to decoupling and utility incentives
- Providing regulatory and legislative analytical support and testimony on all aspects of energy efficiency and related issues, such as Integrated Resource Planning, cost-recovery, participation of efficiency resources in energy markets (e.g., ISO-NE Forward Capacity Market), and DSM as an alternative to supply-side investments.

4.4.1 Representative Projects

Delaware Statewide Potential Study, Delaware Department of Natural Resources and Environmental Control (DNREC) (2013). This study estimated energy efficiency potential scenarios for Delaware for electricity, natural gas and unregulated fossil fuel usage (petroleum fuels) in the buildings sector. Phase II of the project built on an initial effort to estimate Delaware's economic energy efficiency potential report completed in 2013. The analysis considers a 12-year study period, from 2014-2025 and included an update to the original economic potential estimate, a maximum achievable potential scenario, and two program potential estimates. Program potential was the primary focus of the report and is intended to support the discussion and consideration of pending legislation in Delaware regarding energy efficiency goals. To better inform future Delaware efficiency program goals and planning, the study also provides a realistic set of example programs that could be implemented to achieve those savings and the associated cost estimates for acquiring those resources. The Optimal Team researched best practice program designs and drew on its experience in other leading jurisdictions in the development of program design examples. We also conducted primary research to collect locally specific data to reflect more accurately the unique circumstances of energy consumers in Delaware. As a sample of a Potential Study that is representative of our ultimate work product for KPCo, we have included a link to the final report for the Delaware Potential Study in Section 4.6, Prior Work Reports and Deliverables. Contact: Roger Underwood, Delaware Department of Natural Resources and Environmental Control, Division of Energy & Climate, 1203 College Park Drive, Suite 101 Dover, DE 19904, 302-735-3489, robert.underwood@state.de.us.

New York Statewide Potential Studies, NYSERDA and New York Power Authority (1999-2014). Optimal Energy has been conducting potential studies for NYSERDA since the late 1990s. This most recent engagement leverages our team's extensive measure and market

research focusing on long-term projections of currently planned and more aggressive energy efficiency and renewable energy initiatives. Our team is engaged with NYSERDA staff to identify and assess end-use energy efficiency improvement opportunities for all fuels as well as distributed renewable energy resources in the residential, commercial, industrial, and government sectors. As with our previous engagements, OEI is also analyzing the greenhouse gas and other air pollutant emission reductions associated with the various savings estimates. Phase I of this study was completed in 2012, and Phase II in 2014.

In 2003, we conducted a comprehensive analysis of all cost-effective energy efficiency (EE) and renewable (RE) potential throughout the state. This study was updated in 2008. In 2006, OEI conducted a natural gas potential study prior to the New York Public Service Commission's investigation into establishing a natural gas system benefit charge. All three of the earlier studies assessed economic and achievable potential across the state. For the electric potential study, OEI characterized and screened over 2,000 electric measures and evaluated the most likely impacts of federal and state appliance standards scheduled to take effect. The maximum achievable potential analysis included three scenarios. For the natural gas potential study, the Optimal Team characterized and screened over 1,000 measures in an assessment of economic and program scenario potential from natural gas efficiency. Contact: Carl Mas, NYSERDA, 17 Columbia Circle, Albany, NY 12203-6399, 518-862-1090 x3294, cjm@nyserda.org.

The Optimal Team has also conducted a number of potential studies for the New York Power Authority (NYPA), America's largest state power organization. NYPA serves a diverse customer base including state agencies, local and rural electric distribution companies, and large industrial facilities. Our most recent potential assessment was completed in 2011. For this assessment, we examined the energy savings potential in the ten largest state agencies, which together comprise 96% of statewide energy use in state buildings. Assuming an aggressive 5-year implementation horizon, OEI identified all cost-effective existing and emerging energy efficiency technologies and program practices to lower end-use electricity, natural gas, and fuel oil consumption. Our scenarios incorporated the best practice implementation strategies developed thus far in the United States. An integral aspect of the energy efficiency assessment study included OEI's analysis of the impact the cost of financing would have on the state's return on efficiency investments. Our study determined that under a variety of interest rate scenarios, investment in energy efficiency would result in significant net benefits for a large percentage of efficiency opportunities.

In 2007, NYPA commissioned a complete study of the potential for electric energy efficiency among its government customers in Southeastern New York. This study examined the potential available from existing technologies and practices to lower end-use electricity requirements in all existing and new facilities of the government customers over a ten year period. As part of this study, OEI conducted 43 audits of a stratified sample of government customers designed to reflect the population of NYPA's SENY government customers. These audits comprised approximately 7.5 million square feet of facility space and documented current equipment, efficiencies, and opportunities. Contact: Helen

Eisenfeld, Director - Program Administration & Quality Control, New York Power Authority; 123 Main St., Mail Stop 10 – H, White Plains, NY 10601-3170; 914-287-3728; helen.eisenfeld@nypa.gov.

Technical Resource Manual (TRM) Experience, Massachusetts Energy Efficiency Advisory Council, Northeast Energy Efficiency Partnerships EM&V Forum, and Ohio PUC. (2010-present). Optimal Energy employs engineers and technical experts who have extensive experience in measure characterization, having led Technical Reference Manual (TRM) development for three clients in the last four years alone. These clients include the Massachusetts Energy Efficiency Advisory Council, the Northeast Energy Efficiency Partnerships' EM&V Forum, and the Ohio PUC. For example, for the EM&V Forum, Optimal has contributed to developing and maintaining TRM documents containing peer-reviewed common assumptions for residential and commercial efficiency measures in Maryland, Delaware, and the District of Columbia. This project required an in-depth review and analysis of the appropriate savings algorithms for commercially available technologies. An integral aspect of this project was to ensure the reliability and replication of the savings algorithms, especially weather-sensitive measures having critical coincident peak savings impacts. Optimal and its partners were not only charged with documenting measure characteristics in the TRM but also working with a variety of stakeholders to arrive at consensus on TRM inputs. In addition to our direct TRM development work, our staff have performed numerous critical reviews of and commentary on other TRMs. Other jurisdictions where Optimal has been involved in TRM development include Illinois, Louisiana, Pennsylvania, New Jersey, and Vermont. Last, Optimal staff are continually refining and updating our in-house library of measure characterizations as part of our potential study projects. Contacts: Elizabeth Titus, Senior Research and Evaluation Manager, Northeast Energy Efficiency Partnerships; 91 Hartwell Ave, Lexington, MA 02421; 781-860-9177; etitus@neep.org

4.5 Abraxas Energy Consulting

Since 2001, Abraxas Energy Consulting has provided our clients with solid experience and know-how. We are active in two spheres: ***energy analysis*** and ***energy accounting.***

In the ***energy analysis sphere***, we provide energy audits, retro-commissioning and measurement and verification services for the federal government, ESCOs, utilities, and commercial customers. As energy consultants, we assist ESCOs when they are overstaffed, we provide audits for LEED certification, and provide audits for the Federal Government to meet their EISA requirements.

In the ***energy accounting sphere,*** we specialize in fitting our customers with the right utility bill tracking software for their needs. In addition, we set up utility bill tracking databases and maintain them for our ESCO, commercial and federal clients. We work with over one hundred schools, government agencies and private companies on energy management projects of all sizes. We provide clients with the expertise and software tools they need to best help them manage their energy usage.

4.5.1 Representative Projects

Site-specific Measurement and Verification Plans, Empower Maryland (2012). Abraxas developed site-specific measurement and verification plans for eight nonresidential custom incentive projects as part of an ex-post impact evaluation of the EmPower Maryland custom incentive program. This included assessing the key uncertainties in the calculations, determining the proper baseline, and recommending metering and analysis procedures for addressing the key uncertainties. All M&V was required to be compliant with the PJM M&V Manual 18B. The projects we evaluated included: roof-mounted energy recovery units, fume hood replacements, hotel room HVAC control, VFDs on chillers, new chillers, replacing refrigeration display cases and controls retrofit/retro-commissioning. Contact: Kevin Warren, Warren Engineering, 10 Exchange Place, Suite 200, West Grove, PA 19390, 610-869-7590, kevin@warren-energy.com.

M&V of Energy Savings Performance Contracts of Federal Buildings, ABM Industries (2014-2015). ABM contracted Abraxas to write the M&V Plan, conduct baseline and post-retrofit measurements, and write the Year 0 and Year 1 M&V reports for both Phase 1 and Phase 2 of a $30M+ ESPC on five GSA-owned federal buildings in the Los Angeles area. We wrote M&V plans for over 70 ECMs including: chiller plant retrofits, pony chillers, pressure independent control valves, centrifugal separators, replacing cooling coils, fan walls, premium efficiency motors, water side economizer, lighting and lighting controls, building insulation, window tinting, AHU RCx measures, DCV on AHUs and exhaust fans, repairing VFDs, VFDs on CHW pumps, VFDs on cooling tower fans, replacing transformers, instantaneous hot water heaters, water conservation measures, replacement of RTUs, and others. Most of the measures were Option A and Option B, although some Option C was used. We were careful to document building baseline conditions in the M&V Plan, including equipment schedules, existing control sequences and set points, building operation hours, etc. We collected baseline data using calibrated instruments, took pictures of our spot measurements and logger setups, and used government witness forms. We measured amps, power, temperatures, VFD speeds, light intensity, lighting hours, and GPM on 4 chiller plants and a sample of AHUs. Standard sampling methodologies were used, based on FEMP M&V Guidelines. Extensive use was made of data loggers and trend data. For the AHUs, this interval data was integrated into bin simulation models. For many of the ECMs, it was impossible to separate out different ECMs when they were done on the same equipment. For example the following ECMs were all considered together: repairing VFD on SF, DCV, HD and CD resets, and premium-efficiency motors. In many cases, rather than log power measurements, as power meters were expensive, we performed tests of fan kW vs. VFD% on fans. We then were able to track VFD% in the BAS, using our power meters to log the chillers instead. The chiller M&V plans were done in accordance with FEMP M&V Guidelines, using several models: the building cooling load profile (cooling tons vs. OAT), the chiller plant performance model (kW/ton vs. tons), and models for the CHW and CW pumps, and cooling tower fans. eQUEST models were used to estimate energy savings for the building envelope measures. For the Phase 1 project, we conducted post-installation measurements, calculated energy savings and produced a Year 0 M&V Report. We expect to do the same for Phase 2 when it comes. Contact: Michael Bartlett, ABM Industries, 551

Fifth Avenue Suite 300, New York, New York 10176612-315-6040, michael.barlett@abm.com.

Third-Party Verification of Energy Savings Performance Contracts, U.S. Department of Housing and Urban Development (2012-2014). Patrick McLaughlin performed work for this contract while working for Kisan Engineering/C.J. Brown Energy between Oct. 1, 2012 and Sept. 30, 2014. The scope of the contract was to provide myriad technical services to the U.S. Department of Housing and Urban Development's (HUD) Energy Center specifically regarding ESPCs between Public Housing Authorities (PHAs) and Energy Service Companies (ESCOs). Some of the tasks performed were: reviewing draft ESPCs to ensure compliance with federal regulations and HUD guidelines; reviewing annual M&V reports; internal review of past ESPCs approved by HUD; technical assistance to HUD for baseline adjustments to existing ESPCs; technical assistance to PHAs in developing self-managed ESPCs. Each task included a deliverable report with the details of efforts expended and summary of the findings.

Annual M&V reports are required by HUD for PHAs engaged in ESPCs in order to evaluate performance and determine the appropriate level of annual operating funds for the housing authority. These annual reports were analyzed and a deliverable report with the summary of findings was provided to HUD. These deliverable reports typically contained an assessment of the accuracy of the cost savings, issues with energy savings calculations and baseline adjustments, issues with adherence to federal regulations, a risk assessment for HUD and the PHA due to any uncovered issues, and recommendations on how to improve the process.

No annual M&V report submitted by a PHA was perfect. Each M&V report was authored by a third party company (typically the ESCO) on behalf of the PHA, and they all came rife with inconsistencies, omissions and errors. Often times the review of the M&V report required working with the local HUD field office, the ESCO and the PHA to develop corrective actions to ensure energy consumption savings were sufficient to cover legitimate debt costs and that HUD was not at risk of overpaying operating funds to the PHA. Our assistance to HUD for this contract uncovered and rectified many issues which would have gone unnoticed totaling thousands in lost tax payer dollars. Contact: Anthony Misercola, HUD, 716-551-5755 x 5415, anthony.j.misercola@hud.gov.

Retro-commissioning and Energy Auditing on a Federal Building, General Services Administration (2014). Abraxas completed an energy assessment and retro-commissioning (RCx) study of the 600,000 square foot Hagel Federal Building in Richmond, California. The audit and RCx were conducted simultaneously.

During the initial visit, all the relevant information on the existing building conditions was collected. This on-site assessment included reviewing building and equipment data, interviewing site personnel, reviewing the capabilities of the building automation system (BAS), observing equipment operation, and conducting measurements. The HVAC systems, lighting, renewable energy systems, building envelope, and water/plumbing systems were evaluated. Subsequent investigation visits to set up trends in the BAS were required due to the large number of control points needed to monitor the equipment. Utility

data was gathered and analyzed to determine the facility energy utilization index (EUI). The RCx Plan included a detailed plan for monitoring and testing of the systems within the project scope.

Several energy audit measures were identified, including upgrading exterior lighting to bi-level LEDs, upgrading interior lighting to LEDs and installing lighting controls, and installing low flow water fixtures. Investment, cost savings, and simple payback for each measure were calculated.

The focus of the RCx study was to identify RCx measures that would optimize the operation of the twelve main air handling units, the chiller plant, and the heating plant and cogeneration system. It was discovered that the HVAC system was designed for the humid conditions found on the East Coast, even though the building is located in California. The systems are currently controlled by humidity and use enthalpy sensors to control set points. The AHUs have enthalpy wheels, and two of the four chillers in the central chiller plant are low temperature glycol chillers, which are not needed in the Bay Area.

During the investigation phase the RCx Investigation Report was developed with recommendations from the investigation process. This investigation process included several site visits by a team of three engineers. The engineers performed point to point testing as well as functional testing on all twelve air handling units, the CHW plant, and the HHW plant. Points tested included temperature, humidity, fan/pump/enthalpy wheel speeds, damper positions, and valve positions. Functional testing included the operation of the economizer dampers of the AHUs, the operation of the supply fans of the AHUs, the operation of the CHW and HHW valves of the AHUs, and the pump staging of the central chiller and hot water plants. Items identified during the investigation phase included: sensors out of calibration, fans/pumps with VFDs in bypass, economizer dampers manually locked in fixed positions, and actuators/dampers not responding to commands from the BAS.

Several low cost RCx measures were identified and recommended. These included:

- Switching the control of the AHUs from humidity to dry bulb temperature and bypassing the enthalpy wheels.
- Staging the chillers such that the glycol chillers would be used minimally. The regular temperature chillers and a HX are expected to be able to handle most, if not all, the cooling load of the building. The glycol chillers would remain off unless the cooling load was not being met.
- Controlling the cooling tower fans with a floating pressure control based on wet-bulb.
- Implementing reset strategies such as static pressure reset for the AHUs, supply air temperature reset for the AHUs, and chilled water reset for the chiller plant.

RCx measures requiring some capital outlay were also identified. These include replacing three-way valves with two-way valves and installing variable frequency drives (VFDs) on chilled water and hot water pumps, implementing demand controlled ventilation (DCV) for select AHUs, implementing CO control of a garage exhaust fan, and repairing the

pneumatic lines of the central chiller plant. Contact: Susana Mercado, General Services Administration, 415-793-8399, susana.mercado@gsa.gov.

4.6 Prior Work Reports and Deliverables

Table 28 presents examples of prior work reports and deliverables, including web links to the reports.

Table 28: Examples of Prior Work Reports and Deliverables

Report	Web Link
Vermont Single-Family Existing Homes On-site Report	http://publicservice.vermont.gov/sites/psd/files/Topics/Energy_Efficiency/EVT_Performance_Eval/VT%20SF%20Existing%20Homes%20Onsite%20Report%20-%20final%20021513.pdf
Vermont Multifamily Report	http://publicservice.vermont.gov/sites/psd/files/Topics/Energy_Efficiency/EVT_Performance_Eval/VT%20MF%20Onsite%20Report%20-%20Final%20062613.pdf
Connecticut Weatherization Baseline Assessment	http://www.energizect.com/government-municipalities/single-family-weatherization-baseline-assessment-r5
Evaluation of the Year 2 CL&P Pilot Customer Behavior Program (R2)	http://www.energizect.com/sites/default/files/Evaluation%20of%20Year%202%20CL%26P%20Pilot%20Behavior%20Pgm%20%28R2%29%2C%20Final%20Report%2C%208-8-14.pdf
Northeast Residential Lighting Hours-of-Use Study	http://ma-eeac.org/wordpress/wp-content/uploads/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf
Regional Net Savings Research, Phase 2: Definitions and Treatment of Net and Gross Savings in Energy and Environmental Policy	http://www.neep.org/sites/default/files/resources/NEEP%20-%20Regional%20Net%20Savings%20Report%2012-05-12.pdf
Market Effects, Market Assessment, Process and Impact Evaluation of the NYSERDA Statewide Residential Point-of-sale Lighting Program - Final Report	http://www.nmrgroupinc.com/wp-content/uploads/2015/12/Market-Effects-Market-Assessment-Process-Impact-Eval-NYSERDA-POS-Lighting.pdf
Phase 1 Assessment of Direct Job Impacts of the Green Jobs Green New York Program	http://www.nmrgroupinc.com/wp-content/uploads/2015/12/Phase-1-Assessment-of-Direct-Job-Impacts-GJGNY.pdf
2014 Commercial & Residential Light Metering Study	http://www.puc.pa.gov/pcdocs/1340978.pdf
Pennsylvania Statewide Act 129 2014 Non-Residential End Use & Saturation Study	http://www.puc.state.pa.us/Electric/pdf/Act129/SWE-2014_PA_Statewide_Act129_Non-Residential_EndUse_Saturation_Study.pdf
Demand Response Potential Pennsylvania	http://www.puc.pa.gov/pcdocs/1345077.docx
CPS Energy Nest Pilot Evaluation FY2015 - FINAL	http://www.nmrgroupinc.com/wp-content/uploads/2015/12/CPS-Nest-Thermostat-Pilot.pdf
Efficiency Maine Retail Lighting Program Overall Evaluation Report	http://www.efficiencymaine.com/docs/Efficiency-Maine-Retail-Lighting-Program-Evaluation-Report-2015.pdf
Efficiency Maine Appliance Rebate Program Evaluation	http://www.efficiencymaine.com/docs/Efficiency-Maine-Appliance-Rebate-Program-Evaluation-Report-2014.pdf

Report	Web Link
Overall Report	
Energy Efficiency and Renewable Energy Potential Study of New York State (Volume 2: Energy Efficiency Methodology and Detailed Results)	http://www.nyserda.ny.gov/-/media/Files/EDPPP/Energy-Prices/Energy-Statistics/14-19-EE-RE-Potential-Study-Vol2.pdf
Energy Efficiency and Renewable Energy Potential Study of New York State (summary)	http://www.nyserda.ny.gov/-/media/Files/EDPPP/Energy-Prices/Energy-Statistics/14-19-EE-RE-Potential-Study-Summary.pdf
Energy Savings Potential in Delaware	http://www.optenergy.com/wp-content/uploads/2014/08/Delaware-Energy-Efficiency-Potential-Study-Executive-Summary.pdf
Energy Savings Potential in Delaware (presentation)	http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EEAC/OptimalPresentation12.4.14.pdf
Guide for Conducting Energy Efficiency Potential Studies	http://192.185.41.244/~optimale/wp-content/uploads/2014/08/EPA-Guide-for-Conducting-EE-Potential-Studies.pdf

Section 5 Statement of Potential Conflicts of Interest

NMR Group, Inc.

