Long Term Monitoring and Tracking Report on 2007 Activities

PREPARED BY

Summit Blue Consulting, LLC

REPORT #08-199
MAY 28, 2008

NORTHWEST
ENERGY
EFFICIENCY
ALLIANCE

www.nwalliance.org

529 SW Third Avenue, Suite 600
Portland, Oregon 97204
(tel) 503-827-8416 (fax) 503-827-8437

LONG TERM MONITORING AND TRACKING REPORT ON 2007 ACTIVITIES

Submitted to:

Northwest Energy Efficiency Alliance

May 28, 2008

SUMMIT BLUE
CONSULTING, LLC

FINAL REPORT

Submitted to:

Karen Horkitz, Project Manager
Northwest Energy Efficiency Alliance
529 SW Third Avenue, Suite 600
Portland, OR 97204
503.827.8416

Submitted by:

Summit Blue Consulting, LLC
1722 14th Street, Ste. 230
Boulder, CO 80302
720.564.1130

Contact:

Stuart Schare
720-564-1130
sschare@summitblue.com

TABLE OF CONTENTS

E. EXECUTIVE SUMMARY

E.1 Introduction

The Northwest Energy Efficiency Alliance (NEEA) tracks the market progress of its projects during their implementation phase through periodic Market Progress Assessment Reports (MPERs). However, since market diffusion often occurs after NEEA funding has ceased, NEEA also needs a mechanism for tracking ongoing market progress in the post-funding period so that it can verify key assumptions in its cost-effectiveness models. In 2004, NEEA developed a process for tracking and monitoring the market progress of projects that it no longer funds. The goal of this long-term monitoring and tracking (M&T) is to measure and track critical market progress indicators and Alliance Cost-Effectiveness (ACE) model assumptions that are used to estimate on-going and accumulated electricity savings from the market effects. Long-term M&T is *not* intended to be an evaluation of program impacts but rather a relatively conservative look at the market effects of these programs.

The 2007 M&T effort reviewed 11 NEEA initiatives, four of which were assessed for the first time since funding was discontinued. These 11 initiatives include the following:

1. Commissioning and Commissioning in Public Buildings
2. Evaporator Fan VFDs
3. Energy Star Windows
4. Building Operator Certification
5. Energy Star Home Products (new)
6. Drive Power Initiative (new)
7. Verdiem Network Energy Management Software
8. ASiMI (new)
9. Shell Solar
10. Scientific Irrigation Scheduling (SIS)/AM400
11. Opti-Chill Chiller Optimization (new)

Summit Blue developed a work plan for each M&T program under review for 2007, and these were provided to NEEA's M&T project manager for review in the fall of 2007. Data collection and analysis began shortly thereafter. For each program, the M&T project team focused on tracking activity in the market, critically examining NEEA's baseline assumptions, and assessing energy savings. Sections 2 through 12 of this report present background, methodologies, findings, and recommendations for each NEEA initiative in the order listed above.

E.2 Results by Program

This section provides a brief summary of findings for each of the 11 initiatives reviewed as part of the 2007 M&T effort. In many cases, the cumulative energy savings through 2007 are estimated and compared to NEEA's estimated savings through 2006. Savings are calculated as the product of 1) market activity in excess of baseline activity and 2) per-unit energy savings. Savings values are described as "implied energy savings" since NEEA's actual savings estimates are adjusted for the effects of utility incentives and other factors not taken into account in this M&T analysis.

1. Commissioning and Commissioning in Public Buildings

NEEA's commissioning initiatives have accelerated the transformation of the commissioning market in the Northwest and helped to increase the number of commissioning providers, the amount of floor space being commissioned, and in some cases the quality of commissioning being performed. Compared to 2006, estimates of the cumulative market activity through 2007 are higher by an order of magnitude, with commissioning of new buildings increasing from approximately 10 million square feet in 2006 to roughly 61 million square feet in 2007, and retrocommissioning activity increasing from roughly five million square feet to nearly 70 million square feet. Baseline assumptions were also raised (30% of total market activity, as compared to 10% in the 2005 M&T report) based on the interviews and secondary research conducted for this report. There is no change in the per-unit energy savings. The estimated energy savings from the recommended values for key indicators is nearly 12 aMW, or more than a seven-fold increase over the cumulative savings suggested by the key indicator values used by NEEA in 2006.

The significant increase in estimated market activity and energy savings is a result of the 2007 M&T assessment basing estimates on comprehensive surveys of commissioning providers and building owners. By contrast, the 2006 assessment was a bottom-up effort that relied on incomplete state records and a few select interviews with commissioning providers.

2. Evaporator Fan VFDs

The objective of the Evaporator Fan VFD initiative was to make VFDs the industry standard for evaporator fans in all types of refrigerated warehouses in the Northwest For the 2007 assessment, 30 cold storage operators were interviewed across the four states in the Northwest. Based on the results of the surveys, it is estimated that almost half (46%) of the existing cold storage volume in the Northwest uses evaporator fan VFDs. This suggests that VFDs control a total of approximately 45,000 hp of evaporator fan capacity in cold storages in the Northwest, with nearly 34,000 hp (75%) of this capacity in controlled atmosphere cold storage and the remaining 11,000 hp (25%) in refrigerated-only cold storage. Approximately 42% of this VFD usage is considered to be part of the baseline, which is assumed to grow each year by 1.5% of the regional cold storage volume using evaporator fans. The implied energy savings for activity through 2007 are more than 50% greater than the cumulative savings reported by NEEA in 2006, increasing from 4.8 aMW to 7.5 aMW. The increase is likely due to the reach of the cold storage survey into areas of market activity that previous analyses were not able to quantify.

3. Energy Star Windows

NEEA's Energy Star Windows market transformation program continues to achieve significant energy savings into 2007. Although gross window shipments in the Northwest receded in 2006 and 2007, the percentage of those windows that have the efficiency level promoted by NEEA's initiative is nearing 100% and is likely to remain there.

In the 2006 ACE model, NEEA calculated only those savings due to reduced electric heating usage. In addition to electric heating savings, the 2007 *recommended* cumulative values include savings from reduced central air conditioner usage and reduced gas furnace fan operation. The per-unit savings value was weighted by the market share of heating and cooling system types so that it may be used with the total area of Energy Star windows to determine implied energy savings. The NEEA 2006 cumulative implied energy savings were 12.2 aMW, while the 2007 recommended cumulative value is 16.7 aMW.

4. Building Operator Certification

Building Operator Certification activities have continued at just over 100 new certifications per year in the Northwest since 2006, as both NEEC and IBOA continue to provide building operator certification training within the region and in other regions of the country. Due to the fact that some operators certified more than five years ago have not renewed their certifications (and are thus considered "retired"), the growth in the number of certified building operators in the Northwest has dropped off and the number of "active" certified building operators is now essentially flat.

The number of active certified building operators in both 2006 and 2007 is nearly 10% lower than the number reported by NEEA in 2006. It appears that the NEEA analysis inadvertently tallied some certification renewals as new operators due to the manner in which updated databases from NEEC and IBOA were integrated with existing NEEA records. Adjusting for this discrepancy results in a proportional reduction in the implied savings, from 16.8 aMW in 2006 to 15.3 aMW in 2007.

5. Energy Star Home Products

The Energy Star Home Products program was aimed at increasing demand for and sale of high efficiency clothes washers, dishwashers, and refrigerators. NEEA's initiatives supporting Energy Star equipment have increased market acceptance of Energy Star products by raising awareness among both retailers and consumers, and the market share of Energy Star home products has increased for all three appliance types. Cumulative market activity and baseline estimates for all appliance types increased between 2006 and 2007, generally between about 15% and 25%. Cumulative energy savings implied by these values also increased slightly, from 21.8 aMW across the three appliance types through 2006 to 22.5 aMW through 2007.

6. Drive Power Initiative

NEEA projects focusing on motors have led to a significant market transformation in the Northwest. The sale of NEMA Premium ™ motors has increased nearly six-fold since 2001, and *regional growth in sales of premium efficiency motors has been at approximately 34% per year, versus 23% nationally*. Through 2007, estimated sales of NEMA Premium™ motors in the Northwest had reached more than 148,000 units. Baseline sales are estimated at approximately 117,000, or nearly 80% of the total market activity. The cumulative energy savings implied by these figures is 2.2 aMW in 2007.

7. Verdiem Network Energy Management Software

NEEA's partnership with Verdiem helped develop a market-ready product with proven energy savings data. When market forces converged to raise awareness about the energy use of networked information technology systems, Verdiem's technology was able to achieve significant market penetration and create energy savings. Between NEEA's 2006 values and the 2007 findings, market penetration and baseline estimates of Surveyor licenses remained relatively constant. However, the per unit energy savings estimate increased from 125 to 190 kWh/unit per year, resulting in an increase in the cumulative implied energy savings from 0.8 aMW through 2006 to 1.2 aMW through 2007.

8. ASiMI

The NEEA-ASiMI partnership had a dramatic effect on the market viability of continuous flow silicon feedstock using the Teardrop™ method. The partnership also enabled ASiMI to investigate the

manufacturing process and determine how to replicate the process most effectively, thus enabling the transfer of operations from Moses Lake to Butte in 2002. Without the NEEA-ASiMI partnership, it is unlikely that the semi-conductor industry would have used the Teardrop™ or Teardrop™Plus feedstocks in the process of manufacturing silicon crystals. SEH-A is the only silicon crystal grower in the Northwest using the Teardrop™ feedstock, however, and the facility is using the feedstock in the standard batch process common for semi-conductor crystal growth. Thus, SEH-A is not realizing the potential savings that would result from continuous recharge.

Based on the analysis conducted for this long-term monitoring and tracking effort, annual energy savings associated with the NEEA-ASiMI partnership is estimated at between 0.8 aMW and 1.3 aMW, all due to the *production* of TearDrop™Plus at REC facilities in the Northwest. Due to the imprecise nature of this range, however, an estimate of 1 aMW best represents the possible savings from the manufacture of Teardrop™Plus. No savings have accrued from the *use* of TearDrop™Plus at silicon crystal growing facilities.

9. Shell Solar

The SolarWorld facility in Vancouver, Washington continues to operate using the energy efficient technology developed through the original NEEA collaboration with Shell. The number of operating hot zones appears to be similar to those in operation in 2006, although detailed information was not available from SolarWorld to confirm these figures. Based on these findings, the implied energy savings remains the same as recommended in the 2006 M&T report at 1.8 aMW. It is important to note that NEEA did not report any change in savings in 2005 or 2006; therefore, a reduction in savings of 0.3 aMW is recommended for 2007, based on the 2006 M&T recommendations.

10. Scientific Irrigation Scheduling (SIS)/AM400

SIS methods (including AM400 applications) are used on approximately 16% of the acreage of low-value crops irrigated with pressurized systems. Cumulative market activity through 2007 is estimated at an order of magnitude larger compared to figures used by NEEA in 2006, due to expanded breath of the 2007 assessment. The estimate of baseline activity increased by nearly the same amount as total market activity—and is approximately 88% of market activity—owing to the fact that the research did not identify any direct influence of the SIS initiative on the market, outside of the AM400. Per-unit energy savings figures have not changed since the 2006 M&T report, when it was recommended that the savings rate be reduced from 185 kWh per acre per year to 154 kWh per acre per year; however, it does not appear that NEEA adopted this recommendation in its calculations. The net result of the increases in market activity and baseline activity, and the reduction in per-unit savings, is that the implied cumulative energy savings through 2007 (1.2 aMW) are slightly higher than NEEA's 2006 figure (1.0 aMW).

11. Opti-Chill Chiller Optimization

NEEA's funding of the Opti-Chill project may have played a minor role in the microelectronics industry's attention to energy efficient chillers, but it was a one-off project that was not replicated. Since the semi-conductor industry in the Northwest has contracted since the project's inception, it is not likely that other opportunities to apply this approach to other semi-conductor facilities in the Northwest are feasible at this time. Beyond this long-term monitoring and tracking effort, it does not appear practical to commit additional resources to tracking the effects of this project.

E.3 Long Term M&T for 2007 and Beyond

Future long-term monitoring and tracking efforts will include updates to some of the programs included in this report, along with additional NEEA programs that no longer receive funding. A *tentative schedule* for each of the project tracking efforts for 2008-2010 is shown in Table E-1, along with the M&T assessments from the past three years. The list of programs to have reviews conducted in 2008 will be discussed with the NEEA project manager and reviewed by the Cost-effectiveness Committee of the NEEA Board before the 2008 plan is finalized.

Table E-1. Timeline for Conducting / Updating Long-Term Monitoring & Tracking

PROJECT	2005	2006	2007	2008	2009	2010
Energy Star Residential Windows	C		U		U	
Building Operator Certification (BOC)	C		U	U	U	
SAV-AIR	C	U		U		U
Just Enough Air	C	M&T Discontinued				
Evaporator Fan VFDs	C	U	U		U	
Siemens (Shell Solar)	C	U	U	Assess need annually		
BacGen	C	U		U		U
Verdiem	C		U		U	
Commissioning in Public Buildings	C		U		U	
Small Commercial HVAC (AirCare Plus)	C	M&T Discontinued				
Energy Star Home Products			C		U	
MagnaDrive		C		U		U
Dendritic Polysilicon Production (ASiMi)			C	Assess need annually		
Electric Motor Management (Drive Power)			C	U		U
Optichill (Microelectronics)			C	Recommended to discontinue		
SIS/AM400		C	U	Recommended to discontinue		

NOTES: C = Conduct initial analysis; U = Update to initial analysis

1 INTRODUCTION

Market transformation projects are long-term in nature. The development and launching of new products and services can be visualized as an "S"-shaped diffusion curve with little market impact in the initial years and the major market effects occurring many years after a program is launched. The Northwest Energy Efficiency Alliance (NEEA) tracks the market progress of its projects during their implementation phase through periodic Market Progress Assessment Reports (MPERs). However, since market diffusion often occurs after NEEA funding has ceased, NEEA also needs a mechanism for tracking ongoing market progress in the post-funding period so that it can verify key assumptions in its cost-effectiveness models.

In 2004, NEEA developed a process for tracking and monitoring the market progress of projects that it no longer funds. The goal of long-term monitoring and tracking (M&T) is to measure and track critical market progress indicators and Alliance Cost-Effectiveness (ACE) model assumptions that are used to estimate long-term electricity savings. Long term M&T employs methods that provide estimates with a reasonable and sufficient level of confidence in a timely and cost-effective manner. During the data gathering and analysis process, the review team seeks to leverage existing data sources and to identify areas where additional data collection may be required to improve the precision of the market effects estimates. Long-term M&T is *not* intended to be an evaluation of program impacts but rather a relatively conservative look at the market effects of these programs.

The 2007 M&T effort applied a market-wide, top-down approach where feasible and appropriate. This suggests that market penetration rates may be estimated for the product or activity that is being promoted, rather than individual sales or actions being counted. For example, the early stages of many NEEA market transformation initiatives include tracking the adoption of a vendor's energy efficiency product or documentation of a finite number of demonstration projects. However, once the promoted product/activity has begun to transform the market, its impact cannot easily be "counted." For this reason, the M&T assessments generally used a market-wide view of adoption rates, with baseline estimation, to estimate impacts. In some cases, such as certification of building operators, a "bottom-up" accounting of market activity was performed since NEEA believes that it is able to directly quantify all relevant market activity.

1.1 Monitoring and Tracking Methodology

The long-term M&T process was conducted as follows:

1. **Review the NEEA ACE model, or other documentation, for each project.** This includes a review of the critical assumptions, inputs to energy savings calculations, and progress indicators.
2. **Assess data collection options and identify variables to be tracked.** Assessing the options entails a brief review of the feasibility and cost of collecting the data to track market transformation and energy savings. Based on this review, specific data inputs and program indicators are identified for tracking.
3. **Develop a data collection/analysis work plan for each project.** These plans are based on a review of the M&T approach recommended by MPERs or past M&T assessments and on recent market research and insights from NEEA staff familiar with the various markets being addressed by NEEA initiatives. The work plans serve as guides to the individual M&T assessments and include the following elements:
    - Background on the initiative
    - Assumptions, market indicators, and inputs to energy savings calculations
    - Methodology for data collection and analysis

4. **Execute the work plans and report findings and recommendations.** Individual M&T assessment reports include findings on market activity, baselines, and energy savings as well as recommendations for changes in the assumptions/inputs and for approaches to future M&T efforts.

After the long-term M&T report is finalized, NEEA staff presents the findings and recommended changes to the NEEA Cost-Effectiveness Committee and incorporates them into the ACE models once they are approved. As program monitoring and tracking procedures are initiated for each NEEA project after its active funding cycle, some will require greater data collection efforts than others. M&T efforts will continue to focus on developing reliable estimates of real market transformation at the state and regional level and the energy savings attributable to these projects. When there is high uncertainty surrounding energy savings for a particular project, and the savings are significant, additional data collection may be prudent. For those with limited impacts, or with good tracking data, existing data sources may be sufficient. Each project summary in the following chapters contains recommendations for ongoing data collection activities and frequency.

1.2 M&T for Program Year 2007

The 2007 M&T effort reviewed 11 NEEA initiatives, four of which were assessed for the first time since funding was discontinued. These 11 initiatives include the following:

1. Commissioning and Commissioning in Public Buildings
2. Evaporator Fan VFDs
3. Energy Star Windows
4. Building Operator Certification
5. Energy Star Home Products (new)
6. Drive Power Initiative (new)
7. Verdiem Network Energy Management Software
8. ASiMI (new)
9. Shell Solar
10. Scientific Irrigation Scheduling (SIS)/AM400
11. Opti-Chill Chiller Optimization (new)

Summit Blue developed a work plan for each M&T program under review for 2007, and these were provided to NEEA's M&T project manager for review in the fall of 2007. Data collection and analysis began shortly thereafter. For each program, the M&T project team focused on tracking activity in the market, critically examining NEEA's baseline assumptions, and assessing energy savings. Sections 2 through 12 of this report present background, methodologies, findings, and recommendations for each NEEA initiative in the order listed above.

1.3 Long Term M&T for 2007 and Beyond

Future long-term monitoring and tracking efforts will include updates to some of the programs included in this report, along with additional NEEA programs that no longer receive funding. A *tentative schedule* for each of the project tracking efforts for 2008-2010 is shown in Table 1-1, along with the M&T assessments from the past three years. The list of programs to have reviews conducted in 2008 will be discussed with the NEEA project manager and reviewed by the Cost-effectiveness Committee of the NEEA Board before the 2008 plan is finalized.

Table 1-1. Timeline for Conducting / Updating Long-Term Monitoring & Tracking

PROJECT	2005	2006	2007	2008	2009	2010
Energy Star Residential Windows	C		U		U	
Building Operator Certification (BOC)	C		U	U	U	
SAV-AIR	C	U		U		U
Just Enough Air	C	M&T Discontinued				
Evaporator Fan VFDs	C	U	U		U	
Siemens (Shell Solar)	C	U	U	Assess need annually		
BacGen	C	U		U		U
Verdiem	C		U		U	
Commissioning in Public Buildings	C		U		U	
Small Commercial HVAC (AirCare Plus)	C	M&T Discontinued				
Energy Star Home Products			C		U	
MagnaDrive		C		U		U
Dendritic Polysilicon Production (ASiMi)			C	Assess need annually		
Electric Motor Management (Drive Power)			C	U		U
Optichill (Microelectronics)			C	Recommended to discontinue		
SIS/AM400		C	U	Recommended to discontinue		

NOTES: C = Conduct initial analysis; U = Update to initial analysis

2 COMMISSIONING AND COMMISSIONING IN PUBLIC BUILDINGS

In recent years NEEA has administered two separate but related building commissioning projects. Commissioning in Public Buildings, the original project launched in 1998, sought to make commissioning standard practice in public buildings in the Northwest. The project had coordinators in each of the four participating states (Oregon, Washington, Idaho, and Montana) and sought to achieve the following objectives:

- Educating facility and project managers, administrators, and business managers on the benefits of commissioning
- Demonstrating commissioning and analyzing results
- Adoption of state requirements and model policies for commissioning for local government facilities and schools
- Disseminating commissioning results and model policies, including case studies describing the costs and benefits associated with the demonstration projects.

In 2000, NEEA funded a separate Commissioning industry effort aimed at supporting the Building Commissioning Association (BCA) and fostering special projects of the BCA, such as commissioning certification. NEEA-sponsored commissioning efforts took different approaches to achieve a common objective of increasing commercial building commissioning in the region.

These market transformation efforts were intended to establish an infrastructure to support increased commissioning activity well beyond the term of the projects—including knowledgeable and experienced commissioning providers, state and local laws and policies requiring or promoting commissioning, and resources for building owner to learn about the benefits of commissioning and to identify providers. However, there are few obvious sources of information to determine how successful the efforts were in achieving their goals.

Summit Blue's previous M&T review, conducted in 2005, consisted of a bottom-up accounting of commissioning activity identified through state records, other secondary data such as research reports, and interviews with state liaisons to NEEA's Commissioning in Public Buildings initiative and with selected commissioning providers. This second Commissioning M&T effort characterizes the changes in the market—including the amount of documented commissioning activity and the results of a recent survey of commissioning providers—and assesses the impact of NEEA's initiatives on commissioning activity and infrastructure in the Northwest based on another round of interviews with state liaisons and on additional secondary research, including a recent survey of commissioning providers.

2.1 Indicators and Assumptions for Review

According to Summit Blue's review of the ACE model, annual electricity savings from building commissioning in the Northwest is the product of the commissioned public and commercial building space (in square feet) in the Northwest[1] and the savings from commissioning (in kWh per square foot).

The savings can be expressed as follows:

Electricity Savings (kWh/year) =

(1) Commercial and public building space commissioned within the past five years (in square feet)

x (2) Annual electricity savings per square foot attributable to commissioning activities (kWh/ft^2 per year)

where:

Commercial building space commissioned within the past five years has been estimated from available databases of state-sponsored commissioning activity, from interviews with officials from the four participating states, and from a recent survey of commissioning providers.

Electricity savings per square foot attributable to commissioning was assumed to be 0.55 kWh/ft^2 per year for new buildings (*i.e.*, commissioning) and 1.7 kWh/ft^2 per year for existing buildings (*i.e.*, retrocommissioning), based on median data from a meta-analysis of commercial-building commissioning conducted by Lawrence Berkeley National Laboratory (see Section 2.3.3).[2]

2.2 Methodology

Monitoring and tracking for NEEA's commissioning initiatives began with a series of interviews with state coordinators and other government officials familiar with commissioning activity at public buildings. In addition, the M&T effort utilized a Building Commissioning Association (BCA) survey conducted by Portland Energy Conservation, Inc. (PECI) of BCA members and other commissioning providers that included specific questions aimed at quantifying commissioning activity in both public and private buildings. Survey data were analyzed to better quantify the square footage of commissioning projects in the Northwest. [3] Secondary research was also conducted to lend additional credibility to the

[1] Energy savings are achieved during each year of a measure's life. Since the measure life of a commissioning project is assumed to be five years, the ACE model includes all building floor space commissioned within the past five years to estimate cumulative annual energy savings.

[2] Mills, Evan, et al., *The Cost-Effectiveness of Commercial-Building Construction: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States*, LBNL, December 15, 2004. Referred to throughout this report as "LBNL study."

[3] In early 2007, PECI accommodated NEEA's request to allow Summit Blue to propose survey questions specifically addressing the quantification of commissioning activity. This survey effort resulted in valuable information regarding the number and size of commissioning and retrocommissioning projects in the Northwest; however, given that this was not the primary focus of the survey, a comprehensive set of questions regarding project specifics (such as building type and scope of commissioning activity) was not possible.

discussion of relevant state and local legislation and policies and to the estimates of commissioned building space and per-square-foot energy savings.

The data collection process included the following elements:

1. **Contacted each of the state liaisons who coordinated NEEA's commissioning efforts** under contract to either NEEA itself or to the Oregon Office of Energy (NEEA's prime contractor prior to 2004). The purpose of this effort was to obtain an update on how commissioning has been incorporated into policies/procedures, and to obtain estimates of the amount of commissioning being performed in public buildings and in all commercial buildings. The following people were contacted initially, and several referred Summit Blue to additional sources of information:
    a. Washington Department of General Administration, Roger Wigfield
    b. Oregon Department of Energy, Andrzej Pekalski
    c. Montana Department of Environmental Quality (DEQ), Georgia Brensdal (in place of Toby Benson, who is no longer with the DEQ)
    d. Idaho Department of Water Resources (Energy Division), Sue Seifert, who also referred us to Tim Mason of the Division of Public Works.
2. **Analyzed data from BCA's survey of commissioning providers** to assess industry trends and estimate the total amount of commissioning occurring in the Northwest.
3. **Reviewed secondary sources** with the aim of corroborating the results of the interviews (in terms of policy changes and commissioning market activity) as well as validating the assumptions of energy savings per square foot used in the previous M&T effort.

2.3 Findings

Assessing and quantifying commissioning activity requires a precise definition of what true commissioning really is. However, the interviews and additional research conducted for this study indicate significant ambiguity in the term "commissioning." For example, some level of commissioning is performed in all LEED-certified buildings[4] (discussed below), and energy performance contracts often include elements of commissioning as well. Therefore, **any assessment of commissioning activity requires establishing a minimum threshold of what will be considered "commissioning."**

According to John Jennings, the NEEA project manager for the Commissioning initiatives, a critical element of commissioning is that the work be performed by a dedicated person for whom commissioning is the sole or primary responsibility. In full commissioning under a strict definition, this role would need to be filled by a certified, third-party commissioning professional.[5] Mr. Jennings specifically cited the California Commissioning Collaborative (CACx) as providing a useful definition of commissioning for new buildings:

[4] Administered by the U.S. Green Building Council, the Leadership in Energy and Environmental Design (LEED) Green Building Rating System provides benchmarks for high performance building projects, both for new construction and renovation projects.

[5] Mr. Jennings defined commissioning as follows: "For me, it boils down to being in the [commissioning] process during the design, then do functional testing of mechanical and electric equipment, and assure that the manuals are in place and operators are trained."

> *Commissioning…is an intensive quality assurance process that begins during design and continues through construction, occupancy, and operations. Commissioning ensures that the new buildings operates as the owner intended and that building staff are prepared to operate and maintain its systems and equipment.*[6]

The CACx's manual for commissioning new buildings presents five major elements of the commissioning process: (1) document the building's functional and performance requirements; (2) provide tools and documentation to improve the project team's deliverables; (3) verify and document that systems perform as specified in the owner's project requirements; (4) verify that the building owner and manager receive adequate and accurate system documentation and staff training; and (5) bring a holistic perspective to the design and construction process that integrates and enhances its traditionally separate functions. This definition seems consistent with John Jennings' definition stated above.

Another definition of commission comes from the LEED certification system for green buildings, which has grown in popularity in the Northwest, particularly in Washington and Oregon.[7] To obtain any LEED rating, a building must undergo "fundamental commissioning," which appears to meet the CACx definition of commissioning.[8] However, Mr. Jennings indicated that the LEED Existing Buildings program is in the process of modifying the rules for "retrocommissioning" of existing buildings and may be reducing the stringency of the requirements.

The term "commissioning" is used generically in this M&T assessment to refer to both commissioning of new buildings (Cx) and retrocommissioning of existing buildings (RCx). When making distinctions between the two building types, however, "commissioning" applies to new buildings only and "retrocommissioning" to existing buildings. For purposes of assessing commissioning activity in the Northwest, the California Commissioning Collaborative's concise definition (in italics above) is used; however, some sources of information *may* be using a lesser definition as discussed in the following sections. It should be noted that a key distinction exists in the market in terms of the delivery process between those that advocate independent 3rd party commissioning (e.g. BCA, NEEA, PECI) and those that don't (USGBC, etc.). Another major difference is when commissioning should begin in a new construction project, either early (i.e., schematic or design development) or later in construction.

2.3.1 Market Activity

This section presents findings on current and projected commissioning activity in the Northwest, based on the results of survey data analysis, interviews with state liaisons, and secondary research.

---

[6] California Commissioning Collaborative. *California Commissioning Guide: New Buildings.* 2006.

[7] Approximately 13% of all U.S. LEED-certified new construction buildings and 16% of all LEED-EB (Existing Building) certified buildings are located in the four Northwest states, which account for just 4% of the U.S. population. The state of Washington has adopted a LEED certification requirement for all state-owned building projects, and the two largest cities in the region, Seattle and Portland, have adopted similar requirements for all city-owned building projects. The Washington State Energy Code also requires a commissioning report be prepared. The majority of LEED-certified floor space in the Northwest is owned by state or local governments.

