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# NEEA Industrial Initiatives- Market Progress Evaluation Report #8

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# EXECUTIVE SUMMARY

This is the eighth Market Progress Evaluation Report (MPER) on the Northwest Energy Efficiency Alliance's (NEEA's) Industrial Initiative (the Initiative) with specific focus on its energy management efforts in the food processing sector. The goal of the Initiative and related industrial efforts is to transform the market for industrial energy management services and to promote a specific approach known as Strategic Energy Management (SEM) as a standard practice. To qualify as SEM according criteria established in NEEA's Initiative, a company's approach to energy management must contain the following four elements:

- Existence of goal setting in relation to energy use or energy reduction goals
- Existence of executive commitment, i.e., dedication by senior management of staff resources (an energy efficiency champion)
- Appropriate training to help achieve the established goals
- Tracking of progress toward the goal, i.e., tracking energy use and regularly reporting progress to senior management

NEEA engaged DNV KEMA and their subcontractor Research into Action to evaluate the annual progress of this initiative in 2012. The key components of this Market Progress Evaluation Report include:

- An assessment of the long-term effect of the program on the energy management practices of the companies that were part of the initial implementation cohort
- An assessment of the current level of adoption of SEM among companies with large food processing plants in the region, and the contribution of NEEA's efforts to that development
- Estimation of energy savings associated with adoption of SEM by the initial implementation cohort and by companies that received support for implementation of energy management practices through the Northwest Food Processors Association
- An assessment of the feasibility of incorporating savings into regional energy forecasting and planning mechanisms

The conclusions and recommendations presented in this report are based on evaluation data collected from site visits, interviews with industrial end users, and market partners.

## FINDINGS

### Adoption of SEM by the Initial Implementation Cohort

NEEA and their implementation contractor worked directly with a small cohort of large food processors to implement an early version of SEM, called continuous energy improvement (CEI).

The companies in the CEI cohort[1] expressed confidence in the savings achieved through the program. The companies recognized the value of the NEEA implementation contractor in planning and staging activities of SEM. Changes in management at one company have reduced the executive involvement and commitment to SEM. The companies that have a higher level of commitment are actively engaging their production and maintenance staff, while the company with the management change is only including the maintenance staff in their energy reduction work. Most companies with multiple facilities encourage competition and collaboration across facilities to further their progress toward energy reduction goals.

**Overall Market Progress to Date**

Since inception of the Initiative, NEEA has completed seven MPERs documenting how SEM took hold across the food processing industry. Those seven reports established findings on market progress indicators (MPIs) that show how SEM progressed across the food processing industry from 2005 – 2013. The most recently completed evaluation report, MPER #7, concluded the following about the SEM initiative as of August 2012: "NEEA has made considerable progress in getting the food processing industry to adopt SEM. About one-third of food processors exhibited some evidence of SEM practices." Corporate level decision makers are aware of SEM and many of these decision makers credit NEEA with influencing their energy saving actions. Participating facilities demonstrate that SEM practices are persisting and spreading. NEEA has also collaborated successfully with the Northwest Food Processors Association to support that organization's Energy Roadmap program, which helps member companies pursue energy reduction goals.

Market progress identified in this report shows a similar level of evidence of SEM practices in the population of large food processors outside of the direct CEI participants, as about one third of plants contacted indicated action in the four areas of SEM. Facilities participating in the Energy Roadmap program are engaged in more SEM activities than other large facilities. The Initiative's work with the NWFPA to enroll facilities into the Energy Roadmap program likely has helped increase the proportion of facilities with energy goals. Outside of the CEI cohort, the SEM activities are less focused and systematic, with only small proportions of facilities using energy intensity metrics and reviewing periodic electricity use.

**Energy Savings**

DNV KEMA assessed the energy impact of participation in the elements of the initiative on energy consumption in 9 plants owned and operated by the CEI cohort, and on 23 additional plants that participated in the NWFPA Roadmap program. The basic impact evaluation framework consists of two components. A "top-down" regression yields an estimate of change in energy consumption versus a pre-participation baseline, normalizing for weather and volume of production. This total change captures the effects of many influences, including efficiency-

[1] Companies and facilities receiving resources and support, from NEEA, for SEM activities

related capital and maintenance improvements funded by utility programs. In order to estimate the changes associated with adopting SEM outside of the funded improvements, the savings associated with these utility-funded actions were subtracted from the top down regression results.

To assess the improvements funded by utility programs since the previous evaluation, DNV KEMA evaluated the claimed savings of 27 measures at 9 facilities completed in 2011 and 2012. The overall realization rate for the these measures was high for electric (117%) but much lower for gas savings (43%) due to over-stated claims on process heating measures. Overall, 0.4 annual megawatts (aMW) and nearly 300,000 therms were saved annually.

The total electric savings from the CEI cohort participants was 0.62 aMW, and the net savings from CEI alone were 0.23 aMW. These net savings are approximately 1% of annual electric consumption for these facilities. These savings estimates are very conservative because of the method of modeling and likely underestimate the savings significantly. Based on the models with the best explanatory power, actual savings likely exceeded 2% of the annual electricity consumption.

To assess the effect of SEM outside of the cohort of CEI participants, DNV KEMA created top-down models from data collected by the NWFPA from Roadmap participants. Energy savings from combined electricity and natural gas were identified as 79,000 MMBTU, approximately 1% of annual energy consumption of the modeled facilities.

Because market research identified facilities outside of the cohort, methods to assess the savings associated with the diffuse effects of SEM were considered. However, there is little information about the depth of participation in SEM outside of the CEI cohort. Market research has indicated that the NWFPA participants are more thoroughly engaged in SEM activities than the general population of food processors.

The savings analysis by facility has shown a wide range of results, with an average savings of approximately 1% of facility annual energy consumption. This likely represents the maximum savings occurring in the balance of the market of large food processors.

# 1 INTRODUCTION

The Northwest Energy Efficiency Alliance (NEEA) has developed strategic initiatives for the industrial sector to increase energy efficiency. As an alliance of more than 100 utilities and organizations engaged in energy efficiency in the Northwest (Idaho, Montana, Oregon and Washington), NEEA seeks to transform the market toward sustainable energy. NEEA launched the Industrial Initiative (the Initiative) in 2005, building on experience gained through an earlier program known as the Industrial Energy Alliance. The Initiative now focuses on the food processing sector. This is the eighth Market Progress Evaluation Report (MPER) of the Initiative.

## 1.1 Initiative Overview

In 2005, NEEA developed and implemented an initiative designed to integrate continuous energy improvement with NW industrial firms' management culture. The initiative seeks to produce energy savings by causing industrial facilities to include energy management in their operational practices and capital investment decisions. The initiative aims to transform these practices and decisions by supporting a core group of participating companies and facilities to successfully implement and sustain CEI systems with the intent that these facilities will provide a model of success for the rest of the market. NEEA pays for the services of expert consultants and advisors to work with participating companies in implementing strategic energy management activities in their plants. Additionally, NEEA is collaborating with the Northwest Food Processors Association (NWFPA) in support of its program to enroll member companies and have them commit to energy reduction goals.

Since 2005, NEEA's Industrial Initiative (the Initiative) has relied on a framework for strategic energy management known as Continuous Energy Improvement (CEI). The CEI program supports facilities to integrate energy management into their business. The purpose of the program is to obtain long-term, sustainable energy savings in the industrial sector through continuous improvement in energy management. Using the strategies and techniques honed in the continuous quality improvement movement, CEI equips firms with the tools to continually improve their energy performance.

The Initiative and related industrial efforts evolved its offerings to promote a specific approach known as Strategic Energy Management (SEM) as a standard practice. NEEA defines SEM as a management system that is integrated into a company's planning and operational practices, so that energy is managed on an ongoing basis as a controllable expense. To qualify as SEM, a company's approach to energy management must contain the following four elements:

- Existence of goal setting in relation to energy use or energy reduction goals
- Existence of executive commitment, showing dedication by senior management of staff resources such as an energy efficiency champion
- Appropriate training to help achieve the established goals

- Tracking of progress toward the goal, i.e., tracking energy use and regularly reporting progress to senior management

### 1.1.1 Summary of Previous Evaluations

Since Initiative inception, NEEA contracted with evaluation firms to complete seven Market Progress Evaluation Reports (MPER). These reports document how SEM took hold across the food processing industry. Those seven reports provided findings on six market progress indicators (MPIs) that show how SEM progressed across the food processing industry from 2005 to 2013. Table 1 depicts the evolution of the MPIs through each MPER report and shows the MPIs discussed in each report. NEEA revised its key elements of the Initiative prior to the last MPER; therefore, this MPER has a set of MPIs different from the prior evaluations.

**Table 1: Market Progress Indicators by Market Progress Evaluation Report, 2005-2013**

<table>
<tr><td colspan="2">Market Progress Indicators (MPI)[2]</td><td colspan="8">Market Progress Evaluation Reports (MPERs)</td></tr>
<tr><td>#</td><td>Description</td><td>#1</td><td>#2</td><td>#3</td><td>#4</td><td>#5</td><td>#6</td><td>#7</td><td>#8</td></tr>
<tr><td>1</td><td>Percent of Food Processing Firms (as measured in terms of employment share) and Pulp and Paper Firm (as measured in terms of output capacity) that Implement SEM.</td><td rowspan="6">33 Key Progress Indicators (KPI) identified</td><td rowspan="6">Creation of 6 draft MPIs</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td rowspan="6">New Set of 10 MPIs established</td></tr>
<tr><td>2</td><td>Percent of Industrial Facilities from non-targeted sectors that implement SEM</td><td>✓</td><td></td><td></td><td></td><td>✓</td></tr>
<tr><td>3</td><td>Number of Multi-Facility Food Processing or Pulp and Paper Firms that Adopt SEM in Plants or Mills Without Initiative involvement</td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Number of Multi-Facility Food Processing or Pulp and Paper Firms that Adopt SEM in Plants or Mills Outside of the Northwest.</td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Percent of Northwest Utilities by sales that promote SEM as part of their resource acquisition and energy efficiency activities.</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>6</td><td>Additional trade associations promoting SEM</td><td>✓</td><td>✓</td><td></td><td>✓</td><td>✓</td></tr>
<tr><td colspan="10">✓ MPER collected and reported data<br>✓ MPER contained ancillary data about MPI</td></tr>
</table>

[2] Initiative started with pulp and paper and food processing industry. However, the pulp and paper industry dropped out of the initiative in 2008.

The most recently completed evaluation report, MPER #7, concluded the following about the SEM initiative as of August 2012. "NEEA has made considerable progress in getting the food processing industry to adopt SEM. About one-third of food processors exhibited some evidence of SEM practices." Corporate level decision makers are aware of SEM and many of these decision makers credit NEEA with influencing their energy saving actions. Facilities that have received consulting services from the program for some time have continued to expand the scope of their SEM activities.

## 1.2 Study Overview

NEEA engaged DNV KEMA and their subcontractor Research into Action to evaluate the annual progress of this initiative in 2012. The key components of this Market Progress Evaluation Report include:

- An assessment of the long-term effect of the program on the energy management practices of the companies that were part of the initial implementation cohort
- An assessment of the current level of adoption of SEM among companies with large food processing plants in the region, and the contribution of NEEA's efforts to that development
- Estimation of energy savings associated with adoption of SEM by the initial implementation cohort and by companies that received support for implementation of energy management practices through the Northwest Food Processors Association (NWFPA)
- An assessment of the feasibility of incorporating savings into regional energy forecasting and planning mechanisms

Research into Action focused on the assessment of energy management practices of the cohort and the large food processors.

## 1.3 Report Organization

The remainder of this report is structured as follows:

- *Section 2: Summary of Market Progress Results* presents analysis of the current state of the market for energy management services among large Northwest food processing facilities and the effect of the program on the adoption of energy management practices by a) plants who received consulting services directly from NEEA; b) plants that participated in the NWFPA's Energy Roadmap program; and c) the balance of large food processing plants in the region. In this section we also assess recent changes in the market in terms of the current Market Progress Indicators.
- *Section 3: Summary of Impact Results* presents the methods and results of the impact evaluation, as well as an assessment of opportunities to improve impact evaluation approaches.
- *Section 4: Conclusions and Recommendations* summarizes key findings and their implications for further program, evaluation, and energy planning efforts related to strategic energy management.

Several appendices are provided with additional detail. These include:

- Appendix A lists references from the report.
- Appendix B provides the results of the market actor survey used for market characterization.
- Appendix C provides additional observations from the case studies of the CEI participants.
- Appendix D is the memorandum documenting the results of the savings validation of the program participants.
- Appendix E provides the result of the assessment of savings from the facilities that provided production data to the NWFPA.
- Appendix F provides data collection instruments.
- Appendix H provides the logic model
- Appenndix I provides the 2013 evaluation as an addendum to this report.

# 2 SUMMARY OF MARKET PROGRESS RESULTS

## 2.1 Approach

This section describes the energy management activities of large food processing facilities in the Northwest and key factors that influence the market's adoption of SEM practices. The market characterization relies on the following data collection and analysis activities carried out for this evaluation.

- **Market structure analysis.** The consultant team analyzed the pattern of ownership of large food processing plants in the region, using information from a facilities database compiled by NEEA and other contractors. This analysis provides insight into the potential channels for the diffusion of energy management practices.
- **Stakeholder interviews.** The consultant team held interviews with managers of industrial energy management and energy efficiency programs offered by utilities and other sponsors in the region. These interviews focused on the respondents' perspectives on the contributions the Initiative has made to the development of the market and its relationship to activities pursued by other organizations.
- **Initiative contractor interviews.** The consultant team interviewed the Initiative's CEI contractor to gather information on how the Initiative contributed to building the CEI contractor market and to characterize the Initiative's marketing and service delivery strategies.
- **Facility manager interviews.** The consultant team conducted telephone interviews with energy decision makers representing 67 large food processing facilities in the region, including representatives of 37 facilities that took part in the NWFPA's program. The survey probed facility managers' awareness, knowledge, and adoption of energy management practices and knowledge of SEM and the types of energy management activities facilities engage in; energy decision makers at facilities participating in the NWFPA's energy program answered additional questions concerning their experiences with that program and plans to continue in the program.
- **Case Studies of the CEI Cohort.** The consultant team conducted case studies of the CEI cohort participants. These case studies describe the decisions and factors shaping the CEI systems these companies implemented and the role of NEEA activities in supporting the development and implementation of those systems. Findings from this research are helpful to understanding the types of challenges other facilities may face when they implement and maintain SEM systems.

### 2.1.1 Population of Facilities

NEEA and the consultant team identified three distinct population segments to evaluate program influence on the market, based upon the Initiative's level of involvement with each segment. Table 2 presents these segments and the number of facilities each segment contains by size. The CEI segment is the cohort of facilities participating in the Initiatives' CEI program. These facilities receive resources and support directly from the Initiative. The second segment is the

NWFPA Energy Roadmap participants, where members engage in a SEM program developed with NEEA. As a cluster partner[3] the Initiative directly supports the NWFPA's effort to take its Energy Roadmap program to its members. The remaining population of firms, referred to as Balance of Market or BOM, had no documented direct contact with the initiative. These firms may have been influenced by the Initiative through a number of indirect channels such as learning about SEM practices through contact with other program sponsors in the region or purchase of consulting services from SEM contractors supported by the initiative. We conducted a number of research activities, including interviews with firms in the BOM segment and managers of other programs in the region to assess the extent and nature of such potential influence.

The evaluation team accessed the *Database of Northwest Manufacturers, Nurseries and Wineries* (Evergreen Economics, 2011) as the starting point for a sample frame of BOM facilities. The evaluation team intended to use the database to develop weights for survey responses so that results could be reported in terms of the portion of total facilities in the region, where appropriate. The team supplemented the database with lists provided by the Initiative and the NWFPA of facilities in the CEI and NWFPA segments. In conducting the survey, the evaluation team found a number of facilities that were in the CEI and NWFPA cohorts, but not in the database. The team also found a number of firms that met the criteria for inclusion in the survey (in the food processing industry with 150 or more employees) when conducting the survey with the BOM segment. They were in neither the CEI nor the NWFPA segments. Table 2 shows the distribution of the facilities the team identified by employment size category and cohort.

**Table 2. Distribution of Facilities by Employment Size, Category, and Cohort**

| Employment Size Category | Market Segments | | | Total |
|---|---|---|---|---|
| | CEI Direct Support | Energy Roadmap Participant Cluster Partner, Market Effect | BOM Market Effect | |
| 250+ | 6 | 13 | 65 | 84 |
| 150-249 | 1 | 6 | 53 | 60 |
| Unknown | 5 | 31 | 13 | 49 |
| **Total** | **12** | **50** | **131** | **193** |

[3] Cluster partners include associations or organizations associated with Industries targeted by the Initiative, and that the Initiative is working with directly to help promote SEM.

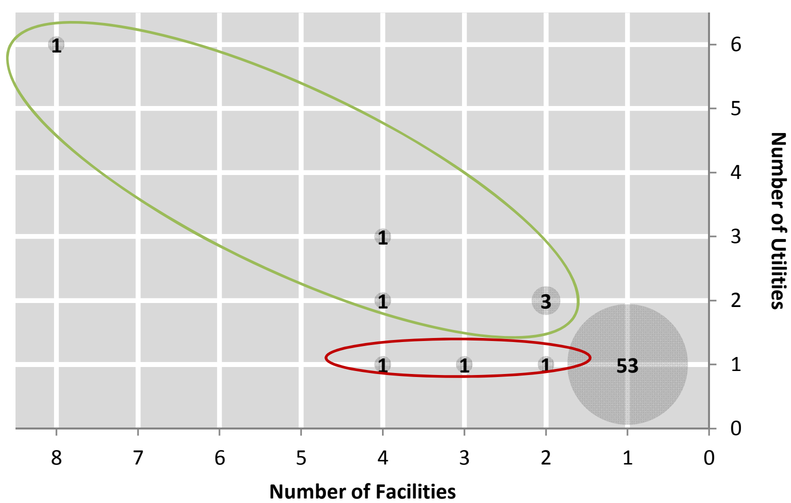
For the purposes of our assessment of the market, the evaluation team identified 193 facilities with 150[4] or more employees. Twelve of those facilities had been in the CEI cohort. The team was able to complete case studies covering 9 of those facilities. Fifty of the facilities or 26 percent of the total market had taken part in the NWFPA Roadmap program. Two of the facilities in the CEI cohort had also participated in the NWFPA Roadmap. The remaining 131 facilities had participated in neither the CEI cohort nor the NWFPA Roadmap.

### 2.1.2 Market Structure

This section describes the relationship of facilities in the region by corporate ownership and the consolidation of these facilities across utility territories—utility contexts are important to understanding the funding support for market actors. In order to describe the market structure the consultant team analyzed a database of NW industrial food producers (Evergreen Economics 2011) and identified 84 facilities with over 250 employees, and these facilities are owned by 62 different companies.

Figure 1 shows the distribution of companies in this database. Fifty-three of the 62 companies own single facilities or facilities that do not have common ownership with other facilities in the NW. The remaining nine companies own and operate between two and eight facilities in the region. Those facilities operate within up to six different utility service territories.

**Figure 1. Distribution of Food Processor Companies by Number of Facilities and Number of Utilities**




[4] The initiative targets facilities with 250 or more employees. The evaluation required a larger sample of facilities than were available from the Economics Database of Northwest Manufacturers, Nurseries and Wineries. This evaluation included facilities with 150 or more employees in order to generate an adequate survey sample and to align with facilities in this size range in the Initiative and the NWFPA's Energy Road Map.

Figure 1 shows that only three companies control multiple facilities in one utility service area (indicated by the red circles) and six companies control multiple facilities in multiple utility areas (indicated by the green circles). This demonstrates that SEM efforts by the nine corporate decision makers influence the energy practices of the 31 facilities represented by the green and red circles. In contrast, most companies (53) operate independent facilities (lower right corner) where corporate energy management policies are limited to affecting one NW facility at a time.

### 2.1.3 Regional Key Stakeholders

This section describes the geographic distribution of energy management resources available to the market and assesses the relevant changes in these resources. To perform this analysis the consultant team accessed US Department of Energy (DOE) and Environmental Protection Agency (EPA) websites to describe federal level funding, reviewed program offerings from regional utility programs and program administrators, and interviewed initiative participants concerning the resources they have accessed. The consultant team found that federal resources provided support for facility energy assessments between 2008 and 2001. As of 2011, the Department of Energy provides support for some training on energy management for selected industrial systems. Participants reported that they had relied on federal support for funding their corporate energy champions and that the DOE reduced or restricted this program as early as 2012. DOE has modified its industrial offerings, encouraging facilities to move toward energy management. DOE offers technical assistance for organizations[5] with the long term goal of achieving ISO 50001 compliance as well as improvements in energy performance. The EPA continues to offer Energy Star recognition for industrial plants with higher energy performance relative to peer facilities.

In 2009, regional programs, funded by the Energy Trust of Oregon (ETO) and Bonneville Power Administration (BPA), began to offer funding and resource support for facilities and corporations implementing SEM in their territories, support such SEM elements as energy champion salaries, facility energy assessments, and system training. Programs offered outside of these administrators' territories include support for some training in energy management, but do not include SEM systems or support for an energy champion.

### 2.1.4 CEI Cohort Facilities

This section describes the experiences of companies and facilities that participated in the Initiative, focusing on the specific ways in which they adopted SEM practices and the challenges they faced in so doing. These facilities are referred to as the CEI cohort facilities.

[5] DOE support is offered through its Better Buildings Better Plants or Superior Energy Performance programs.

## Methodology

The consultant team developed case studies[6] of the three companies in the CEI cohort in order to develop detailed narratives of the processes by which firms adopt, elaborate, and refine CEI systems over time. The consultant team collected data through on-site interviews with facility and corporate level contacts at companies participating in NEEA's initiative. Only two contacts had been involved in CEI since the beginning. Most interviewed contacts had between six months and two years of experience in their energy management roles; therefore, interviews focused on contacts' near-term CEI implementation experiences[7] and their expectations for their CEI systems.

Table 3 describes the roles of contacts the consultant team interviewed. The consultant team held interviews with the following:

- Facility level energy champions from nine of the 12 participating facilities. These interviews were helpful to understand how facility level staffs interact with corporate energy policies and goals.
- Corporate level energy champions from each company. These contacts coordinate CEI activities across all participating facilities and managing corporate level CEI undertakings.
- An executive energy sponsor from one[8] of the participating companies. Corporate sponsors advocate for CEI initiative funding and help to ensure energy management is included in executive level decisions. The consultant team sought to interview these contacts to understand their experiences advocating for energy management at an executive level.

**Table 3: CEI Cohort Interview Disposition**

| Contacts' Role | Number Targeted | Interviews Completed | Number of Facilities Contacts Represent |
|---|---|---|---|
| Executive Energy Sponsor | 3 | 1 | -- |
| Corporate Energy Champion | 3 | 3 | -- |
| Facility Energy Champion | 8 | 8 | 9 |

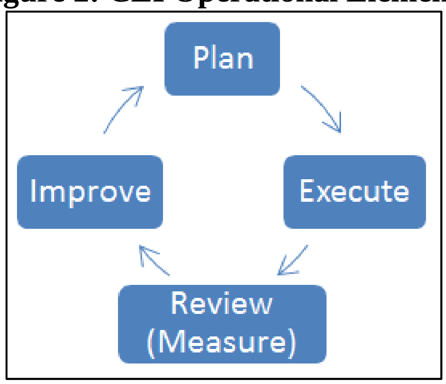
[6] Additional findings and case study details are available in Appendix C.
[7] The evaluation team attempted to make longitudinal comparisons between facilities; however, most respondents did not have direct experience with, or were not able to adequately recall, their facilities initial and mid-term experiences implementing CEI.
[8] Two contacts had scheduling conflicts preventing them from holding interviews with the consultant team.

**Case Study Framework**

The consultant team developed a framework to organize interview findings for the purpose of making comparisons between companies. To better align case study findings with the initiative's CEI implementation practices, the consultant team developed topical domains corresponding to the initiatives operational elements described in NEEA's playbook (Northwest Energy Efficiency Alliance 2008, page 14), which serves as a guide for industrial organizations seeking to implement CEI systems.

Figure 2 illustrates the relationships between CEI operational elements. Collectively these elements provide a strategy to help effectively organize resources and activities. Below, the consultant team described these elements with related categories contained in the case study framework.

**Figure 2: CEI Operational Elements**




**Adapted from NEEA's CEI playbook**

- ***Plan*** concerns the development of a management culture capable of affecting energy management. This element includes:
    - Organizational *commitment* to energy management and includes such activities as planning for executive level roles and involvement in energy management, setting energy reduction goals, and expressing organizational commitment to energy reduction in corporate values
    - *Corporate communication* across the organization concerning the importance of energy management and sharing outcomes from energy management activities
    - *Organizing* employees for energy management and includes coordination of efforts between corporate level and facility level decisions, and implementing facility level energy management teams

- ***Execute*** relates to activities that directly reduce energy consumption and includes *developing staffs'* focus on energy and providing staff with system training; and *production improvement* such as capital projects and operational and maintenance improvements designed to save energy.

- ***Review*** concerns activities undertaken to *monitor* near-term energy intensity, and *update the staging of plans* based upon outcomes of energy management efforts.

- ***Improve*** relates to activities focused on generating new energy saving *opportunities* and sustaining implemented energy management systems.

The prior market progress evaluation report (Energy & Resource Solutions, 2012) surveyed companies in the CEI cohort and found that:

- Almost all facilities implemented capital projects or O&M improvements and most plan to implement these projects in the near future.
- Participants share information across their facilities.
- NEEA was infrequently cited as an influence in setting energy reduction goals.

**Case Study Findings**

This section presents company comparisons of each of the four operational elements of CEI, and discusses the differences and similarities between these companies' CEI systems. This section presents company summaries in table form for the readers' convenience, and further details are discussed in text above each table. The summaries indicate variations between facilities within a company where they exist. Due to small number of organizations involved, the consultant team has suppressed any information that could be used to identify individual companies.

*Planning Activities*

Table 4 summarizes the companies planning activities that shaped their CEI systems and helped to build a culture capable of managing energy use. Company C continues to develop its CEI system largely in response to a new management system implemented after beginning their participation in the initiative. The other companies have well-established planning processes in place. Company A and B demonstrate Corporate commitment to CEI and communicate energy as a priority to production staff, and these companies have taken steps to develop their staff's focus on energy and involve them in all phases of energy management.

**Table 4: Summary of CEI Cohort Participants' Planning Activities**

| Characteristic | Company A | Company B | Company C |
|---|---|---|---|
| Identify energy saving goals | Reduce EUI by 25% in 10 years | Reduce EUI by 25% in 10 years | Reduce EUI by 25% in 10 years |
| Corporate energy sponsor regularly attends energy meetings | Yes | Yes | No |

| Characteristic | Company A | Company B | Company C |
|---|---|---|---|
| Designate facility energy champions | Yes | Yes | Yes |
| Reach out to all employees to encourage energy savings | Reaffirms importance of energy management through internal communications and rewarding top facilities for energy performance | Encourages all staff to come up with energy saving projects and ideas | Encourages staff to save energy by linking facility savings to employee bonuses. |
| Collaboration across facilities and corporate offices re energy management | Monthly conference calls across all facilities and corporate staff focus on energy management. | Quarterly conference calls across all facilities and corporate staff focus on energy management. | Not observed |

*Execution*

Table 5 summarizes the companies' execution activities. All three companies implemented capital projects to help address energy management opportunities. There is some variation in the way these companies developed their production staff's energy focus: Company A began working with its production staff through a kick-off meeting where the company's commitment to CEI was demonstrated and staff were provided with resources to help save energy in their homes—in an attempt to prove that energy is manageable. Company B began by developing energy teams for production and maintenance staff participation. Company C developed system-training materials for voluntary production staff training; one contact estimated that roughly half of the production staff has taken the training. None of the companies identified the cost of SEM as a concern that affected execution of the related activities.

**Table 5: Summary of CEI Cohort Participants' Execution Activities**

| Characteristic | Company A | Company B | Company C |
|---|---|---|---|
| Complete energy saving capital projects | Yes | Yes | Yes |
| Empower employees to save energy | Teach staff importance of energy for company by also helping staff save energy in their homes | Seek input from staff on ways the company can save energy. For example, this resulted in changes to hand washing stations. | Not observed |
| Utilize EE program administrator funds | Yes | Yes | Not observed |
| Work to meet customer expectations re energy use | Changed operations to use less energy to meet customer specifications | Not observed | Not observed |
| Develop energy | Not observed | Not observed | Developed system training |

| Characteristic | Company A | Company B | Company C |
|---|---|---|---|
| management training curriculum[9] for production staff | | | materials that includes energy management |

*Measure and Review*

The companies vary somewhat in the way they review their progress and update the staging of planned CEI activities. Table 6 summarizes measurement and review activities by the cohort. Company B employs intensive energy monitoring systems that include real-time gauges and dashboards for production staff and daily review of energy KPIs between corporate and facility level managers. Company A and B are similar in that their facilities review energy KPIs on a weekly basis, there are monthly reviews between corporate and facility level managers, and the initiative's CEI contractor reviews progress and helps to stage the implementation of additional measures.

**Table 6: Summary of Companies' Review Activities**

| Activities | Company A | Company B | Company C |
|---|---|---|---|
| Energy KPIs reviewed by facility staff | Weekly | Weekly | Daily |
| Corporate and facility managers jointly review energy KPIs | Monthly | Monthly | Daily |
| CEI contractor reviews progress | Annually | Quarterly/Annually | Not discussed as part of their long-term strategies |
| CEI contractor adds new planned activities to CEI plan | Annually | Quarterly/Annually | Not discussed |
| Staff takes corrective actions in response to gauges indicating excessive energy usage | Yes | Yes | One contact noted staffs lack training and motivation to take corrective actions. |

*Improvement*

Table 7 summarizes the activities and strategies cohort participants engage in to improve their CEI systems, and describes threats the companies perceive to the sustainability and persistence of their systems. The companies share many factors that either strengthen or threaten the persistence of their CEI systems. Company A and C view energy reduction as part of their customer facing value offering; they include energy reduction in audits submitted to customers and pursue EPA sponsored energy awards, and Company A and B both drive innovation through collaboration between their facilities. The companies seek external resources from sources that include utility program support, one company receives technical studies from a university, and

[9] Curriculum describes integrated training materials and instruction covering energy management targeting facility wide opportunities; in contrast to standard operating procedures which are developed with the intent of providing instruction for a specific system.

another uses an EPA online SEM forum resource—energy managers from facilities implementing SEM discuss their initiatives and outcomes from SEM activities. Company A and B are concerned their staff's focus on energy may fade from a lack of activity as savings opportunities are addressed. Both companies fear the loss of their initiative-supported CEI contractor will diminish attention to planning and staging new CEI activities. Overall Company C is showing a reduced level of activity and interest in SEM, while Companies A and B continue strong levels of engagement with all levels of staff.

**Table 7: Summary of CEI Cohort Participants' Improvement Activities**

| Activities | Company A | Company B | Company C |
|---|---|---|---|
| Staff involved in identifying savings opportunities | Monthly walkthroughs: Facility energy teams, technical staff | Monthly walkthroughs: Facility energy teams, technical staff | Maintenance staff perform walkthroughs |
| Company recognizes facility with greatest annual energy reduction | Yes | Not observed | Not observed |
| New energy ideas diffuse between facilities | Yes. Quarterly energy champions share project ideas. | Yes. Quarterly energy champions share project ideas. | Not observed |
| Energy focus evident in broader activities | Energy outcomes included in Six Sigma projects | Not observed | Not observed |
| Pursuing EPA Energy Star awards, believes adds value to products | Yes | Not observed | Yes |
| Concerns over threats that may diminish CEI System | Energy focus lessens as opportunities become saturated<br>System may become poorly maintained if CEI contractor no longer reviews / updates CEI plan<br>Gap in energy champion role with staff turnover; energy role not discussed | Energy focus lessens as opportunities become saturated<br>System may become poorly maintained if CEI contractor no longer reviews / updates CEI plan<br>Difficulty tracking savings from smaller projects | Low proportion of production staff engaged in energy management<br>Maintenance staff responsible for identifying opportunities; competes with other tasks |

### Unique Circumstances Supporting Energy Management Efforts for the CEI Cohort

The CEI cohort demonstrated some characteristics different from the rest of the market, and the companies implemented their CEI systems in a funding environment that has changed significantly since the beginning of the Initiative. The CEI cohort companies all operate multiple facilities in the region. This enables them to achieve some economies of scale in that they can use uniform processes and share resources across facilities. Furthermore, all of the firms in the CEI cohort relied on multiple sources of funding which included funding from the DOE to support salaries for their corporate energy champions, and support from the Initiative for CEI contractors. Similar companies with single facilities or facilities in multiple utility territories face greater challenges in identifying and consolidating multiple funding sources to support their energy management efforts.

### 2.1.5 NWFPA Participants

In an effort to help accelerate the diffusion of SEM practices, NEEA initiated a “cluster partnership” with the NWFPA. NEEA supported the development of the NWFPA’s Energy Roadmap program, which provides technical guidance to its members in reducing energy use and costs. The program challenges participating NWFPA members to reduce their energy intensity by 25 percent in 10 years. Participants agree to submit energy usage data to the NWFPA so that their progress towards the energy reduction goal can be tracked. According to the NWFPA, the Energy Roadmap “is a strategy to achieve the energy intensity reduction goals [through] collaboration and input by our partners - federal, states, NEEA, ETO, utilities, suppliers, and others.”[10] To evaluate the experiences and effectiveness of this program the consultant team surveyed participating facility representatives[11] about their involvement in the Energy Roadmap, its influence on energy management at their facilities, and the likelihood that they would continue participating. The facilities contacted are very large plants which nearly all run year round (97%) and employ on average of over 700 people.

Figure 3 summarizes the survey results from facility, production and energy managers representing 37 facilities. Respondents from 26 facilities recall participating in the Energy Roadmap. Results show that executives and plant managers were typically the individuals responsible for beginning Roadmap activities at their company. Roughly one-third of facilities reported receiving administrative or technical support from the NWFPA; most facilities received support from their utility or a regional funder such as ETO or BPA, or from a government agency. Most facility representatives planned to continue their participation in the Roadmap at all their facilities. Only 31 percent of the facilities reported would have implemented energy management without the Roadmap. Only 27 percent report that they had considered undertaking energy management activities before becoming involved in the Roadmap. These findings strongly suggest that the NWFPA’s Roadmap initiative exerted significant influence on the adoption of energy management practices among those members who took advantage of its services.

[10] NWFPA Energy Roadmap website. http://www.nwfpa.org/priorities/energy/energy-roadmap
[11] The NWFPA submitted a list of participating facilities to the evaluation team.

**Figure 3: Summary of NWFPA Participant Survey Responses**

| | | | Facilities | |
|---|---|---|---|---|
| | | | n | % |
| Recall Participating in Energy Roadmap | | | 37 | 70% |
| Of those recalling participation in the Roadmap | First year participated in Roadmap | 2009 - 2010 | 26 | 15% |
| | | 2011 - 2013 | | 35% |
| | | Don't know | | 50% |
| | Who started Roadmap activities at facility | Engineer | 26 | 15% |
| | | Executive | | 65% |
| | | Manager | | 4% |
| | | Plant Manager | | 15% |
| | NWFPA provided this type of support | Admin support | 26 | 12% |
| | | Technical support | | 27% |
| | | No support | | 62% |
| | Resources company relied on when implementing Roadmap (multiple responses allowed) | Utilities and Regional Funders | 26 | 81% |
| | | Government | | 54% |
| | | NEEA | | 50% |
| | | None | | 15% |
| | Plans to continue participation in Roadmap | | 26 | 88% |
| | Would have implemented energy management without Roadmap | | 26 | 31% |
| | Considered energy management before Roadmap | | 26 | 27% |

Note: The size of the green figure bar reflects the percentage listed.

Table 8 displays the portion of Roadmap participants who report having undertaken various energy management activities compared the portion of sample facilities in the "balance of the market". "Balance of Market" here refers to facilities owned by companies that were neither in the CEI cohort nor the group of facilities that availed themselves of the NWFPA Roadmap program. A higher proportion of Roadmap participants than "Balance of Market" facilities reported undertaking virtually all of the energy management activities queried. In particular, the practices identified as components of SEM were generally more prevalent among the Roadmap participants than among the "Balance of Market" facilities, as follows:

- Have established energy management goals: NWFPA – 59 percent; Balance of Market – 23 percent
- Have provided training to staff: NWFPA – 54 percent; Balance of Market – 33 percent
- Report progress on energy reduction goals to top management: NWFPA – 76 percent; Balance of Market – 43 percent
- Have implemented all four elements of SEM (breaking the resource element into dedicated personnel and training): NWFPA – 41 percent; Balance of Market – 10 percent

The NWFPA Roadmap participants showed significantly higher percentages in the execution phase, where actions result in improved energy efficiency. Overall, 31 percent of facilities in the population, including those in the CEI cohort have adopted all of the key elements of SEM. This compares to 33 percent in MPER 7.

**Table 8. Comparison of Energy Management Activities Between NWFPA Roadmap Participants and the Balance of the Market (non-participants)**

| | | Roadmap | Balance of Market | All |
|---|---|---|---|---|
| | *n (facilities represented)=* | *37* | *30* | *67* |
| **SEM Indicators** | Implemented all 4 elements of SEM | 41% | 10% | 27% |
| | Aware of SEM as a System of Practice | 49% | 7% | 25% |
| **Plan** | Have established corporate energy saving goals | 59% | 23% | 39% |
| | Have an energy saving plan | 49% | 27% | 37% |
| | Corporate staff involved in energy saving activities | 73% | 73% | 73% |
| **Execute** | Communicate to staff about energy management | 81% | 40% | 58% |
| | Include energy management in customers audits | 62% | 23% | 40% |
| | Receive energy management certification | 19% | 17% | 18% |
| | Complete capital projects only for energy efficiency | 97% | 57% | 75% |
| | Change O&M for energy efficiency | 70% | 30% | 48% |
| | Provide energy management training | 54% | 33% | 42% |
| | Replace equipment w/ energy efficient models | 100% | 87% | 93% |
| **Review** | Analyze energy bills and EUI | 11% | 7% | 9% |
| | Report progress on goals to management | 76% | 43% | 58% |
| | Review electricity usage daily or weekly | 8% | 10% | 9% |
| **Improve** | Hired contractors to save energy | 62% | 20% | 38% |
| | Seek vendors that promote energy efficiency | 57% | 7% | 29% |
| | Hire vendors that are ISO 50001 qualified | 0% | 0% | 0% |

## 2.2 MPI Results

This section describes the level of market transformation set in motion by NEEA's initiative. The consultant team presents these results in the form of MPIs (market progress indicators) as developed in the MPER#7 (Energy & Resource Solutions 2012) logic model. The logic model described outcomes, or MPIs[12], which specified the order in which initiative activities should influence changes in the market. The initiative's long-term goal is to transform the standards of practice of large food processor market to include strategic energy management. To describe the initiative's progress toward this goal, the consultant team collected and summarized data to evaluate the status of targeted MPIs, using the data sources described in section 2.1.

[12] MPIs are key market factors the initiative seeks to influence, and these indicators were described in the prior MPER's logic model. The logic model is available in Appendix H.

The consultant team organized this section around the two categories of market outcomes as implied by the logic model: supply-side outcomes and demand-side outcomes. Supply-side outcomes concern the factors directly influencing the availability, quality and price of CEI services, resources, and consulting. Key supply-side roles include regional utility programs, which help to reduce CEI implementation costs and promote services to the market, and CEI contractors whose services assist their customers with CEI implementation. Demand-side outcomes concern food processors' and cluster partners'[13] level of involvement in CEI, which includes the markets' level of awareness of and commitment to CEI, and the market's overall level of participation in CEI. The evaluation team discusses short and mid-term outcomes in each of these sections.

NEEA developed the initiative's logic model in 2010, and an Initiative team updated it in 2011 (Energy & Resource Solutions 2012).[14] The logic model reflects the initiative's strategy for 2010-2014 and beyond, and lays out the initiative's activities, and expected outcomes that will result and the conditions that will be present when NEEA has transformed the market.

### 2.2.1 Supply-Side Outcomes

Supply-side outcomes measure the market's overall capacity to deliver CEI services at a level of quality consistent with market demand. Prior to the initiative, there was not a demand for CEI services; the Initiative focused efforts on growing the available supply of CEI services. Short term MPIs focus on the impact the initiative has in helping to increase the number of CEI contractors operating in the market, which in turn provides utility programs with a market of CEI contractors around which they may build their CEI programs. The medium term MPI assesses the outcome from short-term MPIs and indicates how effectively regional funders CEI programs are at driving the volume of qualified CEI contractors operating in the market. Table 9 summarizes the data sources and research objectives pursued by the consultant team in order to measure the supply-side outcomes.

[13] Cluster partners were defined in MPER#7 as regional organizations and associations focused on food processors, and include organizations such as the North West Food Processors Association.
[14] NEEA chose not to reevaluate the logic model at this time.

**Table 9: MPI Data Sources and Research Objectives**

| Data Source | Research Objectives |
|---|---|
| Interview industrial sector program managers at BPA and ETO | Describe program managers' perceptions of the initiative's influence on the food processors market and its contribution to growing the CEI contractor market. |
| Interview managers and staff of CEI contracting firm implementing NEEA's initiative | Illustrate the initiative's contributions to growing the contractor market, and document contractors marketing strategies. |
| Interview CEI participants | Describe participants' perception of the level of quality and availability of CEI contractors. |
| Content review of utility websites | Identify utilities that do/do not offer industrial SEM programs. |

### Supply-Side: Short Term Outcomes

Two MPIs constitute the supply-side outcomes of the logic model and concern the initiative's contributions to growing the CEI contractor market, and stimulating the development of utility SEM programs. MPIs include:

- *MPI I:* Qualified CEI contractors—trained by the initiative—support end-users to implement CEI.
- *MPI V*: Utilities—take advantage of CEI contractors—add SEM offerings to their industrial sector programs.

To measure the outcomes of these MPIs, the consultant team interviewed managers and staff of the CEI contracting firm implementing the Initiative; interview topics concerned the firm's perceptions of the Initiative's contribution to building the CEI contractor market, and the marketing strategies these contracting firms have for this market. Additionally, the consultant team interviewed utilities (here after referred to as "program administrators" including ETO and BPA) concerning their perceptions of the Initiative's contributions to their SEM programs, and contributions to the CEI contractor market. The consultant team used findings from these interviews to assess the status of supply-side MPIs.

The consultant team found that both CEI contractors and program administrators at other organizations believe the Initiative stimulated the development of the CEI contractor market by training and co-funding work for the contractors. The program administrators viewed the initiative as a test case from which they were able to justify the development of their own SEM programs, and these administrators also mentioned that NEEA's online cohort tools are helpful to their development of SEM programs for smaller facilities. The program administrators believe the following factors may have limited the Initiative's contributions to market development:

- Possible market confusion caused by Initiative copyrighting the phrase "CEI" and preventing other program administrators from implementing marketing with this term

- Lack of coordination between the cluster partner's (NWFPA) outreach activities and the work of utility account executives
- Lack of M&V capacity among CEI contractors, which would be helpful in demonstrating savings and reducing uncertainties around cost-effectiveness and program planning

**Supply-Side: Medium-Term Outcomes**

The medium-term outcome will be satisfied when the market has a sufficient number of qualified CEI contractors to implement SEM systems for end-users. The consultant team interviewed regional funders to determine how adequate the CEI contractor market is to meet the demands of their SEM programs, and interviewed CEI cohort participants to describe their perception of the CEI market to meet their continued needs. The Regional Funders stated that the CEI contractor market is sufficient in terms of quality and quantity to implement SEM programs, and all of the CEI cohort participants stated they are able to identify enough qualified CEI contractors for any SEM needs they may have.

### 2.2.2 Demand-Side Outcomes

Demand side outcomes concern food processors' awareness, adoption, and commitment to SEM. Four MPIs pertain to short-term outcomes and two pertain to medium term outcomes. The following paragraphs summarize information from the facility manager interviews and other sources to characterize current market conditions in terms of the six demand-side MPIs.

**Short-Term Outcomes**

Figure 4 summarizes the results of the facility manager (market actor) survey that are relevant to the MPIs that the logic model identifies as changing in the relatively short term. These are:

- MPI III: End users become aware of SEM
- MPI VI: End users increase the pace of adoption of energy efficiency measures
- MPI IV: End users implement ISO 50001
- MPI II: NWFPA members commit to the Energy Roadmap

**Figure 4: Short-Term Demand-Side MPIs and Corresponding Market Actor Survey Results**

| MPI # | MPI Description | Variable | n | % |
|---|---|---|---|---|
| MPI III | End Users Aware of SEM | Aware of SEM as a practice | 67 | 30% |
| MPI VI | Increased Uptake of Measures | Install EE Equip | 67 | 48% |
| | | Capital project just for EE | 67 | 79% |
| | | Replace with EE | 67 | 94% |
| MPI IV | End Users Implement ISO 50001 | Aware of SEM and Heard of ISO 50001 | 67 | 27% |
| | | Facility ISO certified | 67 | 0% |
| MPI II | NWFPA Members Commit to Energy Roapmap | Members of NWFPA | 67 | 78% |
| | | Participating in Energy Roadmap | 67 | 36% |
| | | Recall participating in Roadmap | 67 | 19% |
| | | Plan to continue participation in Roadmap | 67 | 15% |

Overall, findings from the short-term MPIs indicate that while facility managers and staff have engaged in some forms of energy management, they generally are not aware of SEM in general or with ISO 50001. Additional insights provided by the results summarized in Figure 4 are as follows.

- **End-users have a low level of awareness of both SEM (MPI III) and ISO 50001 (MPI IV)**. Less than one in three surveyed energy managers reported being familiar with SEM as a "system of practice" that includes setting goals, dedicating resources, and reporting on progress toward goals. Familiarity with SEM is a pivotal MPI of the logic model and is assumed to contribute to increased uptake of energy efficiency measures and necessarily precedes the medium-term outcome of end-users implementing SEM systems. The goals set were as likely to be from DOE as from the company or facility. DOE's recommended goal of 25% improvement in 10 years is consistent with the NWFPA Roadmap goals. The initiative also promoted ISO 50001, which is an international standard for implementing energy management systems, to the market as a potential model demonstrating the importance of a systematic approach to energy management. No companies reported adopting ISO 50001. However, ninety percent of companies with corporate-level staff involvement reported that they encouraged and provided resources for energy management, as wells as reviewed progress toward energy goals, which are key aspects of SEM.
- **Industrial facilities engage in equipment-based approaches to energy management (MPI VI)**, and this demonstrates energy focus potentially favorable to progressing toward implementation of SEM systems. Consistent with this trend, survey results indicate that 94 percent of facilities report that they replace worn out equipment with energy efficient equipment; 79 percent of facilities completed capital projects where the primary objective was reduction of energy usage; and 48 percent of facilities reported installing efficient equipment to reduce energy usage. Survey respondents' elaborations indicate these activities follow from a concern over energy usage as one respondent representing three facilities stated, "we implement projects with energy efficiency in mind and do most equipment upgrades and replacements with energy efficiency as a consideration." Some

of the measures respondents reported installing included lighting, motors, VFDs, refrigeration upgrades and building shell upgrades.

- **Participation in the NWFPA's Energy Roadmap program may be increasing market interest in SEM (MPI II)**. Seventy-eight percent of survey respondents reported that their facility is a member of the NWFPA. As discussed above, NWFPA members who have taken part in the Roadmap program generally report that it was effective in supporting the adoption of energy management practices. Representatives of 15 of the 36 participating facilities addressed in this survey (42 percent) reported that they planned to continue their engagement with the Roadmap program.

### Medium-Term Outcomes

Medium-term outcomes are milestones the logic model anticipates would be achieved within three to five years of the Initiative's inception, and these outcomes build on prior short-term outcomes. The medium-term MPIs on the demand side are as follows, with MPI IX influencing MPI VIII:

- MPI IX: End-users implement SEM
- MPI VIII: NWFPA members increase the scope of energy management activities.

Figure 5 summarizes the results of the facility manager survey relevant to these MPIs.

**Figure 5: Demand Side MPI Tracking of Mid-term Outcomes**

| MPI # | MPI Description | Variable | n | % |
|---|---|---|---|---|
| MPI III | End Users Aware of SEM | Aware of SEM as a practice | 67 | 30% |
| MPI VI | Increased Uptake of Measures | Install EE equip to reduce energy use | 67 | 48% |
| | | Capital project just for EE | 67 | 79% |
| | | Replace with EE | 67 | 94% |
| MPI IV | End Users Implement ISO 50001 | Aware of SEM and Heard of ISO 50001 | 67 | 27% |
| | | Facility ISO certified | 67 | 0% |
| MPI II | NWFPA Members Commit to Energy Roapmap | Members of NWFPA | 67 | 78% |
| | | Participating in Energy Roadmap | 67 | 36% |
| | | Recall participating in Roadmap | 67 | 19% |
| | | Plan to continue participation in Roadmap | 67 | 15% |

### MPI VIII - NWFPA Members Increase Energy Management

Similar to MPI II, MPI VIII pertains explicitly to the 23 respondents representing 52 facilities that reported being members of the NWFPA. When asked if their firm would continue their commitment to the Roadmap, eight respondents representing 23 facilities stated they would continue their commitment and four respondents representing seven facilities stated they would lessen their degree of participation. Two of these four respondents suggested their participation would lessen because they had completed most energy saving projects at their facilities and they did not see additional opportunities. It was not clear from the remaining two respondents why their participation in the Roadmap would lessen. Additionally, one respondent stated his firm was ceasing participation in the Roadmap. This respondent did not state his firm's reason for this action.

### MPI IX - End-users implement SEM

To assess how many surveyed food-processor facilities were implementing SEM, the evaluation team asked about four key indicators of SEM. 1) Did the facility(ies) set energy saving goals; 2) Does the facility(ies) train staff in efficiency; 3) Does the facility(ies) have an energy manager; and 4) Does the facility(ies) report energy use to top management.

Figure 6 indicates that 27 percent of participating Energy Roadmap and BOM facilities are implementing all four indicators of SEM at some level. The indicators of SEM are defined as all those facilities with energy goals, receive energy efficiency training, have a designated energy manager, and report energy use to top management. The remaining 45 percent of respondent facilities adopted between one and three elements of SEM. Twenty-eight percent of facilities surveyed did not implement any indicator of SEM. Each of those indicators, the number of facilities adopting each reported set of combinations of indicators, and the percent of facilities reporting each indicator is supplied in Figure 6.

**Figure 6: Energy Roadmap Participants and BOM Facility Implementation of Activities Used to Indicate SEM Engagement**

| SEM Indicators | | | Market Acceptance | | | |
|---|---|---|---|---|---|---|
| Indicators | Count | Total % | Set energy reduction Goals | Training provided to staff | Energy Manager Designated | Reporting progress to top management |
| Total | 67 | 100% | 43% | 52% | 36% | 61% |
| Goals, Training, Manager, Reporting | 18 | 27% | 27% | 27% | 27% | 27% |
| Goals, Manager, Reporting | 1 | 2% | 2% | | 2% | 2% |
| Goals, Training, Reporting | 4 | 6% | 6% | 6% | | 6% |
| Goals, Reporting | 4 | 6% | 6% | | | 6% |
| Manager, Reporting | 2 | 3% | | | 3% | 3% |
| Training, Manager | 3 | 5% | | 5% | 5% | |
| Training, Reporting | 8 | 12% | | 12% | | 12% |
| Goals | 2 | 3% | 3% | | | |
| Reporting | 4 | 6% | | | | 6% |
| Training | 2 | 3% | | 3% | | |
| No indicator of SEM | 19 | 28% | | | | |

Although 97% of facilities reported an energy champion only 36% identified an energy manager. Energy-related responsibilities for energy managers are likely to be greater than energy champions. This finding is consistent with lack of focus on energy management among the sampled facilities.

## 2.3 Discussion of Progress to MPIs

This section summarizes the progress the Initiative has made in relation to trends across its MPIs. For purposes of comparison, Table 10 summarizes the changes between the three overlapping MPIs between this evaluation report and the prior evaluation. Findings indicate the portion of food processing facilities with 150 or more employees has largely held stable since late 2010, when the customer surveys for MPER #7 were conducted. The portion of total facilities that reported implementing all four elements of SEM for the 2010 survey was 33 percent, versus 36 percent for the current survey.

The number of utilities offering SEM programs is unchanged, which may be expected, as a very large proportion of utilities are offering these programs through BPA[15]. The number of cluster partners promoting SEM is also unchanged; the NWFPA is promoting SEM in this market and has helped nearly a third of the market commit to energy savings goals.

**Table 10: Review of Market Progress Between MPER #7 & #8**

| MPI | Description | Progress | Notes |
|---|---|---|---|
| 1 | Sufficient qualified CEI Contractors to support CEI implementation demand | Not assessed in MPER#7[16] | Utility program funders report sufficient qualified CEI contractors to meet their needs. |
| 2 | NWFPA members commit to Energy Roadmap | Not assessed in MPER#7 | Roughly 100 facilities have committed to roadmap; some of these facilities have enough employees to qualify as a large facility. |
| 3 | End users are aware of SEM | Unchanged | Surveyed Energy Roadmap participant and BOM facilities' awareness of SEM is 30%; consistent with the prior evaluation (32%). |
| 4 | End users implement ISO 50001 | Unchanged | No facilities have implemented ISO 50001. |
| 5 | Utilities add SEM offerings to their program offerings | Unchanged; high market participation | Utilities supported by ETO and BPA offer SEM program components; investor owned utilities outside of these territories are not. This is consistent with the prior evaluation. |

[15] BPA offers its Energy Smart Industrial (ESI) program to the 109 public owned utilities that it serves. The ESI program also includes SEM components; all 109 utilities offer incentives to their industrial sector customers through the ESI program. However, some of these utilities may not have industrial customers large enough to pursue some of the current SEM components; BPA continues to develop SEM components for smaller industrial customers.

[16] The team cannot determine progress as this MPI was not evaluated in MPER#7.

| MPI | Description | Progress | Notes |
|---|---|---|---|
| 6 | Increased uptake of energy efficiency measures | Not assessed in MPER#7 | Nearly all surveyed Energy Roadmap participant and BOM facilities' reported replacing worn-out equipment with energy efficient equipment, and implementing capital projects for the purpose of improving their energy efficiency; |
| 7 | Sufficient qualified trade allies to implement SEM | Not assessed in MPER#7 | Utility program funders report sufficiently qualified trade allies. CEI contractors report relying on utility programs as their primary supply channel, which means the supply of contractors outside of funders' region may be low. |
| 8 | NWFPA members increase energy management activities | Not assessed in MPER#7 | Compared to the balance of the market, Energy Roadmap participants are more likely to have implemented the operational elements of SEM. |
| 9 | End users implement SEM | Unchanged | Prior evaluation found that 33 percent of surveyed facilities and CEI participating facilities met minimum definition for being SEM active; this evaluation found 31 percent of facilities had implemented all four elements of SEM. Methodology between evaluations varied as this evaluation weighted findings according to population estimates from the database of facilities (Evergreen Economics 2011). |

Figure 7 below summarizes the results of the initiative's progress toward its MPIs. Findings from these outcomes indicate the market is actively engaged in forms of energy management and roughly a third of facilities meet minimum criteria for being SEM active. Opportunities remain available to continue promoting market awareness of SEM (30 percent of the market is familiar with SEM) and to educate the market about rigorous approaches to SEM.

**Figure 7. Summary of the Progress of the Initiative**

| | | Advancing Indicators | Restraining Indicators |
|---|---|---|---|
| SHORT-TERM OUTCOMES | Supply Side | • Initiative helped develop CEI contractor market; provided talent pool for Funders' SEM programs<br>• Initiative provided compelling test case; lead Funders' to develop their own SEM programs | • CEI Contractors' supply channel limited to public utility & ETO's programs<br>• Funders believe outreach strategies would improve by integrating cluster partners' and Funders' industrial account executives' activities |
| SHORT-TERM OUTCOMES | Demand Side | • Facilities demonstrate a focus on energy management and demonstrate increased uptake of EE measures<br>• 36% of facilities have energy goals they committed to through the Energy Roadmap | • Low market awareness of both SEM as a general practice and of internationally recognized standards for SEM systems<br>• Facility engagement in Energy Roadmap lagging compared with commitment; 19% of facilities aware of participating, 36% committed |
| SHORT-TERM OUTCOMES | Status | The initiative helped develop the CEI contractor market; and its successes as a test case opened supply channels, in the form of Funders' SEM programs, for these contractors. However, low market awareness of SEM will likely moderate the uptake these contractors' services in a market primarily addressing energy management through equipment upgrades. | |
| MEDIU-M-TERM OUTCOMES | Supply | • CEI contractor market is sufficient to meet market's demand for SEM implementation services | • *No restraining indicators* |
| MEDIU-M-TERM OUTCOMES | Demand | • One third of market actor facilities meet NEEA's definition of SEM | • Market seems to be implementing SEM elements non-systematically as planning (goals) are the least common implemented SEM indicator |
| MEDIU-M-TERM OUTCOMES | Status | Nearly one third of market actors' facilities have implemented four defining aspects of SEM. It is unclear how rigorous /systematic these facilities are in terms of SEM as the market seems to have a 'do-plan' approach to energy management rather than 'plan-do' where goals precede other activities. | |

# 3 SUMMARY OF IMPACT RESULTS

This section presents estimates of the impact of the program on energy consumption among three sets of facilities. The first set is the CEI participant cohort. These facilities have been the subject of several rounds of impact evaluation. In order to promote comparability over time and to meet schedules for early reporting of savings, the consultant team applied methods developed by NEEA and its contractors that had been used in past evaluations to estimate energy saved by facilities in the CEI cohort. The second set of facilities consisted of 24 plants that had participated in the NWFPA Roadmap. As part of that program, the plants needed to commit to submitting energy consumption records to NWFPA so that progress in energy use reduction could be tracked. We used this billing data, along with information collected from the plants to estimate energy savings for the NWFPA facilities. We applied somewhat different methods to this group versus the CEI cohort, taking advantage of a less restrictive schedule and lessons learned from the earlier work. The final impact result is an assessment of the perceived savings due to the diffuse effect of SEM over all plants in the market, including those that were in neither the CEI cohort nor the NWFPA Roadmap group.