NMR Group, Inc., has previously performed evaluation services for FirstEnergy for Phase I and Phase II of Act 129 as a subcontractor to ADM. ADM has been the prime evaluation contractor for FirstEnergy for Phase I and Phase II of Act 129. Should the NMR team be selected for the Phase III SWE project, NMR will immediately cease all work for ADM on the FirstEnergy Phase II evaluations and refrain from any further EDC work through the end of the Phase III SWE contract period.

Cleantech Advisory Group

Cleantech Advisory Group LLC (Cleantech) has not performed evaluation or conservation services for the EDCs or their affiliates in the past five years. The following Cleantech employees have previous EDC relationships described below.

- Prior to joining Cleantech, Ms. Mansee Muchrikar and Mr. Solomon Rosenbaum performed evaluation services for PECO and PPL as subcontractor to Warren Energy Engineering (WEE) in Phase II of Act 129. WEE is a subcontractor to PECO and PPL's primary evaluation contractors, Navigant, Inc., and Cadmus Group, Inc.
- While working for Nexant, Inc., Mr. Salil Gogte worked for PPL in a small role as an Advisor to the tracking system development project. His involvement was limited to initial kickoff activities, less than 20 hours in total.

If the NMR team is selected for the Phase III SWE project, Cleantech and its employees will not provide evaluation or conversation services or other products to the EDCs or their affiliates in Phase II or Phase III of Act 129.

Jesse Smith, Independent Energy Consultant

Jesse Smith has not performed any evaluation or conservation services for the EDCs in the past five years and does not plan to do so in Phase III of Act 129.

Optimal Energy, Inc.

Optimal Energy, Inc., has previously provided consulting services to PennFuture, a non-profit organization focused on environmental and public health in Pennsylvania. In 2011, Optimal prepared a report for PennFuture on the Phase II Act 129 efficiency goals. Since that time, Optimal has provided PennFuture with reviews of and commentary on TRM updates, DSM plans filed by EDCs, and potential studies conducted by the Statewide Evaluator (SWE).

Optimal Energy does not believe that these previous engagements represent a conflict of interest, nor that they compromise the need for impartiality on the part of the SWE. In all cases, Optimal Energy's role was to provide our best, unbiased, professional opinion on the matter at hand. Having provided these opinions to PennFuture in the past does not limit our ability to provide continued unbiased professional opinions in the future on behalf of the SWE. Should the NMR team be selected for the SWE position, Optimal Energy will

immediately cease all work for PennFuture and refrain from any further work through the end of the SWE contract period.

Abraxas Energy

Abraxas Energy Consulting has not performed any evaluation or conservation services for the EDCs in the past five years and does not plan to do so in Phase III of Act 129.

Section 6 Exceptions to Act 129 Statewide Evaluator Contract

NMR Group, Inc., along with its subcontractors Abraxas Energy Consulting and Cleantech Advisory Group, respectfully submits the following edits upon award of the Contract.

~~Deletions in blue and strikethrough~~

Additions in red and underlined

O. Indemnity.

The Contractor agrees and undertakes to indemnify, defend, and hold harmless the Commission, the Contracting Entity, the EDCs, and their respective agents and employees or subcontractors against all liabilities, claims, damages, causes of action, judgments, costs and expenses, including reasonable attorneys' fees, related to or arising from the negligent acts or omissions or willful misconduct ~~in any way relating to or arising out of any action or operation~~ of the Contractor, or its agents, employees, or subcontractors under this Contract, ~~including but not limited to personal injury or property damage, including but not limited to~~ for injury or damage to the person or property of the Commission, the Contracting Entity, the EDCs, or the Contractor, or their respective agents, employees, or subcontractors, and shall, at the request of the Commission, the Contracting Entity or any of the EDCs, defend any and all actions brought against the Commission, the Contracting Entity or the EDCs, and their respective agents, employees, or subcontractors based upon any such claims or demands. This Indemnity shall not apply relating to any penalty imposed by the Commission on the Contracting Entity or an EDC. The Contractor expressly waives use of the "statutory employer" defenses provided in the Pennsylvania Worker's Compensation Act at 77 P.S. § 481(a) and (b) and 77 P.S. § 52 with regard to this indemnity. The Commission, the Contracting Entity, the EDCs, and their respective agents and employees or subcontractors shall not be indemnified, defended, or held harmless by the Contractor against liability for damages caused by or resulting from their own negligent acts or omissions or willful misconduct.

P. LIMITATION OF LIABILITY.

IN NO EVENT, WHETHER BASED ON CONTRACT, INDEMNITY, WARRANTY, TORT (INCLUDING NEGLIGENCE OR GROSS NEGLIGENCE), STRICT LIABILITY OR OTHERWISE, SHALL ANY PARTY OR THEIR RESPECTIVE AGENTS OR EMPLOYEES OR SUBCONTRACTORS, BE LIABLE TO ANY PARTY OR THEIR RESPECTIVE AGENTS OR EMPLOYEES OR SUBCONTRACTORS, FOR SPECIAL INDIRECT, INCIDENTAL, PUNITIVE, OR CONSEQUENTIAL DAMAGES WHATSOEVER INCLUDING, WITHOUT LIMITATION, LOSS OF PROFITS OR REVENUE OR COST OF CAPITAL.

Notwithstanding the Consultant's indemnification obligations under this agreement, the liability of Consultant for any claim whatsoever shall not exceed 1.5 times the total contract price for services provided by the consultant under this agreement.

Appendix A Key Staff Resumes

Lynn Hoefgen

NMR Group, Inc.

Education

Ph.D., Anthropology, University of Florida	1985
M.A., Anthropology, University of Florida	1977
B.A., Anthropology, University of Kansas	1975

Work Experience

NMR Group, Inc. (formerly Nexus Market Research), Somerville, Massachusetts
Founder and President — 2001 – Present

Opinion Dynamics Corporation, Cambridge, Massachusetts
Vice President and Director, Energy Practice — 1989 – 2001

Behavioral Science Research, Coral Gables, Florida
Vice President — 1987 – 1989

Cambridge Reports, Inc., Cambridge, Massachusetts
Vice President and Director of Analysis — 1982 – 1987
Research Analyst — 1980 – 1981

Social Systems Analysts, Inc., Watertown, Massachusetts
Research Associate — 1979 – 1980

Selected Projects

Energy Efficiency Reporting Guidelines, Northeast Energy Efficiency Partnerships. Helped develop guidelines for reporting energy savings, costs, and emissions reductions for energy efficiency programs in ten states and the District of Columbia.

Evaluation Assistance—General, NYSERDA. Provided assistance to NYSERDA in planning, coordinating, and analyzing evaluation activities for the Energy $mart programs. Tasks included gap analysis, development of preliminary evaluation plans for multiple programs, review of evaluation plans and schedules, and assistance in coordinating the work of individual program evaluators, data collection and tracking, and reporting.

Market Effects—Residential and Commercial, Massachusetts PAs. Led the effort to reach common understanding and definitions of market effects and the conditions that lead to them, identify programs that can reasonably be expected to induce market effects, and develop a framework for conducting market effects studies in the residential and commercial sectors.

New Construction—Residential, Massachusetts PAs. In 2002, led the development of long-term evaluation plans. From 2002 through the present, updated the evaluation plans regularly, and conducted impact, process, and market evaluations.

Residential Sector Evaluation, Connecticut Energy Efficiency Fund. Helped in NMR role as lead contractor for evaluations in the residential sector, including planning and executing

studies such as: conducing 180 on-site assessments of existing single-family homes to establish a baseline of weatherization to help meet the legislated mandate that 80% of residences in Connecticut be weatherized by 2030; an impact and process evaluation of the ground-source heat pump program; and impact and process evaluation of the central air conditioning program; and impact and process evaluation of the home energy services program; a residential lighting net-to-gross study; and long-term planning for estimating net savings from codes & standards programs.

Treatment of Net and Gross Savings in Energy and Environmental Policy, Northeast Energy Efficiency Partnerships EM&V Forum. Conducted a study to help ensure the understanding, transparency, and credibility of electric and gas energy efficiency resources implemented in the Northeast.

Selected Publications and Presentations

"Study It 'til You're Sick of It: CFL Research as an Example for Other Efficiency Markets," IEPEC Conference, August 2013

"Finding and Counting Market Effects: A New Construction Program Example," IEPEC Conference, August 2011

"Choosing the Right Tools: How Different Markets and Programs Call for Different Approaches to Estimating Net Impacts," ACEEE/CEE Symposium on Market Transformation, March 2010.

"Market Effects and Market Transformation: Their Role in Energy Efficiency Program Design and Evaluation," California Institute for Energy and Environment, March 2009 (coauthor).

"Market Effects: Claim Them Now or Forever Hold Your Peace," 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

"Asking the Tough Questions: Assessing the Transformation of Appliance Markets," ACEEE Summer Study on Energy Efficiency in Buildings. August 2006.

"Learning to Play Well with Others: Obtaining Shipment and Sales Data through Long-Term Relationships with Manufacturers," ACEEE Summer Study on Energy Efficiency in Buildings. August 2004.

"Assessing the Effects of Utility Programs on the Market Penetration of ENERGY STAR Appliances," ACEEE/CEE Symposium on Market Transformation. March 2004.

"Market Research for Market Transformation: How It Fits into Product Development," presented at the ACEEE/CEE Market Transformation Conference, 2002, Washington, DC.

"Measuring and Targeting Market Transformation in the New England Residential Lighting Market," *Electric Perspectives,* July, 1999.

"Consumer Reactions to 'Green' Marketing in New England," IEPEC Conference, August 1997

Rohit Vaidya

NMR Group, Inc.

Education

Graduate Studies, Sociology, Columbia University	1979 – 1980
B.A., Economics and Mathematics, University of Delhi, India	1978

Work Experience

NMR Group, Inc. (formerly Nexus Market Research), Somerville, Massachusetts
Vice President — 2008 – Present

Health Focus International, St. Petersburg, Florida
Vice President — 2005 – 2008

Nexus Market Research, Cambridge, Massachusetts
Vice President — 2003 – 2004

Sterling Research Group, St. Petersburg, Florida
Chief Methodologist — 2001 – 2002

PSI Global / NFO Financial Services, Tampa, Florida
Senior Vice President — 1997 – 2001

Opinion Dynamics Corporation, Cambridge, Massachusetts
Vice President — 1991 – 1997

Behavioral Science Research, Coral Gables, Florida
Vice President — 1988 – 1991

Selected Projects

Evaluation Assistance—General, NYSERDA. Provided assistance to NYSERDA in planning, coordinating, and analyzing evaluation activities for the Energy $mart programs; special focus on process and survey evaluation activities.

Process and Impact Evaluation of Program Portfolio, Nova Scotia Power. A comprehensive multi-year evaluation that involved process and impact evaluations of the complete portfolio of commercial/industrial and residential programs.

HVAC Program Market Effects—California Public Utilities Commission. Led a study to establish baselines for current maintenance and installation practices and market share for HVAC quality maintenance (QM) and quality installation (QI) programs in California.

Green Jobs Green New York Job Impacts, NYSERDA. Directed survey research and analysis to support assessment of economic impacts of the Green Jobs Green New York Program (GJGNY).

Methodologies for Estimating Net-to-Gross. Massachusetts Program Administrators. Collaborated on preparation of paper recommending methodologies for estimating Net-to-Gross impacts of residential programs in Massachusetts.

Market Transformation Effective Practices Study, California Public Utilities Commission. This study identified effective program planning, design, implementation, and evaluation practices as described in the market transformation (MT) literature, and examined practices that have been used to support MT outside California. This study had a practical, hands-on focus, specifying what to do for effective market transformation.

Market Progress and Evaluation Reporting. For the Massachusetts ENERGY STAR Homes and Appliances Programs, conducted market research to assess whether hypothesized market effects are occurring, whether major barriers are being addressed, and whether the program is operating efficiently.

Residential HVAC Study. For Long Island Power Authority, study to update a previous baseline study on the values for key indicators of market changes. The study involves depth interviews with HVAC distributors and contractors, a survey of end-users, and a review of government standards and requirements.

Design of an Energy Efficiency Program for Multi-Family Buildings, Energy Efficiency Program Administrators (PAs) in Massachusetts. Based on focus groups with landlords and developers, in-depth interviews with program administrators, and a literature review.

Green Jobs Green New York, NYSERDA. Process evaluation of NYSERDA's "Green Jobs Green New York" program, which operates in conjunction with the Home Performance with ENERGY STAR program. Evaluation was based on interviews with program staff and contractors as well as surveys of participants, nonparticipants, and contractors.

Process and Impact Evaluation of Natural Gas Heating and Water Heating Program, GasNetworks. With Cadmus as a subcontractor, the impact evaluation included estimating gas savings impacts for measures installed by participants. Program elements assessed in the process evaluation included program design, marketing, delivery, awareness, participation, customer experience, satisfaction, free ridership, contractor role in program implementation, contractor installation practices, and effectiveness of rebate processing contractors.

Selected Publications and Presentations

"Process and Market Evaluation of a Program that Integrates Green Legislation Components into a Residential Energy-Efficiency Program," IEPEC Conference, August 2013

"Commercial Building Benchmarking: Will They Manage It Once They've Measured It?," ACEEE Summer Study on Energy Efficiency in Buildings, August 2012.

"Rethinking Multifamily Energy Efficiency Programs and Services: A Program Design Study in Massachusetts," IEPEC Conference, August 2011.

"ENERGY STAR® Portfolio Manager and Utility Benchmarking Programs: Effectiveness as a Conduit to Utility Energy Efficiency Programs," IEPEC Conference, August 2009.

Greg Clendenning

NMR Group, Inc.

Education

Ph.D., Environmental Sociology, Dept. of FEM, University of Wisconsin-Madison	2004
M.S., Forestry, University of Wisconsin-Madison	2000
B.A., Environmental Studies and History, University of Vermont	1994

Work Experience

NMR Group, Inc. (formerly Nexus Market Research), Somerville, MA

Senior Project Manager	2010 – Present
Project Manager	2008 – 2010
Project Analyst	2006 – 2008

U.S. Department of State 2005 – 2006
Evaluation Officer (Contractor)

University of Wisconsin-Madison,
Department of Forest Ecology & Management 1998 – 2004
Research Assistant and Research Fellow (National Science Foundation IGERT Fellow)

U.S. Peace Corps, Togo, West Africa 1995 – 1997
Community Development Extension Agent

Selected Projects

Market Effects, Residential New Construction. California Public Utilities Commission. Lead analyst of the study to identify and quantify market effects stemming from California investor-owned utilities' single-family new construction programs.

Market Effects, Residential and Nonresidential Retrofits. Lawrence Berkeley National Labs and US Department of Energy. Managed the market effects portion of the process and impact evaluation of the US Department of Energy's Better Buildings Neighborhood Program (BBNP). The evaluation included in-depth interviews with program staff and market informants, surveys of participating contractors, non-participating contractors, suppliers and distributors, and program participants as well as coordination with the process and impact evaluation teams to quantify any observed market effects.

Market Effects, Multifamily New Construction (MFNC). California Public Utilities Commission. NMR is leading a two-phase integrated study, with dual objectives of establishing baseline measures for market effects of the California Investor Owned Utilities' (IOU) MFNC programs and characterizing the MFNC market in California. In Phase I the team completed a market characterization and segmentation analysis of the California MFNC market from 2010 through 2012, including an analysis of the program and market theory linking program elements to potential market effects. Phase II includes baseline measurements of MFNC projects built under the 2008 Title 24 standards from 2010 through 2012 as well as case studies of projects included in the baseline.

Net Savings Study on the Definitions and Treatment of Net and Gross Savings in Energy and Environmental Policy. Northeast Energy Efficiency Partnerships Evaluation, Monitoring, and Verification Forum (NEEP EM&V Forum). Conducted a study to increase understanding of how net energy savings is defined and how stakeholders use net savings estimates, and to identify opportunities and barriers to increasing the consistency of and quality in net savings definitions and measurement the Northeast and mid-Atlantic region

Non-Energy Impacts, Residential and Low-income Programs. Massachusetts Program Administrators (PAs). Managed an evaluation identifying and estimating values of the NEIs associated with all of Massachusetts PAs' residential and low-income energy efficiency programs. Evaluation tasks include a review of the literature, in-depth interviews, surveys of program participants and quantification of NEIs. After concluding the evaluation, testified at a Massachusetts Department of Public Utilities (DPU) hearing about the NEI study. As a follow- study, developed adjusted NEI values for early replacement residential heating, cooling, and water heating equipment.

Residential New Construction, Net Savings. Massachusetts Program Administrators. The Massachusetts Residential New Construction (MA RNC) Net Impacts study was designed to estimate the net impacts that may be attributed to the Massachusetts RNC Program for single-family homes and the net-to-gross ratio for the program.

Residential Net to Gross Methodology. Massachusetts Program Administrators (PAs). Conducted a review and provided recommendations of methods that can be used to estimate net program effects for residential programs in Massachusetts.

Residential Retrofit Evaluation. Oak Ridge National Labs and US Department of Energy. Under a subcontract to DNV GL, NMR lead the residential retrofits portion of the National Evaluation of the United States Department of Energy's State Energy Program (SEP). The evaluation quantified key SEP outcomes, including reductions in energy use and expenditures, reduction in carbon emissions and generation of jobs. Key evaluation activities included in-depth interviews with program managers, program implementers, managers of coordinated non-SEP programs, participating contractors and program participants, review of program documentation of program activities and installed measures, and on-site verification of installed measures.

Selected Publications and Presentations

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

"Measuring participant perspective non-energy impacts (NEIs)." Paper presented to 2012 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, August 2012.

"Examining Price Differentials between CFL and Incandescent Light Bulbs: Do Multi-packs and Specialty Bulbs Matter?" Paper presented at the 2009 International Energy Program Evaluation Conference (Portland, OR, August 2009).

Zack Tyler

NMR Group, Inc.

Education

M.A., Energy & Environmental Analysis, Boston University	2010
B.A., Environmental Studies, University of Colorado at Boulder	2008

Certifications

DOE Home Energy Score Assessor	2015 – Present
BPI Multifamily Building Analyst	2014 – Present
Level I Certified Building Investigations Infrared Thermographer, FLIR	2012 – Present
Residential Air Balancing & Diagnostic Technician, National Comfort Institute	2011 – 2013
HERS rater, RESNET	2010 – Present

Work Experience

NMR Group, Inc., Somerville, MA

Senior Project Manager	May 2015 – Present
Project Manager	2012 – 2015
Research Analyst	2011 – 2012
Research Associate	2009 – 2011

Boston University Frederick S. Pardee Center

Research Fellow	May – August 2009

Illustrative Projects

Residential—Single-family Compliance/Baseline Study. Massachusetts Sponsors. Managing a baseline study of 200 single-family homes throughout the state of Massachusetts that will simultaneously update the RNC programs UDRH and assess compliance with homes built under the stretch code, built at the end of the 2009 IECC cycle, and built at the beginning of the 2012 IECC cycle. Tasks include overall project management, client interaction, field work, analysis, and reporting.

Residential—Multifamily High Rise Baseline Study. Massachusetts Sponsors. Co-managing and serving as one of the lead auditors for a baseline study of Multifamily High Rise buildings in Massachusetts. Tasks include managing field work, client interaction, analyzing efficiency characteristics, and reporting on study results.