[8] LEED "fundamental commissioning" requires designating a dedicated commissioning authority (a person that is not directly involved with the design or planning of the building, but not necessarily from a third-party company) to perform the following duties: reviews the design intent documentation; details the commissioning requirements in the construction documents; develops a commissioning plan; verifies installation, functional performance, training and documentation; and completes a commissioning report. A building can also achieve an additional LEED point for conducting a more extensive commissioning process and using an independent commissioning provider. Altwies, Joy E. "Commissioning for LEED." *National Conference on Building Commissioning.* May 8-10, 2002.

Three unique approaches were used to estimate the total amount of commissioned floor space in the Northwest in the five-year period from 2003 through 2007.

1. **BCA survey.** The most comprehensive approach was based on responses from the 2007 BCA survey of 76 commissioning providers and 20 building owners active in the Northwest.[9] The survey provided data on the number of commissioning and retrocommissioning projects performed in the Northwest in 2006, as well as the average size of the projects.
2. **Bottom-up analysis of interviews and secondary research.** The second approach was a bottom-up analysis that represents all individual commissioning projects identified through interviews with state liaisons to the original NEEA Commissioning effort, the previous M&T assessment of commissioning, case studies available on the California Commissioning Collaborative's website (CACx.org), and the LEED database of certified projects.[10]
3. **Top-down analysis of NEEA new construction, O&M, and building stock reports.** The third approach was a top-down analysis based on NEEA reports on the commercial new construction study[11], operations and maintenance practices[12], and the commercial building stock in the Northwest.[13]

The remainder of this section summarizes the three analyses and concludes with a best estimate for the total commissioned floor space in the Northwest in 2003-2007.

Approach #1: Survey of Commissioning Providers

In early 2007, PECI conducted a nationwide survey for the BCA of commissioning professionals and building owners who may have been involved in commissioning projects.[14] Table 2-1 summarizes the respondents by type (commissioning professional vs. building owner) and geography (Northwest-based vs. elsewhere).

[9] The survey had 454 total respondents, but only those respondents who reported conducting any commissioning projects in the four Northwest states were included in this analysis. Note that some of the respondents included in this analysis were not based in the Northwest, but did complete projects in the four Northwest states.

[10] The LEED database is available on the U.S. Green Building Council's website at http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx.

[11] The results of this study were provided to Summit Blue in the form of a draft report entitled *Characteristics of Pacific Northwest Non-Residential New Construction: 2002-2004 Building Stock*, by Ecotope, Inc.

[12] Quantum Consulting. *Commercial Buildings Operations and Maintenance Market Assessment: Market Research Report.* Prepared for the Northwest Energy Efficiency Alliance. Report #06-162. October 27, 2006.

[13] XEMA-XENERGY Inc. *Assessment of the Commercial Building Stock in the Pacific Northwest: Market Research Report.* Prepared for the Northwest Energy Efficiency Alliance. Report #04-125. March 8, 2004.

[14] The survey sample was based on the databases of the Building Commissioning Association and the National Conference on Building Commissioning; approximately 5000 people received the survey. Summit Blue was unable to obtain more detailed information on the recipients of the survey such as the number of Northwest-based commissioning providers who received the survey.

Table 2-1. Summary of Survey Respondents

Total Respondents	**454**
Commissioning Professionals	**282**
Commissioning Professionals Based in Northwest	48
Commissioning Professionals Based Elsewhere	234
*Commissioning Leads Active in Northwest**	*50*
Building Owners/Managers	**99**
Building Owners Based in Northwest	20
Building Owners Based Elsewhere	79
Respondents Not Directly Involved with Commissioning Projects	**73**

*Commissioning Leads Active in Northwest include all commissioning providers whose primary role on commissioning projects is "Commissioning Lead" and who indicated that at least a share of their projects completed in 2006 were located in the Northwest, even if they were not based in one of the Northwest states.

The survey revealed that many of the commissioning professionals based in the four Northwest states have only been active in the field for five years or less (56% of the 48 respondents based in the Northwest who were surveyed[15]), suggesting that the pool of commissioning professionals in the region has grown significantly in the past five years.

Each respondent was asked about the number of commissioning and retrocommissioning projects that they had participated in during the calendar year 2006, the percentage of projects that were done in the Northwest, and the average size of the projects (measured in square feet). These three factors were multiplied together for each respondent, then summed across respondents to estimate the total square footage of commissioning projects in the region in 2006. Total commissioning activity was estimated at 27 million square feet of floor space in 247 new buildings and 16 million square feet of retrocommissioned floor space in 169 existing buildings. To avoid possible double-counting, only respondents who identified their primary role on commissioning projects as "Commissioning Lead" were included in this analysis, which is summarized in Table 2-2.

Table 2-2. Estimate of Total Commissioned Floor Space in Northwest in 2006

Project Type	# of Projects	Average Project Size (ft^2 x 1000)	Total Project Floor Space (ft^2 x 1000)
Commissioning	247	109	**26,952**
Retrocommissioning	169	96	**16,318**
Total - Cx & RCx Combined	**416**	**104**	**43,270**

Source: Summit Blue analysis of commissioning provider survey data; n=50.

[15] This percentage is of Northwest-based commissioning providers (not building owners) only. It includes professionals who play various roles on commissioning projects, including Commissioning Leads, LEED Consultants, Design Professionals, and others.

This total estimate of more than 43 million square feet of commissioned or retrocommissioned floor space is based on self-reports of 50 commissioning leads[16] who indicated that they did at least a share of their projects in the Northwest in 2006.[17] The results may underestimate commissioning activity, as reported by commissioning agents, since it is likely that some (if not a significant percentage) of commissioned buildings were not captured in the survey data. Results were not extrapolated from the sample to the broader population because there was no reliable method to estimate the share of commissioning agents or activity represented in the sample.[18]

It is also important to note that the survey did not provide a strict definition of commissioning for respondents' reference and thus the scope of commissioning projects counted in this analysis may not always be up to the standards of true commissioning as defined above. Consequently, while the survey data may underestimate the total floor space of "commissioning" projects because a census of commissioning providers was not reached, it also may overestimate the floor space that has undergone true commissioning and achieved all the potential energy savings. However, the energy savings estimates recommended in Section 2.3.3 are also based on a range of commissioning projects that may be similar to those performed by survey respondents. Furthermore, many of the survey respondents are members of the Building Commission Association and thus likely have reasonable knowledge of commissioning at a professional level. Therefore, while all commissioning projects represented by the survey respondents may not be up to the strict standards of full commissioning, it is reasonable to count them as such for purposes of assessing market activity and estimating related energy savings using the assumptions discussed below.

This M&T report covers commissioning activity from 2003 through 2007 (the five-year measure life), but the survey specifically asked about projects completed in 2006, so the 43 million ft^2 value is a one-year estimate. It is likely that the floor space commissioned by these providers in 2003, 2004, and 2005 was somewhat below 43 million ft^2 per year, and the value for 2007 was somewhat higher. Although the rate of increase is difficult to estimate, it is assumed that the total floor space of commissioned buildings increased by 20% annually from 2003 through 2006 and held steady between 2006 and 2007.[19] This

[16] This analysis was based on commissioning providers who identified their primary role on commissioning projects as Commissioning Leads, to avoid possible double-counting. The analysis includes all commissioning leads who indicated that at least a share of their projects completed in 2006 were located in the Northwest, even if they were not based in one of the Northwest states.

[17] The same analysis was conducted based on responses from building owners (as opposed to commissioning providers), which resulted in estimates of 1,940,000 ft^2 of commissioned new buildings and 12,695,000 ft^2 of retrocommissioning projects in 2006. The results from the building owners' responses can be expected to underestimate activity since the share of commissioned buildings represented by the owners completing the survey is likely to be lower than the share represented by the commissioning providers because the survey focused primarily on commissioning providers. However, the estimate based on building owners' projects represents a useful lower bound.

[18] Summit Blue attempted to obtain more detailed information on the survey recipients (e.g., the number of Northwest-based commissioning providers who received the survey) to better extrapolate the results to the broader population, but PECI was unable to provide that type of data.

[19] The BCA survey data indicate that commissioning activity is increasing (many commissioning providers in the Northwest have been active in the field for less than 5 years) and is also expected to continue to increase (71% expect their new building commissioning to increase in the next year). Additionally, the interviews with state liaisons indicated that commissioning activity is increasing due to greater acceptance and the increasing popularity of LEED, particularly in Washington and Oregon. The 20% annual growth rate assumed for 2003 to 2006 represents a rapid increase and—since the BCA survey data is from 2006—results in relatively conservative estimates of activity in the years prior to 2006. The assumption that commissioning activity did not expand in 2007 is another

assumption results in a 5-year estimate of 111 million ft^2 of commissioned floor space and 67 million ft^2 of retrocommissioned floor space.

Table 2-3. Commissioned Floor Space based on Commissioning Provider Survey Data, 2003-2007

Year	Commissioned Floor Space (ft^2 x 1000)	Retrocommissioned Floor Space (ft^2 x 1000)	Total Floor Space (Cx + RCx) (ft^2 x 1000)
2003	15,597	9,443	25,041
2004	18,717	11,332	30,049
2005	22,460	13,598	36,059
2006*	26,952	16,318	43,270
2007	26,952	16,318	43,270
5-Year Total	**110,680**	**67,010**	**177,689**
Estimated Total Market Floor Space**	297,404	2,664,388	2,664,388
Implied Market Penetration of Cx & RCx	37%	3%	7%

* 2006 is the year covered by the survey. Estimates for 2003-2005 are based on an assumed 20% increase per year and 2007 is assumed to have been the same as 2006.

** Estimates of total market floor space are based on two NEEA reports: the CNC study (for commissioning of new construction floor space) and the CBSA report (for retrocommissioning of existing buildings). The new construction estimate is a cumulative 5-year estimate covering buildings constructed in 2003-2007; the existing building stock estimate is based on the 2007 estimate. The value for 2007 existing building stock was also used for the total floor space estimate (commissioning and retrocommissioning). See discussion of NEEA reports in subsequent section for more details.

Source: Summit Blue analysis of commissioning provider survey data

The majority of Northwest-based commissioning providers[20] are optimistic about their future business prospects. Nearly three-quarters (71%) expect their new building commissioning business to increase in the next year, and 60% expect their retrocommissioning business to increase.

Approach #2: Bottom-Up Analysis of Interviews and Secondary Research

This approach to estimating commissioning activity represents the total of individual commissioning projects that were identified through interviews with state liaisons, the 2005 M&T report on commissioning activity (including projects from the LBNL study),[21] relevant case studies identified on the California Commissioning Collaborative's website (CACx.org), and data from the LEED database.[22]

conservative assumption given the plethora of evidence suggesting an increase in commissioning throughout the region.

[20] This percentage is of Northwest-based commissioning providers (not building owners) only. It includes professionals who play various roles on commissioning projects, including Commissioning Leads, LEED Consultants, Design Professionals, and others.

[21] The 2005 M&T report included findings from interviews with state liaisons (which were updated for this 2007 M&T research), interviews with commissioning providers, and an LBNL study on commissioning activity. In using these findings, only commissioning projects completed in 2003 or later (and therefore still within the 5-year measure life) were included in the current analysis.

[22] The LEED database is available on the U.S. Green Building Council's website at http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx.

The major findings of the **state liaison interviews** are presented immediately below. For more details on each state's commissioning activity, see Section 2.6.

- **Washington** now requires all state-owned new construction and major renovations to achieve LEED Silver certification, and most of the buildings are seeking the extra point for full commissioning, which Roger Wigfield of the Department of General Administration attributes to their extensive familiarity with the benefits of commissioning (data on LEED-certified projects is included in Table 2-4 below).[23] He also indicated that retrocommissioning is becoming more accepted in the state as building owners recognize that retrocommissioning is a valuable diagnostic tool, not an accusation of poor performance against the facility operators. The Washington State Energy Code requires that new nonresidential buildings undergo commissioning for mechanical and lighting systems, and requires that a commissioning report be delivered to the building owner.[24] Commissioning seems to be the most widely utilized and accepted in Washington.

- In **Oregon**, there is no overarching requirement for commissioning of state-owned buildings, but there is a requirement for schools receiving public purpose charge funds to retrocommission their buildings (data on these projects is included in Table 2-4 below, along with LEED projects and relevant projects from the LBNL study). The Department of Energy offers a tax credit for buildings that achieve LEED Silver status and achieve the full commissioning extra point, and the Energy Trust of Oregon also offers incentives for commissioning.

- **Idaho** considers commissioning to be a recommended practice for state buildings over 5000 ft^2, but Tim Mason of the Division of Public Works indicated that commissioning was "sporadic at best" and retrocommissioning was "even rarer" in state buildings. Table 2-4 below includes LEED projects in the state, as well as relevant projects from the LBNL study.

- Commissioning of new public buildings is considered "standard practice" in **Montana**, but very little new construction is happening in the state. Approximately 2-3 existing state buildings per year are retrocommissioned, and the two major university systems have retrocommissioning programs as well. Table 2-4 below includes the estimate of state buildings retrocommissioned (based on the state liaison interview) as well as LEED projects in the state.

Table 2-4 summarizes the findings of the bottom-up approach and indicates an estimate of approximately 5.7 million square feet for commissioned buildings and 7.4 million square feet for retrocommissioned buildings over the past five years. This estimate likely underestimates the total commissioned floor space due to the lack of state record-keeping, delays in reporting for the Oregon schools program and for the LEED database, and the limited availability of project-specific data on commissioning in the commercial sector. Furthermore, the LEED projects included in the estimate represent only those buildings that have already received their LEED certification, but not the hundreds more LEED-*registered* projects that are

[23] The state database tracking commissioning activity (utilized in the 2005 M&T report) is no longer updated, but projects contained in the database that are still within the 5-year measure life are also included in Table 2-4 below, along with applicable projects from the LBNL study (also incorporated into the 2005 M&T report).

[24] Washington State Building Code Council. *Washington State Energy Code: 2006 Edition. Chapter 51-11 WAC.* Effective July 1, 2007. www.sbcc.wa.gov/docs/codes/WSEC06.pdf. Requirement also summarized at www.energyideas.org/documents/factsheets/BuildingCommissioning.pdf.

still in the process of obtaining certification and have likely undergone or will very shortly undergo commissioning.

Table 2-4. Summary of Commissioned Floor Space Estimates from Interviews, Databases, and Case Studies (Bottom-Up Approach), Projects Completed 2003-2007

Source	Commissioned Floor Space (New Construction) (ft^2 x 1000)	Retrocommissioned Floor Space (Existing Buildings) (ft^2 x 1000)	Total Floor Space (Cx + RCx) (ft^2 x 1000)
State Liaison Interviews			
Washington State Database[1]	1,800	180	**1,980**
Oregon Schools[2]	--	3,273	**3,273**
Montana RCx Estimate[3]	--	500	**500**
NW Case Studies[4]	13	399	**412**
LBNL Study[5]	23	513	**536**
LEED-Certified Buildings[6]	3,890	2,491	**6,381**
TOTAL	**5,726**	**7,356**	**13,082**
Estimated Total Market Floor Space*	297,404	2,664,388	2,664,388
Implied Market Penetration of Cx & RCx	1.9%	0.3%	0.5%

Sources:

[1] Based on 2005 M&T report (updates were not available for 2006-2007)

[2] Based on state database obtained from Andrzej Pekalski, Oregon Department of Energy

[3] Updated from 2005 M&T report based on interview with Georgia Brensdal, Montana Department of Environmental Quality

[4] Case studies found at California Commissioning Collaborative website (www.cacx.org)

[5] Mills, Evan, et al., *The Cost-Effectiveness of Commercial-Building Construction: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States*, LBNL, December 15, 2004. These projects were also presented in the 2005 M&T report.

[6] LEED database available on the U.S. Green Building Council's website at http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx.

* Estimates of total market floor space are based on two NEEA reports: the CNC study (for commissioning of new construction floor space) and the CBSA report (for retrocommissioning of existing buildings). The new construction estimate is a cumulative 5-year estimate covering buildings constructed in 2003-2007; the existing building stock estimate is based on the 2007 estimate. The value for 2007 existing building stock was also used for the total floor space estimate (commissioning and retrocommissioning). See discussion of NEEA reports in subsequent section for more details.

Approach #3: Top-down Analysis of NEEA Reports

The third approach for estimating the total commissioned floor space is based on a recent study of commercial new construction activity conducted by NEEA (hereafter referred to as the CNC study)[25] and two studies related to retrocommissioning also published by NEEA: the *Commercial Buildings*

[25] The results of this study were provided to Summit Blue in the form of a draft report entitled *Characteristics of Pacific Northwest Non-Residential New Construction: 2002-2004 Building Stock*, by Ecotope, Inc.

Operations and Maintenance Market Assessment[26] (hereafter referred to as the O&M report) and the *Assessment of the Commercial Building Stock in the Pacific Northwest*[27] (CBSA report).

The commercial new construction study involved interviews with building operators of non-residential buildings that were constructed between 2002 and 2004. Overall, 21% of newly constructed buildings in the Northwest (by area) are reported to have been commissioned, and 9% have achieved LEED certification; commissioning and LEED certification were much more prevalent in Washington and Oregon than in Idaho and Montana (Table 2-6).

Table 2-5. Commissioning and LEED Certification as Percentage of Total New Construction Floor Space, 2002-2004

State	% LEED Certified (area)	% Commissioned (area)
Idaho	2%	8%
Montana	0%	7%
Oregon	10%	22%
Washington	11%	27%
Total	**9%**	**21%**

Source: Ecotope, Inc. *Characteristics of Pacific Northwest Non-Residential New Construction: 2002-2004 Building Stock.* Draft Summary Tables. January 2008.

The CNC study estimated the total floor space of commercial new construction in 2002-2004 to be 146 million ft^2 or 49 million ft^2 annually based on Dodge data; assuming that new construction increased 10% annually results in a 5-year cumulative estimate of 297 million ft^2 for 2003-2007, the period of time which the M&T analysis covers.[28] To be conservative, Summit Blue assumed that the percentage of floor space undergoing commissioning remained constant at 21%, resulting in a total 5-year estimate of 61 million ft^2 of commissioned new construction.[29] Table 2-6 summarizes the results of this analysis.

[26] Quantum Consulting. *Commercial Buildings Operations and Maintenance Market Assessment: Market Research Report.* Prepared for the Northwest Energy Efficiency Alliance. Report #06-162. October 27, 2006.

[27] XEMA-XENERGY Inc. *Assessment of the Commercial Building Stock in the Pacific Northwest: Market Research Report.* Prepared for the Northwest Energy Efficiency Alliance. Report #04-125. March 8, 2004.

[28] A review of construction trade journals indicated that nonresidential new construction in the Northwest has been booming over the past five years, significantly outpacing the national average. For instance, the volume of publicly reported nonresidential construction contract awards in 2006 increased 15% over 2005 values (reported in *Pacific Builder and Engineer*, http://www.allbusiness.com/construction/construction-overview/6263709-1.html), and then increased by another 12% from 2006 to 2007 (reported at http://www.acppubs.com/article/CA6514502.html).

[29] Based on interviews with state liaisons and the survey of commissioning providers discussed earlier in this report, it seems likely that commissioning activity has increased somewhat over the 2003-2007 time frame. Hypothetically, if a 20% yearly increase in the commissioning rate for new buildings undergoing commissioning were assumed (similar to what was assumed for the PECI survey analysis, the 5-year estimate of commissioned floor space would increase to 94 million, or 31% of all new construction activity.

Table 2-6. Summary of Commissioned New Construction Floor Space based on CNC Study

	Total New Construction (ft^2 x 1000)	Commissioned Floor Space (ft^2 x 1000)
2003	48,714	10,025
2004	53,585	11,028
2005	58,944	12,131
2006	64,838	13,344
2007	71,322	14,678
5-Year Total	**297,404**	**61,206**

Sources: Summit Blue analysis and Ecotope, Inc. *Characteristics of Pacific Northwest Non-Residential New Construction: 2002-2004 Building Stock.* Draft Summary Tables. January 2008.

The O&M report relied primarily on surveys with commercial building owners or their internal facilities engineers or other decision-makers. The study found that a significant percentage (35%) of building owners reported conducted retrocommissioning in their buildings. This percentage varied by building type, with the college/university sector having the most activity (53%), followed by retail (44%), office (26%), and finally government (17%). These findings would appear to indicate that retrocommissioning is substantially more commonplace than the interviews and secondary research indicated. However, it is unclear whether the scope of the retrocommissioning projects would qualify as true commissioning, and the O&M report authors note that they believe that the implementation rate of the practice is substantially over-reported.[30] Thus, in the findings presented in Table 2-7, the retro-commissioning rate has been reduced by 50% to be conservative. The adjusted implementation rates were then multiplied by the total square footage in each market segment (based on the CBSA report) to obtain a total estimate of retrocommissioned floor space of 220 million ft^2, or roughly 8% of all commercial floor space. It is not clear whether respondents were including retrocommissioning activity occurring only during the past five years (the subject of this analysis) or over some unspecified period that could extend back to the year of the construction. This uncertainty in the data may limit the degree to which the results of this analysis are relied upon for external reporting purposes.

[30] Many owners may consider audits, tune-ups, and other diagnostic services to be retrocommissioning.

Table 2-7. Summary of Retrocommissioned Floor Space based on O&M and CBSA Reports

Market Segment	Total Square Footage in Market Segment (ft^2 x 1000)*	% RCx	Adjusted % RCx**	Total RCx Floor Space (ft^2 x 1000)
Government-Owned	532,878	17%	8.5%	45,295
University (excluding government-owned)	68,208	53%	26.5%	18,075
Retail	452,946	44%	22.0%	99,648
Office (excluding government-owned)	440,423	26%	13.0%	57,255
Other Commercial**	1,169,933	--	--	--
Total	**2,664,388**			**220,273**

* Total square footage was based on the 2001 estimate of total square footage in the commercial sector, projected out to 2007 levels based on the average annual increase of 2% from 1987 through 2001. Square footage by market segment was estimated by multiplying that 2007 estimate of total commercial square footage by the percentage represented by each market segment as stated in the CBSA report.

** RCx rates were reduced by 50% to account for overreporting. See text introducing this table.

*** No estimate of the percentage of buildings retrocommissioned was available for market segments other than Government, University, Retail, and Office, so to be conservative, it was assumed that no retrocommissioning is happening in those other market segments (which include Warehouse, Grocery, Restaurants, Hotels/Motels, etc.).

Sources: Quantum Consulting. *Commercial Buildings Operations and Maintenance Market Assessment: Market Research Report.* Prepared for the Northwest Energy Efficiency Alliance. Report #06-162. October 27, 2006.

XEMA-XENERGY Inc. *Assessment of the Commercial Building Stock in the Pacific Northwest: Market Research Report.* Prepared for the Northwest Energy Efficiency Alliance. Report #04-125. March 8, 2004.

The O&M report also asked about the commissioning of specific major energy-using systems. Over half (60%) of building owners/decision-makers indicated that at least one system had been commissioned, most often cooling systems (79%), heating systems (57%), or lighting (39%). Very few respondents reported commissioning of EMS/controls, refrigeration, water heating, or cooking systems. Again, it is unclear whether the building owners are reporting full commissioning activities or tune-ups, diagnostics, or other types of servicing.

Best Estimate of Commissioned Floor Space

Table 2-8 summarizes the results of the three analytic approaches discussed above in terms of estimated commissioned and retrocommissioned floor space. Both the *commissioning provider survey approach* and the *top-down analysis of NEEA reports* were more comprehensive than the bottom-up approach. The bottom-up approach resulted in a lower estimate of commissioned and retrocommissioned floor space; however, the method is known to capture only a fraction of commissioning activity, since private sector commissioning is barely addressed outside of LEED-certified buildings, and records for public building commissioning are not comprehensive. Consequently, the bottom-up approach was deemed to grossly underestimate the true extent of commissioning activity.

Table 2-8. Commissioned and Retrocommissioned Floor Space, 2003-2007

Approach	Commissioned Floor Space		Retrocommissioned Floor Space		Total Floor Space (Cx + RCx)
	ft^2 x 1000	% of Total*	ft^2 x 1000	% of Total**	ft^2 x 1000
Commissioning Provider Survey Data	110,680	37%	67,010	3%	177,689
Bottom-Up Approach	5,727	2%	7,356	<1%	13,083
Top-Down Analysis of NEEA Reports	61,206	21%	220,273	8%	281,479

Source: Summit Blue analysis

* Percentage based on the cumulative 5-year floor space estimate of new construction activity in the Northwest, which was estimated to be 297 million ft^2 based on the Dodge data presented in the CNC study.

** Percentage based on the total estimate of existing commercial floor space of 2,664 million ft^2 as of 2007, based on the data presented in the CBSA report.

For the estimate of new building commissioning, the commissioning provider survey approach resulted in an estimate equivalent to 37% of new building construction. This figure is nearly twice that indicated by NEEA's CNC study, and it is assumed for this M&T analysis that the CNC estimate of 21% market penetration is the more appropriate value, and certainly the more conservative. For retrocommissioning, the top-down analysis from the NEEA study indicated more than double the activity of the survey approach (8% of existing buildings retrocommissioned versus 3%). Given the uncertainty in the data from the NEEA study (including the period of time covered by respondents), the analysis of retrocommissioning activity that follows is based solely on the detailed survey analysis expressly conducted for this M&T effort (*i.e.,* the survey approach), which also produces the more conservative estimate. Thus, the recommended values for this M&T effort are based on the lower values in each case: new building commissioning is based on NEEA's CNC study and retrocommissioning is based on the survey approach (Table 2-9).

Table 2-9. Best Estimate of Commissioned and Retrocommissioned Floor Space in the Northwest, 2003-2007

Year	Commissioned Floor Space (ft^2 x 1000), based on CNC Study*	Retrocommissioned Floor Space (ft^2 x 1000), based on Commissioning Provider Survey**	Total Floor Space (Cx + RCx) (ft^2 x 1000)
2003	10,025	9,443	19,469
2004	11,028	11,332	22,360
2005	12,131	13,598	25,729
2006	13,344	16,318	29,662
2007	14,678	16,318	30,996
Total	**61,206**	**67,010**	**128,215**

* The CNC study found that 21% of all new construction in 2002-2004 was commissioned; to be conservative, the percentage of floor space commissioned in 2005-2007 is assumed to remain at a constant level. The annual increases in commissioned floor space are based on an estimated 10% annual increase in total new construction activity.

**2006 is the year covered by the survey. Estimates for 2003-2005 are based on an assumed 20% increase per year and 2007 is assumed to have been the same as 2006.

Source: Summit Blue analysis of CNC study and commissioning provider survey data

2.3.2 Baseline Activity

Through 2006, NEEA has assumed that baseline activity was 10% of estimated commissioning market activity.[31] To update this estimate, Summit Blue interviewed state liaisons regarding NEEA's influence and reviewed papers and reports to discern other potential influences on the market for commissioning services in the Northwest.

The growing popularity of LEED and all things "green" makes the assessment of baseline commissioning activity problematic. It is clear from the interviews with state liaisons that NEEA had a significant influence in the adoption of commissioning in public buildings as a requirement or standard practice; however, it difficult to assess how much influence NEEA had over the adoption of LEED or other green building policies, or on commissioning in the private sector. It is possible that NEEA's efforts to educate government officials and decision-makers about commissioning's benefits (as well as other energy issues) made them more open to adopting LEED requirements. Georgia Brensdal of the Montana Department for Environmental Quality indicated that in her state, commissioning is poorly understood and is a deterrent to building owners seeking LEED status. Conversely, the state in which commissioning seems to be the most popular and accepted (Washington) has established LEED requirements for state buildings and also has the most LEED buildings in the Northwest region.

The relatively modest baseline estimate of 10% of market activity appears to be reasonable for state government buildings—and likely local government buildings as well—given the high level of influence indicated by state commissioning program liaisons (see below) on the adoption of commissioning as a standard practice (if not requirement) for government buildings. However, the increasing prominence of climate change issues in the public consciousness and the subsequent desire for both governments and corporations to adopt a "green" image (by building LEED buildings, reducing carbon footprints, etc.) introduce more uncertainty into the link between NEEA's efforts and the increase in commissioning

[31] This assumption was based on the Excel file "2006 MAR Cumulative Savings 04-03-07.xls", which cited the high level of NEEA influence described by state liaisons in the 2005 M&T report.

activity, particularly in the commercial sector. There is little doubt that education and outreach provided by NEEA has played a significant role in the apparent increase in commissioning and in the availability of commissioning providers in the region over the past five years, but some portion of the increase was likely sparked by this nationwide "greening" trend. To account for these changing market conditions, **Summit Blue recommends increasing the baseline estimate to 30% of all market activity.** While this value cannot be attributed to specific market data, it represents a three-fold increase in NEEA's current assumptions and reflects the growing impact of market forces beyond NEEA's influence.