## 3.1 Program Impacts with CEI Participants

The impact evaluation consisted of two parts: a top-down regression analysis of changes in energy consumption for each participating facility and a bottom-up energy engineering analysis for each completed energy efficiency measure. The top-down analysis applied regression techniques to estimate changes in annual energy consumption at individual facilities in successive periods compared to a pre-CEI baseline level, after controlling for the effects of outdoor temperature and production volumes. The engineering analysis attempted to estimate the energy savings associated with specific investments in energy efficiency measures that were funded by local utilities. The difference between the total change in energy use estimated through the top-down analysis and the savings associated with specific measures funded by other programs provides an estimate of the energy impacts of the CEI activities. Although the evaluation team recognized that incorporating the energy savings into the model would be better than subtracting the energy savings from the model results, the approach was necessitated by the limited time available for the evaluation.

The consultant team used top-down models developed by NEEA's contractor to estimate changes in annual consumption in 2012 versus the baseline year, normalized for weather conditions and volume of production. For 2012, nine facilities were active in CEI cohort across Oregon, Idaho and Washington states. The facilities installed 29 capital measures to increase energy efficiency in 2012. The consultant team verified all of those measures through on-site inspections and estimated their annual gross savings based on the results of those inspections. At one site, no measures could be evaluated due to insufficient information.

### 3.1.1 Top Down Savings Model

The top-down analysis is designed to capture the savings that result from CEI activities that are not typically included in a measure-by-measure engineering analysis. The types of activities promoted by CEI include planning, setting goals, and incorporating management, operational practice, and behavioral changes into the facility operations, as well as capital and maintenance improvements outside of utility programs. NEEA developed top-down savings for electric energy consumption.

To quantify the CEI savings outside of the specific energy efficiency measures assessed in the bottom up validation, NEEA's subcontractor developed an econometric model for each facility. Each model consisted of a regression analysis of the baseline period to predict electric energy consumption as a function of key variables such as production volume and temperature. The data covered two to three years prior to program participation as well as the five subsequent years. The model for each facility has a unique set of explanatory variables, such as measures of total production per month, and temperature or a variable such as degree-days representing weather conditions. The model for each facility is designed to predict how much energy would have been consumed in each year at that facility after the baseline period if CEI had not been implemented. Since the improvements were not made in the baseline year, the modeler can use the baseline year relationship between production and other key variables with energy consumption to predict energy consumption in the years when CEI was implemented. The difference between the actual consumption in the CEI years should be less than what the model predicts; this difference is the savings due to CEI. However, the model does not account for the effect of energy efficiency measures known to have been implemented through energy efficiency programs from local utilities.

The top down model approach has strengths and limitations, as seen below in Table 11.

**Table 11. Strengths and Limitations of Top-Down Models**

| Strengths | Limitations |
|---|---|
| The model development is relatively simple to perform, and is consistent with the limited amount of data. | The model seeks to quantify a small effect; annual energy efficiency improvements are considerably less than 10 percent compared to the total energy consumption. |
| Statistical measures of fit show how well models are able to explain the variation in energy consumption. | Variables outside of the models may be affecting energy consumption. The data available is limited to weather and net production and the model cannot account for variables that may affect the results, such as product mix or changes in operation. |
| The approach is transparent. | Changes is operations and equipment that drive energy consumption may overwhelm the changes due to energy efficiency improvements |
| | The top down model, based on monthly energy consumption, is based on a pre-CEI baseline period of one to two years or at most 24 data points |

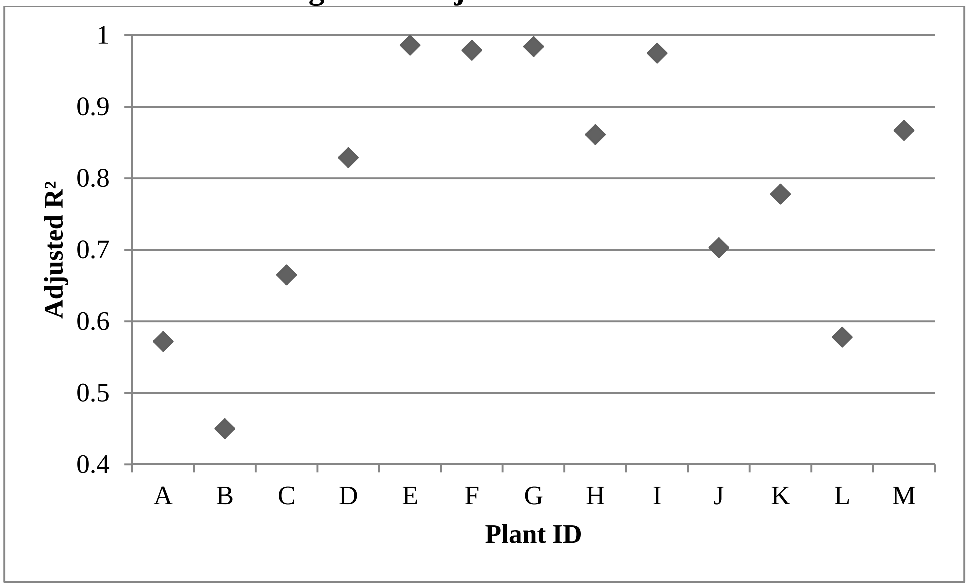
The top down model as developed by NEEA's contractor estimated the top down savings, but was not developed to incorporate the savings from the bottom-up evaluation directly into the model. Due to the time frame of the evaluation, it was not practical to combine the validated savings into the models and develop models that explicitly incorporated the savings. The bottom up savings are subtracted from the predicted consumption from the model, rather than adjusting the actual consumption and modeling the revised plant consumption. Subtracting savings outside of the model increases the uncertainty of the model. Assumptions in the operating conditions for a specific measure at one point in time may not be valid for other periods. These increases in uncertainty are expected to reduce estimates of savings for a given set of facilities and end use data, as results from models with poor fits may be rejected.

DNV KEMA's evaluation team reviewed the concept of the model, the model form, and the variables considered. The evaluation team also duplicated the regression analysis, to check that the model was implemented as planned.

Figure 8 below presents the adjusted $R^2$ measure[17] of each model's overall explanatory power. Two of the plants (A and B) represent 85% of the cumulative savings. Unfortunately, these are also the plants where the models have lowest levels of overall explanatory power.

[17] $R^2$ is a goodness of fit statistic that explains how well a response variable (in this case, energy consumption) is predicted by the model. It varies between 0 and 1, where 1 represents a perfect fit.

**Figure 8: Adjusted Model Fits**




DNV KEMA applied the backcasting technique to the plant with the largest savings, Plant B. Backcasting is the technique of creating a model based on post intervention data and then using that model to determine the difference between observed and modeled energy consumption prior to intervention. The backcasting technique will estimate a similar energy savings as the forecast technique when energy consumption in the pre and post periods is the result of the same underlying process. DNV KEMA found that the backcast savings estimate was statistically different from the forecast savings estimate, indicating that for Plant B the model did not accurately predict facility energy consumption.

Although the overall approach of the top-down model is sound, the two plants that account for the majority of the estimated savings have a relatively low level of overall fit. The results of the backcast test on the largest plant suggest that the model should account for more sources of variation. Given the poor model fit for Plants A and B, and the fact that Plants A, B and M had not participated in the CEI program in 2012, these three plants were dropped from the savings estimate.

The models for Plants C through L all have statistically significant coefficients with reasonable values. Further, the adjusted $R^2$ values are, for the most part, quite high. Opportunities to improve the models include collecting additional data on more explanatory variables such as product mix, applying the backcast technique to provide insight on whether the model accounts for the necessary amount of variation, and gathering anecdotal data from the plants regarding activities the model may not otherwise represent. Further, the models could account for energy efficiency measures directly. The best practice is to use statistically adjusted engineering models with terms that represent engineering savings estimates.

The plant level savings are shown in Table 12. The table shows the annual savings predicted for 2012, and also shows the average annual savings over the years the plant participated in the CEI program, as well as the correlation coefficient for the top-down model.

**Table 12:Top Down Incremental Savings**

| Plant ID | 2012 Annual Savings, aMw | Average Annual Savings (2008 – 2012), aMw | Correlation coefficient, $R^2$ |
|---|---|---|---|
| C | -0.03 | 0.002 | 0.67 |
| D | -0.093 | 0.042 | 0.83 |
| E | 0.255 | 0.082 | 0.99 |
| F | 0.148 | 0.022 | 0.98 |
| G | 0.409 | 0.121 | 0.98 |
| H | -0.007 | 0.019 | 0.86 |
| I | -0.037 | 0.048 | 0.98 |
| J | No Data | 0.199 | 0.70 |
| K | -0.227 | -0.027 | 0.78 |
| L | No Data | 0.114 | 0.58 |
| Total | 0.42 | 0.622 | NA |

### 3.1.2 Bottom-up Savings Validation

DNV KEMA evaluated the savings of 27 measures at nine facilities completed in 2011 and 2012. Each measure was validated following a site visit to the plant. Savings were estimated based on data collected at the facility, data provided by the site contact, and engineering calculations. Table 13 below displays the results for both electric and gas savings. The realization rate of verified to tracked savings was 117% for electric measures and 43% for natural gas measures.

**Table 13: Estimated Gross Savings by Measure Type from Bottom Up Model**

| Measure Group | Number of Measures | Ex Ante MWh | Ex Ante Therms | Ex Post MWh | Ex Post Therms | Electric Realization Rate | Therms Realization Rate |
|---|---|---|---|---|---|---|---|
| Process Heating | 5 | 0 | 635,820 | 0 | 272,375 | NA | 43% |
| Process Cooling | 5 | 1,549 | 0 | 2,004 | 0 | 129% | NA |
| Controls & Process Improvements | 9 | 312 | 0 | 344 | 0 | 110% | NA |
| Lighting | 6 | 795 | 0 | 840 | 0 | 106% | NA |
| Other | 2 | 328 | -2,880 | 295 | -1,261 | 90% | 44% |
| **Total** | **27** | **2,985** | **632,940** | **3,484** | **271,114** | **117%** | **43%** |

Site specific observations and energy saving calculations are available in Appendix D. Projects can be grouped into the following measure categories:

- **Process heating.** Examples of projects include installing heat exchangers, boiler economizers and steam pipe insulation.
- **Process cooling.** Examples include cold room insulation, refrigeration system optimization and VFDs on freeze tunnel fans.
- **Controls and Process Improvements.** Examples include installing new equipment, installing VFDs on motors and pumps and compressed air improvements.
- **Lighting.** Examples include replacing T12 fixtures with energy efficient T8 fixtures, converting 400W metal halide fixtures to high output T5 fixtures and replacing high pressure sodium fixtures with LED fixtures.
- **Other.** This category included non-lighting projects that did not affect the production line, such as office HVAC.

There were some common reasons ex ante and ex post savings differed:

- **Different baseline assumptions.** This occurred when the ex ante savings assumed incorrect or inappropriate initial operating conditions.
- **Unclear tracking data.** This occurred when it was not clear how the savings in the tracking data were calculated.
- **The installed measure differed from the tracking data.** An example would be retrofitting more light fixtures than were credited in the tracking savings.

It should also be noted that there were some measures that were identified by the CEI contractor as implemented but no savings estimates were available. Therefore, DNV KEMA could not review the claimed savings methodology. These measures were not evaluated and no savings were claimed for these measures.

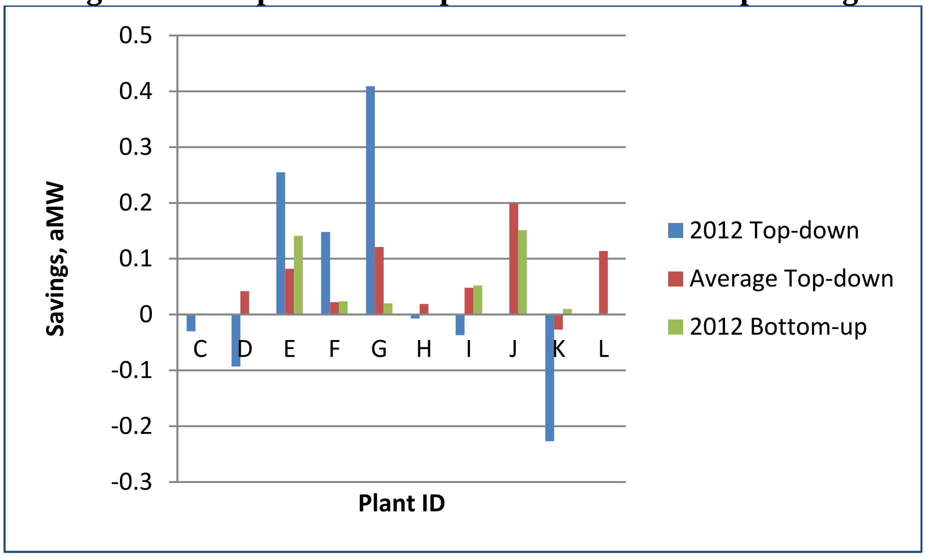
### 3.1.3 Program Savings

DNV KEMA reviewed the contractor's top down savings model to compare it with the bottom-up savings for 2012. Figure 9 below shows the comparison of top-down and bottom-up savings for the facilities that are still part of the program. Many of the model results show negative incremental savings for some years, possibly due to plants periodically making more energy intensive products, overall model fit, or conditions outside of those modeled effecting energy consumption. The top-down model does not take these factors explicitly into account; therefore, the model can overstate or understate expected energy consumption. Thus, the top-down model results for a particular plant may be negative for a year, although the plant may actually be achieving savings compared to what they would have used without the program.

DNV KEMA also reviewed the results of the models compared to the anecdotal information collected in interviews. Two plants identified a processing difficulty with raw materials that reduced their 2012 efficiency. Both these plants showed negative savings in the top down model. Additionally, a plant that described a very effective training combined with new equipment that reduced rework and improved their overall efficiency showed significant savings. These results suggest that when the model fit is good and the model does explain how energy is consumed, the top down model approach accurately reflects activities at the plants. Savings due to the program may be under or overestimated when other effects, such as product mix and raw materials, drive energy consumption but are not modeled. The anecdotal information suggests that the savings due to the program are greater than predicted by the top-down model.

DNV KEMA recommends using the annual savings across all plants that participated for the full program duration. This approach recognizes that the results for individual plants may either overstate or understate energy consumption. Aggregating the results mitigates this issue.

**Figure 9: Comparison of Top-down and Bottom-up Savings**



DNV KEMA considered both the average savings over the years of the program and the annual savings for 2012 alone as indicators of savings achieved. As shown in Figure 9, the use of the average model reduces the variation in the results. Therefore, the average top down model is selected as the best approach, yielding 0.228 aMW savings due to CEI management practices, or 1% of the annual electric consumption of the cohort facilities.

## 3.2 NWFPA Participants

As discussed in Section 2.1.4, NEEA has worked with the NWFPA to encourage SEM among their members and in the food processing industry in the Northwest. One of the aspects of NWFPA's work with individual plants was to collect data on energy consumption and production. NWFPA has been accumulating this data for several years, and now has data from at least 3 years from many facilities. NEEA requested that DNV KEMA review the data and develop top-down models for the facilities to assess whether energy savings are occurring as a result of the uptake of SEM.

The NWFPA provided monthly energy consumption and food production data for 44 member sites that participated in the NWFPA roadmap and including elements of strategic energy management in their operations. These sites ranged in size from a base year load of 7.2 MWh to 1,506 MWh. DNV KEMA developed top-down analysis models of energy consumption, similar to what NEEA developed for the cohort CEI participants.

DNV KEMA recognized the issues identified for the top down models as discussed in Section 3.1, and took the following steps to reduce uncertainties in the model:

- We developed models only for facilities that had data for production variables that could have a plausible and significant effect on energy consumption.[18]
- We accepted models where the correlation coefficient is at least 0.75, indicating a good overall fit and coefficients that are statistically significant with plausible magnitudes.

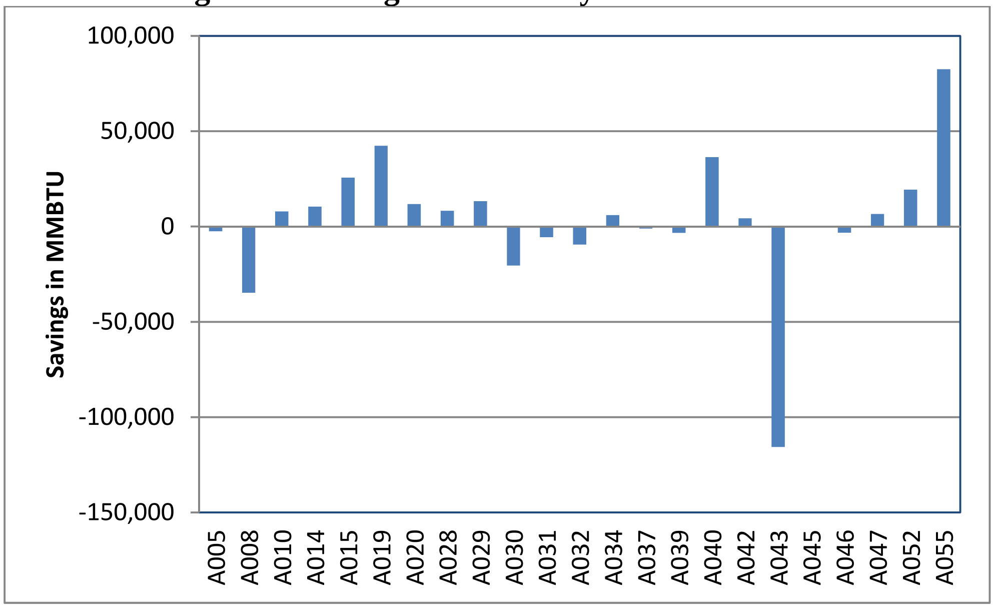
As a result of applying these criteria, we accepted the model results of 23 of the 44 sites. Additionally, DNV KEMA included documented savings from measures installed with the assistance of utility programs directly in the model by adjusting energy consumption prior to developing the models.

The theory of SEM is that facilities can lower their energy consumption through management planning, maintenance and operational procedure modifications. The program should result in increased energy performance over time, after controlling for activity level and environmental factors.

[18] For example, negative production was reported, likely indicating rework or accounting adjustments. These were not considered to have a plausible effect on energy consumption.

Figure 10 shows the savings estimates for each site where the model was accepted. The overall weighted savings is approximately 1% of the base year energy consumption annually.

**Figure 10:Savings Estimates by Site in MMBTU**




We would expect the savings in the NWFPA group to be significantly less than the savings in the cohort of CEI participants, because significantly less support was provided to the NWFPA group. Yet the savings results appear to be quite similar, both approximately 1 percent of the annual electric consumption. However, this similarity is partially an artifact of the difference in the methodology of the top down analysis. When the methodologies are aligned, the cohort savings increase significantly above the NWFPA group.

- The correlation coefficient criterion for the NWFPA analysis is 0.75. If we apply the criteria to the cohort population of only including models with an $R^2$ above 0.75, 3 facilities drop out of the analysis and the average net top down savings are 2% of electric annual consumption.
- The NWFPA group was modeled by integrating the bottom-up savings into the energy consumption. This approach has stronger technical merit than subtracting bottom-up savings outside of the top-down model, as was done for the CEI cohort. In order to understand the implications of the two approaches, DNV KEMA produced as set of savings estimates using the same approach as for the CEI cohort. This comparison savings estimate yielded negative savings for the NWFPA group. Based on this finding, we expect that the CEI cohort savings estimate would increase if we integrate bottom-up savings into the top-down model. Integrating the bottom-up savings for the cohort group would improve the accuracy of the models, reduce the variation, and increase the overall savings estimate.

- For the NWFPA group, DNV KEMA assessed the type of measure when adjusting the energy consumption for the effect of the efficiency measure. Lighting measures would have a fairly constant effect, but an air compressor measure, for example, would likely have more of a relationship with production levels. This approach improved the savings results compared to considering all measure types in the same way. A similar approach would most likely result in more savings for the CEI cohort.

Thus, we expect that for a typical facility in the cohort with a good model fit and the energy savings incorporated into the model rather than subtracted from the model would have a savings of 2% or more annually compared to their annual electric consumption.

Although it was appropriate to incorporate all the facilities in the CEI cohort in the analysis because they were all part of the program, the approach yielded lower average results.

## 3.3 Diffuse Effects: Methods to Estimate Energy Savings among Balance of Market Facilities

NEEA and other organizations in the Northwest have championed SEM, and measured results of direct participants. As shown in the market research discussed above, some food processors are adopting some or all of the key concepts of SEM. These practices are expected to be producing energy savings. To date, NEEA has not attempted to estimate these savings.

As part of this MPER, DNV KEMA assessed potential methods to quantify energy savings generated by adoption of SEM practices by facilities in the Balance of Market Segment. As a starting point, DNV KEMA reviewed the criteria for calculating energy savings from efficiency programs developed by the Regional Technical Forum (RTF), an advisory committee of the Northwest Power & Conservation Council (Regional Technical Forum 2013). Based on the results of this review, the evaluation team assessed the feasibility and appropriateness of the alternative calculation methods with regard to estimating savings from the BOM facilities, and the usefulness of the available information collected to date. To inform and cross-check this assessment, we conducted a short review of methods and results from similar programs. The following sections present the results of our assessment of alternative impact estimation methods and our recommendations with regard to their application in this case.

### 3.3.1 RTF criteria

The Regional Technical Forum, an advisory committee of the Northwest Power & Conservation Council, produced criteria for calculating savings.[19] The publication presents four approaches to savings estimation: unit energy savings, standard protocol, custom protocol, and program impact

[19] Guidelines for the Estimation of Energy Savings Estimation Methods, Regional Technical Forum, March 4, 2013.

evaluation. For each approach, the publication specifies requirements or criteria that the measure and/or program should meet in order for the approach to be applied appropriately. In the following paragraphs, we assess the degree to which these requirements apply to SEM.

### Unit Energy Savings

The unit energy savings approach requires that savings for a given measure can be assessed in a standardized way and that mean unit savings can be estimated with relatively high confidence and precision. Unitized savings are expected to remain stable over the forecast period until a sunset date. Total savings can then be estimated by multiplying the unit savings for the measure by the number of units affected. Table 14 displays the information on the applicability of the Unit Energy Savings method to assessment of SEM savings.

**Table 14. Unit Energy Savings Applicability to SEM**

| Requirement | SEM characteristics | Applicability |
|---|---|---|
| Measure has uniform specifications | Components of the system are defined, but implementation can vary significantly between sites | Somewhat |
| Mean unit savings can be estimated with relatively high level of confidence and precision | Savings are estimated using a top down regression model of plant energy use and relevant factors such as production. Other variables may affect consumption beyond those considered in the model, reducing the confidence and precision. | No. |
| Savings are stable over the performance period | Savings vary year to year, depending on activities performed and level of engagement | No. |
| Total savings can be estimated once the quantity of measures is known | Plant operations are too variable across different plants as well as over time within plants | No. |

Overall, unit energy savings were found not to be appropriate for SEM.

### Standard Protocol

The standard protocol applies when savings can be determined by a standardized procedure, although savings may vary widely. This procedure for data collection and analysis is applicable for many different sites. Where the standard protocol is appropriate, quality standards and guidance can be defined.

For SEM, top down models are used to estimate the changes in energy consumption versus the baseline period, normalized for variations in weather and production patterns. For a standardized protocol to apply, top down models would need to be more accurate than they have proven to be with the limited number of variables generally available for SEM assessment. Additionally, a regular pattern in the share of savings that may be attributed to SEM would need to be observed such that “bottom up” savings do not need to be estimated on a site-by-site basis.

#### Custom Protocol

Custom protocols are appropriate for measures where site-specific planning, data collection and analysis are required to estimate the savings reliably. Measures such as a complex HVAC retrofit or an industrial process modification are example projects for a custom protocol. For each custom measure, a skilled practitioner develops a plan that is relevant to the particular measure as implemented at a specific site.

The current approach for evaluating SEM at a particular site is consistent with the custom protocol, as described in this MPER and in Appendix D. Individual measures are individually evaluated. A top down model is created for each site.

#### Program Impact Evaluation

A program impact evaluation is designed to produce a reliable estimate of savings from program implementation for a particular period. A sample of participants is selected as representative of the program population. The energy savings for the sample is estimated using the appropriate protocol. The savings from the sample are then extrapolated using statistical methods to yield the total program savings.

The program impact evaluation is the approach NEEA has used to date to estimate savings from the program participants. This method has not been used to assess the results from market actors outside the cohort of CEI participants, although the NWFPA Roadmap assessment was similar. This approach would require collecting data from a sample of representative facilities and applying assumptions concerning energy savings associated with those actions, most likely expressed as a percentage of annual energy consumption. The concern here is that the evaluation team has insufficient information about facilities outside the program, both in terms of whether SEM is implemented at a given facility as well as lack of site-specific consumption and production data. The evaluation team does not have enough information about the trends between the program participants and non-participants. Because of this, DNV KEMA cannot endorse extending estimates of savings from facilities in the program to the population outside the program.

### 3.3.2 Review of Methods from Similar Programs

The Bonneville Power Authority (BPA) and the Energy Trust of Oregon (ETO) have developed SEM programs that are similar to NEEA’s. Like NEEA, these programs use regression analysis to estimate savings from the programs.

For ETO’s Industrial Energy Improvement program, program savings were measured by both bottom up and top down approaches. The top down analysis measures an overall change in energy intensity, using regression analysis with one or more variables and cumulative sum of differences. The bottom up documentation of opportunities becomes a cross-check on the top down analysis; identified improvements should show an improvement in energy performance (Wallner 2011).

BPA calculates savings from participants in the High Performance Energy Management program using a regression based software tool to establish a baseline for each facility in the program. The baseline model developed in the tool allows the comparison of the actual energy consumption with the modeled energy consumption. BPA's method tracks the changes in the cumulative sum of differences to identify improvements. The BPA program evaluation used a similar approach to ETO, with a time series variable to identify savings. The evaluation found a 4.4% verification of savings as a percent of consumption, with 2.7% verified as O&M measures (Cadmus 2013).

Superior Energy Performance, DOE's energy certification program for plants, also develops a model for the representative period and employs it as a basis for calculating energy performance improvements. The M&V protocol allows a range of options for the model, which has specific and rigorous requirements. Most facilities elect to use a software tool developed by DOE, which creates a linear regression model similar to BPA, ETO and NEEA. This program includes all forms of savings, including capital and retrofit projects, as part of the savings. Participants must achieve at least 5% performance improvement over 3 years (1.7% annually) to achieve certification. Initial pilot participants achieved between 6 and 17% over 3 years.

### 3.3.3 Proposed Methods

DNV KEMA assessed whether an energy savings method could be developed to apply to diffuse populations, that is, groups of customers with no prior direct contact from the initiative. This section considers how such a method would be developed and what data would be needed to apply it. Options available for estimating energy savings at a given facility include energy intensity (energy consumed per production quantity), development of facility-specific energy models, or application of a savings factor to total energy consumed at a facility.

In seeking to develop a method, DNV KEMA reviewed the literature for savings estimation methods for energy management programs, as discussed in sections 3.3.2. A review of SEM programs indicates that regression models for facility energy consumption are the most common approach (Cadmus 2013, SWEEP 2013). All of the methods reviewed required facility energy consumption data, as well as production data or other site-specific information on how energy is consumed. Even approaches that might involve application of savings factors would require site-level data on energy consumption and information on the timing and extent of energy management activities undertaken. If that information can be collected, then the marginal cost for applying the modeling methods described above in regard to the CEI and NWFPA cohorts are relatively low, and are, we believe, justified by the greater level of accuracy and understanding they afford versus approaches that rely on savings factors. Thus, for a group of facilities with no documented contact with the Initiative, we conclude that the program evaluation approach is the only RTF-approved method that is clearly applicable.

The challenges in estimating SEM-related savings among customers with no documented contact to the Initiative involve obtaining cooperation from the customer in obtaining data on energy management practices and from their energy suppliers in obtaining energy consumption records. We assume that both the customer and their suppliers will want some benefit for cooperation in the research in the absence of program services. Given that this population is not currently participating in SEM despite significant outreach by NEEA, we believe that an incentive is required to achieve cooperation for data collection. The incentive could be a direct payment, or a service considered valuable by the BOM facilities. For example, NEEA could provide a tool for tracking energy consumption and the results of the modeling that would allow the facilities to monitor their energy performance. Alternatively, NEEA could provide benchmarking information about how a given facility ranks in energy usage compared to similar facilities.  To deliver these services, NEEA would need access to the facility’s consumption records, which the respondents would agree to provide in return for the incentive.

The remainder of this section focuses on methods that require site-specific data.

**Defining the population of facilities.** The most robust data collected from the Initiative are from the large food processor group. Although SEM is applicable across many industrial sectors, NEEA’s program focused on this group and has collected data over several years. Data from the NWFPA members significantly expand this dataset. Analysts will want to identify a group of facilities in the same industry, given that production processes vary so greatly from one industry to another. The diffuse effect assessment is therefore focused on large food processors in the Northwest, where NEEA’s program was ongoing.

**Definition of the SEM measure.** The standardized method must define what is considered to be SEM. Organizations that claim to have an energy management system would need to demonstrate integration of energy management in their planning and operational practices. SEM activities such as planning, goal setting, and measuring with the involvement of top management should lead to behavioral, maintenance and capital savings. One key question is whether capital projects should be considered as part of SEM; since SEM often leads to identification of projects, some programs consider that these savings should be included. (Cadmus 2013). However, SEM programs generally seek to avoid double counting of savings for utility-incented projects. For this analysis, the evaluation team assumes that data on utility-incented projects are available and can be included in the method. The evaluation team has not identified data that would allow selecting a standard percentage of SEM savings as due to utility-incented or capital projects. As SEM and similar programs like Superior Energy Performance become more widespread, sufficient data may become available to estimate an average or typical fraction of energy improvements as due to capital projects rather than other SEM activities.

**Savings calculation method.** Savings calculation methods require a definition of the baseline conditions. For the CEI cohort and the NWFPA group, the baseline was defined by at least one year of data prior to significant CEI or SEM implementation. This amount of baseline data is consistent with Option C of IPMVP methods (whole building analysis), other regional NW programs, and Superior Energy Performance. A minimum of one year of data is adopted to determine the baseline for this method. However, one concern with the baseline period is determining a period prior to SEM. Since uptake of SEM may occur gradually, there is not necessarily an obvious baseline period unaffected by any aspect of SEM. Further, some SEM aspects may occur naturally, or outside of influence from NEEA. The lack of an absolute baseline can be factored into the regression analysis such that the method addresses gradual change. This is the approach used for the NWFPA roadmap participants as well as the BPA pilot.

Both the CEI and NWFPA regression models developed for this MPER create a model using baseline conditions and apply the model throughout the period of SEM as a method for forecasting energy consumption in the absence of SEM adoption. The BPA and ETO programs similarly forecast consumption after creating a baseline model. This method of forecasting with a baseline model as the starting point will be retained as a reasonable approach.

The savings algorithm for each facility can be developed by considering the baseline model for energy consumption as a function of relevant variables. An example of a regression model for electricity usage with production and weather as relevant variables is shown below:

$$E= B_{0e} + B_{1e}x_{1e} + B_{2e}W$$

Where:

$E$ = Energy electric energy consumed, monthly, in kWh
$B_{0e}$ = coefficient representing the fixed electric energy consumed (intercept)
$B_{1e}$ = coefficient representing the relationship of manufactured product to electric energy consumption (kWh/ton)
$X_{1e}$ = monthly production (tons)
$B_{2e}$ = coefficient representing the relationship of weather (temperature or degree days) (kWh/$^{o}$F or kWh/CDD)
W= weather variable, such as temperature or degree days

The challenge for a model such as this is the inclusion of relevant variables and adjustment factors. Energy consumption at an industrial facility can be determined by factors that are not easily modeled, particularly in times of change. The basic assumption of the SEM model is that the conditions determining energy consumption in the baseline period can be modeled effectively such that future energy consumption can be predicted. That is, changes between the baseline and forecasted periods are only related to terms identified in the model form. Given that industrial facilities do make changes in operations, equipment, and procedures, the assumption that change is not significant should be probed as part of the modeling effort for each facility. Information about major process or plant changes, additional variables such as product mix, and non-routine events that affect energy consumption can be collected to support developing better models.

The method for estimating savings should include an indication of measure life and persistence. DNV KEMA performed a literature search to assess persistence. Additionally, the evaluation team considered the CEI cohorts as an indication of persistence. The results are discussed in the next section.

### 3.3.4 Program Impact Evaluation Approach Results

This section assesses to what extent the data collected as part of the CEI evaluations and associated market research in the MPERs for this initiative can provide an indication of the diffuse effect of SEM. Although savings cannot be quantified without site-specific data, we can estimate the maximum likely effect based on results from the Initiative and similar programs. This section also includes an estimate of the persistence of SEM.

**Diffuse Effect of SEM**

In the absence of site-specific data, we consider the achievements in NEEA territory and look for trends to assess the diffuse effect of SEM. We reviewed previous MPERs for cohort savings, with the results shown in Table 15. Savings from similar programs also provide useful data points. The initial Superior Energy Performance pilot projects reported between 6 and 17% performance improvements over 3 years (Brown 2011). BPA achieved a 2.7% savings in energy consumption from their energy management pilot program during the first year (Cadmus 2013).

**Table 15. Top Down Savings Estimates**

| Year | Program Document | Annual Savings |
|---|---|---|
| 2006-2008 | MPER #5 | High variability; program savings not quantified |
| 2009 | MPER #6 | 3% of annual consumption, including bottom-up savings |
| 2010 | MPER #7 | 2% of annual consumption, excluding bottom up savings |
| 2011-2012 | MPER #8 | 1 to 2% of consumption, excluding bottom up savings |
| 2010 - 2012 | NWFPA Roadmap | 1% of consumption, excluding bottom up savings |
| 2012 | BPA Pilot Evaluation | 2.7% of consumption, excluding bottom up savings |
| 2011-2012 | SEP Certifications | 2% to 5.6% of consumption, including bottom up savings |

These data suggest that 1 to 3% of annual energy consumption is a reasonable expectation for an active SEM program. The NWFPA Roadmap participants show a slightly lower level of savings at 1%, perhaps reflecting a less intense program. The diffuse effect of SEM would certainly be significantly less than 1%.

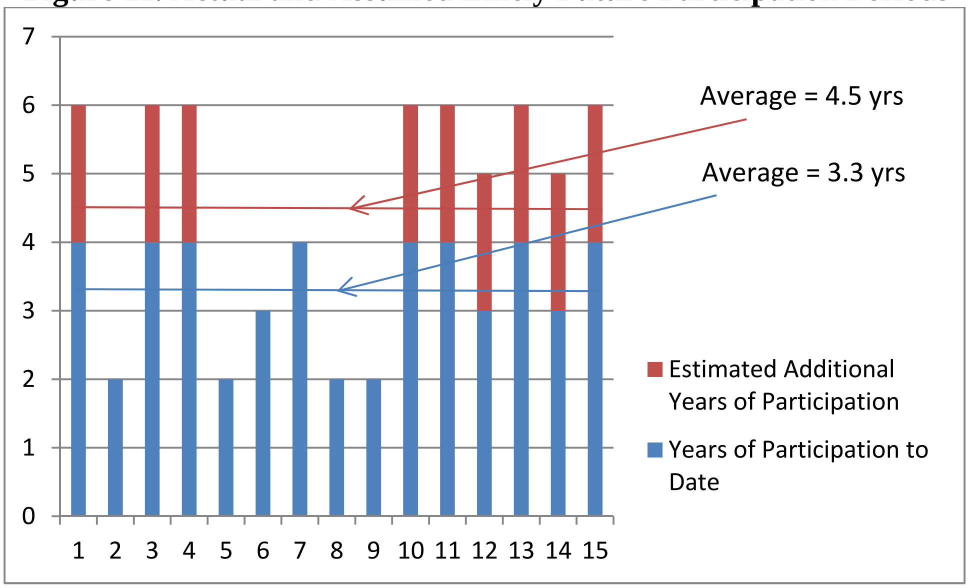
Data collected for this MPER show one third or less of the large food processors showed some effects from NEEA's SEM outreach. Records in NEEA's database show 39 food processors aware of SEM. Fifteen of these facilities (38%) reached the level of sustaining SEM, NEEA's highest level of participation. These 15 food processing facilities participating in the NEEA program were reduced to 11 active participants within 4 years, and only 28% of the facilities initially contacted persist in SEM. Similarly, about a third of the large food processors surveyed in 2013 were identified as implementing all four aspects of SEM. MPERs #5, 6 and 7 also found that about one third of the population of large food processors were implementing the key aspects of SEM. However, there is little information about the depth of participation in SEM outside of the CEI cohort in previous MPERs. Market research in this MPER indicates that the NWFPA participants are more thoroughly engaged in SEM activities than the general population of food processors.

Some diffuse effect in the balance of market is clearly indicated in the market research. The diffuse effect of SEM likely will affect one third or less of the BOM population of food processors. As noted above, a savings result of less than 1% is also expected for the diffuse effect. Although it is not possible to quantify the savings in the balance of market, the maximum indicated effect would be one third of one percent of annual energy consumption.

**Persistence of SEM**

With the oldest SEM program, endurance in NEEA's program provides valuable indications of persistence. DNV KEMA reviewed NEEA's database of participants. A total of 15 food processors were identified as reaching the full level of participation in SEM. Currently 11 facilities participate, and two of these clearly are less active than they were previously. However, 9 are actively participating, and could logically continue participation for another 2 years or more.
Figure 11 shows the number of years of participation to date, as well as estimates for further participation for the most active plants. The average of participation to date has been 3.3 years, and the average of the estimated further participation yields 4.5 years.

**Figure 11. Actual and Assumed Likely Future Participation Periods**




The literature review identifies similar periods of persistence for similar activities, such as retrocommissioning measures. Lawrence Berkeley Laboratory reported 4 years for measure persistence for retrocommissioning projects (LBNL 2004). A measure life study provided values for services performed, such as 2 years for compressed air and vacuum pump servicing and 5 years for HVAC services (Public Service Commission of Wisconsin 2009). In MPER 5, the evaluator suggested 1 to 3 years as a typical measure life for operations and maintenance measures (Cadmus 2009). Energy Trust of Oregon uses a 3-year measure life for their SEM program (ERS 2012). The current data suggests a measure life of 3 to 4 years for SEM.

### 3.4 Steps for Improving Savings Estimates

Better documentation would approve results of the bottom-up evaluation. There were a few measures that did not receive a savings estimate and therefore could not be evaluated. The limited time frame for the evaluation also did not allow for collecting onsite measurements beyond what could be completed during the site visit.

DNV KEMA recommends that top down models address the bottom-up savings as part of the model. The type of measure should be considered when adjusting the energy consumption for the effect of the efficiency measure. Statistically adjusted engineering methods are the best practice as they are able to capture measure savings as dependent variables, as described in Appendix F.

Future top-down models should include data on site-specific variables that affect energy consumption, such as product mix, fuel type, and seasonal effects. The facility also can provide information on changes at the facility that effect energy consumption outside of energy efficiency activities, such as changes in processes or new environmental requirements. DNV KEMA also recommends establishing a baseline when this data is available, which may be after the initiation of the program. Many facilities began tracking additional variables, such as the energy consumption by specific products, after they adopted the methods of the CEI program or the NWFPA roadmap. Additional data would allow the development of more informed conclusions.

# 4 CONCLUSIONS AND RECOMMENDATIONS

## 4.1 Conclusions

Based on the findings presented above, the DNV KEMA team draws the following conclusions about the success of the Initiative, current levels of adoption of strategic energy management practices by targeted food processing facilities, and the state of the market for strategic energy management services.

- **The intensive technical support provided to the CEI cohort was successful in supporting the adoption and continuous long-term development of Strategic Energy Management practices among a large percentage of facilities in the cohort.** As of the summer of 2013, seven years into the launch of the cohort, three companies that own and operate twelve facilities remain in the program. Over the course of their participation in the program, two of the companies have built very robust programs encompassing the full range of SEM activities, as well as intensive communication and coordination of efforts across facilities and levels of management. These two companies continue to add new features and activities to their energy management activities. The third company has retrenched its level of activity somewhat following a change in management. Changes in energy management staff over time also leads to a loss of history on SEM implementation in their facility. Also on this topic, we need to acknowledge that the number of facilities in the CEI cohort has declined from 21 committed and 15 sustaining in 2009 to 12 sustaining in 2013. Facility staff also expressed concern that the energy focus lessens as opportunities were addressed. Persistence of SEM is estimated at 3 to 4 years.
- **The cluster partner arrangement with the Northwest Food Processors Association was successful in recruiting member firms to adopt Strategic Energy Management practices.** Based on the results of our facility manager surveys, we estimate that at least 50 facilities owned and operated by NWFPA members participated in the Association's Energy Roadmap process. This group accounts for 26 percent of all facilities in the targeted population. Forty-three percent of these facilities reported adopting all four of the criterion for Strategic Energy Management versus 20 percent of the facilities, which were in neither the CEI nor the NWFPA groups. These facilities achieved much better progress in executing energy efficiency actions. Nearly three-fourths of these facilities assigned responsibility for energy management to corporate level staff. However, relatively few regularly monitored energy consumption versus savings goals. Efforts to develop cluster partner relationships with other industry associations (prior to the period under evaluation) were not successful.
- **Participants in the CEI cohort and the NWFPA Roadmap process achieved average savings of 1 percent of annual electric energy consumption through energy management activities.** This percentage savings figure is consistent with the results of

MPER #7, which estimated energy savings for roughly the same set of CEI facilities. As discussed above, the finding that energy savings for the CEI and NWFPA groups were similar was surprising, given the large difference between the groups in the extent of adoption of SEM and general energy management practices. We believe, however, that the method used by NEEA to estimate energy savings, which was applied to the CEI cohort, systematically understates actual energy savings attributable to energy management. The DNV KEMA team developed what we believe to be a more suitable savings estimation method for use with the NWFPA group. Application of the original methods to the NWFPA group did not yield any annual energy savings.

- **At the market level, adoption of energy management practices, and specifically the combination of practices defined as SEM, has not progressed since the previous MPER in 2010.** After properly weighting the facility manager survey results and findings from the case studies, we estimated that 36 percent of facilities in the target population had adopted all four elements of SEM, compared to the 33 percent found in MPER #7. The results for MPER #7 were not weighted to reflect different sampling rates from groups of facilities characterized by participation in various programs. However, the application of weights had relatively little impact on the overall estimate of the prevalence of SEM practices. Moreover, we find that adoption of energy management practices by facilities that participated in neither the CEI cohort nor the NWFPA Roadmap process was inconsistent. Fewer than one-third of those firms reported undertaking such key energy management activities as establishing energy savings goals and plans, focusing operating and maintenance resources on energy efficiency, or hiring outside consultants to identify energy savings strategies.
- **Resources for supporting industrial energy management activities are either holding steady or declining.** Federal programs that support industrial energy management have generally been declining in levels of funding and activity. Programs operated by the Bonneville Power Authority and the Energy Trust of Oregon remain in operation. The capacity of private consulting firms to provide SEM-related services to clients in the Northwest is adequate for the relatively low current levels of demand.
- **While the DNV KEMA team made significant progress in identifying methods to improve the accuracy and consistency of energy savings estimates for industrial energy management practices, additional work is required to test those methods and assess their suitability for providing inputs to regional energy planning models.** Our work on this project showed that the results of energy savings estimates using the basic top-down/bottom-up approach could be improved through a number of strategies, including:
    - Collection of data to better characterize variations in production-related energy demand
    - Re-specification of the model form to include verified energy savings from capital projects in the model itself, instead of subtracting bottom-up from top-down savings
    - Application of statistical criteria to the acceptance of model results for use in estimating program-level savings

The implications of these findings are as follows:

- Persistence of the CEI at cohort facilities may be threatened by the removal of support of CEI contractors and familiar federal programs.
- Coordination with NWFPA has increased SEM activities.
- Continued engagement in the market is needed to facilitate SEM engagement.

### 4.2 Recommendations

This is the eighth and final MPER report. The initiative will not be continued into the future. DNV KEMA has come up with recommendations for efforts going forward.

*Market Progress*

- As direct involvement in SEM as an initiative, NEEA should consider opportunities for coordination and outreach with regional partners offering SEM programs.
- There is still low familiarity with SEM in many facilities. Outside of the CEI cohort participants, energy management has been found to lack focus. NEEA should implement outreach campaigns designed to increase awareness of SEM and provide materials helpful to supporting systematic SEM approaches. Continue support of NWFPA Roadmap, where execution of energy efficiency actions is much higher than in the balance of market.
- To aid exchange of ideas around SEM and energy savings, NEEA should consider options for communication among facilities. For example, NEEA could develop its online cohort tool for use by cluster partners Energy Trust of Oregon and Bonneville Power Authority and others.

*Persistence of CEI*

- NEEA should consider options for providing the tracking information for each facility to the cohort. Similarly, NEEA could promote use of CEI contractors for limited services to help companies overcome complacency. NEEA could also encourage cohort firms to participate in other energy efficiency forums focusing on energy management, through trade associations, conferences, and programs offered by others. NEEA should continue to connect with the cohort, possibly through workshops or other outreach that may available to others beyond the cohort.
- NEEA could explore best practices in retaining an energy management focus when a company changes their management structure or organization, such as through a targeted study.
- NEEA can support the persistence of SEM by coordinating with regional programs and federal energy management system offerings such as Better Buildings, Better Plants.

*Impact Evaluation Recommendations*

- Future modeling to assess savings should consider the including the savings from utility programs as part of the model directly, rather than subtracting the utility program savings after the model is developed. This improves accuracy.
- Future modeling of savings can be informed by interviewing plant staff regarding factors affecting energy consumption in the previous year.
- Continue collecting energy consumption and production data to assess the diffuse effect of SEM in the Northwest.

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# APPENDIX B - MARKET ACTOR SURVEY INSTRUMENT AND SURVEY RESULTS

## INTRODUCTION

This appendix provides the results of the survey of the two populations that are potential market actors: the participants in the NWFPA Roadmap and the balance of market. These two populations are combined in the results presented here. A total of 67 facilities are represented, with 32 represented by an engineer or facilities manager and the remainder by management. The facilities we spoke with are very large plants which run year round (97%) employing on average over 700 people. Rarely was energy considered the largest or second largest expense at the facility.

Key findings from the survey include:

- Respondents reported low levels of awareness of SEM and of the NWFPA Roadmap. Seventy percent of respondents did not recognize SEM. More than half of facilities participating in the Roadmap were not aware of receiving any support from the program. Respondents self-identified whether they were part of the NWFPA Roadmap. However, many of the facilities that provided energy and production data (as part of the analysis in Appendix G) did not identify as Roadmap participants. This finding is consistent with the lack of focus on energy management observed among the Roadmap participants.
- Although 97% of facilities reported an energy champion only 36% identified an energy manager. Again, this finding is consistent with lack of focus on energy management among the sample NWFPA and BOM facilities.
- Energy savings goals were as likely to be from DOE as from the company or facility. DOE's common goal of 25% improvement in 10 years is also consistent with the NWFPA Roadmap.
- Ninety percent of companies with corporate-level staff involvement reported that they encouraged and provided resources for energy management, as wells as reviewed progress toward energy goals, which are key aspects of SEM.
- Findings in regard to other elements of SEM were as follows: Fewer than than 20% of sample facilities reported tracking or documenting energy savings; fewer than 50% provide training, and fewer than 40% have procurement policies for energy efficiency.50% provide training, and less than 40% have procurement policies for energy efficiency.

## SURVEY

### Screener

Gatekeeper Intro: Hello, I'm ____________ from Research Into Action calling on behalf of the Northwest Energy Efficiency Alliance. I need to speak to the person responsible for making decisions about energy use for the (RESTORE: [COMPANY NAME]) facility located in (RESTORE: [CITY], [STATE]).

S1. [ASK ALL] Are you the person who is most responsible for making decisions about energy usage for your facility?
1. Yes
2. No [ASK TO SPEAK TO PERSON WHO IS RESPONSIBLE FOR ENERGY DECISIONS]
98. DK
99. REF
100.

S2. Do you manage energy decisions at any other facilities? If so, which facilities do you manage energy use?

S3. **Energy Decision-Maker Intro (once energy decision-maker is reached):** Hello, I'm _______ from Research Into Action calling on behalf of the Northwest Energy Efficiency Alliance, also referred to as NEEA. We're conducting a study to better understand how food processing facilities in the Northwest region manage their energy use. Your participation will help NEEA design and deliver energy efficiency tools or programs for businesses like yours in our region.
1. Contact Name:
2. Company
3. Facility Type
4. NWFPA Member

**Introduction**

IN1. [ASK ALL] First, please tell me your job title?

| | Count | % |
|---|---|---|
| **Engineer** | 25 | 37.3% |
| **Executive** | 21 | 31.3% |
| **Facility/Maintenance manager** | 7 | 10.4% |
| **Finance** | 1 | 1.5% |
| **Manager** | 7 | 10.4% |
| **Plant manager** | 6 | 9.0% |
| **TOTAL** | 67 | 100.0% |

IN2. [ASK ALL] What is the primary product your facility produces?

| | Count | % |
|---|---|---|
| **Cheese and dairy processing facility** | 18 | 26.9% |
| **Frozen specialty food manufacturing** | 7 | 10.4% |
| **Fruit or vegetable processing facility** | 26 | 38.8% |
| **Meat packing** | 16 | 23.9% |

| **TOTAL** | 67 | 100% |
|---|---|---|

IN3. [ASK ALL] Does your facility operate seasonally?

| | **Count** | **%** |
|---|---|---|
| **Yes** | 3 | 4.5% |
| **No** | 64 | 95.5% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **Total** | **67** | **100.0%** |

IN4. [ASK IF IN3 = YES] At the peak of the season, how many seasonal FTE are employed at your facility? [PROGRAMMER – Force value to be a number]

| | **Mean** | **Count** | **Maximum** | **Minimum** | **Median** |
|---|---|---|---|---|---|
| **Total** | 193.33 | 3 | 300 | 130 | 150 |

IN5. [ASK ALL] On average, how many FTE are employed at your facility year-round? [PROGRAMMER – Force value to be a number]

| | **Mean** | **Count** | **Maximum** | **Minimum** | **Median** |
|---|---|---|---|---|---|
| **Total** | 762.06 | 67 | 2000.00 | 30.00 | 425.00 |

IN6. [ASK ALL] Considering all the types of costs your facility has, where does the cost of energy rank? Energy is our….

| | **Count** | **%** |
|---|---|---|
| **Largest expense** | 1 | 1.5% |
| **Second largest expense** | 4 | 6.0% |
| **Third largest expense** | 18 | 26.9% |
| **Fourth largest expense** | 19 | 28.4% |
| **Fifth largest expense** | 9 | 13.4% |
| **Other, please specify:** | 5 | 7.5% |
| **DK** | 11 | 16.4% |
| **REF** | 0 | 0.0% |
| **TOTAL** | 67 | 100.0% |

IN7. [ASK ALL] Is your company a member of the Northwest Food Processing Association, also referred to as N-W-F-P-A?

| | Count | % |
|---|---|---|
| **Yes** | 52 | 77.6% |
| **No** | 10 | 14.9% |
| **DK** | 5 | 7.5% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

**NWFPA Participants Only [Skip Section IF IN7 <> "Yes"]**

A1.[ASK IF IN7 = YES] Does your facility / company currently, or in the past, participate in the NWFPA's Energy Program, including the Energy Intensity Baseline, the Energy Roadmap, or other NWFPA energy projects and energy training? [If respondent unsure of Energy Program: The Energy Program includes the Energy Intensity Baseline (and possibly sharing your energy use data with the NWFPA), the Energy Roadmap consists of setting energy reduction goals, monitoring energy use, and forming an energy management plan]

1. Yes
2. No [Skip to non-NWFPA questions]
98. DNK

NW1a. ASK: Is there someone else at your facility/company who might know more about your facility's/company's work with the NWFPA? May I have their contact information?

______________

| | Count | % |
|---|---|---|
| **Yes** | 31 | 59.6% |
| **No** | 19 | 36.5% |
| **DK** | 2 | 3.8% |
| **REF** | 0 | 0.0% |
| **Total** | 52 | 100.0% |

A2.[ASK IF IN7 = YES AND A1 = YES] Do you recall when your facility / company began participating in the Energy Program? Please tell me when your company began participating. ________________

| | Count | % |
|---|---|---|
| **N/A**[1] | 36 | 54% |
| **2006** | 1 | 1% |
| **2008** | 4 | 6% |
| **2009** | 2 | 3% |
| **2010** | 2 | 3% |
| **2011** | 1 | 1% |
| **2012** | 2 | 3% |
| **2013** | 6 | 9% |
| **DK** | 13 | 19% |
| **TOTAL** | 67 | 100% |

A3.[ASK IF IN7 = YES AND A1 = YES] Who from your facility / company was involved with getting activities started with the Energy Roadmap?

| | Count | % |
|---|---|---|
| **Plant Manager** | 4 | 12.9% |
| **Production Manager** | 1 | 3.2% |
| **Facility/Maintenance Manager** | 0 | 0.0% |
| **Other, please specify:** | 26 | 83.9% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **Total** | 31 | 100.0% |

A4.[ASK IF IN7 = YES AND A1 = YES] How did the NWFPA work with your facility / company in its Energy Program? Did they supply any resources or services?

______________

IF YES: Please describe the resources and services that NWFPA supplied.

| | Count | % |
|---|---|---|
| **Provided admin support** | 3 | 10% |
| **Provided technical support** | 11 | 35% |
| **Provided no support** | 2 | 6% |
| **Don't know what support was provided** | 15 | 48% |
| **TOTAL** | 31 | 100% |

[1] NA are the portion of the population that did not identify as an NWFPA participants.

A5.[ASK IF IN7 = YES AND A1 = YES] Did your facility / company rely on additional resources and services when implementing the Roadmap program. Did you ….

1. Work with your utility company or receive any resources from them? [Please specify] ___________
2. How about any federal or state agencies? _________
3. Other organizations such as the North West energy Efficiency Alliance, Energy Trust of Oregon, BPA's Energy Smart industrial, or others?________________

| | Count (n=31) | % |
|---|---|---|
| **Worked with utility** | 26 | 84% |
| **Worked with BPA** | 18 | 58% |
| **Worked with government** | 14 | 45% |
| **Worked with NEEA** | 13 | 42% |
| **Did not work with any organization** | 4 | 13% |

A6.[ASK IF IN7 = YES AND A1 = YES] In what specific ways, if any, did the Energy Roadmap program help your facility / company to…..

1. Formulate an energy management strategy? _________
2. Convince upper management to fund the strategy?___________
3. Support your facility / company with implementing the strategy? _________
4. Monitor and report progress toward energy goals? ___________
5. Assess the overall success of the strategy at reducing energy usage? __________
6. Other Ways? ____________

| | Count (n=31) | % |
|---|---|---|
| **Helped facility track or analyze data** | 19 | |
| **Helped convince management** | 3 | |
| **Helped create energy management strategy** | 3 | |
| **Helped implement energy management** | 1 | |
| **Helped raise awareness of energy for staff** | 1 | |
| **It did not help in any way** | 11 | |

A7.[ASK IF IN7 = YES AND A1 = YES] Is your facility / company continuing to participate in the Energy Program?

| | Count | % |
|---|---|---|
| **Yes** | 23 | 74% |
| **No** | 1 | 3% |
| **DK** | 0 | 0% |
| **REF** | 0 | 0% |
| **Lesser degree of participation** | 7 | 23% |
| **Total** | 31 | 100% |

A8.[ASK IF IN7 = YES  AND NW7 < > "Yes"] Why did your facility / company discontinue or reduce its participation in the Energy Program? When did this occur? __________ [continue to non-NWFPA questions]

A9.[ASK IF IN7 = YES AND A1 = YES] Would your facility / company have implemented an energy management strategy without relying on the Energy Program?

| | Count | % |
|---|---|---|
| **REF** | 0 | 0.0% |
| **DK** | 3 | 9.7% |
| **No** | 15 | 48.4% |
| **Yes** | 13 | 41.9% |
| **Total** | 31 | 100.0% |

A10. [ASK IF A9 = YES] When do you suppose you would have implemented a similar strategy?