Residential—Code Compliance Model Review. National Grid, Rhode Island. Led the residential review of National Grid's code compliance enhancement initiative (CCEI) model. Tasks included reviewing the baseline code compliance estimate, confirming new construction and retrofit savings from code enhancement activities, and verifying market penetration rates of various residential programs.

Residential—Net Savings Study. Massachusetts Sponsors. Worked as a lead analyst on a study assessing net savings from the Massachusetts Residential New Construction Program. Tasks included Delphi instrument development, modeling counterfactual scenarios, and analyzing savings results.

Residential—Potential Study. Connecticut Energy Efficiency Fund. Conducting a potential savings study to assess the potential savings from energy efficiency upgrades in the residential sector of Connecticut. Tasks include client interactions, management of analyses (including REM/Rate model runs and screening measures for cost-effectiveness), and reporting/presenting on study results.

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

Residential—New Construction. Various Sponsors. Performed a variety of tasks for five separate residential construction baseline studies in four states (MA, RI, CT, & VT). Tasks included but were not limited to, conducting energy audits, coordinating field work, modeling energy usage in REM/Rate, analyzing efficiency characteristics, and reporting on findings from the various studies.

Residential—Appliances. Massachusetts Sponsors. Calculated the gross and net impacts of a secondary appliance turn-in program in Massachusetts. This work included two methodologies, each of which considered partial use, replacement equipment, and free ridership when calculating net program impacts.

Selected Presentations and Publications

"New Construction Multifamily Building Recruitment—A 'Full Contact' Game!," with Pam Rathbun, Carol Sabo, Amber Watkins, and Dorothy Conant. 2015 International Energy Program Evaluation Conference. Long Beach, California. August 2015.

"Just what do you mean by 'Weatherized'? Assessing and Achieving a Statewide Weatherization Target," with Lisa Skumatz, Glenn Reed, Richard Faesy, and Lisa Wilson-Wright. Department of Energy Building Technologies Office Peer Review Conference. Tysons, Virginia. April 2015.

"The Untapped Potential in Code Compliance: A Study in Residential New Construction," Proceedings of the 2011 International Energy Program Evaluation Conference, Boston, MA. August 2011 (co-author with B. Tolkin, W. Blake, C. Hastings, A. Lee, R. Wirtshafter and L. Hoefgen).

Chris Russell

NMR Group, Inc.

Education

Ph.D., Demography, Texas A&M University	2009
M.S., Demography, Texas A&M University	2006
B.A., Sociology, Texas A&M University, Corpus Christi	2004

Work Experience

NMR Group, Inc., Bryan, Texas	
Senior Quantitative Analyst	2012 – Present
Quantitative Analyst	2009 – 2012
Population and Survey Analyst, Bryan, Texas	
Applied Demographer	2007 – 2008
Texas A&M University, Bryan, Texas	
Evaluation & Research Assistant,	2004 – 2007
Americorp VISTA, Austin, Texas	
Program Coordinator	1999 – 2000

Illustrative Projects

Behavioral Modification—Residential, Eversource (formerly Connecticut Light and Power) and the Connecticut Energy Efficiency Board. Lead analyst on multi-year preoject. Data management, analysis and reporting of the billing analysis of a behavioral pilot project in which a participant treatment group received an energy report comparing recipients to their neighbors and suggesting behavioral modifications to save energy. Billing analyses consist of Fixed Effects Linear Regression, compressed OLS, and difference-in-difference on all pre-selected 35,000 participants and 35,000 non-participants to estimate current and persistent energy savings during treatment period as well as over three years of post-treatment period.

Billing Analysis of Behavioral Intervention—Residential. Manager for billing analysis of Pennsylvania FirstEnergy utilities' electrical energy savings derived from Opower behavioral intervention. Managed dataset and tested 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.

Top-Down Macro Econometric Modeling—Residential and C&I, sponsored by PAs in MA. Developed an econometric model that measures the impact energy efficiency programs have had (at the utility level) on energy consumption over the past 23 years. Responsible for data gathering, modeling, and management for Residential and C&I variables across all MA utilities

MA CFLs – EISA Market Adoption Model, Devloped a tool to analyze light technology market adoption in the face of EISA. The tool develops a lighting market baseline and predicts how the Energy Independence and Security Act would influence future lighting purchase behavior and subsequent energy saving. The tool also allows the client to manipulate adoption assumptions for program planning purposes.

Lighting—Residential, Multistate modeling effort: Sponsors- CPUC, NYSERDA, WPSC, CE, ECMB, CL&P, UI, Cape Light, NSTAR, National Grid, Unitil, and WMECO. Combined sixteen sample area RDD and onsite surveys to conduct aggregate non-linear modeling effort in order to determine net-to-gross ratios, CFL saturation, market saturation, assessing market effects, and making recommendations for program improvement for each of the seven sponsors.

New Construction and Existing Homes--Residential, Energy Star; analysis of survey data from over 300 new homebuyers to evaluate differences in home satisfaction and energy usage between Energy Star homes and non-Energy Star homes in MA. Investigated measures to determine whether Energy Star homes met participants' expectations for lower energy bills and greater home comfort.

HVAC—Residential, Massachusetts High Efficiency Heating Equipment Program Sponsors. Analyzed numerous in-depth interviews as well as survey data to determine the effectiveness of the program in getting contractors and supply houses to work with high efficiency HVAC equipment. Survey analysis was also performed on HVAC customers to determine their familiarity with the program and heating system details.

Energy Audit – Commercial. Nova Scotia Power and Lighting; analyzed survey data to evaluate the effectiveness of energy audits and subsequent energy saving measure implementation. Energy savings were measured to determine whether the program had met the designated energy savings goal.

Selected Presentations and Publications

"The View from the Top: top-Down Estimation of Program Savings Using Utility-Level Data in Massachusetts". Paper at the International Energy Program Evaluation Conference (IEPEC), August 2015.

"What's the Point (of Sale)? Program Activity Impacts Efficient Bulb Sales—Proof Across 44 States and Five Years". Paper at the International Energy Program Evaluation Conference (IEPEC), August 2015.

"Behavioral Effects: How Big, How Long, From Whom, How Best?" presented at the 2014 American Council for and Energy-Efficient Economy (ACEEE) Summer Study, August 2014.

"Sure They Work, but for How Long?" presented at the 2013 International Energy Program Evaluation Conference (IEPEC), August 2013.

"Net Impacts from Upstream Lighting Programs" (co-author) presented at the 2012 International Energy Program Evaluation Conference (IEPEC), August 2012.

Alyssa Na'im

NMR Group, Inc.

Education

M.P.P., Public Policy, Harvard University	2000
B.S., Chemistry, Spelman College	1996

Work Experience

NMR Group, Inc. (formerly Nexus Market Research), Somerville, Massachusetts

Project Manager	2013 – Present

Education Development Center, Waltham, MA

Senior Research Associate	2012 – 2013
Project Director	2011 – 2013
Research Associate	2006 – 2012

Massachusetts Budget and Policy Center, Boston, MA

Policy Analyst	2003 – 2006

City Year, Boston, MA

Research Associate	2000 – 2003

Boston EQUIP, Boston, MA

Research Assistant	1999 – 2000

Illustrative Projects

Multifamily Retrofit Process Evaluation, Connecticut Energy Efficiency Board. The Multifamily Initiative is a component of the Home Energy Solutions and Home Energy Solutions – Income Eligible residential retrofit programs. NMR is conducting a retrospective study which seeks to understand the overall program design and implementation, assess participant satisfaction, and identify opportunities for program improvement. Specific responsibilities include conducting in-depth interviews with program administrators, vendors, and multifamily property owners and synthesizing findings across multiple stakeholder groups to identify actionable recommendations for program administrators.

Residential Retrofit Study, Connecticut Energy Efficiency Board. Contributed to an evaluation of Connecticut Home Energy Solutions program practices related to three specific measures: air sealing, duct sealing, and insulation. Collected data from a number of sources including in-depth interviews with program administrators and vendors to determine patterns of participation, examine opportunities for greater savings, assess quality of implementation and vendor practices, and understand customer decision-making. Helped oversee instrument design, data collection, analysis, and reporting.

Low-Income Retrofit Process Evaluation, Connecticut Energy Efficiency Board. Conducted in-depth interviews with landlords, program staff, and other stakeholders to determine progress towards program goals and objectives; explore program strengths and areas for improvement; determine and quantify non-energy impacts; measure the persistence of measures installed through the program; and identify processes that could improve measure persistence.

Real Time Data Collection, Connecticut Energy Efficiency Board. Explored the feasibility of real-time data collection with recent participants of Connecticut utilities' residential and commercial and industrial programs. Research included in-depth interviews with program staff and external stakeholders, review of instruments and program documentation, and related reports. The objective of this project was to design/test, and if successful, institute a process of conducting regular surveys with recent program participants to address process and first-stage attribution evaluation questions.

Residential Retail Products Process Evaluation, Ohio FirstEnergy. Contributed to a process evaluation of Ohio FirstEnergy's Efficient Products Program. Tasks included review of program data and in-depth interviews with program contractors. Summarized findings and contributed to overall report.

Residential Lighting Market Assessment, Massachusetts ENERGY STAR Lighting Program Administrators and Energy Efficiency Advisory Council. Oversaw the analysis and reporting of data from consumer surveys; helped coordinate recruitment for related on-site saturation studies in Massachusetts and comparison areas; and conducted in-depth interviews with program managers and other stakeholders.

Residential Lighting Point-of-Sale Program Evaluation, New York State Energy Research & Development Authority. Recruited and conducted in-depth interviews with lighting manufacturers and retailers across the U.S. in order to obtain estimated sales and related data for use in market effects, net-to-gross and attribution analysis.

Residential Lighting Process Evaluation, Consumers Energy's ENERGY STAR Residential Lighting Program Administrators. Conducted in-depth interviews with manufacturer and retailer program partners to identify program strengths and areas for improvement, assess perspectives on changes in the lighting market, and determine future directions for the program.

Residential Lighting Delphi Study, Consumers Energy. Assisted with the development of a Delphi panel instrument designed to derive utility-specific and statewide net-to-gross estimates. Assembled data from various sources, including program and sales data, saturation rates, and other program-related documentation to create the template which was used to inform market actors' retrospective and prospective NTG estimates.

Residential Lighting Process Evaluation, Efficiency Maine. Contributed to a process evaluation of Efficiency Maine's residential lighting program, which included an assessment of its distribution of free CFLs to low-income households. Conducted in-depth interviews with program partners, synthesized results from various stakeholders, and reported findings.

Scott Walker

NMR Group, Inc.

Education

M.A., Urban and Regional Planning, Portland State University	2003
B.S., Mechanical Engineering, Cornell University	1998

Certifications

RESNET Certified Home Energy Rater (HERS)
Certified Energy Auditor in Training (CEAIT)
Energy Manager in Training (EMIT)

Work Experience

NMR Group, Inc., Somerville, Massachusetts
Research Analyst — 2014 – Present
Research Associate — 2012 – 2014

Greenward Eco-Friendly Goods, Cambridge, Massachusetts
Owner and Manager — 2007 – 2011

Metropolitan Area Planning Council, Boston, Massachusetts
Transportation Planner — 2005 – 2007

City of Somerville Planning Department, Somerville, Massachusetts
Senior Planner — 2003 – 2005

Illustrative Projects

Residential Weatherization Program Assessment, Connecticut Energy Efficiency Fund. NMR is assessing quality and customer satisfaction with air sealing, duct sealing, and insulation measures installed in single-family homes through a residential weatherization program. Developed data collection form, conducting sites visits.

Residential Baseline, Vermont Public Service Department. NMR is conducting a baseline study of recently-constructed and existing single-family and multifamily residential buildings. Designing data collection form, performing analysis.

Multi-family Residential Baseline, Massachusetts Program Administrators. NMR is conducting a baseline study of recently-constructed multi-family buildings in Massachusetts. Performed field visits, data collection, and analysis.

Commercial and Industrial Baseline, Massachusetts Program Administrators. Assisted on data collection site visits to a variety of commercial and industrial properties, including water treatment plants, office buildings, and large retailers, for a baseline study.

Lighting Market Assessment, Massachusetts Program Administrators. NMR conducted residential lighting saturation surveys in Massachusetts in 2014 and 2015, along with

comparison area studies in Kansas, Georgia, and New York, including data collection visits to over 500 homes. Designed and programmed project database, mobile device data collection tools, and in-office scheduling tools. Assisted in development of project protocols and training materials and in managing field technicians. Analyzed data.

Process Evaluation, Consumers Energy. NMR updated a process evaluation for a residential new construction incentive program. Conducted in-depth interviews with HERS raters.

Commercial and Residential Building Energy Code Compliance, National Grid. NMR analyzed savings and attribution logic for a building energy code compliance enhancement initiative. Researched construction trends and savings models for energy code compliance for residential new construction and renovation projects. Assisted with analysis of commercial savings model.

Weatherization, Connecticut Energy Efficiency Fund. NMR inspected and analyzed a representative sample of single-family homes in Connecticut to characterize their energy efficiency. Performed HERS ratings at over 35 homes. Assisted with data analysis and development of baseline measure of weatherization in Connecticut single-family homes. Assisted with fuel switching analysis for HVAC and DHW systems.

Residential Products Program Potential and Characterization, Massachusetts Program Administrators. Conducted in-depth interviews with representatives of major electronics manufacturers and retailers, media service providers, and other consumer electronics stakeholders to inform recommendations for potential state-level energy efficiency programs. Analyzed data on the appliances and consumer electronics present in a sample of Massachusetts homes and assisted on the resulting report.

Evaluation Assistance, US DOE. NMR was part of a team conducting a process and impact evaluation of the US Department of Energy's Better Buildings Neighborhood Program (BBNP). Coded long-from interviews with participants in the commercial building retrofit program. Also prepared GIS maps and geographic analysis for the project.

Jared Powell

NMR Group, Inc.

Education

M.S., Environmental Science, University of Massachusetts Boston 2014
B.A., Political Science, Williams College 2006

Certifications

Certified HERS Rater, RESNET 2011

Work Experience

NMR Group, Inc. (formerly Nexus Market Research), Somerville, Massachusetts
Research Analyst 2015 – Present
Research Associate 2011 – 2015
Research Assistant 2009 – 2011

Harkins Cunningham, LLP, Washington, D.C.
Senior Paralegal/Research Associate 2006 – 2008

Williams College Center for Environmental Studies, Williamstown, Massachusetts
Renewable Energy/Sustainable Architecture Research Intern 2006

Illustrative Projects

New Construction and Existing Home Baseline Studies—Residential, MA, RI, CT, and VT Sponsors. Conducted scores of on-site HERS ratings of new and existing homes for baseline studies, and analyzed results to characterize housing stock, including analysis of mechanical systems and building shell components. In addition, analyzed code compliance using REScheck software and built REM/Rate models to identify measure cost effectivenes.

HERS Ratings and Energy Modeling—Residential. As a certified HERS Rater, performs diagnostic audits of buildings, including blower doors, duct blowers, and conducts modeling using REM/Rate™ software, Manual J load calculations, and EnergyPlus simulations.

Residential Retrofit, Connecticut Sponsors. Designed interview guides for program vendors and on-site protocols for NMR auditors to perform QA inspections of program vendors to identify additional savings opportunities, and led on-site visits. Moderated focus groups with homeowners to identify program participation barriers.

Market Effects—Multifamily Residential New Construction, California Public Utilities Commission. Conducted market characterization and identified market effect indicators; currently testing indicators via case studies. Researched program activities and requirements of code and other efficiency programs. Designed interview guides and conducted dozens of interviews with experts and individuals involved with case study projects, including developers, contractors, code consultants, and investors. Created market and program logic models of program activities and potential market effects.

Market Effects, NYSERDA. Analyzed energy models from new construction and baseline samples to identify BPI impact. Analyzed process, impact, and market transformation evaluation reports to identify strategies for shifting to a market effects evaluation approach for selected programs. Conducted interviews and analyzed NYSERDA and Building Performance Institute records to assess market effects of NYSERDA's investment in BPI.

Market Characterization and Non-Energy Impacts—Residential Appliances, Massachusetts Sponsors. Developed sample, conducted interviews with market actors, and performed research to characterize the appliance disposal and resale markets, and analyzed the non-energy impacts of an appliance recycling program.

New Construction—Residential, Massachusetts Sponsors. As part of an evaluation of an ENERGY STAR pilot program, conducted focus groups with builders to identify opportunities for improving the program, and reported on the results.

New Construction—Residential, Massachusetts Sponsors. Designed survey and conducted interviews for program staff at out-of-state utility/energy efficiency organizations to identify new building technologies and estimate savings derived from their use.

New Construction—Residential, Massachusetts Sponsors. To evaluate trainings that taught real estate agents to market ENERGY STAR homes, conducted mystery shopping visits with agents to assess the training's effectiveness and reported on findings.

New Construction—Residential, Massachusetts Sponsors. To evaluate the Major Renovations Pilot Program, conducted interviews with homeowners and builders.

Renewable Energy, Connecticut Clean Energy Fund (CCEF). Conducted interviews with institutions purchasing Renewable Energy Certificates and analyzed motivations for these purchases. Analyzed monthly clean energy purchase data, calculating rewards for communities that reached certain thresholds.

HVAC—Residential, Massachusetts Sponsors. Conducted in-depth interviews with HVAC contractors and distributors involved with ENERGY STAR Version 3 Pilot Program, to identify current HVAC contractor preparedness for 2012 Version 3 standards.

HVAC and Water Heating, Gas Networks. Created survey and in-depth interview samples, and conducted interviews with participating wholesalers and supply houses.

Lighting—Residential, NYSERDA and Xcel Energy (Colorado). Interviewed lighting retailers and reported on CFL pricing, sales, and program marketing.

Demand Side Management—Commercial and Industrial, Massachusetts Sponsors. Interviewed program staff to identify deep savings opportunities at commercial facilities.

Selected Presentations

- "Multifamily New Construction in California: Getting a Handle on a Growing but Poorly Understood Market," IEPEC Conference Poster Session, August 2015.

Kiersten von Trapp

NMR Group, Inc.

Education

M.A., Urban and Environmental Policy and Planning, Tufts University	2010
B.A., International Politics and International Relations, Wesleyan University	2003
School for International Training, Ft. Dauphin, Madagascar	2001

Work Experience

NMR Group, Inc. (formerly Nexus Market Research), Somerville, MA

Research Analyst	2012 – Present
Research Associate	2010 – 2012

Tufts Institute of the Environment, Medford, MA

Alumni Coordinator	2009 – 2012

Clark University, Worcester, MA

HERO Research Fellow, Graduate Manager	2009

The Nature Conservancy, Boston MA

Student Researcher and Consultant	2008 – 2009

The New England School of English, Cambridge, MA

ESL Teacher	2005 – 2008

Illustrative Projects

Lighting—Residential, Connecticut EEB. This is a continuation of the 2012 and 2013 on-onsite saturation studies in Connecticut with an added focus on the LED lighting market. Project lead. Responsibilities included collaborating with client on work plan, working with the CATI firm, hiring and managing on-site technicians, collecting data and cleaning data, and data analysis.

Lighting—Residential, Massachusetts Sponsors. This is an onsite saturation study and a lighting stagnation study to observe saturation over time. Onsite visits were conducted in Massachusetts and two comparison areas, Georgia and eastern Kansas. Responsibilities included hiring and managing onsite technicians, compiling and writing training handbooks and onsite data collection documents, training technicians, collecting data and cleaning data, and data analysis.