Anecdotes from the interviews with state liaisons in regards to NEEA's influence on commissioning in their states provide support for the continued assumption that the majority of commissioning activity would not have occurred without NEEA's influence:

Washington. Roger Wigfield of the Washington Department of General Administration believes that without NEEA's funding in helping the department establish the commissioning program, "there would have been a lot more reluctance to commissioning. It raised awareness and provided information on the case studies that we were able to provide to our clients." He also indicated that he believes that while NEEA did not likely influence the state legislature's decision to mandate LEED Silver certification for all state-funded buildings, he does believe that almost all of these buildings are going for the extra LEED point for full commissioning due to their extensive knowledge of the benefits of commissioning, which was influenced by NEEA's initiatives.

Oregon. Andrzej Pekalski of the Oregon Department of Energy expressed "serious doubts" that commissioning would have taken off in the state if NEEA "had not stepped in at the time that they did." He described NEEA's funding of case studies and the formation of the Building Commissioning Association as "very critical and important to push commissioning."

Idaho. Sue Seifert of the Idaho Department of Water Resources (Energy Division) believes that most of the commissioning activity in the state was directly influenced by NEEA, including the LEED buildings through the Integrated Design Lab. She said, "It's the education and bringing in speakers…The Northwest Energy Efficiency Alliance is such a huge part of the Northwest, and the education they provide influences all the projects – a huge majority of them." Ms. Seifert gave a specific example of NEEA paying for a speaker (Joe Van Belleghem) on high performance buildings and the whole building approach. The presentation was a major inspiration for construction of the first LEED Platinum building in Idaho (the Banner Bank Building in Boise, built by Gary Christensen).[32]

Montana. Georgia Brensdal of the Montana Department of Environmental Quality believed that NEEA's demonstration projects were very important, "because the state government processes are never very experimental. If they are going to use their own money, they really want to see if it's going to be cost-effective for them. We wouldn't have gotten rolling if we hadn't had these examples from the Northwest Alliance to show them. It was very important."

2.3.3 Per-Unit Energy Savings

The 2005 M&T report used median kWh/ft^2-year savings values of 0.55 kWh/ft^2 for new buildings (*i.e.*, commissioning) and 1.7 kWh/ft^2 for existing buildings (*i.e.*, retrocommissioning), based on median data

[32] Note that Ms. Seifert was not certain whether the speaker was specifically associated with the Commissioning project; thus, the anecdote is provided as an example of the type of influence that NEEA has in the region, rather than specifically attributing this market activity to the Commissioning initiative.

from a meta-analysis of commercial building commissioning conducted by Lawrence Berkeley National Laboratory (LBNL).[33] An update to this study is currently underway, but the lead author, Dr. Evan Mills, was unable to provide an estimate of when the analysis would be completed due to slow data collection efforts.

Savings values for commissioning in new buildings and retrocommissioning were addressed through review of a number of other papers and program evaluation reports to determine if updates to the previously used values for kWh savings per commissioned square foot were warranted. The LBNL study closely analyzed data on 224 building commissioning and retrocommissioning projects (including 33 projects from the NEEA Public Building Commissioning program) and was much more comprehensive than any other study on commissioning energy savings identified for this M&T review.

For retrocommissioning of existing buildings, validation of NEEA's previous savings assumptions was obtained from several sources. A recent evaluation of San Diego Gas & Electric's Retrocommissioning Program conducted measurement and verification on the four participant buildings, with a range of savings values from 0.6 to 20.8 kWh/ft^2-year, with an average of 3.6 kWh/ft^2-year and a median of 1.0 kWh/ft^2-year.[34] A similar study conducted by LBNL of eight participating buildings in the Sacramento Municipal Utility District's (SMUD) retrocommissioning program found that savings ranged from 0.5 to 4.6 kWh/ft^2-year, with an average of 1.8 kWh/ft^2-year and a median of 1.2 kWh/ft^2-year.[35] Given the small sample sizes of these two studies and the fact that the previous assumption of 1.7 kWh/ft^2-year for retrocommissioning falls between the average and median savings value in both studies, Summit Blue does not believe that a change to the savings assumption is warranted.

Summit Blue was not able to find any additional studies or evaluation reports that would provide insights on the energy savings of commissioning for new buildings, and thus recommends that the previous value of 0.55 kWh/ft^2-year continue to be used.

2.4 Conclusions and Recommendations

NEEA's commissioning initiatives have accelerated the transformation of the commissioning market in the Northwest and helped to increase the number of commissioning providers, the amount of floor space being commissioned, and in some cases the quality of commissioning being performed. These achievement have realized thorugh projects supporting public building commissioning and the development of the Building Commissioning Association as well as ongoing promotion of commissioning through the BetterBricks activities. The following are major conclusions of this M&T research:

[33] The median savings figures, which are cited in the LBNL study and whose use is supported by the lead author, provide a more conservative estimate of program savings than do the mean savings figures, which are about 30% higher for existing buildings and double for new construction due to a few outlier projects that raised the mean result. See Mills, Evan, *et al., The Cost-Effectiveness of Commercial-Building Construction: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States*, LBNL, December 15, 2004.

[34] Itron. *PECI San Diego Retrocommissioning Program: SDG&E Service Area. Final Report*. February 2007.

[35] Bourassa, Norman, Mary Ann Piette, and Naoya Motegi. "An Evaluation of Savings and Measure Persistence from Retrocommissioning of Large Commercial Buildings." *2004 ACEEE Summer Study on Energy Efficiency in Buildings.*

1. **The pool of available commissioning providers in the Northwest has increased overall in the past five years,** based on BCA survey data and anecdotes from state liaisons. However, the availability of commissioning providers varies regionally; Washington has 21 members, Oregon has seven, Idaho has two, and Montana currently has no members in the Building Commissioning Association.[36] Georgia Brensdal of the Montana Department of Environmental Quality indicated that the limited pool of qualified commissioning providers may have limited the number of projects her department could initiate.

2. **Commissioning providers based in the Northwest are optimistic that their business will increase in the near future,** particularly with new building commissioning. 71% of survey respondents based in the Northwest said that they expected their commissioning activities to increase in the next year, and 60% said that they expected their retrocommissioning services to be in greater demand.

3. **The demand for commissioning is increasing in response to the popularity of the LEED green building certification process.** LEED is extremely popular in the Northwest, particularly in Washington and Oregon. Approximately 13% of all U.S. LEED-certified new construction buildings and 16% of all LEED-EB (Existing Building) certified buildings are located in the four Northwest states, which account for just 4% of the U.S. population. The state of Washington has adopted a LEED certification requirement for all state-owned building projects, and the two largest cities in the region, Seattle and Portland, have adopted similar requirements for all city-owned building projects. The majority of LEED-certified floor space in the Northwest is owned by state or local governments.

Table 2-10 summarizes **recommendations for the values of key indicators** compared to those presented in NEEA's 2006 MAR Excel file. Estimates of the cumulative market activity through 2007 are higher by nearly an order of magnitude, with commissioning of new buildings increasing from approximately 10 million square feet in 2006 to roughly 61 million square feet in 2007, and retrocommissioning activity increasing from roughly five million square feet to nearly 70 million square feet. Baseline assumptions were also raised (30% of total market activity, as compared to 10% in the 2005 M&T report) based on the interviews and secondary research conducted for this report. There is no change in the per-unit energy savings. The estimated energy savings from the recommended values for key indicators is nearly 12 aMW, or more than a seven-fold increase over the cumulative savings suggested by the key indicator values used by NEEA in 2006. The significant increase in estimated market activity and energy savings is a result of the 2007 M&T assessment basing estimates on comprehensive surveys of commissioning providers and building owners. By contrast, the 2006 assessment was a bottom-up effort that relied on incomplete state records and a few select interviews with commissioning providers.

[36] Based on searches of the BCA member directory located at http://www.bcxa.org/membership/directory.htm. Search conducted on January 24, 2008.

Table 2-10. M&T Recommendations for Key Indicators

Key Indicators Reviewed	NEEA 2006 Cumulative Values*	2007 Recommended Cumulative Values	Source
Current Market Activity (most recent 5 years)			
Commissioned buildings (millions ft^2)	10.5	61.2	Commissioning provider survey data and CNC study; see Table 2-9 in Section 2.3.1
Retrocommissioned buildings (millions ft^2)	5.2	67.0	
Total Market Activity	15.7	128.2	
Current Baseline Activity (most recent 5 years)			
Commissioned buildings (millions ft^2)	1.0	18.4	State liaison interviews and secondary research; see Section 2.3.2
Retrocommissioned buildings (millions ft^2)	0.5	20.1	
Total Baseline Activity	(rounded) 1.6	38.5	
Per-Unit Energy Savings			
kWh/ft^2 (Commissioning)	0.55	0.55	LBNL report; see Section 2.3.3
kWh/ft^2 (Retrocommissioning)	1.70	1.70	
Estimated Energy Savings**			
Commissioned buildings (aMW)	0.6	2.7	ACE model; see Section 2.1. aMW=MWh divided by 8760 hours
Retrocommissioned buildings (aMW)	0.9	9.1	
Total Implied Energy Savings (aMW)	1.5	11.8	

* NEEA 2006 values from Excel file "2006 MAR Cumulative Savings 04-03-07.xls". Breakdown between commissioning and retrocommissiong (67% vs. 33%) was based on the findings from the 2005 M&T report.

** Estimated energy savings are presented for comparison purposes only between NEEA's 2006 values and the 2007 M&T findings. NEEA's reported values may not match those presented here since NEEA adjusts for the effect of utility incentives and other factors not taken into account in this M&T analysis.

Future M&T efforts could enhance NEEA's understanding of market transformation by focusing on the factors driving the market for commissioning, including the rising popularity of LEED and the varying levels of familiarity with commissioning and retrocommissioning in different market sectors. On a continuing basis, it is recommended that the M&T analysis be conducted *every two years* and include the following activities:

1. Contact with state liaisons to obtain updates to existing commissioning databases or identify new sources of state records, and to identify new state requirements or guidelines for commissioning of public buildings, as well as related requirements such as LEED or other green building standards.

2. Survey of commissioning providers, coordinated through PECI if necessary to ensure consistency of questions and to allow for collection of time-series data. Survey instruments could be improved by including more detailed questions about the scope of commissioning projects as well as building type, and also ask about the percentage of commissioning projects that are part of a LEED project.

3. Interviews with some of the largest commissioning providers to better understand the market and the factors driving their business, particularly in the commercial sector.

2.5 Bibliography

Altwies, Joy E. "Commissioning for LEED." *National Conference on Building Commissioning.* May 8-10, 2002.

Bourassa, Norman, Mary Ann Piette, and Naoya Motegi. "An Evaluation of Savings and Measure Persistence from Retrocommissioning of Large Commercial Buildings." *2004 ACEEE Summer Study on Energy Efficiency in Buildings.*

California Commissioning Collaborative. *California Commissioning Guide: New Buildings.* 2006.

Cascadia Region Green Building Council. *Making Change in the Built Environment: 2006 Annual Report.* Report available for download at http://www.cascadiagbc.org/about-us/cascadia-2006-annual-report.pdf.

City of Seattle Sustainable Building Program: 5-Year Report: 2000-2005: Building a Better City. Available at http://www.seattle.gov/dpd/GreenBuilding/OurProgram/Overview/Programhistory/default.asp#5year.

Ecotope, Inc. *Characteristics of Pacific Northwest Non-Residential New Construction: 2002-2004 Building Stock.* Draft Summary Tables. January 2008.

Email correspondence with Evan Mills, Lawrence Berkeley National Laboratory. January 3, 2008.

EnergyIdeas Clearinghouse. *Energy Efficiency Factsheet: Building Commissioning for New Buildings.* Washington State University Extension Energy Program and the Northwest Energy Efficiency Alliance. 2005. www.energyideas.org/documents/factsheets/BuildingCommissioning.pdf.

Interview with Andrzej Pekalski, Oregon Department of Energy. December 4, 2007.

Interview with Georgia Brensdal, Montana Department of Environmental Quality. January 3, 2008.

Interview with John Jennings, Northwest Energy Efficiency Alliance. December 11, 2007.

Interview with Roger Wigfield, Washington Department of General Administration. January 2, 2008.

Interview with Sue Seifert, Idaho Department of Water Resources (Energy Division). January 2, 2008.

Interview with Tim Mason, Idaho Division of Public Works. January 3, 2008.

Itron. *PECI San Diego Retrocommissioning Program: SDG&E Service Area. Final Report*. February 2007.

Mills, Evan, *et al. The Cost-Effectiveness of Commercial-Building Construction: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States.* LBNL. December 15, 2004.

Molesworth, Carl. "Construction Boom Continues for Pacific Northwest in 2008." http://www.acppubs.com/article/CA6514502.html.

Molesworth, Carl. "The Good Times Roll On." *Pacific Builder and Engineer*. January 1, 2007. http://www.allbusiness.com/construction/construction-overview/6263709-1.html.

Quantum Consulting. *Commercial Buildings Operations and Maintenance Market Assessment: Market Research Report.* Prepared for the Northwest Energy Efficiency Alliance. Report #06-162. October 27, 2006.

Washington State Building Code Council. *Washington State Energy Code: 2006 Edition. Chapter 51-11 WAC.* Effective July 1, 2007. www.sbcc.wa.gov/docs/codes/WSEC06.pdf.

Welker, Phil and Aleisha Khan. *Commercial Whole Building Performance: the State of Retrocommissioning, New Directions, and Lessons Learned.* Presentation by PECI to CEE in Boston, June 2006.

XEMA-XENERGY Inc. *Assessment of the Commercial Building Stock in the Pacific Northwest: Market Research Report.* Prepared for the Northwest Energy Efficiency Alliance. Report #04-125. March 8, 2004.

2.6 Supplemental Findings: Commissioning Activity by State

Only a brief summary of commissioning market activity by state was presented in Section 2.3.1. More detailed descriptions of market activity in each state are presented here, based on the state liaison interviews and secondary research on state and local policies, LEED activity, other incentives for commissioning, and the availability of commissioning providers.

Washington

As was stated in the 2005 M&T report, Washington appears to be the state with the most commissioning activity among the four states included in this assessment. According to Roger Wigfield of the Washington Department of General Administration, the only change in state policy related to commissioning since the 2005 M&T report (in which commissioning of state new construction was called for in a non-binding agreement) is the adoption of the LEED silver requirement for state-funded buildings. In 2005, the Washington legislature mandated that all new state-funded buildings over 5000 ft^2 be certified as LEED Silver buildings.[37] According to Mr. Wigfield, nearly all projects are going for the extra point for full commissioning, meaning that almost all state-funded new construction is undergoing an extensive commissioning process, something he attributes to "their knowledge of commissioning." Due to the LEED requirement, his department is no longer maintaining the database of commissioned state buildings that was referred to in the 2005 M&T report, and he was unable to provide any hard data on construction of state buildings; however, Summit Blue was able to collect some data on LEED buildings in the state from the US Green Building Council's website (summarized in the next subsection on LEED Activity). The 2005 M&T report indicated that the now-defunct state database of commissioning projects contained 30 commissioning projects and 3 retrocommissioning projects, with an assumed square footage of 60,000 ft^2 per building. These projects—mainly at community colleges—were all completed in the years 2003-2005 and thus are still within the five year "measure life" assumed for energy savings from commissioning projects.

[37] According to the text of the legislation (available at http://www.leg.wa.gov/pub/billinfo/2005-06/Htm/Bills/Senate%20Passed%20Legislature/5509-S.PL.htm), all major renovations of 5000 ft^2 or more in which the cost of the project is greater than 50% of the assessed building value are subject to the LEED Silver requirement as well.

Mr. Wigfield indicated that retrocommissioning is becoming more widespread as building owners become more knowledgeable about retrocommissioning as a diagnostic tool. He said that there has been a widespread perception that seeking out retrocommissioning was akin to "pointing the finger at the operations and maintenance staff" but that attitude is starting to change. Another challenge is finding the funding for retrocommissioning; a building owner may be able to identify what needs to be done through a retrocommissioning project, but not have the money to make the recommended improvements. The state is trying to better integrate retrocommissioning into performance contracting to address this funding challenge.

Mr. Wigfield only deals with state-funded projects and was unable to comment on commissioning activity in the private sector; he commented that commissioning providers themselves are likely the best source of information on private sector activities.(See Summit Blue's analysis of PECI survey of commissioning providers in previous section.)

The Washington State Energy Code requires systems commissioning for mechanical and lighting systems, and requires that a commissioning report be provided to the building owner.[38] However, according to a factsheet prepared by the Washington State University Extension Energy Program in conjunction with NEEA, the level of commissioning required by the state code is minimal and not consistently enforced.[39]

LEED Activity

As of year-end 2006, there are 54 LEED-certified buildings in Washington and 288 LEED-registered projects (meaning that they are seeking LEED certification but are not yet certified).[40] As discussed above, all LEED-certified buildings must undergo fundamental commissioning. The U.S. Green Building Council's website (www.usgbc.org) provides a listing of LEED certified and registered buildings, including data on owner type and square footage. The following table summarizes the LEED-certified floor space in Washington listed in the LEED Projects Directory. State government buildings account for approximately 24% of the total LEED-certified square footage in the state, and local government buildings account for over 29% of the total square footage.

[38] Washington State Building Code Council. *Washington State Energy Code: 2006 Edition. Chapter 51-11 WAC.* Effective July 1, 2007. www.sbcc.wa.gov/docs/codes/WSEC06.pdf.

[39] EnergyIdeas Clearinghouse. *Energy Efficiency Factsheet: Building Commissioning for New Buildings.* Washington State University Extension Energy Program and the Northwest Energy Efficiency Alliance. 2005. www.energyideas.org/documents/factsheets/BuildingCommissioning.pdf.

[40] Cascadia Region Green Building Council. *Making Change in the Built Environment: 2006 Annual Report.* Report available for download at http://www.cascadiagbc.org/about-us/cascadia-2006-annual-report.pdf.

Table 2-11. LEED Certified Buildings in Washington

Owner Type	Existing Buildings (ft^2)	New Construction (ft^2)	Total ft^2
Local Government	327,000	649,630	**976,630**
State Government	323,000	464,315	**787,315**
Federal Government		102,786	**102,786**
Profit Org	365,432	525,601	**891,033**
Non-Profit		382,942	**382,942**
Other		171,489	**171,489**
Total ft^2	**1,015,432**	**2,296,763**	**3,312,195**

Source: http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx

Note: the table includes only those projects registered between January 2003 and April 2007 (the latest data available), and it includes both new construction and existing buildings.

In 2000, the City of Seattle adopted a green building policy requiring that all City-owned projects greater than 5000 ft^2 (new construction or renovation) must achieve a LEED Silver certification. According to the City of Seattle Sustainable Building Program's most recent status report[41], 3% of *all* LEED-registered projects are located in Seattle (including both City-owned, State-owned, and privately owned buildings), representing over 7.9 million square feet of floor space that will be commissioned as part of the LEED process. As of 2005, the City of Seattle had 12 buildings that were either LEED-certified or pending certification. The City of Seattle also provides incentives to private sector companies looking to build LEED buildings ($15,000 for LEED certified, $20,000 for LEED Silver or above); as of 2005, 18 projects representing 1.8 million square feet have participated in this incentive program.

Other Incentives for Commissioning

Mr. Wigfield mentioned that Puget Sound Energy currently offers incentives for commissioning and retrocommissioning through its Custom Grants Program. He also mentioned that Avista Utilities is considering adding an incentive for retrocommissioning.

Availability of Commissioning Professionals

The state of Washington has the most participants in the Building Commissioning Association (BCA) of all the Northwest states: 21 members and 4 BCA-certified commissioning professionals. To become BCA-certified, a commissioning professional has to have been active in the industry for at least three years and pass a two-hour professional exam.

Oregon

According to Andrzej Pekalski of the Oregon Department of Energy, commissioning is still not required by the state's energy code; however, schools receiving public purpose charge funds for energy efficiency

[41] *City of Seattle Sustainable Building Program: 5-Year Report: 2000-2005: Building a Better City.* Available at http://www.seattle.gov/dpd/GreenBuilding/OurProgram/Overview/Programhistory/default.asp#5year.

capital improvements over a certain dollar value are required to retrocommission their buildings.[42] Mr. Pekalski provided a tracking spreadsheet that listed 41 schools thus far which have been retrocommissioned through this requirement, representing 3.3 million square feet of floor space (Table 2-12). Close to 1000 schools have received public purpose funds for energy efficiency projects during the same time period, so the percentage of schools receiving retrocommissioning services is quite small.

Table 2-12. Oregon Schools Receiving Retrocommissioning Services, 2004-2007

Year	# of Schools Retrocommissioned	Total Floor space Retrocommissioned (ft^2)
2004	9	644,414
2005	13	1,174,179
2006	18	1,407,619
2007*	1	47,275
Total	**41**	**3,273,487**
**Note that the apparent decline in the number of schools being retrocommissioned from 2006 to 2007 is the result of delayed reporting, not an actual decrease in project activity.*		

Mr. Pekalski also discussed the State Energy Efficient Design (SEED) program, which requires that all new public state-owned buildings exceed code by 20%. While not commissioning in the strictest sense of the word, an extensive measurement and verification process which includes some elements of commissioning is a requirement for all new state buildings. According to the SEED program manual, the program requires verification that is integrated into the design phase and continues for 18 months after building occupation and involves documenting the design intent, writing a verification plan, and conducting functional testing. This process can be completed by the building owner or a dedicated professional.

Mr. Pekalski was unable to comment on commissioning activities in the commercial sector in Oregon, suggesting that commissioning providers themselves were the best source of data on that topic. (See Summit Blue's analysis of PECI survey of commissioning providers in previous section.)

In terms of future policy changes, Mr. Pekalski stated that he was planning to propose incorporating commissioning into the next energy code, due in 2009, and that he hoped that commissioning providers in the state would work behind the scenes to promote the code change and to increase demand for commissioning in the marketplace.

LEED Activity

While there is no overarching state requirement for commissioning in public buildings, the city of Portland requires that all new city-owned buildings achieve LEED Gold certification (one level higher than the Silver certification required in Seattle), and that all existing city-owned facilities achieve LEED

[42] This requirement is part of Senate Bill 1149, which mandates that 10% of public purpose charge funds collected by Portland General Electric and PacifiCorp must be spent on energy efficiency efforts in public schools in the respective utility service territories. The *Program Guidelines for Implementation of SB1149: Schools: Public Purpose Charges* document states that commissioning or retrocommissioning is required for all HVAC or building automation system capital projects exceeding $50,000, all boiler or chiller capital projects exceeding $100,000, and all other energy-related capital projects over $150,000.

Silver certification.[43] All LEED-certified buildings must undergo a fundamental commissioning process. Portland's LEED requirements for city-owned facilities were adopted in 2001 and strengthened in 2005.

Altogether, there are 38 LEED-certified buildings and 209 LEED-registered projects in the state of Oregon, as of year-end 2006.[44] The following table summarizes the LEED-certified floor space in Oregon listed in the LEED Projects Directory, by owner type and project type. Local government accounts for nearly 51% of all LEED-certified floor space, which is unsurprising given the LEED Gold requirement for city-owned buildings in Portland.

Table 2-13. LEED-Certified Buildings in Oregon

Owner Type	Existing Buildings (ft^2)	New Construction (ft^2)	Total ft^2
Local Government	1,000,000	236,300	**1,236,300**
Profit Org	125,189	482,336	**607,525**
Non-Profit		514,193	**514,193**
Other		72,260	**72,260**
Total ft^2	**1,125,189**	**1,305,089**	**2,430,278**

Source: http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx

Note: the table includes only those projects registered between January 2003 and April 2007 (the latest data available), and it includes both new construction and existing buildings.

Other Incentives for Commissioning

The Oregon Department of Energy offers a Business Energy Tax Credit for sustainable buildings which are built to the LEED Silver certification level *and* undergo additional commissioning beyond the fundamental commissioning required of all LEED buildings.[45]

The Energy Trust of Oregon provides incentives of up to $40,000 per project for commissioning through its New Buildings Program.

Availability of Commissioning Professionals

Among the Northwest states, Oregon is second only to Washington in the number of commissioning professionals active in the Building Commissioning Association, with seven BCA members and three BCA-certified professionals.

Idaho

According to Sue Seifert of the Idaho Department of Water Resources (Energy Division), Idaho still does not require commissioning of public buildings, but considers it a "recommended practice" for state

[43] The LEED requirements are part of the City of Portland's green building resolution. The resolution can be viewed at: http://www.portlandonline.com/osd/index.cfm?c=41701&a=112681.

[44] Cascadia Region Green Building Council. *Making Change in the Built Environment: 2006 Annual Report.* Report available for download at http://www.cascadiagbc.org/about-us/cascadia-2006-annual-report.pdf.

[45] More information on the Business Energy Tax Credit can be found at http://oregon.gov/ENERGY/CONS/BUS/tax/sustain.shmtl.

buildings over 5000 square feet. There is currently proposed legislation (the Energy Efficient State Buildings Act) that would require all new state buildings and major remodels to be designed and constructed to a standard that exceeds the current energy code by at least 30% and to *consider* undergoing enhanced commissioning on a case-by-case basis.[46] Ms. Seifert explained that the word "consider" meant that commissioning would be "strongly recommended" but not required. She stated that the legislators "are focusing on energy efficiency and they know how important commissioning is but they aren't going to put it in as a requirement." However, she also noted that the Division of Public Works, which would administer the program, is pro-commissioning and would likely strongly encourage commissioning to be implemented, regardless of the wording of the legislation. Ms. Seifert also mentioned possible legislation regarding energy efficient school buildings, which would require and pay for fundamental commissioning of the mechanical systems for newly constructed schools. It is unclear when these two pieces of legislation will be brought up for a vote.

In terms of current levels of commissioning in public buildings, Ms. Seifert indicated that the practice was increasing slightly but still not where it should be. Ms. Seifert suggested contacting Tim Mason at the Division of Public Works to get more specifics on commissioning in state-owned buildings. Mr. Mason stated that commissioning of new state buildings was "sporadic at best" and most often on the larger projects that have more sophisticated building systems. His division budgets for commissioning when they believe it's appropriate, but sometimes the client (tenant state agency) decides that commissioning is using funds they'd rather apply elsewhere. He described the likelihood of commissioning actually happening on a state building project as "a function of how robust [the tenant agency's] budget is and whether they believe it's worth the money." He does believe that the awareness of commissioning and its benefits has grown slightly over the past few years.

Mr. Mason said that retrocommissioning is even rarer than commissioning in state buildings, due to lack of budget. He stated, "Once a project is through, getting more funds for the building is pretty difficult." He did indicate that the state does some performance contracting projects that include some level of retro commissioning (testing the functioning of energy-using systems, providing recommendations for better efficiency and controls).

Idaho does not maintain a database of commissioned buildings and neither Ms. Seifert nor Mr. Mason was able to provide a firm estimate of the number or size of commissioning projects in the state.

Mr. Mason also mentioned that his division had opposed legislation that would have mandated LEED certification for state buildings on the grounds that a costly LEED certification does not necessarily mean higher energy efficiency or energy cost savings.

City and County Policies

As mentioned in the 2005 M&T report, the County of Ada adopted a policy in 2003 that all new construction and major retrofit projects for County facilities must incorporate building commissioning into their projects. Ms. Seifert indicated that Ada County has four or five LEED buildings.

[46] This legislation was introduced in February 2007 and was discussed during a meeting of the Energy Interim Committee in October 2007, according to meeting notes available at http://www.legislature.idaho.gov/sessioninfo/2007/Interim/energy1025min.pdf.

LEED Activity

In 2005, the Boise City Council issued a resolution striving to achieve and implement LEED standards in all new construction and remodels of city owned facilities; this appears to be a non-binding resolution. In August 2007, the Boise Climate Protection Program Advisory Committee issued a recommendation that the city require all new municipal buildings be designed to meet LEED Silver standards, with particular emphasis on maximizing energy reduction credits (which would likely include achieving the extra point for full commissioning).[47] It is unclear whether the city has formally adopted the LEED Silver requirement, but the city's Public Works webpage indicated that at least one LEED Silver new construction project (a new library branch) was in the planning stages.

Ms. Seifert indicated that several other cities had already adopted or were considering LEED requirements for municipal building projects, including Caldwell and Nampa.

The following table summarizes the LEED-certified floor space in Idaho by owner type and project type. The majority (63%) of square footage is owned by local governments.

Table 2-14. LEED-Certified Buildings in Idaho

Owner Type	Existing Buildings (ft^2)	New Construction (ft^2)	Total ft^2
Local Government	350,000	9,922	**359,922**
Profit Org	191,512	16,900	**208,412**
Total ft^2	**541,512**	**26,822**	**568,334**

Source: http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx

Note: the table includes only those projects registered between January 2003 and April 2007 (the latest data available), and it includes both new construction and existing buildings.