A11. [ASK IF A9 = YES] Had your facility / company considered energy management before working with the NWFPA's Energy Program?

| | Count | % |
|---|---|---|
| **Yes** | 4 | 31% |
| **No** | 2 | 15% |
| **DK** | 7 | 54% |
| **Total** | 13 | 100% |

A12. [ASK IF A9 = YES] Do you believe your facility / company would have had the necessary resources and support to implement an energy management strategy without the Energy Program?

| | Count | % |
|---|---|---|
| **Yes** | 4 | 31% |
| **No** | 3 | 23% |
| **DK** | 6 | 46% |
| **Total** | 13 | 100% |

A13. [ASK IF A9 = YES] Would your facility have implemented all of the energy efficiency capital and operations improvements that you undertook with support of the Energy Roadmap program?

| | Count | % |
|---|---|---|
| **Yes** | 3 | 23% |
| **No** | 1 | 8% |
| **DK** | 9 | 69% |
| **Total** | 13 | 100% |

A14. [ASK IF A9 = NO] Which measures or projects would you most likely have omitted if you had not participated in the Energy Program?

| | Count | % |
|---|---|---|
| **Rebuild of air compressors** | 1 | 7% |
| **Refrigeration project** | 1 | 7% |
| **Metering** | 1 | 7% |
| **DK** | 12 | 80% |
| **TOTAL** | 15 | 100% |

A15. [ASK IF IN7 = YES AND A1 = YES] What aspects of the Energy Program are most critical to sustaining your facility's / company's energy management strategy?

| | Count | % |
|---|---|---|
| **Voice in legislative process to support efficiency** | 13 | 42% |
| **Opportunities to save more energy** | 5 | 16% |
| **Networking with other facilities** | 2 | 6% |
| **Ability to measure energy use** | 1 | 3% |
| **No aspects are critical** | 6 | 19% |
| **DK** | 4 | 13% |
| **TOTAL** | 31 | 100% |

A16. [ASK IF IN7 = YES AND A1 = YES] Which benefits from participating in the Energy Program, are most important to you and your management in terms of motivating continued participation to reduce energy use?

| | Count | % |
|---|---|---|
| **Acquiring data to make decisions** | 15 | 48% |
| **Audit support** | 3 | 10% |
| **Networking with other facilities** | 2 | 6% |
| **No aspects are most important** | 5 | 16% |
| **DK** | 6 | 19% |
| **TOTAL** | 31 | 100% |
| **Acquiring data to make decisions** | 15 | 48% |

**Awareness of Energy Management as a Practice**

A1.[ASK ALL]Does your facility do anything to control or reduce the amount of energy it uses? [Please describe?]

| | Count | % |
|---|---|---|
| **Focus staff on managing energy** | 23 | 34% |
| **Analyze energy bills and Energy Use Intensity (EUI)** | 6 | 9% |
| **Install EE equipment** | 32 | 48% |
| **Implement O&M** | 6 | 9% |
| **Receive energy audit** | 4 | 6% |
| **Implement Corp energy policy or program** | 30 | 45% |
| **Participate in EE incentives** | 6 | 9% |
| **TOTAL** | 67 | - |

A2.[ASK ALL] Strategic Energy Management, or S-E-M, is a system of practices that are designed to yield reliable and persistent energy savings. At a minimum, these practices include setting a goal related to energy, dedication of resources by top leadership to achieve the goal, and ensuring staff regularly reports progress toward the goal to top leadership. Have you heard of SEM or similar practices?

| | Count | % |
|---|---|---|
| **Yes** | 20 | 30% |
| **No** | 47 | 70% |
| **DK** | 0 | 0% |
| **REF** | 0 | 0% |
| **Total** | 67 | 100% |

A3.[ASK IF A2 = YES] How did you first learn about strategic energy management practices? [DO NOT READ.]

| | Count | % |
|---|---|---|
| **Energy Trust** | 2 | 10% |
| **Word of mouth** | 18 | 90% |
| **Total** | 20 | 100% |

A4.[ASK IF A2 = “Yes”] I’d like to know how familiar you are with SEM practices. Would you say you….

| | Count | % |
|---|---|---|
| **Understand SEM well enough to determine if it is right for your facility?** | 18 | 90% |
| **Know of reliable sources of information on how to implement SEM systems?** | 17 | 85% |
| **Know where to access technical support helpful to implementing SEM systems?** | 17 | 85% |
| **Know how to promote SEM as a system to key decision makers in your company?** | 18 | 90% |
| **Have you heard of ISO 50001, an international certification standard for energy management practices?** | 18 | 90% |
| **TOTAL** | 20 | |

A5.[ASK ALL] Have you been contacted by any of the following organizations or firms with ways to reduce your energy use? [MULTIPLE SELECTIONS ALLOWED]

| | Count | % |
|---|---|---|
| **Your utility** | 48 | 72% |
| **A vendor or equipment supplier** | 23 | 34% |
| **A technical contractor or specialist** | 18 | 27% |
| **DOE** | 13 | 19% |
| **EPA** | 13 | 19% |
| **Energy Trust** | 8 | 12% |
| **TOTAL** | 67 | |

A6.[ASK FOR EACH SELECTION IN A5] What activities or services did [PIPE IN EACH SELECTION FROM A5] offer?

1. Incentives
2. Equipment installation
3. Improved operations and maintenance
4. Implementing energy reduction goals
5. Other, Please specify:______

What activities or services did your **utility** offer?

| | Count (n=48) | % |
|---|---|---|
| **Incentives** | 36 | 80% |
| **Equipment installation** | 1 | 2% |
| **Improved operations and maintenance** | 9 | 20% |
| **Implementing energy goals** | 8 | 18% |
| **Audits** | 5 | 11% |
| **Training or Consulting** | 4 | 9% |
| **Track Energy** | 1 | 2% |
| **Don't know** | 2 | 4% |

A7.[ASK FOR EACH SELECTION IN A5] What activities or services did [PIPE IN EACH SELECTION FROM A5] offer?

1. Incentives
2. Equipment installation
3. Improved operations and maintenance
4. Implementing energy reduction goals
5. Other, Please specify:______

What activities or services did your **vendor** offer?

| | Count (n=23) | % |
|---|---|---|
| **Incentives** | 3 | 13% |
| **Equipment installation** | 18 | 78% |
| **Improved operations and maintenance** | 1 | 4% |
| **Admin Support** | 1 | 4% |
| **Audit or Tech Support** | 7 | 30% |
| **Training** | 1 | 4% |

A8. [ASK FOR EACH SELECTION IN A5] What activities or services did [PIPE IN EACH SELECTION FROM A5] offer?

1. Incentives
2. Equipment installation
3. Improved operations and maintenance
4. Implementing energy reduction goals
5. Other, Please specify:______

What activities or services did your **tech contractor** offer?

| | Count (n=18) | % |
|---|---|---|
| **Equipment installation** | 2 | 11% |
| **Improved operations and maintenance** | 10 | 56% |
| **Implementing energy goals** | 11 | 61% |
| **Audit or Tech Support** | 7 | 39% |

A9. [ASK FOR EACH SELECTION IN A5] What activities or services did [PIPE IN EACH SELECTION FROM A5] offer?

| | Count (n=13) | % |
|---|---|---|
| **Training** | 13 | 100% |

A10. [ASK FOR EACH SELECTION IN A5] What activities or services did [PIPE IN EACH SELECTION FROM A5] offer?

| | Count (n=13) | % |
|---|---|---|
| **Advice/networking thru Energy Star program** | 13 | 100% |

A11. [[ASK FOR EACH SELECTION IN A5] What activities or services did [PIPE IN EACH SELECTION FROM A5] offer?

1. Incentives
2. Equipment installation
3. Improved operations and maintenance
4. Implementing energy reduction goals
5. Other, Please specify:_____

| | Count (n=18) | % |
|---|---|---|
| **Incentives** | 8 | 44% |
| **Improved operations and maintenance** | 5 | 28% |
| **Implementing energy goals** | 3 | 17% |
| **Other** | 2 | 11% |

A12. [ASK ALL] I am going to read you some yes/no questions. Please tell me, does your facility …

| | Count (n=67) | % |
|---|---|---|
| **Have corporate wide energy reduction goals** | 29 | 43% |
| **Have facility level energy reduction goals** | 31 | 46% |
| **Have a dedicated "energy manager" whose primary responsibility is focused on reducing energy use** | 24 | 36% |
| **Have at least one "energy champion" or person who allocates some time to help to reduce energy use** | 65 | 97% |
| **Track energy usage** | 67 | 100% |
| **Report progress toward energy goals to top management** | 41 | 61% |
| **Have an action plan to reduce energy use** | 26 | 39% |
| **Provide energy management training to staff** | 35 | 52% |
| **Invest in energy efficient devices and equipment** | 67 | 100% |
| **Replace worn out equipment with energy efficient equipment** | 63 | 94% |
| **Include energy in audits submitted to your customers** | 30 | 45% |
| **Receive certification acknowledging your energy management practices. Which certification?** | 12 | 18% |
| **Track progress towards energy reduction goals at a department level** | 25 | 37% |
| **Communicate energy management activities to production staff** | 42 | 63% |

**Energy Management Practices**

CS1. [ASK IF A12_1= NO] How likely is it that your facility will adopt specific energy reduction goals in the next two years?

| | Count (n=38) | % |
|---|---|---|
| **Very likely** | 21 | 55.3% |
| **Likely** | 3 | 7.9% |
| **Somewhat likely** | 4 | 10.5% |
| **Definitely will not** | 10 | 26.3% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **TOTAL** | 38 | 100% |

CS2. [ASK IF A12_1 = NO] Why hasn't your facility set energy reduction goals for this facility? [CHECK one]

1. Relative to our overall costs, energy costs are very small at this facility
2. Other priorities are more important
3. There is nothing we can do to save energy at this facility

4. The cost of saving energy is too high
5. Have already done everything we can to save energy
6. Other, please specify: _______
98. DK
99. REF

| | Count (n=38) | % |
|---|---|---|
| **Lack staff** | 5 | 13% |
| **Other priorities** | 16 | 42% |
| **Facility to move** | 1 | 3% |
| **Management not supported** | 12 | 32% |

CS3. [ASK IF A12_1 = YES] Are your goals defined by overall reduction in energy use or by reduction in the amount of energy used per unit of production? [Check one]

1. Overall reduction in energy use
2. Reduction in the amount of energy used per unit of production (energy intensity)
98. DK
99. REF

| | Count (n=29) | % |
|---|---|---|
| **Overall reduction in energy use** | 11 | 38% |
| **Reduction in the amount of energy used per unit of production** | 24 | 83% |

CS4. [ASK IF A12_1= YES] What is your facility's specific goal for [overall reduction in energy use OR reduction in the amount of energy used per unit of production]?

1. ________
98. DK
99. REF

| | Count | % |
|---|---|---|
| **3% annual** | 16 | 55% |
| **4% annual** | 1 | 3% |
| **5% annual** | 1 | 3% |
| **Don't know** | 5 | 17% |
| **Have general goals** | 6 | 21% |
| **Total** | 29 | 100% |

CS5. [ASK IF A12_1= YES ] Approximately, how long ago were these goals set?

| | Count (n=29) | % |
|---|---|---|
| **Less than 1 year ago** | 1 | 3.4% |
| **1 to less than 2 years ago** | 1 | 3.4% |
| **3 to less than 4 years ago** | 19 | 65.5% |
| **More than 4 years ago** | 4 | 13.8% |
| **DK** | 4 | 13.8% |
| **REF** | 0 | 0.0% |

CS6. [ASK IF A12_1 = YES] Can you describe the process by which those goals were set? PROBE WHO WAS INVOLVED, USE OF OUTSIDE CONSULTANTS, BENCHMARKS REFERENCED, ETC.

1. ___________
98. DK
99. REF

| | Count (n=29) | % |
|---|---|---|
| **Corporate provided goals** | 10 | 34% |
| **Facility provided goals** | 3 | 10% |
| **DOE provided goals**[2] | 13 | 45% |
| **Not sure** | 3 | 10% |

CS7. [ASK ALL] Does your facility track usage of electricity and natural gas?

| | Count | % |
|---|---|---|
| **Electricity only** | 14 | 20.9% |
| **Natural gas only** | 0 | 0.0% |
| **Both electricity and natural gas** | 52 | 77.6% |
| **Amount of steam used/purchased or provided by a cogeneration plant** | 0 | 0.0% |
| **Other, please specify:** | 1 | 1.5% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **TOTAL** | 67 | 100% |

CS8. [ASK IF CS7 = 1 or 3] Is electricity usage tracked via the bill, meter reads by your own staff, or some other way?

[2] In DOE's Better Buildings Better Plants program, for example, facilities are encouraged to set energy performance improvement goals of 25% in 10 years.

| | Count | % |
|---|---|---|
| **Bill** | 52 | 77.6% |
| **Meter** | 11 | 16.4% |
| **Onsite data collection, such as a SCADA (supervisory control and data acquisition) system** | 1 | 1.5% |
| **Other, please specify: ____________** | 2 | 3.0% |
| **DK** | 1 | 1.5% |
| **REF** | 0 | 0.0% |
| **TOTAL** | 67 | 100 |

CS9. [ASK IF CS7 = 1 or 3] How often is your electricity usage data reviewed?

| | Count | % |
|---|---|---|
| **Daily** | 5 | 7.5% |
| **Weekly** | 1 | 1.5% |
| **Monthly** | 44 | 65.7% |
| **Quarterly** | 5 | 7.5% |
| **Annually** | 11 | 16.4% |
| **A few times a year but less than quarterly** | 0 | 0.0% |
| **Less than once a year** | 0 | 0.0% |
| **Never** | 0 | 0.0% |
| **DK** | 1 | 1.5% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

CS10. [ASK IF CS7 = 2 or 3] How often is your natural gas usage data reviewed?

| | Count (n=52) | % |
|---|---|---|
| **Daily** | 8 | 15.4% |
| **Weekly** | 1 | 1.9% |
| **Monthly** | 38 | 73.1% |
| **Quarterly** | 5 | 9.6% |
| **Annually** | 0 | 0.0% |
| **A few times a year but less than quarterly** | 0 | 0.0% |
| **Less than once a year** | 0 | 0.0% |
| **Never** | 0 | 0.0% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **TOTAL** | 52 | 100% |

**Commitment to Energy Efficiency**

CE1. [ASK ALL] Are any corporate level staff involved with energy management activities?

| | Count | % |
|---|---|---|
| **Yes** | 49 | 73.1% |
| **No** | 18 | 26.9% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

D

CE2. [IF CE1 = "Yes"] Have corporate level staff taken concrete steps to…

| | Count (n=49) | % |
|---|---|---|
| **Encourage energy management activity.** | 47 | 96% |
| **Provide resources for energy management.** | 45 | 92% |
| **Reviewing progress toward energy goals.** | 45 | 92% |

CE3. [ASK ALL] In the past two years, has your facility completed any capital projects with the primary objective to reduce energy usage?

| | Count | % |
|---|---|---|
| **Yes** | 53 | 79.1% |
| **No** | 13 | 19.4% |
| **DK** | 1 | 1.5% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

CE4. [ASK IF CE3 = YES] Briefly describe the project(s) that contributed the largest savings in this time period. (Note to interviewer maximum of three).

- Project 1________________
- Project 2 ________________
- Project 3 ________________

CE5. [ASK IF CE3 = YES] Has your facility tracked or documented energy savings for these capital projects? [open texts]

| | Count (n=53) | % |
|---|---|---|
| **Yes** | 38 | 71.7% |
| **No** | 4 | 7.5% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **Intends to track or document** | 11 | 20.8% |
| **Total** | 53 | 100.0% |

CE6. [ASK IF CE3= YES] Did your company use the estimated energy savings to: [CHOOSE ALL THAT APPLY]

| | Count (n=53) | % |
|---|---|---|
| **Help justify to management other energy saving projects** | 10 | 19% |
| **Demonstrate how much money can be saved** | 12 | 23% |
| **Provide funding for other energy efficiency actions** | 6 | 11% |
| **The savings figures were not used** | 9 | 17% |
| **DK** | 1 | 2% |
| **Project too new** | 8 | 15% |
| **To calculate ROI** | 6 | 11% |
| **Not specified** | 15 | 28% |

CE7. [ASK IF CE3= YES] Did your company receive financial or technical assistance from a government or utility-operated program to install the capital projects?

1. Yes
2. No

98. DK
99. REF

| | Count | % |
|---|---|---|
| **Yes** | 48 | 90.6% |
| **No** | 5 | 9.4% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **Total** | 53 | 100.0% |

CE8. [ASK IF CE3= YES] From which organizations did your company receive financial assistance for the capital projects?

| | Count (n=53) | % |
|---|---|---|
| **Utility or program administrator** | 47 | 89% |
| **University** | 1 | 2% |
| **State** | 4 | 8% |
| **Don't know** | 3 | 6% |

CE9. [ASK ALL] In the past five years, has your facility changed operating practices in any way to save energy? [IF NEEDED: This could include changing a process such as a line operators checklist or any other change to how things are done that led to reduced energy use.]

| | Count | % |
|---|---|---|
| **Yes** | 35 | 52.2% |
| **No** | 29 | 43.3% |
| **DK** | 3 | 4.5% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

CE10. [ASK IF CE9 = YES] Please describe one example of how your facility changed operating practices to reduce energy usage.

__________________

98. DK
99. REF

| | Count | % |
|---|---|---|
| **Shutoff or startup procedures changed** | 7 | 20% |
| **Clean condenser** | 2 | 6% |
| **Refrigeration operations change** | 1 | 3% |
| **Reduced number of cleaning cycles** | 1 | 3% |
| **Airleak detection** | 17 | 49% |
| **Change boiler operations** | 2 | 6% |
| **Shift production** | 1 | 3% |
| **Phase out waste wash system** | 1 | 3% |
| **No response** | 1 | 3% |

CE11. [ASK IF CE9 = YES] Please Did your company receive financial or technical assistance from a government or utility-operated program to identify and/or implement these changes to your operations?

| | Count | % |
|---|---|---|
| **Yes** | 8 | 22.9% |
| **No** | 27 | 77.1% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **Total** | 35 | 100.0% |

CE12. [ASK IF CE9 = YES] Please From which organizations did your company receive financial assistance for the operational improvements?

| | Count (n=8) | % |
|---|---|---|
| **Utility or program administrator** | 7 | 87.5% |
| **Vendor** | 1 | 12.5% |

CE13. [ASK IF CE9 = YES] Has your facility tracked or documented energy savings from these operations changes?

| | Count | % |
|---|---|---|
| **Yes** | 6 | 17.1% |
| **No** | 28 | 80.0% |
| **DK** | 1 | 2.9% |
| **REF** | 0 | 0.0% |
| **Total** | 35 | 100.0% |

CE14. [ASK IF CE9 = YES] Did your company use the estimated energy savings to ….[CHOOSE ALL THAT APPLY]

| | Count | % |
|---|---|---|
| **Help justify to management other energy saving projects** | 1 | 3% |
| **Demonstrate how much money can be saved** | 5 | 14% |
| **Provide funding for other energy efficiency actions** | 2 | 6% |
| **Other, please specify:** | 8 | 23% |
| **The savings figures were not used** | 4 | 11% |
| **Don't know** | 17 | 49% |

CE15. [ASK ALL] What, if any, training related to reducing energy usage has your staff received in the last year?

| | Count (n=67) | % |
|---|---|---|
| **General orientation to industrial energy management** | 28 | 42% |
| **Analysis of energy usage in specific industrial systems such as pumps, compressors** | 14 | 21% |
| **Capital improvements to specific industrial systems** | 1 | 1% |
| **Maintenance and operation of specific industrial systems** | 3 | 4% |
| **No training** | 34 | 51% |
| **Don't know** | 2 | 3% |

CE16. [ASK ALL] Does your facility have a policy in place related to purchasing energy efficient equipment? [IF NEEDED: For example, do you have a policy that states you will always purchase equipment that is more efficient than code?]

| | Count | % |
|---|---|---|
| **Yes** | 24 | 35.8% |
| **No** | 42 | 62.7% |
| **DK** | 1 | 1.5% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

**Perspective on Trade Allies**

PT1. [ASK ALL] In the past two years, have you hired consultants/contractors to help you identify energy saving projects?

| | Count | % |
|---|---|---|
| **Yes** | 29 | 43.3% |
| **No** | 35 | 52.2% |
| **DK** | 3 | 4.5% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

PT2. [ASK ALL] When seeking outside assistance for any capital project, do you seek vendors that promote energy efficient options …

| | Count | % |
|---|---|---|
| **for all such projects** | 23 | 34.3% |
| **for most projects** | 24 | 35.8% |
| **for some specific types of projects** | 15 | 22.4% |
| **Never** | 2 | 3.0% |
| **DK** | 3 | 4.5% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

PT3. [ASK ALL] In your recent experience, have the vendors who have provided new production equipment or other capital improvements offered energy efficient options …

| | Count | % |
|---|---|---|
| **in all cases** | 17 | 25% |
| **in most cases** | 33 | 49% |
| **in some cases** | 15 | 22% |
| **Never** | 1 | 1% |
| **DK** | 1 | 1% |
| **REF** | 0 | 0% |
| **Total** | 67 | 100% |

PT4. [ASK IF A4_5 = YES] Were any of the consultants/contractors you hired in the last two years qualified to help implement an ISO 50001 energy management system?

1. Yes, how many firms were ISO 50001 certified? _____
2. No

   98. DK
   99. REF

| | Count | % |
|---|---|---|
| **Yes, how many firms were ISO 50001 certified?** | 0 | 0.0% |
| **No** | 17 | 94.4% |
| **DK** | 1 | 5.6% |
| **REF** | 0 | 0.0% |
| **Total** | 18 | 100.0% |

PT5. [ASK IF CE3= YES] Did you receive any technical assistance (external to your company) for these energy saving projects?

| | Count | % |
|---|---|---|
| **Yes** | 38 | 71.7% |
| **No** | 11 | 20.8% |
| **DK** | 4 | 7.5% |
| **REF** | 0 | 0.0% |
| **Total** | 53 | 100.0% |

PT6. [ASK IF CE3 = YES] Who provided the technical assistance? [DO NOT READ.]

| | Count (n=53) | % |
|---|---|---|
| **NEEA (Northwest Energy Efficiency Alliance)** | 14 | 26.4% |
| **BPA (Bonneville Power Administration) Energy Smart Industrial (ESI)** | 18 | 34.0% |
| **ETO (Energy Trust of Oregon)** | 27 | 50.9% |
| **NWFPA (Northwest Food Processors Association)** | 16 | 30.2% |
| **Equipment distributors** | 3 | 5.7% |
| **US DOE (U.S. Dept. of Energy)** | 13 | 24.5% |
| **US EPA (Environmental Protection Agency)** | 13 | 24.5% |
| **Independent consultant** | 1 | 1.9% |
| **Utility** | 8 | 15.1% |
| **University** | 1 | 1.9% |

## Firmographics

F1. [ASK ALL] Which of the following associations does your company belong to?

1 respondent representing 1 facility was part of Northwest High Performance Enterprise Consortium (NHPEC). No other respondents reported other associations.

F2. [ASK ALL] About what proportion of your total operating costs for this facility (not including labor costs) are accounted for by your total energy costs?

| | Count | % |
|---|---|---|
| **Less than 1%** | 0 | 0.0% |
| **1% to less than 5%** | 6 | 9.0% |
| **5% to less than 10%** | 17 | 25.4% |
| **10% to less than 20%** | 25 | 37.3% |
| **More than 20%** | 5 | 7.5% |
| **DK** | 13 | 19.4% |
| **REF** | 1 | 1.5% |
| **Total** | 67 | 100.0% |

F3. [ASK ALL] Which energy source accounts for the highest proportion of your facility's/company's total energy costs? Is it….

| | Count | % |
|---|---|---|
| **Electricity** | 43 | 64.2% |
| **Natural Gas** | 20 | 29.9% |
| **Or a different source** | 3 | 4.5% |
| **DK** | 1 | 1.5% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

F4. [ASK ALL] In what state is your facility headquarters located?

| | Count | % |
|---|---|---|
| **CA** | 1 | 1.5% |
| **IL** | 1 | 1.5% |
| **MA** | 1 | 1.5% |
| **MI** | 1 | 1.5% |
| **NE** | 2 | 3.0% |
| **OH** | 1 | 1.5% |
| **OR** | 23 | 34.3% |
| **WA** | 37 | 55.2% |
| **Total** | 67 | 100.0% |

F5. [ASK ALL] How many facilities does your company have in…

1. Washington
2. Oregon
3. Idaho
4. Montana

98. DK
99. REF

| | Total |
|---|---|
| **WA** | 49.00 |
| **OR** | 50.00 |
| **ID** | 4.00 |
| **MT** | 1.00 |

F6. [ASK ALL] Approximately what percentage of your company's total revenues were accounted for by this facility?

| | Count | % |
|---|---|---|
| **Less than 1%** | 0 | 0.0% |
| **1% to less than 5%** | 0 | 0.0% |
| **5% to less than 10%** | 2 | 3.0% |
| **10% to less than 20%** | 1 | 1.5% |
| **More than 20%** | 41 | 61.2% |
| **DK** | 23 | 34.3% |
| **REF** | 0 | 0.0% |
| **Total** | 67 | 100.0% |

F7. [ASK IF A4.5 = "Yes"] Is your facility ISO 50001 certified?

1. Yes, if so, when did it achieve this certification
2. No

98. DK
99. REF

| | Count | % |
|---|---|---|
| **Yes** | 0 | 0.0% |
| **No** | 18 | 100.0% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **Total** | 18 | 100.0% |

F8. [ASK IF F7 = "No"] Has your facility considered pursuing ISO 50001 certification?

| | Count | % |
|---|---|---|
| **Yes** | 2 | 11.1% |
| **No** | 16 | 88.9% |
| **DK** | 0 | 0.0% |
| **REF** | 0 | 0.0% |
| **Total** | 18 | 100.0% |

F9. [ASK ALL] Is there anything else you would like to tell us about your experiences with SEM?

F10. Thank you for your time.

****************************END OF SURVEY*********************

# APPENDIX C - CASE STUDY OBSERVATIONS

The materials below organize case study observations around the elements of CEI operations.

**Figure 1: Company A Case Study Observations**

| | CATEGORY | DETAIL | OBSERVATIONS |
|---|---|---|---|
| PLAN | Commitment | Executive Involvement | o Staff report executive sponsor routinely involved with CEI; sponsor oversees environmental department<br>o Corporate energy champion part of cross-functional teams: environmental dept. and product category dept.—ensures energy is a focus across departments |
| | | Energy Goals | o Reduce energy intensity by 25% in 10 years |
| | | Corporate Values | o Updated values statement to include energy in 'sustainability'—interpreted in two ways: environmentally sustainable confers business sustainability |
| | Corporate Communication | Energy Priority | o Produced videos of staff and executives describing the importance of energy management<br>o CEI Kick-off with production staff; importance of energy reduction emphasized |
| | | Outcomes | o Produced videos describing achievements made<br>o Reward top performing facilities with sandwiches and award<br>o Include energy topics in monthly newsletter to staff |
| | Organization | Corporate / Facility Coordination | o Facility and corporate level energy managers meet one-on-one once a year to discuss planned activities<br>o Corporate energy champion holds group web-cast meeting quarterly with facility energy champions to share ideas / review progress |
| | | Facility Energy Teams | o Facility energy champion (production, facility, or env. manager) assigned personal goals by corporate energy champion<br>o ~10-20 production staff at each facility; monthly internal energy meeting<br>o Communicate energy topics in monthly production staff meetings; at some facilities energy not included for month b/c no new energy topics—some concerned losing energy focus |

| | | | |
|---|---|---|---|
| EXECUTE | Staff Development | Energy Focus | o CEI kick-off meeting describing energy as manageable factor of production; important to corporate goals and values<br>o Provide production staff with resources/training to help reduce energy use at home; believed to help reinforce concept that energy is manageable, and helps increase awareness<br>o Some facilities created “energy-wheel,” production staff spin wheel and win a prizes, wheel contains energy information |
| | | System Training | o Energy champions concerned production staff are not adequately trained in operation of new equipment and systems; leads to inefficient operation |
| | Production | Capital Projects | o Work with utilities for funds for EE equipment on projects<br>o Believed has addressed ‘low-hanging’ fruit |
| | | O&M | o Revise operating specs targeting customers’ minimum qualifications; were dehydrating product beyond specs<br>o Believes addressed most opportunities, worried that progress will be slowed without more opportunities |
| REVIEW | Monitor | KPIs | o Facility energy champion reviews energy dashboard weekly: monitor steam (natural gas) and electricity. |
| | Update Plans | Review Plans | o CEI contractor reviews database of CEI planned activities and performs audit of CEI system; facility and corporate energy champions concerned these activities will not be performed when NEEA discontinues support |
| IMPROVE | Opportunities | Identificati on | o Facility energy teams perform quarterly walk-throughs of facility to identify new savings targets<br>o Technical teams audit facilities for gas and air leaks annually<br>o Facilities compete with each other and collaborate about solutions and new approaches |
| | | Procedures | o Including energy reduction in 6 Sigma initiatives; black-belts create new energy focused standard operating procedures |
| | Sustaining | Strengths | o Include energy reduction in audits to customers; energy management viewed as part of product’s quality<br>o Target EPA energy programs with customer facing awards |

| | | | |
|---|---|---|---|
| | | Threats | ○ Turnover creates a gap; 1 facility energy champion informed of responsibilities after 6 months<br>○ Concern energy focus will decrease as new energy initiatives are infrequent because of saturated savings opportunities<br>○ Concern company will not review and update CEI plans after NEEA support for CEI contractor discontinued; some plans to hire contractor |

**Figure 2: Company B Case Study Observations**

| | CATEGORY | DETAIL | OBSERVATIONS |
|---|---|---|---|
| PLAN | Commitment | Executive Involvement | o Corporate engineer reviews energy usage by facility<br>o Plant managers and corporate engineer involved in facility level energy meetings<br>o Corporate engineer prioritizes budget for energy saving projects across all facilities |
| | | Energy Goals | o Reduce energy intensity by 25% by 2020 |
| | | Corporate Values | o No value or mission statements specific to energy savings |
| | Corporate Communica-tion | Energy Priority | o Energy management seen as something necessary to be competitive<br>o Corporate energy manager thinking about ways to go beyond technical staff for energy savings and engage operations staff in energy saving |
| | | Outcomes | o Quarterly conference calls across facilities to discuss energy and conservation topics and projects<br>o Seek input from all employees about how to use less energy with suggestions box |
| | Organization | Corporate / Facility Coordination | o Quarterly conference calls of energy champions to discuss energy saving projects; hosted by corporate energy manager. |
| | | Facility Energy Teams | o Facility energy champion assigned to each facility; typically the champion is a production manager<br>o Energy committee (8-20 people) meet monthly at most facilities; representatives include: plant manager, production manager, refrigeration lead, electrician, line supervisors, shift supervisors, and maintenance. |
| EXECUTE | Staff Development | Energy Focus | o Sought input from operations staff on energy saving. Three recent projects were provided as examples of this input. 1) Change sensors at hand-washing station. 2) Insulate pipes at hand-washing station. 3) Tint windows in lab.<br>o Employees are proactive rather than reactive to energy. Example: Electrician empowered to replace sensors that were keeping lights on too long in parking lot. This would not have happened prior to energy focus at facilities. |

| | | | |
|---|---|---|---|
| | | System Training | o Corporate energy manager concerned about documenting energy savings resulting from operations and production staff.<br>o Refrigeration staff participated in refrigeration operations training that resulted in less use of motors powering refrigeration. |
| | Production | Capital Projects | o Doing fewer capital projects than they did a few years ago, but their recent/current projects tend to be larger.<br>o Projects are evaluated at corporate level and prioritized by which ones will save the most energy. |
| | | O&M | o Corporate energy manager see O&M as place to save energy as capital projects become exhausted. However, concern about documenting savings from these activities.<br>o Refrigeration staff participated in refrigeration operations training that resulted in less use of motors powering refrigeration. |
| REVIEW | Monitor | KPIs | o Facility energy champion monitors electricity and natural gas use weekly.<br>o Corporate energy manager reviews facilities energy use.<br>o Concern about how change in process affects EUI |
| | Update Plans | Review Plans | o Facility and corporate energy champions concerned that loss of CEI contractor (NEEA's support) will result in lack of emphasis on energy savings. |
| IMPROVE | Opportunities | Identification | o Facility energy committees perform regular walk-throughs of facility to identify possible energy saving projects.<br>o Company hires consulting firms (independent of program), uses university engineering department, and participates in utility programs to help identify energy saving projects. |
| | | Procedures | o Starting to participate in LEAN manufacturing process. |
| | Sustaining | Strengths | o Coordination across facilities re energy saving projects makes energy management part of corporate culture, not just facility culture. |

| | | | |
|---|---|---|---|
| | | Threats | o Loss of emphasis on energy management if facilities feel they have exhausted energy saving opportunities.<br>o Loss of emphasis on energy management if facilities do not have regular contact with CEI contractor that keeps focus on energy saving opportunities.<br>o It is difficult to document energy savings that result from operations staff (such as window tinting and pipe insulation).<br>o Company not focused on marketing energy saving activities to customers but company is starting to market itself as a “green” company. |

**Figure 3: Company C Case Study Observations**

| | CATEGORY | DETAIL | FINDINGS |
|---|---|---|---|
| PLAN | Commitment | Executive Involvement | o Executive sponsor rarely involved. |
| | | Energy Goals | o 25% in 10 years.<br>o Attempted more aggressive goals stated in dollars saved, but scaled back. |
| | | Corporate Values | o Energy management is not expressed as corporate value; is viewed purely as cost cutting measure. |
| | Corporate Communica-tion | Energy Priority | o Planning on embedding fiscal emphasis in system training delivered to employees. |
| | | Outcomes | o Plan to motivate employees with share of savings in the form of bonus. Value of bonus intended to sensitize employees to change in level in energy savings. |
| | Organization | Corporate / Facility Coordination | o Corporate energy champion reviews facility level energy performance daily with facility energy champion, as part of daily review of wider production metrics. |
| | | Facility Energy Teams | o Facility maintenance staff tasked with identifying savings opportunities.<br>o Facility energy champion's personal goals are facility wide KPIs which also include energy KPIs. |
| EXECUTE | Staff Development | Energy Focus | o Refused utility resources to help employees save energy at home. |
| | | System Training | o Developed system training materials that include energy management through O&M. Employees voluntarily take training, roughly have of operation staff have taken training. |
| | Production | Capital Projects | o Saturated most capital improvement opportunities. |
| | | O&M | o Implementing system training which includes O&M. Desire more funding for technical studies to identify additional O&M opportunities; DOE funding dried up. |
| REVIEW | Monitor | KPIs | o KPI (steam and electricity usage) measured in 15 minute increments.<br>o Reviewed daily across all facilities. |
| | Update Plans | Review Plans | o No specific priority or order for staging implementation of measures |

| | | | |
|---|---|---|---|
| IMPROVE | Opportunities | Identification | o Corporate energy champion identifies most capital opportunities<br>o Maintenance staff identify O&M opportunities quarterly |
| | | Procedures | o No additional procedures were observed. |
| | Sustaining | Strengths | o Targeting EPA energy management awards; viewed as way to differentiate product on the market. |
| | | Threats | o Corporate concerned SEM system employs a top-down approach to energy management and does not have buy-in from production level staff. |

## APPENDIX D - SAVINGS VALIDATION

Memorandum

| | |
|---|---|
| **To:** | Steve Phoutrides, Northwest Energy Efficiency Alliance |
| **From:** | Julia Vetromile, DNV KEMA Energy and Sustainability |
| **Subject:** | Food Processing Initiative Energy Savings Memorandum |
| **Date:** | March 14, 2013 |

### Introduction

The Northwest Energy Efficiency Alliance (NEEA) has been implementing its Industrial Initiative since 2005. The initiative encourages industrial organizations to incorporate energy management practices for Strategic Energy Management (SEM) in their operations. Currently this initiative focuses on the food processing industry. NEEA has engaged DNV KEMA to evaluate the annual progress of this initiative. This memorandum presents the results of the validation of energy savings portion of the evaluation. The validation was performed in January and February 2013.

The validation consisted of two parts, a bottom-up energy engineering analysis for each energy efficiency measure completed and a top-down regression analysis of changes in energy consumption for each participating facility.

For 2012, nine facilities were active in the program across Oregon, Idaho and Washington states. A total of 29 measures were validated for these sites, which included all the completed measures for 2012. Since all completed projects with savings estimates were included in the validation, uncertainty regarding the representativeness of the sample was eliminated. At one site, no measures could be evaluated due to insufficient information. For each of the remaining eight facilities, DNV KEMA visited the site, verified whether the measures reported were installed, and collected information to estimate the energy savings. Based on the collected information, DNV KEMA used engineering analysis to estimate the energy savings.

NEEA's contractor developed top-down analyses for each facility, estimating savings since each facility adopted SEM. The top-down analysis is designed to capture the savings that result from SEM activities that are not typically included in a measure-by-measure engineering analysis. The types of activities promoted by SEM include planning, setting goals, and incorporating behavioral and structural changes into the facility operations, as well as other capital and maintenance improvements. Structural change, such as revising standard operating procedures to incorporate practices, controls, and set points that improve energy efficiency, is a more appropriate term than behavioral change for many actions in an industrial setting. Energy management actions, outside of capital and some maintenance improvements, are not typically quantified in savings verification efforts. To assess all types of savings, the top-down method estimates changes in consumption between the program period and a pre-participation baseline period, after controlling for non-program factors such as ambient temperatures and production volumes.

### Top-Down Savings Methodology

NEEA's contractor developed a statistical model to assess top-down savings for electricity. Savings for natural gas were not modeled. The basic approach of the econometric model is to identify and collect relevant explanatory or predictor variables for energy consumption, and develop a regression analysis that can be used to predict energy consumption as a function of these variables. The predictor variables in this analysis are total production, and temperature or a variable such as degree days representing weather conditions. The monthly energy use for the baseline period is fit to a model in the form of

$$\text{Energy} = \text{Intercept} + B_1 \times \text{Production} + B_2 \times \text{Temperature variable}$$

Where:

Energy = monthly electricity consumption by the facility

Intercept = constant, representing fixed electricity consumption independent of other variables

$B_1$ and $B_2$ are coefficients representing the relationship between production and weather, respectively, with energy consumption

The model is fit to the data of the baseline period. Assuming that the model form is appropriate in both the baseline and most recent year, the model predicts the energy consumption of the most recent year. The modeled consumption does not take into account the improvements made through SEM, which were implemented after the baseline period. Therefore the savings due to SEM can be estimated by comparing the modeled and actual energy savings for the current year.

### Evaluation of the Top-Down Model

The evaluation team reviewed the concept of the model, the model form, and the variables considered. The evaluation team also duplicated the regression analysis, to check that the model was implemented as planned. As a cross-check, the evaluation team developed a regression of the current data, and modeled the baseline year.

#### Top-Down Modeling Approach

The model that NEEA's contractor developed estimated facility energy consumption as a function response of the overall monthly production level, and temperature. Modeling consumption this way supports the comparison of predicted energy consumption to observed energy consumption. The difference between the two represents the energy savings associated with all energy savings efforts undertaken during the period under review.

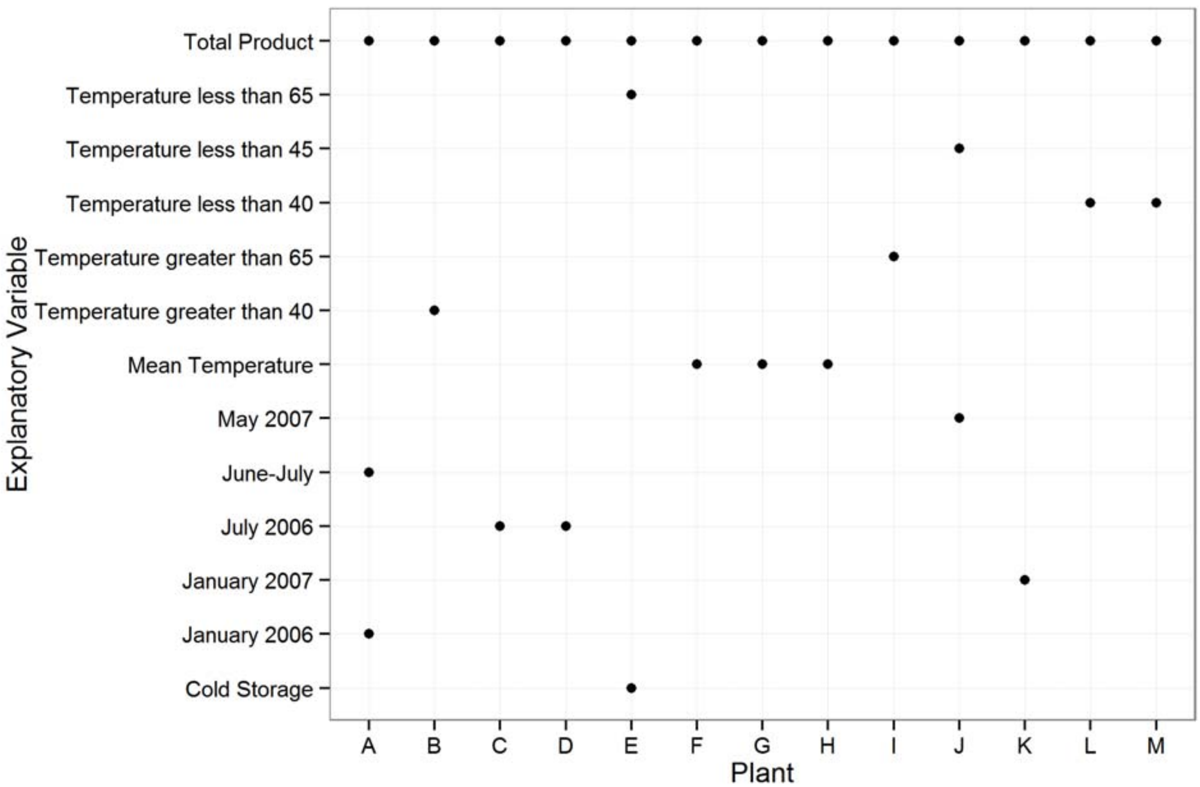
The NEEA and its contractor assembled monthly data of energy consumption, production, and weather for each subject facility. The data covered two to three years prior to program participation as well as the five subsequent years. The model for each facility has a unique set of explanatory variables.

Figure 4 depicts which variables the facility equation includes with a dot. The specific variables in the equation include:

- Total Product: the total amount of a product the plant produced in terms of units sold or accounted as produced. Note, for some plants this variable takes a negative value in a few months. This is likely an accounting adjustment to represent product either not sold or not accepted by the plant as meeting quality standards.
- Temperature threshold: the number of hours in the month the temperature was above or below a threshold value.
- Mean temperature: the average temperature reading throughout the month.
- June-July dummy variable: 1 if the month is June or July; 0 otherwise. Note, that this variable captures both a temperature effect and any effect due to the product the factory processed during June and July.
- Date-specific dummy variables: these variables capture specific effects observed in the pre program activity period.
- Cold storage: this variable is not explained in the documentation, but only occurs for one facility.

As shown, all facilities included total production as a predictor variable in the model for energy consumption. The temperature variables were determined for each facility, based on the best fit in the regression analysis. For a few plants, a dummy variable applies only for a specific month in the baseline period. Using a dummy variable to capture effects in a specific month improves the overall fit of a model by removing outliers. However, a better approach is to capture what makes the outlier month unique. Using a dummy variable in this way means that the model will not be able to explain significant sources of variation in the post intervention period.

**Figure 4 Variables in the Top-Down model**




## Findings

Table 1 presents the cumulative estimate of energy savings using the top-down approach. Plant B dominates the savings estimate, accounting of 73% of the savings. The top-down approach predicted negative savings for Facility B. That is, the model predicted lower energy consumption than was observed at the site. The implication is that the program activity led to higher energy consumption.  However, this implication is inconsistent with the history of energy saving measures at the facility.

**Table 1 Cumulative Energy Savings**

| Plant | MMBtu | MW | Percent of Total Estimated Top-down Savings |
|---|---|---|---|
| A | 39,066 | 1.308 | 12% |
| B | 246,745 | 8.261 | 73% |
| C | 343 | 0.011 | 0% |
| D | 6,291 | 0.211 | 2% |
| E | 15,022 | 0.503 | 4% |
| F | 3,255 | 0.109 | 1% |
| G | 18,081 | 0.605 | 5% |
| H | 2,260 | 0.076 | 1% |
| I | 8,285 | 0.277 | 2% |
| J | No Data | No Data | |
| K | (3,466) | (0.116) | -1% |
| L | No Data | No Data | |
| M | 3,007 | 0.101 | 1% |
| *Total* | *338,889* | *11.347* | *100%* |

The electric energy in this table is presented as MMBtu, based on a conversion which only accounts for the energy received at the facility. It does not address the fuel required to produce the energy, which typically includes a factor of about three. ‘

### Implicit Model Assumptions

The top-down approach builds off the assumption that total production units and temperature are sufficient to explain the monthly changes in energy consumption. Changes in the energy consumption that the model cannot explain are on average assumed to be due to adoption of energy savings measures and practices. However, production activity constantly changes, particularly for food processing plants. Plant activity can vary in at least the following dimensions:

- Fuel mix. The model assumes that the fuel mix that each plant uses prior to the treatment is consistent with the fuel mix post treatment. One plant reported switching its fuel mix after the program intervention.
- Product mix. Food processing plants produce different products. In some plants, a range of seasonal products are produced throughout the year as crops have different growing seasons. Other plants produce products that require different processes, such as French fried potatoes and potato granules. Since crops require different amounts of energy for processing, the expected usage depends on the product mix. The models are not sensitive to changes in product mix, because only total production is modeled.

- Plant configuration. The model assumes that the physical layout of a plant is consistent between the period prior and after the intervention. The models are not sensitive to changes in product lines, building additions, building closures, or changes in equipment.
- Raw materials. Changes in raw materials used for food processing may change the overall energy consumption. The model does not account for changes in raw materials between the baseline and post-participation periods.
- Months and hours of operation. Food processing operations are highly seasonal, with all the production occurring from May through October at some plants, and no significant production in the winter. The hours of operation also may vary by product.
- Non-routine adjustments. Plant operations occasionally change in a significant way from the baseline period for reasons not related to production or weather. For example, the introduction of a new packaging type after the baseline period could require more or less energy per unit weight of product. The model does not capture their effects.

**Evaluating a Model**

The strength of a model follows from its ability to tell a concise, consistent, and compelling story.

- *Concise* models are able to explain the appropriate amount variation in the dependent variable under conditions that are experienced most frequently. There can be a large amount of variation in total annual production at a facility. For example, food processing volumes are highly dependent on the success of any given crop. The intention of the energy consumption models is to best explain energy consumption as a function of production volumes and temperature when those values are in the middle regions of their respective ranges. That is, explaining the volumes of the highest production year and the lowest production year is less important than explaining the average production volume.
- *Consistent* models have coefficient values with logical relationships. For example, a model should yield higher estimates of energy consumption increases as production increases.
- *Compelling* models have a strong statistical fit. The probability that the coefficients are different than zero should be greater than 90%. Further, the overall model should account for a large amount of the observed variation in energy consumption. The adjusted $R^2$ statistic captures how much of the production variation from the mean that the model explains. Values over 0.8 denote very a very strong statistical fit. Models have an adjusted $R^2$ is under 0.5 are not able to explain half the energy consumption variation. This may be due to unobserved factors such as those mentioned in the section on Implicit Model Assumptions above to a limited number of observations.

For the Industrial Initiative program, the basic form of a linear regression model is appropriate. The keys are whether (1) the estimated coefficients are plausible and statistically significant, (2) the overall explanatory power of the model is satisfactory, and (3) the model captures the appropriate amount of variation. The documentation of model documents estimation results that satisfy requirement (1). The subsequent subsection discusses the question of overall explanatory power in requirement (2). The following two subsections describe different ways to test whether the model captures an appropriate level of variation, requirement (3).

### Overall Explanatory Power

Table 2 presents the adjusted $R^2$ measure of a model's overall explanatory power. The measure takes values between 0 and 1 where 0 indicates that the model provides no explanatory power and 1 indicates that the model provides perfect explanatory power. The adjusted $R^2$ values range from 0.450 to 0.986. The latter value is a remarkably high level of fit. The former value, however, is below the desired range. As shown in Table 1, two of the plants combine for 85% of the cumulative savings. These are also the plants where the models have lowest levels of overall explanatory power.

**Table 2 Overall model fits**

| Plant | Adjusted $R^2$ |
|---|---|
| A | 0.572 |
| B | 0.450 |
| C | 0.665 |
| D | 0.829 |
| E | 0.986 |
| F | 0.979 |
| G | 0.984 |
| H | 0.861 |
| I | 0.975 |
| J | 0.703 |
| K | 0.778 |
| L | 0.578 |
| M | 0.867 |

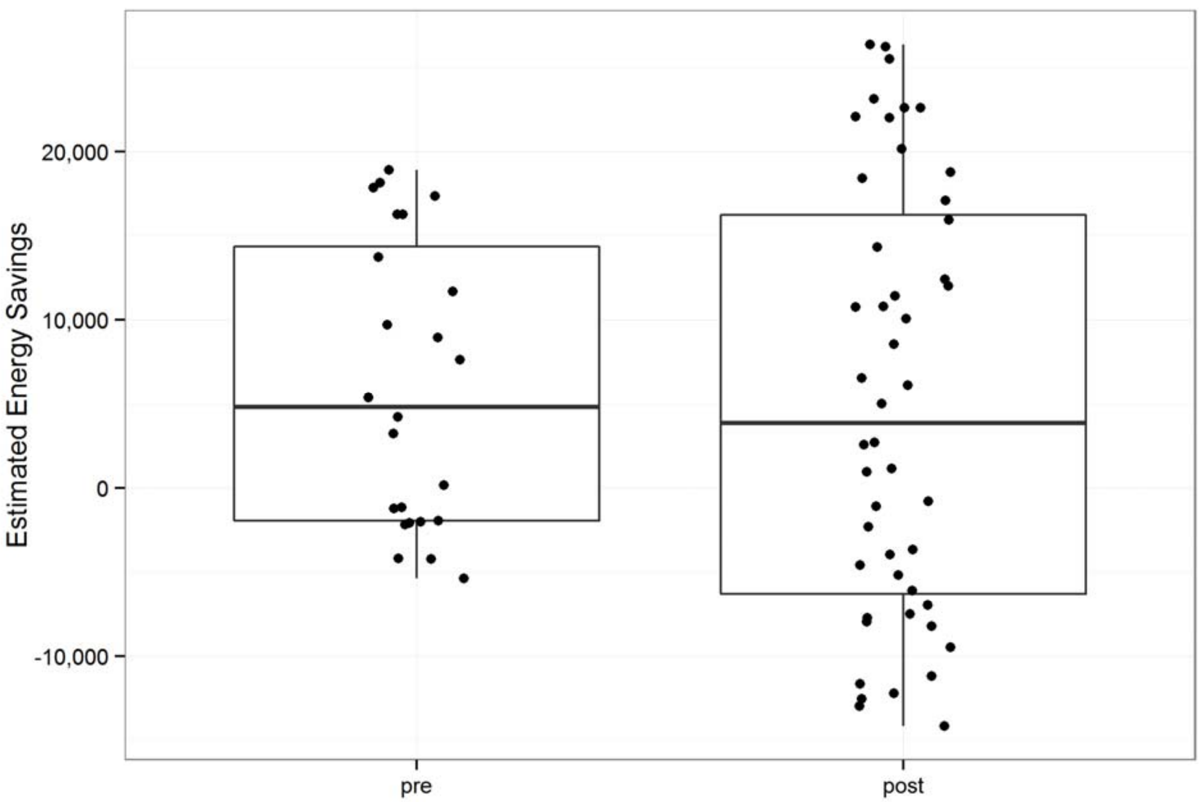
### Backcasting Test

As mentioned above, one important requirement is that the models capture an appropriate amount of variation. In essence, do the variables in the models explain energy consumption post intervention? If they do, then the mean monthly estimated energy savings would be the same as estimating a hypothetical savings of what would have happened pre intervention. That is, create a model using the post intervention data, estimate how much energy the plant would have consumed given production and outdoor temperature conditions during the pre-participation period with the energy improvements in place, and subtract that from the observed energy consumption during the pre-participation period to compute savings. This technique is known as "backcasting."

This subsection applies the backcasting technique to Plant B as this plant accounts for 73% of the total estimated cumulative savings for all nine facilities. Figure 5 shows the monthly estimated savings in post invention period and hypothetical savings from the backcasting technique in the pre-intervention period. Both the forecast and backcast model have an identical specification—energy consumption is a function of total production and hours greater than 40 degrees. The monthly estimates of energy savings has a much greater range and variance using the post intervention period.

The statistical test to determine of the means of the two distributions are different is Welch's Two Sample t-test (with unequal variance). The test shows that the mean savings between the forecast and backcast approach are statistically different. The probability of the monthly savings from the forecast and backcast having the same mean has a 0.71 P-value. This confidence level is less than the typical standard confidence levels of 90 or 95%.

**Figure 5 Monthly Savings Estimates, using forecast and backcast techniques**




**Anecdotal information from facilities**

As part of the top-down evaluation, DNV KEMA interviewed four facility contacts regarding their production, their energy management, and factors they could identify that affected their energy consumption. Two common patterns emerged: one associated with plants that were highly dependent on seasonal crops, and one associated with plants that focused on crops such as potatoes that were available all year. The seasonal plants processed one or two crop types at a time, beginning with spring crops like asparagus and ending with summer crops like lima beans and carrots. Different products were generated for some crops, with the greatest variation among the potato plants, which could produce dehydrated products, granules, and French fries requiring quite different processes.

Different crop products required specific processes, such as blanching, cutting, drying, frying, and freezing. Some products have higher energy consumption per unit weight of product (also called energy intensity). If there is a change in product mix, energy consumption by unit weight of product may stay the same, but the energy consumption of the plant as a function of total production will change.

Raw material variation was also cited as affecting energy consumption; one plant found that the 2011 crop required process modifications to reach their quality requirements; more energy was consumed during the period where they were adjusting their process to match the raw material characteristics.

Changes in hours of operation also were identified. One facility contact mentioned a 2011 increase in operating days from 5 to 7 days per week for a specific product line. This product required more than twice the energy per pound than their other products, resulting in an increase in energy intensity and energy consumption in 2011 and 2012 that was unrelated to their energy management strategy.

Overall, the information supplied by the plants suggested that a simple model of energy consumption as a function of total production and weather is likely not to be sufficient to predict energy consumption. Large effects like changes in operating hours, raw materials, product mix are likely to dominate changes in energy consumption. Operational changes of a few percent per year are likely to be too small to be clearly identified.

### Implications and Conclusions

The overall approach of the top-down approach is sound. The models all have statistically significant coefficients with reasonable values. Further, most of the models show a very strong level of overall fit. The adjusted $R^2$ values are, for the most part, quite high.

The results show a few areas of concern. First, the two plants that account for 85% of the estimated savings have a relatively low level of overall fit. Getting a strong fit on the models for these plants is more important than the fits for the other plants. Second, the backcast test on the largest plant shows that the mean monthly savings estimate is statistically different the estimate from the backcast. This result suggests that the model does not account for enough variation. Plant operations are not static from year-to-year. The models should account for more sources of variation. Third, the use of specific month dummy variables is not good practice. A model should only contain explanatory variables that are observable in both the pre and the post periods.

There are a few opportunities to improve the models. These improvements will increase the degree of confidence around the estimated savings. The opportunities for improvement include:

- Collect additional data. The models would greatly benefit from some measure of the product mix. Other data to collect include hours of operation and raw materials.
- Model overall energy consumption. One of the plants reported fuel switching. The current set of models is only sensitive to electricity consumption.
- Avoid using month and year specific dummies.
- Apply the backcasting technique to all the models. This technique provides insights as to whether the model accounts of the necessary amount of variation.
- Talk with plant energy managers. Plant managers know if the plant undergone major changes that the models are not able to represent. These could include changes to the plant configuration or non-routine adjustments to equipment.

**Bottom-Up Analysis**

DNV KEMA evaluated the savings on 29 measures from 2011 and 2012 that were completed since the last evaluation. Each measure was validated following a site visit to the plant and savings were estimated based on data collected at the facility, data provided by the site contact, and engineering calculations. Table 3 displays the results for both electric and gas savings. Two facilities had natural gas savings only, five facilities had only electric savings and one facility had both. Overall, we found the realization rate of verified to tracked savings to be 117% for electric measures and 43% for natural gas measures. Misspecification of baseline practices and conditions led to significant overstatement of the savings for one measure in the program tracking system. This led to the low average realization rate for gas measures.

**Table 3. Program Savings Achieved in the Evaluation Period**

| Facility | Tracking Savings, kWh | Verified Savings, kWh | Realization Rate, kWh | Tracking Savings, therms | Verified Savings, therms | Realization Rate, Therms |
|---|---|---|---|---|---|---|
| C | - | - | | 399,500 | 33,969 | 9% |
| D | - | - | | 202,252 | 210,683 | 104% |
| E | 824,758 | 1,231,355 | 149% | - | - | |
| F | 192,000 | 207,045 | 108% | - | - | |
| G | 102,904 | 171,326 | 166% | - | - | |

| Facility | Tracking Savings, kWh | Verified Savings, kWh | Realization Rate, kWh | Tracking Savings, therms | Verified Savings, therms | Realization Rate, Therms |
|---|---|---|---|---|---|---|
| H | - | - | | - | - | |
| I | 512,433 | 458,738 | 90% | 31,188 | 26,462 | 85% |
| J | 1,294,485 | 1,323,862 | 102% | - | - | |
| K | 58,391 | 91,328 | 156% | - | - | |
| Total | 2,984,971 | 3,483,654 | 117% | 632,940 | 271,114 | 43% |

### Site Visit Findings

This section describes each measure evaluated or reviewed for the nine sites currently in the program. All of the site visits took place in February 2013.

*Facility C*
**Boiler condensate replacement:** The facility diverted some of its high pressure condensate to run an existing heating process previously supplied by the boiler. This saves energy in two ways. First, by using a lower temperature steam it prevents the efficiency loss from the boiler re-heating the steam. Second, using condensate allows the process to be run with electric water pumps rather than unreliable steam pumps, preventing the plant from dumping condensate whenever these pumps fail. DNV KEMA verified the installation of the measures, hours of operation, and the quantity and pressure of steam used for this process. A significant percentage of the fuel used in the boiler is wood. DNV KEMA estimated savings based on product production and therms/product information from data provided by the plant contact, separating out natural gas and wood heat. The savings are significantly less than the tracking data, because the program did not account for the wood boiler, and all the condensate used for the process prior to adoption of the measure was dumped. The site contact confirmed the condensate had been recycled prior to the installation of the measure. This verification yielded a gross savings estimate of 33,969 therms per year, which was 9 percent of the tracking system value.