Lighting – Residential Regional Hours of Use Study, Massachusetts, Rhode Island, Connecticut and New York Energy-Efficiency Program Administrators. This is an onsite saturation study and estimation of the hours of use of light bulbs in homes to add to the evaluation of energy-efficiency programs in Massachusetts, Connecticut, Rhode Island, and New York (NYSERDA). Responsibilities include hiring and managing onsite technicians, compiling and writing training handbooks and onsite data collection documents, training technicians, collecting data and cleaning data, and data analysis.

Lighting – Residential, Connecticut Light and Power. The goal of the 2012 Connecticut Residential Retrofit and Retail Products Study was to explore the potential impact of EISA on the residential lighting market. Responsibilities were mainly focused on the lighting conservation and saturation surveys task and included hiring and managing onsite technicians, compiling and writing training handbook and onsite data collection documents, training technicians, collecting and analyzing onsite saturation data and contributing to the final report.

Lighting—Residential, Massachusetts Sponsors. For years NMR has conducted annual market progress and evaluation reporting, which involves consumer surveys, 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, assessing market effects, and making recommendations for program improvement. Transcribed interviews, created tables, SPSS analysis, collected articles and info on Delphi, acted as contact person for Delphi panel members, collected Delphi responses for both rounds, complied phase one and two responses, wrote up round two Delphi instrument and final summary of responses.

Lighting – Residential, Connecticut Light and Power. Process and impact evaluation of the CL&P residential electric energy reports pilot. Developed protocols for cleaning billing and weather data using both Access and GIS. Performed analysis determining rate of participation in other programs, and contributed to analysis reports and memos.

New Construction – Residential, Massachusetts Electric Companies. As part of the evaluation of Massachusetts energy efficiency programs in the residential new construction area, performed a mini baseline study of homes built at the end of the IECC 2006 cycle as well as a baseline study of homes built under the IECC 2009 code. Managed Massachusetts participant recruitment. Called and visited town halls throughout the state to collect building permit and energy code information for addresses of new homes in Massachusetts; researched current contact information for MA, and managed letter and postcard mailings. Also assisted on parallel studies in Rhode Island, Connecticut and New Hampshire.

Selected Presentations And Publications

"A Lighting Study to Stand the Test of Time: Exploring the Results of a Residential Lighting Study Designed to Produce Lasting Data," IEPEC Conference, 2015. Long Beach, CA.

"We Know What you Did Last Summer: Revelations of a Lighting Panel Study," IEPEC Conference, 2015. Long Beach, CA.

"Are You Turned On? A Hierarchical Modeling Approach for Estimating Lighting Hours of Use," (co-author) IEPEC Conference, 2015. Long Beach, CA.

"Fifteen Secret Tips That Will Change Everything You Think You Know About On-site Data Collection (Poster)," IEPEC Conference, 2015. Long Beach, CA.

Lauren Abraham

NMR Group, Inc.

Education

M.A., Energy & Environmental Analysis, Boston University	2010
B.S., Management, Keene State College	2003

Work Experience

NMR Group, Inc. (formerly Nexus Market Research), Somerville, MA
Research Analyst — 2010 – Present

Dalbar, Inc., Boston, MA
Senior Research Analyst/Research Analyst — 2004 – 2010

NOP World, Oxford, England
Interviewer — 2002

Illustrative Projects

New Construction—Residential, Various Sponsors. Analyzed efficiency characteristics of new homes and reported findings for five separate residential new construction baseline studies in four states (MA, RI, CT, and VT).

New Construction—Residential Multifamily, California Public Utilities Commission. Developed thematic maps displaying multifamily new construction program participation rates by climate zone among the investor-owned utility territories in California. Programmed, conducted, analyzed, and reported findings from a survey of multifamily developers in California.

HVAC—Residential and Commercial, California Public Utilities Commission. Analyzed results of CATI surveys of commercial and residential customers as part of a baseline characterization of HVAC maintenance and installation practices among contractors who work in the residential and small commercial sectors.

Homes—Existing, Ohio FirstEnergy. Led a process evaluation of a program that provides discounted home energy audits and rebates for energy-efficiency measures. Conducted in-depth interviews with residential retrofit contractors and home energy auditors, analyzed program tracking data, summarized findings and developed conclusions based on analyses of the data.

Homes—Existing, Oak Ridge National Labs and US Department of Energy. Conducted in-depth interviews with building owners and contractors in order 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 inputs into engineering algorithms to estimate gross and net energy savings.

Homes—Existing, NYSERDA. Conducted and summarized in-depth interviews with Home Performance with ENERGY STAR program implementation contractors as part of a process evaluation of Green Jobs Green New York-related services.

Homes—Existing, Public Service Commission of Wisconsin. Conducted in-depth interviews with Home Performance with ENERGY STAR contractors and consultants in order to assess the impacts of increased program incentives on the installation of recommended energy-efficiency measures.

HVAC—Residential, Ohio First Energy. Conducted in-depth interviews with HVAC contractors as part of a process evaluation of a program that gives rebates for HVAC equipment and maintenance tune-ups to residential customers. Developed thematic maps displaying population density in addition to the location of the population and sample of contractors interviewed.

Lighting—Residential, Wisconsin Focus on Energy. Estimated gross and net energy savings for the residential ENERGY STAR lighting program based on CFL reward data.

Low-Income Weatherization, Nova Scotia Power and Interim DSM Administrator. Analyzed results of a CATI survey of participants in a low-income weatherization program. Summarized key findings from in-depth interviews with program managers and implementers. Developed process recommendations based on participant survey and in-depth interview results.

Market Transformation Best Practices White Paper, California Investor-Owned Utilities. Contributed to literature review summarizing best practices for programs that aim to transform markets. Gathered and summarized program descriptions, logic models, and market indicators from exemplary market transformation programs in the United States.

Renewable/Clean Energy, Vermont Clean Energy Development Fund. Developed a timeline and narrative of CEDF activities based on a review of CEDF annual reports. Developed thematic maps displaying the geographic distribution of CEDF awards in VT.

Residential Retail Products, Ontario Power Authority. Developed input assumptions from CATI survey responses for an impact evaluation of retailer events and coupon initiatives promoting energy-saving products. Conducted in-depth interviews with corporate-level staff of participating retailers for a process evaluation of the retailer events and coupon initiatives.

Matt Rusteika

NMR Group, Inc.

Education

M.P.P., Public Policy, Brown University	2011
B.A., Literature, Emerson College	2007

Certifications

Home Energy Rating System (HERS), RESNET	2012

Work Experience

NMR Group, Inc., Somerville, MA

Research Analyst	2013 – Present
Research Associate	2011 – 2013

Office of U.S. Senator John Kerry, Boston, MA

Energy & Environment Constituent Services	2010 – 2011

Taubman Center for Public Policy at Brown University, Providence, RI

Public Opinion Poll Manager	2009 – 2010

Illustrative Projects

MA RNC Baseline Study. Massachusetts sponsors. Auditor and analyst for a 2015 baseline & code compliance study. Conducting HERS ratings on new single-family homes, developing home energy models, and analyzing home characteristics.

Vermont Residential Baseline Study. Vermont Public Service Department. Lead analyst and auditor for residential baseline study of new & existing homes in the state of Vermont. Audited single-family and multifamily homes, analyzed & reported onsite data.

Connecticut Weatherization Baseline Assessment. Connecticut Energy Efficiency Board. Assessed the energy efficiency characteristics of existing single-family homes. Audited homes, developed REM/Rate energy models, analyzed building shell & HVAC data, and assessed compliance with the state's weatherization standard.

Connecticut Potential Savings Study. Connecticut Energy Efficiency Board. Project lead for an ongoing study to estimate potential savings associated with 43 home energy upgrades and fuel-switching measures in existing single-family homes in Connecticut using a combined REM/Rate modeling and spreadsheet approach.

MA & RI RNC Baseline Study. Massachusetts & Rhode Island sponsors. Auditor and analyst for a 2012 study establishing a baseline for the Massachusetts & Rhode Island ENERGY STAR™ Homes Programs.

Maine Residential Baseline Study. Efficiency Maine. Analysis & reporting task lead for a 2015 baseline study assessing the characteristics of single-family existing homes in Maine.

BPI Impacts Study. NYSERDA. Quantified the value of incorporating BPI accreditation into NYSERDA new construction programs through statistical analysis of program & non-program home energy models.

Lighting Interactive Effects. Connecticut Energy Efficiency Board. Led a study that used REM/Rate home energy models to calculate lighting savings adjustment factors for the state's TRM. These factors are used to adjust savings claims to take HVAC interactive effects into account.

Cost-Effectiveness Analysis. Efficiency Maine. Assessed the cost-effectiveness of the Maine residential lighting incentive program using a modified Total Resource Cost test.

MA RNC Net Savings. Massachusetts sponsors. Assisted in developing data collection instruments for a 2013 RNC net savings study. Analyzed energy consumption data derived from MA RNC Baseline Study home energy models.

HVAC Market Characterization. Vermont Public Service Department. Reported on a series of in-depth interviews with HVAC contractors in Vermont to assess attitudes toward energy efficiency and the market penetration of energy efficient technologies.

Process Evaluation & Market Effects. U.S. Department of Energy. Conducted a series of in-depth interviews with ARRA Better Buildings Program grantees as part of a study to assess the process and market effects of the program.

Process Evaluation. NV Energy. Led a process evaluation of NV Energy's Residential High-Efficiency Air Conditioning Program. Developed a program theory and logic model, conducted in-depth interviews with program stakeholders, and reviewed tracking data in order to recommend improvements and begin to measure market effects.

Market Effects. California Public Utilities Commission. Developed a series of market indicators for use in assessing market transformation progress. To that end, conducted in-depth interviews with program staff and HVAC distributors and performed a literature review to better understand the behavior of stakeholders in the California HVAC market.

Homeowner Survey. Vermont Public Service Department. Analyzed surveys of Vermont homeowners. Topics included perception of home's energy efficiency, history of program participation, familiarity with efficient products and behaviors, and others.

Large C&I. Massachusetts sponsors. Analyst & building auditor for a study estimating the market penetration of energy efficient commercial & industrial HVAC systems and controls. Conducted building energy assessments on site and interviewed HVAC industry stakeholders.

Market Assessment. Connecticut Energy Efficiency Board. Examined baseline data and conducted secondary research for a study identifying possible additional program measures.

Ari Stern

NMR Group, Inc.

Education

M.A., Energy and Environmental Analysis, Boston University 2013
B.S., Environmental Analysis and Policy, Boston University 2013
Magna Cum Laude

Certifications

Certified Provisional HERS Rater, RESNET 2015
Home Energy Score Assessor 2015

Work Experience

NMR Group, Inc., Somerville, Massachusetts
Research Associate 2015 – Present

Boston University Department of Earth and Environment, Boston, Massachusetts
Research Fellow 2013 – 2015

Save the Harbor Save the Bay, Boston, Massachusetts
Research Assistant 2012

Improv Boston, Cambridge, Massachusetts
Improvisational Comedy Instructor 2014 – Present

Illustrative Projects

Residential New Construction Baseline - Massachusetts, Recruit participants, and conduct 100 energy audits including blower doors, duct blasters, and modeling with REM/Rate software. Analyze and report on a data.

Residential New Construction Baseline - Vermont, Design collaborative data collection system, recruit participants, conduct 100 energy audits following both HERS and HES standards including blower doors, duct blasters, and modeling with REM/Rate software.

Residential New Construction Baseline - Maine, Analyzed and reported on appliance, lighting and ENERGY STAR trends.

Billing Analysis of Behavioral Intervention – Pennsylvania, Perform statistical analysis of Pennsylvania First Energy utilities' electrical energy savings derived from Opower behavioral intervention.

Commercial and Residential New Construction Lighting Survey – Washington, Analyze and report on data gathered through phone surveys on lighting choices for the Bonneville Power Authority.

Multi-Family Retrofit - Connecticut, Recruit, conduct, and analyze in depth interviews with landlords and property owners who participated in the Home Energy Solutions program.

Published Papers and Manuscripts in Review

Sue-Wing I, Monier, E., Stern A., Mundra, A. 2015 *Environ. Res. Lett.* 10 115002 US major cross' uncertain climate change risks and greenhouse gas mitigation benefits

Sue-Wing, I. DeCian, E. Stern, A. (2015). Climate Change Vulnerability of Future Calorific Supply.

Noelke, C. Sue-Wing, I. Stern, A. (2014). Increasing Ambient Temperature Reduces Subjective Well Being.

Rob Baker

NMR Group, Inc.

Education

B.S., Energy, Business, and Finance, Pennsylvania State University 2008

Certifications

BPI Building Analyst	2010 – Present
DOE Home Energy Score Assessor	October 2015 – Present
RESNET HERS Rater	December 2015 – Present

Work Experience

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

Next Step Living, Boston, MA
Senior Energy Auditor 2011 – 2013

Illustrative Projects

Residential—Residential Baseline Study. Vermont Public Service Department. Contributing as an auditor on a study of the single-family and multifamily housing markets in Vermont. Tasks include conducting onsite inspections, completing data collection forms, modeling homes in the DOE Home Energy Score software, and contributing to overall analysis and reporting efforts.

Residential—Single-Family New Construction Baseline Study. Massachusetts Sponsors. Contributing as an auditor on a study of 200 new single-family homes in Massachusetts. Tasks include leading onsite inspections, completing data collection forms, developing energy models, modeling results in Manual J software, completing code compliance checklists, and contributing the overall analysis and reporting efforts.

Residential—Single-Family Baseline Study. Efficiency Maine. Served as the lead auditor for a baseline study of the single-family housing market in Maine. Tasks included the conducting onsite inspections, completing data collection forms, developing energy models, and contributing to the overall analysis and reporting efforts.

Residential—Code Compliance Assessment, Massachusetts Sponsors. Assessed energy code compliance in single-family homes that were built at the end of the 2006 IECC code cycle. Tasks included revising PNNL checklists, compiling database, and analyzing results.

Residential—Lighting Saturation Study, Massachusetts Sponsors. Conducted lighting saturation assessments of residential units in Massachusetts.

Residential—Energy Audits and Implementation, Massachusetts. Conducted over 1,500 energy audits in single-family and multifamily units as part of the MassSAVE program. Tasks

included detailed data collection for all energy-related building components, energy modeling, and weatherization-based retrofits.

Residential—Thermostat Recycling. Started a thermostat recycling program that resulted in over 2,000 thermostats being recycled and more than 25 pounds of mercury being properly disposed of.

Kailey Pratt

NMR Group, Inc.

Education

A.S., Occupational Therapy, North Shore Community College 2010-2012

Work Experience

NMR Group, Inc., Somerville, MA
Research Assistant 2015 – Present
On-site Coordinator 2014 – 2015

Illustrative Projects

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

Residential- 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.

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

Residential—Lighting. Massachusetts Sponsors. This was an on-site saturation study and a lighting stagnation study to observe saturation over time. Onsite visits were conducted throughout Massachusetts. Responsibilities included recruiting and scheduling over 350 on-site visits for six technicians, as well as completing follow up quality control calls.

Lori Golzmane

NMR Group, Inc.

Education

B.A., English, University of Massachusetts Amherst 2002

Work Experience

NMR Group, Inc., Somerville, Massachusetts
Research/Administrative Assistant 2012 – Present

PaperCheck.com/Proof-Reading.com
Associate Editor 2008 – 2012

Naropa University, Department of Contemplative Psychology, Boulder, Colorado
Research/Administrative Assistant 2007 – 2008

Illustrative Projects

Editing, NMR Group, Inc. Edited and formatted dozens of reports, proposals, and memos that NMR produced. Wrote company style guide detailing proper report format, punctuation, style, and citation. Performs ongoing training for employees in this area.

Editing, PaperCheck.com. Edited a high volume of academic and business papers within strict deadlines, providing corrections and recommendations in regard to grammar, spelling, document flow, punctuation, usage, word choice, formatting, and clarity.

Appliances, Ohio FirstEnergy. Conducted in-depth interviews with key retailers throughout Ohio regarding customer uptake of and retailer participation in Ohio FirstEnergy's Residential Energy Efficient Products program.

Codes and Standards, Massachusetts Program Administrators. This study was a review of the Massachusetts energy code trainings for contractors, equipment suppliers, builders, building code officials, and others working with the residential and commercial energy codes. Tasks included survey data entry.

Existing Construction—Residential, Connecticut Energy Efficiency Board. Recruited participants to take part in home energy audits as part of an effort to determine the current baseline of homes that meet the state's criteria for being weatherized. Prepared homeowners for what to expect during the energy audit. Coordinated scheduling between NMR auditors and Connecticut-based home energy efficiency vendors who jointly conducted the home energy audits.

Lighting—Residential, Efficiency Maine. Recruited and scheduled participants in on-site visits to assess lighting usage and saturation as part of an evaluation of Efficiency Maine's Residential Lighting program.

Lighting—Residential, Multiple sponsors. Recruited and scheduled participants for a multi-client, multi-state project to measure the hours of use of lighting products in single-family and multifamily homes. Trained and oversaw other recruiters and schedulers. Coordinated

schedules for multiple on-site technicians in multiple states. Tracked multiple participant quotas in different areas.

Lighting—Residential, Massachusetts Program Administrators. Recruited participants in Massachusetts and Georgia to participate in on-site saturation and panel surveys in order to better understand the sales, use, and saturation of energy-efficient bulbs in areas both with and without residential programs. Tasks included calling and recruiting participants, scheduling appointments, and coordinating visits with participants and on-site technicians.

Institutional Leadership Evaluation, Naropa University. Assisted with compiling and coding data on faculty evaluations of the university's leadership, strategic planning, and decision-making processes. Transcribed confidential interviews and suggested appropriate coding methods.

Residential—Code Compliance Review, Massachusetts electric companies. Collected code compliance information from building departments throughout Massachusetts as part of a baseline study of homes built under the IECC 2006 and 2009 codes.

Student Program Evaluation, Naropa University. Aided in designing a qualitative survey to evaluate undergraduate psychology students' responses to a newly implemented series of weekend learning/meditation retreats. Coded data, compiled report, and presented the results to faculty.

Erin Coates-Connor

NMR Group, Inc.

Education

B.A., Environmental Studies, Mount Holyoke College 2008

Work Experience

NMR Group, Inc. (formerly Nexus Market Research), Somerville, Massachusetts
Research/Administrative Coordinator 2014 – Present
Research/Administrative Assistant 2010 – 2014

University of California Santa Barbara, SNARL reserve at Mammoth Lakes, California
Research Assistant 2008

Mount Holyoke College Department of Biology, South Hadley, Massachusetts
Research Fellow/Research Assistant 2006 – 2010

Mount Holyoke College Environmental Health and Safety, South Hadley, Massachusetts
Office Liaison/Campus Sustainability Coordinator 2005 – 2008

Illustrative Projects

Appliances, New York Refrigerator Retirement, National Grid. Recruited participants for a logger study to help determine energy savings in the New York Residential Refrigerator-Freezer Recycling Program.

Billing Analysis – Low-Income Weatherization. Efficiency Maine. Assisted in billing data collection for billing analysis of Maine's Low-Income Multifamily Weatherization Program. Tasks included mailing and calling customers to obtain authorization for utilities to provide us with their billing data, data cleaning, and data entry.

Codes and Standards. Massachusetts Program Administrators. This study was a review of the Massachusetts energy code trainings for contractors, equipment suppliers, builders, building code officials, and others working with the residential and commercial energy codes. Tasks included survey data entry.