Availability of Commissioning Professionals

Idaho has two members in the Building Commissioning Association and no BCA-certified professionals. Mr. Mason stated that the Division of Public Works had not had any difficulty finding qualified commissioning providers when they needed them, but qualified that statement with a reminder that "we haven't really been saturating the market" with RFPs for commissioning projects.

Montana

In November 2007, the Governor of Montana announced that a target of reducing state government's energy consumption by 20% by 2010. Georgia Brensdal of the Montana Department of Environmental Quality believes that retrocommissioning will probably play a significant part in meeting that target, but indicated that the plans for meeting the target had not been put together yet. She mentioned that leased buildings are subject to the target as well as state-owned buildings.

Ms. Brensdal believes that commissioning for new state buildings was introduced as a recommended practice two or three years ago and is now the standard practice. However, the state is not doing much new construction. Ms. Brensdal's department deals only with existing state buildings. Over the past five years, the frequency of retrocommissioning has held steady at an average of two buildings per year,

[47] Recommendations available at http://www.cityofboise.org/Departments/Public_Works/PDF/CPPBuildRecommdations2007.pdf.

generally as part of a retrofit or energy study. She mentioned that buildings sometimes receive retrocommissioning to deal with comfort issues or to achieve LEED certification. She thinks that retrocommissioning may be decreasing slightly, possibly due to lack of qualified providers.

Ms. Brensdal also discussed the legislation that allows county and city governments and school districts to enter into energy performance contracts for existing buildings. Participating ESCOs must be pre-qualified by her department, and they made sure that each firm was qualified to provide commissioning services or had a relationship with a commissioning provider as a subcontractor. She indicated that these ESCOs always market their services to include commissioning.

Ms. Brensdal stated that the two major university campuses (University of Montana at Missoula and Montana State University at Bozeman) both had their own retrocommissioning programs and possibly do commissioning on new buildings as well.

LEED Activity

It appears that in Montana, the commissioning requirement is a deterrent to achieving LEED certification. Ms. Brensdal stated that the message about commissioning was not being marketed well enough; people understand more efficient windows and appliances, but they see commissioning as purely "a cost and not a benefit." She offered an anecdote about working with a local non-profit that was interested in LEED, but felt that commissioning was an additional cost that would make it prohibitive to go after LEED certification. The Department of Environmental Quality tried to educate them about the benefits of commissioning that would pay for themselves, but the non-profit could not be convinced. They built an energy-efficient building but did not get commissioning or achieve LEED certification.

A review of the LEED Project Directory shows that Montana has the fewest LEED buildings of the four Northwest states: just four certified buildings and 16 registered projects, as of April 2007. The following table summarizes the LEED-certified floor space in Montana by owner type.

Table 2-15. LEED-Certified Buildings in Montana

Owner Type	New Construction (ft^2)	Total ft^2
Local Government	52,300	**52,300**
Non-Profit	10,160	**10,160**
Profit Org	7,837	**7,837**
Total ft^2	**70,297**	**70,297**

Source: http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx

Note: the table includes only those projects registered between January 2003 and April 2007 (the latest data available). Montana did not have any existing buildings with LEED certification so the table includes only new construction.

Availability of Commissioning Professionals

Montana has no members in the Building Commissioning Association. Ms. Brensdal of the Montana Department of Environmental Quality indicated that there was a limited pool of qualified commissioning providers and that may be affecting the number of projects her department has taken on; she also believed that some of the engineering firms that would be qualified for retrocommissioning are too busy with new construction projects.

3 EVAPORATOR FAN VFDS

In January 1998, NEEA contracted with Cascade Energy Engineering (Cascade) to implement the Evaporator Fan Variable Frequency Drive (VFD) Initiative, which was funded for 6 years until the program's end in January 2004. The initial objective was to make VFDs the industry standard for evaporator fans in all types of refrigerated warehouses in the Northwest, including controlled atmosphere rooms, regular fruit storage, food distribution centers, dairy-milk coolers, food-processor blast cells, and other types of common cold storage. The strategy was to demonstrate to warehouse owners and facility operators the energy-efficiency benefits of VFDs, as well as the non-energy advantages such as reduced mass loss and other positive impacts on product quality. The effort focused on market acceptance and the possible emergence of additional products and service providers. This initiative was considered successful, and an additional objective was added in early 2002 to investigate making VFD ventilation fans standard practice in potato and onion storage facilities.

Previous M&T efforts focused on determining market activity via a "bottom-up" approach in which energy savings from VFD installations were incrementally added as they were reported by Cascade. Research conducted for the 2006 M&T report indicated that the VFD Initiative generated *considerable market effects that* are *not being captured* by Cascade in its reporting. As a result, the M&T effort for 2007 focused on determining the market penetration of VFDs on evaporator fans in the Northwest using a representative survey of cold storage facilities that could be extrapolated to all cold storage facilities in the region. This "top-down" approach is designed to capture VFD installations region-wide, including those occurring without the knowledge of Cascade.

3.1 Assumptions and Indicators for Review

The gross energy savings impact of the VFD Initiative is based on the total evaporator fan capacity (horsepower) in cold storage facilities in the Northwest, the market penetration of VFDs on these evaporator fans, and an estimate of the annual energy savings per unit horsepower.

Specifically, the gross annual energy savings can be calculated as:

Electricity Savings (kWh/year) =

(2) Total evaporator fan capacity in cold storage facilities in the Northwest (HP)

x (2) Market penetration of VFDs on evaporator fans (%)

x (3) Annual energy savings per unit horsepower (kWh/HP)

where:

Total evaporator fan capacity in cold storage facilities in the Northwest (HP) has been estimated using a conversion factor of HP per cubic foot of refrigerated volume. The total refrigerated volume came from the USDA report, Capacity of Refrigerated Warehouses, 2007 Summary.[48]

[48] USDA, *Capacity of Refrigerated Warehouses: 2007 Summary*, January 2008.

Market penetration of VFDs on evaporator fans (%) has been estimated by analyzing the results of interviews with cold storage facility operators in the Northwest. Getting a better estimate of this key indicator was the primary focus of this year's M&T efforts.

Annual energy savings per unit horsepower (kWh/HP) has been assumed to be 3,500 kWh per horsepower for regular storage and 2,400 kWh per horsepower for controlled atmosphere storage, based on information from Cascade Engineering field trials cited in MPER-3.[49]

One special type of cold storage is "controlled atmosphere" storage, in which the composition of the atmosphere in the storage room is controlled to reduce fruit spoilage. According to MPER-3, VFDs installed on evaporator fans in controlled atmosphere rooms will achieve different savings than the same measure in common cold storage rooms (refrigerated only) because of different cooling requirements for long-term fruit storage. As a result, each of the previous three inputs to the savings calculation must be disaggregated by storage type (controlled atmosphere or refrigerated only).

3.2 Methodology

Previous M&T efforts suggested that the baseline and per-unit savings assumptions used by NEEA are reasonable, even conservative. However, the bottom-up approach to determining regional market penetration of VFDs using only data from Cascade likely does not capture a significant portion of the VFDs installed in the region. As a result, data collection for the 2007 M&T effort focused exclusively on providing a better estimate of VFD market penetration by surveying cold storage facility operators in the Northwest. This survey effort included the following major activities:

1. Defining the population and compiling a database of cold storage facilities in the Northwest;
2. Constructing a representative sample, including both controlled atmosphere and refrigerated only cold storage facilities;
3. Administering a short survey instrument to meet the M&T research objectives;
4. Compiling survey results, especially the share of facilities and cold storage space using VFDs on evaporator fans, and extrapolating results to the population of cold storage facilities.

The remainder of this methodology section describes the population, development of the sample, and content of the survey instrument. Survey results and extrapolation methods are discussed in the Findings in Section 3.3.

3.2.1 Defining the Population and Developing a Sample

The population of units for this study is defined as all of the cold storage facilities in Idaho, Montana, Oregon, and Washington. The United States Department of Agriculture (USDA) compiles a biennial census of refrigerated warehouses throughout the United States. The data is split into two major sectors:

[49] Per unit savings data was obtained from MPER-3: Pacific Energy Associates, Inc. and MetaResources Group, *Evaporator Fan VFD Market Tranformation Initiative: Market Progress Evaluation Report #3*, prepared for Northwest Energy Efficiency Alliance, 2002. The 2006 M&T report confirmed that these figures are still appropriate.

1) apple and pear storage, collectively known as "fruit storage" and 2) general cold storage.[50] The first sector, fruit storage, is further divided into *controlled atmosphere (CA)* rooms and *refrigerated-only (regular)* fruit storage rooms.[51] The second major sector, the general cold storages, are divided into *public general storages* and *private/semi-private general storages*.[52,53] All of the fruit storage facilities are private, while all of the general cold storages are refrigerated only (*i.e.*, there are no CA rooms in the general cold storages sector).

The USDA report specifies the storage volume and number of facilities for each of these divisions by state. The contents of the USDA report are presented in Table 3-1 and used in this M&T work as indicative of the characteristics and size of the population of cold storages in the Northwest.[54]

Table 3-1: Cold Storage Volume in the Northwest (million cubic feet)

State	General Cold Storage			Fruit Storage			Total All Cold Storage
	Public	***Private***	***Total***	***Regular***	***CA***	***Total***	
Idaho	36.6	24.4	61.0	2.3	2.2	4.5	***65.5***
Montana	*	*	1	0	0	0	***1***
Oregon	68.9	35.6	105	37.0	17.8	54.8	***159.8***
Washington	142.1	48.6	190.7	130.2	350.3	480.5	***671.2***
Total	**247.6**	**109.1**	**357.7**	**169.5**	**370.3**	**539.8**	**897.5**

* Not published to avoid disclosure of individual operations. Included in totals.

Source: USDA, National Agricultural Statistics Service, Capacity of Refrigerated Warehouses, 2007 Summary, January 2008

Summit Blue collected contact information from a variety of sources for 290 unique facilities. The sample frame consisted of cold storage facilities in the Northwest for which contact information was available, and Summit Blue stratified the sample by state and facility type. A sample size of 30 was selected as large enough to provide reasonable statistical precision (see Section 3.3.1) while keeping within the allotted M&T budget. With a target sample size of 30 facilities, the proportional number of desired sample facilities in each state/facility-type division, rounded to whole numbers, is shown in Table 3-2. More details on identifying the population and selecting a sample are presented in Section 3.6.1 as a supplement to this M&T assessment.

[50] USDA, *Capacity of Refrigerated Warehouses: 2007 Summary*, January 2008.

[51] In general, the controlled atmosphere rooms are used as long-term storage, while the refrigerated only fruit storage rooms are used while the fruit is being transitioned from the field to long-term storage.

[52] Public general storages are defined as "refrigerated facilities maintained for others at specified rates [prices] per unit." Private/semi-private general storages are defined as "refrigerated facilities maintained by an operator to facilitate his principal function as a producer, processor, or manufacturer of food products. The space is used to store the owner's products, although some space may be used by others at specified rates per unit stored."

[53] For ease of reading, the *private/semi-private general storages* will be referred to throughout this document as *private*.

[54] Total cold storage of 897.5 million cubic feet corresponds to 92,625 horsepower based on the conversion rates presented in Table 3-7. This implies a conversion ratio of approximately 103 hp/ft^3. This value is used in the baseline calculation in Section 3.3.2.

Table 3-2: Target Sample Sizes by State and Facility Type

State	Public General Refrigerated Storage	Private General Refrigerated Storage	Private Fruit Refrigerated and CA Storage	Total All Cold Storage
Idaho	1	1	0	***2***
Montana	0	0	0	***0***
Oregon	2	1	2	***5***
Washington	5	2	16	***23***
Total	**8**	**4**	**18**	**30**
Source: Summit Blue analysis based on cold storage facility data in Table 3-1				

3.2.2 Constructing the Survey Instrument

The survey instrument was intended to capture both quantitative and qualitative information from cold storage facility operators. The *quantitative goal* of the survey was to determine the proportion of the cold storage capacity in the Northwest that is currently using evaporator fan VFDs, disaggregated by controlled atmosphere versus refrigerated only cold storage. Although the key indicator for market activity is total evaporator fan capacity (hp) controlled by VFDs, the survey and subsequent analysis was necessarily focused on storage volume, which is the only related metric that could actually be tracked. To this end, questions were asked about the capacity (volume) of each storage type and the proportion of each storage type that was served with evaporator fan VFDs. The survey instrument can be found in the Supplement to this assessment in Section 3.6.2.

The *qualitative objective* of the survey was to get thoughts and opinions from facility operators about what drove the change to evaporator fan VFDs. What were their views on installation of VFDs in new construction? What had been the reason for retrofitting their evaporator fans with VFDs if they used them currently? If they only used VFDs on some evaporator fans, what made them choose some fans and not others? In this mode, the survey instrument was intended to function as a vehicle to facilitate a candid discussion of the decision-making process for installing new evaporator fan VFDs. This discussion served to provide further insight into market penetration, what companies are thinking, and what barriers and incentives drive their decisions.

3.3 Findings

3.3.1 Market Activity

Quantitative Market Penetration Survey Results

The results of the market penetration survey show variation across the market, with a majority of facilities indicating use of evaporator fan VFDs. Eighteen out of thirty (60%) of the facility operators surveyed have VFDs installed on at least some of their evaporator fans. Of the 18 operators of fruit storage facilities that were interviewed, nearly three-quarters (72%) had at least some VFDs installed.

Table 3-3 shows the breakout by sector of facility operators reporting evaporator fan VFDs in at least some of their cold storage facilities.

Table 3-3: Facility Operators with At Least Some Evaporator Fan VFDs (from Survey)

Facility and Storage Type*	Total Cold Storage Facilities in Sample	Facilities in Sample With At Least Some VFDs	Percent of Facilities With At Least Some VFDs
Public General Refrigerated Storage	8	4	50%
Private General Refrigerated Storage	4	1	25%
Private Fruit Refrigerated**	18	13	72%
Private Fruit CA Storage**			
Total All Cold Storages	**30**	**18**	**60%**

* This table reports survey results for each facility/storage type. However, conclusions about market activity are made only at an aggregated level across these sub-samples (see Table 3-5). For purposes of estimating energy savings, market activity is aggregated into "refrigerated storage" and "CA storage."

** See Section 3.6.1 for supplemental discussion on how the sample was selected and, in particular, why the sample for private fruit storage is a combination of both refrigerated and CA storage.

Source: Summit Blue cold storage survey

The M&T project team also asked the interview respondents to estimate the total volume of their cold storage space for which evaporator fans were controlled by VFDs. Exactly half of the cold storage volume represented in the survey sample was served by evaporator fan VFDs. This result was not evenly distributed by storage type, however, as 69% of the CA storage volume was served by evaporator fan VFDs as compared to not more than 40% in any of the refrigerated-only storage categories. Table 3-4 shows the breakdown of cold storage volume served by evaporator fan VFDs as reported by the surveyed facility operators.

Table 3-4: Volume of Cold Storage with and without VFDs (from Survey)

	Millions of Cubic Feet		
Facility and Storage Type*	**Total Cold Storage Volume in Sample**	**Sample Volume Controlled by VFDs**	**Percent of Volume Controlled by VFDs**
Public General Refrigerated Storage	54.4	21.3	39%
Private General Refrigerated Storage	4.5	1.5	33%
Private Fruit Refrigerated Storage	7.2	1.3	18%
Private Fruit CA Storage	47.1	32.5	69%
Total All Cold Storages	**113.2**	**56.6**	**50%**

* This table reports survey results for each facility/storage type. However, conclusions about market activity are made only at an aggregated level across these sub-samples (see Table 3-5). For purposes of estimating energy savings, market activity is aggregated into "refrigerated storage" and "CA storage."

Source: Summit Blue cold storage survey

Extrapolating Survey Results to the Population

The sample of 30 facilities accounts for 13% of the total population volume and is sufficient to draw conclusions about the use of VFDs in cold storage facilities in the Northwest. Although the strata sample sizes may be insufficient to reliably disaggregate findings by state or facility type, the strata-specific results for facility type can be weighted and used in estimating the region-wide market activity, as measured by the *volume of cold storage facilities using VFDs* on evaporation fans.

Two strata-weighting approaches were utilized for the analysis of market penetration, one based on the *share of respondents* who used VFDs and another based on the *share of the volume* of respondents' facilities for which VFDs are used. The respondent-based approach weights each response evenly and does not account for differences in the volume of the facilities surveyed. This approach is appropriate since the population data did not include volumes for individual facilities, and the facility types could not be stratified by size.

Conversely, the volume-based approach weights the results from larger facilities proportionally more than the results from smaller facilities. In a large sample, extrapolation based on volume is generally preferred since a facility's storage volume is directly related to its energy consumption. However, stratum sample sizes for the individual facility types were relatively small, and several large facilities selected at random could skew the results. Furthermore, within the fruit storage market sector, many of the surveyed facility operators reported using VFDs with some of their evaporator fans but not necessarily all of them. Therefore, a volume-based approach to calculating market penetration of VFDs within the sample likely provides the most accurate assessment of the market.

Given the competing attributes of each extrapolation method, the volume of facilities controlled by VFDs in the Northwest was estimated using both methods (Table 3-5). Based on weighting by the count of respondent using VFDs, 60% of all cold storage capacity in the Northwest (541 million cubic feet) uses VFDs on evaporator fans. Weighting by volume of facilities using VFDs results in a market share estimate of 47%, or 418 million cubic feet.

Table 3-5: Extrapolation of Survey Results

Facility and Storage Type	Cold Storage Volume in the Northwest (*millions of cubic feet)* **(A)**	Extrapolation by Respondent Count		Extrapolation by Facility Volume	
		Share of Survey Respondents Using VFDs (B)	**Cold Storage Volume Controlled by VFDs** (mcf) **(A * B)**	**Share of Sample Facility Volume Controlled by VFDs (C)**	**Cold Storage Volume Controlled By VFDs** (mcf) **(A * C)**
Public General Refrigerated Storage	247.6	50%	123.8	39%	97.0
Private General Refrigerated Storage	109.1	25%	27.3	33%	36.0
Private Fruit Refrigerated Storage	169.5	72%	122.4	18%	29.9
Private Fruit CA Storage	370.5	72%	267.5	69%	255.4
Total All Cold Storage*	**896.5**	**60%**	**541**	**47%**	**418**

* Precision of total results is within 13% of cold storage volume in the Northwest at a 90% level of confidence.

Source: USDA and Summit Blue analysis of cold storage survey data

The two extrapolation methods provide a market penetration estimate of between 47% and 60%, with the volume-based approach the lower, more conservative value (Table 3-6). This approach is adopted in the subsequent analysis below, with the exception that extrapolation for the Private General Refrigerated Storage facility category is based on respondent count. In this particular sample stratum, volume data was not available for every facility surveyed and only one respondent reported any volume controlled by VFDs. Therefore, extrapolation based on respondent count was deemed the more appropriate approach. This modification lowered the overall market share estimate from 47% to 46%, or 410 million cubic feet.

MPER-3 estimated the evaporator fan VFD market penetration in 2001 to be only 18% in controlled atmosphere storage and 43% in general refrigerated storage (not including fruit storage). The results of this M&T analysis indicate a 69% market penetration in controlled atmosphere storage and a 35% market penetration in general refrigerated storage. This suggests a significant increase in the market penetration of evaporator fan VFDs over the past six years for CA storage and a modest, although only marginally statistically significant, drop in VFD use for general refrigerated storage.

Table 3-6: Total Cold Storage Volume with Evaporator Fan VFDs (million cubic feet)

Facility and Storage Type	Extrapolation Method	Total Cold Storage Volume in the Northwest	Percent of Market Sector Controlled by VFDs	Cold Storage Volume Controlled By VFDs
Public General Refrigerated Storage	Facility Volume	247.6	39%	97.0
Private General Refrigerated Storage	Respondent Count*	109.1	25%	27.3
*Subtotal General Refrig. Storage***	*NA*	*356.7*	*35%*	*124.3*
Private Fruit Refrigerated Storage	Facility Volume	169.5	18%	29.9
Private Fruit CA Storage	Facility Volume	370.3	69%	255.4
Total All Cold Storage* **		**896.5**	**46%**	**410**

* In this particular sample stratum, volume data was not available for every facility surveyed and only one respondent reported any volume controlled by VFDs. Therefore, extrapolation based on respondent count was deemed the more appropriate approach.

** "General refrigerated storage" is subtotaled in order to facilitate the linkage of data from Table 3-6 to Table 3-7.

*** Precision of total results is within 13% of cold storage volume in the Northwest at a 90% level of confidence.

Source: Summit Blue analysis of cold storage survey data and USDA

The conversion from cubic feet of cold storage *volume* to the key indicator of *horsepower of evaporator fan capacity* controlled by VFDs yields a total of 45,130 hp across all market sectors (Table 3-7). The conversion from volume to evaporator fan capacity for each facility/storage type requires disaggregation to account for different storage temperatures and usage patterns. Specifically, General Refrigerated Storage (both public and private) was disaggregated into cooler space and freezer space, while the two fruit storage categories (refrigerated and CA) remained distinct. Additionally, the results in Table 3-7 have been aggregated by storage type (refrigerated-only versus controlled atmosphere) in order to facilitate the energy savings calculation as described previously in Section 3.1 and used below in the Conclusions and Recommendations, Section 3.4.

Table 3-7: Horsepower of Evaporator Fans Controlled by VFDs in the Northwest

Facility and Storage Type	*Volume Controlled By VFDs (million cubic feet) [A]*	*Connected Load Per Unit Volume* (kW/ft^3) [B]*	*Universal Constant Conversion Factor (hp/kW) [C]*	*Evaporator Fan Capacity Controlled by VFDs (hp) A*B*C=D*
Refrigerated-Only Storage				
General Refrigerated Storage – Cooler Space**	9.3	0.0000293	1.34	366
General Refrigerated Storage – Freezer Space**	115.0	0.0000459		7,068
Subtotal General Refrig. Storage	*124.3*			*7,434*
Fruit Refrigerated-Only Storage	29.9	0.0000986		3,954
Subtotal Refrigerated Only Storage	***154.2***	***NA***	***NA***	***11,388***
Controlled Atmosphere Storage				
Private Fruit CA Storages	255.4	0.0000986	1.34	33,742
Subtotal Controlled Atmosphere Storage	*255.4*	***NA***	***NA***	*33,742*
Total All Cold Storage	**409.6**	Implied 110 hp/ft^3		**45,130**

* Estimates for the connected load of evaporator fans required per unit volume of storage capacity are based on analysis conducted by Cascade Energy Engineering and provided as part of Cascade's original proposal to NEEA. As reported in the 2007 M&T report, Cascade's Marcus Wilcox confirmed that the conversion factors from cubic feet to horsepower presented here are still appropriate.

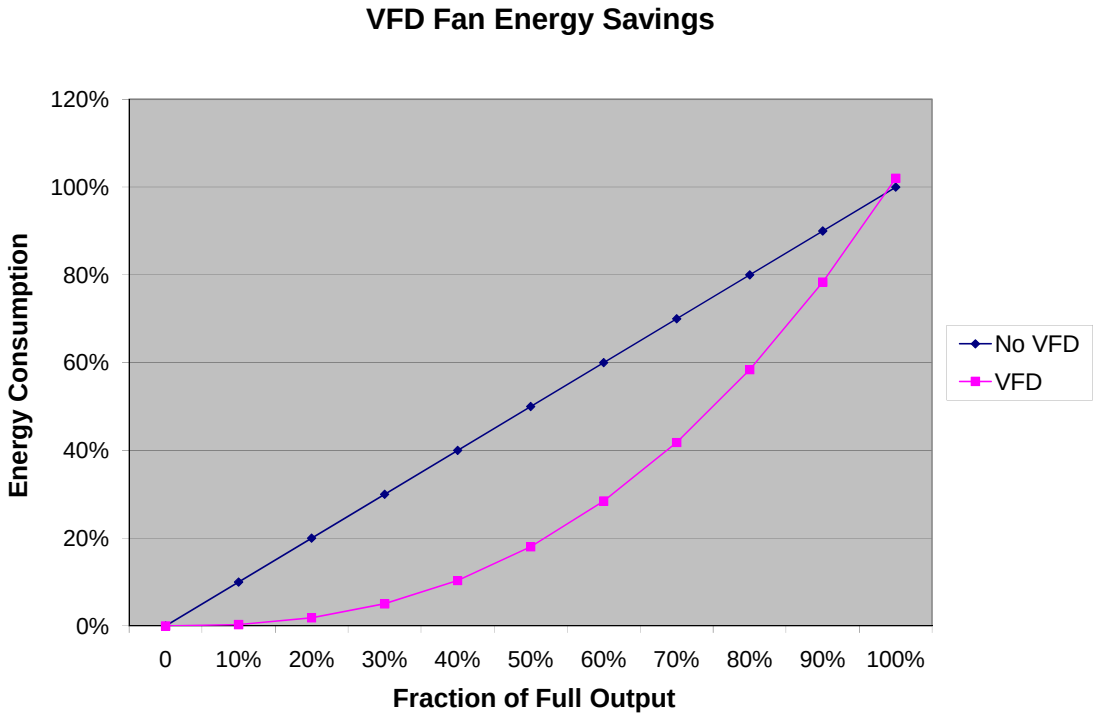
** Cooler and Freezer gross volume is derived from Cooler/Freezer split for Oregon and Washington Public and Private storages, as reported in 2007 USDA Capacity of Refrigerated Warehouses report. Summit Blue's analysis indicates that general refrigerated storage consists of 8 % cooler storage and 92% freezer storage.

Sources: Cascade Energy Engineering, USDA, and Summit Blue analysis of cold storage survey data

Technical Barriers to Evaporator Fan VFD Applications

Interviewees identified a number of technical barriers that prevent them from using VFDs in some cases. On a purely technical level, variable frequency drives save energy on evaporator fans by running the fans at partial speed when only partial capacity is required. Energy consumption of a fan is approximately proportional to the cube of flow rate, so a fan running at half speed may theoretically use as little as $1/8^{th}$ of the energy of a fan running at full speed. The best applications for VFDs occur when the typical load on the system is significantly lower than the peak load on the system, but still above zero, as shown in Figure 3-1. The largest savings occur in the middle of the operating range. In cold storage applications, the sizing of the fans is critical for determining when VFDs will make the most economic sense. If the fans are sized to give a high peak capacity to quickly cool the contents, they are good candidates for using VFDs. If, on the other hand, the system only has enough fan capacity to meet the base loads and the fans are required to run at full load all the time, then a VFD will save little, if any, energy. Multiple interview respondents reported that they have implemented VFDs on their higher capacity fans, while leaving them off some older systems that don't have enough fan capacity. In some systems that have a winter load that is only a few percent of the peak load, turning off most of the fans saves almost as much energy as using VFDs.

Figure 3-1: VFD Savings for Different System Applications



Additional technical barriers to the installation of VFDs on evaporator fans in cold storage applications include:

- **Existing motor size.** Because smaller VFDs have much higher cost per horsepower of capacity than larger VFDs, the size of the existing evaporator fan motors can be a barrier. If a facility utilizes many small evaporator fan motors, it will require more VFDs at a higher total cost than if the facility had fewer large evaporator fan motors.

- **Inadequate air flow.** One fruit storage engineer stated that while two of the facilities the company had recently purchased were equipped with VFDs on their controlled atmosphere evaporator fans, the facility managers had decided not to use them. Their reasoning was that they had inadequate airflow over part of the room when running at low speed, which they felt led to microbial growth in that area of the room and early spoilage, resulting in lost revenue. The opinion was echoed by other interview respondents as well.

Finally, several interview respondents seemed to base their opinions of evaporator fan VFDs on either incorrect information or outdated experience. For example, the fruit storage engineer quoted above as not using VFDs because of inadequate airflow also cited a study claiming just 3% energy savings from evaporator fan VFDs. Another respondent reported that his company had used evaporator fan VFDs "a long time ago, probably in the 80s" and had terrible maintenance problems with electronic components failing. While these problems may have existed at one time in the past, or in certain applications of VFDs, they are not likely to be relevant in properly designed cold storage applications. The operator with

"terrible maintenance programs" will again consider using VFDs on his evaporator fans because of positive recent experience with condenser fan VFDs.

Non-Energy Influences on Use of Evaporator Fan VFDs

Within the current market, there are some distinctions to be made that may help identify where the market is headed. Different sectors of the market may have different benefits and costs associated with the use of variable frequency drives, and energy saving are not the lone factor affecting adoption of the technology. The following non-energy factors were identified through conversations with members of the Northwest cold storage industry.