*Facility D*
**Pipe and valve insulation:** The facility added insulation to existing boiler pipes and valves. At the site visit, DNV KEMA verified the installation of insulation, type and size. The savings calculation used tables provided by the DOE 3E+ software, using the pipe and valve sizes as a lookup and taking savings values from the tables. DNV KEMA verified these calculations as accurate.

**Condensing heat exchanger install:** The customer added a condensing heat exchanger to the boiler. At the site visit, DNV KEMA verified the installation, size, and quantity of water fed through the condensing heat exchanger. DNV KEMA confirmed with the plant contact the amount of water heated and sent to the deaerator. Using an enthalpy calculation, we estimated the amount of savings from avoiding using water supplied from the boiler for this purpose. These verification activities yielded a gross savings estimate of 210,683 therms per year, which was 104 percent of the tracking system estimate.

*Facility E*

**Reduce Number of belts**: This measure involves the elimination of one drive motor from a conveyor belt system, used to move product from an intake hopper and to subsequent process steps. The baseline condition consisted of two separate, end-to-end conveyor belts, each driven by independent motors. The division between the two belts was not critical to the process application. The upgrade condition consists of one new, longer belt, which spans the entire process line. DNV KEMA verified system is installed and operational. DNV KEMA developed a savings estimate based on some reduced frictional drag of additional gearing and belt rollers resulting in less motor work required to move the product. DNV KEMA has consulted the Conveyor Equipment Manufacturers Association (CEMA) for calculation of power requirements of the belt, based on observed parameters on site. Some parameters such as the weight of the belt, belt speed, and conveyed product weight have been estimated using field observations and guidelines provided by CEMA, as well as the annualized product weight data provided by the plant. Based on these calculations, we estimate that the load on these 1HP motors is quite low relative to their power rating. In addition, elimination of the second belt has only removed some minor frictional losses from the system. We therefore consider the savings estimate to be significantly overstated, with the realized savings due primarily to a perhaps unintended result of elimination of one motor: the increase in motor efficiency associated with the new higher load factor may actually result in more significant savings than the elimination of frictional elements.

**Reduced pressure on fresh water line:** This measure involves the installation of a pressure reducing valve in a 3/4" water supply line that is used to prime the gutter water sump tank irrigation transfer pumps. Water from the plant that is used in the process is all gravity-flushed to the sump tank, from which the water is reused for irrigating surrounding cropland. The existing condition consisted of 85 pounds per square inch, gauge (psig), facility water plant-pumped water being fed into the sump tank input line, which was done to prime the sump pumps in recirculation mode, during periods when the plant was operating. Once this pressure reducing valve was installed, reduced flow at a lower pressure is allowed past the valve, although still sufficient for pump priming, resulting in flushing less water to the sump tank. The basis for the energy savings calculation is that less water pumped from the plants wells results in less energy used. The calculation was developed by creating a general system schematic for this operation, and estimating the flow rate from the expected velocity range. Our estimate assumed 20 gallons per minute in the existing condition, reduced down to 7.5 gallons per minute by the pressure reducing valve.

**Freeze Tunnel Fan VFDs:** This measure involves the installation of manual VFD controls on evaporator fans in a process freeze tunnel. The baseline condition consisted constant speed fans. The upgrade condition consists of manual controls for the VFDs. As described by the site contact, various products are processed in the freeze tunnel and it was found that depending on the type of product, a lower cooling rate was acceptable (for example strawberries are more dense than sliced beans). The line operators are therefore manually adjusting the drive frequency down to 50 Hz for periods of time when beans are being produced. As coolant to the evaporator is not being concurrently adjusted, a low limit on the drive frequency will potentially be reached based on acceptable coil temperature or icing. The primary driver of the baseline energy usage and resulting energy savings, (other than the run hours) is the load factor assumption, which was assumed at a very specific 0.79: it is unclear the basis for this assumption. DNV KEMA recommends spot metering the load to confirm the energy usage at the 50 Hz and 60 Hz conditions. Based on the DNV KEMA observed diameter of the axial direct drive fans and a corresponding typical air flow rate and pressure drop across the coil, we find the load factor assumption reasonable for the baseline condition. The calculation of reduced power at 50 hz was conducted in the ex-ante analysis utilizing a cubic relationship of power to frequency. DNV KEMA has observed that while this is the theoretical relationship according to the affinity laws, in some cases the actual relationship on flow to power is something less than cubic. Utilizing the same baseline energy consumption and applying a flow rate to pressure factor of 1.8, we calculate a slightly reduced energy savings. Additionally we consider some reduction in motor and the inclusion of a VFD efficiency loss in the post installation condition.

**Refrigeration system optimization per Refrigeration Operator Coaching training:** After participating in the Energy Trust of Oregon's Refrigeration Operator Coaching workshop, facility personnel were able to implement multiple low and no-cost energy efficiency improvements on their refrigeration system. The existing control settings were modified, such as revising suction pressure in the tunnels and the main plant freezer area and reducing the plant minimum head pressure 125 psig to 108 psig. Other changes included adjusting evaporator fan speeds by VFDs or other controls, and revised staging of fans. These changes were observed during the site visit. Savings result from a more efficient refrigeration cycle, tailored to ambient conditions and load. The savings were estimated in a report prepared by Cascade Energy on December 14, 2012, utilizing a pre- and post-measure regression modeling analysis, which was performed based on the timing of specific measures implemented. Savings were estimated at 12% of refrigeration system. The tracking savings was less than the savings presented in the Cascade Energy report, but no rationale for the discrepancy was provided. Based on our review of the analysis, and given the available information, we find the conclusions reasonable, and do not recommend any adjustment to the calculated savings in the Cascade Energy report. It may be possible for the plant to gain additional confidence in the results with additional data collection. The overall plant energy usage metric (tracked in units of Btu/Lb considering all sources of energy), should be impacted by this measure by 3-4%. From 2010 to 2011 there was an increase in Btu/Lb of 3.5%, therefore it is possible that the impact of measures associated with this project will not be visible in this metric, given the typical year to year variation in usage due to weather, product mix or other operational changes.

These verification activities yielded a gross savings estimate of 1,231,355 kWh per year, which was 149 percent of the tracking system estimate. The difference is the ROC measure, which was credited based on the observed changes and the regression analysis of savings provided by the ROC contractor.

*Facility F*

**Raptor purchase and installation:** This project involved the installation of a color sorter, which minimized re-work of peas that failed inspection, saving energy by reducing plant operation days per year. Energy savings associated with this project is based on the number of kWh per day and number of days that the plant is no longer required to run batches of snap peas for reinspection. DNV KEMA verified the operation of the sorter, reviewed the information and calculation provided by the site contact.

**Cold room re-insulation:** This project involved replacing ruined insulation on the ceiling and one wall of the cold room. Because this project did not receive an estimate of savings from the program, DNV KEMA could not review estimates for this project.

**T5 lighting installation:** This project involved replacing (54) 400W HID lighting in the plant production area with (54) 6-lamp T5 lighting fixtures. DNV KEMA verified the replaced fixtures, and used a simple delta-watts calculation to estimate the savings.

**Shut down floor heat cables under cold room:** This project was part of the track-and-tune measure performed over the past two years. The estimate provided here was made as a placeholder for this portion of the track-and-tune project. No basis or calculation for this savings was provided, and so we cannot evaluate this savings estimate at this time.

These verification activities yielded a gross savings estimate of 207,045 kWh per year, which was 108 percent of the tracking system estimate.

*Facility G*

**Boiler stack economizer install:** This project involved the installation of a back pressure regulator which allowed them to use the condensing economizer in the condensate line. Previously steam was flashing, which prevented them from using the economizer at all. Because the program had not created a savings estimate for this measure, we were not able to review it.

**Install VFDs on packaging augers:** This project involved replacing an existing conveyor system with new VFD-controlled motors on an auger. This allowed them to run the motors at partial speed rather than using a start-stop mechanism to adjust throughput. DNV KEMA verified the installation of the VFDs, operating hours, size, and operating conditions. DNV KEMA found that the facility was controlling constant-torque loads rather than variable-torque loads as shown in the calculations.

**Install VFD and VFD-ready motor on carrot wash:** This project involved replacing an existing conveyor motor with a new VFD-controlled motor. This allowed them to run the motor at partial speed rather than using a start-stop mechanism to adjust throughput. DNV KEMA found that the facility was controlling constant-torque loads rather than variable-torque loads as shown in the calculations.

**Replace 3 bulb 40w T-12 lights with 3 bulb T-8 energy efficient bulbs 7 ballasts:** The customer replaced existing T12 lighting with new T8 lighting. DNV KEMA verified the installation of the fixtures, operating hours, size and wattage. More lighting had been installed than claimed. DNV KEMA compared wattages and operating hours of old and new fixtures, incorporating dual level switching used in some locations.

**Replace 400w metal halide lights with energy efficient T5HO 4 bulb fluorescent fixtures:** The customer replaced metal halide high bay fixtures with new T5HO high bay fixtures. DNV KEMA verified the installation of the fixtures, operating hours, size and wattage. More lighting had been installed than claimed. DNV KEMA compared wattages and operating hours of old and new fixtures, incorporating cooling savings.

These verification activities yielded a gross savings estimate of 171,326 kWh per year, which was 166 percent of the tracking system estimate. The plant installed more energy efficient lights in their facility than were credited in the tracking savings, resulting in more savings. DNV KEMA incorporated cooling savings for lighting measures in refrigerated spaces. Also, the verified savings used the observed control strategy for the VFD measures, resulting in additional savings.

*Facility I*

**Small HP fire riser air compressors:** This measure involves the installation of new small compressors to charge the fire suppression system with air, rather than running a modulating air compressor. The existing condition was running modulating compressors to maintain system pressurization at no load, while after implementation, the facility connected small portable compressors and installed an isolation valve for the fire control system. Energy savings result due to less run time of the modulating compressor at no load. TheThe tracking system savings calculation assumed eleven 1/3 hp machines installed. During DNV KEMA's verification, it was confirmed that six 2 hp machines were actually installed instead. DNV KEMA utilized the air load duration estimate from the air audit for the verification savings calculation. It is unclear what the load will be on the 2 hp machines will be, due to leaks in the system. The ex-ante assumption was conservative in stating that these would run at all times when the main air plant was shut down. We have utilized the same conservative assumption, but note that 2 hp compressors were in service but not running during our site visit.

**Replace air dryer with cycling dryer:** This measure involves the installation of a new cycling air dryer to replace the existing air dryer which did not cycle and consumed power when operating irrespective of air demand. Once the cycling dryer was installed, the dryer only consumed power as there is air demand. The reduced run time of the dryer results in energy savings. DNV KEMA verified the installation of the cycling dryer. The new cycling air dryer was assumed to consume 16KW at full load in the tracking system calculation. The actual dryer verified as installed is rated at 13.5kW, while still handling the same 2000 cubic feet per minute load, therefore we estimate a greater energy savings than the tracking system value. For the savings estimate, DNV KEMA utilized the air load duration estimate from the air audit, while recognizing that there is significant uncertainty associated with measuring for one weekend and extrapolating to 5700 hours of usage.

**Boiler #1 Economizer:** This measure involves the installation of a flue gas economizer on the 700 hp boiler #1. Savings result from waste heat recovered from flue gas to boiler supply-side water. DNV KEMA verified the economizer installation. We estimated the savings using the overall plant boiler fuel consumption in 2011 as the baseline and an assumption of base loading on the #1 boiler as described by plant personnel. The economizer performance specification was then used to calculate energy savings..

**Adjust office AC units:** The measure involves the replacement of two existing roof top AC units (RTU) which had electric heat with more efficient units, including 13 SEER cooling, gas-fired heating. Savings accrue from the increase in cooling efficiency, and eliminating inefficient electrical heat. DNV KEMA verified the installation of the AC units. The ex-ante calculation for this measure relies on nameplate information and an assumed full load hours run time only. Based on the conditioned square footage, Unit #7 appears to be oversized, when considering a similar thermal load density for Units #7 and #10, which both serve office space in the same area of the building. DNV KEMA has used TMY wet bulb temperature binning for a nearby city and an assumed balance point of 55 degrees F to estimate the full load hours (FLH) cooling. We additionally estimated Unit #7 is 25% oversized for the design day cooling load, based on the square footage served. For the change in heating energy, we note that the base case and post installation case in the ex-ante calculations do not assume the same heating load. (12.5kW heaters are equivalent to 42.6 million BTU per hour (MBH), where the new units have a thermal output capacity of 56 MBH). In both cases, the ex-ante assumption is 2000 FLH heating, and does not consider square feet served in the calculation. We have calculated full load hours based on dry bulb binning and 55 degrees F balance point. We have estimated that Unit #7 is 45% oversized for the heated sq ft,.

**LEDs trial install- self direction:** Eight existing 460W high pressure sodium (HPS) lights were replaced with 8 260W LED. DNV KEMA verified the lighting fixtures were installed as specified and calculated the savings for reduced energy usage from lower wattage fixtures and a cooling bonus in cooled space. DNV KEMA used a simple delta-watts calculation to estimate the savings from lighting, and estimated slightly different run hours from the ex-ante assumption, based on discussion with plant personnel.

**Warehouse 3 & 4 and blancher area lighting- R&M lighting 2012:** Thirty existing HPS lights were replaced with thirty 4lamp T5 high-bay lights, of which 15 were equipped with occupancy sensors. DNV KEMA verified the lights were installed as specified and that the wattage appears correct. The site contact supplied information on run hours . DNV KEMA used a simple delta-watts calculation to estimate the savings from lighting, with additional savings of reduced run hours with occupancy sensors.

**Compressed Air - Reduce regulated pressure setting by 15psig:** This measure involves reduction in compressed air pressure from a 110 psig supply to 95 psig supply . Energy savings are based on less work required by the compressors at a lower set point pressure. DNV KEMA verified the air pressure supply. Savings were calculated based on 0.5% savings per psig reduction.

These verification activities yielded a gross savings estimate of 458,738 kWh per year and 26,462 therms per year, which was 90 percent of the electric savings and 85 percent of the natural gas savings in tracking system estimate. The difference was primarily related to the air cycling dryer, which the tracking savings based on a higher full load electric consumption than what was verified in the site visit. This equipment also was assessed to be oversized, which reduced the therm savings.

*Facility J*

**Install 5 additional cold room doors:** The customer replaced (5) 7' x 13' motor-operated strip curtains with well-sealed, fast-acting doors on their freezer warehouse. The warehouse is maintained at approximately minus 4°F, and the doors open into an unconditioned loading dock which stays at about 40 °F year-round due to machinery used in the area, and leakage from the warehouse. The chiller system operates at a COP of approximately 5.0. During the site visit, DNV KEMA verified the installation, dimensions, and open/close timing of the new doors. DNV KEMA also verified the conditions of the replaced doors, the temperatures of the freezer and loading dock, and the cooling efficiency of the warehouse. DNV KEMA used a methodology found in ASHRAE Fundamentals 1997 section 25.13 for heat transfer through an open door.

**Install 160 LED fixtures in frozen warehouse:** The lighting measure was actually implemented over two years. In 2011, (80) fixtures were installed, while (75) were installed in 2012. Of the total (160) fixtures, (17) remain on all the time while the rest are on motion sensors, shut off approximately 80 percent of the time. The project replaced 1000W Metal Halide fixtures with 278W LED high bay fixtures. DNV KEMA verified the wattage, quantity, and operating hours of the lights, as well as the cooling efficiency of the warehouse. DNV KEMA used a simple delta-watts calculation with refrigeration savings based on a COP of 5.0 to estimate the energy savings. Because none of the always-on fixtures were included in the 2011 calculation, all of those fixtures were included for 2012.

These verification activities yielded a gross savings estimate of 1,323,862 kWh per year, which was 102 percent of the tracking system estimate.

*Facility K*

**Install additional high speed doors, a person door and a forklift door:** The customer replaced a 7' x 10' motor-operated sliding forklift door with well-sealed, fast-acting sliding door on their freezer warehouse. The warehouse is maintained at approximately 5°F. The chiller system operates at a COP of approximately 5.0. Initially, the program had suggested that the plant may be replacing a 3.5' x 6' person-door as well, though that portion of the savings was not included in the analysis. In reality, the plant went ahead with the person door replacement. During the site visit, DNV KEMA verified the installation, dimensions, and open/close timing of the new forklift door, the conditions of the replaced door, the temperatures of the freezer and loading dock, and the cooling efficiency of the warehouse.

For the person door, DNV KEMA verified the dimensions of the new door, and the operating conditions of the replaced door. For the doors savings calculation, DNV KEMA used a methodology found in ASHRAE Fundamentals 1997 section 25.13 for heat transfer through an open door. For the person door, DNV KEMA assumed that it would be functioning properly 50% of the time, as it was found to have a closing mechanism problem which the site contact promised to fix.

These verification activities yielded a gross savings estimate of 91,328 kWh per year, which was 156 percent of the tracking system estimate. The additional measure of the high speed door resulted in additional savings.

### Comparison of Top-down and Bottom-up Energy Savings

DNV KEMA reviewed the top down savings model to compare it with the bottom-up savings for 2012. Table 4 shows the savings results of the top-down model for the facilities that are still part of the program. Many of the model results show negative incremental savings for some years and even over the course of the entire program in the case of plant K. As noted above, one plausible explanation for this result is that some plants periodically make higher energy intensity products. The top-down model is insensitive to the product mix and the coefficient on production units represents the average energy use per product during the pre-program period. The implication is that the model will both overstate and understate expected energy consumption. Thus, the model results for a particular plant may be negative for a year, although the plant may actually be achieving savings. Additionally, the top-down model is not sensitive to the fuel switching that one plant reported.

**Table 4. Estimated Gross Electric Savings from Top-down Model**

| Estimated Gross Electric Savings (MWa) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cumulative Savings | | | | | | Incremental Savings | | | | | |
| Plant ID | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| A | - | 0.094 | 0.403 | 1.027 | 1.448 | 1.308 | | 0.094 | 0.309 | 0.624 | 0.421 | (0.140) |
| B | - | (2.324) | 5.433 | 0.023 | 5.112 | 8.261 | | (2.324) | 7.758 | (5.411) | 5.089 | 3.150 |
| C | - | 0.087 | 0.190 | 0.151 | 0.042 | 0.011 | | 0.087 | 0.104 | (0.039) | (0.110) | (0.030) |
| D | - | (0.137) | 0.146 | 0.239 | 0.304 | 0.211 | | (0.137) | 0.283 | 0.094 | 0.064 | (0.093) |
| E | 0.094 | 0.154 | 0.243 | 0.424 | 0.248 | 0.503 | | 0.060 | 0.089 | 0.180 | (0.176) | 0.255 |
| F | - | 0.024 | (0.010) | 0.066 | (0.039) | 0.109 | | 0.024 | (0.035) | 0.077 | (0.106) | 0.148 |
| G | - | (0.195) | (0.136) | 0.146 | 0.196 | 0.605 | | (0.195) | 0.059 | 0.283 | 0.050 | 0.409 |
| H | (0.017) | 0.072 | 0.089 | 0.098 | 0.082 | 0.076 | | 0.089 | 0.018 | 0.009 | (0.016) | (0.007) |
| I | 0.036 | 0.206 | 0.272 | 0.335 | 0.314 | 0.277 | | 0.170 | 0.065 | 0.063 | (0.021) | (0.037) |
| J | - | (0.474) | 0.243 | 0.702 | 0.797 | No Data | | (0.474) | 0.717 | 0.459 | 0.095 | No Data |
| K | - | (0.045) | 0.220 | 0.110 | 0.111 | (0.116) | | (0.045) | 0.265 | (0.110) | 0.000 | (0.227) |
| L | (0.154) | 0.010 | 0.015 | 0.089 | 0.300 | No Data | | 0.163 | 0.006 | 0.074 | 0.211 | No Data |
| M | - | 0.031 | (0.041) | 0.313 | 0.295 | 0.101 | | 0.031 | (0.072) | 0.354 | (0.019) | (0.194) |
| **Total, Excluding A, B, and M** | (0.041) | (0.299) | 1.272 | 2.361 | 2.354 | 1.676 | | (0.258) | 1.571 | 1.089 | (0.007) | 0.420 |

DNV KEMA recommends using the incremental cost across all plants that participated for the full program duration. This approach recognizes that the results for individual plants may either overstate or understate energy consumption. Aggregating the results mitigates this issue. The top-down results in Table 5 show both the 2012 incremental savings and average yearly incremental savings from 2008 to 2012. The bottom-up results are the engineering estimate of yearly savings for 2012.

**Table 5. Comparison of 2012 Top-down and Bottom-up Savings**

| Plant ID | Incremental Savings, MWa | | |
|---|---|---|---|
| | 2012 Top-Down | Average Top-Down | 2012 Bottom-Up |
| A | -0.14 | 0.262 | 0.000 |
| B | 3.15 | 1.652 | 0.000 |
| C | -0.03 | 0.002 | 0.000 |
| D | -0.093 | 0.042 | 0.000 |
| E | 0.255 | 0.082 | 0.141 |
| F | 0.148 | 0.022 | 0.024 |
| G | 0.409 | 0.121 | 0.020 |
| H | -0.007 | 0.019 | 0.000 |
| I | -0.037 | 0.048 | 0.052 |
| J | No Data | .199 | 0.151 |
| K | -0.227 | -0.027 | 0.010 |
| L | No Data | 0.114 | 0.000 |
| M | -0.194 | 0.020 | 0.000 |
| Total | | | 0.398 |
| Total of current plants only (exclude A, B, and M) | 0.418 | 0.625 | 0.398 |

Three plants did not participate in the program in 2012 (A, B and M). Two of these plants also had poor model correlation. Overall modeled savings from those two plants appeared to be quite unrealistic; savings were modeled at about 20% for Plant A and over 50% from Plant B. These are clearly anomalous results. Therefore, DNV KEMA focused on the current plants, which had models with better fits, to determine the savings from the program.

There are two plausible methods for determining the amount of program's behavioral and structural savings with these data:

1. Use the total incremental savings from year 2012, after excluding plants A, B, and M. This approach yields a 0.02 MWa savings for a 5% savings due to management improvements and behavioral changes.

2. Use the average incremental savings from 2008 to 2012, after excluding plants A, B, and M. This approach yields and incremental savings of 0.227 MWa for a 36% due to management improvements and behavioral changes.

The large variation in the results stems from the inability of top-down models to account for significant sources in energy consumption variation.

As an additional cross check, KEMA calculated the relationship between the top down savings for 2012 and the modeled energy consumption for the current plants in the program. The total savings is 1% of modeled energy consumption using the average top down savings. The average top down approach is considered the most appropriate approach.

**Table 6 Net Savings Compared to Total Plant Electricity Consumption**

| Plant | Bottom up Savings | Average Top Down | 2012 Annual Top Down | Net Savings, based on Average Top-Down Results | Net Savings as a % of Plant's Average Energy Consumption | Net Savings, based on 2012 Top-Down Results Only | Net Savings, % of Plant's 2012 Energy Consumption |
|---|---|---|---|---|---|---|---|
| C | 0.000 | 0.002 | (0.030) | 0.002 | 0% | -0.030 | -1% |
| D | 0.000 | 0.042 | (0.093) | 0.042 | 2% | -0.093 | -5% |
| E | 0.141 | 0.082 | 0.255 | (0.059) | -3% | 0.115 | 5% |
| F | 0.024 | 0.022 | 0.148 | (0.002) | 0% | 0.125 | 11% |
| G | 0.020 | 0.121 | 0.409 | 0.102 | 3% | 0.390 | 14% |
| H | 0.000 | 0.019 | (0.007) | 0.019 | 6% | -0.007 | -2% |
| I | 0.052 | 0.048 | (0.037) | (0.004) | 0% | -0.089 | -3% |
| J | 0.151 | 0.199 | No Data | 0.048 | 1% | No Data | 0% |
| K | 0.010 | (0.023) | (0.227) | (0.034) | -1% | -0.237 | -4% |
| L | 0.000 | 0.113 | No Data | 0.113 | 2% | No Data | 0% |
| Total | 0.398 | 0.625 | 0.420 | 0.228 | 1% | 0.022 | 0.1% |

DNV KEMA also reviewed the results of the models compared to the anecdotal information collected in interviews. Two plants identified a processing difficulty with raw materials that reduced their 2012 efficiency. Both these plants showed negative savings in the top down model. A plant that described a very effective training combined with new equipment that reduced rework and improved their overall efficiency showed significant savings. Another plant that identified an increase in the production of a more energy intensive product showed negative savings. These results suggest that when the model fit is good, the top down model approach reflects activities at the plants. Savings due to the program may be under or overestimated when other effects, such as product mix and raw materials, drive energy consumption but are not modeled. The anecdotal information suggests that the savings due to the program are greater than predicted by the top-down model.

DNV KEMA recommends future top-down models include data on site-specific variables that affect energy consumption, such as product mix, fuel type, operating hours, and seasonal effects. The facility also can provide information on changes at the facility that effect energy consumption outside of energy efficiency activities, such as changes in processes or new environmental requirements. DNV KEMA also recommends establishing a baseline when this data is available, which may be subsequent to the initiation of the program. Many facilities began tracking additional variables, such as the energy consumption by specific products, after they adopted the methods of the Food Processing Initiative program. Additional data would allow the development of more informed conclusions.

# APPENDIX E - NWFPA TOP DOWN SAVINGS ASSESSMENT

## APPENDIX E.1 - NWFPA DATA DESCRIPTION MEMO

Memo to : Steve Phoutrides

From : Andrew Stryker, Madhur Lamsal, and Julia Vetromile

Subject : NWFPA Data Description

DNV KEMA is performing a top-down analysis of energy consumption at food processing facilities. The facilities are part of the Northwest Food Processing Association (NWFPA) and are all implementing a strategic energy management program. The goal of the top-down analysis is to quantify changes in energy consumption as a result of this program.
This memorandum reports on the NWFPA data. The memorandum (1) documents the NWFPA data, (2) assesses the sufficiency of the data for a top-down analysis, and (3) explores the relationship between energy consumption and food production. The objective is to identify sites where there is enough data to explain the month-to-month variation in energy consumption. The results in this memorandum will inform the remainder of the top-down analysis.

### Data Documentation

The NWFPA delivered a total of 45 files of monthly energy consumption and food production data, 39 of which were delivered, processed, and were available when we began drafting this memorandum. All but one file follow an identical format. The primary[3] variables in these files are:

- Site ID—site specific identifier
- NAICS—the industrial classification for each site
- Electricity consumption—in kilowatt-hours (kWh)
- Gas consumption—in British thermal units (BTU)
- Other energy consumption—in BTU
- Net Food Product—in pounds (lbs)
- Raw material input—in lbs

The data for one site (A123) did not follow this format. The data for site A123 shows separate production data by product type and characterizes the different raw material inputs. Since the data for this site is quite different than other sites, we will report on this site separately.

[3]The data files include several *derived* variables (e.g., total energy consumption). All of the derived variables are the result of calculations using the primary variables.

These variables are generally sufficient for modeling the variation in energy consumption. The data appear to include all energy consumption as opposed to strictly electricity. There are, however, a few concerns:

- Net product obscures the plant activity. Net product is the total amount of product minus the amount that discarded as waste due to spoilage, defects, or similar issues. Total product is a strong predictor of energy consumption as it more closely reflects the amount of production activity.
- The data do record product variation. Except for site A123, the model will not be sensitive to the effects that changes in the product mix have on energy consumption.
- The NAICS codes are missing for some sites. A basic understanding of the plant operations is a useful model development. The sites with a missing NAICS code are: A011, A022, A031, A044, A059, A061, and A069.

**Data Sufficiency**

The most basic requirement for the top-down analysis is three years of non-zero production and consumption data. That is, the analysis requires monthly observations when the site is in production. Figures 1-4 show the number of non-zero energy consumption, raw material, and food production observations. Not all sites consume natural gas or alternative fuels. We fully expected not to see data in these consumption categories for some sites.
Nearly all sites have more than three years of monthly consumption and production observations. Further, nearly all the sites have a consistent number of observations across measurements. However, several sites deviate from the general expectations:

- Two sites (A042 and A046) have less than three years of data.
- One site has weekly (A023) data.
- Some sites (A027, A028, A034, A036, and A109) have energy consumption without production. This is reasonable as the food production is seasonal. Some plants are likely to have management and storage activity when not running production operators.
- Two sites (A011 and A033) have production in months without recorded electricity consumption. We need further clarification on the plant operations at this site.

Note that there is one site, A033, where there is food production without recorded electricity consumption. We need further clarification from the NWFPA before we can include this site in the top-down analysis.

**Figure 6 Number of Non-Zero Monthly Observations by Measure and Site (part 1)**

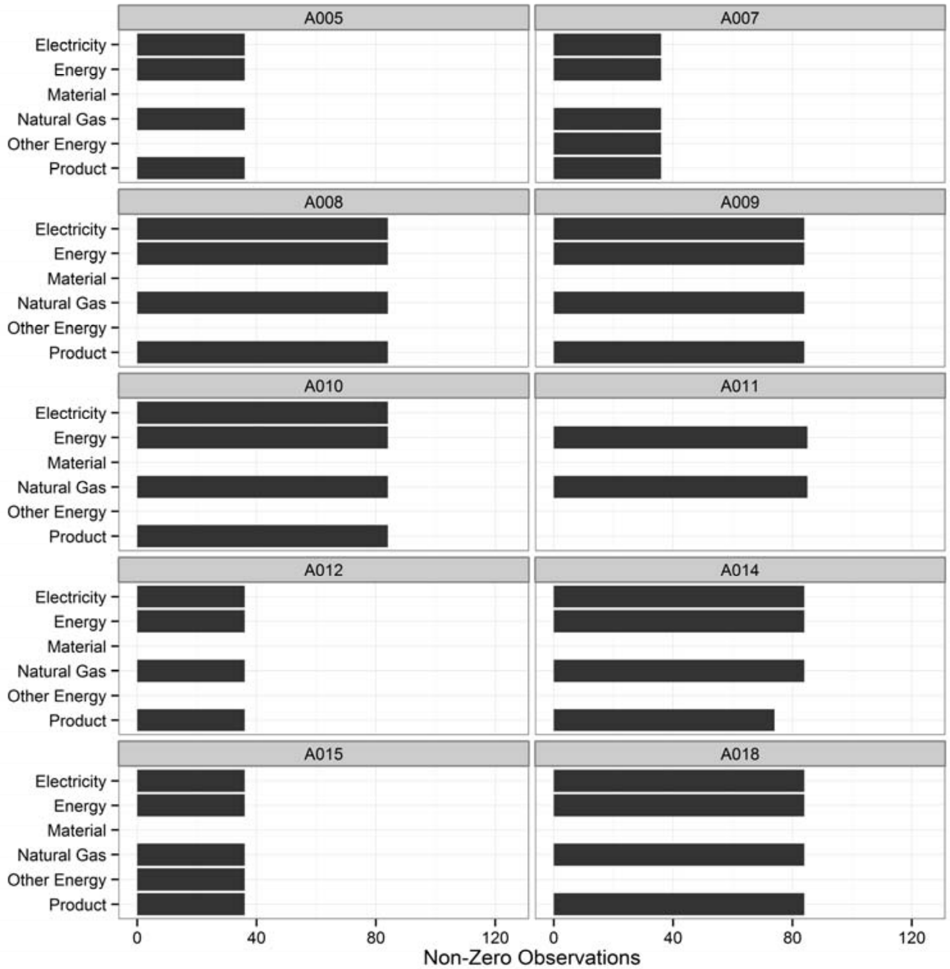


**Figure 7 Number of Non-Zero Monthly Observations by Measure and Site (part 2)**

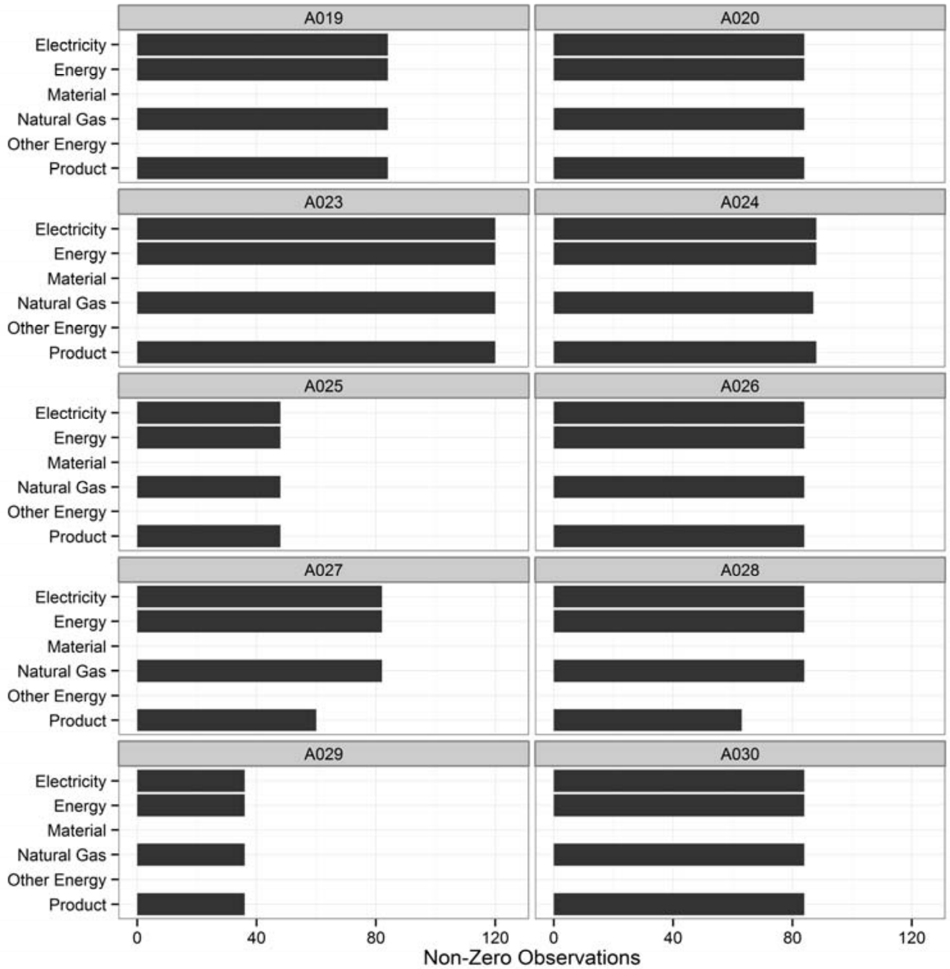


**Figure 8 Number of Non-Zero Monthly Observations by Measure and Site (part 3)**

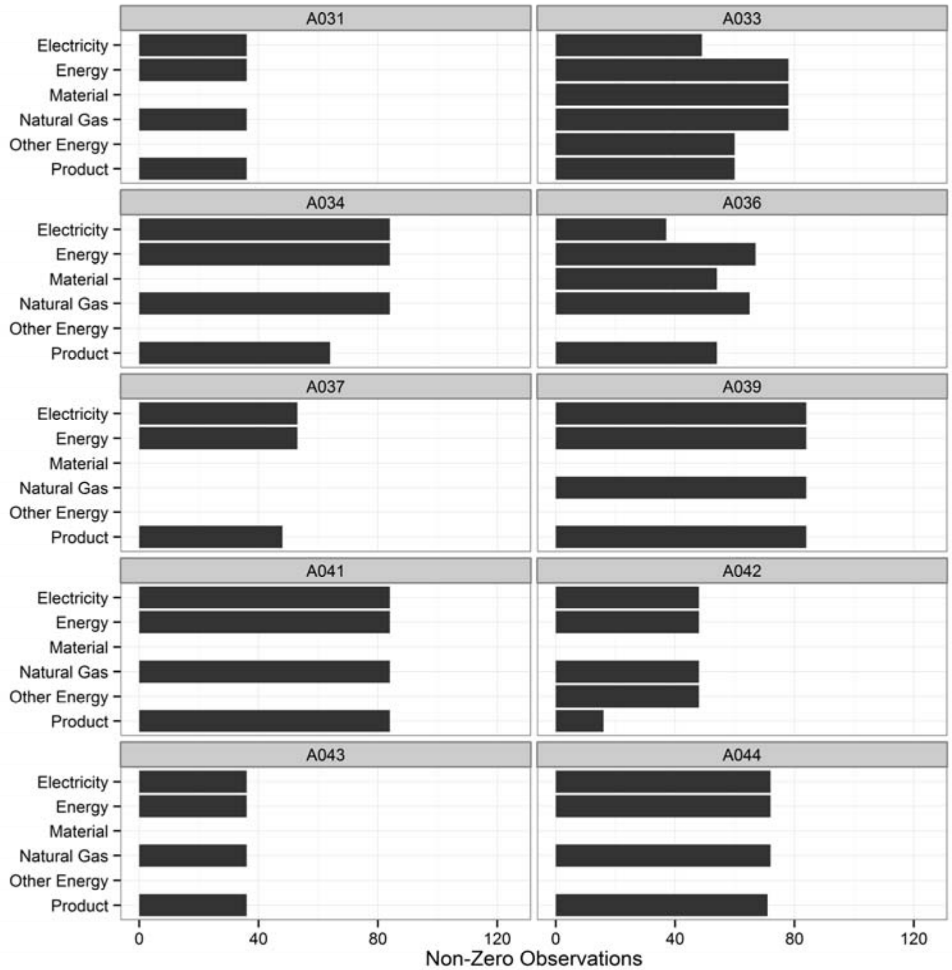
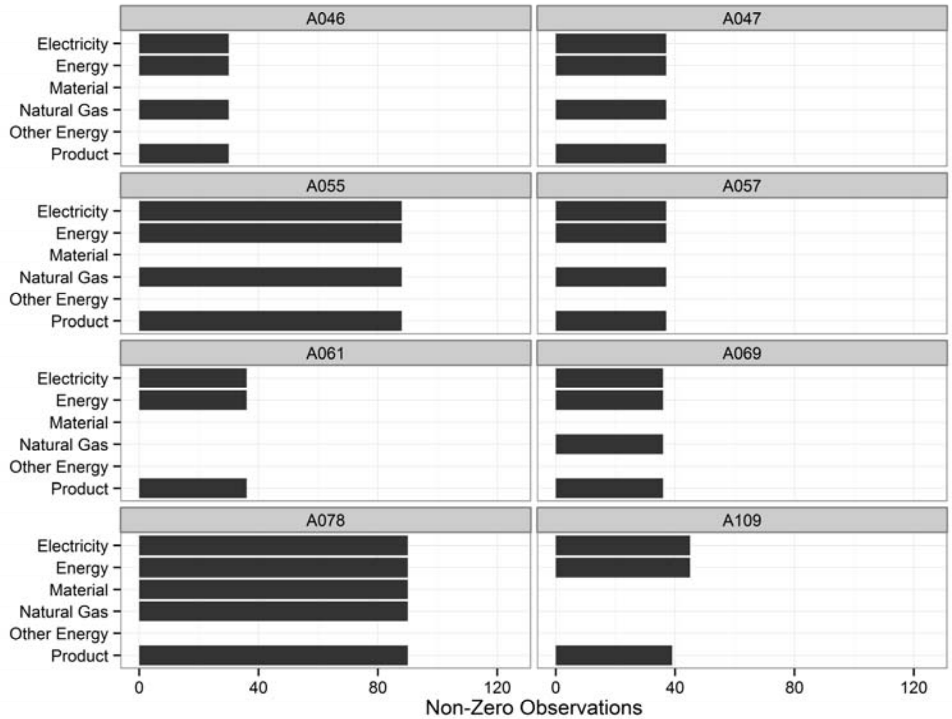


**Figure 9 Number of Non-Zero Monthly Observations by Measure and Site (part 4)**




The second element of data sufficiency is whether the data appear reasonable. That is, are there outliers that suggest data problems? Figure 10 and Figure 11show energy consumption and food production over time. The vertical scale is in nominal units, allowing the graph to show energy consumption in MMBTU and food production in pounds. The expectation is that both energy consumption and food production should both vary together over time. In most cases, this is exactly what the graphs show. There are, however, a few sites where this is not the case, suggesting data errors:

- One data error that is typical of monthly data is two successive and opposite extreme reads. Sites A026 and A061 provide a clear example where one month in 2011 is much higher than all other data points. The following month is lower than all other data points. This is often case in billing data where the second month corrects for an inaccurate estimate in the first month.
- A second data concern is local minimums and maximums in one series without a corresponding movement in the other series. For example, site A030 shows a drop in food production in 2009 without a drop in energy consumption. Likewise, site A061 has a large increase in food production in 2011followed by a sharp decrease. Since we expect production and consumption to move together, these data points are suspect. As we model these sites, we may uncover similar issues in other sites.
- Site A023 shows a radical change in both energy consumption and food production in 2010. We need further information to understand the underlying process.

**Figure 10 Energy Consumption and Food Production over Time by Site (part 1)**

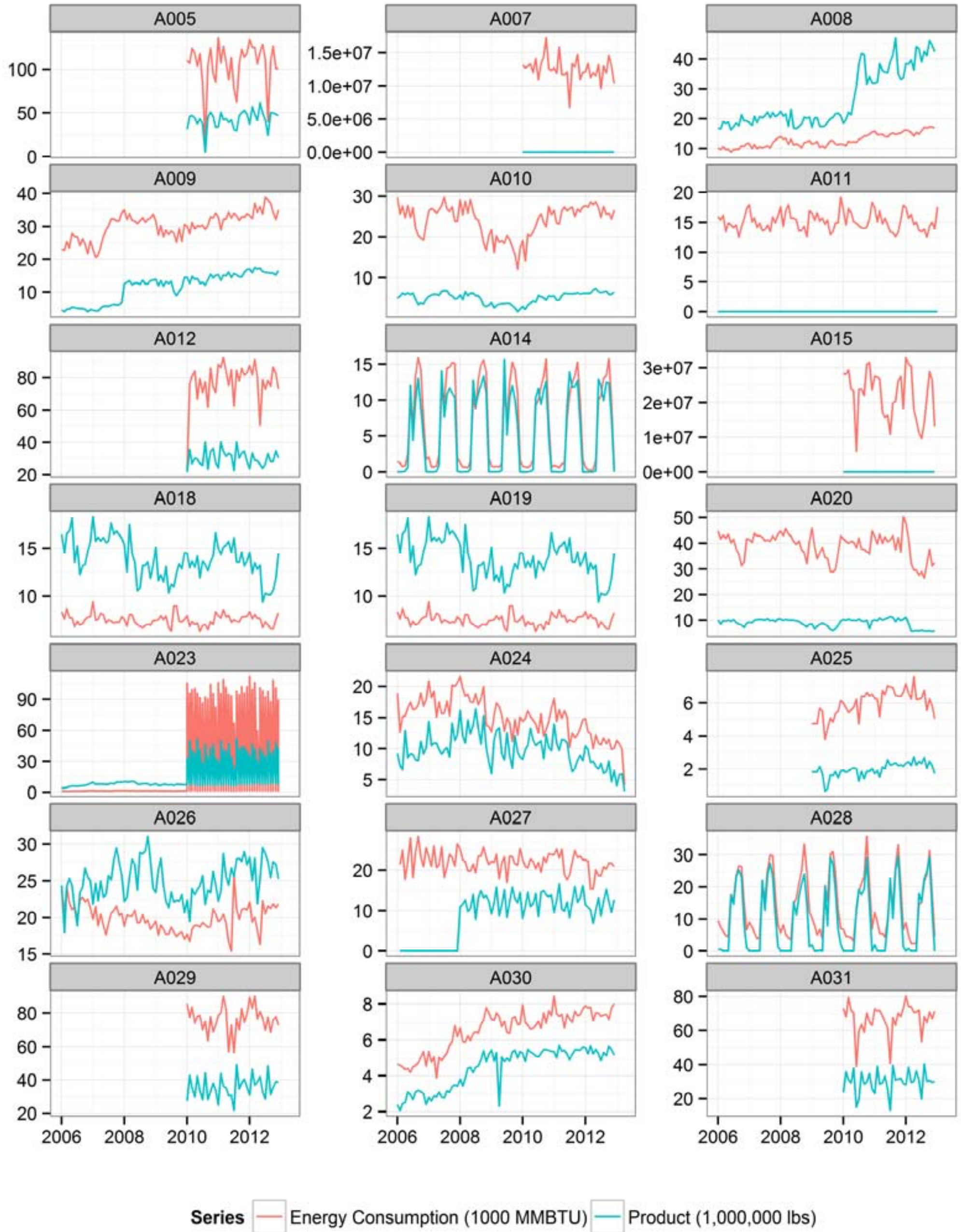
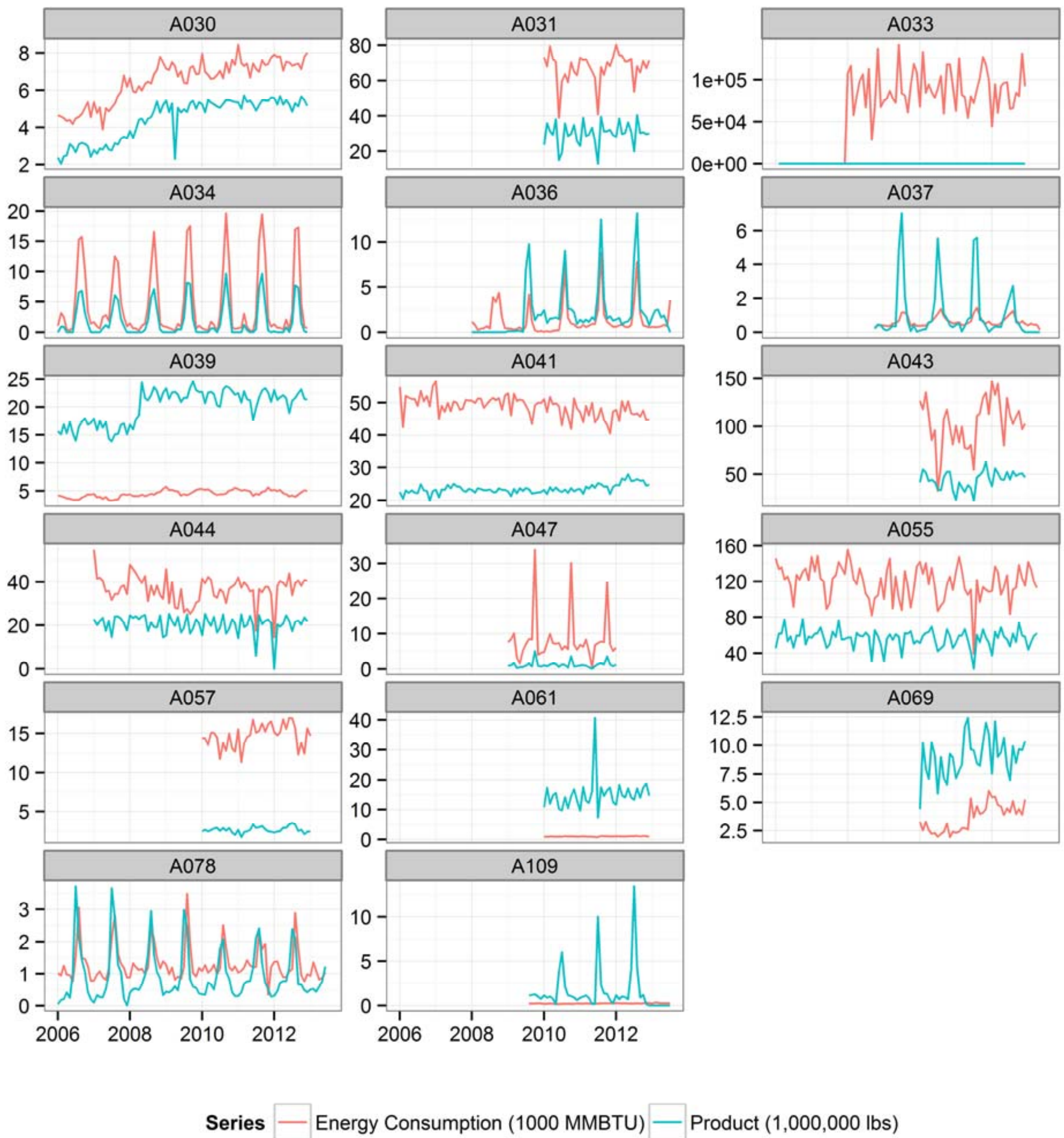


**Figure 11 Energy Consumption and Food Production over Time by Site (part 1)**




The graphs show several sites where either food production or energy consumption does not appear to vary. As noted above, site A011 is missing food production data. For other sites (A007, A011, A015, A109, and A061) this is due to a scaling issue on the graphs. The variation in the underlying data is not evident in Figure 10 and Figure 11 due to the vertical scale.

**Consumption and Production relationships**

The final purpose of this memorandum is to document relationships between energy consumption and food production. Our expectation is that we can use the relationship between food production and energy consumption to model the variation in energy consumption.

Figure 12 and Figure 13 show a scatterplot of the log food production (on the horizontal axis) and the log of energy consumption (on the vertical axis). The graphs use a natural logarithm transformation of food production and energy consumption in order to show the data from all the sites using a common scale. Figure 12 does not include a scatterplot for site A011 as this site is missing production data.

Nearly all the sites show the relationship that we expect: energy consumption rises with rising food production. This trend is also evident in the time series plots shown in Figure 10 and Figure 11. However, Figure 12 and Figure 13 show this relationship more directly. We can use these graphs to form expectations on how to model energy consumption:

- With few exceptions, energy consumption is a linear function of food production.
- There are a few sites where there are different linear responses. For example, the site A009 plot suggests that the relationship between consumption and production depends on the food production level. Sites A028 and A034 also show a bifurcated response to changes in food production. This suggests using spline regression techniques to control for differences between high and low levels plant operational intensity.
- Sites A027, A041, and A109 do not show the linear relationship that we expect. This could be due to an error in the data errors. We will need further information to understand how to model energy consumption for these sites.

**Figure 12 Scatterplot of Food Production and Energy Consumption by Site (part 1)**

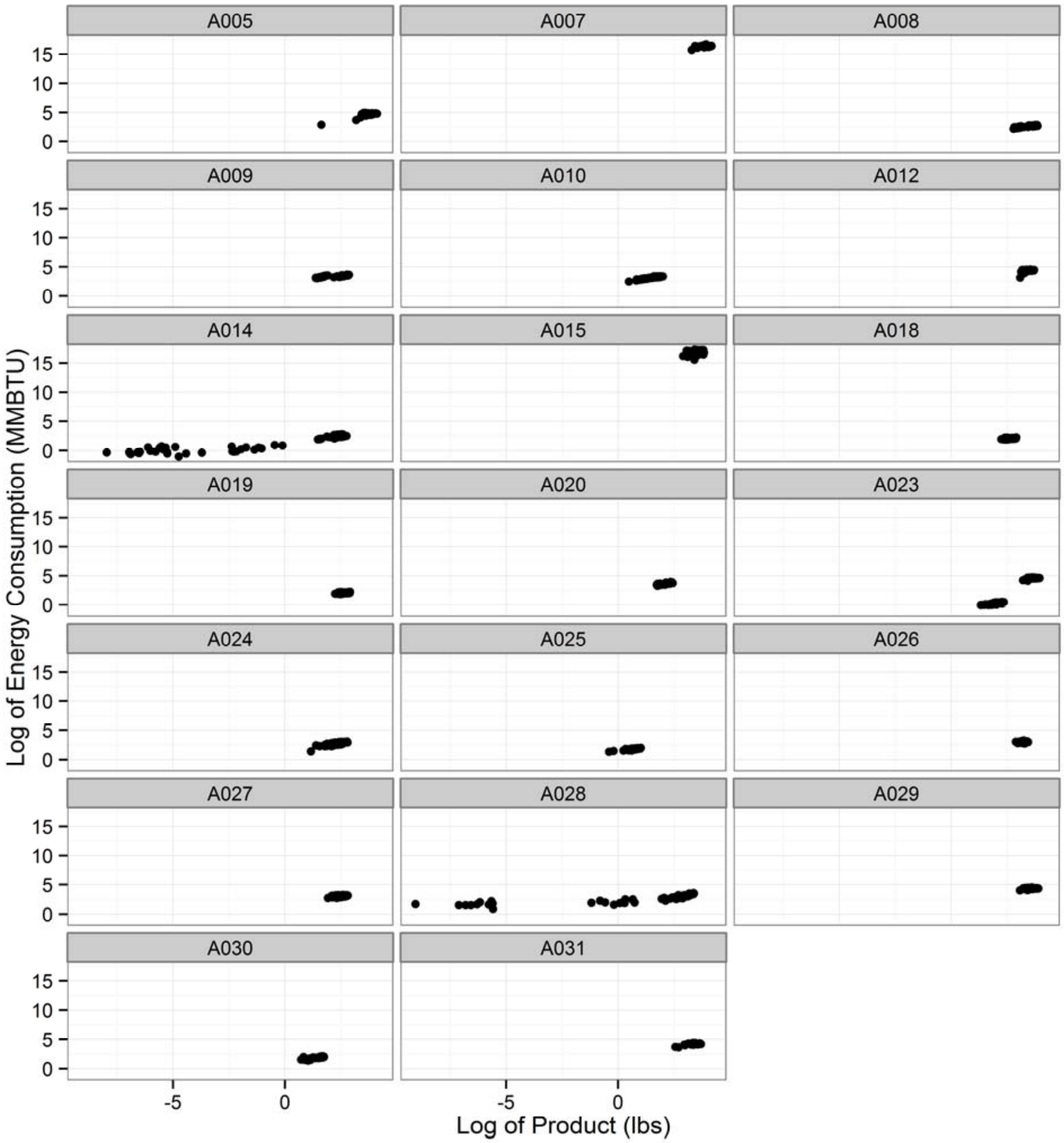


**Figure 13 Scatterplot of Food Production and Energy Consumption by Site (part 2)**

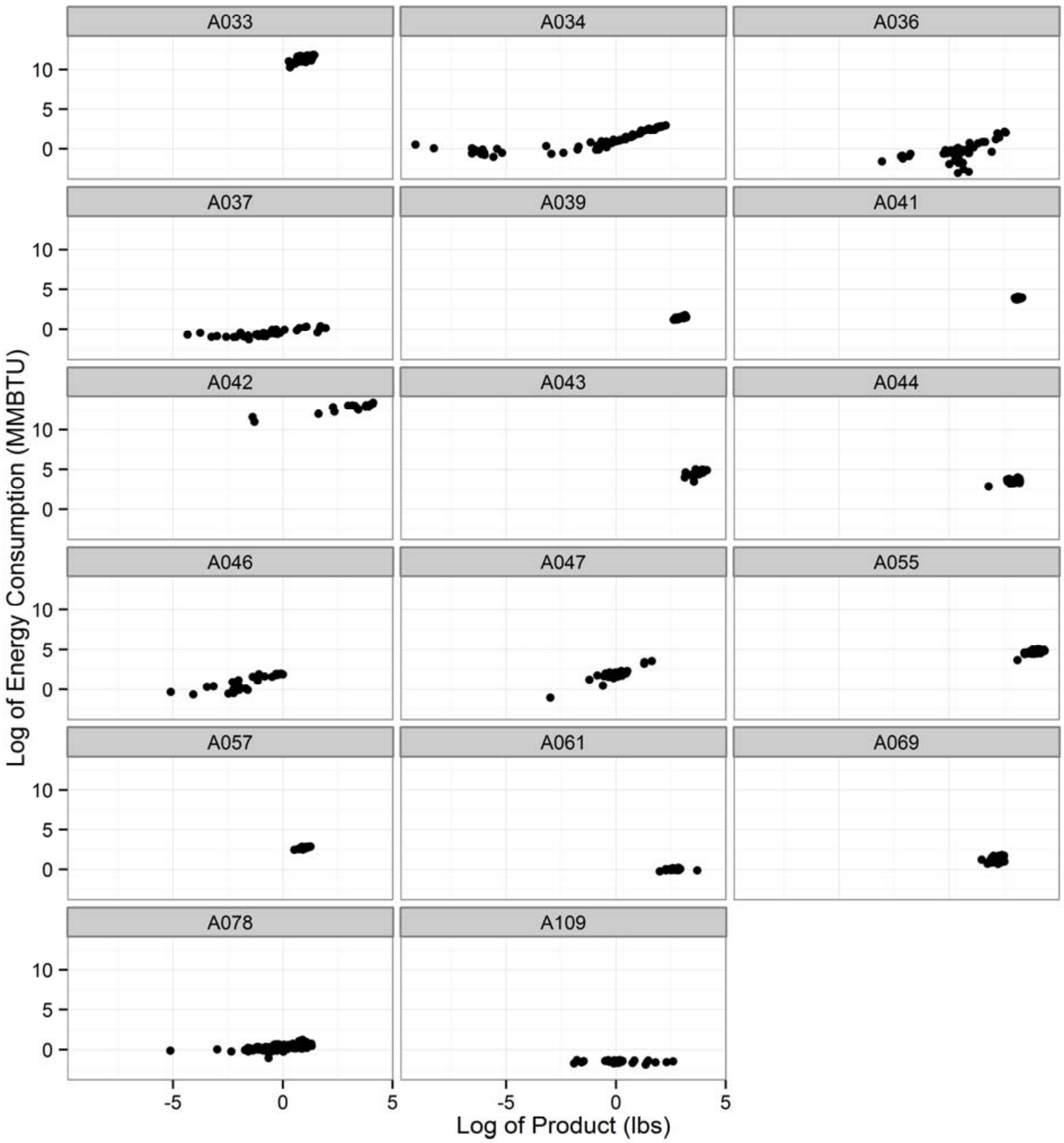



Table 7 shows the correlation between food production and different energy measurement by site. Many sites have a very high (over 0.85) correlation value between production and total energy consumption. High correlation values suggest that food production will be able to explain variation in energy consumption. This finding is consistent with Figure 12 and Figure 13. The table does highlight that for some sites (e.g. A007 and A008) there is a stronger correlation between food production and electricity and production than between total energy and food production. For these sites, we could benefit from additional information on the underlying industrial process and how the plant uses various fuel types.