Existing Construction – Residential, Connecticut Energy Efficiency Board. Recruited participants to take part in home energy audits as part of an effort to determine the current baseline of homes that meet the State's criteria for being weatherized. Prepared homeowners for what to expect during the energy audit. Coordinated scheduling between NMR auditors and Connecticut-based home energy efficiency vendors who jointly conducted the home energy audits.

Lighting – Residential, Massachusetts Program Administrators. Recruited participants in Massachusetts and Georgia to participate in onsite saturation and panel surveys in order to better understand the sales, use, and saturation of energy-efficient bulbs in areas both with and without residential programs. Tasks included calling and recruiting participants, scheduling appointments, and coordinating visits with participants and onsite technicians.

Lighting—Residential, Efficiency Maine. This was an onsite saturation study and estimation of the hours of use of light bulbs in homes to add to the evaluation of energy-efficiency programs in Maine. Responsibilities included calling and recruiting participants for the onsite study, scheduling onsite appointments, and communication about schedules with onsite staff.

Lighting – Residential, Connecticut Energy Efficiency Board. Recruited and scheduled participants for a statewide lighting saturation study as part of an evaluation of Connecticut's Residential Retail Products program. Coordinated schedules for onsite technicians.

Lighting – Residential, Multiple sponsors. Recruited and scheduled participants for a multi-client, multi-state project to measure the hours of use of lighting products in single-family and multi-family homes. Trained and oversaw other recruiters and schedulers. Coordinated schedules for multiple onsite technicians in multiple states. Tracked multiple different participant quotas in different areas.

Renewable/Clean Energy, Connecticut Clean Energy Finance and Investment Authority (CEFIA). As part of monitoring and evaluation of CEFIA's voluntary clean energy purchase program, analyzed monthly data of residential and commercial clean energy purchases, tracking changes in program participation. Contacted Renewable Energy Credit (REC) suppliers in an effort to collect and analyze data on non-residential voluntary clean energy purchasers in Connecticut. Reviewed project participant feedback from CCEF's Community Innovation Grants Program. Assisted in writing the program's yearly reports for three consecutive years.

Residential—Code Compliance Review. Massachusetts Program Administrators. This study was a review of code compliance rates for single-family homes built at the end of the 2006 International Energy Conservation Code (IECC) cycle and at the beginning of the 2009 IECC code cycle. Tasks included contacting and visiting building departments around the state to collect documentation of energy code compliance paths.

Presentations and Publications

"Native and non-native *Hypericum* species in meadows in Massachusetts." Poster presented at Ecological Society of America Conference, August 2008 (Primary author).

Cleantech Advisory Group

Salil Gogte | CMVP, LEED AP | Principal

Salil Gogte is Principal at Cleantech Advisory Group (Cleantech). Salil is an active proponent of economical energy production, transmission, and distribution. He has spent more than 10 years advising the energy industry on structuring policies and regulations that govern the economic management of demand side resources. Salil's expertise includes a variety of energy efficiency and demand response consulting services including policy planning, goal setting, program design, assessing market potential, market research and characterization, and evaluation, measurement and verification. Formerly a Principal Consultant in Nexant's Utility Services business unit, he directed DSM planning and evaluation studies for multi-sector utilities and regulators in North America and provided leadership to a team of over 30 engineers, statisticians, and economists. Salil is a Certified M&V Professional and a co-author of the International Performance Measurement and Verification Protocol (IPMVP) 10000-1:2012 Volume I.

Education and Licensing

MS, Mechanical Engineering, University of New Mexico, Albuquerque, NM, May 2005
BE, Mechanical Engineering, University of Pune, Maharashtra, India, August 2003
Certified Measurement & Verification Professional (CMVP)
LEED Accredited Professional

Work Experience

Cleantech Advisory Group, Chester Springs, PA
Principal (2015-present)
Nexant Utility Services, Malvern, PA
Principal Consultant (2006–2015)
ACR Engineering, Inc., Austin, TX
Mechanical Engineer (2005–2006)

Areas of Expertise

Program Evaluation, Measurement, and Verification (EM&V): Setting evaluation objectives; defining baseline scenarios; providing statistical sampling and probability analysis, and metering studies; calculating energy and demand savings; performing quality assurance, gross billing analyses, deemed savings estimation, emissions analyses, statistical forecasting, and attribution and benefit-cost analyses.

Conservation Planning and Program Design: Designing, implementing, marketing, and managing DSM programs focused on electric energy efficiency and demand response measures. Assessing the available potential for energy efficiency, demand response, distributed generation, and renewable energy sources, including expertise in the following: measure development; cost-effectiveness; primary market research; customer billing analysis; and estimating technical, economic, and achievable potentials. Ensuring compliance with energy program rules; working directly with service providers and customers on projects; advising contractors on savings estimates; and providing technical advice to service providers.

Representative Project Experience

Pennsylvania Public Utility Commission (PA PUC) – PA Act 129 Statewide Evaluator (2009–2015)
Salil was the Principal-in-Charge of Nexant's role on the PPUC Statewide Evaluation team to develop policy and technical guidelines, and verify the energy savings and peak demand reduction claims made by seven large electric distribution companies for the Act 129 DSM portfolio. He co-chaired the Act 129 Program Evaluation Group tasked with updating the PA Technical Reference Manual, and conducting market potential assessments and market characterization studies. Salil also managed stakeholder discussions on numerous topics including policy planning, demand response, hours of use studies, statistical methods for savings verification, PJM resource offerings, and annual reporting.

Wisconsin Public Service Commission – Statewide Evaluation of Focus on Energy Portfolio (2012–2015)
Salil was the Principal-in-Charge of multi-sector evaluations of the Focus on Energy program conducted by Nexant for the Wisconsin Public Service Commission. Salil was responsible for all key deliverables and staff activities. He provided leadership and authored key sections of the Strategic and Program Specific long-term evaluation plans developed by the Nexant team. The evaluation spanned all market sectors and energy efficiency measure types, both custom and prescriptive in nature. The project involved developing statistical sampling algorithms, reviewing M&V methods, performing on-site inspections, and calculating gross and net impacts.

Ontario Independent Electric Systems Operator (IESO) – Portfolio Evaluation of Business Incentive, and Consumer Products Programs (2007–2015)
Salil was the Principal-in-Charge of Nexant's multi-year EM&V contracts with the IESO to conduct an impact and process assessment of the Business Incentive, Small Business Lighting, and Consumer Products programs. The programs included large commercial custom and prescriptive, small commercial lighting, and upstream residential buy down rebates. The evaluations involved developing statistical sampling algorithms, developing M&V plans, on-site inspections, metering studies, calculating gross and net impacts and cost effectiveness analysis.

Con Edison of New York – Evaluation of System-Wide Demand Reduction Program (2007–2010)
Salil managed a team of engineers providing measurement & verification, market assessment, and causality and cost-effectiveness study services to the Con-Edison (NYSERDA) System-Wide Demand Reduction program. The team's evaluation results were used to file lost revenue claims by Con-Edison to the New York Public Service Commission.

NYSERDA – New York Energy $mart Program Evaluation (2006–2009)
As a team leader of NYSERDA's M&V team, Salil 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 and flow measurements to support engineering savings calculations, monitoring energy use, and reviewing energy savings calculation algorithms.

Con Edison of New York – Distributed Load Relief Program Evaluation (2007-2008)
As a team leader of the evaluation team, Salil conducted an evaluation of the Con Edison Demand Response Programs. The project involved developing and administering surveys to participants, non-participants, and demand response aggregators to conduct a market assessment and make recommendations to improve savings estimation.

Public Service Electric & Gas Company (PSE&G) – PJM M&V Plans (2011–2012)
Salil worked as the Project Manager for the effort to create M&V plans for all of PSE&G's DSM programs to participate in PJM's Forward Capacity Market. The plans were drawn within the framework of PJM's capacity bidding requirements, and committed PSE&G to deliver over 10MW of capacity to the grid.

Cleantech Advisory Group

Manasi (Mansee) Muchrikar | Quantitative Analyst

Mansee Muchrikar is Owner and Quantitative Analyst at Cleantech Advisory Group (Cleantech). Mansee is a quantitative analyst and sociologist with over eight years of experience in consumer data collection, behavior modification, statistical analysis and experimental design. She has spent the last five years conducting statistical analysis including parametric and non-parametric testing, regression modeling, analysis of variance, central tendency, data correlations and theory of probability. Mansee's expertise includes applying statistical and socio economic theories to optimize the utility end-user's energy consumption with a focus on behavioral interventions. Mansee manages Cleantech's operations and is responsible for statistical data processing, analysis and reporting.

Education and Licensing

Certification in Applied Statistics, West Chester University of Pennsylvania, Expected May 2017

MA, Clinical Psychology, West Chester University of Pennsylvania, PA, May 2013

M.Phil, Clinical Psychology, Manipal University, India, August 2007

BA, MA, Psychology, University of Pune, India, August 2005

Work Experience

Cleantech Advisory Group, Chester Springs, PA
Owner and Quantitative Analyst (2015-present)

Warren Energy Engineering, West Grove, PA
Research Analyst (March 2015-December 2015)

Cadmus Group Inc., Madison, WI
Research Analyst (October 2013-March 2014)

West Chester University of Pennsylvania
Principal Research Investigator (August 2010-May 2013)

Areas of Expertise

Program Evaluation, Measurement, and Verification (EM&V): Setting evaluation objectives; defining baseline scenarios; providing statistical sampling and probability analysis, and metering studies; calculating energy and demand savings; performing quality assurance, gross billing analyses, deemed savings estimation, emissions analyses, statistical forecasting, and attribution and benefit-cost analyses.

Savings Estimates Through Billing Analysis: Quantifying energy savings produced by energy efficiency measures through billing analysis; separating billed energy into baseline and weather dependent loads; and comparing weather dependent loads before and after the implementation of energy efficiency measures and estimating the associated savings using both monthly billing data and interval meter data from AMI; selection of control groups through statistical analysis to assess treatment effects.

Representative Project Experience

Survey Design and Administration

Mansee is experienced in using a variety of survey approaches, and some of her representative projects are summarized here:

- ***Small Business Direct Install Program, Vectren Energy Delivery of Indiana.*** To evaluate customer satisfaction and the savings from no-cost and low-cost measures, Mansee led a team of sociologists to conduct a comprehensive literature review, administer surveys and interview guides, and conduct statistical analysis.
- ***Home Energy Services Delivery Program, for Massachusetts Utilities.*** Mansee conducted a literature research in preparation for developing the interview and survey instruments that were used to assess the program performance and cross-over effects.
- ***Entergy and SWEPCO Residential Lighting and Appliances Programs, Arkansas.*** Mansee developed survey instruments to measure and quantify the leakage of CFL savings from the utility service territory.

Energy Efficiency Program Evaluation

Mansee has conducted numerous energy efficiency program evaluations that involved engineering analysis, on-site inspections, and statistical analysis of energy consumption data sets to measure and verify energy savings produced by equipment replacement and behavioral interventions. Examples of her work are included here:

- As part of an impact evaluation team of the Efficiency Maine Business Incentive and Large Consumer Programs and PPL and PECO Act 129 Phase II programs, Mansee implemented site specific M&V Plans for prescriptive and custom incentive projects. Her responsibilities included reviewing implementer calculations and approaches, and determining and documenting the verified savings for projects. Excel based analyses included statistical examination, regression analysis, and the use of pivot tables to scrutinize large quantities of data.
- As part of the M&V team for the Con Edison Demand Management Program, Mansee developed and implemented M&V plans, analyzed metered data of lighting and mechanical equipment, and calculates savings achieved through energy upgrade projects.

Statistical Data Analysis

Mansee has conducted statistical data analysis to study the effects of and correlations between a variety of cognitive-behavioral dispositions and modification programs. Some of her projects are summarized here:

- For the correlational study, *"Trait-State Anxiety and Working Memory Performance"* at West Chester University of Pennsylvania, she investigated the relationship between high- and low trait-state anxiety and the working memory performance. In addition to developing survey instruments and computerized experiments, she tested the reliability and validity of questionnaires; and analyzed and interpreted the statistical data using correlations and ANOVA techniques.
- For the After-School Preventive Intervention program, "R.I.S.E." funded by the National Institutes of Health, Mansee developed instruments to assess session integrity and the effectiveness of an evidence-based program on coping with stress for adolescents exposed to chronic urban poverty. She assessed participants on stress appraisal measures and symptoms of behavioral disorders. She also analyzed statistical data using regression modeling and ANOVA in SPSS and Excel.

Cleantech Advisory Group

Robert Iodice | PE, CEM, DGCP | Senior Engineer

Robert (Bob) Iodice is a Senior Engineer at Cleantech Advisory Group (Cleantech). Bob's fifteen years of diverse technical experience in the energy efficiency industry has enabled him to establish a strong reputation for best-in-class demand side management (DSM) program design and evaluation, technical study delivery, code compliance assurance, facility energy audits, energy efficiency analyses, and renewable energy generation assessments. He provides guidance and mentoring to the teams he leads in the form of technical knowledge, a practical applied skillset, and an ability to cultivate others' aptitudes.

Education and Licensing

BA, Lighting and Thermal Systems, Temple University, Philadelphia, PA, December 1981
Certified Energy Manager (CEM)
Professional Engineer (PE)
Certified Distributed Generation Professional (DGCP)

Work Experience

Cleantech Advisory Group, Chester Springs, PA
Senior Engineer (2015-present)
Clark Energy Engineering, Broomall, PA
Senior Engineer (2013-2015)
Cabrini College, Radnor, PA
Chief Engineer (2003–2013)
Worthington Steel, York, PA
Automation Engineer (1998-2001)

Areas of Expertise

Measurement and Verification: Gathering comprehensive data on installed energy efficiency and renewable energy generation projects through on-site measurement and verification and statistical sampling; then leveraging IPMVP Option A, B, C, or D to analyze the collected data, determining energy and demand savings, as well as informing cost-benefit analyses.

Facility energy audits: Walking through and understanding the base building systems and structure; developing a baseline to evaluate usage; evaluate and calculate savings from various measures; determine viability of measures; implement measure installation; commission and measure savings.

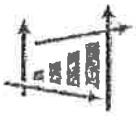
Engineering review & analysis: Review of engineering reports & calculations; ensure accuracy and matching data throughout; ability to reconstruct calculations & determine the key variables; detail oriented; review of energy audits, facility and property condition assessments

Representative Project Experience

Following are the highlights of Bob's Demand Side Management experience –

- As Senior Engineer at Clark Energy, subcontractor to GDS Associates for the Act 129 Phase II Statewide Evaluator (SWE) project, Bob performed baseline study on-site inspections, conducted logging / data acquisition for the metering studies, and conducted ride along site inspections and prepared reports for the audit activities. Responsibilities includes performing final analysis and writing final reports for the PUC.

- As Chief Engineer at Cabrini College, Bob reduced energy expenses by 47.7% over a 5 year period by installing improved lighting, upgrading HVAC equipment, and optimizing building automation systems. He demonstrated repeated success obtaining buy-in for progressive ideas from key stakeholders college-wide. Positioned the organization well within the top 10% of colleges nationwide for energy performance as determined by independent third party review.
- As Chief Engineer at Cabrini College, Bob co-chaired Environmental Health & Safety compliance efforts campus-wide. Bob completed EPA Region III Peer Audit with distinction and served as peer auditor for other institutions. He was the primary contact with PA/DEP, EPA, DOE, and external environmental consultants conferring regularly on a spectrum of topics.
- As Chief Engineer at Cabrini College, Bon exhibited exceptional leadership by building professional, cooperative, motivated teams from existing personnel who had previously dissolved into divisive, acrimonious cliques; radically changed the entrenched, pervasive culture from reactive to proactive; implemented effective Continuous Improvement Processes (CIP).
- In previous employment at industrial businesses, Bob has project managed capital projects from conception to completion. He was responsible for project proposals, document prep, approvals, field supervision, contracts administration, contractor management/oversight, schedule and budget, payment approval, communication with stakeholders, training.
- Managed all utilities including electricity, fuel oil, natural gas, steam, and water (potable, gray, black, septic, RO, DI, ultra-pure, soft, storm, well, and chilled).
- Negotiated electricity, natural gas, and fuel oil contracts, including renewables, resulting in rates which were consistently more competitive than peer institutions.
- Designed and directed lighting upgrades so that 42% of residential sq. ft. and 28% of total sq. ft. is lit exclusively with state-of- the-art LED solid-state technologies, and resulting in a total of 51% of sq. ft. lit with some form of high performance lighting (LED, occupancy/daylight sensing, etc.)



Cleantech Advisory Group

William Bland | Senior Manager

William (Bill) Bland is Senior Manager at Cleantech Advisory Group (Cleantech). Bill brings 30+ years of experience in load research, market research, savings estimation, EM&V and forecasting to the Cleantech team. Bill has evaluated numerous load management and energy efficiency programs for Commonwealth Edison, East Kentucky Power and Gulf Power Company. He has conducted several hundred residential baseline saturation surveys and commercial audit projects for Savannah Electric, Oglethorpe Power Corporation, and Southern Company Services including Alabama Power, Georgia Power, Gulf Power, and Mississippi Power during his career. Bill understands the importance of conducting quality commercial equipment audits to document equipment types and connected load for marketing, forecasting, and load research. He also has extensive experience in market characterization and assessment for programmatic improvements.

Education and Licensing

MA, Applied Mathematics, University of Georgia, 1980

BS, Physical Geography, University of Georgia, 1976

Load Research Fundamentals Certificate, Georgia Institute of Technology, 1980

Advanced Load Research Certificate, Georgia Institute of Technology, 1984

PUR Certificate in Utility Studies, 1984

Certificate in HVAC and Refrigeration Technology, Alabama Heat Pump Training Center, 1994

Work Experience

Cleantech Advisory Group, Chester Springs, PA
Senior Manager (2015-present)

GoodCents, Atlanta, GA
VP Consulting (2001-2015)

Southern Company Services, Atlanta, GA
Business Analyst- Executive and Marketing (1998-2001)

End Use Load Research Project Manager (1991-1998)

Oglethorpe Power Corporation, Atlanta, GA
Forecast Production Coordinator (1986-1991)

Savannah Electric, Savannah, GA
Load Research and Forecasting Supervisor (1980-1986)

Areas of Expertise

Energy Efficiency Program Evaluation, Measurement, and Verification (EM&V): Setting evaluation objectives; defining baseline scenarios; providing statistical sampling and probability analysis, and metering studies; calculating energy and demand savings; performing quality assurance, gross billing analyses, deemed savings estimation, emissions analyses, statistical forecasting, and attribution and benefit-cost analyses.

Demand Response Measurement & Verification: Designing data collection and analysis plans to assess demand reduction produced using a variety of commercial and residential curtailment techniques including critical peak pricing (CPP), air conditioning and water heater cycling, and programmable communicating thermostats (PCTs); using regression models to create time-temperature matrices of expected demand reductions during curtailment and demand increase following curtailment events; and evaluating the cost-effectiveness of securing demand response and load curtailment resources as an alternative resource to generation in forward capacity planning.

Statistical Programming: Creating analysis and reporting programs for use by others; working with extremely large utility databases and billing records in a variety of formats. Bill is a SAS Master Level programmer and proficient with SQL.