- **Improved fruit quality with VFDs.** VFDs produce additional benefits for many controlled atmosphere rooms, with the largest benefit being reduced mass loss of fruit. Mass loss refers to the process whereby fruit gradually loses moisture and dries out. Mass loss results in a lower quality grade of fruit and ultimately a lower price paid for the fruit. As a result, there is additional incentive for CA room operators to implement evaporator fan VFDs. Evaporator fan VFDs are much more common in CA rooms than in refrigerated-only rooms of fruit storage facilities, although the latter may also benefit from reduced mass loss. Many fruit storage operators referred to reduced "shrivel" (*i.e.*, mass loss) as a major reason for switching to evaporator fan VFDs.

- **Ownership and operation of the cold storage facility**. The problem of split incentives[55] for energy saving measures shows up in cold storage just as it shows up in any leased building where the owner pays for equipment and the lessee pays the electricity bills. In addition, there may be a separate issue of local equipment decision-making vs. remote equipment decision-making. Some of the facility operators indicated that if the decision was made to install evaporator fan VFDs, it would come down from the national corporate office. These corporate decision-makers are less likely to be influenced by regional market changes and more likely to be influenced by national market changes.

- **Facility age and size**. Newer facilities are more likely to have included VFDs at the time of construction, which is more cost effective than retrofitting VFDs into existing facilities. Many operators reported that they add VFDs as they add new capacity. Larger facilities are more likely to have a dedicated refrigeration engineer on staff who may have more time to learn about the latest refrigeration equipment. It appeared that firms with dedicated engineers were more likely to have undertaken energy efficiency projects, including VFD retrofits.

- **Different rate structures and utility incentive programs**. The unique utility landscape in the Northwest has a high degree of variability in rate structures and incentive programs. Many facilities with evaporator fan VFDs reported rate structures or utility incentives as an important influence on their decision to install evaporator fan VFDs.

In spite of the various technical and market barriers to evaporator fan VFDs, facility operators indicated that the use of VFDs in the market is growing, especially in new construction. The majority of public and

[55] In a split incentive situation, the person who makes energy efficient equipment upgrade decisions (typically the owner) does not receive any of the direct benefits, which go to the person paying the energy bills (the lessee). Some of the people who were interviewed indicated that their firm was only leasing the space and we needed to talk to the owner, because they were in charge of the evaporator fans. Another person indicated that they were leasing warehouse space, and as such would not pay for any energy efficiency upgrades when it was uncertain that they would be remaining in the space and getting the benefits of the upgrades.

fruit storage facility managers said they would definitely use VFDs in all new capacity additions. Some of the respondents also indicated that they were either in the process of retrofitting existing evaporator fans to use VFDs or that they were considering a VFD retrofit of existing evaporator fans. Only two interviewees expressed an unfavorable opinion of evaporator fan VFDs, and both of these referred to problems with dead air in the storage bins. While there are still plenty of facilities that lack VFDs on evaporator fans, it appears that VFD penetration will continue to increase in the near term, especially if utilities continue to offer incentives for their installation.

3.3.2 Baseline Activity

Adoption of VFDs for evaporator fans was assumed to be slow due to several market barriers, including the following:[56]

- Lack of information to evaluate the return on investment from the installation of evaporator fan VFDs;
- Uncertainty regarding the impact on fruit quality in warehouses where fruit is stored;
- Uncertainty regarding adequate air flow distribution in large refrigerated rooms;
- Fear of evaporator fan motor burnout induced by VFDs;
- The generally conservative nature of facility owners.

The initial estimates of baseline activity were provided by Cascade in the early phases of the VFD Initiative and were based on Cascade's significant involvement in industrial refrigeration activities. Any growth beyond these initial estimates is assumed to be a result of NEEA's initiative.

Cascade and NEEA together estimated the evaporator fan VFD capacity (in horsepower) already in place at the start of the project in 1998 at approximately 9% of the total market, and they further estimated the size of the market and the amount of VFD capacity that was added to the baseline in 1999, 2000, and 2001. In order to correspond with the current NEEA ACE model, these horsepower values for 1998 through 2001 have been converted to cubic feet using the conversion factor for evaporator fans *equipped with VFDs* of 110 hp/ft^3 from Table 3-7.

Starting in 2002, the *incremental* evaporator fan VFD capacity due to baseline activity was assumed to grow at 1.5% per year until 2010.[57] This is assumed to imply that the baseline *measured in cubic feet* and presented *as a share of the market* grows at 1.5% per year. The market size in 1998 was 76,096 horsepower or 737 million cubic feet (mcf), growing to 771 mcf by 2001.[58] Thus, the 11.8% baseline in 2001 (baseline VFD usage in mcf as a share of the total volume used for evaporator fans at cold storage facilities) would increase to 13.3% in 2002, 14.8% in 2003, and so on. By 2007, the baseline is assumed to be 20.8% of the 898 mcf market for evaporator fans, or roughly 187 mcf (Table 3-8). This corresponds to 20,573 horsepower.

---

[56] Macro International, Inc., Market Baseline Evaluation Report: Evaporator Fan VFD Initiative (Executive Summary), April 1999.

[57] Northwest Energy Efficiency Alliance, "Evaporator Fan VFD: Cost-Effectiveness Analysis Key Assumptions – Converted," January 26, 2005.

[58] See NEEA assumptions from source referenced in Footnote 57. Conversion from horsepower to volume for evaporator fans in the market (regardless of whether they are equipped with VFDs) was based on the implied conversion factor of 103 hp/ft^3 from the market data in Table 3-1, as explained in Footnote 54.

Table 3-8. Baseline Use of VFDs in the Northwest

	Baseline VFD Usage (hp)	**Conversion** (hp/mcf)	**Baseline VFD usage** (mcf)	**Total Market** of Evap Fans (mcf)	**Baseline VFD Usage** as Share of Market Volume (%)
1998	**6,557**	110	60	737	8.1%
1999	**7,468**	110	68	748	9.1%
2000	**8,904**	110	81	760	10.6%
2001	**10,028**	110	91	771	11.8%
2002	11,611	110	105	792	13.3%
2003	13,264	110	120	813	14.8%
2004	14,987	110	136	834	16.3%
2005	16,779	110	152	855	17.8%
2006	18,641	110	169	876	19.3%
2007	20,573	110	187	898	20.8%

Source: 1998 through 2001 baseline horsepower estimates and total market data are from NEEA and Cascade Energy Engineering, using conversion factors discussed in the text above. Baseline VFD usage as a share of the total market are calculated directly from the table through 2001 and increased nominally by 1.5% per year from 2002 through 2007.

The baseline value of 20,573 horsepower of VFD fan capacity was then apportioned into baseline values for refrigerated-only storage and CA storage according to the 2007 market activity (see Table 3-7), as shown below in Table 3-9. The baseline values for refrigerated-only storage and CA storage are used individually in the conclusions section of this assessment to estimate the implied energy savings (see Section 3.4).

Table 3-9. 2007 Baseline Activity by Storage Type

Storage Type	**2007 VFD Market Activity (hp)** **[A]**	**2007 Share of Market Activity** **[B = A / A_{total}]**	**2007 Baseline Evaporator Fan VFDs (hp)** **[C]**	**2007 Baseline Evaporator Fan VFDs (hp)** **[B * C]**
Refrigerated-Only	11,388	25%	20,573	5,191
Controlled Atmosphere	33,742	75%		15,382
Total	**45,130**	**100%**	**20,573**	**20,573**

Source: Summit Blue cold storage survey; NEEA; Cascade Energy Engineering

As noted in Section 3.2, a review of the baseline assumptions was not a focus of the 2007 M&T effort for the VFD Initiative. Previous M&T efforts have demonstrated that the ACE model assumptions regarding baseline activity are reasonable, even conservative. None of the information gathered from the surveys contradicts these assumptions, although the increase in market activity suggests that a review of the baseline assumptions may be warranted in future M&T assessments.

3.3.3 Per-Unit Energy Savings

The current per-unit savings assumption is that refrigerated-only cold storage savings are 3,500 kWh per horsepower of evaporator fan VFD capacity, while controlled atmosphere cold storage savings are 2,400 kWh per horsepower of evaporator fan VFD capacity. These values are based on research conducted by Cascade across a multitude of projects. Previous M&T efforts have demonstrated that these assumptions are reasonable and still applicable. Although a review of the per-unit savings assumptions was not a focus of the 2007 M&T effort, future efforts may revisit this assumption if new data become available.

3.4 Conclusions/Recommendations

Thirty cold storage operators were interviewed across the four states in the Northwest. Based on the results of the surveys, it is estimated that almost half (46%) of the existing cold storage volume in the Northwest uses evaporator fan VFDs. The interviews also revealed anecdotal information about the market for evaporator fan VFDs in the Northwest. The major conclusions of this work were as follows:

1. **More than two-thirds (69%) of the 370 million cubic feet of controlled atmosphere storage uses VFDs to control the evaporator fans, while nearly one-third (29%) of the 526 million cubic feet of refrigerated-only cold storage in the Northwest uses VFDs.** This represents a significant increase in market penetration in CA facilities over the estimates made in MPER-3 in 2002. The survey results showed that evaporator fan VFDs are used across different states and sectors and throughout the Northwest. There appear to be anecdotal differences depending on size of the facility (small facilities were less likely to have implemented VFDs), ownership situation (leased or nationwide corporate facilities were less likely to have VFDs), and the age of the facility (newer facilities were more likely have implemented VFDs).

2. **VFDs control a total of approximately 45,000 hp of evaporator fan capacity in cold storages in the Northwest, with nearly 34,000 hp (75%) of this capacity in controlled atmosphere cold storage and the remaining 11,000 hp (25%) in refrigerated-only cold storage.** The total evaporator fan VFD capacity as determined by the facility operator interviews is within 10% of the 50,000 hp predicted for 2007 by the original ACE model in 1998.

3. **Nearly all cold storage operators interviewed hold favorable opinions of evaporator fan VFD technology**. Most of the interviewees indicated that they would be using VFDs in all future capacity expansions. Some of the respondents also indicated that they were either in the process of retrofitting existing evaporator fans to use VFDs or that they were considering a VFD retrofit of existing evaporator fans. Only two interviewees expressed an unfavorable opinion of evaporator fan VFDs. Both of them alluded to problems with “dead air” within fruit storage bins.

4. **VFDs are not well-suited for all evaporator fans.** Some respondents indicated that they had installed VFDs wherever it made sense, leaving VFDs off of undersized evaporator fans and small evaporator fans.

5. **Utility incentives play a significant role in convincing companies to install evaporator fan VFDs.** Eight of the 18 surveyed facilities with evaporator fan VFDs indicated that utility incentives had played a significant role in their decision to install evaporator fan VFDs.

Table 3-10 summarizes **recommendations for the values of key indicators** compared to those used by NEEA in 2006, where applicable. Since NEEA tracks savings based on kWh savings as reported by Cascade Energy Engineering, a comparison of VFD horsepower capacity would require assumptions

regarding the mix of facility types in Cascade's findings. As a result comparisons are made only for energy savings not for market activity. The per-unit energy savings remains unchanged. However, the implied energy savings for activity through 2007 are more than 50% greater than the cumulative savings reported by NEEA in 2006, increasing from 4.8 aMW to 7.5 aMW. The increase is likely due to the reach of the cold storage survey into areas of market activity that previous analyses were not able to quantify.

Table 3-10: M&T Recommendations for Key Indicators

Key Indicators Reviewed	NEEA 2006 Values*	2007 Recommended Values	Source
Market Activity (Evaporator fan VFD capacity)			
Refrigerated-only storage (hp)	*NA*	11,388	Summit Blue cold storage survey; see Table 3-7
CA storage (hp)		33,742	
Total Market Activity (hp)		*45,130*	
Baseline Activity			
Refrigerated-only storage (hp)	*NA*	5,191	See Section 3.3.2
CA storage (hp)		15,382	
Total Baseline Activity (hp)		*20,573*	
Per-Unit Energy Savings			
Refrigerated-only storage (kWh/hp)	3,500	3,500	2006 M&T Report and Cascade
CA storage (kWh/hp)	2,400	2,400	
Implied Energy Savings**			
Refrigerated-only storage (aMW)	NA	2.5	ACE Model, see Section 2; aMW = MWh divided by 8760 hours
CA storage (aMW)	NA	5.0	
Total Implied Energy Savings (aMW)	*4.8*	*7.5*	

* NEEA 2006 values were obtained or derived from the Excel file "2006 MAR Cumulative Savings 04-03-07.xls" and the latest ACE model. Since NEEA tracks savings based on kWh savings, comparisons are made only for energy savings not for market activity.

** Implied energy savings are net of baseline activity and are presented for comparison purposes only between NEEA's 2006 values and the 2007 M&T findings. NEEA's reported values may not match those presented here since NEEA adjusts for the effect of utility incentives and other factors not taken into account in this M&T analysis.

Summit Blue recommends the following for future M&T work:

1. **Expand the sample size for future surveys, but conduct this work only once every four years.** Although this research uncovered anecdotal evidence of different market conditions among the various segments, a larger sample would allow for better identification of differences in market penetration across different market segments and would lend additional support for the finding that market activity is increasing. Because of the resource-intensive nature of completing interviews in this market sector, however, Summit Blue recommends completing this task only once every four years in order to get the maximum utility from a limited M&T budget.

2. **Revisit the baseline and per-unit savings assumptions every two years.** Although prior M&T work confirmed that the baseline and per-unit savings values are still applicable, the growth in market activity raises the prospect that influences beyond the NEEA initiative may be affecting

adoption of VFDs. Higher market activity also increases the importance of ensuring well-documented energy savings assumptions.

3.5 Bibliography

International Association of Refrigerated Warehouses, Directory of Public Warehouses, http://www.iarw.org/directory/

Interview with Andy Ekman, Northwest Energy Efficiency Alliance, November, 2007.

Macro International, Inc., *Market Baseline Evaluation Report: Evaporator Fan VFD Initiative (Executive Summary),* April 1999.

Northwest Cherries, Growers/Shippers List, http://www.nwcherries.com/?q=industry/shipperslist, accessed November 20, 2007.

Northwest Energy Efficiency Alliance, "Evaporator Fan VFD: Cost-Effectiveness Analysis Key Assumptions – Converted," January 26, 2005.

Pacific Energy Associates, Inc. and MetaResources Group, Evaporator Fan VFD Market Tranformation Initiative: Market Progress Evaluation Report #3, prepared for Northwest Energy Efficiency Alliance, 2002.

Summit Blue Consulting, *2006 Long Term Monitoring and Tracking Report, Prepared for Northwest Energy Efficiency Alliance*, 2007

Taiwan Bureau of Animal and Plant Health Inspection and Quarantine Council, List of August 2006 participants in Northwest Taiwan Apple Export Program, http://www.baphiq.gov.tw/public/Data/711716344371.pdf.

United States Department of Agriculture, *Capacity of Refrigerated Warehouses: 2007 Summary*, January 2008

Washington State Deparment of Agriculture, Faxed List of Licensed Controlled Atmosphere Firms, November 13, 2007.

Wilcox, Marcus H. and Robert D. Morton, Cascade Energy Engineering, *The Evaporator Fan VFD Initiative*, 14th Annual Postharvest Conference, Yakima, Washington, March 10-11, 1998.

Yakima Valley Growers and Shippers Association, Letter to WSDA, October 20, 2005, http://www.wahort.org/Loveland%20Letter.pdf.

3.6 Supplemental Discussion and Material

3.6.1 Selecting a Representative Sample

The population of units for this study is defined as all of the cold storage facilities in Idaho, Montana, Oregon, and Washington. The United States Department of Agriculture (USDA) compiles a biennial census of refrigerated warehouses throughout the United States. The data is split into two major sectors: 1) apple and pear storage, collectively known as "fruit storage" and 2) general cold storage.[59] The first sector, fruit storage, is further divided into *controlled atmosphere (CA)* rooms and *refrigerated-only (regular)* fruit storage rooms. A controlled atmosphere room is one in which the chemical content of the atmosphere in the storage room is controlled to reduce fruit spoilage. In general, the controlled atmosphere rooms are used as long-term storage, while the regular fruit storage rooms are used while the fruit is being transitioned from the field to long-term storage.

The second major sector, the general cold storages, are divided into *public general storages* and *private/semi-private general storages*. Public general storages are defined as "refrigerated facilities maintained for others at specified rates [prices] per unit." Private/semi-private general storages are defined as "refrigerated facilities maintained by an operator to facilitate his principal function as a producer, processor, or manufacturer of food products. The space is used to store the owner's products, although some space may be used by others at specified rates per unit stored."[60]

The USDA report specifies the storage volume and number of facilities for each of these divisions by state. The contents of the USDA report are presented in Table 3-11 and used in this M&T work as indicative of the characteristics and size of the population of cold storages in the Northwest.

Table 3-11: Cold Storage Volume in the Northwest (million cubic feet)

State	General Cold Storages			Fruit Storages			Total All Cold Storages
	Public	*Private*	*Total*	*Regular*	*CA*	*Total*	
Idaho	36.6	24.4	61.0	2.3	2.2	4.5	***65.5***
Montana	*	*	1	0	0	0	***1***
Oregon	68.9	35.6	105	37.0	17.8	54.8	***159.8***
Washington	142.1	48.6	190.7	130.2	350.3	480.5	***671.2***
Total	**247.6**	**109.1**	**357.7**	**169.5**	**370.3**	**539.8**	**897.5**

* Not published to avoid disclosure of individual operations. Included in totals.

Source: USDA, National Agricultural Statistics Service, Capacity of Refrigerated Warehouses, 2007 Summary, January 2008

The next step was to compile contact and company information for as much of the population as possible. Summit Blue sought existing lists of cold storage facilities in the Northwest from a variety of sources. The primary source for information regarding *public general storage warehouses* was the International

[59] USDA, *Capacity of Refrigerated Warehouses: 2007 Summary*, January 2008.

[60] For ease of reading, the *private/semi-private general storages* will be referred to throughout this document as private.

Association of Refrigerated Warehouses (IARW), a trade organization for public cold storage facilities[61]. The principal sources for information regarding *fruit storage facilities* were a list of Washington Controlled Atmosphere license holders from the Washington State Department of Agriculture[62], a list of members of the Yakima Valley Growers and Shippers Association[63], a Taiwanese government list of Northwest apple shippers in the Taiwan export program[64], and the Northwest Cherries shippers list[65]. Additional facilities were added by searching yellow pages listings for cold storage providers.

Summit Blue collected contact information from these sources for 290 unique facilities. Because facilities were identified from a variety of sources, however, complete information for every facility was not always available. Table 3-12 shows the number of contacts compiled by the M&T project team by sector and storage type. All of the fruit storage in the Northwest is also private storage. The "Private Fruit - CA" column includes facilities that are known to have controlled atmosphere rooms. The "Private Fruit - Unknown" column includes facilities that are known to process or ship fruit, but which have storage of an unknown type. The "Facility Type Unknown" column includes all facilities for which the sector is not known. In states that have many fruit storage facilities, the "facility type unknown" sector is likely primarily split between private fruit storage and private general storage. In states that do not have fruit storage, the "facility type unknown" sector is likely primarily private general storage.[66]

Table 3-12: Sample Frame: Facilities with contact information by state and sector

State	Public General Storages	Private General Storages	Private Fruit Storages – CA*	Private Fruit Storages – Unknown**	Facility Type Unknown	Total All Cold Storages
Idaho	7	3	0	7	6	***23***
Montana	0	2	0	0	6	***8***
Oregon	12	3	1	5	27	***48***
Washington	39	0	93	25	54	***211***
Total	**58**	**8**	**94**	**37**	**93**	**290**

* CA storage facilities may also contain some regular fruit storage

** Fruit storage facilities that may or may not contain CA storage

Source: IARW, WSDA, Taiwan BAPIQC, YVGSA, NW Cherries, See footnotes 3-7

[61] International Association of Refrigerated Warehouses Directory of Public Warehouses, http://www.iarw.org/directory/

[62] Faxed list of licensed CA facilities, Washington State Department of Agriculture

[63] List of members contained in letter from Yakima Valley Growers and Shippers Association to WSDA, October 20,2005, http://www.wahort.org/Loveland%20Letter.pdf

[64] Bureau of Animal and Plant Health Inspection and Quarantine Council, Taiwan, List of Fall 2006 participants in Northwest Taiwan Apple Export Program, http://www.baphiq.gov.tw/public/Data/711716344371.pdf

[65] Northwest Cherries, Growers/Shippers List, http://www.nwcherries.com/?q=industry/shipperslist, accessed 11/20/07

[66] Since there are only 8 *known* private facilities in the population database and 93 *unknown* facilities in the population database (see Table 3-13), while there are supposed to be more than 70 private facilities in the population, according to the USDA report, *Capacity of Refrigerated Warehouses: 2007 Summary*, it follows that the missing private facilities in the population are showing up as *unknown* facilities in the database.

The sample frame is defined as the cold storage facilities in the Northwest for which contact information was available. Summit Blue stratified the sample by state and facility type. Table 3-13 shows the percentage of the total cold storage volume in the population in each of these stratified "buckets." With a target sample size of 30 facilities, the proportional number of desired sample facilities in each state/facility-type division, rounded to whole numbers, is shown in Table 3-14.

Table 3-13: Population breakdown by sampling bucket

State	Public General Storages	Private General Storages	Private Fruit Storages	Total All Cold Storages
Idaho	4.1%	2.7%	0.5%	***7.3%***
Montana	0.0%	0.0%	0.0%	***0.1%***
Oregon	7.7%	4.0%	6.1%	***17.8%***
Washington	15.8%	5.4%	53.5%	***74.8%***
Total	**27.6%**	**12.2%**	**60.1%**	**100.0%**
Source: Summit Blue Consulting (see Table 3-1)				

Table 3-14: Target Sample Sizes by State and Facility Type

State	Public General Storages	Private General Storages	Private Fruit Storages	Total All Cold Storages
Idaho	1	1	0	***2***
Montana	0	0	0	***0***
Oregon	2	1	2	***5***
Washington	5	2	16	***23***
Total	**8**	**4**	**18**	**30**

Next, Summit Blue randomly assigned a number from 0 to 100 to each of the facilities in the population database. Within each state/facility-type division, the facilities were sorted by rank, with the highest numbers chosen first for the survey. For the purposes of this sorting, known private facilities were combined with unknowns and fruit facilities were combined with CA facilities. If a particular firm appeared to be overrepresented within a particular division, then the lower ranked facilities of the firm were rejected in favor of the next facility on the list. As previously noted, most of the private population for which contact information is available is likely in the category marked "Facility Type Unknown" as shown in Table 3-12. Therefore, facilities of "unknown" type had to be contacted in order to meet the target sample sizes for private facilities. Facilities of "unknown type" in the initial sample were contacted before contacting private fruit facilities. As surveys of "unknown type" facilities were completed, these facilities were classified and counted towards the target sample quotas. Once enough surveys of private general facilities were completed, all remaining unknown facilities were removed from the sample and surveys of private fruit facilities commenced, in order to finish the quota for private fruit facilities. After a reasonable effort to contact a given facility, if the facility proved to be either unreachable, out of business, or not a cold storage facility, then the next facility in order on the list was added to the sample.

3.6.2 Survey Instrument

1. What is your name and position within X company?

2. What is your company's primary business?

3. Does your company have cold storage warehouses and/or controlled atmosphere rooms?

[IF BOTH] Ok, let's start with your cold storage warehouses…

[IF YES TO COLD STORAGE]

> 4. What is the capacity of your cold storage warehouses at this X site? (breakdown, in cubic feet or in bushels or boxes)
>
> 5. Do you use VFDs to control the evaporator fans in your cold storage warehouses?
>
> [IF YES TO ABOVE] What percentage of your existing cold storage capacity uses VFDs to control its evaporator fans?
>
> 6. Do you know what the total horsepower of the evaporator fans with and without VFD's is?

7-9. Are you planning to add cold storage capacity in the next 3 years? If so, when and how much?

10. What percentage of your new cold storage volume will be built with VFDs to control its evaporator fans?

[IF YES TO CONTROLLED ATMOSPHERE]

> 11. What is the capacity of your controlled atmosphere rooms at this X site? (breakdown, in cubic feet or in bushels or boxes)
>
> 12. Do you use VFDs to control the evaporator fans in your controlled atmosphere rooms?
>
> [IF YES TO ABOVE]
>
> 13. What percentage of your existing controlled atmosphere capacity uses VFDs to control its evaporator fans?
>
> 14. Do you know what the total horsepower of the evaporator fans with and without VFD's is?

15-17. Are you planning to add controlled atmosphere capacity in the next 3 years? If so, when and how much?

18. What percentage of your new controlled atmosphere capacity will be built with VFDs to control its evaporator fans?

19. What influences your company to decide whether or not to use VFDs on evaporator fans? Has this changed over the years?

Do you have any additional thoughts about the direction the cold storage market is moving with respect to using VFDs for evaporator fans?

Thank you very much for your time. Your input will help NEEA determine the prevalence of variable frequency drives in the Northwest. If you would like more information about variable frequency drives and other energy efficient technologies, you can visit http://www.industrialefficiencyalliance.org.

4 ENERGY STAR WINDOWS

The Energy Star (ES) Residential Windows program was funded by NEEA from February 1998 to June 2001. The key market actors targeted by the program included, among others, window manufacturers, regional utilities, builders, retailers, and wholesalers. The purpose was to increase the market share for high efficiency fenestration products in the residential market and also to decrease at least two market barriers – lack of awareness and initial cost premiums. NEEA adjusted the regional standards for Energy Star windows to fit the national standard of Class 35 (U-value = 0.35) as defined by the Energy Star program. The market transformation effort showed rapid results as the market penetration of ES windows jumped significantly from just 13% in 1997 to 57% in 2000.

The first M&T effort focused on estimating the size of the market, determining the market penetration of Energy Star windows in the Northwest, and estimating the expected energy savings due to reduced electric furnace operation. The second effort included estimates of electric savings due to reduced cooling loads, as well as natural gas savings due to reduced gas furnace operation. This third M&T effort for the Energy Star Residential Windows program focused on:

- Updating the market size for residential windows;
- Reviewing and updating the market penetration of Energy Star windows;
- Critically analyzing NEEA's approach to estimating baseline activity through 2007 and beyond;
- Adding electric savings due to reduced furnace fan operation.

4.1 Assumptions and Indicators for Review

The energy savings impact of the Energy Star Windows program is broadly based on the total area of residential windows installed, the market share of Energy Star windows, and the energy savings per-unit of installed window area. The energy savings are further dependent on home type, vintage, and heating and cooling system type of the home. Generically, energy savings for a given calendar year are calculated as follows:

Annual Energy Savings =

(1) Windows shipped in the Northwest
x (2) Average area per window
x (3) Market share of ES windows
x (4) Market penetration of heating and cooling system types
x (4) Savings per unit of window area

where:

Windows shipped in the Northwest is based on an analysis of data contained in market research studies published by Ducker Research Company.[67,68] This data was disaggregated in these reports by

[67] *Study of the U.S. Market for Windows, Doors, and Skylights*; Ducker Research Company; April 2004

window type (windows, patio doors, or skylights) and application (replacement/remodel or new construction).

Average area per window varies by window type. The initial values were supplied by NEEA's evaluation contractor for the Energy Star Windows program and later validated by staff at Ducker Research Company.

Market share of Energy Star windows is the percentage of shipped residential windows that are Energy Star and is based on data from interviews with window manufacturers in the Northwest.

Market penetration of heating and cooling system types come from data supplied by the NW Council. The appropriate market penetration value to use in the savings calculation depends on home type, home vintage, and the type of savings being calculated (electric or gas, heating or cooling, etc).

Savings per unit of window area is defined as the annual energy savings due to reduced HVAC energy consumption per unit of window area. The values were taken directly from analysis conducted by the Northwest Power and Conservation Council (NW Council); they vary based on home type, vintage, fuel type, and the HVAC system component demonstrating reduced energy usage. The M&T analysis includes:

- Electricity savings due to reduced electric-heating usage
- Electricity savings due to reduced central air conditioner usage
- Gas savings due to reduced gas-heating usage
- Electricity savings due to reduced gas furnace-fan operation

4.2 Methodology

The 2007 M&T effort for the Energy Star Windows program included an update to the market size for residential windows, an update to the market share of Energy Star, critically analyzing NEEA's approach to estimating baseline activity, and reviewing and updating the per-unit savings estimates. Specifically, Summit Blue conducted the following data collection and analysis activities:

- **Reviewed the most up-to-date windows data from Ducker Research.** National growth rates were used in combination with Northwest-specific data for 2001-2004 to calculate Northwest shipments from 2005-2007 (see Section 4.3.1).