**Summary and Recommendations**

This memorandum highlights a minimal set of data issues. There are a few places were the data do not follow expectations and appear suspect. Additionally, the relationships between energy consumption and food production do not follow expectations for a small number of sites. Of the 39 sites we examined, we have noted:

- 19 have high correlation statistics of over 0.75. This indicates that production is able to explain a large amount of variation in energy consumption without addition explanatory variables. These sites tend to have tight lines in the scatterplots in Figure 7 and Figure 8.
- 11 have medium correlation statistics of over 0.35 and under 0.75. These sites have large amounts of variation that production alone cannot explain. This could be due to base loads during non-production months or to more complicated relationships between production and consumption.
- 7 have low correlation statistics under 0.35. We need further information on the data validity and operations of these sites in order to model energy consumption.
- 1 site (A011) is missing production data.

Our recommendations on how to proceed are as follows:

- Request clarification on the data for sites A011, A 23, A026, A30, and A061. These sites all appear to have data errors.
- Request additional information on the sites with low correlation statistics. With additional insights, we may able to better understand the variation in energy consumption.

Overall, the data received from NWFPA seem reasonable and show the relationships that we expect to see. Our next steps in the top-down analysis are:

1. Combine the production and consumption data with weather data.
2. Develop models that explain energy consumption as a function of production and weather.
3. Test for program effects.

**Table 7 Correlation between Food Production and Energy**

| Site | Total Energy | Electricity | Natural Gas | Other Energy |
|---|---|---|---|---|
| A005 | 0.754 | 0.739 | 0.747 | NA |
| A007 | 0.373 | 0.544 | 0.498 | 0.373 |
| A008 | 0.878 | 0.924 | 0.783 | NA |
| A009 | 0.777 | 0.803 | 0.752 | NA |
| A010 | 0.935 | 0.793 | 0.926 | NA |
| A012 | 0.437 | 0.265 | 0.429 | NA |
| A014 | 0.955 | 0.987 | 0.904 | NA |
| A015 | 0.246 | 0.304 | 0.257 | 0.246 |
| A018 | 0.495 | 0.571 | 0.361 | NA |
| A019 | 0.495 | 0.571 | 0.361 | NA |
| A020 | 0.842 | 0.803 | 0.796 | NA |
| A023 | 0.974 | 0.973 | 0.973 | NA |
| A024 | 0.767 | 0.689 | 0.698 | NA |
| A025 | 0.776 | 0.681 | 0.724 | NA |
| A026 | 0.333 | 0.161 | 0.335 | NA |
| A027 | -0.057 | -0.057 | -0.049 | NA |
| A028 | 0.959 | 0.976 | 0.896 | NA |
| A029 | 0.362 | 0.397 | 0.339 | NA |
| A030 | 0.879 | 0.850 | 0.656 | NA |
| A031 | 0.612 | 0.647 | 0.560 | NA |
| A033 | 0.919 | 0.710 | 0.005 | 0.919 |
| A034 | 0.991 | 0.880 | 0.984 | NA |
| A036 | 0.752 | 0.730 | 0.509 | NA |
| A037 | 0.771 | 0.771 | NA | NA |
| A039 | 0.764 | 0.713 | 0.575 | NA |
| A041 | -0.018 | 0.415 | -0.163 | NA |
| A042 | 0.903 | 0.974 | 0.992 | 0.903 |
| A043 | 0.654 | 0.530 | 0.623 | NA |
| A044 | 0.504 | 0.593 | 0.438 | NA |
| A046 | 0.908 | 0.951 | 0.896 | NA |
| A047 | 0.951 | 0.951 | 0.946 | NA |
| A055 | 0.493 | 0.589 | 0.426 | NA |
| A057 | 0.694 | -0.043 | 0.784 | NA |
| A061 | 0.088 | 0.088 | NA | NA |
| A069 | 0.299 | 0.130 | 0.278 | NA |
| A078 | 0.635 | 0.455 | 0.596 | NA |
| A109 | -0.212 | -0.212 | NA | NA |

## APPENDIX E.2 - TOP DOWN SAVINGS ESTIMATE MEMO

Memo to : Steve Phoutrides

From : Andrew Stryker, Madhur Lamsal, and Julia Vetromile

Subject : Top-Down Savings Estimate

DNV KEMA has performed a top-down analysis of energy consumption at food processing facilities. The data was provided by the Northwest Food Processing Association (NWFPA), which has been working with facilities under NEEA's guidance to implement a program encouraging strategic energy management (SEM). The goal of the top-down analysis was to quantify changes in energy consumption as a result of the SEM program. This top-down analysis incorporated results from the bottom-up savings achieved through utility programs. Further, evaluations of SEM programs are particularly germane as NEEA and other energy efficiency program sponsors are considering whether to increase their investments in commercial and industrial programs that seek lower energy consumption through more efficient operations. The results in this memorandum demonstrate measureable savings from NWFPA's program. Further, the memorandum discusses where better visibility into plant operations and more rigorous analysis will result in better estimates of activity.

This memorandum describes the methods and analysis DNV KEMA used to model monthly energy consumption and to calculate gross savings estimates due to the program. The memorandum begins with a summary of findings. The memorandum continues with a description of the weather data and a summary of the modeling process, detecting program influence, and estimating savings.

### Summary of Findings

The NWFPA provided monthly energy consumption data and food production data for 44 member sites that participated in the NWFPA Roadmap program. These sites ranged in size from a base year load of 7,200 kWh to 1,505,800 kWh. The top-down analysis models energy consumption as a response to the activity level and environmental conditions at each. The top-down models contain four groups of variables:

- Total energy as the dependent variable. The data for many sites listed energy consumption by fuel type. The goal of top-down analysis is quantify changes in the overall energy consumption regardless of fuel. Savings from utility programs are reflected in the energy consumption.
- Net production as the primary measure of activity level. The data contains net production rather than gross production. The difference is that net production is the total product of a plant minus the amount discarded. Energy consumption is a response to gross production,

regardless of its final disposition. As such, net production is not an ideal measure of activity level. Moreover, this measure does not take into account differences in product throughout the year. Food processing facilities may switch products in response to agricultural growing seasons and seasonal product cycles.

- Heating and cooling degree days as a measure of the environmental conditions. Indoor climate control is not typically a major energy use at industrial sites. However, drying and refrigeration processes can show a significant response to degree days.
- Monthly effects to other activity and environmental influences. Many of the sites show strong seasonal patterns in energy consumption after controlling for activity level and degree days. The most likely source is seasonal changes to the product mix.

DNV KEMA was able to fit reasonable models for 23 of the 44 sites. We accepted the models as reasonable if the results met the following criteria:

- The production coefficient was statistically significant and had a reasonable magnitude.
- The $R^2$ value was at least 0.75.

The theory behind strategic energy management is that site operators will make continual efficiency improvements over time through better maintenance and operations practices. When the program is working as expected, the food processing sites should show a decrease in energy consumption over time after accounting for the installation of energy efficiency measures, plant activity level, and environmental conditions. To test this theory, we added a time index to each of the 23 models. The savings estimate is the difference between energy consumption in the first year of measurement compared to what the model would have predicted in the last observed year of the program.

Table 8 shows the base year consumption, the predicted consumption and the savings estimates. Our analysis shows that the measurable savings due to program activity are about 1% of baseload, although the variation by individual facility is very high. The range of savings results is likely due to unknown factors that influence energy consumption but could not be included in the models. Further refining this estimate using statistically adjusted engineering techniques will likely increase the savings estimate.

Table 8: Base year consumption and savings estimates in MMBTU

| Site | Base Year Consumption | Predicted Consumption | Annual Savings | Savings Percent |
|---|---|---|---|---|
| **A005** | 1,190,064 | 1,192,545 | -2,481 | -0.21% |
| **A008** | 121,362 | 156,083 | -34,721 | -2928.61% |
| **A010** | 292,204 | 284,239 | 7,964 | 31.79% |
| **A014** | 76,261 | 65,825 | 10,436 | 1413.69% |
| **A015** | 1,060,079 | 1,034,464 | 25,616 | 2.42% |
| **A019** | 425,398 | 383,015 | 42,383 | 109.96% |
| **A020** | 475,594 | 463,825 | 11,769 | 2.03% |
| **A028** | 163,841 | 155,555 | 8,286 | 5.06% |
| **A029** | 904,879 | 891,581 | 13,298 | 1-0.72% |
| **A030** | 55,416 | 75,845 | -20,428 | -3740.80% |
| **A031** | 783,172 | 788,746 | -5,574 | -12.51% |
| **A032** | 165,846 | 175,321 | -9,475 | -67.02% |
| **A034** | 60,830 | 54,809 | 6,021 | 109.90% |
| **A037** | 7,236 | 8,332 | -1,096 | -1526.03% |
| **A039** | 46,222 | 49,582 | -3,360 | -716.05% |
| **A040** | 300,120 | 263,696 | 36,424 | 12.14% |
| **A042** | 73,990 | 69,702 | 4,288 | 65.80% |
| **A043** | 1,170,772 | 1,286,375 | -115,603 | -109.87% |
| **A045** | 15,471 | 15,523 | -52.4 | -0.34% |
| **A046** | 33,458 | 36,697 | -3238 | -1015.96% |
| **A047** | 102,846 | 96,281 | 6,565 | 6.38% |
| **A052** | 136,887 | 117,531 | 19,357 | 14.14% |
| **A055** | 1,505,750 | 1,423,239 | 82,511 | 5.48% |
| | 9,167,699 | 9,088,810 | 78,889 | 0.86% |

## Data Preparation

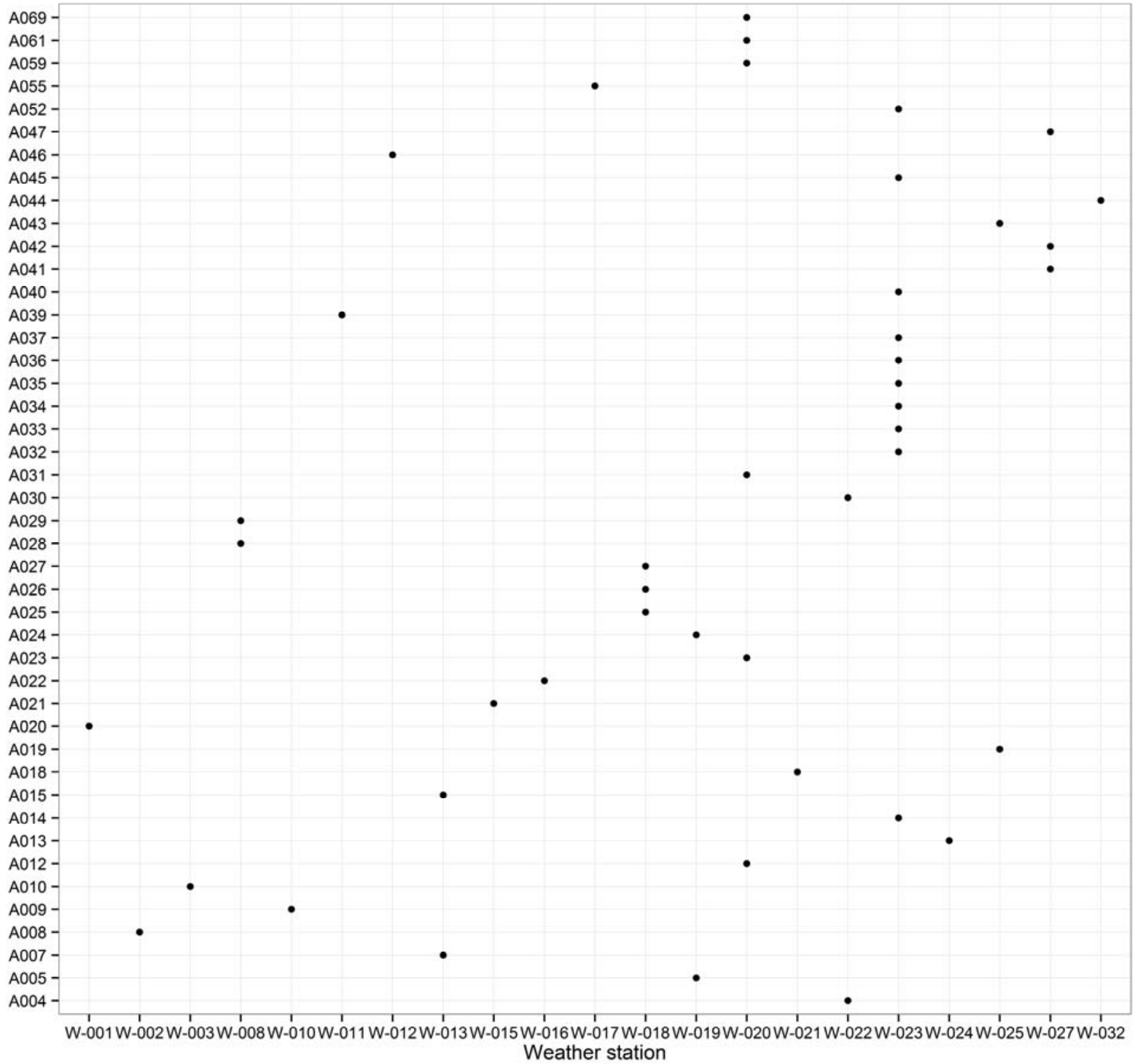
### Weather Data

Top-down models model energy consumption as a response to the activity level and environmental conditions at each site. In a previous memo (provided in Appendix E-1), DNV KEMA described the energy consumption and site production data. In this section, we describe the NWFPA supplied weather stations data and the degree calculations based on these weather data.

### Weather Stations

To maintain the confidentiality of the data provided by participating facilities, NWFPA provided the data to DNV KEMA without the names or addresses of any of the food processing sites. The NWFPA mapped each site to the most appropriate weather stations, as shown in **Figure 14**.

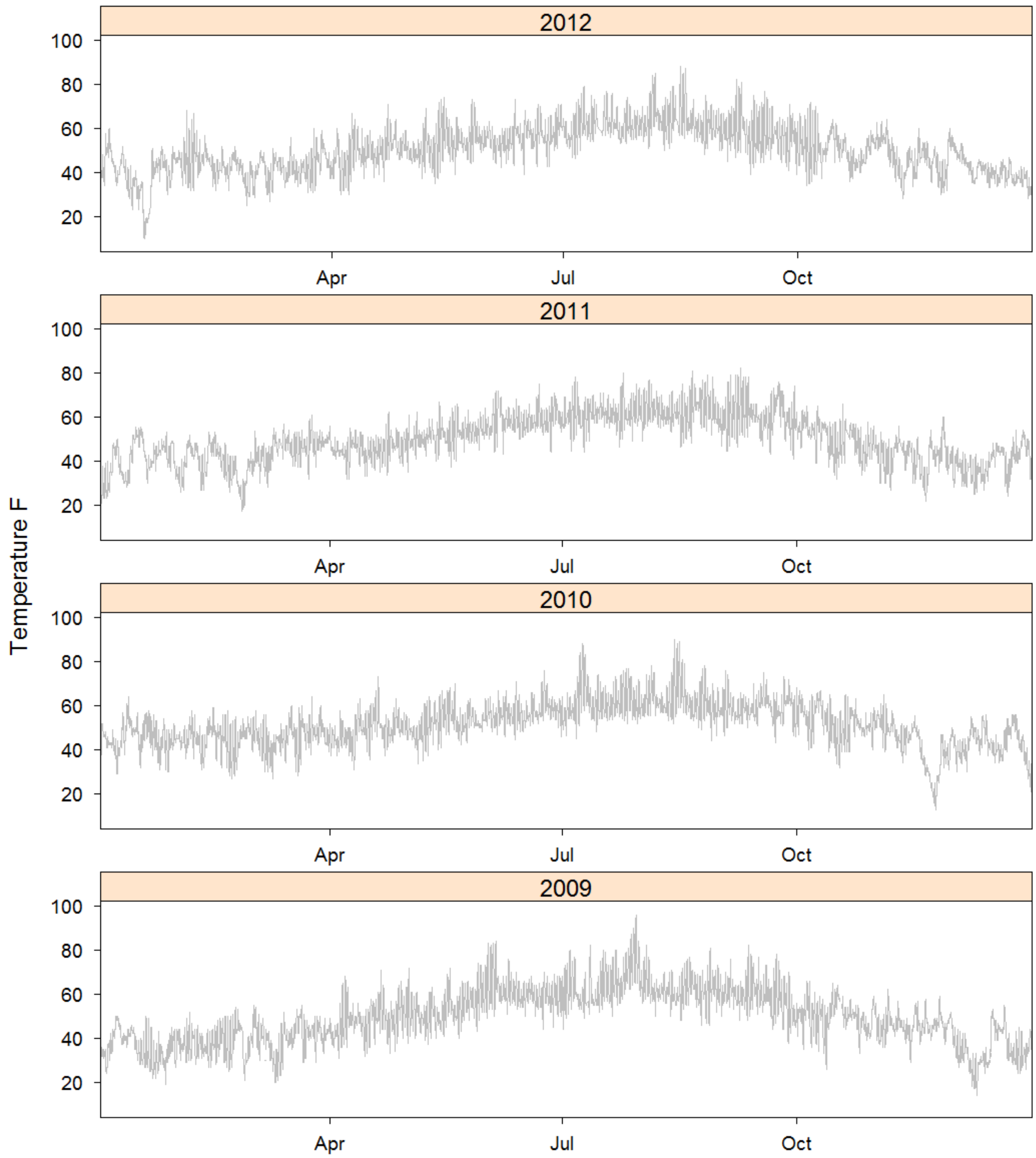
**Figure 14 Weather station to site mapping**




Each of the weather files contains 20 minute or hourly metrological readings. The readings include the dry bulb, wet bulb, and dew point temperatures, and the relative humidity. The data include a mix of nominal twenty minute and hourly readings.

**Figure 15** shows an example of the dry bulb temperatures for station W-001. The temperatures show strong diurnal and seasonal patterns. The temperature range is consistent with climate in the Pacific Northwest where there are typically few readings above 100 degrees Fahrenheit or below freezing.

**Figure 15 Temperatures for station W-001**



### Degree day calculations

The energy consumption data are monthly data. As is typical with energy consumption models, we use the concept of degree days to map the high frequency weather data onto the monthly consumption data. Degree days measure the amount of time during the monthly a site is below or above a reference or basis temperature. For residential and office buildings, this number is usually 65 degrees Fahrenheit. When the outside temperature is above (below) 65, buildings spend energy cooling (heating). Cooling and heating degree days are the cumulative time over the month that the building is above and below, respectively, the reference temperature.
The reference temperature for food processing plants, unlike residential and office buildings, varies considerably depending on the plant configuration. We computed cooling and heating degree for reference temperatures between 50 and 70 degrees Fahrenheit.

### Bottom-up Savings Estimates

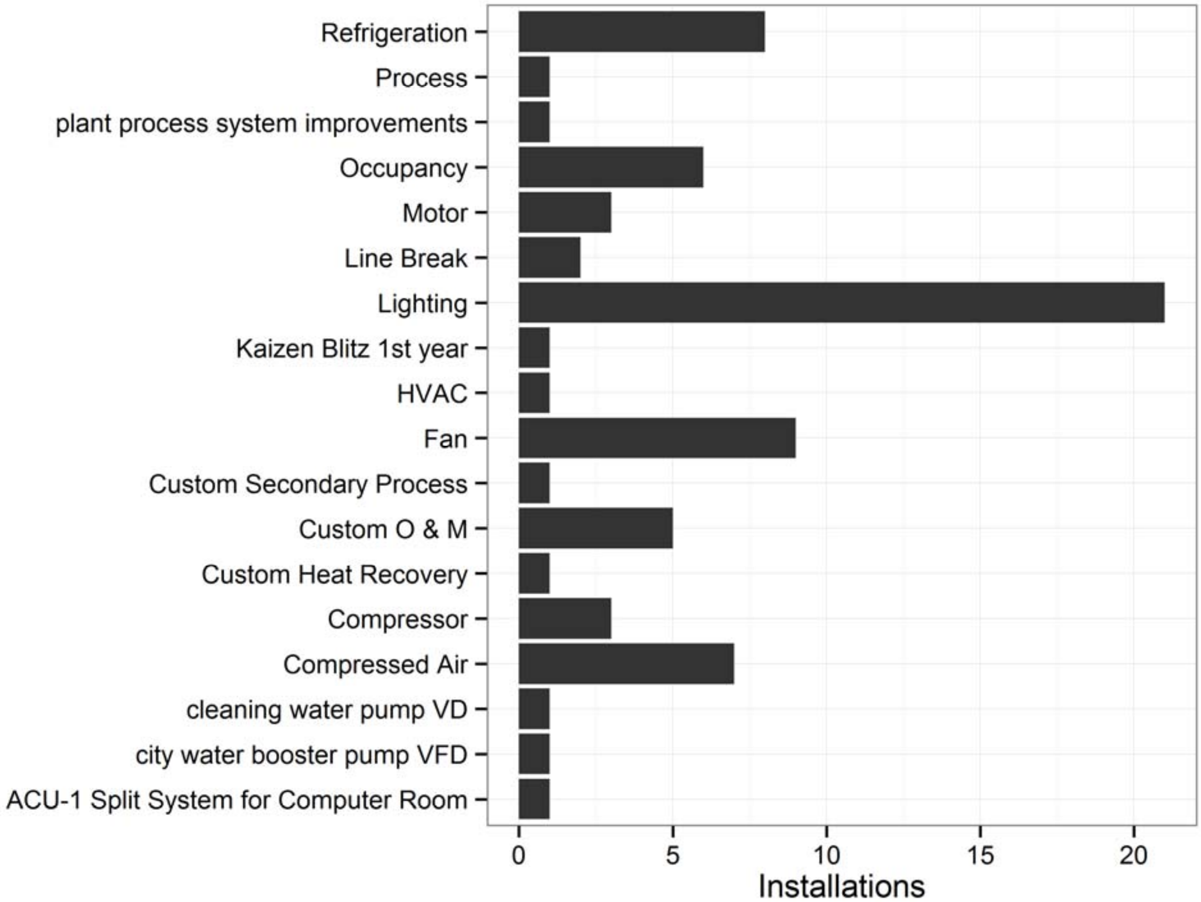
Twenty one sites reported implementing a variety of energy efficiency measure during the study period. **Figure 16** shows a tabulation of measures by type. Estimating savings at these sites poses a special challenge. Reductions in energy consumption are potentially the result of the energy efficiency measures and SEM program activity. The top-down analysis needs to disentangle these two effects.

NEEA and the NWFPA provided annual engineering savings estimates for each of the efficiency measures. There are two basic approaches to handling savings estimates within a monthly top-down analysis framework:

1. Allocate annual savings to months and add the savings estimates to observed energy consumption. This method recognizes that some measures not closely tied to production levels (e.g., lighting) while other (e.g., compressors) are. In this approach, we allocated annual savings to months based on the proportion of production that typically occurs in that month for measures tied to production. Likewise we allocate weather sensitive in proportion to the amount of yearly heating or cooling that occurs within each month.
2. Similar to above, but express the measure savings as a dependent variable within the model. This approach is known as *statistically adjusted engineering*. The coefficients on each of the measure savings are effectively realization rates. Since this approach incorporates the estimates into the statistical analysis process, estimation verifies the annual to monthly allocation.

While the results of the statistically adjusted engineering approach have superior properties, statistically adjusted engineering models take additional time and effort to estimate. To meet time and budget constraints, we did not use the statistically adjusted engineering approach. Instead, we allocated annual measure savings to each month and added the monthly allocation to the observed energy consumption.

**Figure 16 Installed Energy Efficiency Measures**




## Model Estimation

The goal of the model estimation is to find a specification that has both statistically significant explanatory power and exhibits a compelling and consistent story about energy consumption. The models in this section all treat consumption as a linear response to explanatory variables[4]. The energy consumption in each of the food processing plants is a response to the characteristics, activity level, and environmental conditions unique to each site. Our approach, therefore, was to estimate independent models for each site.

The organization of this section follows how we build models. We begin with a model that includes only the term that has the largest theoretical explanatory power. We then add other terms in the expected level of importance to the model. The final model includes only those terms that are statistically significant and have reasonable magnitudes. That is, the section describes a model

[4] Energy consumption is typically a linear response to production. However, other response forms are possible. DNV KEMA explored log-linear, log-log, and linear-log model forms. These models did not yield better levels of fit than the linear-linear model.

with (1) production only, (2) production and degree days, and (3) production, degree days, and adjustments for seasonal effects.

**Production only models**

**Figure 17** shows the overall fit as measured by the $R^2$ or the coefficient of determination value. Models with high $R^2$ values show an overall better fit than models with lower $R^2$ values. A model with an $R^2$ value of 1 is able to explain all monthly variation. A model with an $R^2$ value of 0 is unable to explain any variation. Within the context of modeling monthly energy consumption, models with $R^2$ values over 0.75 can be considered a very good fit, based on the experience of the evaluation team.

**Figure 18** shows the intercept and the production coefficient values for the production only models. The horizontal line segments show the 95% confidence interval around the estimate. The intercept value is effectively the baseline load: the amount of energy a plant consumes when not in operation. The production coefficient is the response in energy consumption from a one unit increase in production.

Overall, the production only models show a wide range of results:

- Twelve sites (A036 to A042) have $R^2$ values over 0.75.
- Several sites (A052, A034, and A042) have $R^2$ values near 1.0. This is a plausible result as energy use for production processes tends to dominate all other end uses.
- Sixteen sites (A041 to A018) have $R^2$ values less of less than 0.25. This result suggests that the data do not show adequately visibility in the underlying process to model the variation in energy consumption. The lack of visibility could be due to large variation in the raw materials, different products throughout the year, or substantial differences between net production and gross production. These factors are potentially large drivers in energy consumption.
- No sites show negative relationship between production and consumption.

**Figure 17 R-squared values for production only models**

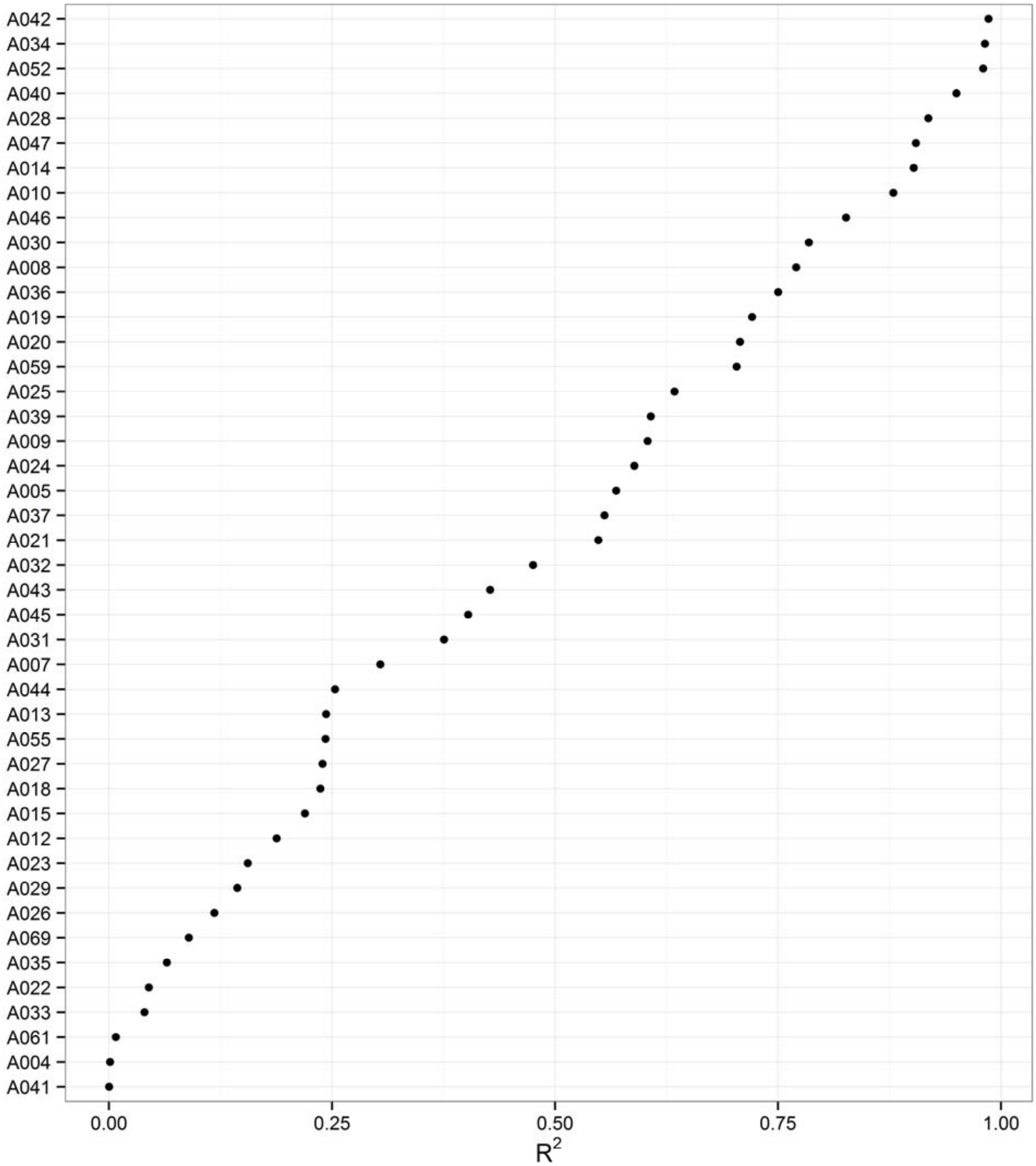
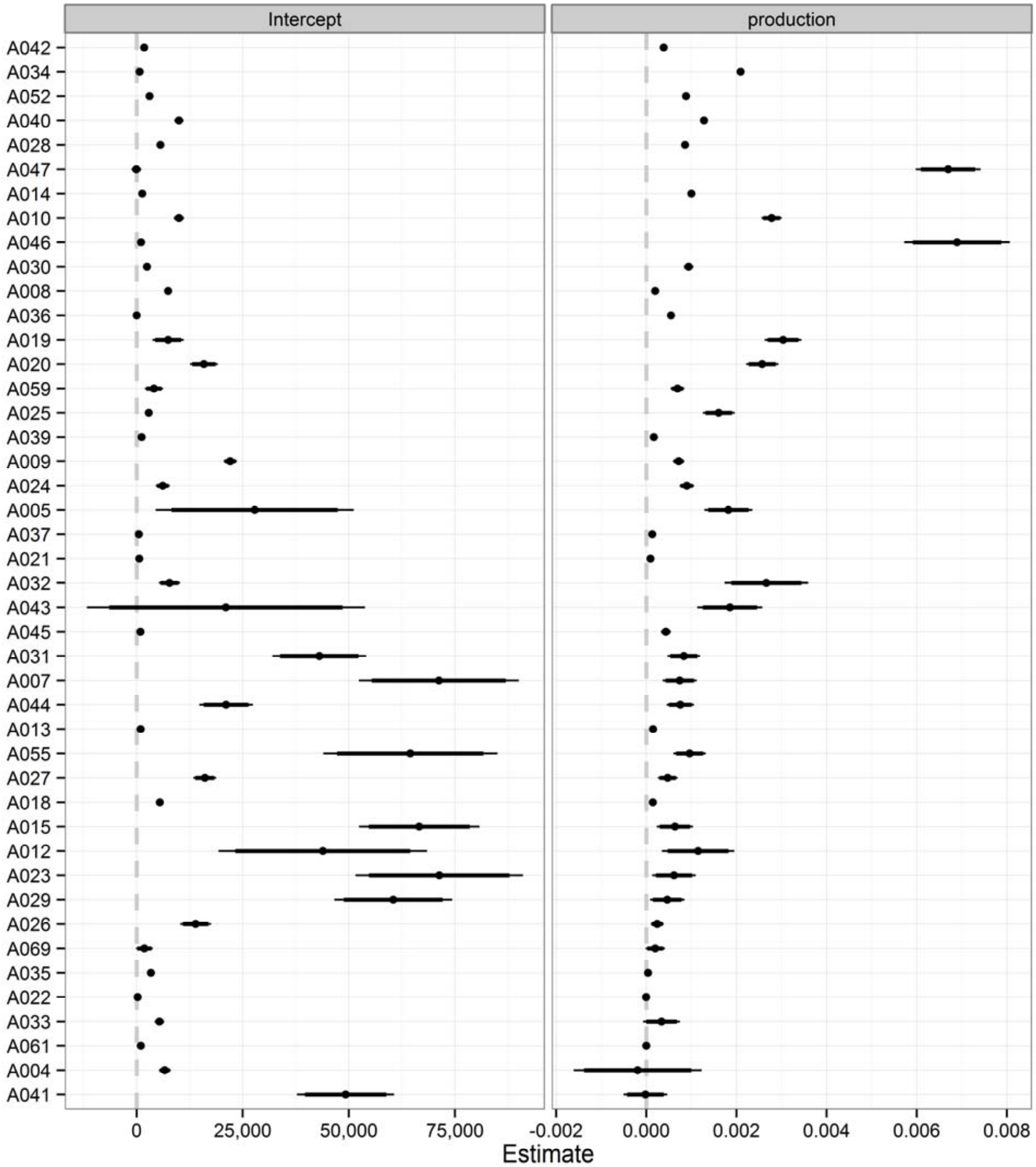


**Figure 18 Production only coefficients**




## Degree Day Models

The secondary driver of the energy consumption is environmental conditions as measured in degree days. As noted above, we tested each site for a unique degree day reference temperature.

**Figure 19** shows the overall fit of the production only model alongside the production and degree day model.

**Figure 20** shows the estimated coefficients for heating and cooling degree days.
Adding degree days to the model resulted in several findings:

- Four models (A041,A035, A032, and A039) show a dramatic improvement in the $R^2$ value. This suggests that these sites are weather sensitive.
- Nearly all models show some improvement in the overall fit. This is expected as adding variables to a model generally improves the fit. However, the models for sites A042, A034, A052, A040, A047, A014, A025, and A045 show negligible improvement. In general, weather influence is not significant except for a few sites.
- Coefficients for heating and cooling degree days are typically positive. Degree days are designed to capture the amount of work heating and cooling systems need to do. That many degree day coefficients are negative when modeling an industrial site is not an issue. Should the site include a heating process, the heating process might need to work in hotter temperatures. Likewise, many food processing plants include freezing and refrigeration components. A negative coefficient on heating degree days could signal that that the cooling units do not work as hard in cold weather.
- Most of the cooling degree day coefficients and several of the heating degree day coefficients are not statistically significant. This is shown in the plot where the horizontal line segments representing confidence intervals cross the 0 line. That at a large number of sites do not show a strong response to degree days is common for industrial sites.

**Figure 19 Production and degree day model overall fit**

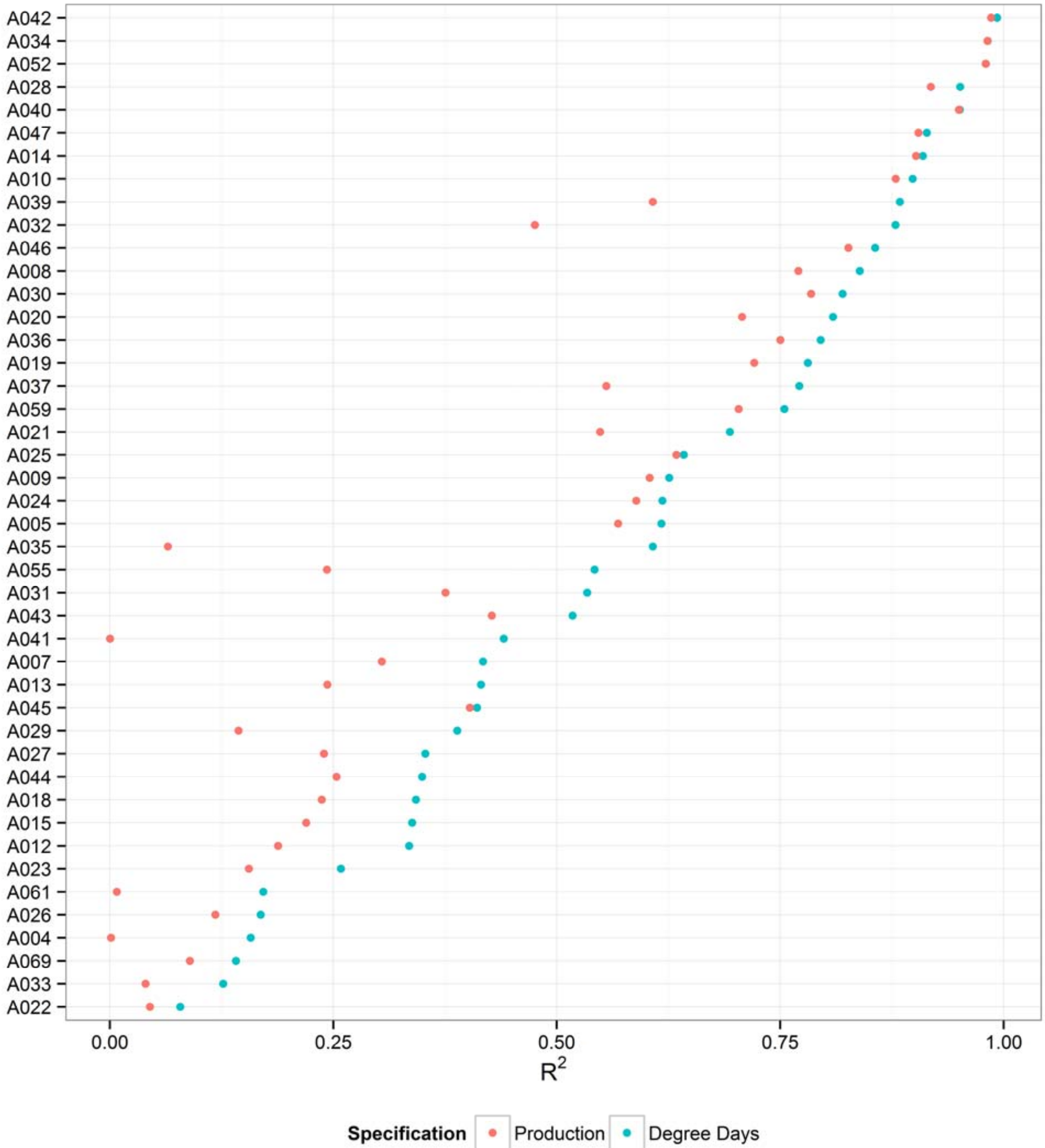
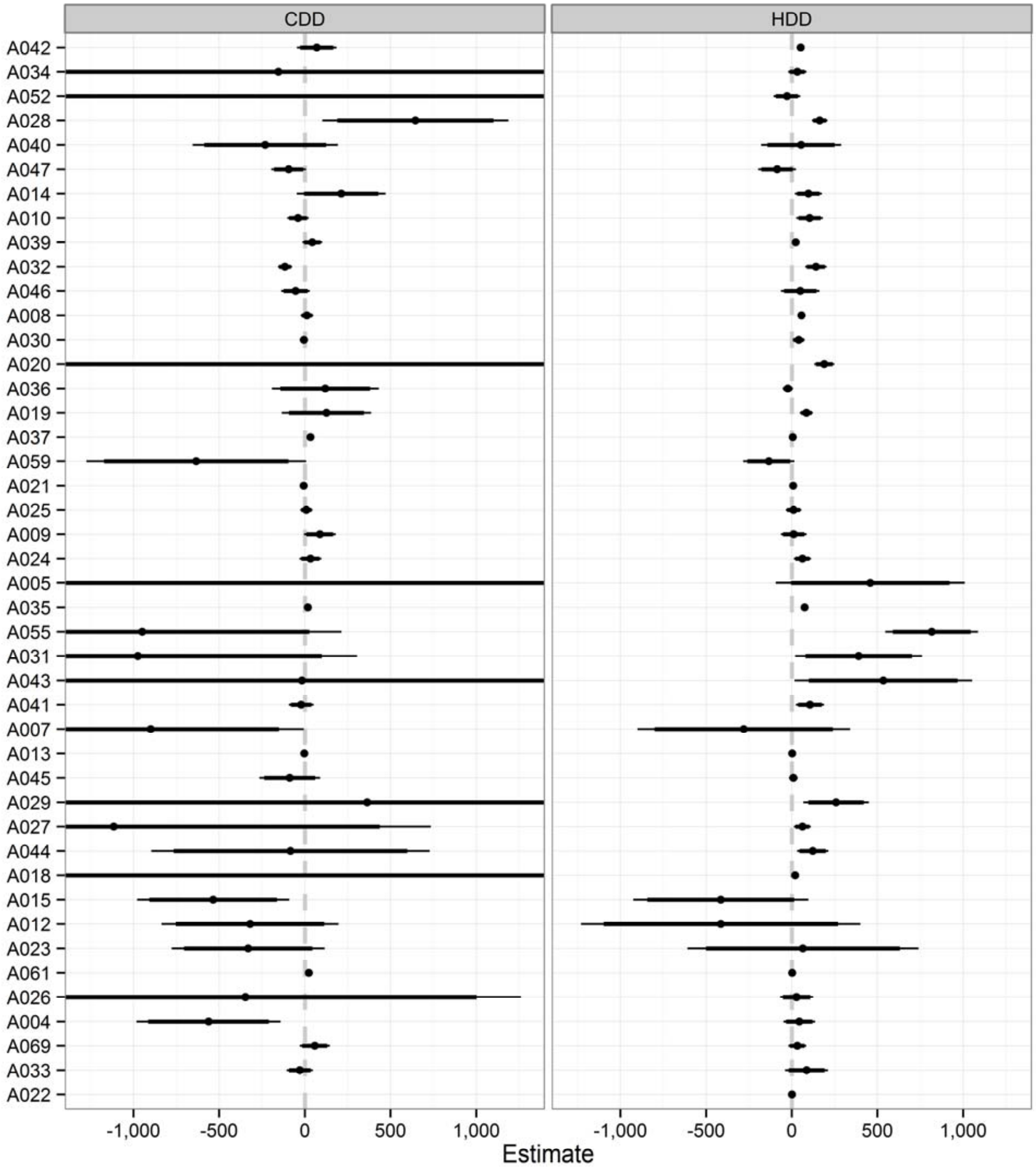


**Figure 20 Production and degree day model degree day coefficients**




## Monthly Effects

With the exception of one site, the NWFPA did not provide DNV KEMA data on different product types or raw material inputs. This is particularly important for agricultural sites as raw material and products change by season. Changes in the raw materials and the product mix may explain energy consumption variation. When changes to the product mix or raw material mix are seasonal, we can capture this through monthly dummy variables. The variables control for the tendency of some month to consistently require less or more energy than other months, after accounting for degree days and production levels.

Figure 21 through Figure 25 show the residuals by month for the model with production and degree days. The residuals measure the difference between the observed energy consumption and the amount of energy consumption that the model predicts. Several sites (e.g. A012, A014, A015, A028, A030, A036, A056, and others) show patterns. The model consistently over or under predicts for certain months of the year.

Figure 26 shows the R2 values for the three models described thus far. After adding monthly effects, only six of the 44 sites have an R2 value of less than 0.5. This demonstrates that there is a large seasonal component that explains variation in energy consumption.

**Figure 21 Residuals after degree day models (part 1)**

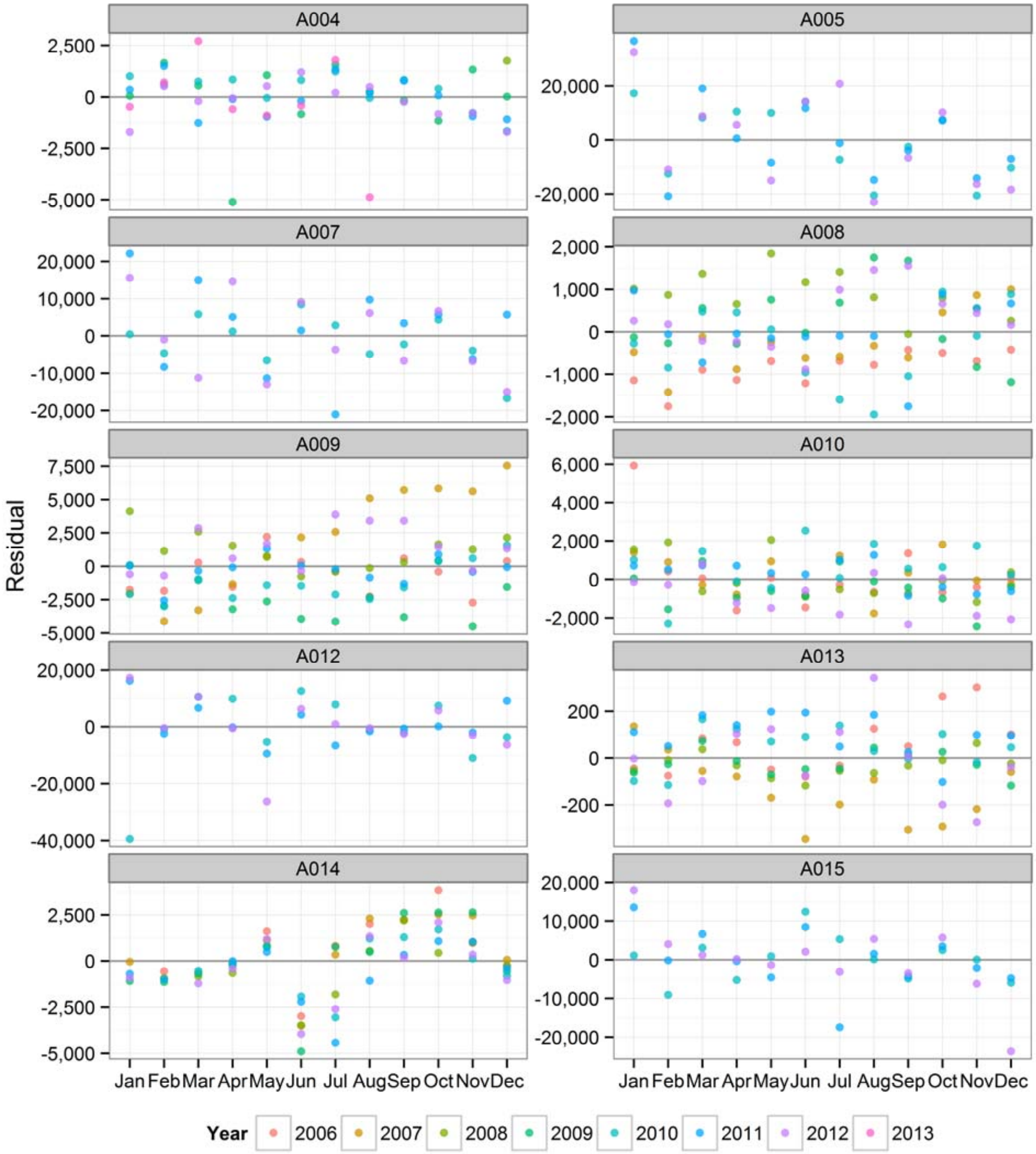


**Figure 22 Residuals after degree days (part 2)**

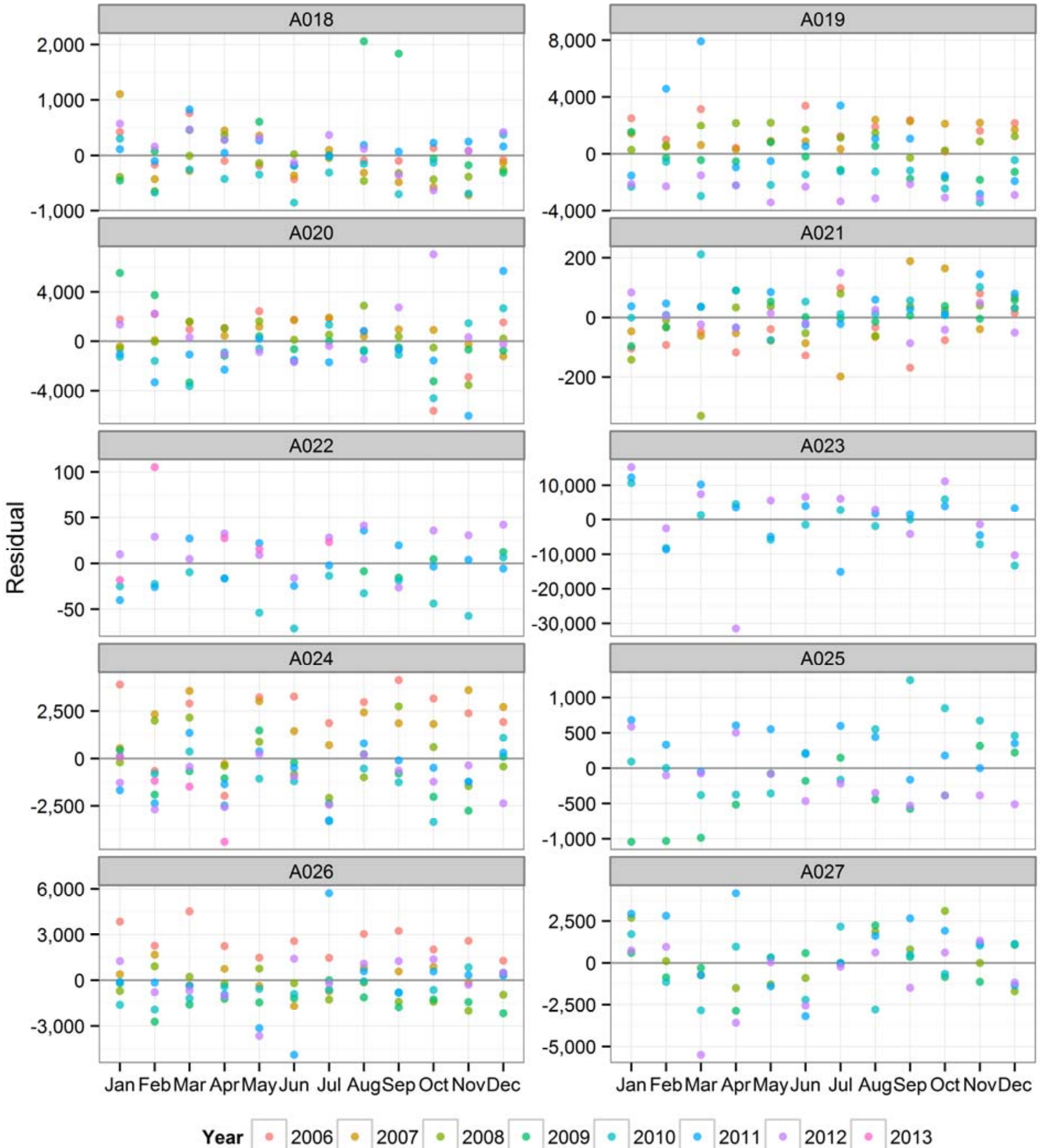


**Figure 23 Residuals after degree day model (part 3)**

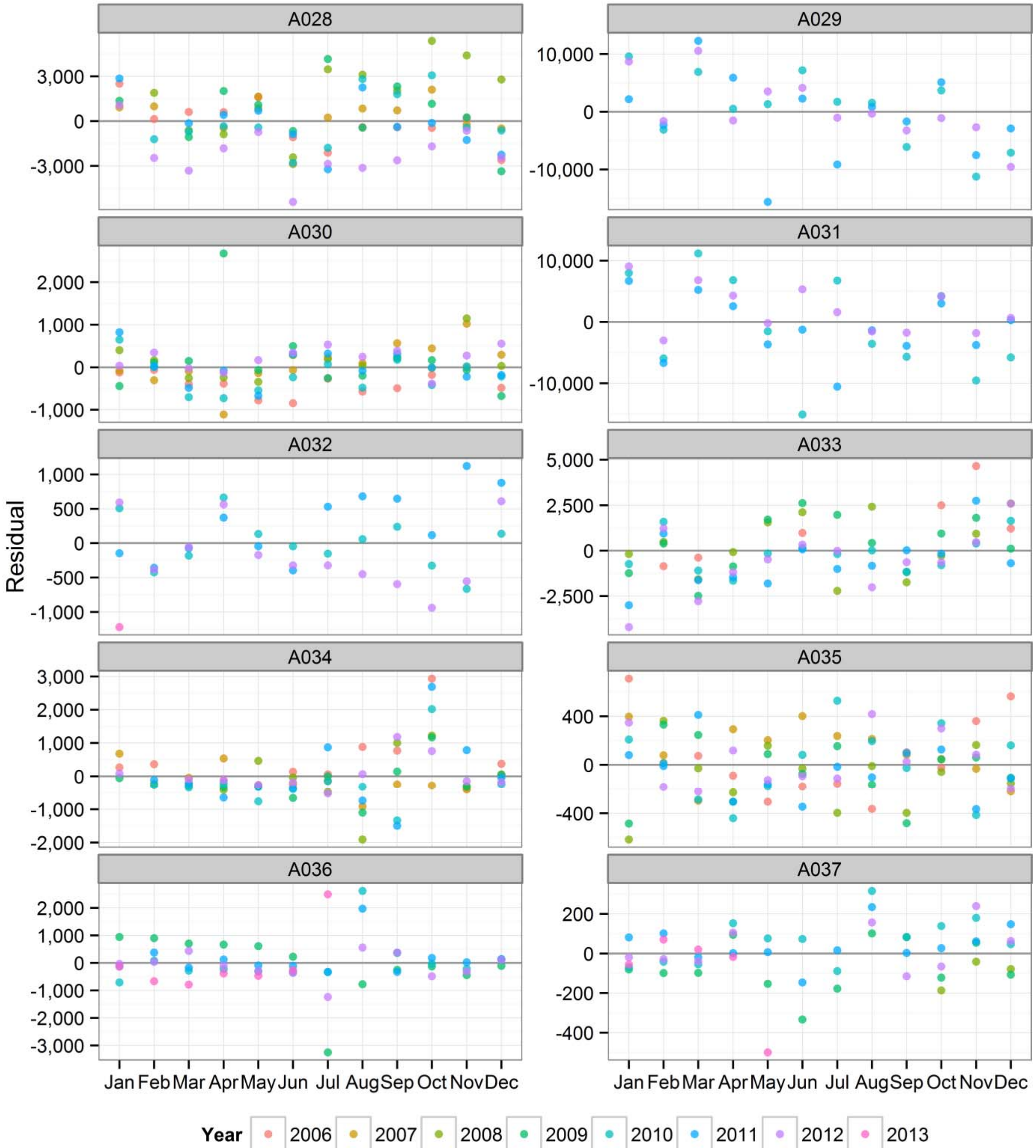
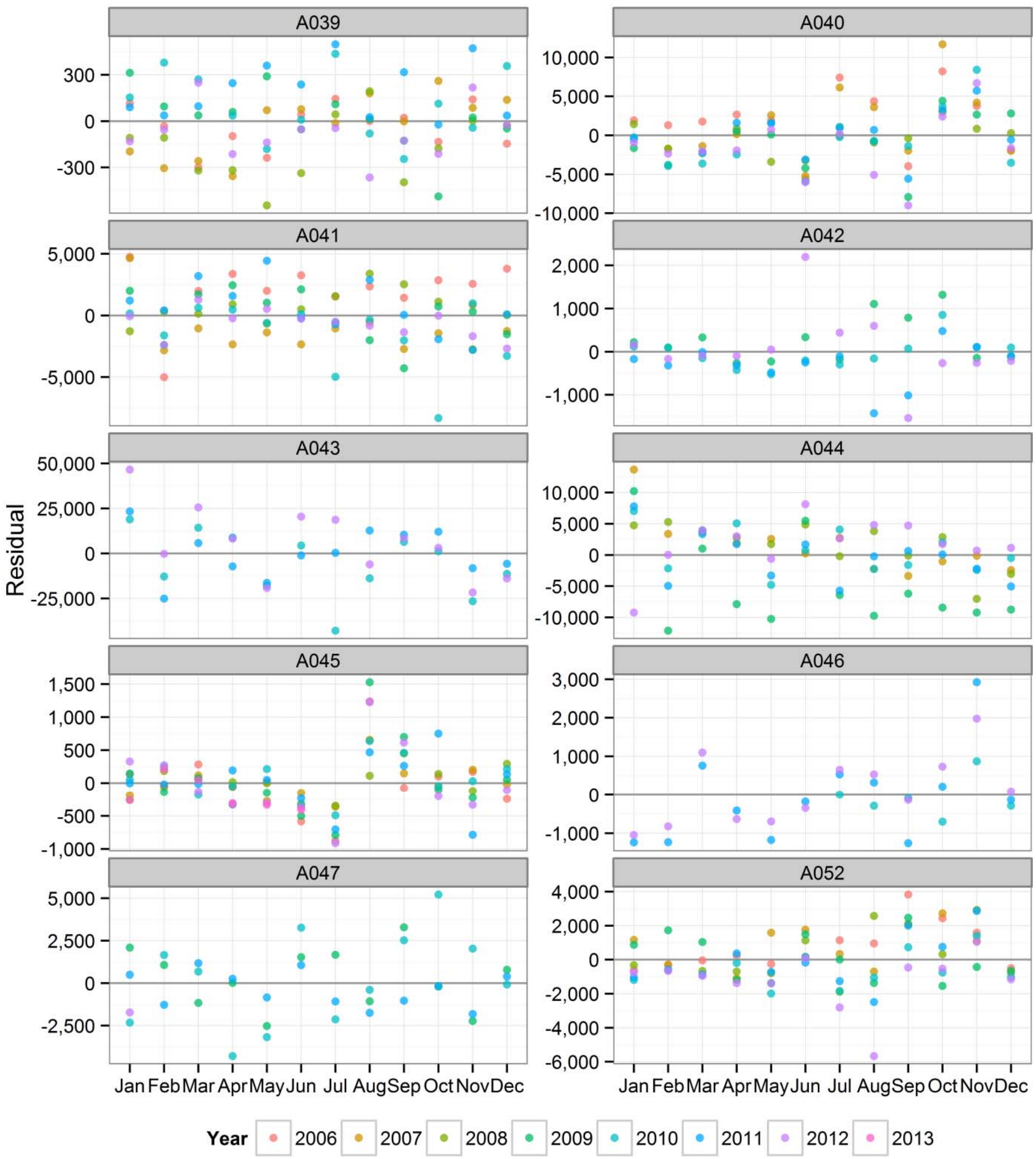


**Figure 24 Residuals after degree day model (part 4)**



## Figure 25 Residuals after degree day model (part 5)

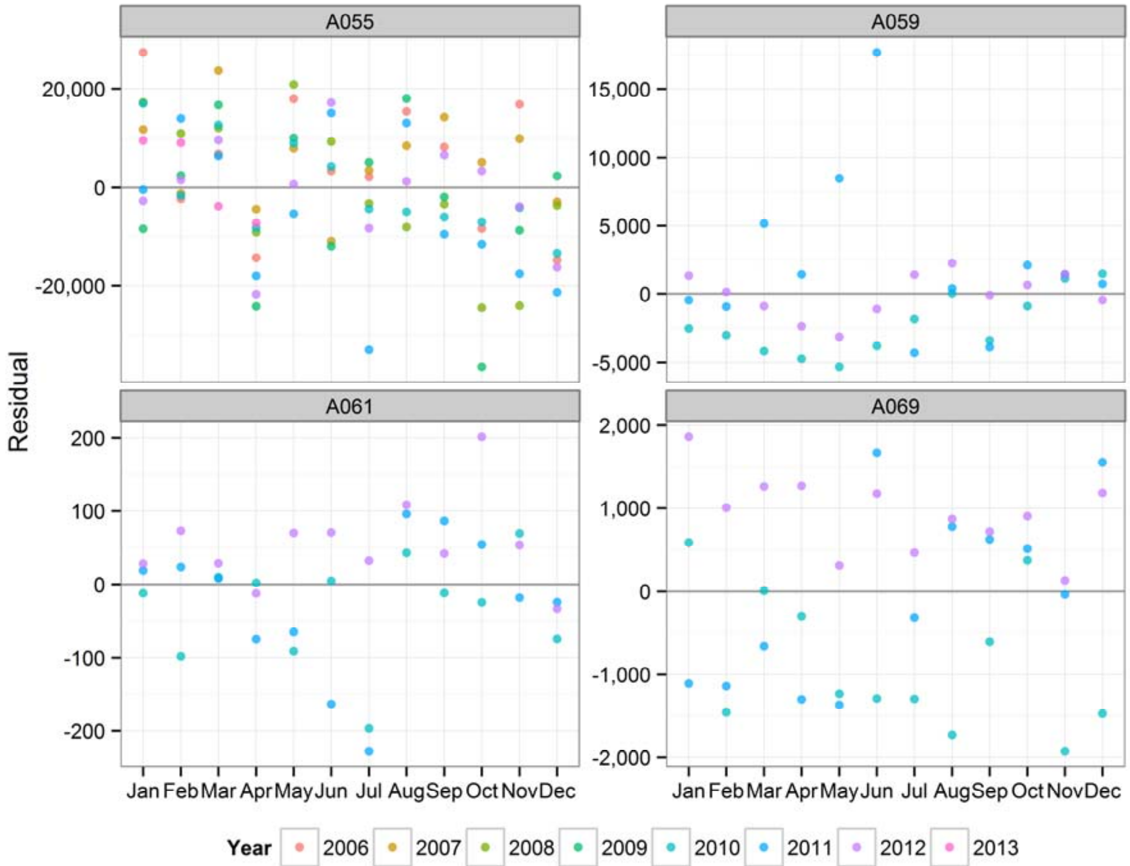
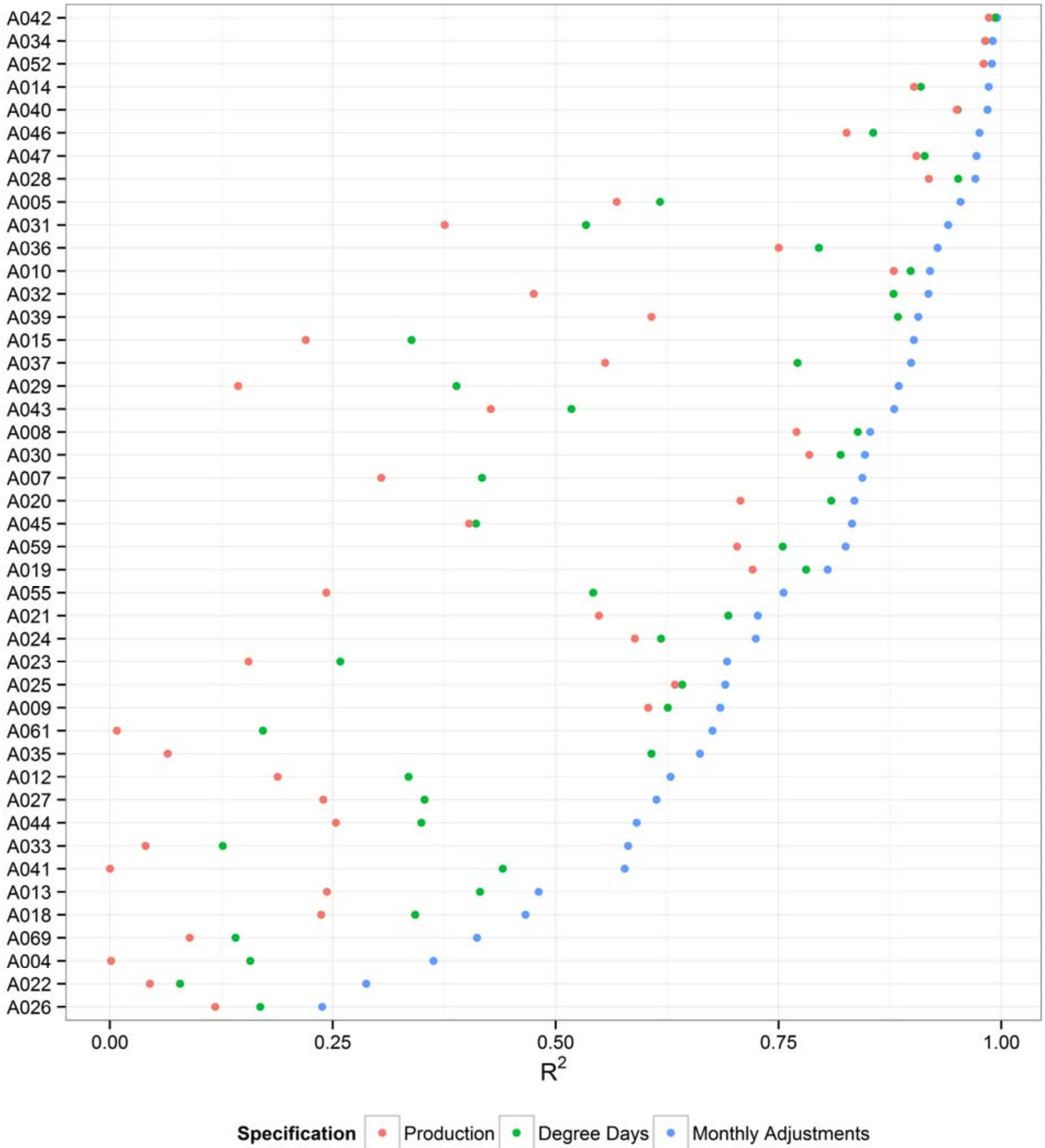


**Figure 26 Adjusted R-squared for the model with monthly effects**



### Recommended Model Specifications

In order to detect the program influence, we need models with a good overall fit and coefficients that are statistically significant with plausible magnitudes. We applied the following criteria to select and specify the recommended models:

- Eliminate degree day variables with a significance of less than 95%.
- Only accept models on sites where the $R^2$ is 0.75 or higher. This shows that we were able to achieve a good level of overall fit.
- Only accept models with a plausible and significant production variable. Models for industrial sites need to include production as an explanatory variable. A plausible production coefficient is a strong indication that we have sufficient visibility in the underlying process to detect program influence

As a result of applying these criteria, we accepted the model results of 23 of the 44 sites. Also, the criteria had the effect of eliminating all cooling degree variables and most of the heating degree day variables. The sites with a heating degree day term include A014, A019, A032, A040, and A042.