Savings Estimates through AMI Analysis: Quantifying energy savings produced by energy efficiency measures through AMI analytics; separating billed energy into baseline and weather dependent loads; and comparing weather dependent loads before and after the implementation

Representative Project Experience

Bill's substantial load research experience includes design of test and control sample populations for pilot programs, data acquisition, data warehousing, and load management impact analysis. In recent projects, Bill has implemented a large residential and solar water heating end-use study for Progress Energy Florida. In addition, Bill developed sample designs for Illinois Power's cost of service study for each rate and customer class. Following are examples of demand response (load management) and energy efficiency EM&V studies Bill has completed in the past decade –

Demand Response EM&V

- Mississippi Power- Pilot HVAC Control
- LG&E- Annual Analysis of LM program
- East Kentucky Power Cooperative G&T- Annual Analysis of LM program
- Oglethorpe Power Corporation G&T- Annual Analysis of LM Program
- Gulf Power- Pilot HVAC and Appliance Control
- Alliant Energy- Analysis of Residential program and Commercial LM Pilot
- Toronto Hydro- annual Analysis of LM and CPP program
- Dominion Virginia Power- Analysis of LM and CPP Pilot

Energy Efficiency EM&V

- Progress Energy Florida (Duke Energy)- HVAC, Refrigeration, Appliances, Solar WH
- LG&E- Energy Orb, GE Smart Appliances
- Gulf Power- Tankless and Heat Pimp Water Heaters
- Dominion Virginia Power- Envelope Improvements, High SEER AC
- Carolina Electric Power Cooperative G&T- Solar PV, Marathon WH, Envelope Improvements

Bill has prepared and presented reports to numerous professional organizations during his career on his work including the annual AEIC Load Research Conferences for the past 15 years, Southeastern Rate Exchange, Southeastern Geographical Society, SAS SUGI Conferences, SAS Southeast conference and many others.

Cleantech Advisory Group

Solomon Rosenbaum | PE, CEM | Engineer II

Solomon Rosenbaum is Engineer II at Cleantech Advisory Group (Cleantech). Solomon began his career working on energy savings performance contracting (ESPC) and helped federal and military institutions implement energy savings projects. Since that time, Solomon has continued to work in various capacities to assist commercial and institutional entities with their energy reduction goals. Over the past several years as an independent consultant, Solomon has worked on many Act 129 projects in Pennsylvania and Local Law 87 projects in New York City. Solomon has been involved in every facet of energy efficiency projects from the initial walk through audits & savings calculations to construction management, measurement, verification and commissioning. Soloman performs all types of M&V activities at Cleantech including surveys, site inspections, deploying and collecting loggers, sampling design, analyzing equipment consumption trends, calculating energy savings and reporting results. Soloman excels in the application of IPMVP protocols and is critical contributor to Cleantech's engineering work force.

Education and Licensing

MS, Mechanical Engineering, Columbia University, New York, NY, February 2002

BE, Mechanical Engineering, Columbia University, New York, NY, May 2000

Professional Engineer – Licensed in Maryland and New York

Certified Energy Manager (AEE)

Work Experience

Cleantech Advisory Group, Chester Springs, PA
Engineer II (2015-present)

Independent Mechanical & Energy Consultant
Principal (2007-2015)

Trigen Baltimore Energy (now Veolia Energy)
Business Development Manager (2005–2007)

Select Energy Services Inc. (now Ameresco)
Project Engineer (2002–2005)

Areas of Expertise

Facility energy audits: Walking through and understanding the base building systems and structure; developing a baseline to evaluate usage; calculate savings from various measures; determine viability of measures; implement measure installation; commission and measure savings.

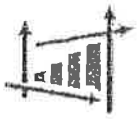
Engineering review & analysis: Review of engineering reports & calculations; ensure accuracy and matching data throughout; ability to reconstruct calculations & determine the key variables; detail oriented review of energy audits, facility and property condition assessments.

Measurement and Verification: Gathering comprehensive data on installed energy efficiency and renewable energy generation projects through on-site measurement and verification and statistical sampling; then leveraging IPMVP Option A, B, C, or D to analyze the collected data, determining energy and demand savings, as well as informing cost-benefit analyses.

Representative Project Experience

Following is a summary of Solomon's Demand Side Management Experience -

- **Local Law 87 (LL87) energy compliance projects in New York City.** Work included onsite inspections, calculation of energy conservation measures, completion and submission of recommissioning and LL87 tools, writing of energy audit reports for clients. Buildings consisted primarily of multi-family residential, but also included offices, medical facilities, nursing homes, and artist studios.
- **Engineering reviews of Property Condition Assessments and Energy Audits** - Recently surpassed a total of 4,000 reports reviewed. Facilities have ranged from small retail buildings to military campuses. Energy audits have been ASHRAE Level I and II and condition assessments are generally for due diligence purposes and meet ASTM guidelines. Reviews include checking all calculations, ensuring accuracy of facility description, and estimation of project costs & savings.
- **Act 129 EM&V in Pennsylvania** - On site verification of installed lighting systems and controls for participants in Act 129 programs. Facilities included banks, large manufacturing plants, warehouse facilities, and production plants. Verification also included review of submitted savings calculations. Further Act 129 work included checking and verifying of energy saving calculations in commercial custom programs.
- **HVAC system design and analysis**– Projects included cataloguing all HVAC equipment at 13 public schools and the development of energy savings measures. Work entailed the calculations of energy savings and report write-up.
- **Measurement & verification** – Development of site specific M&V plans in an effort to confirm energy savings. Responsibility included determining the crucial variables for the project and then creating a method to measure these variables before and after the implementation of the energy savings measures.



Cleantech Advisory Group

Thomas Walker | Project Coordinator

Thomas Walker is an Engineering Intern and Project Coordinator at Cleantech Advisory Group (Cleantech). Thomas is a Mechanical Engineer with strong academic understanding of mechanical systems and processes. He has fundamental knowledge of thermal systems, building energy savings calculations, and Excel based data analysis. Thomas excels in administration and coordination of various activities in a project life cycle. He has managed large cohorts of participants in research studies. At Cleantech, Thomas provides analytical, engineering and coordination support for a wide range of energy efficiency projects, including end-use and saturation studies, metering studies, and impact evaluations.

Education and Licensing

BS, Mechanical Engineering, University of Delaware, DE, Expected May 2017

Work Experience

Cleantech Advisory Group, Chester Springs, PA
Intern and Project Coordinator (2015-present)

University of Delaware, Newark, DE
Undergraduate Researcher (June 2015-September 2015)

Areas of Expertise

Energy Savings Analysis: Establishing baseline energy usage characteristics of sectors, segments, end-uses and equipment type; conducting on-site audits/site visits; survey analysis; and ensuring data integrity through established QA/QC protocols.

Project Support: Preparing project set up forms and providing project support such as calling, scheduling, site visit confirmation, data entry, application processing and more, in order to help project teams meet project goals.

Editing: Providing meticulous, yet efficient, QA/QC for both project reports and proposals. Ability to spot errors in style and format while proof-reading and ability to avoid errors while composing documents.

Representative Project Experience

Thomas has participated in numerous building energy research projects including the following –

- Effects of temperature and humidity changes on cooling heat exchanger membranes for the Summer Scholars Research Program.
- Reviewing and updating savings protocols by analyzing savings assumptions, deemed savings, baseline efficiencies, and source documentation.

Jesse Smith – Independent Energy Consultant

Jesse Smith is experienced DSM consultant whose work is focused on estimating the impacts of demand side interventions to alter the way homes and businesses use energy and helping clients improve those offerings. He has been involved in the design, and evaluation, measurement and verification (EM&V) of a wide variety of demand response, 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 was a key member of the Statewide Evaluation Team for Phase I and Phase II of Pennsylvania's Act 129 energy efficiency and demand response programs. His duties included a wide range of technical assessments, policy guidance, audit activities, and independent research to improve the accuracy and reliability of energy and demand savings estimates. Prior to joining Nexant, Jesse worked as a load research analyst for GoodCents Solutions where he performed statistical analyses of the energy and demand savings of a number of direct load control and energy efficiency projects for client utilities.

Education

Master of Science, Applied Statistics — December 2010
Kennesaw State University — Kennesaw, GA

Bachelor of Science in Psychology, Minor in Chemistry — May 2001
University of North Carolina — Chapel Hill, NC

Work Experience

Nexant Inc. – Malvern, PA
Managing Consultant — 2015
Project Manager — 2013-2015
Senior Project Analyst — 2011-2013

GoodCents Solutions, Inc. – Atlanta, GA
Load Research Analyst — 2010-2011

Representative Project Experience

Pennsylvania Public Utility Commission (PA PUC) – PA Act 129 Statewide Evaluator – Evaluation of Pennsylvania Electric Distribution Companies' Energy Efficiency and Conservation Programs (2011–2015)

Jesse was the Project Manager for Nexant's contract as the Statewide Evaluator of PA's energy efficiency and demand response programs. The Statewide Evaluator's role is to provide guidance and oversight to each of the seven electric distribution companies (EDCs) in the state and to audit the energy and peak demand savings values reported to the PA PUC. Jesse lead a team of analysts and engineers responsible for maintaining the Pennsylvania Technical Reference Manual (TRM) and compiling tracking data supplied by each of the seven EDCs on their commercial & industrial energy efficiency and demand response programs and verifying that this information is being calculated and reported correctly. Jesse was a lead author of the Pennsylvania Evaluation Framework, and his team recently completed a statewide Commercial Lighting Metering Study and a Commercial and Industrial Baseline Study. These studies include over 1000 site inspections and will inform future TRM updates and savings targets in the state. Jesse also led an assessment of non-residential demand response potential for the PAPUC that was completed in 2015. The seven EDCs have a combined summer peak of load of nearly 30,000 MW and $244 million in annual DSM program budgets. Previous rate-payer funded demand response offerings in the state failed to pass the TRC test so the first task in the study scope was to consider program design characteristics and recommend a more effective model given the various technical and policy constraints in place. The study classified residential and small commercial accounts by building type, demand magnitude, and weather-sensitivity. Large commercial and industrial accounts were assigned to one of fourteen distinct business types. Jesse calculated price elasticity values for each business type using actual demand response program data in California, PJM, and previous offerings in Pennsylvania. These estimates of electricity price sensitivity provided data-driven intelligence on how large commercial and industrial accounts can be expected to respond to DR offerings. The study also considered the interplay between a potential state DR program and the PJM DR markets, which many large C&I customers already actively participate in. The study presents both full potential and potential net of existing DR commitments in wholesale markets.

Duke Energy – MyHER Impact Evaluation (2014–2015)
Jesse was the lead analyst for the evaluation of Duke Energy's residential behavioral conservation initiative, MyHER. The program provides neighbor comparison reports to over 2 million residential customers in Duke's service territory spanning Ohio, Indiana, Kentucky, North Carolina, and South Carolina. MyHER is a flagship program in Duke's DSM portfolio, generating nearly 500 GWh of savings annually. Jesse's responsibilities include requesting, processing, and analyzing in Stata the significant volume of data from Duke's data warehouse that is required to estimate the effect of the MyHER treatment. Because of the staggered deployment of MyHER across Duke's service territories, the impact evaluation of the program requires a careful consideration of impacts on a cohort basis to ensure that impact estimates aren't confounded by cohort imbalances in the treatment and control groups. Once the total change in energy consumption is estimated via regression analysis, Jesse performs an "overlap analysis" using program tracking records from all other Duke DSM offerings to determine the quantity of savings which must be subtracted from the MyHER effect to prevent double-counting of savings. Jesse and his team also recently completed a bootstrapping simulation to provide Duke with strategic intelligence regarding the optimal size and composition of the control groups for each state.

CPS Energy – Home Manager and Smart Thermostat Program Evaluations (2011–2014)
Jesse was the primary analyst for the evaluation of CPS Energy's Home Manager and Smart Thermostat demand response programs. These programs control residential and small commercial HVAC units, hot water heaters, and pool pumps allowing CPS Energy to curtail the energy use of these devices during peak periods. Nexant was tasked with quantifying system demand reduction resulting from curtailment events throughout the summers of 2012, 2013, and 2014. Jesse authored the statistical sample design portion of the M&V plans for the programs and led the data analysis portion of the evaluation. He wrote numerous SAS programs to import, manipulate, graph, and analyze the consumption data collected within the M&V plan. Jesse also developed time-series weather regression models to estimate program performance under both observed weather conditions and possible system emergency conditions.

CPS Energy – Nest Thermostat and ThinkEco Pilot Evaluations (2014)
Jesse managed the evaluation of two demand response pilot programs offered by CPS Energy in the summer of 2014. The Nest Rush Hour Rewards program offers existing Nest thermostat owners in CPS service territory an incentive to allow CPS to modify their set points on hot summer days. A randomized control trial (RCT) experimental design was developed and implemented for the pilot to accurately estimate load impacts and inform CPS's decision making about expanding the pilot into a full program within its portfolio. The ThinkEco pilot attempts to reach the 17% of CPS customers with room air conditioning. Participants are provided a control device that allows them to operate their room AC unit like a programmable thermostat and control it from their smart phone. During DR events, the device will increase the thermostat setting in the room to reduce cooling load. Nexant used a within-subjects regression model to estimate impacts for the program.

Efficiency Maine Trust – Impact Evaluation of Residential Retail Products Program (2013–2014)
As a subcontractor to NMR, Jesse contributed to the impact evaluation team for Efficiency Maine's Residential Retail Products program, which includes the Appliance program and the Lighting program. Through designing the evaluation and M&V approaches to comply with ISO-NE requirements for M&V, set forth in the M-MVDR document to support the client's bid of resources into the Forward Capacity Market, he developed a comprehensive metering study to investigate energy consumption patterns of clothes washers, electric water heaters, refrigerators, and dehumidifiers. He coordinated and executed data collection efforts on the field with engineering staff to deploy and retrieve over 400 data loggers across nearly 100 homes. He developed SAS code to import and analyze all logger data in order to estimate ex-post energy and peak demand savings as well as develop 8760 load shapes for each appliance. Jesse also led an analysis of free ridership within the upstream component of the Efficiency Maine's Residential Lighting Program. Using two years of sales data at various rebate levels, his team modeled the price elasticity of demand for various efficient lighting technologies and used these values to estimate the sales that would have occurred at the sales prices absent any program rebates. This modeling approach relies on the same founding principle as the program—a reduction in price will lead to increased adoption of efficient lighting options.

Representative Publications

Jesse Smith and Salil Gogte, *Rate-Payer Funded DR Programs in RTO Competitive Markets – Incremental Benefit or Double-Dip?*, AESP National Conference 2014, San Diego, USA

Optimal ENERGY *Integrated Energy Resources*

ERIC J. BELLIVEAU
PARTNER

PROFESSIONAL EXPERIENCE

Optimal Energy, Inc. — **Hinesburg, VT**

Partner, August 1999–present

- Provides clients with expert guidance on design and development of efficiency services delivery: developing sales staff, establishing new markets, working with business focus groups to design the marketing outreach strategies.
- Overall project manager and team lead providing services for the Massachusetts Energy Efficiency Advisory Council. Team provides EEAC with consulting services including planning, evaluation, residential and commercial/industrial best practice, analysis, and design. Massachusetts is currently completing its first three year plan which made it Number 1 on ACEEE scorecard. The last year of the plan is targeted to achieve 2.3% reduction in statewide load and will spend over $600 million dollars. Currently negotiating goals and budgets for Massachusetts' next three year plan.
- Co-author and expert witness on achievable potential for energy-efficiency resources in Quebec. Provided design and implementation support to Hydro Quebec in reassessing and redesigning energy efficiency programs.
- Project leader for the development of a slate of programs for the Delaware Department of Natural Resources and Environmental Control.
- C&I interim program manager and program designer for the District of Columbia Sustainable Energy Utility. Providing ongoing services in account management, C&I program staff mentoring, and program design and analysis.
- C&I team lead in assisting AMP Ohio with efficiency potential analysis and potential program designs for the 132-member utilities of the association. Continuing to support program roll-out with C&I sector program design, market research, and analytical support.
- Led the analysis and program design teams for LIPA's Efficiency Long Island, a ten-year, $1 billion energy efficiency portfolio (520 MW and 1,600 GWh) introduced in 2009. Provided scenario analysis data for inclusion in LIPA's integrated resource plan for least cost investment in attaining Long Island's energy and demand needs through 2018.
- For the Efficiency Maine Trust, developed a three-year plan for commercial buildings sector energy efficiency programs. Programs targeted electric, natural gas, and un-regulated fossil fuel consumption.
- Lead consultant to the New York Power Authority for assessing and improving existing commercial programs, developing a comprehensive program evaluation plan, and designing a new business customer program.

- Working under the leadership of the Northeast Energy Efficiency Partnership, reviewed the energy efficiency delivery model in NJ. As lead of the C&I Existing Building Team, duties included reviewing existing delivery model, programs, and contracting structure. Developed new program designs and model reconfiguration for 2010 implementation.
- Prime contractor representative in providing the Asian Development Bank with a prefeasibility study for establishing an efficiency power plant demonstration project In Guangdong Provence, PRC. Provided all consulting and design services for business development, outreach and capacity building for project design model.
- Led C&I team in assisting Hydro Quebec in restructuring their energy efficiency approach to the existing building sector.
- Led C&I team in a comparison of North American best practices for Manitoba Hydro.
- Leading effort to evaluate investment opportunities for energy service companies in a wide range of commercial and industrial businesses.

EDUCATION

B.A., International Affairs/German, University of Maine, Orono, ME, 1981.

PROFESSIONAL ACTIVITIES AND MEMBERSHIPS

- Member USGBC. LEED Accredited 2003
- Speaker - Society for Manufacturing Engineers - Chicago Il
- Speaker - Harvard University roundtable discussions on food solutions.
- Instructor - Post and Beam House Construction.
- Board Member, Energy Co-op of Vermont, 2000-2009

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PHILIP H. MOSENTHAL
PARTNER

PROFESSIONAL EXPERIENCE

Optimal Energy, Inc. Hinesburg, VT

Founding Partner, 1996-present

- Manager of NY statewide electric, gas and petroleum efficiency and renewable energy resource assessments and program design and analysis; multiple projects over a period of a decade. Responsible for coordinating large multidisciplinary teams to assess residential, commercial, and industrial efficiency potential, and design and analyze a portfolio of efficiency programs to be delivered statewide.
- Assist the Vermont Electric Power Company to analyze and propose resource solutions to address a T&D constrained area in southern VT. Analyzed the efficiency potential in the region and proposed and designed a portfolio of efficiency programs to avoid or defer the need for substantial T&D upgrades.
- C&I lead advisor on development of electric and unregulated fuels efficiency potential and development of 20-year forecasts of expected Efficiency Vermont achievements under various policy, planning and funding scenarios. Includes zonal analysis to support distributed utility planning for transmission system reliability for all Vermont electric utilities.
- Chief architect of Efficiency Vermont, the nation's first and only state efficiency utility, on behalf of the Vermont Department of Public Service, as well as advisor on C&I planning, program design, EM&V, and regulatory. Managed program design, development, and planning. Includes design, development, and start-up of programs to serve the commercial, industrial, institutional, and agricultural sectors in Vermont. (1997 – present)
- Lead researcher on energy efficiency issues for EPA's Clean Energy Partnerships with State and Local Government to advance State Clean Energy Action Plans, and as consultant to the EPA's National Action Plan for Energy Efficiency. As part of this role, served as the lead author of the EPA NAPEE's *Guide to Conducting Efficiency Potential Studies* (2006 – 2010)
- Lead developer of an EM&V framework for the State of Delaware as advisor to the Delaware Energy Efficiency Advisory Council. (2015)
- Advisor to the Rhode Island Energy Resource Management Council developing and overseeing efficiency planning, policy, program design and implementation, cost-benefit analysis, and EM&V. (2008-present)
- Lead author and advisor to the New Hampshire Public Utility Commission on utility performance incentive design for a section of the *Independent Study of Energy Policy Issues* report (2011)
- Advisor to the Illinois Attorney General on policy, planning, program design and evaluation, and utility oversight regarding electric and gas efficiency programs

throughout Illinois. This project has included expert testimony on development of initial plans, funding mechanisms, policy, and evaluation and verification issues. Currently, Mr. Mosenthal represents the AG in a collaborative addressing all issues surrounding planning, program development, implementation and evaluation, and cost recovery. For ILL AG (2007 – present).