- **Reviewed historic program documentation.** The program's Market Progress Evaluation Reports (MPERs) provided a material understanding of previous market penetration estimates.

- **Conducted short, informal interviews with regional window manufacturers to confirm and update the high level of Energy Star market share.** With the market for Energy Star windows in the Northwest nearly saturated, Summit Blue decided not to focus resources on a statistically valid survey of manufacturers for this M&T effort.

[68] *U.S. Industry Statistical Review and Forecast;* Ducker Research Company; April 2007

- **Reviewed NEEA's approach to estimating baseline activity.** Summit Blue found NEEA's analysis of active versus inactive regions to be both a reasonable and practical approach to estimating baseline activity (see Section 4.3.2).

- **Reviewed and updated the per-unit savings estimates.** The Northwest Power and Conservation Council will not update their simulated per-unit savings estimates until spring of 2009, and the existing values remain the most appropriate for M&T. Summit Blue updated the gas furnace efficiency to reflect differences between new construction and existing homes. Savings due to reduced gas furnace fan operation were also estimated and should be added to the electricity savings estimates (see Section 4.3.3).

4.3 Findings

4.3.1 Market Activity

Summit Blue tracked the number and total area of windows shipped in the Northwest from 2001 to 2007, the market share of Energy Star windows, and the total Energy Star window area shipped to homes with electric space heating, gas space heating, and central air conditioning.

Windows Shipped in the Northwest

The *number of windows shipped in the Northwest*[69] from 2001 to 2007 was derived from market research reports published by Ducker Research Company.[70,71] Ducker publishes complete reports with data disaggregated by region once every two years, and summary reports with data aggregated at the national level for the in-between years. The last complete report that NEEA purchased was published in 2004, and it contains final data only through 2003. Since the most recent report is a summary report, Summit Blue applied the national growth rates in window, skylight, and patio door shipments for new construction and replacement/remodel applications to the *actual regional shipment data from 2003*[72] to get the total number of windows shipped in the Northwest for the years 2004-2007. Table 4-1 shows the number of fenestration products shipped in the Northwest from 2001-2007. Gross window shipments declined in 2006 and 2007.

[69] The M&T analysis uses shipment data as a proxy for sales data.

[70] *Study of the U.S. Market for Windows, Doors, and Skylights*; Ducker Research Company; April 2004

[71] *U.S. Industry Statistical Review and Forecast;* Ducker Research Company; April 2007

[72] Ducker's regional shipment data for the Northwest includes shipments to Washington and Oregon only. Summit Blue used population data from the US Census Bureau as a proxy to add in the number of windows shipped to Idaho and Montana.

Table 4-1. Fenestration Products Shipped in The Northwest from 2001-2007 (thousands)

Year	New Construction			Existing Homes		
	Windows	*Skylights*	*Patio Doors*	*Windows*	*Skylights*	*Patio Doors*
1997-2000	Data Not Available[73]					
2001	1,199	37	73	1,372	42	96
2002	1,137	38	78	1,446	43	103
2003	1,087	40	85	1,520	47	111
2004	1,158	39	92	1,630	46	116
2005	1,257	39	97	1,661	43	119
2006	1,139	33	88	1,634	42	116
2007	999	29	79	1,534	39	109

Source: Summit Blue analysis of Ducker Research market reports (2004 and 2007)

The *average area per window* varies by window type, and the initial values were supplied by Gary Curtis, NEEA's implementation contractor for the Energy Star Windows program. Mr. Curtis suggested the following values:

- Windows – 16 square feet per unit shipped
- Skylights – 6 square feet per unit shipped
- Patio Doors – 40 square feet per unit shipped

These assumptions were later validated in a separate discussion with staff at Ducker Research. Table 4-2 shows the total area of windows shipped in the Northwest from 1997-2007.

[73] NEEA tracked the total area of windows shipped in the Northwest between 1998 and 2000, but the number of units shipped was not available to the M&T project team.

Table 4-2. Total Area of Windows Shipped in the Northwest from 1997-2007 (thousand square feet)

	New Construction	Existing Homes	Total
1997	*	*	48,709
1998	*	*	48,709
1999	*	*	48,709
2000	*	*	48,709
2001	22,316	26,053	48,369
2002	21,533	27,494	49,027
2003	21,046	29,048	50,094
2004	23,913	29,083	52,996
2005	21,385	28,631	50,015
2006	20,225	27,079	47,304
2007	18,427	24,673	43,100
Total	*****	*****	***535,741***

Source: Summit Blue calculations of data in Table 4-1 and assumptions regarding average area per window

** Data disaggregated by vintage was not available to the M&T project team for 1997-2000.*

Market Share of Energy Star Windows

The *market share of Energy Star windows* during the years 1998-2000 was researched as part of the evaluation contract for the program. The estimates were based on interviews with window manufacturers, retailers, wholesalers, distributors, and builders, and the results suggested that market share of Energy Star in windows shipments had risen from just 13% in 1997 to 57% by the end of 2000, and 66% by the second quarter of 2001.

Based on research conducted for the 2004 M&T effort, Summit Blue found that Energy Star market share continued to grow rapidly after NEEA had ceased funding, and that it had risen to 89% by 2004. This estimate and the estimates for 2001-2003 were based on interviews with a small sample of window manufacturers in the Northwest, the group of which was estimated to represent more than 50% of the market.[74]

With the annual market share of Energy Star windows in the Northwest nearing 100%, Summit Blue decided not to focus resources on a statistically valid survey of manufacturers. Instead, the high level of market penetration was confirmed and updated through informal discussions with a small group of regional manufacturers. The contact list was the same as used for the 2004 M&T effort, and the M&T project team spoke with four manufacturers in total. When asked what percentage of their windows are Energy Star, the responses were “All of them”, “Close to 100%”, “99.5%”, and “Very high”. Without a statistically valid sample, however, Summit Blue recommends that NEEA assume a gradual increase in Energy Star market share from the established value of 89% in 2004 to 95% in 2007. This estimate of 95% in 2007 recognizes that market share of Energy Star in the Northwest is nearing 100%, but it discounts the fact that only one of the four respondents answered unequivocally that 100% of the

[74] See the 2004 M&T report for more details. *NW Alliance Residential Energy Star Windows Program – Draft M&T Findings;* Prepared by Summit Blue Consulting for the Northwest Energy Efficiency Alliance; March 11, 2005

windows his company manufactures are Energy Star. Table 4-3 shows the market share of Energy Star windows as a percentage of all windows shipped and as total window area.

Table 4-3. Market Share of Energy Star Windows Shipped in the Northwest from 1997-2007

	Energy Star Market Share (%)	New Construction (sqft x 1,000)	Existing Homes (sqft x 1,000)	Total (sqft x 1,000)
1997	13%	*	*	6,218
1998	41%	*	*	19,971
1999	47%	*	*	22,893
2000	54%	*	*	26,303
2001	75%	16,737	19,540	36,277
2002	81%	17,442	22,270	39,712
2003	88%	18,521	25,562	44,083
2004	89%	21,282	25,884	47,166
2005	91%	19,460	26,054	45,514
2006	93%	18,809	25,184	43,993
2007	95%	17,505	23,439	40,945
Total		*****	*****	***373,074***

Source: Summit Blue analysis of interview data applied to gross window areas from Table 4-2
** Data broken out by vintage was not available to the M&T project team for 1997-2000.*

Market Penetration of Heating and Cooling System Types

All of the assumptions regarding the *market penetration of heating and cooling system types* come directly from data supplied by the Northwest Power and Conservation Council[75]. These data points are researched in detail by the NW Council to assist in power planning for the region. Table 4-4 shows the breakout of heating system fuel and home type by vintage.[76] While more than two out of five existing homes (44%) use electricity to heat their homes, just one-third of new construction uses electric heat.

[75] Although NEEA has updated data regarding heating and cooling system types, the NW Council won't revise the percentages that are germane to this analysis until preparation for the new power plan in the spring of 2009. Thus the existing percentages remain the most appropriate for M&T.

[76] The data from the Ducker reports is disaggregated by vintage only, yet the per-unit savings values (Section 4.3.3) are a function of fuel type, vintage, and home type. Thus the market share percentages in Table 4-4 and Table 4-5 are presented so that they can be multiplied directly by both the data from the Ducker reports *and* the per-unit savings data.

Table 4-4. Market Penetration of Heating Fuel and Home Type by Vintage

Heating Fuel	Home Type	New Construction	Existing Homes
Electric Heat	Single Family	9.1%	25.1%
	Multi-Family	15.1%	12.0%
	Manufactured	9.1%	6.6%
Gas Heat	Single Family	53.6%	41.0%
	Multi-Family	10.2%	1.5%
	Manufactured	1.5%	0.7%
All Other Heating	All Home Types	1.4%	13.2%
Total		**100.0%**	**100.0%**

Source: Summit Blue analysis of regional data from the NW Council

Table 4-5 shows the presence of central air conditioning in the Northwest by home type and vintage. According to the data from the NW Council, new homes are nearly twice as likely to have central air conditioning than existing homes.

Table 4-5. Market Penetration of Central Air Conditioning by Home Type and Vintage

	New Construction	Existing Homes
Single Family	26.6%	17.2%
Multi-Family	6.7%	1.6%
Manufactured	4.5%	2.0%
Total	**37.8%**	**20.8%**

Source: Summit Blue analysis of regional data from the NW Council

Summit Blue applied the percentages from Table 4-4 to the window area shipment data as presented in Table 4-3 to get the area of Energy Star windows shipped to homes with electric and gas heat from 2001-2007. Table 4-6 shows the Energy Star window area for homes with electric heat, while

Table 4-7 shows the Energy Star window area for homes with gas heat.[77] This same method was also employed for homes with central air conditioning as presented in Table 4-8.[78]

[77] This analysis assumes that window shipments are made in the same proportion as the market share percentages of heating and cooling system types by home type and vintage. In reality, this assumed relationship between shipments and residential building stock may not be exactly proportional. While the M&T team finds this to be a reasonable assumption for this analysis, it may be prudent to explore this further in future efforts.

[78] The window area values presented in the heating and cooling end-use tables (Table 4-6,

Table 4-7, and Table 4-8) are not additive to the values in Table 4-3 because a) not all heating end-uses are represented in the heating end-use tables, and b) the values in Table 4-8 are actually a subset of the heating end-use tables, i.e. some window shipments that affect heating consumption also affect air conditioning consumption.

Table 4-6. Area of Windows Shipped to Homes with Electric Space Heating from 2001-2007 (thousand square feet)

Year	New Construction			Existing Homes		
	Single Family	*Multi-Family*	*Manufactured*	*Single Family*	*Multi-Family*	*Manufactured*
1997-2000	Data Not Available*					
2001	1,530	2,525	1,518	4,897	2,340	1,291
2002	1,595	2,631	1,582	5,582	2,667	1,472
2003	1,693	2,794	1,680	6,407	3,061	1,689
2004	1,946	3,210	1,931	6,487	3,100	1,711
2005	1,779	2,935	1,765	6,530	3,120	1,722
2006	1,720	2,837	1,706	6,312	3,016	1,664
2007	1,601	2,641	1,588	5,875	2,807	1,549

Source: Summit Blue analysis of Ducker Research market reports (2004 and 2007) and data from the NW Council
** Data broken out by vintage was not available to the M&T project team for 1997-2000.*

Table 4-7. Area of Windows Shipped to Homes with Gas Space Heating from 2001-2007 (thousand square feet)

Year	New Construction			Existing Homes		
	Single Family	*Multi-Family*	*Manufactured*	*Single Family*	*Multi-Family*	*Manufactured*
1997-2000	Data Not Available*					
2001	8,977	1,701	253	8,014	285	138
2002	9,354	1,773	264	9,134	324	158
2003	9,933	1,883	280	10,484	372	181
2004	11,414	2,163	322	10,616	377	183
2005	10,437	1,978	294	10,685	379	184
2006	10,088	1,912	284	10,329	367	178
2007	9,389	1,779	265	9,613	341	166

Source: Summit Blue analysis of Ducker Research market reports (2004 and 2007) and data from the NW Council
** Data broken out by vintage was not available to the M&T project team for 1997-2000.*

Table 4-8. Area of Windows Shipped to Homes with Central Air Conditioning from 2001-2007 (thousand square feet)

Year	New Construction			Existing Homes		
	Single Family	*Multi-Family*	*Manufactured*	*Single Family*	*Multi-Family*	*Manufactured*
1997-2000	Data Not Available*					
2001	4,458	1,123	753	3,356	316	384
2002	4,645	1,170	785	3,824	360	437
2003	4,933	1,243	833	4,390	414	502
2004	5,668	1,428	957	4,445	419	508
2005	5,183	1,306	875	4,474	422	511
2006	5,009	1,262	846	4,325	408	494
2007	4,662	1,175	787	4,025	379	460

Source: Summit Blue analysis of Ducker Research market reports (2004 and 2007) and data from the NW Council
** Data broken out by vintage was not available to the M&T project team for 1997-2000.*

4.3.2 Baseline Activity

NEEA's baseline market assessment[79] established the market penetration of Energy Star windows in the Northwest to be 13% in 1997. The original ACE model assumed that this value would grow by 8% the first year and 5% every year thereafter, thus reaching a value of 20% by 2006. In 2007, NEEA revised its baseline estimates based on an analysis of regions *with* active promotions of Energy Star windows ("active regions") versus those regions of the country *without* active promotions ("inactive regions"). According to this analysis, the market share of Energy Star windows in inactive regions would be a reasonable proxy for the baseline. The formula used to determine market share in inactive regions was:

IRMS = [(USPop * NMS) - (ARPop * ARMS)] / IRPop

where:

IRMS = Inactive Region Market Share of Energy Star windows

USPop = the population of people in the United States in 2006

NMS = National Market Share of Energy Star windows

ARPop = the population of people in active regions in 2006

ARMS = Active Region Market Share of Energy Star windows

IRPop = the population of people in inactive regions in 2006

[79] *Baseline Market Assessment: ENERGY STAR High Efficiency Residential Windows, Executive Summary;* Prepared by Macro International, Inc. for the Northwest Energy Efficiency Alliance; December 1998

The national, active, and inactive region market share data was taken from the Environmental Protection Agency's (EPA) Energy Star partner resource guide for windows, doors, and skylights[80]. This document presents the national market share of Energy Star windows from 2001-2005, and a market share estimate for 2005 only, disaggregated by 11 representative regions. NEEA's methodology for choosing states to represent active regions was somewhat subjectively based on an examination of utility and regional market transformation initiatives across the country. Table 4-9 was reprinted from the Key Assumptions document for the 2006 MAR[81] and shows the states included as active regions.

Table 4-9. Active Region Population and Market Share of Energy Star Windows for 2005

State	2006 Population	Market Share[82]	Wtd Avg Mkt Share
Idaho	1,429,367	75%	1,072,025
Montana	934,737	75%	701,053
Delaware	841,741	53%	446,123
California	36,154,147	57%	20,607,864
Wisconsin	5,527,644	64%	3,537,692
New Jersey	8,703,150	74%	6,440,331
New York	19,315,721	74%	14,293,634
Oregon	3,638,871	74%	2,692,765
Washington	6,291,899	74%	4,656,005
Maine	1,318,220	75%	988,665
Massachusetts	6,433,367	75%	4,825,025
Rhode Island	1,073,579	75%	805,184
Vermont	622,387	75%	466,790
Connecticut	3,500,701	75%	2,625,526
Active Region Population	***95,785,531***	***67%***	-
US 2006 Population	***295,233,783***	***53%***	-
Inactive Region Population	***199,448,252***	***46%***	-

Source: 2006 Cost-Effectiveness Analysis Key Assumptions

After calculating the inactive region market share for 2005, NEEA used the national market share growth rates from the partner resource guide for 2001-2005 to determine the inactive region share back to 2001. In the years 1998, 1999, 2000, 2006, and 2007, NEEA revised its initial growth estimates of 5% per year to instead use a diffusion of innovation curve (S-curve) to estimate the rate at which the baseline would grow.[83] Figure 4-1 shows the market share of Energy Star windows in the Northwest as compared to the baseline from 1997-2007. In 2001, the first year for which market share data was reported in the partners

[80] http://www.energystar.gov/ia/partners/manuf_res/windows/Windows_PRG.pdf

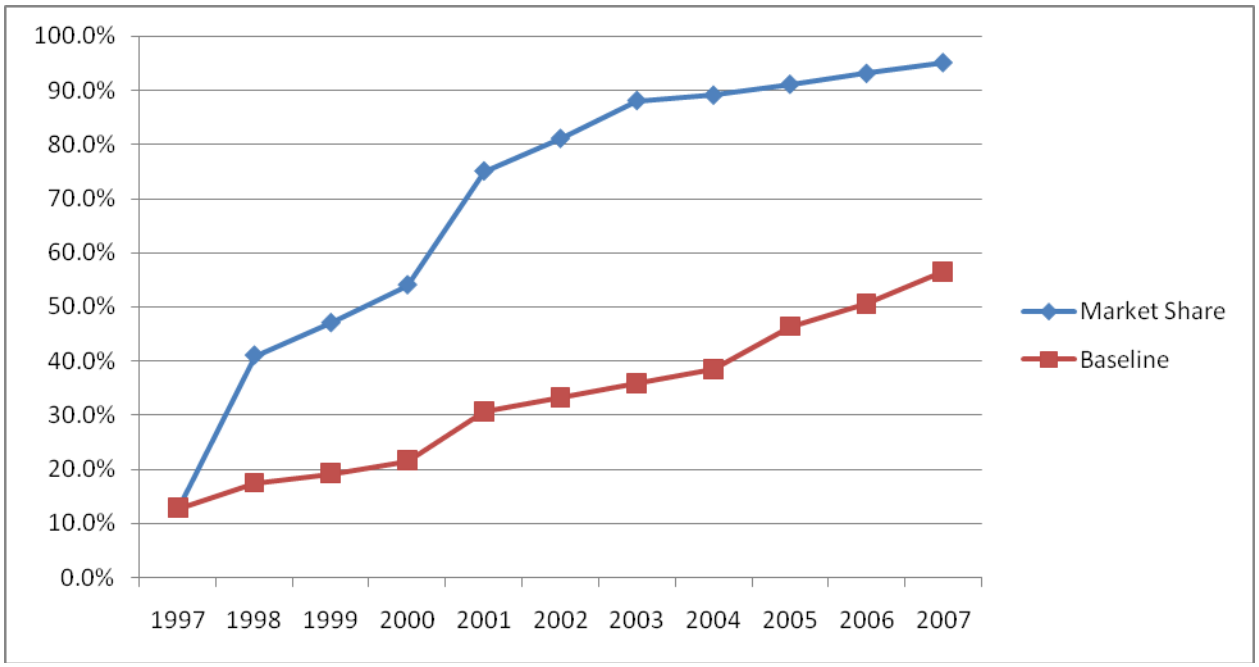
[81] *2006 Cost-Effectiveness Analysis Key Assumptions: Energy Star Windows;* Northwest Energy Efficiency Alliance; May 8, 2007

[82] Although the actual market share of Energy Star windows is higher in the Northwest than is indicated in Table 4-9, NEEA used the values from the EPA's partner resource guide to ensure consistency in the analysis.

[83] The S-curve theory of technology diffusion was initially propounded by Everett Rogers in his 1962 book "Diffusion of Innovations."

resource guide, baseline activity is estimated to be 31% or the market. By 2005, this value had risen to 46%, and NEEA estimated it at 56% in 2007.

Figure 4-1. Comparison of the Market Share of Energy Star Windows to the Baseline



Source: 2007 M&T analyses and the 2006 Energy Star Windows ACE model

Summit Blue critically analyzed NEEA's approach to estimating the baseline and found it to be both reasonable and practical. An alternative would be to use the national market share of Energy Star windows as the baseline, but this method overestimates the baseline by including market share estimates from regions with efforts similar to NEEA's. One area where NEEA could improve its methodology would be to develop an objective system to classify active regions versus inactive regions, perhaps by basing active region status on some threshold of per-capita spending to promote Energy Star windows. None of the states listed as active have an Energy Star market share below the national average which, if untrue, would serve to increase the baseline. Conversely, some of the states with a high share of Energy Star are labeled inactive which, if labeled as active, would serve to decrease the baseline and increase the net market effects. In the absence of data to support an objective classification, however, Summit Blue recommends no change to NEEA's baseline estimates.

4.3.3 Per-Unit Energy Savings

The *savings per unit of window area* is defined as the annual energy savings due to reduced HVAC energy consumption per unit of window area. HVAC savings comes in several forms:

- Electricity savings due to reduced electric-heating usage
- Electricity savings due to reduced central air conditioner usage
- Gas savings due to reduced gas-heating usage
- Electricity savings due to reduced gas furnace-fan operation

Prior M&T efforts have defined the per-unit savings values for reduced electric-heating usage, reduced gas-heating usage, and reduced central air conditioner usage. The values for electric-heating savings and central air conditioner savings come directly from analysis conducted by the Northwest Power and Conservation Council, and they vary based on home type and vintage. Table 4-10 shows the per-unit electric heating savings values used in the 2005 M&T analysis, while Table 4-11 shows the per-unit central air conditioner savings. According to the NW Council, these values won't be updated until a new power plan is released in the spring of 2009, and the values used in the prior M&T analyses remain the most appropriate for the current analysis.[84,85]

Table 4-10. Per-Unit Electric Savings Due to Reduced Electric-Heating Usage (kWh/sqft-yr)

Home Type	2006 ACE Model Values		2007 M&T Values	
	New Construction	*Existing Homes*	*New Construction*	*Existing Homes*
Single Family	0.86	1.62	No change	No change
Multi-Family	1.50	1.51	No change	No change
Manufactured	1.53	1.74	No change	No change

Source: Northwest Power and Conservation Council

Table 4-11. Per-Unit Electric Savings Due to Reduced Central Air Conditioner Usage (kWh/sqft-yr)

Home Type	2006 ACE Model Values		2007 M&T Values	
	New Construction	*Existing Homes*	*New Construction*	*Existing Homes*
Single Family	0.05	0.04	No change	No change
Multi-Family	0.05	0.04	No change	No change
Manufactured	0.06	0.07	No change	No change

Source: Northwest Power and Conservation Council

Summit Blue calculated the values for reduced gas-heating usage by converting the electric-heating savings units (kWh) to units of gas energy[86] (kBtu) and dividing by a gas furnace efficiency of 74% for both new construction and existing homes. A more appropriate assumption for gas furnace efficiency is 90% for new construction and 78% for existing homes. Table 4-12 shows the 2006 ACE model values, based on the 2005 M&T effort, as compared to those used for the 2007 M&T analysis, which use the updated gas furnace efficiency assumptions.

[84] See the 2005 M&T report for more details. *Long Term Monitoring and Tracking Report on 2005 Activities;* Prepared by Summit Blue Consulting for the Northwest Energy Efficiency Alliance; April 14, 2006

[85] Summit Blue examined the possibility of calculating savings for windows with a significantly lower U-value than Energy Star and determined it not to be feasible with the currently available data from the NW Council.

[86] The conversion from electric units to gas units is 3.412 kBtu per kWh.

Table 4-12. Per-Unit Gas Savings Due to Reduced Gas-Heating Usage (kBtu/sqft-yr)

Home Type	2006 ACE Model Values		2007 M&T Values	
	New Construction	*Existing Homes*	*New Construction*	*Existing Homes*
Single Family	3.97	7.47	3.28	7.08
Multi-Family	6.92	6.96	5.68	6.60
Manufactured	7.05	8.02	5.82	7.61

Source: Summit Blue calculations converting electric heating savings to gas heating savings

For the 2007 M&T effort, Summit Blue also conducted analysis to determine electric savings due to reduced gas furnace fan operation. To compute these savings, Summit Blue first needed to determine the relationship between the electric energy consumed by the furnace fan and the gas energy consumed by the furnace. Since the furnace fan generally runs only when air is being heated, Summit Blue assumed this correlation to be approximately linear, i.e. the electric fan energy savings are proportional to the gas furnace energy savings. The relationship between gas energy and *airflow* can be determined from the following equation[87]:

$$\mathbf{Q = (m * C_p) * dt / \mu}$$

where:

Q = the amount of gas energy needed to one CFM of air from the return or room air temperature to the furnace supply air temperature in units of Btu/cfm-hr.

$(m * C_p)$ = the specific heat per unit mass of air, which is 1.08 Btu/cfm-hr-°F

dt = is the difference between the supply air temperature (assumed to be 120°F) and the return or room air temperature (assumed to be 70°F)

μ = is the furnace efficiency, assumed to be 90% for new construction and 78% for existing homes

Using this formula, Summit Blue calculated the relationship between gas energy and airflow to be 60.0 Btu/cfm-hr for new construction and 69.2 Btu/cfm-hr for existing homes. The Air Conditioning and Refrigeration Institute (ARI) specifies a default of 365 watts of fan power per 1,000 cfm airflow for residential HVAC systems. Therefore the correlation between electric energy consumed by the furnace fan and the gas energy consumed by the furnace can be described by the following equations:

- New Construction Correlation (kWh fan energy / kBtu gas energy) =

  [0.365 kW fan power / 1,000 cfm airflow] / [0.0600 kBtu/cfm-hr]

- Existing Homes Correlation (kWh fan energy / kBtu gas energy) =

  [0.365 kW fan power / 1,000 cfm airflow] / [0.0692 kBtu/cfm-hr]

[87] *Energy Audit of Building Systems – An Engineering Approach;* Moncef Krarti, PhD; (CRC-2000); pg 225

Using these formulas, Summit Blue arrived at a final correlation of 0.00751 kWh/kBtu for new construction and 0.00867 kWh/kBtu for existing homes. The per-unit savings values were then calculated by multiplying these correlations by the gas furnace savings for each home type and vintage and are presented in Table 4-13.

Table 4-13. Per-Unit Electric Savings Due to Reduced Gas Furnace Fan Operation (kWh/sqft-yr)

Home Type	2006 ACE Model Values		2007 M&T Values	
	New Construction	*Existing Homes*	*New Construction*	*Existing Homes*
Single Family	N/A	N/A	0.02	0.06
Multi-Family	N/A	N/A	0.04	0.06
Manufactured	N/A	N/A	0.04	0.07

Source: Summit Blue analyses

Summit Blue then calculated the average per-unit savings weighted by the market share of heating and cooling system types as presented in Table 4-4 and Table 4-5. The weighted average values can be used to calculate energy savings from the total area of Energy Star windows alone. The final weighted average electricity savings due to the Energy Star windows is 0.63 kWh/sqft-yr, while the weighted average gas savings is 2.78 kBtu/sqft-yr. Table 4-14 shows the weighted average savings values by savings end-use and vintage.

Table 4-14. Electric and Gas Weighted Average Per-Unit Savings

Savings End-Use	New Construction	Existing Homes	Weighted Average
Electric Heating (kWh/sqft-yr)	0.44	0.70	0.59
Central Air Conditioning (kWh/sqft-yr)	0.02	0.01	0.01
Reduced Furnace Fan Operation (kWh/sqft-yr)	0.02	0.03	0.02
Total Electricity Savings (kWh/sqft-yr)	***0.48***	***0.7***	***0.63***
Total Gas Savings (kBtu/sqft-yr)	***2.42***	***3.05***	***2.78***

Source: Summit Blue analysis of per-unit savings values and heating and cooling system market share data

4.4 Conclusions / Recommendations

NEEA's Energy Star Windows market transformation program continues to achieve significant energy savings into 2007. Although gross window shipments in the Northwest receded in 2006 and 2007, the percentage of those windows that have the efficiency level promoted by NEEA's initiative is nearing 100% and is likely to remain there. Specific findings from the 2007 M&T effort include:

- **The number of windows shipped in the Northwest dropped off in 2006 and 2007.** The total area of windows shipped in the Northwest dropped from just over 50 million square feet in 2005 to 43.1 million square feet in 2007.

- **The market share of Energy Star windows remains very high and is estimated at 95% in 2007.** With the annual market share of Energy Star windows in the Northwest nearing 100%, Summit Blue decided not to focus resources on a statistically valid survey of manufacturers.

However, informal discussions with regional window manufacturers suggest that the market share could potentially be even higher than 95%.

- **Baseline activity represents 56% of the market in 2007.** In addition, Summit Blue found NEEA's analysis of active versus inactive regions to be both a reasonable and practical approach to estimating baseline activity.

- **Electricity savings due to reduced gas furnace fan operation range from 0.02 kWh/sqft-yr to 0.07 kWh/sqft-yr.** Though small, these savings can be quantified and added to the program's energy impact.