### Program Influence

The theory of strategic energy management is that facilities can lower their energy consumption through management, behavior, maintenance and operational procedures. The program should result in increased energy performance over time, after controlling for activity level and environmental factors. If the program is working, we should be able to see this in the model results from section0. The model predicts the average energy consumption per month. The program theory holds that sites will lower energy consumption over time. As a result, the model will under-predict energy consumption during the beginning of the program period and over-predict consumption at the end of the program period. That is, the residuals should have a negative, downward slope.

Figure 27 through Figure 29 shows the residuals for each of the energy consumption models. The plots also show a linear regression through the residuals as a blue line with 90% confidence interval in grey. Twelve sites show evidence of program influence, including: A010, A014, A015, A019, A020, A028, A034, A040, A042, A047, A052, and A055. Other sites either do not show a time trend in the residuals or show increasing energy consumption over time.

**Figure 27 Changes in residuals over time (part 1)**

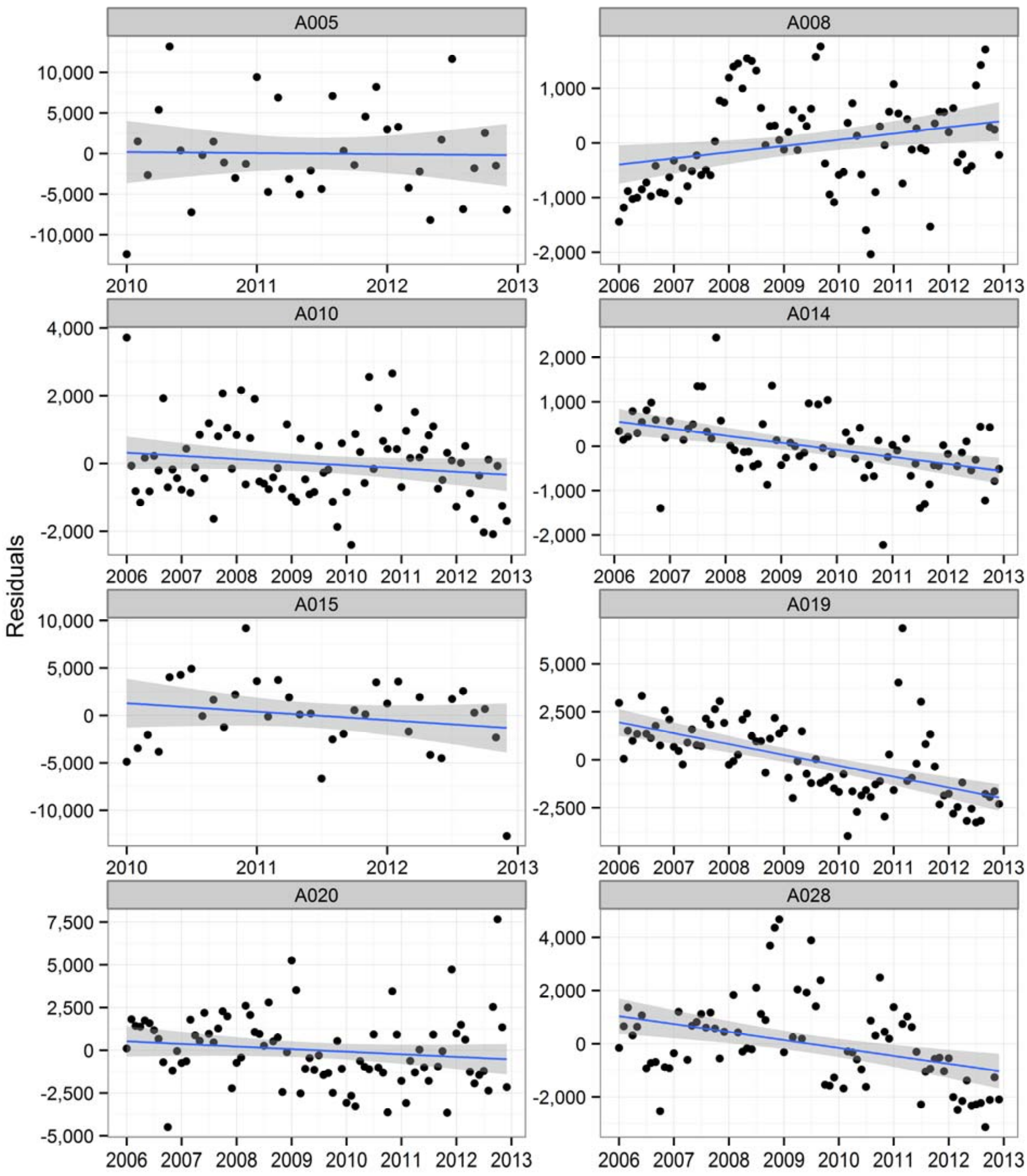


**Figure 28 Changes in residuals over time (part 2)**

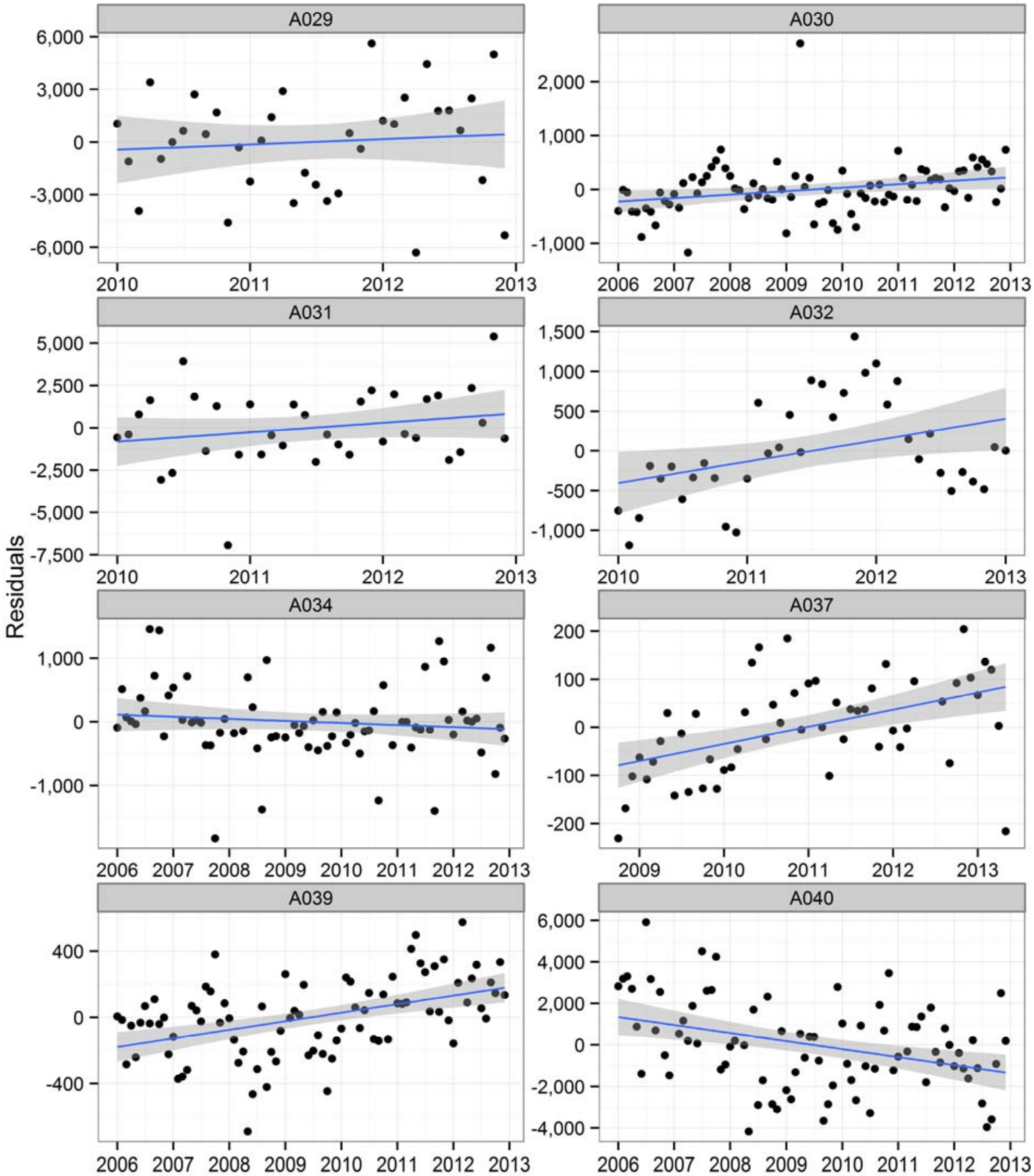
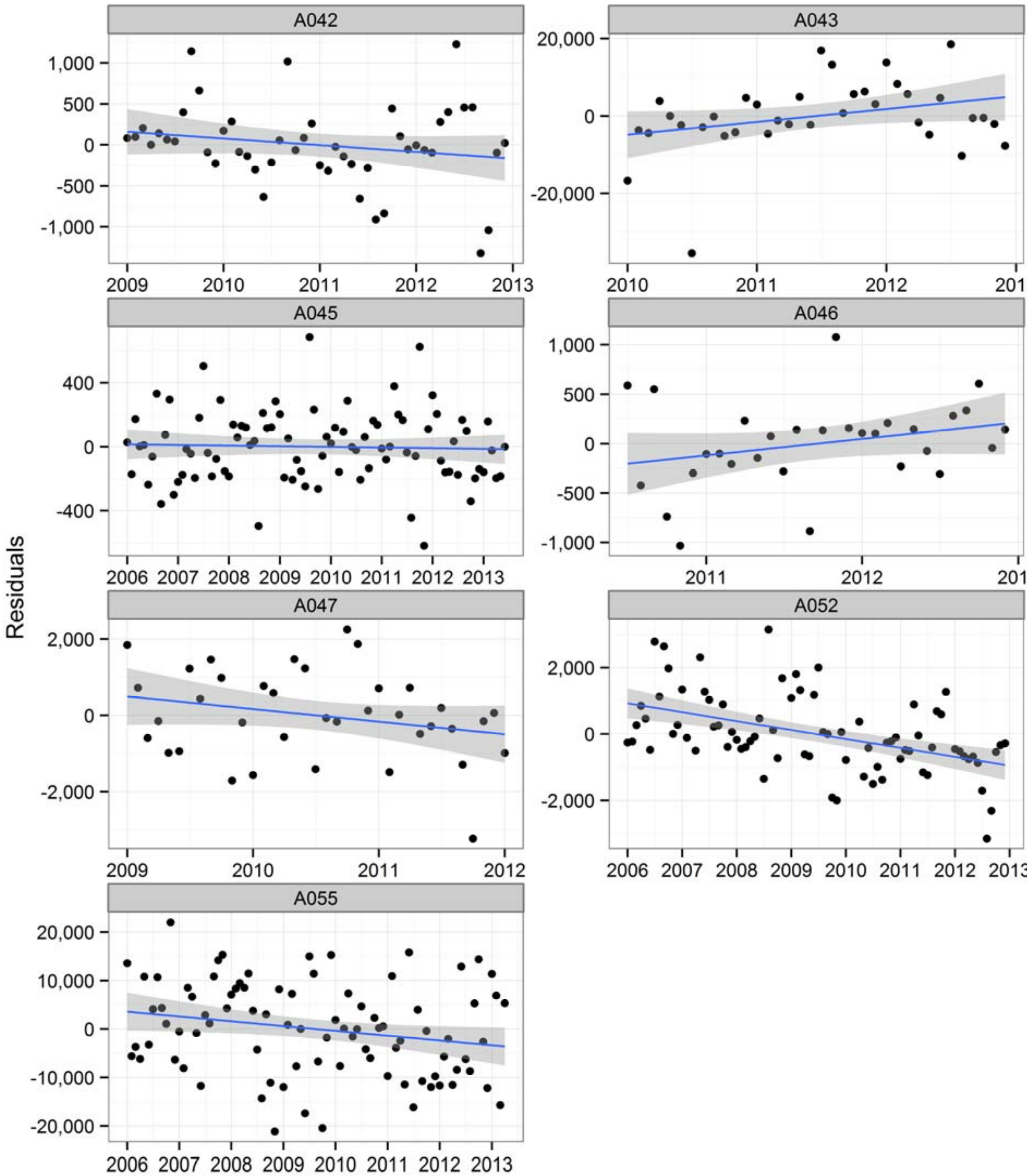
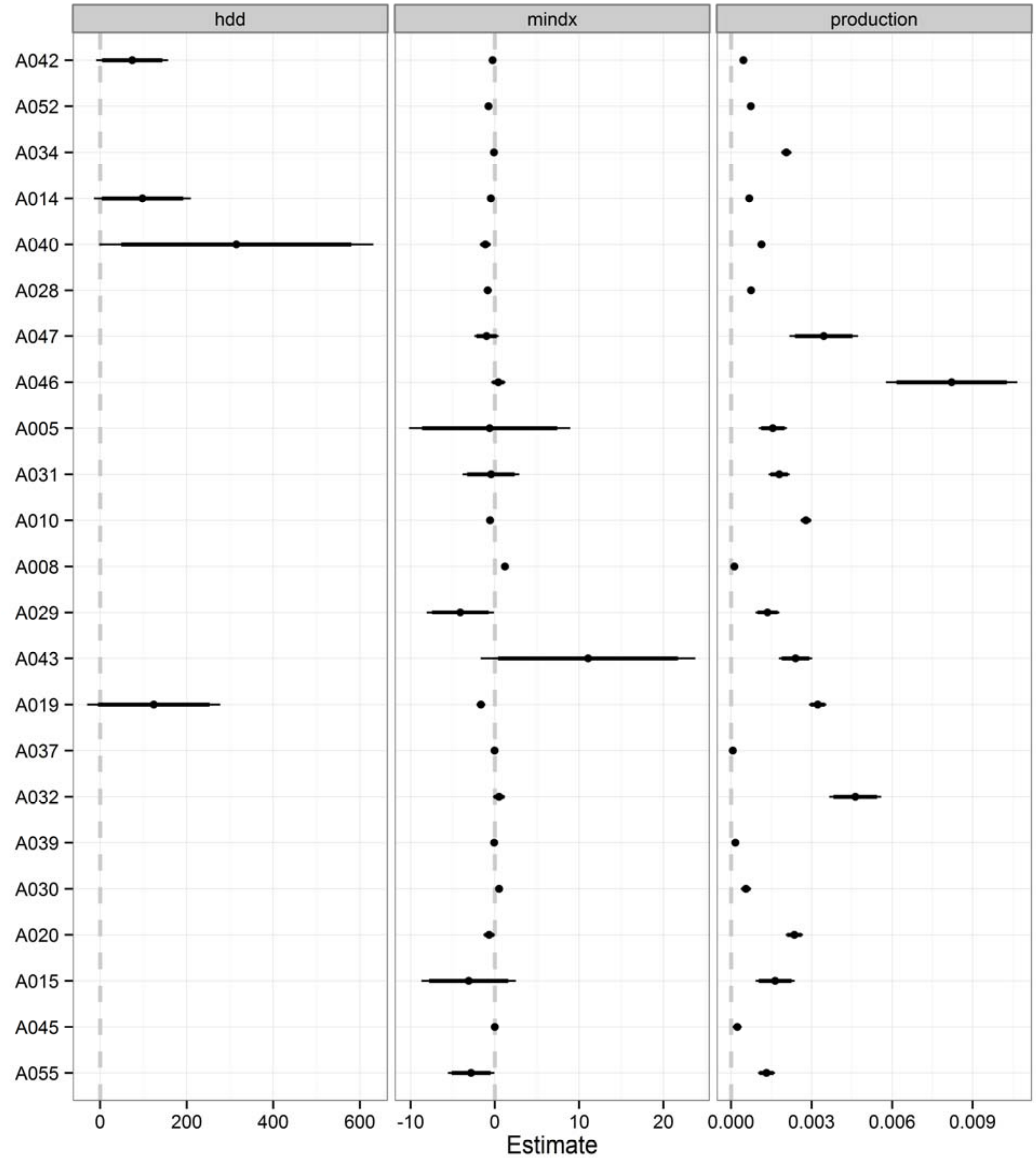


**Figure 29 Changes in residuals over time (part 3)**




In order to quantify energy consumption changes over time, we added a time index variable (mindx) to consumption model. **Figure 30** shows the coefficient values for the heating degree term, the time index, and the production. Sites with a negative time index variable coefficient decreased energy consumption over time and sites with positive coefficients increased energy consumption over time. Although the models include monthly effects, these are not shown in **Figure 30**.

**Figure 30 Program detection model results**



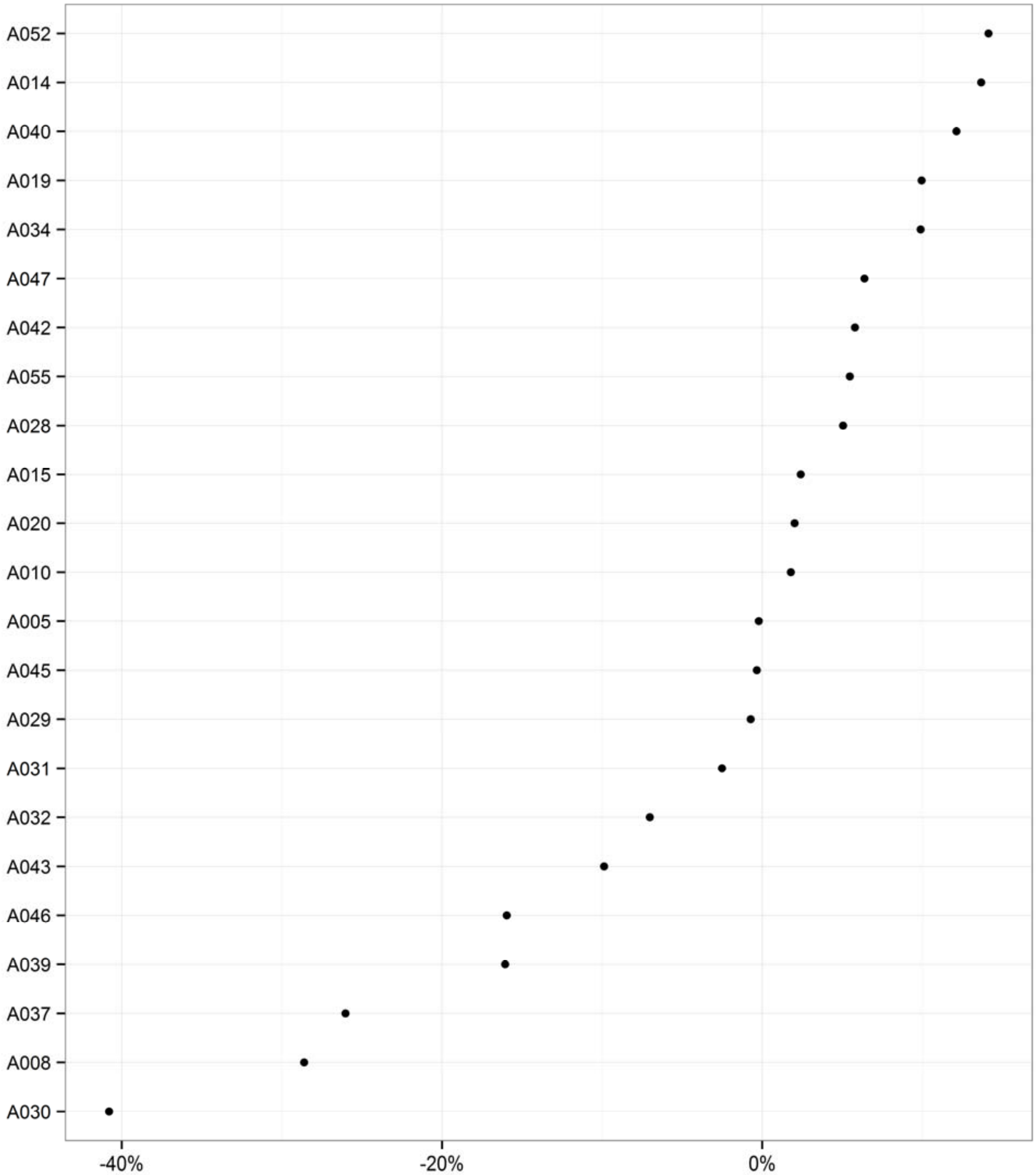
## Savings Estimate

Savings estimates for continuous improvement programs typically measure how the site would have performed in the last year of the program given the activity level and environmental factors of the first year. We apply the following steps to measure savings:

1. Use the first year of data from every site.
2. Shift the time index so that the data appear as if they were in the last. For example, if the first month of a 3-year program was January 2009, the shift transforms the value to January 2012.
3. Apply the model decribed in the "Model Estimation" section. The model is sensitive to the shifted time index and will predict how much energy the site would have consumed after three years of the program.
4. Sum the observed consumption minus the predicted consumption by site. This is the site level energy consumption.
5. Sum across sites for the total energy savings.

**Figure 31** shows the savings estimates by site. The results are consistent with the discussion of program influence described above.

**Figure 31 Savings as a percent of base year load**



# APPENDIX F - DATA COLLECTION INSTRUMENTS

## Utility Interview Guide

### Background

Utility programs in NEEA's territory are administered by two separate funding organizations: the Bonneville Power Administration (BPA) and the Energy Trust of Oregon (ETO). Energy Smart Industrial (ESI)—BPA's industrial energy efficiency program—is delivered to the market through a program implementation contractor on behalf of participating utilities. Production efficiency—ETO's industrial program—is delivered to the market through the use of program delivery contractors. The program managers for both BPA's and ETO's industrial programs are targeted contacts for this interview guide. The SEM services offered through these programs are generally referred to as "components" and are often bundled with incentives for resource acquisition.

### Research Objectives

This interview guide is designed to answer the MPIs identified for this MPER#8, as well as collect data pertinent to the market characterization. One overarching goal for these interviews is to describe how NEEA's efforts contributed to BPA's and ETO's SEM program components in the food processing industry.

**MPIs Targeted by This Interview Guide**

- **MPI 1**: Qualified Trade Allies are able to support end users to implement SEM with NEEA funding.
- **MPI 4:** Registered (ISO50001) end user facilities implement ISO50001 procedures.
- **MPI 5:** Utility SEM offerings become more widespread.
- **MPI 6:** Industrial facilities increase their uptake of energy efficient measures
- **MPI 7**: Sufficient Qualified Trade Allies to implement SEM.

**Additional Research Objectives**

In addition to covering MPI's, these interviews will answer key research questions concerning utility support for SEM. Research objectives include describing:

- The business models (delivery channels, payment and incentive structures) used by BPA and ETO to deliver their SEM components to the market.
- How influential NEEA's initiative was for preparing the market for utility SEM programs.
- BPA and ETO's plans for SEM program components in the food processing industry.

### Interview Approach

Interviews will be held over the phone; and interviews will last between twenty to forty minutes. Semi-structured interview questions are used to compare responses between BPA and ETO.

### Interview Audience

Respondents will be selected based upon their role, and with a preference for industrial sector program managers. We are targeting two interviews, one from BPA and ETO each.

### Interview Introduction

During this interview we will discuss your experiences offering SEM components in the industrial food processing industry, and your perspectives on NEEA's initiatives in this market. We understand your SEM services are those components [for BPA respondent] –which originally comprised your SEM Pilot Program—[ETO respondent]—in your Custom Strategic Energy Management track. For the purposes of this interview we would like you to only think about your SEM components which include end user corporate level involvement. We will hold interviews with representatives from both BPA and ETO; and our research informs NEEA's market progress evaluation report for its industrial SEM initiative.

### Overview

I'd like to begin by discussing the SEM components you offer the industrial food processing industry. [These may also be referred to as Continuous Energy Improvement.]

1. What SEM components do you offer? And when were these components first offered to the food processing firms in your service territory?

2. How do the SEM components fit within the range of energy efficiency programs you offer to industrial customers? PROBE STRATEGIC, PROGRAM DESIGN, AND LOGISTICAL ASPECTS]

3. What motivated your organization to offer the SEM components? Did you receive requests for this type of assistance from customers, consultants, others in the food processing industry?

4. Relative to other industries, are you familiar with any advantages or challenges to offering SEM components to the food processing industry? What are they?

5. Since your initial entry into this SEM market, have you made changes to the program? IF YES: Please describe those changes. What were the main reasons you made those changes?

6. [MPI 5, 6] Over the past few years, how would you characterize the level of SEM activities by adopted your food processing customers; would you say it has been increasing, decreasing, or staying about the same? How so?

7. [MPI 5] Over the next five years how do you see your SEM components evolving in this market?

8. [MPI 4, 5] Will you be offering support to customers to achieve ISO 50001certification?

9. [If Q8 = Yes] When will you begin to offer support to achieve ISO 50001 certification? How many food processing facilities do you expect will achieve the certification in the next 5 years?

10. [If Q8 = No] What are your reasons for not offering support for ISO 50001?

**Effects of NEEA's Initiative**

11. Are you familiar with any NEEA activities or initiatives that promoted SEM practices among food processors in the Northwest? IF YES: What is your understanding of NEEA's offerings?

12. Have NEEA's SEM activities facilitated your organization's SEM components?

13. [If Q12 = Yes] How did it help your components?

14. [If Q12 = No] Are there things NEEA could have done differently which would have helped your SEM component progress?

**SEM Business Models**

[To the extent possible, the information for these questions will be developed through review of utility program materials and evaluations.]
I'd like to discuss the way your components are packaged or offered to customers.

15. First, how do your customers learn about your components? (Probe: What strategies do you have to promote your components?)

16. What resources and support do you offer to assist with SEM implementation?

17. Do you offer any resources or support to help sustain savings from SEM projects?

18. Concerning your SEM components, what activities and incentives are covered by public purpose charges?

**MPI 1 & 7: Qualified CEI Contractors**

I'd like to discuss your perspectives on the quality and supply of contractors capable of helping to implement SEM projects.

19. First, has the quality or supply of these contractors influenced the way you developed your SEM components? [If yes] How so?

20. Has the quality or supply of contractors influenced the rate by which the food processing industry implements SEM projects? How so?

21. Has the number of contractors who offer SEM consulting to food processing in the region increased, decreased, or stayed about the same since your organization initiated its SEM components?

22. Has the capacity of the contractors who offer those services increased, decreased, or stayed about the same? PROBE DETAILS.

23. Has the quality and effectiveness of the services offered by SEM consultants in the region increased over the time period your organization has supported those activities. PROBE FOR DETAILS.

**Effects of NEEA's Initiative**

24. What effects do you think your organization's activities in support of SEM in the food processing industry have had on customer awareness, understanding, and adoption of SEM practices?

25. What effects do you think your organization's activities in support of SEM in the food processing industry have had on consultants' capacity to deliver effective services to accelerate customer adoption of SEM practices?

26. Do you think that NEEA's programs have had an effect on customers or contractors in this field, beyond those achieved by your company?

    a. IF YES: PROBE FOR EXAMPLES AND DETAILS.

    b. IF NO: Why do you say that

## CEI Contractor Interview Guide

### Background

Continuous Energy Improvement (CEI) contactors are a key component of NEEA's industrial initiative as they deliver the initiative to the market by helping industrial end-users to implement energy management programs. NEEA's support for CEI contractors helps to build the technical capacities of the industrial SEM market.

### Research Objective

These interview guides are designed to help characterize the MPIs identified for this MPER (see below), as well as to collect data for the following market characterization research objectives. These include describing: the business models employed by CEI contractors to deliver their SEM services to the market, the effects of NEEA's support on their market, and CEI contractors' experiences working with industrial end-users.

MPER#8 includes 10 MPIs, seven of relate to CEI contractors. The following MPIs are targeted by this interview guide:

| MPI # | MPI | Interview Questions |
|---|---|---|
| 1 | Qualified Trade Allies (certified ISO50001 practitioners) support end users with implementing SEM using NEEA funding. | 39, 40 |
| 3 | End Users are aware of SEM (reach stage 3 of commitment). | 37 |
| 4 | Registered (ISO50001) end user facilities implement ISO50001 procedures. | 42, 43 |
| 7 | There are sufficient qualified trade allies to implement SEM. | 38, 39,40 |
| 10 | SEM becomes a Northwest industrial industry best practice | 44, 45 |

Interviews will be held over the phone with two CEI contractors; and interviews will last between 30 to 45 minutes.  Other data sources to answer MPI questions will include surveys and interviews with other sources, and comparison with prior MPERs.

### Interview Population

Contacts will be selected from the firm NEEA has contracted with, and contacts will be selected based upon their roles as they relate to delivery of the initiative. If possible, we will attempt to interview two individuals at each firm, with one contact having a managerial or supervisory role over the initiatives, and the other contact having more of a day-today role managing activities with initiative participants.

**Name**______________________________________ **Date**______________________
**Firm**________________________________________________________________________
**Contact Information** ______________________________________________________

**Interview Introduction**

During this interview, we will discuss your company's experiences promoting and implementing NEEA's industrial energy management initiative with the industrial food processing market.

**Interviewee's Experience**

When did you as a representative of your company, start working on this initiative?
What was your job position at the time and what is it now?
What key activities do you perform for the initiative?
What services do continuous energy improvement contractors generally provide?

**Market Assessment**

To begin with I would like to discuss the overall characteristics of the energy management market as it relates to the industrial food processing industry in NEEA's territory.

27. How would you characterize the market for energy management services in the food processing industry prior to the development of NEEA's initiative (2005) in regard to ….
    a. Customer awareness of energy management services and their benefits?
    b. Customer interest in these services and willingness to purchase.
28. As compared to other industrial industries, are you aware of any factors specific to the food processing industry which make this market…
    a. more attractive to providers of energy management services?
    b. less attractive?
29. [If Q28 = Yes] In your opinion, did the design and operating procedures of NEEA's initiative take these factors into account?
    a. How so?
    b. Are there additional ways the initiative could have been better designed to address opportunities and challenges to marketing and providing energy efficiency services to the food processing industry?
30. Other than those supported by NEEA's initiative, is your company working with other industrial companies to implement SEM? [If yes]
    a. How many facilities?

b. In what industries?

## Corporate Level Implementation

I'd like it if you could take me through the key steps of implementing NEEA's SEM initiative.

31. First, in regard to working at the corporate level, please describe….
    a. Your understanding of your specific responsibilities as a contractor
    b. The types of activities and meetings involved at a corporate level [Probe if needed:
        i. Development of corporate goals and energy policy
        ii. Development of facility goals
        iii. Energy performance in long term planning
            1. Capital energy efficiency projects
            2. Implementing energy-saving eforts
        iv. Data tracking and analysis
        v. Energy training
        vi. Management reviews]
    c. And desired outcomes, and indicators of progress to be applied

32. In our interviews with firms, we noticed that corporate staffs were more actively involved with SEM activities in some companies than others.
    a. What factors influence how actively involved corporate level staff are involved with SEM?
    b. What challenges did you face, if any, when trying to get things 'moving in the right direction' when working with corporate staff? [If not discussed: How do corporate sponsors come to understand their roles and know what they should be doing?]

## Facility Level Implementation

33. In the same way, please discuss what you do at a facility level. Please be specific about the….
    a. Roles of people you work with [Probe if needed:
        i. Plant manager
        ii. Energy champion
        iii. Facility/maintenance manager
        iv. Production team]
    b. Types of SEM activities at this level [Probe if needed:
        i. Setting goals
        ii. Developing action plans
        iii. Identifying energy champions
        iv. Tracking energy savings
        v. Auditing and corrective action
        vi. Training for energy management]
    c. And desired outcomes from these activities

34. Similarly, we saw differences in the level of SEM adoption at a facility level.
    a. What are some factors that influence the way SEM is adopted by facilities?
    b. What challenges do you face at a facility level to ensure the implementation is implemented correctly?

35. In your opinion, what energy management activities at a facility level will likely require continued support from CEI contractors? [Probe if needed:
    a. Setting goals
    b. Training
    c. Identifying savings opportunities
    d. Tracking energy savings ]

    Why do you say that?

36. What energy management activities do you think facility staff will be able to continue on their own, without support from a contractor? [Probe if needed:

    a. Setting goals
    b. Training
    c. Identifying savings opportunities
    d. Tracking energy savings ]

    Why do you say that?

**Market Characterization**

37. Does your firm attempt to manage industrial energy management support services outside the context of programs offered by NEEA, utilities, and similar organizations?
    a. IF YES: Please describe these offerings. PROBE NATURE OF SERVICES OFFERED, BUNDLING OF SERVICES FOR DELIVERY AND PRICING, PRICING APPROACH.
    b. What industries and regions do you target in marketing these offerings?
    c. Which types of firms – in terms of industry and size – have been the most responsive to your marketing efforts?
    d. Are you currently engaged in any projects with to provide energy management support services to industrial firms in the PNW?
        i. IF YES: How many such projects are currently underway?
        ii. Has the volume of such services provided in the Northwest increased, decreased, or stayed about the same over the past 3 years?
        iii. IF INCREASED/DECREASED: By about what percentage has the volume of such work for your firm increased/decreased over the past 3 years?

iv. By your count, how many firms offer competing services in the region?
v. Has the number of firms offering energy management support services to industrial customers increased, decreased or stayed about the same over the past 3 years?
vi. In your opinion, what are the most important factors contributing to these changes?

e. Are you currently engaged in any projects with to provide energy management support services to industrial firms outside the PNW?
   i. IF YES: How many such projects are currently underway?
   ii. Has the volume of such services provided in the Northwest increased, decreased, or stayed about the same over the past 3 years?
   iii. IF INCREASED/DECREASED: By about what percentage has the volume of such work for your firm increased/decreased over the past 3 years?
   iv. By your count, how many firms offer competing services in the region?
   v. Has the number of firms offering energy management support services to industrial customers increased, decreased or stayed about the same over the past 3 years?
   vi. In your opinion, what are the most important factors contributing to these changes?

38. What is your best estimate of the percentage of large food processing facilities in the Pacific Northwest that have adopted Strategic Energy Management as defined by the NEEA initiative? We define large as employing 250 workers or more.
    a. Has your companies tried to promote SEM to these companies?
    b. [If Yes] What challenges did you face promoting SEM to these companies?
    c. How well do these facilities understand SEM?

39. Are there any DOE resources helpful to promoting SEM in the northwest? (Probe: Are the DOE Superior Energy Performance and Better Buildings/Plants programs helpful?)

40. Does your firm offer services to help companies become ISO 50001 certified? [If No] Why not?

41. Are any of your customers or potential customers asking for support to implement ISO 50001?

42. Are you aware of any facilities in the NW attempting to achieve this certification, or facilities that have achieved it? [IF Yes] How many facilities? In which industries?

43. How would you characterize most industrial food processing companies' intentions to pursue ISO 50001 certification? What lead you to state that?

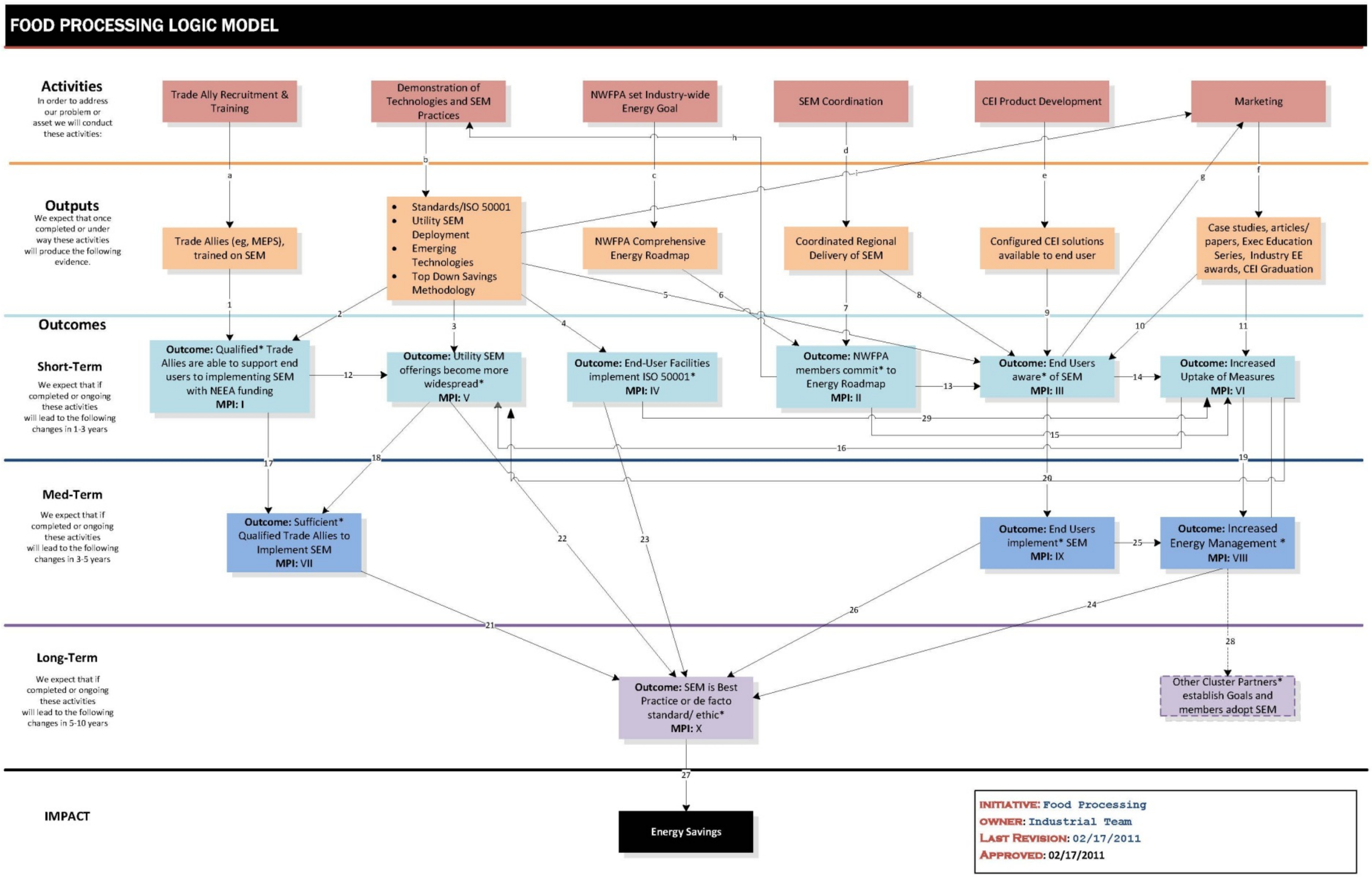
44. When you consider that quality management is a standard of practice for NW industrial food processing facilities, how close is SEM to becoming a standard of practice, if at all?

    a. Are there aspects of SEM that are becoming a standard of practice?
        i. Setting energy performance goals
        ii. Tracking energy performance and energy intensity
        iii. Executive commitment to energy reduction

45. What types of changes, if any, need to occur for SEM to become a market wide best practice?

46. Given your understanding of the Northwest industrial food processors level of interest in SEM, is the CEI contactor market able to meet the….
    a. Volume of demand for CEI services?
    b. Level of quality demanded by food processors?

# APPENDIX H - FOOD PROCESSING INITIATIVE LOGIC MODEL



# APPENDIX I. ADDENDUM: 2013 Savings Assessment

Memorandum

| | |
|---|---|
| **To:** | Steve Phoutrides, Northwest Energy Efficiency Alliance |
| **From:** | Julia Vetromile, DNV KEMA Energy and Sustainability |
| **Subject:** | Revised Food Processing Initiative 2013 Savings Validation |
| **Date:** | March 3, 2014 |

## Introduction

The Northwest Energy Efficiency Alliance (NEEA) has been implementing its Industrial Initiative since 2005. The goal of the Initiative is to transform the market for industrial energy management services and to promote a specific approach known as Strategic Energy Management (SEM) as a standard practice. Currently focusing on the food industry, the initiative encourages facilities to incorporate continuous energy improvement (CEI) through energy management practices in their operations. NEEA has engaged DNV KEMA to evaluate the annual progress of this initiative for 2013. This memorandum presents the results of the validation of energy savings. The validation was performed in January and February 2014.

The validation consisted of two parts, a bottom-up energy engineering analysis for each energy efficiency measure completed and a top-down regression analysis of changes in energy consumption for each participating facility. We combine the two approaches to estimate savings resulting from each part of the program: quantified measures and energy reduction activities.

For 2013, three firms and ten facilities were active in the program across Oregon, Idaho and Washington states. DNV KEMA developed top-down models for each active facility. Additionally, DNV KEMA validated a total of 25 measures for these sites, which included all the measures completed and documented for 2013. Only eight of the ten sites completed energy efficiency measures. For each of the eight facilities with reported measures, DNV KEMA visited the site, verified whether the measures reported were installed, and collected information to estimate the energy savings.

DNV KEMA developed top-down analyses for each facility, estimating the change in annual energy consumption for each year since each facility adopted SEM as a sustainable practice, after accounting for non-program factors such as weather and production volume. The top-down analysis is designed to capture the savings that result from all SEM activities, including those that are otherwise not included in a measure-by-measure engineering analysis. The types of activities promoted by SEM include planning, setting goals, and incorporating behavioral and operational changes into the facility operations, as well as capital, retrofit, and maintenance improvements. SEM captures changes actions such as revising standard operating procedures to incorporate energy efficiency practices and optimizing controls and set points.

## Summary of Results

For 2013, ten facilities were active in the program across Oregon, Idaho and Washington states. Top-down analysis was developed for each facility, reflecting the current savings from identified measures in the SEM program, as well as savings from actions not individually quantified. The modeled top-down savings are disaggregated between specific energy efficiency measures and other actions due to SEM. The net top-down savings represent savings outside of specific energy efficiency measures. A detailed description of the model is provided in Appendix A.

For the bottom-up savings, a total of 25 measures were validated for eight sites, which included all the measures completed and documented for 2013. Validated savings from these measures totaled 0.37 aMW and over 300,000 therms.

The net top-down analysis was completed for natural gas and electricity for all 10 facilities. DNV KEMA found additional savings due to SEM in 2013 of 0.37 aMW and nearly 900,000 therms. The net top-down savings represent 1 % of 2013 annual electric base load consumption for these facilities and 2.4% of 2013 annual natural gas base load consumption.

## Bottom-Up Analysis: Engineering Assessment of Individual Measures Installed

DNV KEMA validated the savings claimed by each facility for each measure, which was the purpose of the bottom up analysis. The validated savings demonstrates the effects of SEM in measures that can be readily quantified. It also allows NEEA to identify savings from measures incented by other utilities.

## Methods

DNV KEMA evaluated the savings on all measures that were documented as completed since the 2012 evaluation where savings estimates were available. Twenty-five specific energy measures were identified at 8 plants for 2013. Since all completed projects with savings estimates were included in the validation, uncertainty regarding the representativeness of the sample was eliminated. For each of the eight facilities, DNV KEMA visited the site, verified whether the measures reported were installed, and collected information to estimate the energy savings. Based on the collected information, DNV KEMA estimated the energy savings by either validating the calculations performed by the facility or developing revised calculations based on site data collected. A detailed description of each measure and the approach used to derive the savings is provided in Appendix B.

## Results

Table 1 displays the results for both electric and gas savings. Two facilities had natural gas savings only, four facilities had only electric savings and two facilities had both. Overall, DNV KEMA found the realization rate of validated to claimed savings to be 95% for electric measures and 169% for natural gas measures. As shown inTable 1, the validated natural gas savings at one plant were much higher than the original estimates. One measure had significantly more operating hours than originally estimated in the savings claim, which led to significantly more savings than expected. Overall, we estimated that the measures installed during the evaluation period yielded annual savings of over 0.37 aMW (3,253 MWh) and over 300,000 therms. These results are similar to the 2012 bottom-up analysis, which validated 0.42 aMW (3,484 MWh) and nearly 300,000 therms in annual savings. The similarity reflects the level of effort of the cohort overall. The types of measures implemented varied, although many similar types of measures were included in both years.

**Table 1. Bottom-up Program Savings Achieved in the Evaluation Period**

| Facility Identifier | Claimed Electric Savings | Validated Electric Savings | Electric Realization Rate | Claimed Natural Gas Savings | Validated Natural Gas Savings | Natural Gas Realization Rate |
|---|---|---|---|---|---|---|
| | Annual kWh | Annual kWh | | Annual Therms | Annual Therms | |
| A | NA | NA | NA | 92,900 | 113,634 | 122% |
| C | NA | NA | NA | 55,400 | 177,806 | 321% |
| D | 2,339,966 | 2,499,114 | 107% | NA | NA | NA |
| E | 478,529 | 311,604 | 65% | NA | NA | NA |
| F | 64,900 | 87,700 | 135% | NA | NA | NA |
| G | 119,549 | 27,787 | 23% | NA | NA | NA |
| H | 73,700 | 48,647 | 66% | 15,080 | 19,519 | 129% |
| I | 345,600 | 277,807 | 80% | 22,800 | 3,865 | 17% |
| Total | 3,422,244 | 3,252,659 | 95% | 186,180 | 314,824 | 169% |

Table 2 shows the distribution of electric and gas savings by measure type. Lighting measures resulted in the most electric savings. However, 90% of the lighting savings resulted from a single large retrofit throughout one plant. Other significant sources of electric savings included refrigeration equipment, most notably through addition of variable frequency drives to evaporator fan motors at two facilities owned by the same company. One air handler shut down measure was found not to result in new savings, as the site contact confirmed that the air handler had previously been shut off in the early spring when it was not needed. Overall, the realization rate for electric measures was 95%. None of the measures involved fuel switching between gas and electricity.

Natural gas savings were derived primarily from boiler improvements and optimization of steam usage. One dryer optimization measure dominated the results. At this facility, a wood fired boiler generates steam used in the drying process. The wood-fired boiler was less expensive to run than their natural gas boiler, although it sometimes failed and the plant used steam from the natural gas boiler. The plant found they could utilize direct fired drying rather than steam whenever their wood fuel boiler was down. Since the wood boiler was down more often than predicted in the claimed estimate, three times more savings resulted following validation. Excluding this measure, the average realization rate of all the other natural gas measures was 1.05%.

Table 2 shows the savings achieved in different measure categories.

**Table 2. Savings by Type of Measure**

| | Claimed Electric Savings | Validated Electric Savings | Realization Rate, Electric | Claimed Natural Gas Savings | Validated Natural Gas Savings | Realization Rate, Natural Gas |
|---|---|---|---|---|---|---|
| Measure type | Annual kWh | Annual kWh | | | Annual Therms | Annual Therms |
| Boiler | 56,000 | 46,039 | 82% | 102,600 | 127,627 | 124% |
| Compressed air | 48,500 | 23,378 | 48% | - | - | NA |
| HVAC | 93,996 | 0 | 0% | - | - | NA |
| Lighting | 2,511,019 | 2,695,220 | 107% | - | - | NA |
| Refrigeration | 712,729 | 488,022 | 68% | - | - | NA |
| Steam | - | - | NA | 83,580 | 187,197 | 224% |
| Total | 3,422,244 | 3,252,659 | 95% | 186,180 | 314,824 | 169% |

## Top-Down Analysis

DNV KEMA performed a top-down analysis of energy consumption at the cohort facilities in parallel to the bottom-up analysis. The goal of the top-down analysis was to quantify changes in energy consumption in 2013 as a result of the SEM program. Total energy consumption results from the cumulative effects of the activity, environmental conditions, and the equipment in use at the plant. The top-down analysis attempts to isolate the effects of changing production levels, environmental conditions, and changes in equipment from the SEM practices that promote more efficient equipment use and maintenance. That is, the top-down analysis allows us to quantify the changes in energy consumption due to the SEM program.

The top-down analysis combined historical production, energy consumption, and weather data with claimed energy efficiency savings to estimate energy savings during 2013.[1] By incorporating the claimed savings from energy efficiency measures completed in the facilities, DNV KEMA was able to develop the net top-down savings directly from the model. The model also estimated total top-down savings. Our

[1] Validated savings estimates were not complete when we conducted the top-down analysis.

net top-down findings show that the SEM program lowered total energy consumption (electricity and gas) in cohort facilities by 2.1% for an incremental savings of over 95,000 mmBTU. The SEM program lowered electricity consumption by 1.2% for an incremental savings of 0.37 aMW and lowered gas consumption by 2.4% for a savings of 870,000 therms. The total 2013 programs savings is the net top-down savings plus the bottom up savings.

This section summarizes the data and modeling methodology and presents savings estimates for each of the ten cohort facilities. We provide a data review and a detailed explanation of the methodology and results in a separate document as an appendix to this memorandum (Appendix A).

## Data and Modeling Methodology

The top-down analysis makes use of linear regression techniques to predict changes in electric and gas consumption. We used three data sources:

- *Monthly energy consumption and production data.* NEEA provided historical data[2] for ten of the cohort facilities. The energy consumption data include monthly electric, gas, and other fuel sources.[3] The production data are monthly volumes of the sum of all products generated at the facility, expressed as *net production*.[4] The production volume data do not include any indication of the volume of types of products or product mix, although some products may require considerably more energy than others..
- *Historical weather data.* DNV KEMA matched each of the ten cohort facilities to the nearest National Oceanic and Atmospheric Administration (NOAA) weather station.
- *Project savings estimates.* NEEA's contractor developed savings estimates for each Energy Efficiency Measure (EEM) that cohort participants installed during the course of the program. DNV KEMA evaluated these savings, as described in the above section on bottom up analysis. However, the validated savings were not available in time for the modeling. Given that the overall realization rates were close to 100%, this assumption yielded reasonable results.