- Lead advisor to Natural Resources Defense Council on electric and gas energy efficiency and policy issues in Missouri. This project has involved expert testimony in numerous integrated resource planning and DSM Plan dockets. In addition, lead representative to NRDC in utility collaboratives with Ameren and Kansas City Power and Light, Advising on decoupling, cost recovery, performance incentives, program design, implementation and EM&V. (2011-present)
- Manager of numerous comprehensive electric and natural gas efficiency and renewable potential assessments for New York State Energy Research and Development Authority. (2003 – 2014)
- Report and testimony on performance of DSM initiatives and proposed shareholder performance incentives for administrators of conservation and load management programs in Connecticut, on behalf of Connecticut Office of Consumer Counsel. Led C&I analysis. (2003 – 2004)

Resource Insight, Inc. — **Middlebury, VT**

Senior Research Associate, 1995-1996

Xenergy, Inc. (now DNV GL) — **Allendale, NJ**

Chief Consultant for Mid-Atlantic Region, 1990-1995

Community Energy Development Corp. (CEDC) — **Philadelphia, PA**

Acting Executive Director, 1986–1988

Pennsylvania Energy Center — **Philadelphia, PA**

Director of Technical Services, 1983 – 1986

Managed, designed and developed energy services for the Southeast Regional branch of the Pennsylvania State Energy Office. Designed and developed technical energy services for commercial, industrial and institutional building owners; supervised staff of energy auditors and subcontractors; performed over 400 commercial and industrial energy audits; and taught energy management workshops.

EDUCATION

M.S., Energy Management and Policy, University of Pennsylvania, Philadelphia, PA, 1990.

B.A., Design of the Environment, University of Pennsylvania, Philadelphia, PA, 1982.

Certificate in Electrical Engineering, Pennsylvania State University, Ambler, PA, 1984.

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JEFFREY M. LOITER
MANAGING CONSULTANT

PROFESSIONAL EXPERIENCE

Optimal Energy, Inc. — Hinesburg, VT

Partner, 2015-present; Managing Consultant, 2006-2014

- Led or contributed to several studies of efficiency potential, ranging from meta-analyses to detailed sector-specific assessments. Assessments have included both the residential sector and the commercial/industrial sectors, in locations including New York, Vermont, New England, Texas, and a Canadian Atlantic province.
- Prepared two documents for inclusion with EPA's National Action Plan for Energy Efficiency: a guidebook on conducting efficiency potential studies and a handbook describing the funding and administration of clean energy funds.
- Providing broad program planning, analysis, and strategic guidance to the Delaware Energy Efficiency Advisory Council as they begin 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.
- Leads Optimal's energy efficiency consulting services to the Connecticut Municipal Electric Energy Cooperative (CMEEC). These services include program planning, program savings analysis and reporting, developing incentive and delivery strategies, and managing CMEEC's participation in the ISO-NE Forward Capacity Market.
- Submitted expert testimony on behalf of environmental interveners or state agencies in several cases related to utility Integrated Resource Plan and Demand Side Management Plan filings. Cases typically involve filing review, developing alternative analyses, drafting pre-filed testimony, and appearing before public service commissions for cross-examination. Cases have included utility filings in Arkansas, Kansas, Kentucky, Maryland, Ohio, Virginia, and West Virginia.
- Supporting program implementation and on-going program design and development for Orange and Rockland Utilities. Previously managed the preparation of a DSM plan and Commission filings for this client. The project included on-site customer audits and residential surveys, efficiency program designs, and an efficiency potential study.
- Led Optimal's participation in preparing a Technical Resource Manual for the Mid-Atlantic States (Maryland, Delaware, District of Columbia), for the Northeast Energy Efficiency Partnerships' Regional EM&V Forum.
- Managed Optimal's participation in a team developing a Five-Year Energy Efficiency and Demand Response Plan for the Tennessee Valley Authority. Optimal's role focused on programs for the commercial sector in TVA's service territory, encompassing efforts to reach a variety of markets and end-uses, including specific offerings for both very large and small commercial entities.

Independent Consultant — Cambridge, MA

2005-2006

Industrial Economics, Incorporated — Cambridge, MA

Associate, 1997-2000; Senior Associate, 2001-2004

Managed multi-disciplinary qualitative and quantitative assessments of natural resource damages and environmental policy for clients such as NOAA, USFWS, USEPA, USDOJ, the National Park Service, the State of Indiana, and the United Nations.

URS Consultants, Incorporated — New Orleans & Boston

1991-1995

EDUCATION

M.S., Technology & Policy, Massachusetts Institute of Technology, Cambridge, MA, 1997
B.S. with distinction, Civil and Environmental Engineering, Cornell University, Ithaca, NY, 1991

PUBLICATIONS & PRESENTATIONS

"Collaboration that Counts: The Role of State Energy Efficiency Stakeholder Councils," (with D. Sosland, M. Guerard, and J. Schlegel), *2012 ACEEE Summer Study on Energy Efficiency in Buildings*, Pacific Grove, CA, August 2012.

"Persistence and Cost of Behavioral Programs," presented at National Association of State Utility Consumer Advocates Mid-Year Meeting, Charleston, SC, June 2012.

"Impending EISA Lighting Standards: Impacts on Consumers and Energy Efficiency Lighting Programs," presented at National Association of Regulatory Utility Commissioners Annual Meeting (with M. DiMascio), Atlanta, GA, November 2010.

"From Resource Acquisition to Relationships: How Energy Efficiency Initiatives Can Work Effectively with Large Commercial & Industrial Customers," (with E. Belliveau, J. Kleinman, D. Gaherty, and G. Eaton), *2008 ACEEE Summer Study on Energy Efficiency in Buildings*, Pacific Grove, CA, August 2008.

National Action Plan for Energy Efficiency (2007). *Guide for Conducting Energy Efficiency Potential Studies*. Prepared by Philip Mosenthal and Jeff Loiter, Optimal Energy, Inc. December.

Loiter J.M and V. Norberg-Bohm (1999), "Technology policy and renewable energy: public roles in the development of new technologies," *Energy Policy* Vol.27 no.85-97

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MICHAEL GUERARD
MANAGING CONSULTANT

PROFESSIONAL EXPERIENCE

Optimal Energy, Inc. — **Providence, RI**

Managing Consultant, July 2008 to present

Primary role is to provide project management, research, stakeholder coordination and technical analysis to support clients' development of strategies for achieving energy efficiency and attainment of least-cost resources. Key tasks include the following.

- Leading research and analysis to establish three-year savings targets
- Providing review and input on qualitative and quantitative elements of annual energy efficiency program plans
- Supplying tactical and strategic support to state energy offices and for other key stakeholders to facilitate collaborative efforts to achieve common objectives
- Providing oversight of program implementation and verification performance results.

Main clients for these tasks have included the following.

- Rhode Island Energy Efficiency and Resources Management Council
- Rhode Island Office of Energy Resources
- Massachusetts Energy Efficiency Advisory Council
- Delaware Energy Efficiency Advisory Council
- Long Island Power Authority for the Clean Energy Initiative

Conservation Services Group, Inc. (1991 – 2008) — **Westborough, MA**

Senior Project Manager, 2006-June 2008

- Primary responsibility to direct CSG's research, development and delivery of LEED for Homes provider services; the launch of a Northeast regional green building program, Earth Advantage; and multi-family new construction initiatives.
- Provided coordinated development of the technical, program, staff and business strategies to address serving these new initiatives for the company.

Program Manager, Pacific Northwest New Construction Programs, 2004-2006

- Developed, launched and managed the ENERGY STAR-labeled Home™ Program in the Pacific Northwest for the Energy Trust of Oregon and the Northwest Energy Efficiency Alliance, covering Oregon, Washington, Idaho, and Montana

- Hired and managed staff; coordinated operations with primary partner and minor partners; served as primary liaison with multiple stakeholders including state energy offices and universities
- Served on board of PNW Technical Review Committee, to establish and advance program technical standards and protocols

Director, New England Residential Energy Services, 2000-2003

- Overall management of over 50 staff delivering thousands of energy audits and new home certifications annually throughout New England, along with the associated building science training and contractor infrastructure development required to successfully complete production levels.
- Provided primary interface with multiple utility clients and other funding sources, and oversight of all required tracking, reporting and analysis

Program Management Roles, 1991-2000

- 1998-2000, Program Manager, ENERGY STAR Homes
- 1996-1997, Developed successful grant request, and subsequently managed and delivered *HERS: Infrastructure Development for the Northeast HERS Alliance* funded by the U.S. Department of Energy
- 1995-1997, Developed successful grant request, and subsequently managed and delivered *Promotion and Evaluation of Energy Efficient New Construction in the Northeast* funded by the U.S. EPA
- 1994-1998, Program Manager, EUA Lighting Program
- 1994-1995, Program Manager, Advanced Retrofit pilot program
- 1991-1997, Program Manager, Energy Crafted Homes Program

EDUCATION

University of Kansas, graduate studies

University of Rhode Island and Rhode Island College, Bachelor's degrees

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MATTHEW T. SOCKS, PE, CEM, BESA
SENIOR CONSULTANT

PROFESSIONAL EXPERIENCE

Optimal Energy, Inc. — **Hinesburg, VT**

Senior Consultant, September 2007–Present

- Project manager for a study of energy efficiency potential in affordable multifamily housing in nine state conducted for Energy Efficiency for All, a joint initiative of the Natural Resources Defense Council, the National Housing Trust, and others (2014-2015)
- Primary analyst for development of a statewide energy efficiency potential study for the Delaware Department of Natural Resources and Environmental Control (2013)
- Project manager for a study of statewide energy efficiency and renewable energy best practices for public and private K-12 schools in New York State conducted for the New York Power Authority. Study includes high-impact measure opportunities, best practice program designs, and an assessment of statewide potential (2012-2013)
- Collaborated with Duke Energy's New Product Development division to develop new non-residential measure characterizations and participation projections for inclusion in 2013 EE program portfolios in North Carolina, South Carolina, Ohio, Indiana, and Kentucky. (2012-2013)
- Primary contributor for development of a statewide energy efficiency and renewable energy potential study for the New York State Energy Research and Development Authority. (2011-2012)
- Project manager for a study of statewide energy efficiency and renewable energy potential for New York State government facilities. This study led directly to an initiative by Governor Cuomo to release $450 million in state financing with the goal of reducing energy consumption in State buildings by 20%. (2011-2012)
- Primary contributor for development of commercial and industrial measure characterizations for a novel, multi-state Technical Reference Manual for use by utilities in the Mid-Atlantic region. Project required comparative analyses between regional energy efficiency savings estimation methodologies and working with stakeholders to reach consensus on the characterizations. (2010-2015)
- Primary contributor for development of a Statewide, multi-jurisdictional electric and natural gas Technical Reference Manual for the Massachusetts Energy Efficiency Advisory Council. (2009-2010)
- Primary contributor for development of commercial and industrial measure characterizations for a statewide Technical Reference Manual for use by Ohio EE programs. (2010)

NSK Corporation Ann Arbor, MI

Engineering Intern, 2000 - 2003

EDUCATION

B.S., Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, MA, 2006

PUBLICATIONS

"Leveraging Financing for Comprehensive Efficiency in the Public Sector," Proceedings of the American Council for an Energy Efficient Economy 2014 Summer Study on Energy Efficiency in Buildings. Washington, D.C. August 2014.

"Non-Transmission Alternatives: The Emerging Importance of Regional Planning to the Clean Energy Industry Under FERC 1000,"Proceedings of the American Council for an Energy Efficient Economy 2012 Summer Study on Energy Efficiency in Buildings. Washington, D.C. August 2012.

"Streamlining the Small New Construction Market: A Prescriptive Approach to Comprehensive Savings with Core Performance," Proceedings of the American Council for an Energy Efficient Economy 2008 Summer Study on Energy Efficiency in Buildings. Washington, D.C. August 2008.

PROFESSIONAL MEMBERSHIPS

- American Society of Heating, Refrigerating and Air-Conditioning Engineers
- Association of Energy Engineers

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GEORGE LAWRENCE
SENIOR CONSULTANT

PROFESSIONAL EXPERIENCE

Optimal Energy, Inc. — **Hinesburg, VT**

Senior Consultant, 2014-present

- Commercial and Industrial (C&I) Advisory Group Coordinator for the eight Massachusetts (MA) energy efficiency Program Administrators and the MA Department of Energy Resources. Led the Energy Efficiency Advisory Council effort to set appropriately aggressive C&I goals for the Massachusetts 2016-2018 three year energy efficiency plan. Review evaluation reports and potential studies, consult on the MA Technical Resource Manual, provide direction on baseline and market study work plans. Consult on program planning and design, program savings analysis and reporting; and developing incentive and delivery strategies.
- Leads Optimal's C&I energy efficiency consulting services to the Rhode Island Energy Efficiency Resource Management Council and the RI Office of Energy Resources. These services include consultation on program planning, program savings analysis and reporting, and developing incentive and delivery strategies.
- Audited Enbridge Gas custom industrial projects for the 2014 program year.

Vermont Energy Investment Corporation — **Burlington, VT**

Consultant, 2011-2014

Lead Consultant for all commercial and industrial projects, which included:

- Designed and helped implement a pilot Strategic Energy Management program for a cohort of industrial, institutional, and commercial customers in Vermont for Efficiency Vermont
- C&I lead for development and review of the Illinois Technical Resource Manual
- Managed technical review of projects for NYSERDA's Industrial and Process Efficiency and Existing Facilities programs
- Reviewed and consulted on C&I programs in New Hampshire and Iowa
- C&I lead for a penetration and potential study for both technical and behavioral savings for Commonwealth Edison Illinois
- Led the renewable energy portion of a potential study for NYSERDA

Planning and Development Manager, Efficiency Vermont, 2007-2011

Managed multiple commercial, municipal, and industrial business market initiatives for Efficiency Vermont. Designed and implemented efficiency programs for the Ski Industry, K-12 Schools, Water and Wastewater, and Agricultural markets as well as for industrial users of compressed air.

Energy Consultant, Efficiency Vermont, 2006-2007
Identified and quantified energy efficiency opportunities in commercial and industrial facilities. Worked with corporate officers to negotiate incentives and to present the process improvement and financial arguments for doing efficiency projects.

The McKernon Group Brandon, VT

Construction Sales, Green Building Products, 2004-2006
Managed sales of multiple lines of environmentally friendly construction materials such as insulating concrete forms and structural insulated panels.

Northern Power Systems Waitsfield, VT

Sales Manager, 2000-2004
Managed domestic and international sales of renewable and fossil fuel powered energy systems that were used in extreme environments to provide reliable electricity.

Windstream Power Systems Burlington, VT

Sales Manager, 1999-2000
Managed domestic and international sales of renewable energy power systems.

Self Employed, Yearsley Construction Jackson, WY and Addison, VT
General Contractor, Cabinetmaker and Carpenter, 1990-1999

EDUCATION

B.A. Physics, Middlebury College, Middlebury, VT, 1989

CERTIFICATIONS

Institute for Energy Management Professionals: Certified Practitioner of Energy Management Systems - Industrial
Association of Energy Engineers: Certified Energy Manager
Association of Energy Engineers: Certified Energy Auditor
Department of Energy: AirMaster+ Compressed Air Specialist

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CLIFFORD S. MCDONALD
CONSULTANT

PROFESSIONAL EXPERIENCE

Optimal Energy, Inc. **Hinesburg, VT**

Analyst 2006-2007/Senior Analyst August 2009-2011/Consultant January 2012-present

- Reviewed and provided comments on the Pennsylvania TRM and the Pennsylvania EDCs' efficiency plans.
- Developed alternative high level potential estimates for Pennsylvania Act 129 Phase III.
- Led analysis and review of NYPA's current program strategies to evaluate feasibility and strategy for a potential targeted demand reduction program in the load constrained Brownsville region.
- Co-authored US Environmental Protection Agency guides to action on potential studies and clean energy funds
- Wrote paper on the potential of continuing Pennsylvania's efficiency programs, and their economic and environmental benefits.
- Project manager for impact evaluations for New Orleans' efficiency programs for 2011, 2012, and 2013.
- Extensive support to energy efficiency advisory councils in Massachusetts and Rhode Island, including goal and budget setting, program design, and white papers on program practices and technologies.
- Provide ongoing implementation support for Orange & Rockland Utilities, including verifying savings estimations, screening custom projects for cost-effectiveness, and reviewing the incentives offered. Also performed analysis that became the basis for their latest 3-year efficiency plan.
- Led best practice reports on efficiency program design for the health care sector, retro-commissioning, commercial leased spaces, and data centers.
- Worked with NYSERDA to develop a new sub-metering program.
- Developed detailed evaluation of ground source heat pump technologies.
- Performed review of NYPA's efficiency projects, and developed recommendations concerning NYPA's Evaluation, Measurement, and Verification protocols
- Developed recommendations for an industrial sector energy efficiency program for NYPA, and provided an analysis of its potential costs and benefits
- Developed measure characterizations for Technical Resource Manuals in New Brunswick, Vermont, Ohio, the Mid-Atlantic, and Long Island
- Used building modeling to develop prescriptive savings recommendations for VFDs.
- Developed an operations manual for LIPA's commercial efficiency programs.

Viridian Energy and Environmental New York, NY

Energy Analyst, 2008- 2009

- Used DOE2 to create energy models to analyze the energy use in existing and new construction buildings
- Developed specific recommendations on the implementation of energy efficiency measures
- Worked with architects and developers to get LEED certification on new construction projects and building renovations

University of Pennsylvania Medical Center Philadelphia, PA

Medical Physics Researcher, Summers 2004 and 2005, April – August 2008

- Used computer simulations and Monte Carlo algorithms to support development of new, state-of-the-art proton therapy center for cancer treatment
- Developed recommendations on materials and dimensions to be used in multi-leaf collimator
- Created micro-dosimetry simulations to investigate neutron doses at a molecular level

Volunteer Experience

- Taught environmental issues and alternative income methods in the Peruvian Amazon
- Taught English and environmental issues in Quilotoa, Ecuador, a small indigenous village
- Developed bio-diesel capability at an organic permaculture farm in Bahía, Ecuador

EDUCATION

B.S., Physics, Middlebury College, Middlebury, VT, 2006

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CRAIG JOHNSON

ANALYST

PROFESSIONAL EXPERIENCE

Optimal Energy, Inc. — **Providence, RI**

Analyst, August 2014 – Present

- Support the Rhode Island Energy Efficiency and Resource Management Council (EERMC) and Massachusetts Energy Efficiency Advisory Council (EEAC) during planning and implementation phases of three-year and annual energy efficiency program plans. This has included reviewing recent energy efficiency potential assessments, tracking and analyzing current and historical program performance at the portfolio, sector, and program levels, and assessing cost-effectiveness and total cost to achieve energy savings.
- Contributor on an effort to outsource and manage the Connecticut Municipal Electric Energy Cooperative's (CMEEC) energy efficiency program data. This has included coordinating collection, review, and processing of project data and assisting in the development of an online technical reference library and savings calculation engine and database.
- Provide technical analysis and research support for various initiatives including energy efficiency training and education opportunities, upstream energy efficient technologies, providing energy efficiency services to customers not covered by utility-offered programs, and a study of energy efficiency potential in affordable multifamily housing.