In the 2006 ACE model, NEEA calculated only those savings due to reduced electric heating usage. The area of Energy Star windows for the NEEA 2006 cumulative value as shown in Table 4-15 therefore includes only those Energy Star windows in homes with electric heating. In addition to electric heating savings, the 2007 *recommended* cumulative values include savings from reduced central air conditioner usage and reduced gas furnace fan operation. The per-unit savings value was weighted by the market share of heating and cooling system types so that it may be used with the total area of Energy Star windows to determine implied energy savings. The NEEA 2006 cumulative implied energy savings were 12.2 aMW, while the 2007 recommended cumulative value is 16.7 aMW.

Table 4-15: M&T Recommendations for Key Indicators

Key Indicators Reviewed	NEEA 2006 Cumulative Values*	2007 Recommended Cumulative Values	Source
Current Market Activity			
Total Area of Energy Star Windows (sqft x 1,000)	129,928**	373,074	Ducker Research Company, Inc.; see Section 4.3.1
Baseline Activity			
Baseline Energy Star Windows (sqft x 1,000)	59,571**	138,901	Review of approach; see Section 4.3.2
Per-Unit Energy Savings			
kWh/sqft-yr	1.52**	0.63	NW Council and Summit Blue analyses; See Section 4.3.3
Implied Energy Savings* **			
Implied Energy Savings (aMW)	12.2	16.7	aMW = MWh divided by 8760 hours

*NEEA 2006 values from the 2006 ACE model, Excel file "Energy Star Windows APR 2007.xls"

** The 2006 ACE model captures savings from reduced electric heating usage only, and this is reflected in the NEEA 2006 cumulative value for both total area and per-unit energy savings. The NEEA 2006 cumulative value for total area of *all* Energy Star windows would be 326,612 sqft x 1,000.

*** Implied energy savings are presented for comparison purposes only between NEEA's 2006 values and the 2007 M&T findings. NEEA's reported values may not match those presented here since NEEA adjusts for the effect of utility incentives and other factors not taken into account in this M&T analysis.

The following recommendations are intended to guide future M&T work:

- **Align future M&T efforts with the release of the complete Ducker report.** Ducker Research releases a complete report with the data disaggregated by region in March or April of every even-numbered year, while summary reports with data aggregated at the national level are released in odd-number years. M&T for Energy Star Windows should therefore be conducted once every two years in the even-numbered years to take advantage of the most up-to-date and Northwest-specific data available.

- **Update the market share of Energy Star windows every 6 years until it has reached 100%, or when new, more stringent U-value requirements are promulgated.** With the annual market share of Energy Star windows in the Northwest nearing 100%, it is not cost-effective to conduct a statistically significant survey of window manufacturers for every M&T effort. Therefore this research should only be conducted when it is likely to yield significantly different values from those that can be reasonably assumed from prior M&T work.

- **Develop an objective, defensible system to classify active regions versus inactive regions for the baseline analysis, perhaps by basing active region status on some threshold of per-capita spending to promote Energy Star windows.** The labeling of regions as active or inactive significantly affects the baseline activity, and the methodology behind it should be clarified.

- **Obtain and use the most up-to-date market share and savings values from the Northwest Power and Conservation Council.** The NW Council will release a draft of the next power plan in spring of 2009, and the preparation for its release should include an update of all heating and cooling system types by home type and vintage, as well as any new per-unit savings estimates that may have been developed.

4.5 Bibliography

Study of the U.S. Market for Windows, Doors, and Skylights; Ducker Research Company; April 2004

U.S. Industry Statistical Review and Forecast; Ducker Research Company; April 2007

Market Research Report: Baseline Characteristics of the Residential Sector – Idaho, Montana, Oregon, and Washington; Ecotope; December 2001.

Single-Family Residential New Construction Characteristics and Practices Study; RLW Analytics; March 27, 2007.

NW Alliance Residential Energy Star Windows Program – Draft M&T Findings; Prepared by Summit Blue Consulting for the Northwest Energy Efficiency Alliance; March 11, 2005

Baseline Market Assessment: ENERGY STAR High Efficiency Residential Windows, Executive Summary; Prepared by Macro International, Inc. for the Northwest Energy Efficiency Alliance; December 1998

Windows, Doors, and Skylights: 2007 Partner Resource Guide;
http://www.energystar.gov/ia/partners/manuf_res/windows/Windows_PRG.pdf

2006 Cost-Effectiveness Analysis Key Assumptions: Energy Star Windows; Northwest Energy Efficiency Alliance; May 8, 2007

Long Term Monitoring and Tracking Report on 2005 Activities; Prepared by Summit Blue Consulting for the Northwest Energy Efficiency Alliance; April 14, 2006

Energy Audit of Building Systems – An Engineering Approach; Moncef Krarti, PhD; (CRC-2000); pg 225

5 BUILDING OPERATOR CERTIFICATION

Building Operator Certification (BOC), which was funded by the Alliance from 1997 through 2003, was offered as a professional development program that teaches facility managers, building operators, maintenance personnel, and others who monitor commercial building controls how to reduce energy and resource consumption in the facilities they operate. The effort was intended to achieve lasting improvement in the energy-efficient operation and maintenance of commercial buildings by developing a market for educated and certified building operators. Since the time that the BOC curriculum and delivery mechanism were firmly established several years ago, BOC has continued to be offered *without* Alliance assistance through the Northwest Energy Efficiency Council (NEEC) and the International Building Operators Association (IBOA, formerly the Northwest Building Operators Association, NWBOA). The program offerings include an initial set of courses that constitute the Level 1 curriculum, while Level 2 is comprised of a second set of somewhat more advanced courses.

This third Long-Term Monitoring and Tracking report for the BOC is intended to assess the current state of the market for certified building operators, including the following:

- Updating previous certification figures;
- Qualitatively assessing the market to determine whether to maintain the current zero baseline; and
- Assessing the validity of current assumptions for energy savings due to certification;

5.1 Assumptions and Indicators for Review

As indicated in the NEEA ACE model, the energy savings impact of the BOC venture is based on the number of operators receiving certification and a series of assumptions regarding the size of the facilities and the percentage of energy consumption that is reduced. Specifically, energy savings for a given calendar year are calculated as follows:

Annual Energy Savings (kWh/year) =
- (1) Number of operators certified within the past five years
- x (2) Square footage per operator
- x (3) Electricity consumption per square foot of participating facilities
- x (4) Savings from certification (as a percentage of electricity consumption).

where:

Number of operators certified within the past five years is based on NEEC and NWBOA records.

Measure life is assumed to be five years, implying that savings are only counted for five years, beginning in the year of certification. If a student receives a Level 2 certification or a certification renewal, then the measure life extends for five years from the most recent date of certification. Throughout the report, building operators who have had a renewal or new certification within five years are referred to as "active building operators."

Square footage per operator is the average number of square feet of building space that is managed by operators receiving certification.

Electricity or gas consumption per square foot of participating facilities is based on office buildings and schools, which are among the most common facilities participating in the BOC training.

Savings from certification (as a percentage of electricity or gas consumption) is a measure of the reduction in facility energy consumption resulting from operator certification.

Additional market transformation indicators include the total number of students who have attended BOC training (regardless of receiving certification) and the total number of Level 1 and Level 2 certifications (regardless of whether the operators' most recent certifications were granted in the past five years, *i.e.*, regardless of whether the ACE model currently counts energy savings associated with the certification).

5.2 Methodology

The 2007 M&T work began with an interview of Andy Ekman of NEEA, who reviewed the present and past BOC activities in the Northwest and advised the M&T process. Following this consultation, a secondary literature search was completed, as well as interviews of select individuals at NEEC and the Northwest Energy Education Institute (NEEI), which delivers the NEEC BOC training in Oregon. Interviewees provided primary insights into BOC in the Northwest and did not suggest any additional secondary literature for review. Certification data from these organizations was obtained. Christine Jerko of NEEA was consulted during the analysis of this data to ensure that the work would be easily integrated into the existing ACE model. Secondary literature was reviewed for potential updates to assumptions from past M&T activities.

In brief, the following data collection activities were conducted:

1. **Contacted NEEC and IBOA staff for the following:**

    a. **Obtained current database of certification activity.** NEEC provided an Excel file containing the certification date, student name and contact information, and some building information for all certifications through December 2007. Counts of certifications from IBOA for 2006 and 2007 were obtained from Andy Ekman at NEEA.

    b. **Interviewed staff to assess views on BOC activity, drivers, impacts, and market perceptions.** Interviews were conducted with Cynthia Putnam of NEEC and Erik Westerholm of NEEI.

2. **Reviewed literature on building energy consumption and operations and maintenance activities.** The current ACE model uses 16 kWh per square foot per year, based on a 2004 publication of the Commercial Building Stock Assessment.. The *Commercial Buildings Operations and Maintenance Market Assessment*, published by NEAA in October 2006, was also reviewed.

3. **Reviewed evaluations of other BOC programs.** Programs reviewed included those from the Northeast Energy Efficiency Partnership and from California.

5.3 Findings

5.3.1 Current Market Activity

Through 2007, the NEEC curriculum had certified 996 building operators and the IBOA curriculum had certified 376 building operators in the Northwest. In total, 946 (69%) of the 1372 operators that have been certified in the Northwest to date were still active at the end of 2007 (Table 1-1). "Active" operators are

those whose five year measure lives have not expired, as determined by whether they have received new or renewed certification within the past five years (*e.g.*, between 2003 and 2007, inclusive). NEEC administrators believe that training activity in the Northwest has reached a steady state, and the NEEC program in particular has expanded to serve other regions of the country.[88]

Table 5-1: Certified Building Operators

	NEEC			IBOA			Combined Total		
Year	**Annual New**	**Annual Retired***	**Total Active****	**Annual New**	**Annual Retired***	**Total Active****	**Annual New**	**Annual Retired***	**Total Active****
1997	1	0	1	18	0	18	19	0	**19**
1998	45	0	46	18	0	36	63	0	**82**
1999	126	0	172	37	0	73	163	0	**245**
2000	125	0	297	37	0	110	162	0	**407**
2001	99	0	396	34	0	144	133	0	**540**
2002	155	1	550	62	18	188	217	19	**738**
2003	105	34	621	41	14	215	146	48	**836**
2004	58	62	617	41	18	238	99	80	**855**
2005	118	50	685	36	14	261	154	64	**946**
2006	76	67	694	26	23	264	102	90	**958**
2007	88	92	690	26	34	256	114	126	**946**
Total	**996**	**306**	**690**	**376**	**120**	**256**	**1,372**	**426**	**946**

* Annual Retired refers to certified building operators whose measure lives have expired because they did not receive a new certification or renewal within five years of the year (table row) in which the data is presented. Annual retirements for IBOA operators were derived by applying the annual renewal rates of the corresponding cohort (by year) of NEEC operators to the IBOA operators.

** Total Active is the number of certified building operators who have receive a new certification or renewal within five years of the year (table row) in which the data is presented. Total active(present year) = Total active (previous year) + Annual new – Annual net retired.

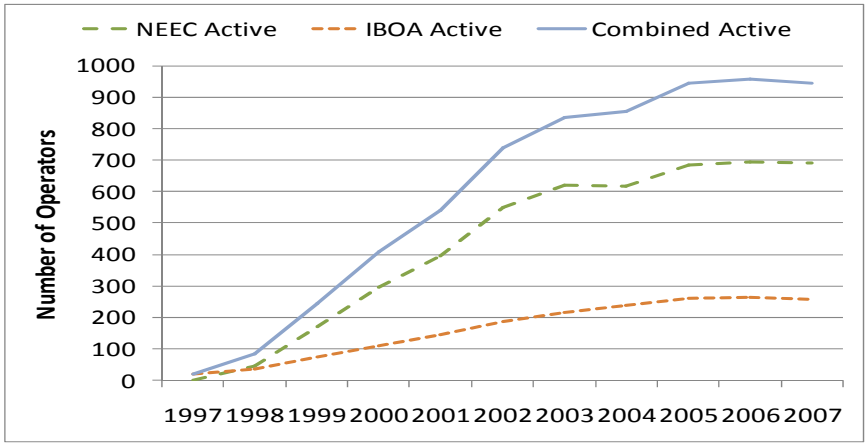
Source: Summit Blue analysis of NEEC certification database and IBOA certification data obtained from Andy Ekman

While new certifications continue at or near historical levels, the number of certified operators who have *not* recertified within the past five years has grown such that that the number of active certified building operators has been essentially flat for the last three years (Figure 5-1).[89]

[88] Interview with Cynthia Putnam, Northwest Energy Efficiency Council, November, 2007.

[89] The lifetime assumption of five years is likely conservative. The intent behind the five year expiration of BOC training is that building operators who do not continue training and certification activities gradually forget what was taught and stop generating energy savings, or they may transfer to new positions or to new facilities that may or may not be within the Northwest. Some O&M measures need to be conducted every year to be successful in saving energy, but other activities, especially equipment upgrade decisions, may have much longer lives. These equipment upgrades represent a large, unknown, potential source of energy savings. If certified building operators continue to push for more energy-efficiency equipment upgrades, they could generate much larger energy savings over a longer period of time than is currently being assumed. However, given the uncertainty (this M&T review identified no available data in the literature on this point), it seems reasonable to continue with the current assumptions for measure lifetime. If the rate of renewals among certified building operators continues to increase, the lifetime assumption will become less important.

Figure 5-1. Trend in Number of Active Certified Building Operators, 1997-2007



Source: Summit Blue analysis of NEEC certification database and IBOA certification data from Andy Ekman

The nationwide profile of BOC training has risen dramatically over the last 10 years. In 2006, the National School Plant Management Association entered into a partnership with NEEC to provide training and credentialing for members through the BOC program[90]. The NEEC BOC program is now offered in eight states in the Northeast, California, North Carolina, Wisconsin, and through the Midwest Energy Efficiency Alliance in Illinois, Iowa, Minnesota, Missouri, and Ohio. The elevated nationwide profile of BOC training may lead to increased awareness and support of BOC training among national corporate decision makers, which could lead to an increase in BOC training activity. National BOC growth continues at a rapid rate.

Building operator certification in the Northwest may increase in the future as a result of these national market impacts, as well as other reasons. The total number of active certified building operators, as tracked currently, is a lagging measure of market activity because unengaged building operators are retired five years after their last certification. The high number of retirements in 2007 are a direct result of the high number of new certifications in 2002. As a result, the number of retirements in future years may decrease, which could lead to an increase in the number of certified building operators if new certification and renewal activity continues at the current pace. Utility incentives clearly play a role in building operator certification. While utility incentives for building operator certification are very small in Washington and Oregon, [91] utility incentives still play a large role in Idaho and Montana. In 2007, no utility incentives for building operator training were offered in Idaho and no building operator certification training occurred in Idaho. [92] Future training activity in Idaho and Montana is likely to depend on utility incentives, at least in the near term.

5.3.2 Baseline Activity

The baseline activity for building operator certifications was clearly zero before NEEC and IBOA training started in the 1990s. They were the first programs of their kind when they were developed. Studies of nationwide BOC training have specifically stated that BOC training was started in the Northwest by

[90] NEEC, *NSPMA and NEEC Announce Educational Partnership to Offer Building Operator Certification Program for Energy Efficiency*, October 2006, http://www.theboc.info/ne/pdf/PRelease_NSPMA_10_30_06.pdf

[91] Conversations with Cynthia Putnam, NEEC, and Erik Westerholm, NEEI, November, 2007.

[92] Conversation with Andy Ekman, NEEA, November, 2007.

IBOA and NEEC and championed and supported by NEEA in the early stages.[93] BOC training has now expanded to the Northeast, Midwest, and Southwest, utilizing curricula developed by NEEC and IBOA. There are no comprehensive building operator training curricula being offered other than those developed by NEEC and IBOA. It is clear from the literature that formal building operator training has its roots in the Northwest and continues to grow nationally from this base.

However, it is likely that informal educational outreach and training activities would have captured some of the same savings currently being captured by formal training of building operators. The ideas and strategies for saving energy presented in the BOC curricula are not unique, only the delivery method. Some of these same ideas and strategies for savings energy may have become known to a certain fraction of building operators *with or without* formal BOC training, via informal educational delivery methods, such as best practices guides, articles in trade publications, and in-house sharing of knowledge from self-motivated champions of energy efficiency. However, there is little evidence in the current research to suggest that a non-zero baseline is warranted at this time.

5.3.3 Per-Unit Energy Savings

Energy savings achieved by each active, certified operator are assumed to be the product of the final three factors of the energy savings equation described in Section 5.1, namely:

- Square footage per operator
- Electricity consumption per square foot of participating facilities
- Savings from certification (as a percentage of electricity consumption).

Square Footage per Operator

The area under management by each building operator is highly variable, with program participants reporting areas ranging from 4,000 square feet to four million square feet. The value used in the 2005 M&T report, 355,000 square feet per building operator, was based on the most recent MPER and supported by two years of M&T assessments. The most recent data, from 2006 and 2007, show that the average size of facilities managed by certified operators actually *increased* over previous years. (NEEC participants reporting facility area through 2007 averaged 527,000 square feet, as compared to 492,000 through 2005 when the last M&T assessment was performed.

While this increase in facility size of more than 5% continues a trend that was first identified in the 2004 M&T assessment, it is not sufficient to warrant increasing the assumed value for purposed of estimating the average (per-unit) energy savings from operator certification. The assumed value will remain at 355,000 square feet per building operator due to the uncertainty in how the data is provided to NEEC and the fact that it is not know with certainty how many operators may be reporting building areas for the same facilities as other operators receiving certifications.

Electricity Consumption per square foot of participating facilities

The 2005 M&T input value of 16 kWh/ft^2 for the annual electricity consumption at participating facilities is an appropriate value for use in the savings analysis. As discussed in the 2004 and 2005 M&T reports,

[93] Marjorie McRae and Beatrice Mayo, *What Building Operators are Saying about BOC Training*, ACEEE 2006 Summer Study

this value was proposed by the Alliance in March 2004, it was based on recently published data, and it is consistent with values for multiple relevant building types and from multiple sources.

Savings from certification

The assumed percent energy savings realized as a result of BOC certification is 2.5%. Multiplying this value by the assumed energy intensity (above) of 16 kWh/ft^2 yields and estimate of 0.4 kWh of savings per square foot, which is consistent with a study prepared for Northeast Energy Efficiency Partnerships (NEEP) by RLW Analytics,[94] which calculated minimum annual savings 0.4 kWh/sq.ft. for non-schools. These estimates were based on engineering estimates for savings associated with certain O&M actions and on surveys of Certified Building Operators to determine the frequency with which these O&M actions were performed. The estimates do not cover the full range of possible O&M activities associated with the training, so they likely underestimate the savings associated with BOC. The current percent energy savings may be conservative, but there is no conclusive evidence to change this assumption.

As stated above, the **energy savings per certified building operator** is the product of the following factors:

	355,000 square feet per operator
x	16 kWh electricity consumption per square foot per year
x	2.5% savings

which equals 142,000 kWh of annual savings per operator, the same as in the 2005 M&T report.

5.4 Conclusions/Recommendations

Building Operator Certification activities have continued at just over 100 new certifications per year in the Northwest since 2006, as both NEEC and IBOA continue to provide building operator certification training within the region and in other regions of the country. Due to the fact that some operators certified more than five years ago have not renewed their certifications (and are thus considered "retired", the growth in the number of certified building operators in the Northwest has dropped off and the number of "active" certified building operators is now essentially flat. Specific findings from the 2007 M&T assessment include the following:

- **The number of certified building operators has begun to level off at roughly 950 operators in the Northwest.** Both Cynthia Putnam of NEEC and Erik Westerholm of NEEI indicated that they were seeing certifications level off, and that they thought they were near saturation in the current market.
- **Trainings by IBOA are sensitive to utility incentives.** While utility incentives have been mostly eliminated in Oregon and Washington, utility incentives are still a primary driver of BOC training in Idaho and Montana. There were no BOC training incentives in Idaho in 2007, which resulted in no BOC trainings in Idaho in 2007. Meanwhile, Montana continued to have utility incentives and BOC training.

[94] RLW Analytics, *Impact and Process Evaluation: Building Operator Training and Certification (BOC) Program Final Report*, Prepared for Northeast Energy Efficiency Partnerships, June 2005

- **Nationwide BOC training activity has increased dramatically.** Training activity in the Northwest is now dwarfed by the total national training. Curricula from NEEC and IBOA are being used in the Midwest, Northeast, and Southwest for BOC training.

The number of active certified building operators in both 2006 and 2007 is nearly 10% lower than the number reported by NEEA in 2006. It appears that the NEEA analysis inadvertently tallied some certification renewals as new operators due to the manner in which updated databases from NEEC and IBOA were integrated with existing NEEA records. Adjusting for this discrepancy results in a proportional reduction in the implied savings, from 16.8 aMW in 2006 to 15.3 aMW in 2007 (Table 4-15).

Table 5-2: M&T Recommendations for Key Indicators

Key Indicators Reviewed	NEEA 2006 Cumulative Values*	2007 Recommended Cumulative Values	Source
Current Market Activity			
Number of Active Certified Building Operators	1039	946	NEEC and IBOA; see Section 5.3.1
Baseline Activity			
Number of Active Certified Building Operators	0	0	Interviews; see Section 5.3.2
Per-Unit Energy Savings			
kWh/operator per year	142,000	142,000	See Section 5.3.3, ACE Model.
Implied Energy Savings**			
Implied Energy Savings (aMW)	16.8	15.3	aMW = MWh divided by 8760 hours

*NEEA 2006 values from Excel file "2006 MAR Cumulative Savings 04-03-07.xls"

** Implied energy savings are presented for comparison purposes only between NEEA's 2006 values and the 2007 M&T findings. NEEA's reported values may not match those presented here since NEEA adjusts for the effect of utility incentives and other factors not taken into account in this M&T analysis.

The following **recommendations are intended to guide future M&T work:**

- **Obtain annual BOC tracking database updates directly from NEEC and IBOA for integration into the spreadsheet model developed by Christine Jerko.** Both IBOA and NEEC now have functional tracking databases that track building operator certification and renewal activities, and NEEA has a good tool for calculating the number of active certified building operators.

- **Modify the NEEA tracking spreadsheet to account for missing IBOA data.** It appears that the database provided by IBOA—which did not exist until the past few years—may be missing some records from prior to 2006. Therefore, NEEA's spreadsheet model should be supplemented with certification activity that was collected by Andy Eckman and provided to Summit Blue for the 2004 and 2005 M&T assessment but that is missing from the database. (This 2007 assessment used the original data from Andy Eckman and added only the 2006 and 2007 certification activity that was contained in the IBOA database.)

- **Consider eliminating the need to track recertifications and retirements of individual operators by using historical recertification data to estimate how many years newly certified operators remain "active."** For example, under this approach for 2008, NEEA would estimate active certifications by 1) adding newly certified operators listed in the 2008 databases and then 2) applying values for the percentage of "active" operators whose certifications "retire" in 2008. Retirements would be based on the number of new certifications from each year's cohort (going back to 1998) that is assumed to retire, based on historical retirement rates after five years, six years, seven years, etc. from the date of the original certification. In the records that NEEA currently has, there is robust data concerning recertification rates, especially for the years immediately following initial certification. This approach would be less costly than maintaining a BOC tracking database over time, and only require annual new certification data to be collected.

- **Update energy savings assumptions every other year as potentially conclusive new data becomes available,** such as through BOC evaluations for other programs. One issue that may affect the assumed energy savings per operator is the possible increase in awareness of energy savings measures among building operators as electricity prices rise and environmental concerns have taken a greater prominence in the media. It is possible that informal educational outreach and training activities would have captured some of the same savings currently being captured by formal training of building operators. The ideas and strategies for saving energy presented in the BOC curricula are not unique, only the delivery method. Some of these same ideas and strategies for savings energy may have become known to a certain fraction of building operators *with or without* formal BOC training, via informal educational delivery methods, such as best practices guides, articles in trade publications, and in-house sharing of knowledge from self-motivated champions of energy efficiency.

5.5 Bibliography

Interview with Andy Ekman, Northwest Energy Efficiency Alliance, November, 2007.

Interview with Cynthia Putnam, Northwest Energy Efficiency Council, November, 2007.

Interview with Erik Westerholm, Northwest Energy Education Institute, November, 2007.

KEMA-XENERGY, *Assessment of the Commercial Building Stock in the Pacific Northwest*, Prepared for Northwest Energy Efficiency Alliance, 2004

Marjorie McRae and Beatrice Mayo, *What Building Operators are Saying about BOC Training*, ACEEE 2006 Summer Study

NEEC, *NSPMA and NEEC Announce Educational Partnership to Offer Building Operator Certification Program for Energy Efficiency*, October 2006, http://www.theboc.info/ne/pdf/PRelease_NSPMA_10_30_06.pdf

Quantum Consulting, *Commercial Building Operations and Maintenance Market Assessment*, Prepared for Northwest Energy Efficiency Alliance, 2006.

RLW Analytics, *Impact and Process Evaluation: Building Operator Training and Certification (BOC) Program Final Report*, Prepared for Northeast Energy Efficiency Partnerships, June 2005.

6 ENERGY STAR HOME PRODUCTS

The Energy Star Home Products (ESHP) program was active from March 2001 through the first quarter of 2004. Created with the goal of increasing demand for and sale of high efficiency clothes washers, dishwashers, and refrigerators, the program focused on relationships with key market actors as its core strategy for achieving success. Through targeted public outreach campaigns as well as partnerships with manufacturers, utilities, and retailers, the program staff deployed a set of tools that would enhance consumer awareness about Energy Star Home Products and their non-energy benefits, including cost savings. According to the Energy Star Home Products Market Progress Evaluation Report (MPER) No. 2, "it has effectively involved utilities, retailers, manufacturers, and consumers in recognizing and embracing high efficiency appliances."[95]

The ESHP program around clothes washers was sandwiched in between two other NEEA efforts in the market for energy efficient clothes washers. ESHP built on NEEA's prior involvement in the market, which began with the WashWise Program (1997 through 2000). Prior to NEEA's involvement in WashWise, there was no Energy Star standard for clothes washers. NEEA helped open the market for Energy Star clothes washers in the Northwest. Following ESHP, NEEA continued its active role in the market for clothes washers. This later effort was designed to promote ultra-high efficiency clothes washers and to increase the Energy Star specifications.

This M&T effort includes NEEA's involvement in the market for Energy Star clothes washers, dishwashers, and refrigerators. For dishwashers and refrigerators, this involvement is limited to NEEA's ESHP program. For clothes washers, this includes NEEA's WashWise and ESHP programs as they relate to clothes washers; it does not include the Consumer Products program's focus on ultra-high efficiency clothes washers.

This first Energy Star Home Products M&T effort is focused on determining the extent to which the market transformation is evident in the purchasing behavior of Energy Star dishwashers, clothes washers, and refrigerators by consumers in the Northwest. Using sales data for the Northwest and the nation, this M&T report will discuss the baseline activity and per-unit energy savings generated by these measures.

6.1 Assumptions and Indicators for Review

Calculating the energy savings created by the sale of the appliances covered by the Energy Star Home Products program will be done using a spreadsheet model developed by NEEA based on input from the Regional Technical Forum. Inputs used to determine energy savings include the following:

- Quantity of each appliance that was sold in the Northwest.
- Energy savings per unit.

Energy savings are calculated by multiplying these factors together for each category of appliance separately; the savings by category are then summed to estimate the aggregate program effects. A more formal equation for each appliance's energy savings calculation follows:

[95] Dethman & Associates. *Energy Star Home Products Program: Market Progress Evaluation Report, No. 2.* August 24, 2005. Prepared for NEEA, Report #E04-131.

Gross Annual Energy Savings for appliance type X (kWh/year) =

Number of units of Energy Star appliance type X * Per-unit capacity energy savings for appliance type X (kWh/year)

Where:

- **Number of units of Energy Star appliance X is** the total number of the specific Energy Star appliance type in use in the Northwest, and
- **Per-unit capacity energy savings for appliance type X** is the annual energy savings for each appliance type.

Other factors that may be relevant to evaluating the net market impacts include the following:

- National and regional market share data (which may provide insight into the level of baseline market activity)
- Effect of utility incentives in sale of Energy Star home products

6.2 Methodology

In order to determine the Energy Star Home Products program's market effects, data about the three product types' baseline activity, current market activity, and anticipated future activity was gathered and analyzed. The first part of this M&T effort focused on the market-level activity and how NEEA's Energy Star Home Products program contributed to that activity. The second part of the effort involved verifying per-unit savings estimates currently being used by NEEA.

- **Interview with Marci Sanders (formerly of NEEA).** Ms. Sanders provided information about the program's history as well as some background information on the market prior to the development of the NEEA program.

- **Interview with Christine Jerko (NEEA).** Ms. Jerko assisted Summit Blue in obtaining Association of Home Appliance Manufacturers (AHAM) sales data for the nation and the Northwest. She also explained NEEA's method of estimating the baseline.