The regression models adjust energy consumption as a response to production and environmental conditions. Our savings estimation method proceeds in the following steps:

1. *Adjust energy consumption.* The observed energy consumption, both electric and gas, includes savings due to actions quantified as specific energy efficiency measures (EEM) as well as other SEM activities. We computed the adjusted energy consumption by adding the project EEM savings to the observed energy consumption. The adjusted energy consumption reflects the amount of energy that a plant would have consumed without installing EEMs.

[2] NEEA protected the confidentiality of the data.
[3] One facility used hydrogen fuel in their boilers when it was possible to purchase this from a neighboring chemical plant. We did not estimate hydrogen fuel savings. Another facility used wood in its boilers.
[4] Net production is the gross production minus production that was discarded. Net production obscures somewhat the relationship between the physical activity at a facility and energy consumption.

2. *Compute monthly heating and cooling degree days.* The NOAA provides historical weather data in hourly frequency. In this step, we compute monthly heating degree days (HDD) and cooling degree days (CDD) using 65 °F as the basis temperature.
3. *Estimate production only models.* These models predict adjusted consumption using net production as the only explanatory variable. Our expectations is that variable in production levels should explain most of the variation in energy consumption. In industrial settings, such as food processing plants, the energy spent making products dominates all other energy uses.
4. *Estimate models with production, CDD, and HDD.* The CDD and HDD terms have a different interpretation than they do in residential settings. When modeling residential buildings, the coefficients on CDD and HDD measure the sensitivity of the building to environmental changes. For the food processing plants in the cohort, the interpretation is different. The facilities are mostly not climate controlled. Instead, the CDD and HDD terms measure how the production process responds to temperature variation and to seasonal changes to the plant operations.

Table 3 shows model specification (P for production only, PCH for production, cooling degree days, and heating degree days) and the $R^2$ value fit as a measure of statistical fit. We preferred the PCH models except for facilities where the HDD and CDD did not contribute to the model's explanatory power or the estimated coefficient values were not plausible. In nearly every case, the $R^2$ value was 0.9 or higher, meaning that we able to explain at least 90% of the variation in energy consumption. This level of fit is higher than typical for top-down models with monthly data.

In one case, Facility C, we were not able to fit a good model to the data. This is likely due to fuel switching from natural gas to wood, as well as possible product mix or other factors affecting electrical use. During interviews, plant staff described operational and raw material problems in 2012 resulting in higher energy consumption, although these were resolved by 2013. The model fit likely was affected by factors outside of production volume and weather.

## Savings Estimates

Tables 3, 4 and 5 present the results of the top down modeling for each facility, showing the savings by fuel type for electricity (in aMW), natural gas (in therms), and total fuels (in mmBTU), respectively. Each table provides the following for each site:

- Model variables: production only (P) or production plus heating and cooling degree days (PHC)
- Coefficient of determination ($R^2$) for each model
- Fuel consumption in the reference year (2009)
- Ratio of production in 2013 to production in the reference year, which indicates the amount of change in this variable
- Fuel consumption in 2013, adjusted to account for quantified energy efficiency measures
- Net top down savings due to behavioral and operational actions under SEM

- Modeled savings from identified energy efficiency measures, since the beginning of the program[5]
- Total top down savings, from all SEM actions as modeled
- Percent of savings compared to energy consumption.

The net top down savings estimates are the difference between the observed energy consumption in 2013 (as adjusted for quantified energy efficiency measures) and consumption in the reference year, after adjusting for differences in production levels and environment conditions. Results are presented with and without Facility C results. DNV KEMA recommends leaving out facility C, because the model is not able to explain the variation in energy consumption (as demonstrated by the $R^2$ of less than 0.75) for electricity and fuel switching from wood to natural gas in 2013. The overall savings validated are the savings without Facility C.

[5] The modeled savings from energy efficiency measures, as discussed in Appendix B, reflect the modeled energy that would have been consumed if the measures were not implemented. Energy consumption was adjusted based on the month and year validated measures were completed, extending back to 2010. In some cases, modeled energy consumption was not reduced despite the implementation of quantified measures. This reflects the inability of the model to capture all the variables that effect energy consumption; it is not necessarily an indication that the implemented measures did not save energy.

### Table 3 Model Fit and Net Top-Town Savings Summary, Electricity

| Site | Fuel | Model | Coefficient of Determin-ation $R^2$ | Reference Year Consumption (aMW) | Production Ratio (2013/ Baseline) | Adjusted 2013 Reference Consumption (aMW)[6] | Net Top-Down | | Energy Efficiency Measures (modeled) | | Total Top-Down (cumulative)[7] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Savings (aMW) | Percent | Savings (aMW) | Percent | Savings (aMW) | Percent |
| A | Elec | PHC | 0.88 | 5.94 | 0.82 | 4.87 | 0.24 | 4.95% | 0.32 | 6.63% | 0.56 | 11.58% |
| C | Elec | P | 0.69 | 2.23 | 0.92 | 2.05 | -1.19 | -58.17% | 1.23 | 60.00% | 0.04 | 1.83% |
| D | Elec | PHC | 0.81 | 3.16 | 0.76 | 2.40 | -0.10 | -3.98% | 0.00 | 0.00% | -0.10 | -3.98% |
| E | Elec | PHC | 0.98 | 2.30 | 1.15 | 2.65 | 0.10 | 3.66% | 0.20 | 7.42% | 0.29 | 11.08% |
| F | Elec | P | 0.99 | 1.23 | 0.77 | 0.95 | 0.01 | 0.87% | 0.07 | 7.70% | 0.08 | 8.57% |
| G | Elec | PHC | 0.96 | 3.40 | 1.02 | 3.46 | 0.20 | 5.75% | 0.64 | 18.55% | 0.84 | 24.30% |
| H | Elec | PHC | 0.94 | 0.44 | 0.83 | 0.37 | -0.06 | -15.06% | 0.07 | 17.77% | 0.01 | 2.71% |
| I | Elec | PHC | 0.97 | 3.11 | 1.16 | 3.60 | 0.27 | 7.51% | 0.33 | 9.13% | 0.60 | 16.64% |
| K | Elec | PHC | 0.95 | 5.97 | 0.89 | 5.31 | -0.28 | -5.18% | 0.30 | 5.65% | 0.03 | 0.47% |
| M | Elec | PHC | 0.96 | 6.15 | 1.12 | 6.86 | -0.02 | -0.28% | 0.48 | 6.96% | 0.46 | 6.68% |
| Overall | Elec | | 0.91 | 33.93 | 0.96 | 32.52 | -0.82 | -2.53% | 3.63 | 11.18% | 2.81 | 8.65% |
| Excluding C | Elec | | 0.94 | 31.70 | 0.96 | 30.47 | 0.37 | 1.21% | 2.41 | 7.90% | 2.78 | 9.11% |

Program savings for 2013 are the total of the net top-down savings of 0.37 aMW and the bottom up savings which coincidentally are similar at 0.37 aMW, for total SEM savings of 0.74 aMW.

[6] Energy consumption adjusted to reflect what would have been consumed if the EEMs had not been implemented, to isolate the effect of SEM that was not quantified by the bottom up validation.
[7] The total top down estimate reflects cumulative savings since 2009.

**Table 4. Model Fit and Net Top-Town Savings Summary, Natural Gas**

| Site | Fuel | Model | Coefficient of Determination $R^2$ | Reference Year Consumption (therms) | Production Ratio (2013/ Baseline) | Adjusted 2013 Reference Consumption (therms) | Net Top-Down | | Energy Efficiency Measures (modeled) | | Total Top-Down (cumulative) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Savings (therms) | Percent | Savings (therms) | Percent | Savings (therms) | Percent |
| A | gas | PHC | 0.96 | 11732279 | 0.82 | 9616949 | 113480 | 1.18% | 526060 | 5.47% | 639540 | 6.65% |
| C | gas | PHC | 0.94 | 10475792 | 0.92 | 9610492 | 293120 | 3.05% | -1029220 | -10.71% | -736100 | -7.66% |
| D | gas | PHC | 0.94 | 8692611 | 0.76 | 6604646 | 298530 | 4.52% | 511530 | 7.75% | 810060 | 12.27% |
| E | gas | PHC | 0.98 | 556919 | 1.15 | 641515 | 21170 | 3.30% | 0 | 0.00% | 21170 | 3.30% |
| F | gas | P | 0.91 | 454547 | 0.77 | 350228 | 7670 | 2.19% | 0 | 0.00% | 7670 | 2.19% |
| G | gas | PHC | 0.95 | 770844 | 1.02 | 784565 | 132670 | 16.91% | 0 | 0.00% | 132670 | 16.91% |
| H | gas | PHC | 0.99 | 475961 | 0.83 | 395000 | 790 | 0.20% | -67650 | -17.13% | -66860 | -16.93% |
| I | gas | PHC | 0.97 | 1588786 | 1.16 | 1838384 | 18200 | 0.99% | 143780 | 7.82% | 161980 | 8.81% |
| K | gas | PHC | 0.90 | 7736759 | 0.89 | 6883395 | 373080 | 5.42% | 753320 | 10.94% | 1126400 | 16.36% |
| M | gas | PHC | 0.97 | 7875507 | 1.12 | 8796154 | -91480 | -1.04% | 396320 | 4.51% | 304840 | 3.47% |
| Overall | gas | | 0.95 | 50360006 | 0.90 | 45521328 | 1167230 | 2.56% | 1234140 | 2.71% | 2401370 | 5.28% |
| Excluding C | gas | | 0.94 | 39884214 | 0.90 | 35910836 | 874110 | 2.43% | 2263360 | 6.30% | 3137470 | 8.74% |

The 2013 total natural gas savings are the sum of the net top-down savings of 0.87 million therms plus the bottom-up savings of .31 million therms, for a total of 1.2 million therms.

**Table 5 Model Fit and Net Top-Town Savings Summary, Total Fuels**

| Site | Fuel | Model | Coefficient of Determination $R^2$ | Reference Year Consumption (mmBTU) | Production Ratio (2013/ Baseline) | Adjusted 2013 Reference Consumption (mmBTU) | Net Top-Down | | Energy Efficiency Measures (modeled) | | Total Top-Down | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Savings (mmBTU) | Percent | Savings (mmBTU) | Percent | Savings (mmBTU) | Percent |
| A | elec | PHC | 0.88 | 177426 | 0.82 | 145436 | 7199 | 4.95% | 9642 | 6.63% | 16841 | 11.58% |
| | gas | PHC | 0.94 | 1173228 | 0.82 | 961695 | 11348 | 1.18% | 52606 | 5.47% | 63954 | 6.65% |
| | total | P | 0.91 | 1350653 | 0.82 | 1107131 | 18547 | 1.68% | 62248 | 5.62% | 80795 | 7.30% |
| C | elec | P | 0.69 | 66634 | 0.92 | 61130 | -35559 | -58.17% | 36678 | 60.00% | 1119 | 1.83% |
| | gas | PHC | 0.92 | 1047579 | 0.92 | 961049 | 29312 | 3.05% | -102922 | -10.71% | -73610 | -7.66% |
| | total | PHC | 0.81 | 1114213 | 0.92 | 1022179 | -6247 | -0.61% | -66244 | -6.48% | -72491 | -7.09% |
| D | elec | PHC | 0.81 | 94505 | 0.76 | 71805 | -2858 | -3.98% | 0 | 0.00% | -2858 | -3.98% |
| | gas | PHC | 0.94 | 869261 | 0.76 | 660465 | 29853 | 4.52% | 51153 | 7.75% | 81006 | 12.27% |
| | total | PHC | 0.88 | 963766 | 0.76 | 732269 | 26995 | 3.69% | 51153 | 6.99% | 78148 | 10.67% |
| E | elec | PHC | 0.98 | 68644 | 1.15 | 79071 | 2894 | 3.66% | 5870 | 7.42% | 8764 | 11.08% |
| | gas | PHC | 0.98 | 55692 | 1.15 | 64152 | 2117 | 3.30% | 0 | 0.00% | 2117 | 3.30% |
| | total | PHC | 0.98 | 124336 | 1.15 | 143223 | 5011 | 3.50% | 5870 | 4.10% | 10881 | 7.60% |
| F | elec | P | 0.99 | 36847 | 0.77 | 28391 | 247 | 0.87% | 2185 | 7.70% | 2432 | 8.57% |
| | gas | P | 0.91 | 45455 | 0.77 | 35023 | 767 | 2.19% | 0 | 0.00% | 767 | 2.19% |
| | total | P | 0.95 | 82302 | 0.77 | 63414 | 1014 | 1.60% | 2185 | 3.45% | 3199 | 5.05% |
| G | elec | PHC | 0.96 | 101412 | 1.02 | 103217 | 5935 | 5.75% | 19148 | 18.55% | 25083 | 24.30% |
| | gas | PHC | 0.95 | 77084 | 1.02 | 78457 | 13267 | 16.91% | 0 | 0.00% | 13267 | 16.91% |
| | total | PHC | 0.96 | 178497 | 1.02 | 181674 | 19202 | 10.56% | 19148 | 10.54% | 38350 | 21.10% |
| H | elec | PHC | 0.94 | 13274 | 0.83 | 11016 | -1659 | -15.06% | 1958 | 17.77% | 299 | 2.71% |
| | gas | PHC | 0.99 | 47596 | 0.83 | 39500 | 79 | 0.20% | -6765 | -17.13% | -6686 | -16.93% |
| | total | PHC | 0.97 | 60870 | 0.83 | 50516 | -1579 | -3.13% | -4806 | -9.51% | -6385 | -12.64% |
| I | elec | PHC | 0.97 | 92856 | 1.16 | 107443 | 8069 | 7.51% | 9808 | 9.13% | 17877 | 16.64% |
| | gas | PHC | 0.97 | 158879 | 1.16 | 183838 | 1820 | 0.99% | 14378 | 7.82% | 16198 | 8.81% |
| | total | PHC | 0.97 | 251734 | 1.16 | 291282 | 9889 | 3.39% | 24185 | 8.30% | 34074 | 11.69% |

| Site | Fuel | Model | Coefficient of Determination $R^2$ | Reference Year Consumption (mmBTU) | Production Ratio (2013/ Baseline) | Adjusted 2013 Reference Consumption (mmBTU) | Net Top-Down | | Energy Efficiency Measures (modeled) | | Total Top-Down | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Savings (mmBTU) | Percent | Savings (mmBTU) | Percent | Savings (mmBTU) | Percent |
| K | elec | PHC | 0.95 | 178404 | 0.89 | 158726 | -8222 | -5.18% | 8975 | 5.65% | 753 | 0.47% |
| | gas | PHC | 0.90 | 773676 | 0.89 | 688339 | 37308 | 5.42% | 75332 | 10.94% | 112640 | 16.36% |
| | total | PHC | 0.92 | 952080 | 0.89 | 847065 | 25780 | 3.04% | 87620 | 10.34% | 113400 | 13.38% |
| M | elec | PHC | 0.96 | 183544 | 1.12 | 205000 | -574 | -0.28% | 14277 | 6.96% | 13703 | 6.68% |
| | gas | PHC | 0.97 | 787551 | 1.12 | 879615 | -9148 | -1.04% | 39632 | 4.51% | 30484 | 3.47% |
| | total | PHC | 0.96 | 971094 | 1.12 | 1084615 | -9722 | -0.89% | 53909 | 4.97% | 44187 | 4.08% |
| Overall | elec | | 0.91 | 1013545 | 0.96 | 971235 | -24528 | -2.53% | 108542 | 11.18% | 84013 | 8.65% |
| | gas | | 0.95 | 5036001 | 0.90 | 4552133 | 116723 | 2.56% | 123414 | 2.71% | 240137 | 5.28% |
| | total | | 0.93 | 6049546 | 0.91 | 5523368 | 88890 | 1.61% | 235269 | 4.26% | 324158 | 5.87% |
| Excluding C | elec | | 0.94 | 946911 | 0.96 | 910105 | 11031 | 1.21% | 71863 | 7.90% | 82895 | 9.11% |
| | gas | | 0.95 | 3988421 | 0.90 | 3591084 | 87411 | 2.43% | 226336 | 6.30% | 313747 | 8.74% |
| | total | | 0.94 | 4935332 | 0.91 | 4501188 | 95137 | 2.11% | 301512 | 6.70% | 396650 | 8.81% |

## Conclusions

The Industrial initiative continued to generate similar savings to 2012. These plants have been at NEEA's level of sustaining SEM since 2009 or 2010, overall showing no reduction in opportunities after 4 years of engagement at the sustaining level plus 3 to 5 years at earlier stages of development in the program.

DNV KEMA did observe a pattern regarding company participation in 2013. One company focused on boiler, steam and lighting measures, completing 5 measures. The other active company completed a broader range of actions over 20 measures, including refrigeration, boilers, lighting, process equipment and process operation improvements, steam and compressed air. Both of the more active companies continued to find opportunities in their operations, as well as specific retrofits and upgrades. The less active company, represented by Facilities K and M, did not achieve much incremental savings in 2013 due to SEM, whether from quantified measures or other actions.

Plant activities outside of strict efficiency actions effect energy consumption; modelers do not have visibility into many factors that may increase or decrease consumption. According to interviews with the cohort participants, Facility H produced more energy intensive products in 2013 compared to 2012, resulting in no apparent savings due to SEM. We did not include Facility C in the final results as the top-down model was not able explain variation in energy consumption due a switch from wood to natural gas.

The active facilities (excluding facility C) averaged savings of 3% overall (electric and gas combined as MMBTU) compared to expected consumption without the program, where the less active facilities yielded less than 1% savings overall.

# Appendix A: Top-Down Energy Savings Model for 2013 Food Processing Initiative Facility Participants

## 1 Introduction

This Appendix presents the results and methodology of a top-down modeling analysis of energy consumption at ten NEEA food processing facilities. The selected sites were actively involved in the Strategic Energy Management (SEM) program through the end of 2013. The objective of the top-down analysis was to quantify and disaggregate energy savings in 2013 from the otherwise unquantified behavioral/operational aspects of the SEM program and quantified Energy Efficiency Measures (EEM) implemented by the facilities while they participated in SEM.

The modeling results demonstrate proportional and satisfactory savings from both aspects of the SEM program. The top-down models incorporated the bottom-up engineering estimated savings for EEMs, demonstrated excellent goodness-of-fit (GOF) in all but one instance, and captured the underlying system dynamics of nine out of ten involved facilities. Furthermore, the estimated savings are consistent with the end-use energy efficiency records of involved facilities. Consequently, the estimated savings demonstrate both statistical and practical significance. The overall estimated savings support NEEA's decision to invest in industrial energy management.

The rest of this Appendix is organized as follows: Section 2 provides a summary of savings and GOFs of the models for each facility. Section 3 illustrates the modeling approach and data pre-processing in detail. Section 4 presents the results, followed by conclusions in Section 5.

## 2 Summary

### 2.1 Data Source

The ten facilities participating in NEEA's food processing initiative are located in three states within the Pacific Northwest region. Through their contractor, NEEA collected the monthly electricity, gas consumption, and net production data for each facility since the involvement of each facility, stored in a confidential database. Data was available in some cases from as early as 2004. NEEA tracks the stages of engagement for each facility. Eight of the ten facilities advanced to the sustaining level by 2009; two facilities reached this level in 2010. The contractor also collected data on specific EEMs completed and associated savings for each facility since beginning the plant's involvement in the program. With weather data retrieved from the National Oceanic and Atmospheric Administration (NOAA), these historical datasets serve as the foundation for the top-down analysis.

## 2.2 Top-Down Model

DNV KEMA developed top-down models for each facility, estimating the change in annual energy consumption for each year since each facility adopted SEM, after accounting for non-program factors such as weather and production volume. The top-down analysis makes use of linear regression techniques to predict changes in electric and gas consumption.

DNV KEMA tested two top-down model specifications. The first model, referred to as the P Model, includes only production as its independent variable. The second model, namely the PHC Model, adds heating degree days (HDD) and cooling degree days (CDD) as two extra independent variables. Modeling results show that both models are able to capture well the highest monthly energy consumption (occurring typically from June to November). The PHC Model tracks base load better for some facilities. To produce accurate savings estimation, we have evaluated and selected the best-fit model for each facility individually.

## 2.3 Savings Disaggregation

The top-down model adopted a System Dynamics Recovery (SDR) strategy to disaggregate energy savings into two categories, referred to by the shorthand abbreviations of SEM and EEM in this appendix:

- SEM in this appendix refers to the behavioral and operational savings from the SEM program. This represents the net top-down savings.
- EEM, referring to savings from identified retrofit, capital and/or utility-incented measures implemented during the period of SEM participation.

The model is designed to compare actual energy consumption where SEM and EEM actions affected energy consumption with scenarios where no actions were taken. The two no action scenarios assume: (a) no EEM projects had been implemented, and (b) no SEM or EEM actions had been implemented. With these two recovered trends and energy consumption data in 2013, we disentangled savings caused simultaneously by net top-down SEM and EEM, and estimated their individual contributions.

## 2.4 Modeling GOF

The top-down models demonstrate excellent modeling results for nine out of ten involved facilities. The average correlation coefficient between modeling and measurement is above 0.94 for the nine facilities. This provides solid mathematical justification and confidence in the model's ability to capture the underlying system dynamics of energy consumption at involved facilities.

## 2.5 Estimated Savings

Based on the individually selected best-fit top-down models, we predict energy consumption in 2013, and calculate electricity saving and gas saving for both SEM and EEM annually. Figure 1 presents the total savings: 0.37 aMW electricity, 87411 MMBTU gas due to the SEM program, and 2.41 aMW electricity, 226,336 MMBTU gas due to the EEM programs. Thanks to both SEM and EEM activities, the total energy consumption of all selected facilities in 2013 is reduced by 8.8% compared to their consumption in the reference year.

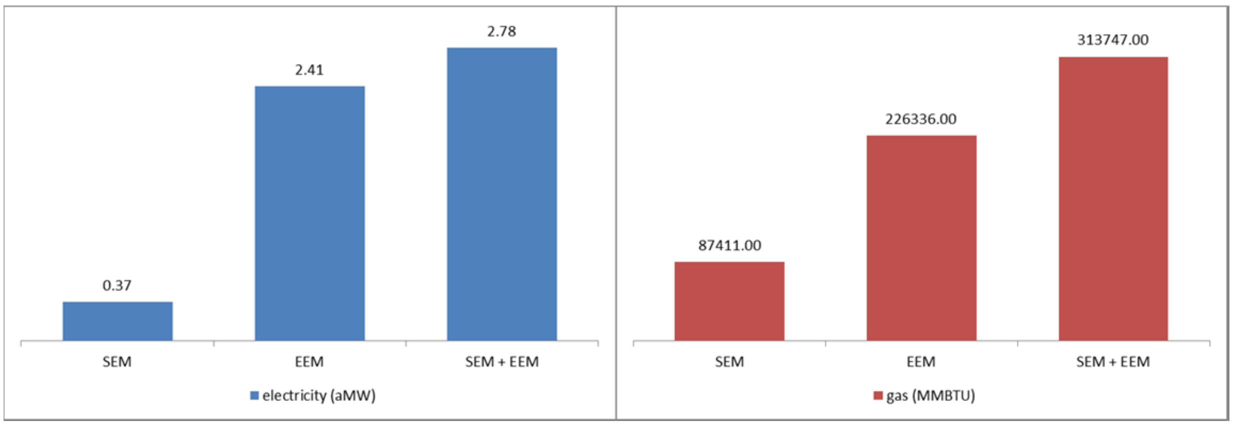



Figure 1 – 2013 estimated total energy savings due to SEM and EEM.

# 3 Modeling Approach

## 3.1 Methodology

The biggest challenge of the top-down analysis is to disaggregate energy savings in terms of SEM and EEM actions. The available energy consumption data reflects only the overall effect of both SEM and EEM. The situation is similar to when a driver tries to reduce his car's fuel consumption by both improving his driving behavior (SEM in our case), and upgrading his car with energy-efficient components, such as a diesel engine (EEM in our case). With annual consumed fuel records (consumption data in our case) before and after his efforts becomes effective, he wants to estimate how many gallons are saved due to changes in his driving behavior, and how many are saved due to the energy-efficient component upgrade.

The savings due to the driving behavior change and component upgrade occur simultaneously. With only the consumption record, the driver is not able to achieve his evaluation goals. This is because no consumption references are available for the scenarios: (a) if the driver only improves his driving behavior without upgrading any energy-efficient components, or (b) if the driver only upgrades energy-efficient components without changing his driving behavior. Luckily, the diesel engine manufacturer provides annual estimated saving (bottom-up savings from completed EEM projects in our case). If the driver adds this saving to his end-use consumption records, he recovers an approximate consumption record of the needed scenario (a).

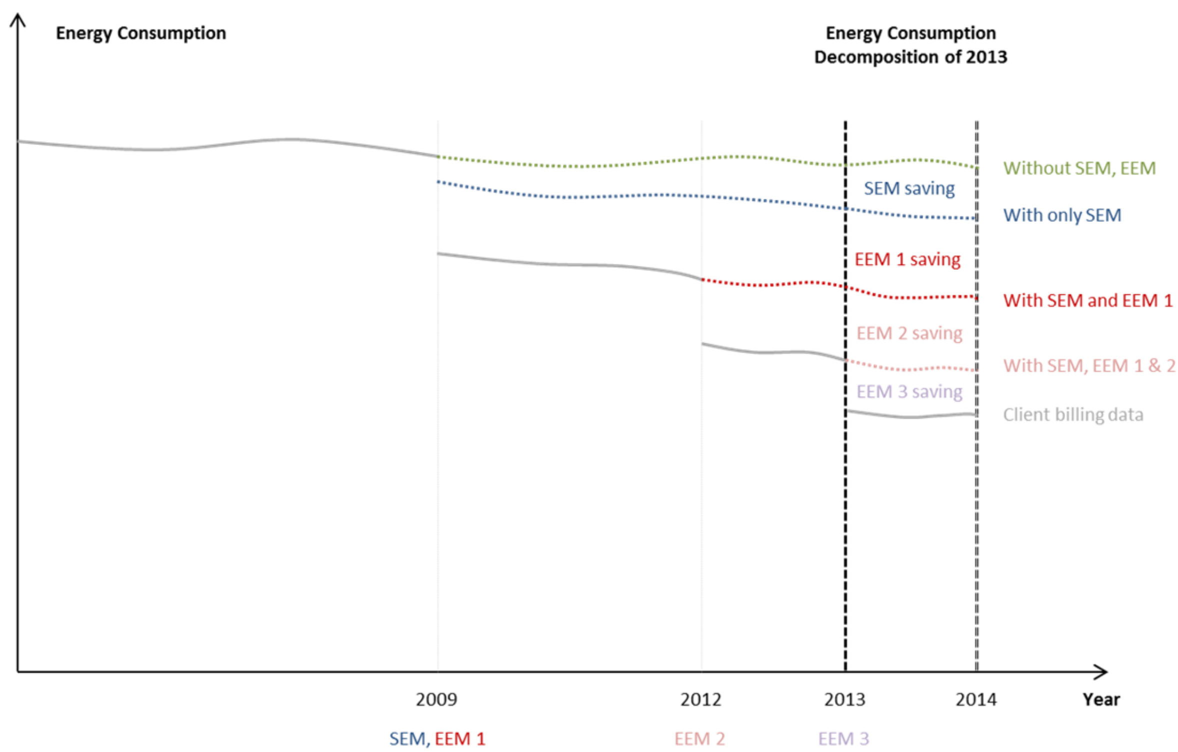



Figure 2 – Facility energy consumption trends under different scenarios.

In our analysis, we apply a similar strategy to recover the energy consumption trend for one reference scenario, i.e., only the SEM activities are implemented, with no EEMs. We use this reference, together with the energy consumption data in both the reference period and 2013, to evaluate savings that occurred in 2013.

Figure 2 illustrates energy consumption trends for an example facility. It engaged in the SEM program from the beginning of 2009. Between 2009 and 2013, the facility implemented EEMs. For this analysis, DNV KEMA grouped the projects by when they were completed in three phases: 2009-2011 (EEM 1), 2012 (EEM 2) and 2013 (EEM 3). The solid line in gray represents the energy consumption (billing) data that are directly available. The dashed lines in green, blue, and red represent recovered trends under three reference scenarios. For example, the blue dashed line recovers what energy consumption would be if only the SEM actions had been implemented. The red dashed line recovers what consumption would be if only the SEM actions and EEM 1 had been implemented.

Let us focus on 2013 in Figure 3. If we recover: (a) the green dashed line, which represents the scenario that no SEM and EEM actions had been implemented at all, and (b) the blue dashed line, under the scenario only the SEM program (with no EEM projects) had been implemented, the area in-between these two trends is the saving due to the SEM program. On the other hand, the area in-between the blue dash line and the gray solid line (2013 billing data) is the saving due to the cumulative effect of EEMs.

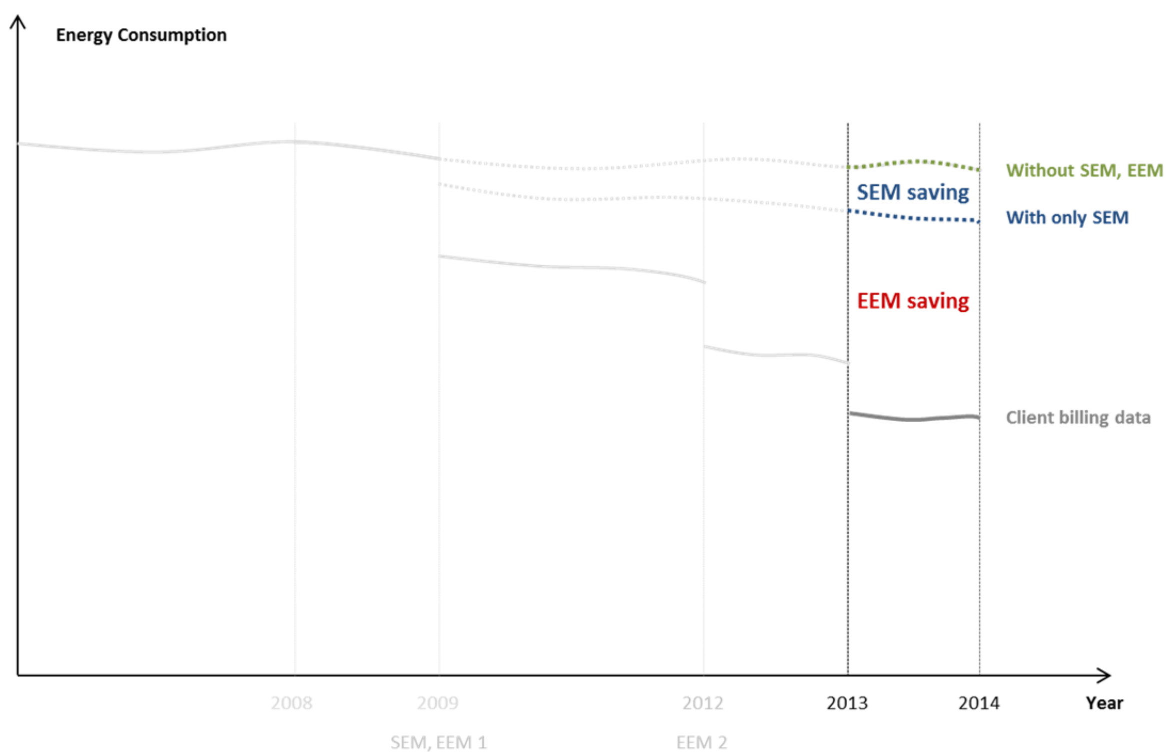



Figure 3 – Facility energy consumption trends under different scenarios.

Now the question is how to recover the green and blue dash lines based on the consumption data, and the bottom-up estimated savings.

Figure 4 illustrates the procedures of recovering the blue dashed line by allocating bottom-up savings. In the top subplot, end-use consumption data (gray dashed lines) are used as the baseline. During 2012, we add the bottom-up EEM 2 saving on top of the baseline. This recovers the energy consumption trend (half gray half red solid line in the middle subplot) if only the SEM and EEM 1 actions are implemented. To further distinguish the effect by the EEM 1 program, we add the estimated EEM 1 savings to each year from 2009 to 2013, because measures implemented in 2009 are expected to persist into 2013. Eventually, we obtain the needed trend (red solid line) in the bottom subplot that represents the trend when only the SEM program is implemented.

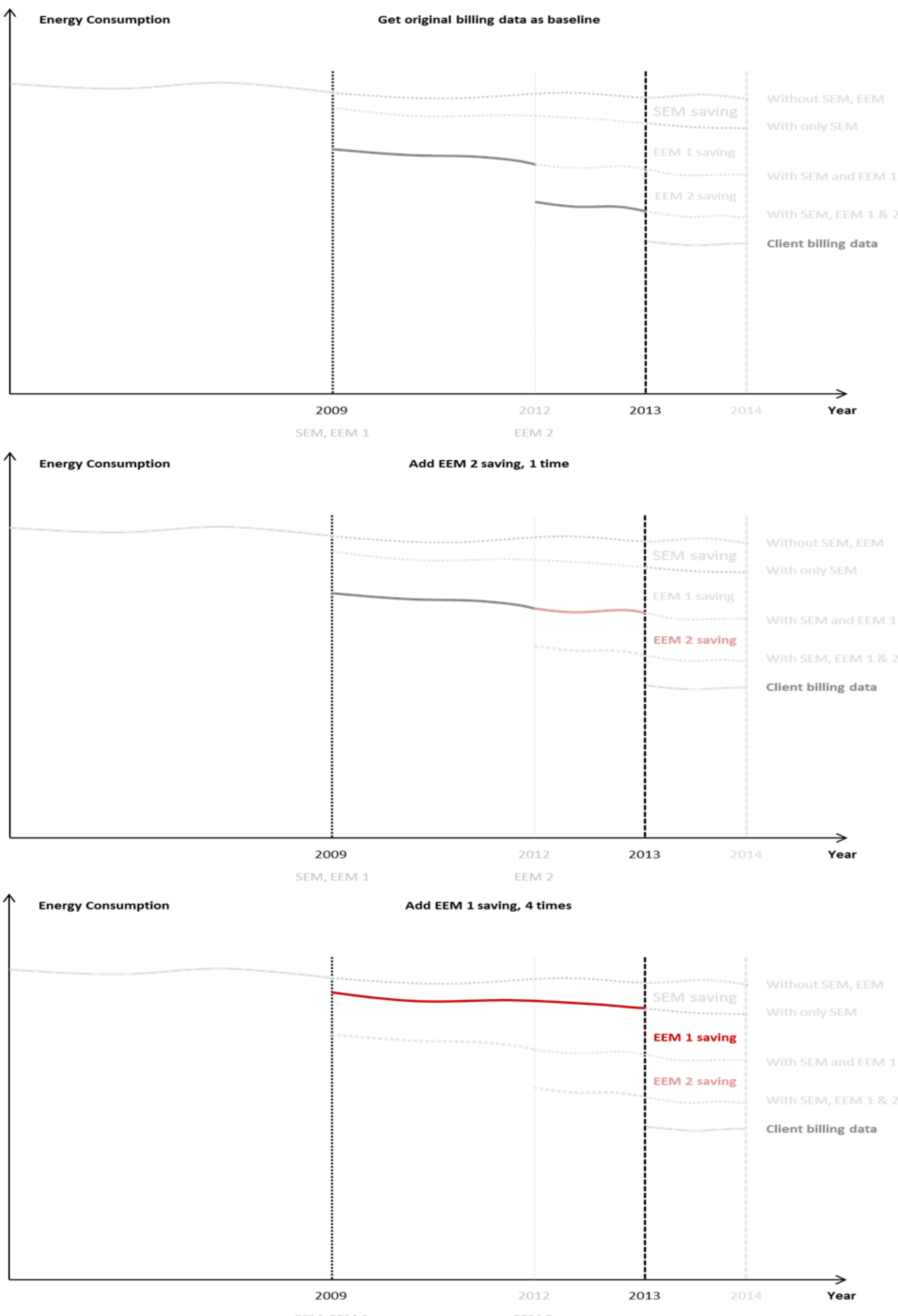



Figure 4 – Recovered consumption trend of the scenario when only SEM was implemented.

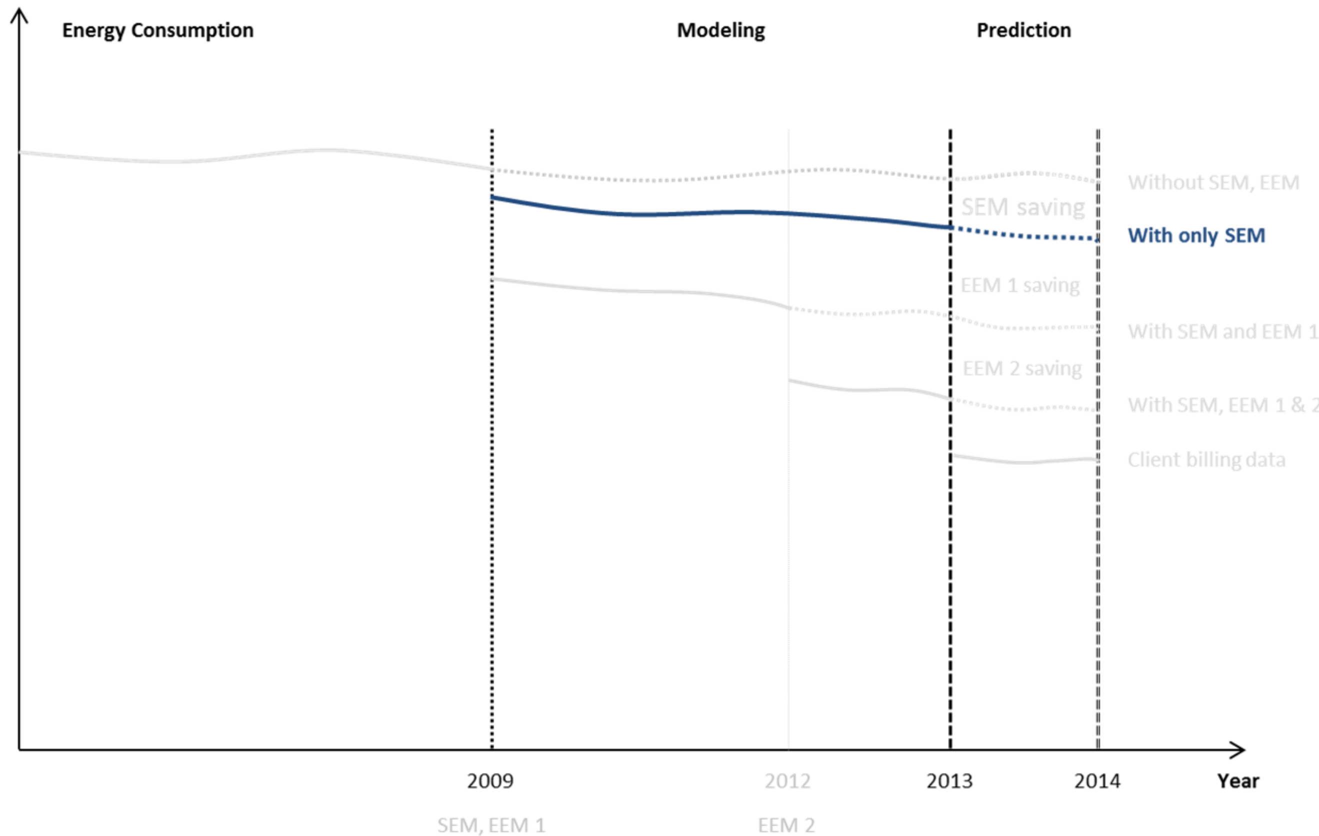



Figure 5 – Top-down model modeling and prediction.

With the recovered energy consumption trend, and production and weather data during the same period time, we conduct regression to obtain the coefficients of the top-down model. Eventually, we use the resultant model to predict energy consumption in 2013 (blue dashed line). This modeling and prediction procedure is shown in Figure 5.

Thus far, we have demonstrated how to recover the blue dashed line. In the following paragraphs we will describe how to recover the green dashed line.

To recover the energy consumption of the scenario when neither SEM nor EEM actions had been implemented, we start with the facility energy consumption one year prior to SEM became effective. SEM was considered to be effective when the facility achieved the sustaining level as defined by NEEA. This energy consumption serves as the reference for evaluating the consumption change in 2013. Take the facility in Figure 6 as example. The SEM program became effective in 2009. Energy consumption in 2008 (green solid line in the top subplot) becomes the reference.

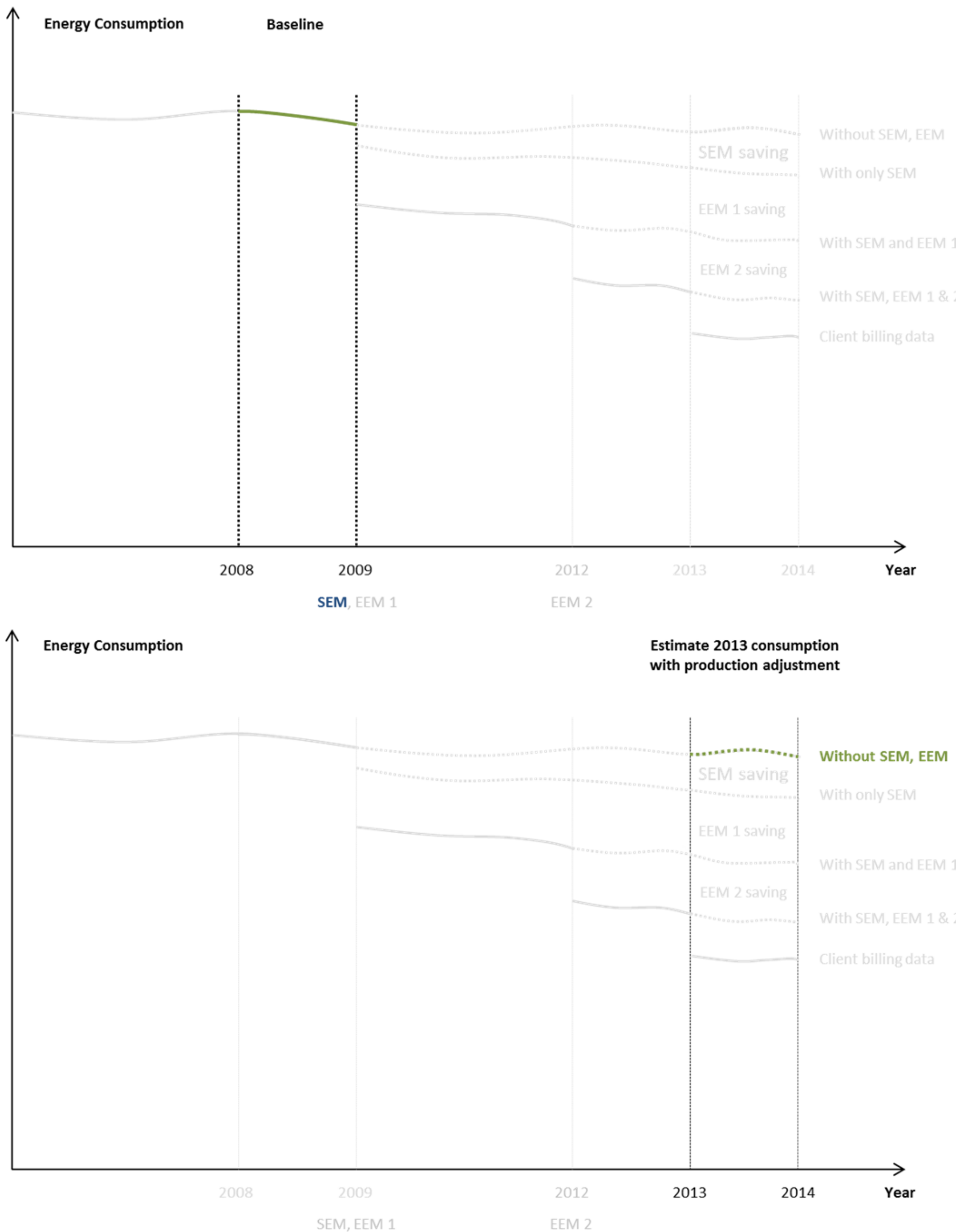



Figure 6 – Recovered consumption trend of the scenario without any programs.

To compensate for the production difference between the reference year and evaluation year, we adjust the reference year's energy consumption by the production ratio between the evaluation and reference year. This adjusted consumption becomes the final reference (green dashed line in the bottom subplot) for calculating the savings. Mathematically,

$$\begin{aligned} &Adjusted\ 2013\ ref. \\ &\qquad = Annual\ energy\ consumption\ in\ the\ year\ pior\ to\ SEM \\ &\qquad * \frac{Annual\ production\ in\ 2013}{Annual\ production\ in\ the\ year\ prior\ to\ SEM}. \end{aligned}$$

To this end, we have recovered all consumption trends needed for the 2013 saving evaluation.

In the 2012 evaluation, the top-down model used regression analysis with a baseline year of typically 2006 and 2007. EEM savings were not incorporated in the model. Net SEM savings were imputed by subtracting out the validated EEMs saving in 2013 from the total savings estimated by the model. In the 2013 analysis, our model similarly looks at the total, but estimates the net top down directly by incorporating the EEMs in the model.

## 3.2 Model structure

By examining the original time series of production and energy consumption, we identified a strong linear relationship between them. Figure 7 demonstrates such observations between total energy consumption and production for all involved facilities.

In previous evaluation of similar facilities located in the same region, local weather conditions, in terms of temperature, were identified to influence energy consumption to a limited but measureable extent. Considering these facts, we tested two top-down models with different sets of independent variables: (1) the production only model (P Model), and (2) the production, HDD, and CDD model (PHC Model). For both models, the dependent variable, energy consumption, is represented as linear combinations of independent variables. Mathematically,

P Model:

$$Energy\ consumption = a * production + b\ +\ \varepsilon,$$

where a is the regression coefficient, b is the intercept, and ε is the residual.

PHC Model:

$$Energy\ consumption = c * \ production + d * HDD + e * CDD + f + \ \varepsilon,$$

where c, d, and e are regression coefficients, f is the intercept, and ε is the residual.

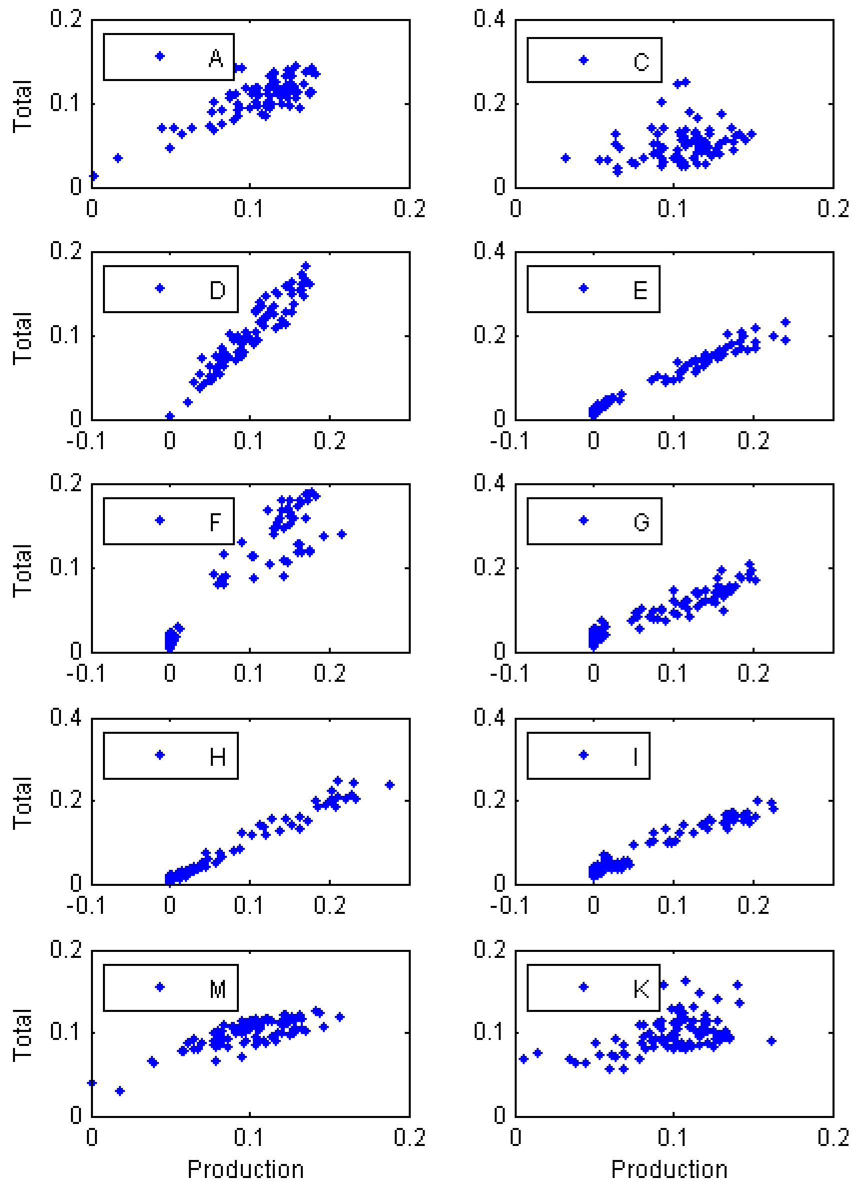



Figure 7 – Scatter plots of normalized production and energy consumption for involved facilities.

## 3.3 Bottom-up saving adjustment

As outlined in Section 3.1, we adopted the SDR strategy, and allocated bottom-up savings to observed energy consumption on a month by month basis. The SDR strategy recognizes that some measures are not closely tied to production levels (e.g., lighting) while other (e.g., compressors) are. For this analysis, we allocated annual savings to months based on the proportion of production that typically occurs in that month for measures tied to production.

There is an alternative approach for handling the bottom-up savings, i.e., statistically adjusted engineering, in which the bottom-up savings are used as an extra independent variable other than being allocated to the dependent variables.

To meet time and budget constraints, we did not use the statistically adjusted engineering approach. In fact, the adopted SDR strategy in this analysis provided excellent modeling GOF. For some facilities, the SDR strategy increased correlation coefficients dramatically from 0.62 to 0.89, that is, a value with minimal statistical significance to a value with excellent statistical significance. In the following section, we will present such results.

## 3.4 Data

### 3.4.1 Consumption data

We examined the original datasets to ensure their quality prior to numerical analysis. Some previous known data issues have been addressed rigorously:

1. Data sufficiency
   (1) All ten facilities have more than three years of data with non-zero production and energy consumption.
   (2) All ten facilities have the desired formats and consistent units.
2. Negative production has been identified for six facilities. In these cases, production was assumed to be zero.
3. No positive production with zero energy consumption has been identified.
4. No outliers have been identified for both electricity and gas for all facilities.

### 3.4.2 Weather data

We identified the nearest possible NOAA weather station for each facility, and retrieved metrological readings accordingly. The original NOAA weather data included the dry bulb, wet bulb, dew point temperature, and relative humidity. All measurements have an hourly interval.

We have verified the original weather data by checking its range, and seasonal patterns. The temperature range is consistent with climate in the Pacific Northwest region where there are typically few readings above 100 degrees Fahrenheit or below freezing.

To resolve the resolution difference between hourly weather data and monthly energy consumption data, we calculated monthly HDD and CDD for each facility. Degree days measure the amount of time during the month a facility is below or above a reference or basis temperature. For residential and office buildings, this number is usually 65 degrees Fahrenheit. When the outside temperature is above (below) 65, buildings spend energy cooling (heating). Cooling and heating degree days are the cumulative time over the month that the building is above and below, respectively, the reference temperature. In this analysis, we computed HDD and CDD for an average reference temperature, 65 degrees Fahrenheit. Figure 8 shows the calculated HDD and CDD for one example facility during the modeling period.

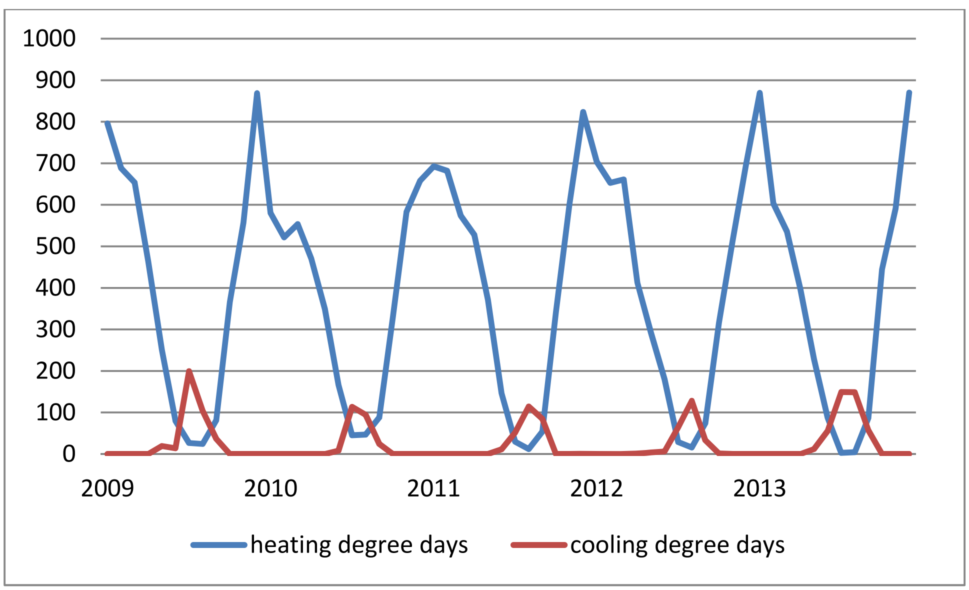



Figure 8 – Heating and cooling degrees days of one involved facility.

# 4 Results

## 4.1 Goodness-of-fit

In this Section, we demonstrate the numerical results of estimated energy savings in 2013. We first present the top-down model's GOF results, which serve as the mathematical confirmation to support the model's prediction accuracy.

### 4.1.1 P model vs. PHC model

Both the P model and the PHC model demonstrated excellent accuracy in tracking energy consumption for all involved facilities. The average correlation coefficient between modeling results and actual measurements are above 0.90 (including or excluding facility C). Given the uncertainties of data collection, and relative low data resolution, this is a highly satisfactory GOF result. Figure 9 shows gas modeling results from both models for one facility. Other facilities demonstrated similar good results.

While both models tracked peak energy consumption fairly well, ranging typically from June to November, the PHC model outperformed the P model in capturing the base loads cycled in red in Figure 9. This is especially true when the production is zero. The extra HDD and CDD information enhance the top-down model's ability to recover the fact that minimal energy consumption exists, even when there is no production.

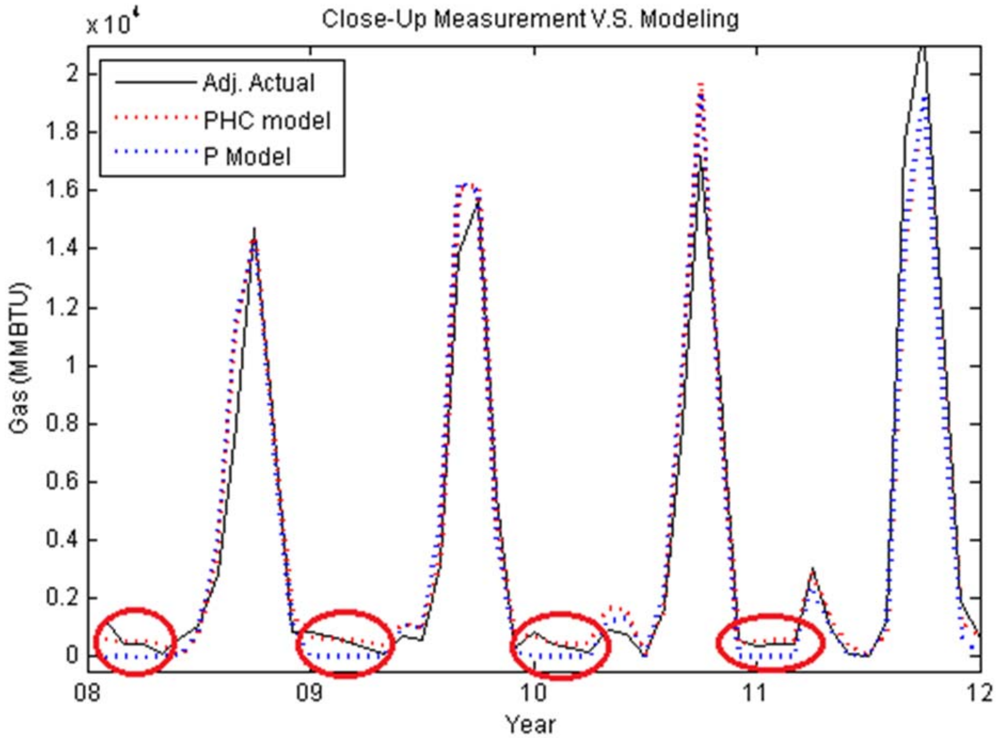
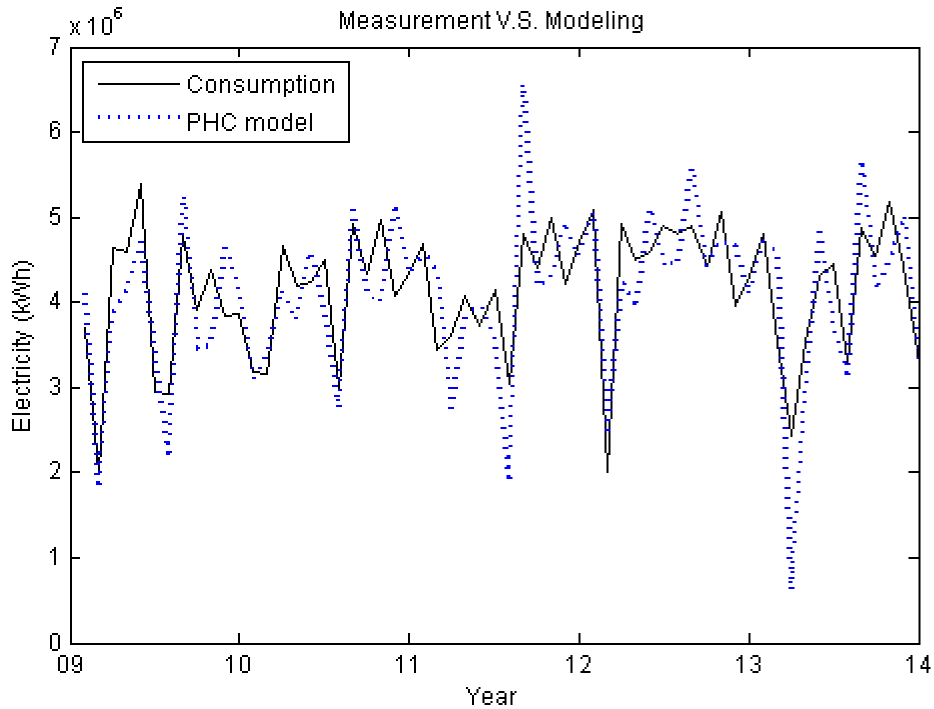



Figure 9 – Comparison of gas modeling produced by P model and PHC model.