Acadia Center, f.k.a. Environment Northeast — **Providence, RI**

Climate Change & Policy Intern, June 2013 – December 2013

- Collaborated with stakeholders to develop and implement Rhode Island's Energy Efficiency Program Plans.
- Performed quantitative and qualitative analysis to support organization's core initiatives with a primary focus on sustainable transportation.
- Research areas included: Conversion of freight shipping fuel from diesel to natural gas, electric vehicle incentives and policies, and alternative options for funding transportation projects.

Bard Center for Environmental Policy Annandale-on-Hudson, NY

Teaching Assistant, Dr. Jennifer Phillips, September 2012 – May 2013

- Researched and led discussions on sustainable farming practices and GHG emissions associated with agricultural systems.

Lyndon State College Atmospheric Sciences Department Lyndonville, VT

Research Assistant, Dr. Nolan Atkins, 2010-2012

- Collected and photogrammetrically analyzed data of severe thunderstorms during the Verification on the Origins of Rotation in Tornadoes Experiment (VORTEX2).
- Produced graphics for peer reviewed research papers and presented results at national and regional conferences.

EDUCATION

M.S., Climate Science and Policy, Bard Center for Environmental Policy, Annandale-on-Hudson, NY, 2014

Masters Thesis: *Driving Sustainability: Estimating Lifecycle Private Costs of Electric Vehicles*

B.S., Atmospheric Sciences, Lyndon State College, Lyndonville, VT, 2012

Robert Urban

Education

Bachelor of Science in Mechanical Engineering, California Polytechnic State University 2008

Certifications

Association of Energy Engineers, Certified Energy Manager (CEM)

Certified Commissioning Agent (CxA)

Work Experience

Operations Manager, Abraxas Energy Consulting	2010 to present
Senior Project Manager, Abraxas Energy Consulting	2008 to 2010
Energy Analyst, Abraxas Energy Consulting	2007 to 2008

Illustrative Projects

Project Management - Managed Energy Audits of US Naval Hospitals and Campuses

Abraxas was awarded a multi-year contract to conduct energy audits and project feasibility studies of US Naval Hospitals and campus buildings around the world. During the first two years of this contract, Robert has managed the audits of 24 hospitals, clinics, and administrative offices at 10 different sites, including Twentynine Palms, Lovell Federal Healthcare Center, and Naval Hospital Guantanamo Bay. The comprehensive assessments are organized into two phases including preliminary baseline assessment and final recommendations and feasibility studies. The feasibility studies include assessing opportunities for renewable energy systems, cogeneration, and retro-commissioning. The rigor with which each audit is reviewed by the Navy requires Robert to closely manage the team's budget and pay attention to detail and quality. For this reason, and because of the nature of the facilities, Robert has adjusted the team's approach to the work and refined their efforts to produce a quality end product.

Project Management - Managed Detailed Energy Audits, Project at Joint Base Lewis McChord

Robert was responsible for overall project management and supervision of a team of 14 engineers performing detailed energy assessments of 112 buildings at Joint Base Lewis McChord, located in Fort Lewis, Washington. The team included two subcontractors as well as five engineers from Abraxas Energy. The engineers had various backgrounds including electrical engineers, mechanical engineers, energy engineers, and technicians. Robert organized and guided this diverse group to successfully complete the site visits in six weeks. Measure evaluation and reporting were completed in the two months that followed. The team identified nearly $3M worth of energy-saving projects with an overall payback of fewer than five years.

Project Management - Managed a Comprehensive Energy Service Project for the US Coast Guard Training Center in Petaluma, CA

Robert was the project manager for the comprehensive energy services performed at TRACEN Petaluma. The services performed required AEC to perform much of the work and also coordinate 10 different sub-contractors. Robert directly managed aspects of the project that included ASHRAE Level 1 and 2 energy audits, retro-commissioning, water audits, and incentive opportunity research and analysis. Additionally, Robert coordinated with additional team members installing sub meters, performing leak detection services, evaluating waste streams, and assessing compliance of buildings with ASHRAE Standards 55 and 62.1.

Project Management - Managed Energy and Water Audit Project for US Bureau of Reclamation

Mr. Urban managed energy and water audits for the US Bureau of Reclamation located at 28 sites across the western United States. The audits included ASHRAE Level 1 and 2 assessments of 90 buildings by a team of five engineers. Robert was responsible for coordinating the audits, setting performance standards and tracking metrics, developing deliverable formats and content, and all customer coordination. The audits included a detailed inventory and evaluation of energy consumption by equipment, presented to the customer in an equipment database, and an inventory of refrigerant-using equipment. Overall, the project identified over 340 individual measures with an expected payback of four years. The audit contract value was $701,000.

Energy Auditing, Project Management - Energy Audits and Project Management for Audits at Marine Corps Air Station Miramar

Abraxas conducted ASHRAE Level 2 energy audits and water audits at MCAS Miramar from October 2010 through January 2011. Robert was one of two on-site engineers who completed the audits of eight major buildings in this short three-month period. The audits, which included a grocery mart, three office buildings and four aircraft hangars, totaled over 700,000 square feet. Robert served as a Jr. Engineer on this project responsible for on-site information gathering, analysis support, and reporting.

ABRAXAS Steve Rottmayer

Education

M.S. in Mechanical Engineering, University of Wisconsin, Madison, Solar Energy Lab	1997
B.S. in Mechanical Engineering, University of Washington, Seattle	1994

Work Experience

Senior Engineer, Abraxas Energy Consulting	2015 to Present
Project Manager, kW Engineering	2007 to 2014
Senior Engineer, kW Engineering	2001 to 2006
Project Engineer, Schiller Associates	1999 to 2001
Applications Engineer, Johnson Controls	1997 to 1999

Illustrative Projects

Project Management - Managed Energy Audits of SFPUC municipal buildings

Steve managed kW Engineering's effort in auditing SFPUC municipal buildings. He oversaw a project which identified and implemented opportunities for energy efficiency and demand response measures for multiple departments with 2,800,000 square feet of building space, including City Hall, the SF Main Library and the Bill Graham Auditorium. To date, 7,000,000 kWh, 1,200 kW and 150,000 therms in savings have been identified. Following completion of the energy audits, kW Engineering also oversees the design, implementation and verification of the recommended measures.

Project Management/Energy Auditing - Energy Audits for PG&E Large Commercial Customers

Steve performed energy efficiency site evaluations for PG&E Large Commercial customers under PG&E's More-than-a-Million Offering. The scope of services included identifying and estimating the savings for energy efficiency projects, providing technical support for the projects and assisting customers with enrollment in PG&E's core energy efficiency programs. In total, approximately 13,775,000 kWh, 2,700 kW and 170,000 therms were submitted to PG&E's core programs through this effort.

RCx - Retro-commissioning Assessment of Cupertino Building

Steve completed a Retro-commissioning study at a 102,000 square-foot building in Cupertino California. Short-term monitoring through stand-alone meters and the building's automation system was used to identify nine measures totaling 660,000 kWh and 46,000 therms in energy savings with an overall payback of 0.4 years. Measures included garage lighting control, repair of chilled water valve, scheduling, economizer commissioning, resets on temperature setpoints (air and water) and installation of variable frequency drives on hot deck furnaces.

Project Management - Managed Technical Reviews of PG&E's SPC Program

Steve managed kW Engineering's work performing technical reviews of projects in PG&E's Standard Performance Contract (SPC) program. This involved general program support and quality control for the technical reviews completed by kW Engineering staff under the SPC program. Performed individual technical reviews and site inspections for projects in the program.

Measurement and Verification - Managed Verification of Alliant Energy's Performance Contracting Program

Steve managed kW Engineering's effort to perform third-party verification of project savings for Alliant Energy's Performance Contracting Program in Iowa. During this time, submitted savings totaled over 50,000,000 kWh and 400,000 therms. Project measures included lighting, HVAC, compressed air, and process (boilers, chillers and motors) retrofits.

Measurement and Verification - Developed and Implemented M&V plans for Alliant Energy

Steve developed and implemented measurement and verification (M&V) plans for performance contracts in Alliant Energy's Performance Contracting Program in Iowa. All M&V plans were based on the FEMP guidelines. The type of M&V performed depended on the magnitude of the cost savings and the amount of risk associated with achieving those savings. Implementation involved data collection and analysis. Data collection has been performed for energy use, production, temperatures, and hours of operation. Analysis included billing analysis and engineering calculations.

Energy Auditing - Performed Energy Audits for PG&E's Standard Performance Contract Program

Reviewed project applications for PG&E's Standard Performance Contract Program. Assisted applicants participating in the program by providing technical support for questions concerning program procedures, energy savings estimates, and M&V strategies. Performed project site inspections and conducted spot measurements on equipment. Projects included measures for chillers, unitary equipment, fan & pump replacement, VFD upgrades, controls and piping modifications, energy management systems, and lighting efficiency and controls.

Patrick McLaughlin

Education

Bachelor of Science in Physics, University of Rochester, NY — 2008

Certifications

Association of Energy Engineers, Certified Energy Manager (CEM)

Association of Energy Engineers, Certified Energy Auditor (CEA)

Green Building Certification Institute, Leadership in Energy and Environmental Design, Building Design & Construction (LEED AP BD&C)

Work Experience

Energy Engineer, Abraxas Energy Consulting — 2014 to present

Energy Engineer, C.J. Brown Energy, P.C. — 2009 to 2014

Illustrative Projects

Energy Auditing — Detailed Energy Assessments of US Naval Medical Center Portsmouth

Mr. McLaughlin was assigned to audit buildings at Naval Medical Center Portsmouth, including satellite medical and dental clinics at Joint Expeditionary Base Little Creek and Naval Air Station Oceana. Patrick's contribution on these projects included a site visit, field measurements and assessments, identification of energy-saving opportunities, and more. For many of the buildings, Mr. McLaughlin identified and completed an intensive analysis of the existing air handling units systems for energy and indoor air quality improvements.

M&V Analysis — M&V Analysis for Federal ESPC

Mr. McLaughlin was responsible for verifying energy savings at two federal buildings in the Los Angeles area through Option B. Working with the facility and plant managers, he troubleshot, calculated, and verified the energy savings from the implementation of Chiller Plant Optimization and Demand Control Ventilation measures through a careful analysis of trend data.

Energy Auditing — Detailed Energy Assessments of US Naval Base Kitsap & Air Station Whidbey Island

Mr. McLaughlin was assigned to audit over three million square feet of building floor space at Naval Base Kitsap and Air Station Whidbey Island. Patrick's contribution on these projects included multiple site visits, field measurements and assessments, identification of energy-saving opportunities, and more. For many of the buildings, Mr. McLaughlin identified and completed an energy analysis of the existing building's envelope, refrigeration, and compressed air systems.

Technical Assistance, M&V Review, Energy Auditing – Technical Assistance to the US Dept. of Housing and Urban Development (HUD)

As the sole engineer, Mr. McLaughlin performed various tasks on behalf of HUD. His tasks included the review of ESPCs between ESCOs and Public Housing Authorities (PHAs) across the United States; the development of feasibility studies (which included an energy audit, 20-year financial analysis and M&V plan) for PHAs pursuing a self-managed ESPC; and verifying Option A and Option C energy savings in annual M&V reports from PHAs with ongoing ESPCs, one of which was the Washington, D.C., Housing Authority (DCHA), with 33 asset managed properties (AMPs). Mr. McLaughlin also conducted third-party analyses of HUD's internal ESPC reviews noting federal regulation adherence, procurement risks, past errors, and associated financial risks and provided recommendations for corrective actions and review process improvements to HUD.

Energy Auditing, Safety Inspections – Green Physical Needs Assessment (GPNA) for the Poughkeepsie Housing Authority

Mr. McLaughlin performed a Green Physical Needs Assessment (GPNA) audit for the Poughkeepsie Public Housing Authority in collaboration with GDS Associates, Inc., to identify various energy-related capital projects for the housing authority's 20-year capital spending plan. Mr. McLaughlin also performed safety inspections to locate natural gas leaks and detect carbon monoxide levels in residential units as well as the central boiler plant.

Energy Auditing – City of Lackawanna, NY

Mr. McLaughlin conducted ASHRAE Level 2 audits for the City of Lackawanna on all major city government-owned buildings including fire stations, police stations, city hall, a senior center, and a public works garage.

Energy Auditing, ESPC Development – Town of Greenfield, MA ESPC

Mr. McLaughlin conducted ASHRAE Level 3 detailed energy audits of all Greenfield city government buildings on behalf of an ESCO in order to develop an ESPC. All major city government-owned buildings were audited and monitored extensively with data loggers and then evaluated for accurate energy savings opportunities which could be remedied with an Energy Management Control System (EMCS).

ABRAXAS Clayde Barkley

Education

B.S. in Mechanical Engineering, Cal Poly, San Luis Obispo 2010

Certifications

Association of Energy Engineers, Certified Energy Manager (CEM)

Board for Professional Engineers, Land Surveyors, and Geologists, Engineer-in-Training (EIT)

Work Experience

Energy Engineer, Abraxas Energy Consulting 2010 to present

Various Positions, Cal Poly University Housing 2006 to 2010

Illustrative Projects

Energy Auditing – Robert E. Bush Naval Hospital in Twentynine Palms

Clayde Barkley performed a field assessment and provided detailed documentation and analysis for the ASHRAE Level 2 energy audit performed at Naval Hospital Twentynine Palms. Clayde worked as the Junior Engineer assigned to this project. He was responsible for nearly all of the draft report documentation and analysis of many of the measures that were identified. On site, Clayde assisted with measurements, interviews with occupants and facility staff, documentation of all the systems, and understanding the system operation. The opportunities identified at NH Twentynine Palms will save over 20% of the energy used by the building and have a payback of 5.5 years.

Energy Auditing - ASHRAE Level 1 Energy Audits at VA Medical Campuses

Clayde performed on-site assessments of over three million square feet of buildings at VA medical campuses, including Bronx, NY; St. Albans, NY; San Francisco, CA; and Palo Alto, CA. Clayde was responsible for evaluation of equipment, deployment of select data loggers, identification of measures, and performing the energy calculations and write-ups.

RCx - Retro-commissioning Assessment of VA Medical Campuses

Clayde was responsible for an RCx team that performed a retro-commissioning assessment of multiple VA medical campuses in Arizona, including Phoenix, Tucson, and Prescott. Equipment involved included over 60 air-handling units and multiple chilled-water plants and a thermal energy storage system in Tucson, over 50 air-handling units and a central plant in Phoenix, and 20 air-handling units in Prescott. Clayde was the field engineer for each piece of equipment and observed the response of each piece of HVAC equipment when it was commanded from the EMS, working with team members at the control center to troubleshoot issues. He was responsible for deployment and collection of data loggers, functional testing, identification of measures, and performing engineering analysis.

Energy Auditing - ASHRAE Level 2 Energy Audits at TRACEN Petaluma

Clayde performed on-site assessments of three major buildings at the US Coast Guard Training Center in Petaluma. He performed this work alongside the Senior Engineer assigned to the project and assisted with field measurements, identification of measures, and performing of engineering analysis.

RCx - Retro-commissioning Assessment of Foothill Transit Center

Clayde was responsible for all aspects of performing a retro-commissioning assessment of a 40,000-square-foot office building in West Covina, California. He performed this work alongside the Senior Engineer assigned to the project and assisted with field measurements, deployment and collection of data loggers, functional testing, identification of measures, and performing of engineering analysis. The retro-commissioning assessment was completed through the program for Southern California Edison.

Energy Auditing RCx - Orange City Square ASHRAE Level 1, Retro-commissioning, and LEED Support

Clayde was responsible for all aspects of performing an ASHRAE Level 1 audit of three office buildings known as Orange City Square in Orange, CA, with a combined floor area of approximately 375,000 square feet. His work for the audits was performed in conjunction with a retro-commissioning assessment on which he supported the Senior Engineer. The retro-commissioning assessment was completed through the program for Southern California Edison. Clayde completed all the documentation, recommendations, and analysis of the low-cost/no-cost measures identified as part of the Level 1 audit. His work was then reviewed by the Senior Engineer. He also completed additional measurements, functional testing, and field data collection for the retro-commissioning assessment. Because this facility was pursuing a LEED certification, Clayde was responsible for gathering ventilation, zoning, space use, and occupant density data used to assess the buildings' compliance with ASHRAE 62.1. Clayde also assessed the operating practices of the building, performed research, and documented an ongoing commissioning plan for the buildings. The ongoing commissioning plan will be a valuable tool for on-site staff to use going forward to repeat some of the activities done during the retro-commissioning assessment with the primary objective of persistence of savings.

ABRAXAS ENERGY CONSULTING Christian Orsi

Education

Bachelor of Science in Electrical Engineering, California Polytechnic State University 2013

Certifications

Association of Energy Engineers, Certified Water Efficiency Professional (CWEP)

Work Experience

Energy Engineer, Abraxas Energy Consulting	2014 to present
Energy Analyst, Abraxas Energy Consulting	2011 to 2013
Engineering Intern, Sierra Precision Optics	2008

Illustrative Projects

Energy Auditing, Commissioning – Energy Study and Commissioning for Weinberger US Courthouse

Under the supervision of a senior engineer, Mr. Orsi was responsible for performing the energy audit and commissioning for the Weinberger US Courthouse. Mr. Orsi's contribution to this project included three site visits for field measurements and assessments, identification of energy-saving opportunities, and functional testing/trend data analysis. The energy audit and commissioning included an assessment of all energy- and water-using systems in the facility. The facility contained pumping systems, AHUs, FCUs, a chiller, a boiler, and a cooling tower. Measures found include advanced lighting control systems, lighting retrofits, occupancy sensors, variable frequency drives on pumps and fans, high-efficiency water fixtures, on-site renewable energy, xeriscaping, and more. The commissioning report included measures such as AHU and central plant optimal start/stop, chilled water reset, economizer operation optimization, and supply air reset strategy.

Energy Auditing - Detailed Energy Assessment of Naval Base Ventura County

Mr. Orsi worked as a Junior Energy Engineer on energy assessment work for Naval Base Ventura County. Facilities included office spaces, bunkers, hangers, industrial spaces, living quarters, grocery stores, and secured labs. He was responsible for the assessment of 65 of 193 buildings on NBVC. The audits included an assessment of all energy- and water-using systems in these facilities. The facilities included complex pumping systems, humidity control requirements, filtration systems, research laboratories, irrigation systems, antiquated complex controls, and refrigeration equipment.

Energy Auditing - Energy Assessment of US Veterans Affairs Campus Palo Alto

Mr. Orsi was the Junior Energy Engineer assigned to audit 26 buildings on the VA Palo Alto campus. These buildings included a hospital, clinics, warehouse spaces, office spaces, and laboratory spaces. Identified measures included replacing air-cooled chillers, replacing the existing steam plant with modular hot water boilers, lighting retrofits, occupancy sensors, high-efficiency water fixtures, replacing refrigeration equipment, and increasing on-site solar PV.

Energy Auditing - ASHRAE Level 1 Assessments for CODA Energy

Mr. Orsi was the Energy Engineer assigned to audit 25 buildings for CODA Energy throughout Southern California. These buildings included industrial spaces, warehouse spaces, grocery stores, and office spaces. Identified measures included replacing air-cooled chillers, combining cooling loops of process loads, upgrading inefficient HVAC systems, lighting retrofits, occupancy sensors, high-efficiency water fixtures, and replacing refrigeration equipment.