### 4.1.2 The SDR strategy

Modeling results show that the SDR strategy to allocate bottom-up savings is a success. Modeling GOF of all facilities demonstrated an increase in correlation coefficient (r) and a decrease in mean squared error (mse) with the strategy implemented. Consider the example of electricity modeling in Facility K as shown in Figure 10, which compares the results when the SDR strategy is (and not) implemented. The correlation coefficient increased significantly from 0.75 to 0.94 when bottom-up savings are included in the model.

Similar results have been observed for gas modeling. Figure 11 shows such gas modeling results for the same facility. The correlation coefficient increased even more by 43.5% from 0.62 to 0.89.



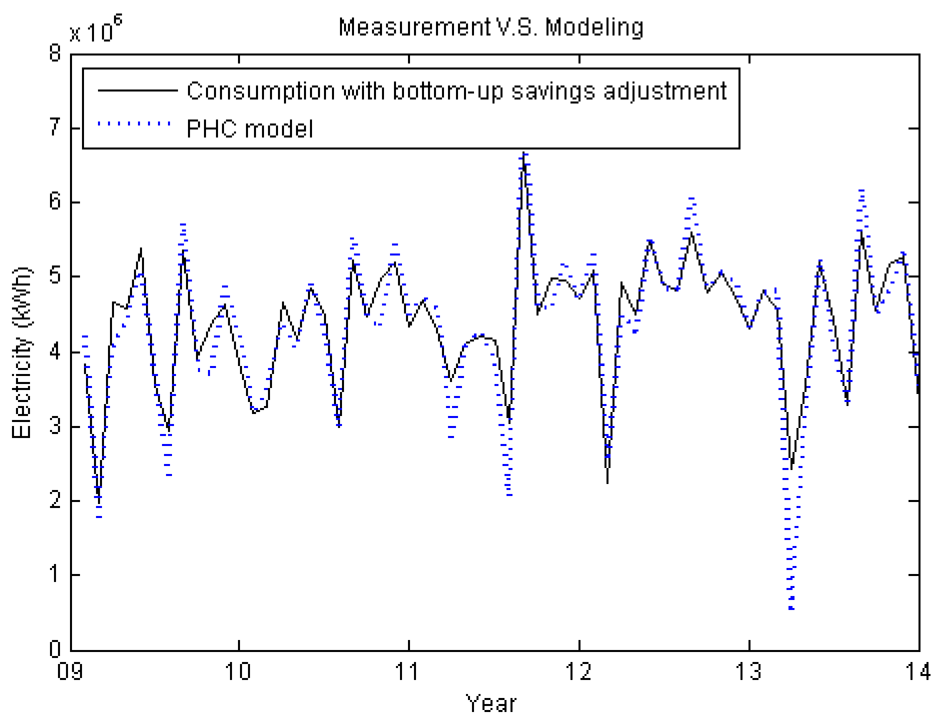
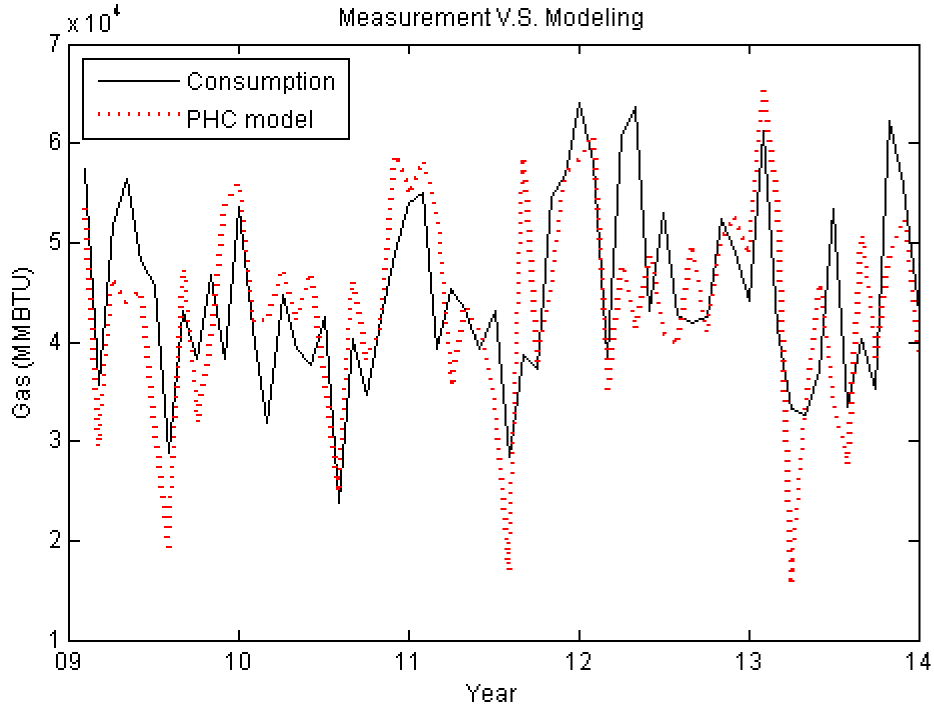




Figure 10 – Modeling of electricity consumption with and without the bottom-up savings



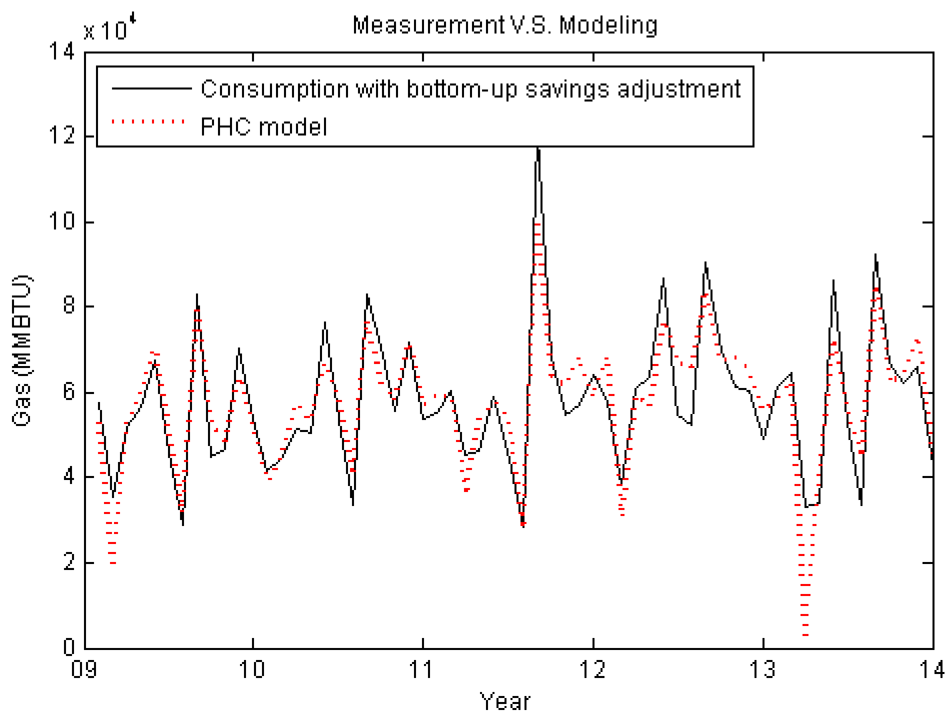




Figure 11 – Modeling of gas consumption with and without the bottom-up savings

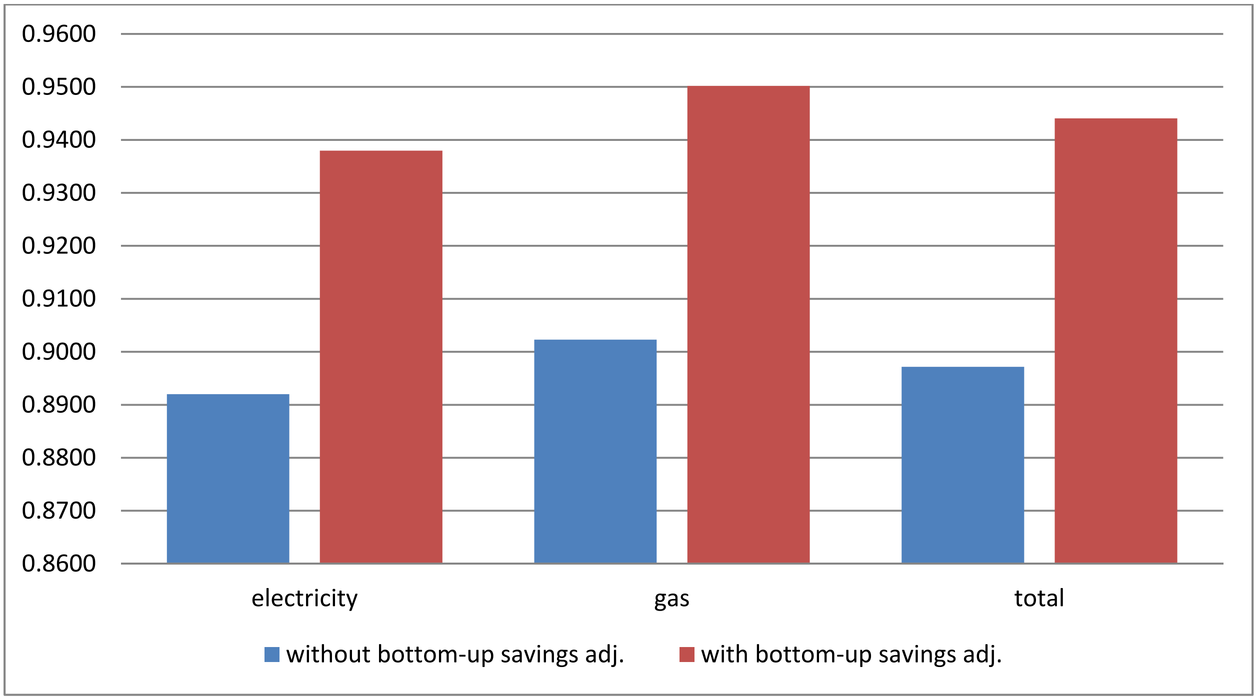



Figure 12 – Correlation coefficient comparison with and without the SDR strategy.

The GOF improvements for all facilities are shown in Figure 12. For both electricity modeling and gas modeling, the correlation coefficient increased by 5.23%, while the mean squared error decreased by 63.24%.

The mean squared error measures the exact location of modeling. In our modeling, this measure represents the exact deviation of modeling from the actual energy consumption, and hence it relates directly to the estimated energy savings. Consequently, a 63.24% reduction in the mean squared error significantly increases the accuracy of our estimated energy savings.

### 4.1.3 Overall GOF

With HDD and CDD as extra independent variables and the SDR strategy, the top-down model demonstrated excellent GOF results for both gas and electricity modeling. Tables 1 takes PHC total energy consumption model as example, and lists the identified regression coefficients and their standard errors. The results are proportional and consistent among all involved facilities except facility C, the production related regression coefficient standard error of which is one order of magnitude smaller than those of the other nine facilities.

Table 2 lists the complete results of correlation coefficients and mean squared errors for all facilities involved. The average correlation coefficients for electricity and gas modeling are 0.93 and 0.95 respectively, excluding Facility C. These excellent GOF results prove mathematically that the top-down model is able to capture system dynamics of energy consumption accurately. Therefore, the estimated savings produced by the top-down model are of mathematical significance.

Table 1 – Regression coefficients and their standard errors of the PHC total energy consumption model.

| Site | Production | | HDD | | CDD | |
|---|---|---|---|---|---|---|
| | Estimated coefficent | Standard error | Estimated coefficent | Standard error | Estimated coefficent | Standard error |
| A | 0.0139 | 2071298.89 | 15.1950 | 447.48 | 16.9658 | 75.49 |
| C | 0.0046 | 974998.10 | 3.5468 | 486.93 | 49.3105 | 45.61 |
| D | 0.0097 | 1577936.57 | 10.4035 | 482.47 | 40.6828 | 54.31 |
| E | 0.0011 | 12320383.92 | 4.4746 | 269.68 | 3.1902 | 45.17 |
| F | 0.0011 | 5527336.66 | 1.6826 | 359.35 | 0.7453 | 105.81 |
| G | 0.0010 | 10379353.44 | 7.0511 | 420.88 | 6.0438 | 111.24 |
| H | 0.0026 | 2730869.67 | 1.1589 | 271.19 | -3.3374 | 42.66 |
| I | 0.0015 | 13826808.20 | 15.8206 | 266.33 | 8.9324 | 44.73 |
| K | 0.0026 | 6780205.79 | 1.3343 | 387.40 | 30.5061 | 103.61 |
| M | 0.0022 | 10940954.34 | 17.8328 | 373.70 | 34.7859 | 106.66 |

Table 2 –Goodness-of-fits of the top-down models

| Site | Source | Without bottom-up savings | | With bottom-up savings | |
|---|---|---|---|---|---|
| | | $r^2$ | mean squared error | $r^2$ | mean squared error |
| A | electricity | 0.8460 | 2.73E+11 | 0.8792 | 3.40E+11 |
| | gas | 0.9184 | 9.1070E+07 | 0.9365 | 7.2808E+07 |
| | average | 0.8822 | 1.3637E+11 | 0.9079 | 1.6996E+11 |
| C | electricity | 0.4816 | 7.07E+10 | 0.6909 | 9.10E+11 |
| | gas | 0.9184 | 9.1070E+07 | 0.9216 | 8.7728E+07 |
| | average | 0.7000 | 3.5404E+10 | 0.8063 | 4.5500E+11 |
| D | electricity | 0.8146 | 1.5244E+11 | 0.8146 | 1.5244E+11 |
| | gas | 0.9391 | 2.2906E+07 | 0.9419 | 2.1845E+07 |
| | average | 0.8769 | 7.6231E+10 | 0.8783 | 7.6231E+10 |
| E | electricity | 0.9641 | 2.3030E+11 | 0.9767 | 1.0723E+11 |
| | gas | 0.9817 | 1.4851E+06 | 0.9817 | 1.4851E+06 |
| | average | 0.9729 | 1.1515E+11 | 0.9792 | 5.3616E+10 |
| F | electricity | 0.9843 | 1.5878E+10 | 0.9859 | 1.4811E+10 |
| | gas | 0.9144 | 1.8899E+06 | 0.9144 | 1.8899E+06 |
| | average | 0.9494 | 7.9399E+09 | 0.9502 | 7.4064E+09 |
| G | electricity | 0.9633 | 1.5270E+11 | 0.9649 | 1.4898E+11 |
| | gas | 0.9508 | 2.4807E+06 | 0.9508 | 2.4807E+06 |
| | average | 0.9571 | 7.6351E+10 | 0.9579 | 7.4491E+10 |
| H | electricity | 0.9363 | 2.3025E+10 | 0.9427 | 7.2672E+09 |
| | gas | 0.9819 | 1.0481E+06 | 0.9898 | 4.9089E+05 |
| | average | 0.9591 | 1.1513E+10 | 0.9663 | 3.6338E+09 |
| I | electricity | 0.9690 | 1.9787E+11 | 0.9740 | 1.8207E+11 |
| | gas | 0.9714 | 8.1756E+06 | 0.9723 | 7.9840E+06 |
| | average | 0.9702 | 9.8939E+10 | 0.9732 | 9.1039E+10 |
| K | electricity | 0.7592 | 3.6475E+11 | 0.9464 | 1.1536E+11 |
| | gas | 0.6285 | 6.8725E+07 | 0.8993 | 5.3237E+07 |
| | average | 0.6939 | 1.8241E+11 | 0.9229 | 5.7707E+10 |
| M | electricity | 0.7914 | 5.5983E+11 | 0.9573 | 1.7756E+11 |
| | gas | 0.8344 | 8.9893E+07 | 0.9650 | 2.5230E+07 |
| | average | 0.8129 | 2.7996E+11 | 0.9612 | 8.8793E+10 |
| Overall | electricity | 0.8510 | 2.0401E+11 | 0.9133 | 2.1555E+11 |
| | gas | 0.9039 | 3.7874E+07 | 0.9473 | 2.7518E+07 |
| | average | 0.8774 | 1.0203E+11 | 0.9303 | 1.0779E+11 |
| Excluding C | electricity | 0.8920 | 2.1883E+11 | 0.9380 | 1.3840E+11 |
| | gas | 0.9023 | 3.1964E+07 | 0.9502 | 2.0828E+07 |
| | average | 0.8972 | 1.0943E+11 | 0.9441 | 6.9208E+10 |

Table 3 – 2013 estimated electricity and gas savings due to SEM and EEM (MMBTU).

| Site | Fuel | Reference Year Energy Consumption | Production Ratio | Adjusted 2013 Energy Consumption | SEM 13 | | EEM 13 | | SEM + EEM | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Saving | Percent | Saving | Percent | Saving | Percent |
| A | elec. | 177426 | 0.82 | 145436 | 7199 | 4.95% | 9642 | 6.63% | 16841 | 11.58% |
| | gas | 1173228 | 0.82 | 961695 | 11348 | 1.18% | 52606 | 5.47% | 63954 | 6.65% |
| | total | 1350653 | 0.82 | 1107131 | 18547 | 1.68% | 62248 | 5.62% | 80795 | 7.30% |
| C | elec. | 66634 | 0.92 | 61130 | -35559 | -58.17% | 36678 | 60.00% | 1119 | 1.83% |
| | gas | 1047579 | 0.92 | 961049 | 29312 | 3.05% | -102922 | -10.71% | -73610 | -7.66% |
| | total | 1114213 | 0.92 | 1022179 | -6247 | -0.61% | -66244 | -6.48% | -72491 | -7.09% |
| D | elec. | 94505 | 0.76 | 71805 | -2858 | -3.98% | 0 | 0.00% | -2858 | -3.98% |
| | gas | 869261 | 0.76 | 660465 | 29853 | 4.52% | 51153 | 7.75% | 81006 | 12.27% |
| | total | 963766 | 0.76 | 732269 | 26995 | 3.69% | 51153 | 6.99% | 78148 | 10.67% |
| E | elec. | 68644 | 1.15 | 79071 | 2894 | 3.66% | 5870 | 7.42% | 8764 | 11.08% |
| | gas | 55692 | 1.15 | 64152 | 2117 | 3.30% | 0 | 0.00% | 2117 | 3.30% |
| | total | 124336 | 1.15 | 143223 | 5011 | 3.50% | 5870 | 4.10% | 10881 | 7.60% |
| F | elec. | 36847 | 0.77 | 28391 | 247 | 0.87% | 2185 | 7.70% | 2432 | 8.57% |
| | gas | 45455 | 0.77 | 35023 | 767 | 2.19% | 0 | 0.00% | 767 | 2.19% |
| | total | 82302 | 0.77 | 63414 | 1014 | 1.60% | 2185 | 3.45% | 3199 | 5.05% |
| G | elec. | 101412 | 1.02 | 103217 | 5935 | 5.75% | 19148 | 18.55% | 25083 | 24.30% |
| | gas | 77084 | 1.02 | 78457 | 13267 | 16.91% | 0 | 0.00% | 13267 | 16.91% |
| | total | 178497 | 1.02 | 181674 | 19202 | 10.56% | 19148 | 10.54% | 38350 | 21.10% |
| H | elec. | 13274 | 0.83 | 11016 | -1659 | -15.06% | 1958 | 17.77% | 299 | 2.71% |
| | gas | 47596 | 0.83 | 39500 | 79 | 0.20% | -6765 | -17.13% | -6686 | -16.93% |
| | total | 60870 | 0.83 | 50516 | -1579 | -3.13% | -4806 | -9.51% | -6385 | -12.64% |
| I | elec. | 92856 | 1.16 | 107443 | 8069 | 7.51% | 9808 | 9.13% | 17877 | 16.64% |
| | gas | 158879 | 1.16 | 183838 | 1820 | 0.99% | 14378 | 7.82% | 16198 | 8.81% |
| | total | 251734 | 1.16 | 291282 | 9889 | 3.39% | 24185 | 8.30% | 34074 | 11.69% |
| K | elec. | 178404 | 0.89 | 158726 | -8222 | -5.18% | 8975 | 5.65% | 753 | 0.47% |
| | gas | 773676 | 0.89 | 688339 | 37308 | 5.42% | 75332 | 10.94% | 112640 | 16.36% |
| | total | 952080 | 0.89 | 847065 | 25780 | 3.04% | 87620 | 10.34% | 113400 | 13.38% |
| M | elec. | 183544 | 1.12 | 205000 | -574 | -0.28% | 14277 | 6.96% | 13703 | 6.68% |
| | gas | 787551 | 1.12 | 879615 | -9148 | -1.04% | 39632 | 4.51% | 30484 | 3.47% |
| | total | 971094 | 1.12 | 1084615 | -9722 | -0.89% | 53909 | 4.97% | 44187 | 4.08% |
| Overall | elec. | 1013545 | 0.96 | 971235 | -24528 | -2.53% | 108542 | 11.18% | 84013 | 8.65% |
| | gas | 5036001 | 0.90 | 4552133 | 116723 | 2.56% | 123414 | 2.71% | 240137 | 5.28% |
| | total | 6049546 | 0.91 | 5523368 | 88890 | 1.61% | 235269 | 4.26% | 324158 | 5.87% |
| Excluding C | elec. | 946911 | 0.96 | 910105 | 11031 | 1.21% | 71863 | 7.90% | 82895 | 9.11% |
| | gas | 3988421 | 0.90 | 3591084 | 87411 | 2.43% | 226336 | 6.30% | 313747 | 8.74% |
| | total | 4935332 | 0.91 | 4501188 | 95137 | 2.11% | 301512 | 6.70% | 396650 | 8.81% |

## 4.2 Estimated savings

Table 3 lists the estimated electricity, gas, and total savings for all involved facilities. SEM led to a total savings of 0.37 aMW electricity, and over 870,000 therms of gas. EEM led to a total saving of 2.41 aMW electricity, and over 2 million therms. Overall, ten involved facilities reduced total energy consumption by 8.8% when compared their consumption in the reference year before both program components of SEM and EEM were implemented.

It should be noted that the GOF results of facility C were poor with an average correlation coefficient being below 0.75, thus we were not able to fit a statistically significant model to its data. The electric model poor fit likely reflects factors other than production and weather. The regression used data between 2010 and 2012 to fit the model. During interviews, plant staff noted operational and raw material problems that resulted in higher energy consumption. The gas consumption results for 2013 reflect fuel switching from natural gas to wood. Because the modeling process does not account for fuel switching and the electric model had poor fit, DNV KEMA recommends that facility C is excluded in the final summaries.

As shown in Figure 13, the SEM behavioral and operational improvements led to a 1.21% reduction in electricity, and 2.43% reduction in gas in 2013. The EEM actions led to even higher savings with a 7.9% reduction in electricity, and 6.3% reduction in gas. Together, both aspects of SEM saved 2.1% and 6.7% of total energy consumption in 2013 respectively.

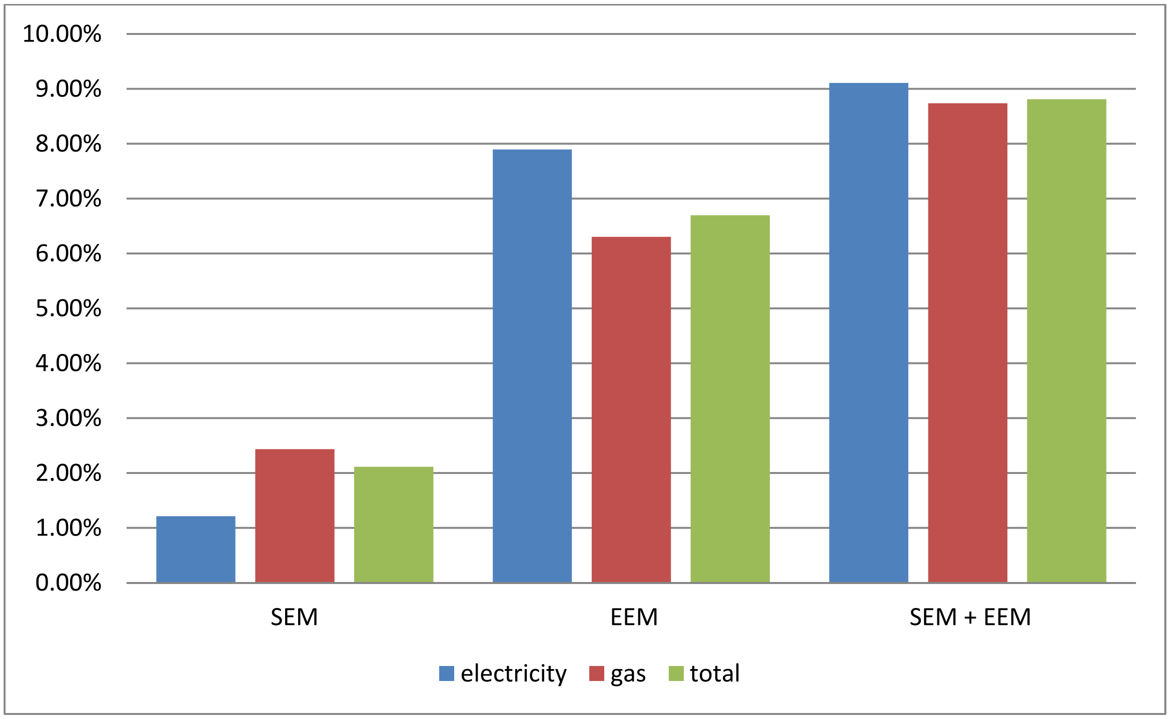



Figure 13 – 2013 estimated energy savings in percentage.

# 5 Conclusions

A top-down model has been developed to identify the energy consumption change in 2013 for ten NEEA facilities. The model adopted monthly production, and weather data as independent variables, and utilized the bottom-up savings to decompose total savings into the SEM and EEM programs respectively.

The top-down model captured the underlying system dynamics accurately, and demonstrated excellent GOF results with an average correlation coefficient above 0.94 for the nine accepted models. One model was not acceptable.

With the top-down model, we identified that:

- 0.37 aMW electricity, and 87,411 MMBTU gas were saved due to behavioral and operational aspects of SEM;
- 2.41 aMW electricity, and 226,336 MMBTU gas were saved due to EEM actions;
- Overall, the total energy consumption of nine out of ten involved facilities is reduced by 8.8% in 2013 when compared to the reference year.

# Appendix B. Bottom-up Savings Validation

DNV KEMA evaluated 25 measures at 8 facilities under NEEA's Industrial Initiative for food processing facilities. This appendix describes the evaluation of each measure. These measures are listed in Table A-1.

Following Table A-1, the measures completed at each facility are described, and the evaluation approach and results is presented.

**Table A- 1. Validated Energy Efficiency Savings for Each Measure**

| Facility Identi-fier | Measure Type | Project | Description | Claimed kWh | Validated kWh | Realization Rate KWh | Claimed Therms | Validated Therms | Realization Rate Therms |
|---|---|---|---|---|---|---|---|---|---|
| A | Boiler | Boiler Parallel Positioning & Economizer | Parallel Positioning and an economizer were added to the west end boiler. | | | | 42,700 | 52,981 | 124% |
| A | Boiler | 250 HP Boiler Economizer | Installation of an economizer on 250 HP Boiler to recover 140 degrees from stack gas for heating boiler feedwater. | | | | 28,000 | 33,696 | 120% |
| A | Boiler | 200 HP Boiler Economizer | Installation of an economizer on 200 HP Boiler to recover 140 degrees from stack gas for heating boiler feedwater. | | | | 22,200 | 26,957 | 121% |
| C | Steam | Dryer Optimization | Increasing heat input from the dryer's more efficient direct fire burner and decreasing heat input from the natural gas boiler when the wood fired boiler goes down. | | | | 55,400 | 177,806 | 321% |
| D | Lighting | Lighting Upgrade | A variety of luminaires in different areas of the facility were upgraded with lower wattage replacements and occupancy sensors were installed. | 2,339,966 | 2,499,114 | 107% | | | |
| E | Refrigeration | Evaporator fan motor VFD | (6) VFDs installed on (12) new 10 HP evap fan motors (replacing 2-speed motors) .Savings achieved through reduced motor speed and greater low speed run hours. | 265,600 | 187,236 | 70% | | | |

| Facility Identi-fier | Measure Type | Project | Description | Claimed kWh | Validated kWh | Realization Rate KWh | Claimed Therms | Validated Therms | Realization Rate Therms |
|---|---|---|---|---|---|---|---|---|---|
| E | Refrigeration | Cold room door control | Motion sensor controlled door replaced pull-string closure. Reduced time of door open per entry results in less conditioned air loss. | 23,600 | 26,246 | 111% | | | |
| E | Refrigeration | Evaporator fan motor VFD | VFDs installed on final (4) 30 HP evap fans in freeze tunnel. Energy savings from reduced motor fan speed when full flow is not required. | 76,900 | 78,252 | 102% | | | |
| E | Refrigeration | Refrigeration compressor VFD | VFD and FES pannel added to a 300 HP booser compressor motor. Savings resulted from reduced motor speed when full flow not required. | 112,429 | 19,870 | 18% | | | |
| F | Lighting | Lighting Upgrade | Existing fixture types in the Main Process Area were replaced with lower wattage fixtures over the course of roughly 8 months. | 64,900 | 87,700 | 135% | | | |
| G | HVAC | Air Handler Savings | Anticipated energy savings with South air handler shut off for roughly the period March 19 - May 31 | 93,996 | 0 | 0% | | | |
| G | Lighting | Exterior lighting corrections | R&R defective daylight sensors which were keeping exterior lights on 24/7. Replaced 5 malfunctioning sensors and cleaned 5 dirty/malfunctioning sensors. | 25,553 | 27,787 | 109% | | | |

| Facility Identi-fier | Measure Type | Project | Description | Claimed kWh | Validated kWh | Realization Rate KWh | Claimed Therms | Validated Therms | Realization Rate Therms |
|---|---|---|---|---|---|---|---|---|---|
| H | Boiler | Boiler heat exchanger | Heat exchanger installed on boiler, preheating the boiler fedwater. Estimated 1.5% reduction in natural gas consumption | | | | 9,700 | 13,993 | 144% |
| H | Steam | Briner modification | New cascading waterfall brine system replaced drip line. Additional system improvements included new piping, line insulation, and controllers. Modifications result in reduced brine splash out loss by estimated 83%. | | | | 80 | 94 | 117% |
| H | Lighting | Daylight sensors | Daylight sensors installed on (7) 325W LED exterior lighting fixtures reduces annual hours of operation by ~364. | 800 | 828 | 104% | | | |
| H | Lighting | Exterior lighting | Replace (16) existing 400W HPS fixtures with (7) 325W LED fixtures | 24,400 | 24,441 | 100% | | | |
| H | Compressed air | Red hose air lines | (15) Red hose compressed air lines replaced with hard plumbing lines. Savings resulting from elimination of 40% of leakage. | 12,200 | 912 | 7% | | | |
| H | Compressed air | Compressed air solenoid valves | Solenoid valves installaed to control compressed air flow to (4) engineered nozzles on canning lines to shut off compressed air when not nedded, therefore | 16,000 | 20,776 | 130% | | | |

| Facility Identi-fier | Measure Type | Project | Description | Claimed kWh | Validated kWh | Realization Rate KWh | Claimed Therms | Validated Therms | Realization Rate Therms |
|---|---|---|---|---|---|---|---|---|---|
| | | | reducing compressed air leakage. | | | | | | |
| H | Compressed air | Stainless steel air line fittings | (80) Brass air line fittings replaced with (80) stainless steel fittings. Assumed 25% of ftttings had leaks, and that retrofit will reduce leaks by 50%. | 20,300 | 1,690 | 8% | | | |
| H | Steam | Steam line removal | Excess/unused steam lines removed:<br>75' of 2.5" diameter pipe(50% insulated)<br>150' of 0.75" diameter pipe<br>150' of 0.5" diameter pipe (35% insulated) | | | | 2,100 | 2,690 | 128% |
| H | Steam | Steam pipe insulation | Steam pipe insulation installed on ~200' of 2.5" diameter pipe, ~100' of 1.0" diameter pipe | | | | 3,200 | 2,742 | 86% |
| I | Refrigeration | Evaporator fan motor VFD | VFDs installed on (8) 10 HP evap fans in cold room. Energy savings from reduced motor fan speed when full flow is not required. | 234,200 | 176,418 | 75% | | | |
| I | Steam | Water level probe placement | New probe placement reduced heated water overflow. | | | | 22,800 | 3,865 | 17% |
| I | Lighting | Lighting Upgrade | Replace (30) 469W HPS and (20) 227W 2L T12 fixtures with (30) 144W 6L T8 and (20) 117W 2L T8 fixtures | 55,400 | 55,350 | | | | |

| Facility Identi-fier | Measure Type | Project | Description | Claimed kWh | Validated kWh | Realization Rate KWh | Claimed Therms | Validated Therms | Realization Rate Therms |
|---|---|---|---|---|---|---|---|---|---|
| I | Boiler | Pressure Transducer installation | Pressure tranducer eleminates the need for (1) 25 HP boiler feedwater pump. | 56,000 | 46,039 | 82% | | | |
| Total | | | | 3,422,244 | 3,252,659 | 105% | 186,180 | 314,824 | 169% |

# Facility A

## Boiler Parallel Positioning & Economizer

The facility team installed an economizer on a 900 horsepower boiler to preheat boiler feedwater. Based on the information provided by the site contact, the rated boiler input and output were 301 therms/hr and 375 therms/hr, respectively. This boiler was typically loaded at 30% for 8,000 hours per year. The only additional information about the boiler performance improvement was that the excess air percentage decreased by 7.5% and the flue gas temperature dropped by 140$^{o}$F. The claimed savings calculations used some rules of thumbs based on the USDOE Tip Sheets to estimate energy savings at 42,700 therms per year. It was assumed that the boiler efficiency increased by 1% for each 15% reduction in excess air or 40$^{o}$F flue gas temperature reduction. The total boiler efficiency increase was 4.5%.

On-site, DNV KEMA verified the economizer installation and boiler size and control scheme. However, the site contact could not provide additional trending data or spot readings of the boiler operations. The evaluation team used a DOE approved tool named PHAST3.0 to estimate baseline and proposed boiler efficiencies. It was assumed that the baseline flue gas oxygen was 6% (corresponding excess air was 35.8%) and flue gas temperature was 540$^{o}$F. With the new economizer and parallel positioning control in place, the flue gas temperature dropped to 400$^{o}$F and the flue gas oxygen dropped to 5.04% (corresponding excess air was 28.3%). The baseline and proposed boiler efficiency was 78.89% and 83.73%, respectively. The validated annual gas savings was calculated at 52,981 therms.

## 200 HP & 250 HP Boiler Economizers

Boiler 2 and Boiler 3 are two dehydration boilers. The customer installed economizers on two boilers which share load but did not implement the parallel positioning upgrade to decrease excess air. According to the introduction by the site contact, the flue gas temperature dropped by 140$^{o}$F. Both boilers were loaded at 75% and operated 8000 hours per year. The calculations used the same rules of thumbs based on the USDOE Tip Sheets to estimate energy savings at 28,000 therms per year for Boiler 2 and at 22,200 therms per year for Boiler 3.

The evaluation team used the PHAST 3.0 tool to estimate baseline and proposed boiler efficiencies. It was assumed that the baseline flue gas oxygen was 6% (corresponding excess air was 35.8%) and flue gas temperature was 540F. With the new economizer in place, the flue gas temperature dropped to 400F and the flue gas oxygen was still 6%. The baseline and proposed boiler efficiency was 78.89% and 83.30%, respectively. The validation annual gas savings was calculated at 33,696 therms for Boiler 2 and at 26,957 therms for Boiler 3.

## Facility C

### Dryer Optimization

The facility produces steam for its plant, when they can, using a wood-fired boiler. This boiler is unreliable, however, and breaks down on a regular basis. When it is down, the 83% efficient natural gas fired boiler takes over. One of their dryers includes a 93% efficient natural gas fired burner, normally used to raise the temperature of incoming air beyond what the boiler can produce. While the burner can provide nearly all the heat needed by the dryer, they only use it to top up the heat because the wood boiler is less costly to run. On the other hand, the natural gas boiler is more costly. This year, they began turning up this burner when the wood boiler fails and the gas boiler operates, thus producing heat for the dryer operation at 93% efficiency rather than 83%. On-site, we verified the existence of the gas burner, the size of the gas boiler, and the controls scheme used to manage the dryer. The site contact also provided us with the actual schedule of boiler downtime during the past three years. As it turns out, the wood boiler is often down for long periods, much longer than the original calculation suggested. This leads to a greater savings estimate, given that the burner is used for the entire down period starting one day after the wood boiler fails.

## Facility D

### Lighting Savings

The facility replaced a large number of T12 and pulse start metal halide light fixtures with 2,4, and 6 lamp T8 light fixtures. Most fixtures operate 8760 hours per year, but some areas operate at a lower number of hours. On-site, we verified light fixture types and counts for a sample of spaces representing about ten percent of the plant. These spaces matched the tracking data exactly. Because the program calculations used odd wattages for both existing and new fixtures, including some that were clearly typos, we adjusted the fixture wattages to match standard values. For spaces with occupancy sensors, we adjusted the assumed post-installation hours to match 50% of pre-installation hours, which is consistent with estimated savings from warehouses. The values estimated by the program were unrealistic.

## Facility E

### Evaporator fan VFD installation on BCS cold storage refrigeration

Six VFDs were installed on the twelve 10 hp evaporator fan motors serving the six BCS cold storage rooms. The claimed savings analysis claims that prior to the control retrofit, the evaporator fans operated at high speed (98.6%) for 3,600 hours per year and at low speed (55.1%) for 5,160 hours per year. The claimed savings approach estimated the VFD controlled high speed setting to be 75% of maximum output for 2,200 hours per year, while the low speed setting would be 40% of maximum for 6,560 hours per year. The claimed savings calculation produced an energy savings estimate of 265,600 kWh.

Post retrofit, the drive speed is dictated by the cold room temperature and the drives were observed operating a high speed of 79% and a low speed of 40%. The validation analysis calculation utilized the same methodology as the claimed savings approach, but included the observed fan motor speeds as well as estimated motor efficiency, load factor, and VFD efficiency factors in the calculation of the existing and retrofitted annual energy consumption. Following are some additional assumptions made by the evaluation team:

1. The motor rated efficiency was revised from 95% to 89.5% for a 10-hp, TEFC, 1800RPM, NEMA standard efficiency motor.
2. The motor load factor at full speed was estimated at 80%.
3. According to fan affinity law, the fan motor brake HP at 55% speed was estimated at 17% of the motor brake HP at 100% speed. At 79% speed, fan motor BHP was 48% of the motor brake HP at 100% speed. At 40% speed, fan motor BHP was 6% of the motor brake HP at 100% speed.
4. Motor and variable frequency drive efficiencies at part speed are corrected using default correction tables.

The savings validation calculation produced an annual energy savings of 187,236 kWh. The major reason for the savings discrepancy is the application of fan affinity law to calculate part speed fan power as well as motor and VFD drive efficiency corrections.

### Cold room door control

The existing cold room door and door pull string actuator controls were replaced with a new door, with motion sensors controlled door actuation. Savings comes from the reduced amount of time the door remains open per room entry, and the resulting reduction in infiltration losses to the conditioned space. For the existing condition, the door is estimated to remain open for 60 seconds per room entry. Under the retrofit condition, the estimated door open time was 15 seconds. The claimed savings analysis leveraged the Target Sustainability calculator for refrigerated doors[8] to calculate the existing condition daily energy loss due to infiltration during the on-season (41 kWh/ day) and off-season (182 kWh/ day) periods of the year. The reduction in infiltration losses was calculated to be proportional the reduction in the amount of time the door is open per room entry (75%), which results in an estimated annual energy savings of 23,621 kWh. During the on-site visit, DNV KEMA observed operation of the door controller system, and recorded a minimum door open time of approximately 2.8 seconds. The validated savings analysis calculation utilized the same methodology as the claimed savings approach, but with a revised value of 10 seconds for the post-retrofit door open time. The validated savings analysis produced an annual energy savings of 26,246 kWh.

### Evaporator fan VFD installation on freeze tunnel

VFD control was installed on the four 30 hp evaporator fan motors located in freeze tunnel #8. The claimed savings analysis estimated that prior to the control retrofit, the evaporator fans operated at full speed under 79% load for 2,400 hours per year. The claimed savings approach estimated the VFD controlled fan motors would operate at frequency of 50 Hz, or about 83% of full speed for the same 2,400 annual hours. The claimed savings calculation produced an energy savings estimate of 76,900 kWh. The savings validation analysis calculation utilized the same methodology as the claimed savings

[8] http://www.targetsustainability.co.nz/download/

approach, but included the reported operating frequency of 48 Hz, or 80% of full speed from the site contact, as well as the estimated VFD efficiency factor in the calculation of the retrofitted annual energy consumption. At 80% speed, the fan motor brake HP was calculated at 51% of the motor brake HP at 100% speed according to fan affinity law. The savings validation calculation produced an annual energy savings of 78,252 kWh.

### Refrigeration compressor VFD

A VFD control was installed on a single 300 hp refrigeration compressor motor, replacing the existing slide valve control mechanism. This compressor is operated as a trim or booster, supplementing the capacity of the other compressors when refrigeration demand is high. For both the existing and retrofit cases, the annual operating hours are estimated to be one third of the year, or 2,920 hours. In the claimed savings analysis, the existing motor loading was calculated as the product of the estimated full load capacity factor (80%) and the slide valve control setting (70%), which resulted in a calculated motor loading of 56%. The VFD control scenario for the claimed savings used the same approach to calculating motor loading, but used an estimated 50% drive power to produce a motor loading value of 40%. To calculate annual energy consumption, the motor loading values were multiplied by the motor nameplate power output and annual operating hours, and divided by the motor efficiency (93%). Savings was calculated as the difference in annual energy consumption between the existing and retrofit case. The claimed savings analysis produced an annual energy savings of 112,429 kWh.

During the on-site visit, DNV KEMA verified the installed VFD and motor nameplate values, as well as confirmed the pre and post-retrofit motor loading values and operating hours with the site contacts. The validation analysis utilized a generic screw compressor part-load performance curve to estimate compressor power at part load. For the slide valve control, the motor brake HP at 70% capacity was around 80% of the brake HP at full capacity. For the VFD control, the motor brake HP at 70% capacity was approximately 70% of the motor BHP at full capacity. The VFD efficiency was 97% and the efficiency correction factor was estimated at 95% when the motor BHP was 56% (80% of 70%) of the rated motor BHP. The validation analysis produced an annual energy savings of 19,870 kWh. The validated savings were much lower than the claimed savings because generic curves instead of assumed values were used to estimate part load performance of a constant speed and a VFD compressor.

## Facility F

### Lighting Savings

The facility replaced 98 of its existing 400-watt lighting fixtures with four-lamp T5 fluorescent light fixtures. The documentation suggested that all of these replaced light fixtures were metal halide, but according to the site contact at the facility six of them were high pressure sodium. The site contact verified the hours reported for the metal halide fixtures, but the high pressure sodium fixtures were actually installed outdoors and on photo eyes and switches, allowing them to operate less often. In addition, the wattages reported for the baseline fixtures in the program’s estimate were the light bulb rated wattages of 400 watts, rather than the ballast input wattages 465 and 458, respectively, for high pressure sodium and metal halide. Overall, the savings were validated at 135% of the claimed savings, estimating nearly 88,000 kWh saved annually.

## Facility G

### Air Handler Savings

The facility has two 60 horsepower air handling motors to provide ventilation and heat to their manufacturing space. The plant staff discovered this year that only one air handler is needed to provide ventilation during non-processing, non-heating times, from approximately March 15 to May 30. During this time, they now shut off one air handler. However, under further discussion with multiple plant staff, it became clear that they had already been shutting off one air handler during this period, as well as during many other periods throughout the year. Therefore this measure is not new and does not result in savings.

### Lighting Savings

The facility replaced a variety of exterior lighting fixture types and wattages, and either cleaned or replaced their photo eye sensors. The lights had photo eyes that had gotten so dirty that they operated all the time. Now the fixtures operate only at night. The plant contact who had done the replacement was not available. However, the project manager who had been involved suggested they were all High Pressure Sodium. DNV KEMA adjusted calculations to account for ballast input wattages rather than bulb wattages. Overall, savings of nearly 28,000 kWh were 109% of claimed savings.

## Facility H

### Boiler Heat Exchanger

One heat exchanger was installed on a steam boiler to preheat cold make-up water with flue gas. Based on the claimed savings analysis, this boiler operated 100 days per year and 24 hours per day. The daily natural usage was around 6,500 therms and the annual natural gas usage was calculated at 650,000 therms. The claimed savings calculations use an estimated 1.5% reduction to calculate gas savings of 9,700 therms. During the site visit, the evaluation team found that the heat exchanger was used to preheat boiler make-up water from 55F to 180F. The steam pressure was 121 psig. The validation analysis estimated annual steam production of 59,701,493 lbm based on the boiler efficiency of 80% and the steam enthalpy of 1,192 Btu/lbm. The customer could not provide the percentage of condensate returned to the boiler. Based on the observation at the site, the evaluation team made a conservative estimation of 85% condensate returned. Therefore, the cold make up water flow is 15% of the total steam production.

The annual natural gas savings were estimated at 13,993 therms. The savings estimation discrepancy is due to different method used to estimate savings.

## Brine Liquid Loss Reduction

One of seven brine lines was upgraded by installing a Honeywell controller to reduce brine loss. Based on the information provided by the customer, the upgraded line operated 24 hours per day and 60 days per year, leading to an annual operations of 1,440 hours. Before the retrofit, the brine loss was 30% of the total or 5 gal per hour. After the retrofit, the splash out was reduced to 5% of total. The brine water was produced by heating city water from 55F to 205F (originally 185F but raised to 205F with the triple tube heat exchangers) using steam. The steam boiler efficiency was estimated at 80%. The claimed savings analysis calculated the total brine loss in the baseline at 7,200 gallons per year and annual energy consumed at 100 therms. When the brine loss was reduced by 83%, the annual energy was saved by 83% at 80 therms. The validation calculations used the same method; however, the brine temperature was updated from 185F to 205F. The validated energy savings were 93.8 therms.

## Daylight sensor

Photo cell controls were installed on the seven 325W exterior LED lighting fixtures serving the plant parking lot. These fixtures were previously controlled by manual switch operation. Because of the manual control, it is estimated that the lighting fixtures operated approximately 13 hours per day, or about one extra hour than required. Savings from the eliminated extra operating time is calculated to be 828 kWh.

## Exterior lighting

The existing sixteen 400W HPS exterior lighting fixtures serving the plant parking lot were replaced with seven 325W LED lighting fixtures. Under baseline conditions, these fixtures operated year round for 13 hours per day. The annual energy calculation for the baseline and post-retrofit fixtures was calculated as the product of the fixture quantity, fixture wattage, and annual operating hours. The annual energy savings, calculated as the difference in annual energy consumption between the baseline and post-retrofit fixtures, is 24,441 kWh.

## Red hose air line

For this measure, fifteen flexible red hose compressed air lines were replaced with hard plumbed lines, reducing leaks from the flexible line, and thus saving compressed air input energy. The claimed savings approach uses the DOE compressed air tips sheet #3[9] to estimate the flow rate 0.244 CFM per leak, based on operating pressure (100 PSIG) and leak orifice size (1/64”) and type (sharp). This leakage rate was then multiplied by the number of hoses, 2,400 annual operating hours, and the 3.47 kW/CFM value calculated from the compressed air report to produce the annual energy consumption from the 15 flexible hoses. The leakage reduction is estimated to be 40%, or approximately 12,200 kWh. During the on-site visit, DNV KEMA verified the quantity of hoses replaced, and the operating pressure and hours of the compressed air system. The validation analysis utilized the same approach as the claimed savings, however the savings review revealed that the 3.47 kW/CFM value used was actually CFM/kW, and that the correct kW/CFM value is 0.29. The actual system operation pressure was 95psig, corresponding leakage rate at 95psig and 1/64” orifice diameter was 0.36 cfm. Using this corrected value, the validation analysis produced an annual energy savings of 912 kWh.

[9] https://www1.eere.energy.gov/manufacturing/tech_assistance/compressed_air.html

### Compressed air solenoid valves

Solenoid valve controls were installed on the compressed air nozzle of the canning lines to eliminate the compressed air flow through the nozzles when the line is in operation but no cans are passing by. Similarly to the red hose air line measure above, the claimed savings approach used the DOE compressed air tips sheet # 3 to estimate the flow rate through the nozzles. Assuming sharp 1/8" nozzles at 100 PSIG, the claimed savings leakage was estimated to be 15.38 CFM per nozzle. This leakage rate was then multiplied by the number of nozzles (four), 1,440 annual operating hours, and 0.29 kW/CFM value from the compressed air report to produce the annual energy consumption of 25,600 kWh. The solenoid control was estimated to reduce the operating hours by 25% when the line operating and no cans on the line, and an additional 50% reduction in the remaining operating hours due to the more precise application of compressed air release. These claimed savings estimates produced a post-retrofit annual operating hour value of 540, which resulted in a calculated energy savings of 16,000 kWh. The validation analysis utilized the same approach as the claimed savings method, but with a revised leakage rate per nozzle of 20 CFM, based on manufacturer's technical specification and the systems operating pressure. The validation annual energy savings was calculated to be 20,776 kWh.

### Stainless steel air line fittings

For this measure, 80 existing brass compressed air fittings were replaced with new stainless steel fittings that reduce existing leakage and resist corrosion that causes additional leakage. The claimed savings approach assumed that 25% of the existing 80 fitting had leaks equivalent to the sharp 1/64" orifice at 100 PSIG, or approximately 0.244 CFM per leaky fitting. This leakage rate was then multiplied by the number of leaky fittings (20), 2,400 annual operating hours, and (incorrect) 3.47 kW/CFM value to produce the annual energy consumption of 40,600 kWh. The estimated post-retrofit leakage reduction is estimated to be 50%, therefore the claimed annual energy savings was calculated to be 20,300 kWh. The validation analysis utilized the same approach as the claimed savings, however, like for the red hose air line measure, the savings review revealed that the 3.47 kW/CFM value used was actually CFM/kW, and that the correct kW/CFM value is 0.29. Using this corrected value, the validation analysis produced an annual energy savings of 1,690 kWh.

### Steam Pipe Removal

The following unused steam lines were removed from the plant:

- 75 feet of 2.5 inch diameter pipe (50% insulated)
- 150 feet of 0.75 inch diameter pipe (no insulation)
- 150 feet of 0.5 inch diameter pipe (35% insulated)

Steam is supplied at 121 psig by an 80% efficient central boiler. Both before and after the retrofit, the plant operates 100 days a year, 24 hours per day (2,400 hours/year). The ex ante analysis used default heat loss rates provided by the DOE for uninsulated steam pipes and assumed insulated pipes had zero heat loss. The total ex ante savings for this measure was 2,100 therms.

The ex post analysis used 3E Plus software to estimate heat loss rates for both bare and insulated steam pipes. The software inputs included pipe diameter and material, insulation material and thickness, process and ambient temperatures and wind speed. Ambient temperature was assumed to be 75° F and wind speed was assumed to be zero. Based on the pressure of the steam, process temperature was calculated to be 350° F. Because no information was given about the insulation, code minimums were used. It was assumed that insulation material was mineral fiber and the thickness was the minimum required to keep surface temperature below 140 degrees (OSHA standard). These heat loss rates were multiplied by the length of the pipe and the hours of operation and converted to therms, for a total pre-retrofit energy loss of 2,690 therms. Because the energy loss after pipe removal is zero, total savings are 2,690 therms.

### Steam Pipe Insulation

The following steam lines were fitted with insulation:

- 200 feet of 2.5 inch diameter pipe, 70% of this pipe was insulated
- 100 feet of 1.0 inch diameter pipe, 80% of this pipe was insulated.

Steam is supplied at 121 psig by an 80% efficient central boiler. Both before and after the retrofit, the plant operates 100 days a year, 24 hours per day (2,400 hours/year). Like the previous measure, ex ante analysis used default heat loss rates provided by the DOE for uninsulated steam pipes and assumed insulated pipes had zero heat loss. The total ex ante savings for this measure was 3,200 therms.

The ex post analysis again used 3E Plus software to estimate heat loss rates for both bare and insulated steam pipes. The software inputs included pipe diameter and material, insulation material and thickness, process and ambient temperatures and wind speed. Assumptions about temperatures, wind speed and insulation are the same as described in the previous measure. Pipe diameter was 2.5 inches or 1.0 inches, depending on the pipe section. The difference in heat loss rates (before and after insulation installation) were multiplied by the length of the pipe where insulation was installed and the hours of operation and then converted to therms, for a total savings of 2,742 therms.

## Facility I

### Cold Room Evaporator Fan VFDs

Eight VFDs were installed on the eight 10 hp evaporator fan motors serving cold-rooms 10 and 11. Prior to retrofit, the evaporator fans operated at full speed 24 hours a day, for 365 days per year (8,760 hrs). Post VFD retrofit, the fans motors operate at fifty percent speed for approximately half the 8,760 annual operation.  The claimed savings calculation used an estimated low speed of sixty percent of full motor speed (40 Hz), which produced estimated annual energy savings of 234,230 kWh. However, during the on-site visit the drives were observes operating at (30 Hz). The validation savings calculation utilized the observed fifty percent low operating speed, as well as assumed drive efficiency levels at full (0.97) operation. Following are some additional assumptions made by the evaluation team:

1. The motor rated efficiency was revised from 87.5% to 89.5% for a 10-hp, TEFC, 1800RPM, NEMA standard efficiency motor.

2. The motor load factor at full speed was estimated at 80%.
3. According to fan affinity law, the fan motor brake HP at 50% speed is 12.5% of the motor brake HP at 100% speed.
4. Motor and variable frequency drive efficiencies at part speed are corrected using default correction tables.

The validated annual energy saving was calculated as 176,418 kWh. The kWh savings drop because of higher baseline motor efficiency and motor and the VFD efficiency degrade at lower speed.

### Defrost Tank Water Level Probe Placement

This measure involved improved fluid level probe placement on the two 17,000 gallon Engine Room 1 defrost tanks. The lower probe placement allows the tanks to be filled primarily with heated water from the chiller and reduced overflow loss due to excess city water supplied to the tanks. The new tank fluid level probe placement reduced the excess municipal water at 55$^{o}$F) that previously required heating via the steam system.

The claimed saving analysis provided in the measure description calculated the therm savings from the volume of reduced overflow water—7,289,477 gallons per year based on the overflow pipe geometry and flow rate—and the energy associated with heating that volume of water from 55°F to the tank operating temperature of 85 °F using the on-site steam boiler system. The validation analysis utilized the site contact supplied estimation of annual avoided city water consumption (1,235,850 gallons/year) and calculated the energy savings as the amount of therms required to heat that volume of water from 55 °F to the tank operating temperature of 85 °F using the on-site steam boiler system. The validated annual energy savings were calculated at 3,865 therms. The major reason for the discrepancy is the reduction of avoided city water overflow.

### Lighting Upgrade

This measure involved the replacement of two fixture groups: thirty existing 400W HPS fixtures replaced with thirty 6L T8 fixtures, and twenty existing 2L T12 fixtures replaced with twenty 2L T5 fixtures. The HPS/T8 fixtures are used 24 hours per day during the summer months and approximately 10 hours per day the remainder of the year for a total of approximately 5000 annual operating hours. The T12/T5 fixtures are used roughly 8 hours per day, for a yearly total of approximately 3000 annual operating hours. Savings was calculated as the difference in annual kWh consumption between the existing and retrofit fixtures for each fixture group. The validated total annual energy savings was calculated to be 55,350 kWh.

### Pressure Transducer

A pressure transducer was installed on the boiler feed water system which allowed plant operators to meet the boiler feed water pressure requirements without having run the auxiliary 25 hp feed water pump . Installation of pressure transducer revealed that the third pump was not necessary to maintain the required boiler feed water pressure. The claimed savings was calculated using the following values: 25 hp, 60% load factor, 87.5% nameplate motor efficiency, and 4,380 annual hours of operation. The claimed annual energy savings estimate was 56,014 kWh. Review of the documentation and plant operating schedule prompted the DNV KEMA evaluation engineer to use 3,600 annual hours—five months of 24 hour per day operation instead of six—for the validation savings calculation. Using these reduced operating hours, the validation savings calculation produced a savings estimate of 46,039 kWh. The annual operation hour change contributed to the energy savings reduction.