- **Review of per-unit energy savings spreadsheets provided by Tom Eckman (Regional Technical Forum).** Mr. Eckman provided spreadsheets that were used to calculate per-unit energy savings for 2007, using the latest federal and Energy Star standards. These spreadsheets were reviewed in detail with special attention given to the savings algorithm and the input assumptions.

- **Analysis of AHAM sales data reports from 2000 to 2006.** These reports were analyzed to approximate current and baseline market activity from a top-down perspective. Market activity for 2007 was projected based on earlier years' activity.

- **Analysis of D&R reports for clothes washers from 1998 to 2000 (provided by NEEA).** These reports were used to study the market trend before NEEA's program came into place, an important element in estimating the baseline.

- **Review of available Market Progress Evaluation Reports (MPERs).** The two available MPERs were studied to review how the market for ESHP has evolved since the start of the program.

- **Review of the Energy Star website.** The Energy Star website was reviewed specifically for the purpose of comparing the assumptions made to calculate per-unit energy savings for all three home products. The Energy Star calculators were downloaded and their inputs and calculations were studied. Section 0 on per-unit energy savings highlights differences among the Energy Star assumptions and the Regional Technical Forum's (RTF) assumptions, which underlie NEEA's estimates.

6.3 Findings

This section presents Summit Blue's findings after conducting interviews, reviewing secondary sources, and analyzing the gathered information. Summit Blue's findings have been presented in the following manner:

- **Section 6.3.1 Market Activity** – This section focuses on recent market activity for each of the three home appliances in question. Present market activity is determined and future market trends are predicted using information gathered on the market from the inception of the program to the present.

- **Section 6.3.2 Baseline Activity** – NEEA already has a method for estimating the baseline market trend for Energy Star Home Products. This estimated baseline was analyzed and some changes were recommended.

- **Section 6.3.3 Per-Unit Energy Savings** – NEEA uses per-unit energy savings figures as estimated by the RTF. The RTF spreadsheets were analyzed to validate the calculation procedure, assumptions made, and inputs to the model.

6.3.1 Market Activity

NEEA's projects supporting Energy Star equipment have generated increased market acceptance of Energy Star products by raising awareness amongst both retailers and consumers. [96] The market share of Energy Star home products has increased substantially for all three appliance types and so have the sales for these products. The top success of the program was increasing the awareness of retailers of the Energy Star brand of appliances and lighting.[97] This section presents the following metrics to quantify market trends for the three appliance types:

- **Market Units -** This is the total number of appliances (Energy Star and non-Energy Star) that have been sold in the Northwest from the beginning of NEEA's involvement in the market for each appliance (1999 to 2007 for clothes washers, 2001 to 2007 for dishwashers and refrigerators).

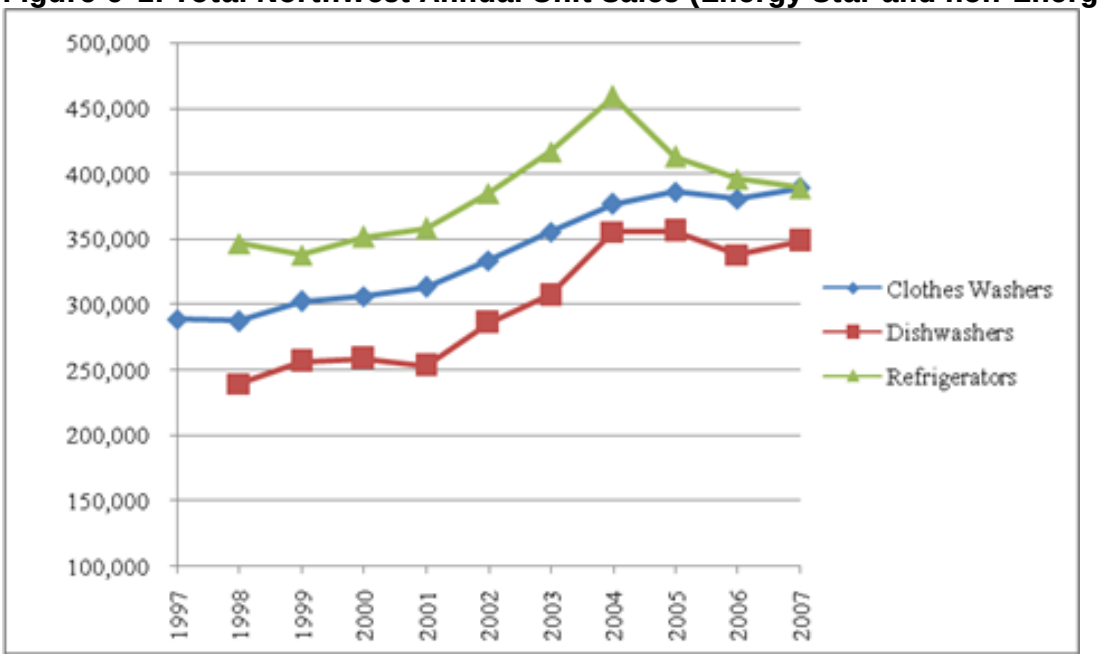
[96] *Ibid.*

[97] Interview with Marci Sanders, NEEA.

- **Energy Star Market Share** – This is the percentage of units sold in the Northwest that are rated Energy Star.

The first step in estimating current market activity is to forecast the total (Energy Star and non-Energy Star) units sold in the Northwest for each of the appliance types (clothes washers, dishwashers, and refrigerators). Market trends from 1998 through 2006 were analyzed for the three appliance types (Figure 6-1). While annual sales for each appliance type increased through 2004, sales seem to have reached a plateau since 2004 (and in the case of refrigerators, sales have declined). As there is no obvious trend in unit sales from 2004 to 2006, the change in sales from 2006 to 2007 was estimated to be the average change in sales from 2004 to 2006.

Figure 6-1. Total Northwest Annual Unit Sales (Energy Star and non-Energy Star)



Source: AHAM sales data and Summit Blue's analysis

Clothes Washers

As discussed earlier, NEEA's involvement in the market for energy efficient clothes washers spans three programs, the first of which began in 1997 and the last of which concluded in 2006. As shown in Figure 6-1 above, the annual sales of clothes washers have shown a steady increase throughout the program. Table 6-1 shows the trend in Energy Star clothes washer sales and market share as a percentage of all units sold in the Northwest from 2001 to 2007. The decrease in market share in 2004 can be attributed to the change in Energy Star standards that took effect in 2004. The market share increased in 2005 and then remained constant from 2005 to 2006.[98]

[98] AHAM projections for 2006, available at http://www.northwestenergystar.com/index.php?cID=226.

Table 6-1. Clothes Washer Unit Sales in the Northwest[99]

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007*
Energy Star Market Share	8%	13%	12 %	19%	21%	32%	43%	38%	46%	46%	46%
Energy Star Units Sold	21,820	37,100	37,114	58,142	66,919	106,064	152,365	144,005	177,938	175,181	179,004

Source: Summit Blue analysis of AHAM data from www.energystar.gov and AHAM data provided by NEEA

*Market share for 2007 was assumed to remain constant from 2006 to 2007; unit sales were estimated by multiplied the assumed market share by the total unit sales (based on AHAM data).

Since actual sales data for 2007 were not available, market share in 2007 was held at the same level as 2006 due to the fact that both federal and Energy Star efficiency standards were increased, effective January 1, 2007.[100] Only one previous data point, 2004 sales, is available to serve as a reference for these circumstances. In 2004, Energy Star standards were raised, and sales of Energy Star clothes washers experienced a temporary decrease. Manufacturers can experience some lag time in producing appliances that meet the new standards, which decreases the availability of Energy Star appliances in the first year of the new standard. In cases where increases in the cost of the appliance are realized due to the improved efficiency, consumers may be less willing to immediately purchase an appliance that meets the new standards. Since only one data point existed for estimating the change in market activity due to revised standards, market share was simply held constant, rather than decreasing the sales by some arbitrary amount.

Dishwashers

Market activity for both dishwashers and refrigerators is only examined during and after the ESHP program since NEEA was not involved in these markets prior to that program. Energy Star dishwasher market share increased from less than 20% in 2001 to 81% by the end of the program in 2004 (Table 6-2).[101] Market share further increased to 88% in 2005 and remained at that level in 2006 as well. With a market share of nearly 90%, it is difficult to predict changes in future market share as the market is close to saturation; thus, market share for 2007 was assumed to remain at 88%. Energy Star has new standards that became effective on January 1, 2007.[102]

[99] 2007 numbers are projected by Summit Blue and 2006 numbers are AHAM projections available on the Energy Star website.

[100] Energy Star minimum standard was raised from a minimum Modified Efficiency Factor (MEF) of 1.42 to 1.72 and the federal standard was raised from a minimum MEF of 1.04 to 1.26 as per http://www.energystar.gov/ia/partners/product_specs/program_reqs/CW_ProgramRequirements_2007.pdf.

[101] AHAM data as provided to Summit Blue by Christine Jerko.

[102] http://www.energystar.gov/ia/partners/product_specs/program_reqs/dishwash_prog_req.pdf

Table 6-2. Dishwasher Unit Sales in the Northwest[103]

	2001	2002	2003	2004	2005	2006	2007*
Energy Star Market Share	18%	29%	55%	81%	88%	88%	88%
Energy Star Units Sold	45,703	83,237	169,885	288,164	313,553	297,871	306,909
Source: Summit Blue analysis of AHAM data from www.energystar.gov and AHAM data provided by NEEA *Market share for 2007 was assumed to remain constant from 2006 to 2007; unit sales were estimated by multiplying the assumed market share by the total unit sales (based on AHAM data).							

Refrigerators

Market share for Energy Star refrigerators in the Northwest steadily increased during NEEA's program from 2001 to 2004. After the program ended in 2004, the sales increased by less than 1% to 39% in 2005. Then, market share stayed constant at 39% for 2006. Generally speaking, the incremental increase in energy savings from federal efficiency refrigerator standards to Energy Star refrigerators is not substantial enough to make manufacturers set and achieve more ambitious efficiency goals.[104] This is likely why we are not seeing a regular increase in the market share of Energy Star refrigerators. Taking a conservative view, the M&T team estimated that the market share would stay constant at 39% for 2007 as well.

Table 6-3. Refrigerator Unit Sales in the Northwest

	2001	2002	2003	2004	2005	2006	2007
Energy Star Market Share	17%	23%	28%	38%	39%	39%	39%
Energy Star Units Sold	60,052	89,755	117,164	175,619	160,218	153,695	151,040
Source: Summit Blue analysis of AHAM data from www.energystar.gov and AHAM data provided by NEEA							

6.3.2 Baseline Activity

To estimate the baseline market activity, NEEA divides the nation into three distinct regions: Northwest, active, and inactive regions. All states that have Energy Star-related promotional activity are classified as active states; the rest of the states are classified as inactive. The states in the Northwest are not included in either the active or inactive region. Until 2005, the market share in the inactive region was taken as the baseline market share rate for the Northwest region. For the years 2006 and beyond, NEEA considers the national average to be the baseline market share.[105] NEEA concluded that there was no longer any region in the country devoid of any Energy Star promotional activity.[106]

[103] 2007 values forecasted by Summit Blue, 2006 values are those projected by AHAM and Energy Star as per http://www.northwestenergystar.com/index.php?cID=226.

[104] Marci Sanders stated that the federal standard for refrigerators is very efficient; the Energy Star standard is not enough higher to make manufacturers set and achieve goals. The average per-unit savings for an Energy Star refrigerator is 91 kWh/year, relative to the average per-unit consumption for a non-Energy Star refrigerator of 573 kWh/year. See Section 0 for more details on per-unit energy savings.

[105] Information obtained from Summit Blue's interview with Christine Jerko, NEEA.

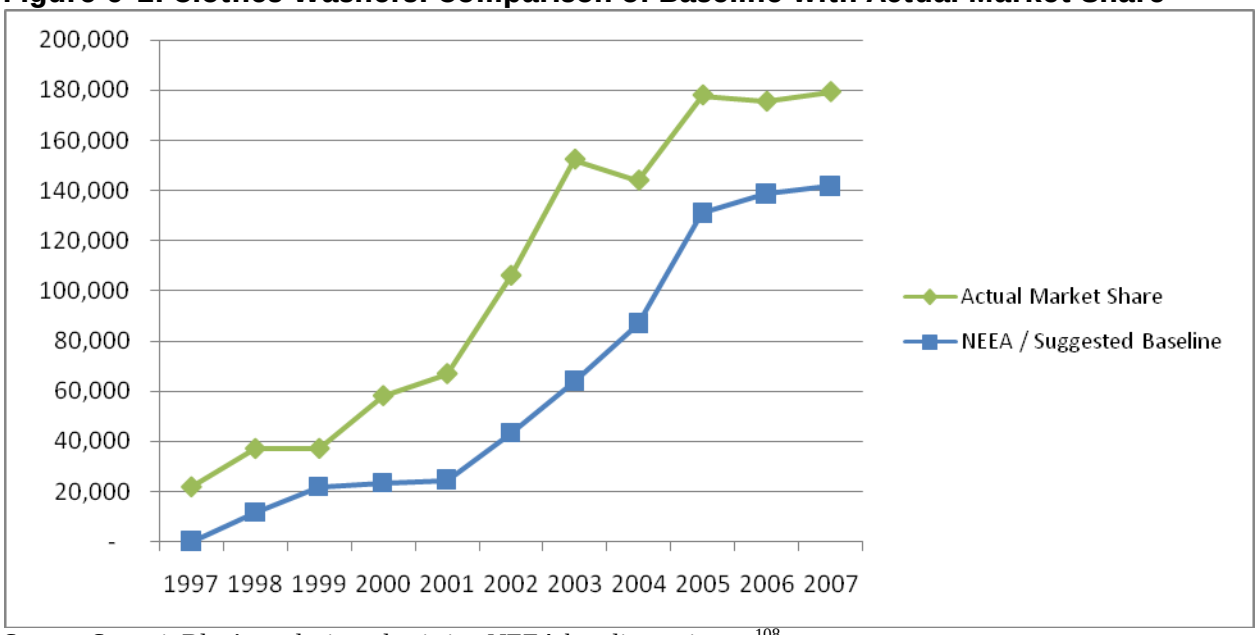
[106] The difference in market share between the inactive regions and the national average was small in 2005 (less than 5% in all three cases).

While the general approach of using either the national average or the inactive region's market share as a baseline is sound, a slight modification to this approach is recommended. For one of the two home products covered only by the ESHP program (dishwashers), the Northwest was behind the inactive region and the national average in Energy Star market share before NEEA's program began. Summit Blue suggests decreasing the baseline by the difference between the Northwest region and the inactive region prior to when NEEA's involvement to account for this discrepancy. NEEA's baseline estimates and Summit Blue's revised estimates are provided in graphical form in the following discussion. The overall effect of this change on Energy Star dishwashers was negligible but still worth noting.

Clothes Washers

For clothes washers, such an adjustment is not necessary. NEEA launched its involvement in the market just as the Energy Star specification was created. Although the Northwest market was ahead of the inactive and national markets when the ESHP program began in 2001, NEEA's prior involvement in that market accounts for the difference. As a result, the baseline for clothes washers is unaffected by this type of adjustment. The M&T team agrees with NEEA's baseline, which is shown in Figure 6-2.

Figure 6-2. Clothes Washers: Comparison of Baseline with Actual Market Share[107]



Source: Summit Blue's analysis and existing NEEA baseline estimate.[108]

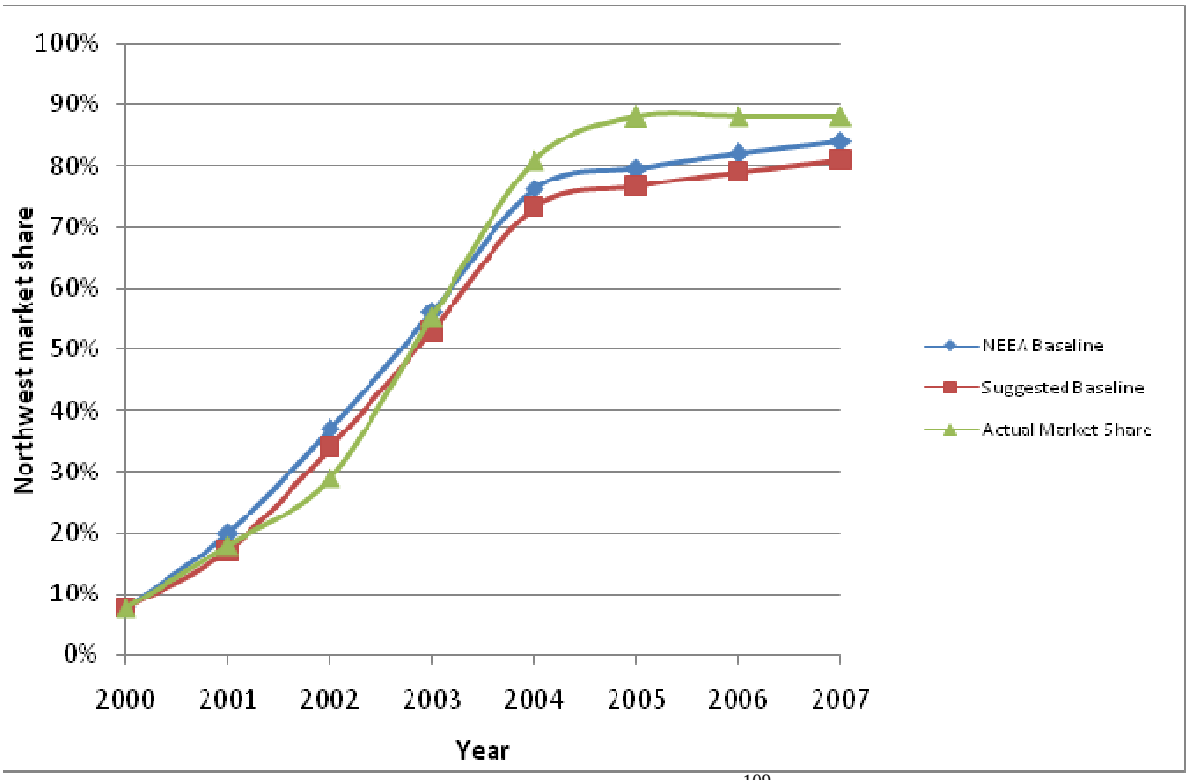
Dishwashers

The baseline market activity for dishwashers was adjusted as described earlier. The Energy Star market share in the Northwest was 2-3% *lower* than the national average and the inactive region before NEEA's program started. This trend was taken into account and the baseline market activity projected by NEEA was lowered to adjust for this discrepancy.

[107] Baseline estimate for 2007 was projected based on AHAM sales data for the previous six years.

[108] Data obtained through correspondence with Ms. Christine Jerko.

Figure 6-3. Dishwashers: Comparison of NEEA's Baseline with Suggested Baseline



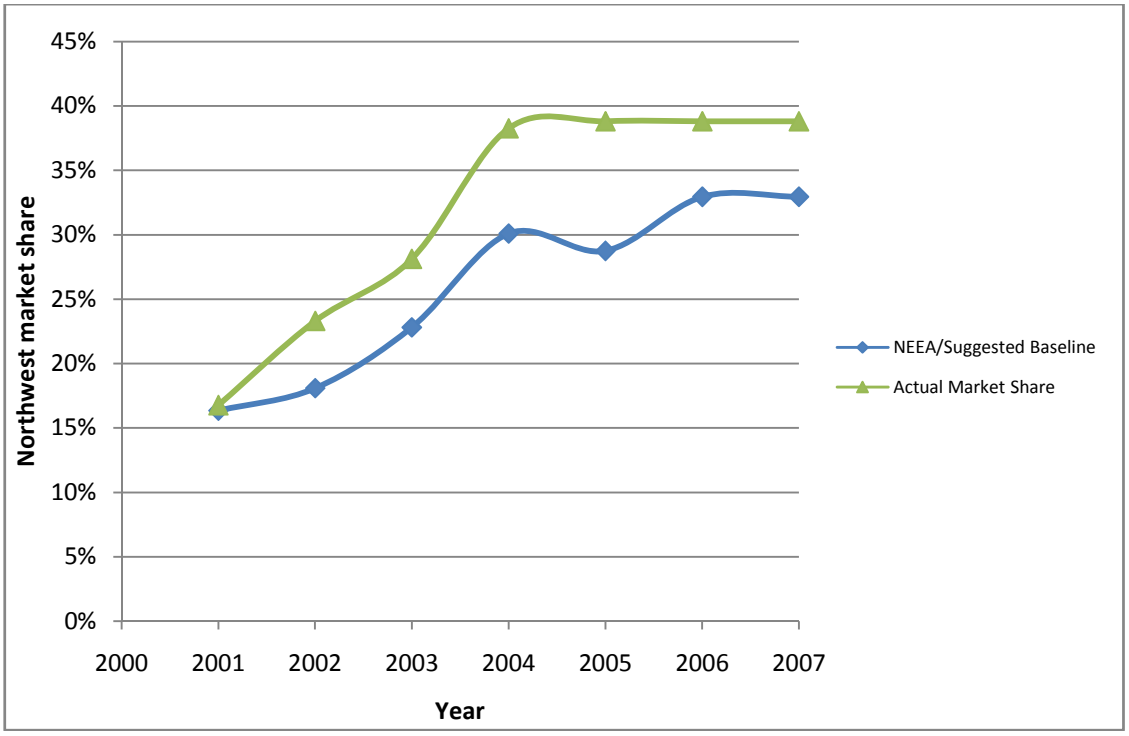
Source: Summit Blue's analysis and existing NEEA baseline estimate[109]

Refrigerators

For refrigerators, no changes are recommended to NEEA's baseline estimate because the Northwest market share was the same as the national average in 2001.

[109] Baseline estimate for 2007 was projected based on AHAM sales data for the previous six years.

Figure 6-4. Refrigerators: Comparison of NEEA's Baseline with Suggested Baseline



6.3.3 Per-Unit Energy Savings

NEEA's method of calculating per-unit energy savings was reviewed for each of the three appliance types. Table 6-4 presents the values from the RTF spreadsheet models provided by Mr. Tom Eckman. The M&T team studied and verified key inputs and assumptions of the models along with the calculation methodologies.

Table 6-4. Per-Unit Energy Savings

Appliance	Per-unit energy savings from 2001 to 2004	Per-unit energy savings 2004 to 2007	Per-unit gross energy savings (kWh/unit) for 2007 and beyond
Clothes washers			
Tier I (MEF 1.26 – 1.41)	337.9	-	-
Tier II (MEF 1.42 – 1.79)	416	416	142
Tier III (MEF > 1.8)	471	471	296
Dishwashers	97	97	136
Refrigerators	50	92.9	92.9
Source: RTF spreadsheets, NEEA savings assumptions 2006 as provided by Ms Christine Jerko.			

Clothes Washers

The measure of efficiency of clothes washers has changed since the WashWise program began in 1997.[110] Since 2004, both Energy Star and federal standards for clothes washer efficiency have used the Modified Energy Factor (MEF) to represent a unit's energy efficiency. MEF is the energy used per cycle normalized by clothes washer capacity; the units are cubic feet/kWh/cycle. Energy savings calculations for Energy Star clothes washers are dependent on two assumptions: kWh/cycle and cycles per year. The annual energy consumption of a clothes washer can be calculated by the following equation:

Savings (kWh/year) = cycles/year * kWh/cycle

Prior to the MEF, both Energy Star and federal standards used the Energy Factor (EF) to measure clothes washer efficiency. While Energy Star moved to the MEF in 2001, the federal standard used the EF until 2004. EF is essentially the same as the MEF, except that it includes one fewer input.

The M&T team reviewed RTF's method of calculating energy savings for Energy Star clothes washers, and the assumptions and calculation algorithms were found to appropriately include this change as well as other relevant inputs. The most important inputs to the model are the amount of water used by the clothes washer and the number of cycles per year. RTF's values for these two inputs were compared with the inputs used by the Energy Star calculator. Although the RTF differed from the DOE in the number of cycles per year, RTF data was based on research done in the Pacific Northwest. This local input (352 cycles per year) is preferred over the national average (392 cycles per year).[111]

Table 6-5 shows recent changes in both Energy Star and federal efficiency standards.

Table 6-5. Clothes Washers: Change in Energy Star and Federal Standards

Standard	As of January1, 2004	As of January1, 2007
Energy Star	MEF > 1.42	MEF > 1.72
Federal	MEF > 1.04	MEF > 1.26
Note: Modified Energy Factor (MEF) represents the energy used by a clothes washer during one cycle (normalized by capacity) and uses the units cu.ft/kWh/cycle.		

The assumptions made by NEEA to calculate the energy savings from clothes washers were found to be relevant. The RTF spreadsheet uses updated efficiency numbers to reflect the change in Energy Star and federal standards.

---

[110] All information about the MEF and EF is from
"Clothes Washers Key Product Criteria." Energy Star. Available:
http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers
"*Energy Star Criteria for Clothes Washers – Overview of Energy Star Criteria Setting Process and History of Clothes Washer Criteria.*" R.H. Karney, P.E. August 2004. Available:
http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/clotheswash/4CW083104MeetingKarney_final.ppt

[111] Energy Star lists DOE (2007) research as its source for its cycles/year values. The Energy Star assumption would lead to an increase in per-unit energy savings by 11%.

Refrigerators

The savings from the use of an Energy Star refrigerator was aggregated after compiling data on Energy Star and non-Energy Star refrigerators. These were separated first by configuration, then by manufacturer, model number, and volume. For each refrigerator, the annual energy savings were calculated by simply subtracting the total consumption of an Energy Star refrigerator from the energy consumption of its corresponding federal standard refrigerator. A weighted average of these savings was calculated to develop a single estimate of per-unit savings for Energy Star refrigerators, weighted by the market share of each configuration type. Table 6-6 shows the energy savings for each configuration and its weighting.

Table 6-6. Annual Savings for Energy Star Refrigerators

Refrigerator Configuration	Annual Savings (kwh/yr)	Weights [112]
Energy Star Refrigerator with Bottom Freezer - No Ice	101	5.6%
Energy Star Refrigerator with Bottom Freezer - Ice	156	0.0%
Energy Star Refrigerator with Top Freezer - Ice	86	33.3%
Energy Star Refrigerator with Top Freezer - No Ice	84	38.9%
Energy Star Refrigerator with Side-by-Side - No Ice	110	5.6%
Energy Star Refrigerator with Side-by-Side - Ice	120	16.7%
Average Weighted savings	**92**	**100 %**
Source: Summit Blue's analysis of RTF savings spreadsheets.		

The per-unit savings estimates calculated by the RTF for NEEA were found to be correct. The RTF uses measured consumption data for 1,534 different Energy Star refrigerators and their corresponding (same configuration type) federal standard refrigerators to calculate savings for different categories of refrigerators. AHAM sales data is used to calculate aggregated per-unit energy savings.

Dishwashers

The annual per-unit energy consumption for dishwashers is calculated using an Energy Factor (EF) and total washer cycles per year. The EF is the measure of energy consumed per cycle and has the units "cycle/kWh." The annual energy consumption for dishwashers is calculated by the formula:

kWh = Cycles per year / EF

The inputs for the Energy Star calculator and the RTF calculator are almost identical, with the only difference being that Energy Star considers average annual use to be 215 cycles/year, whereas the RTF model uses a value of 212; the difference is negligible and the RTF value is based on a survey done in the Pacific Northwest, so no change to RTF's assumption is recommended.

Table 6-7 compares input assumptions used by RTF and Energy Star. The average annual per-unit savings are 136 kWh.

[112] These weights are based on AHAM sales data for 2005.

Table 6-7. Dishwashers: Comparison of Inputs to Calculate Annual Energy Consumption

	Conventional unit		Energy Star	
	RTF	Energy Star	RTF	Energy Star
Number of cycles/year	212	215	212	215
EF (cycles/kWh)	0.46	0.46	0.65	0.65
Source: RTF per-unit energy savings spreadsheets and Energy Star calculators available at www.energystar.com.				

As NEEA's assumptions are based on measured data and correlate well with assumptions made by Energy Star to calculate per-unit energy savings, Summit Blue concludes that NEEA's per-unit energy savings estimate is accurate.

6.4 Conclusions/Recommendations

NEEA's projects supporting Energy Star equipment have increased market acceptance of Energy Star products by raising awareness amongst both retailers and consumers. [113] The market share of Energy Star home products has increased substantially for all three appliance types, as have the sales for these products. The following are the major conclusions of this M&T research:

- Energy Star refrigerators have not achieved the same amount of market share that clothes washers and dishwashers have. This is thought to be because the difference in efficiency between federal and Energy Star standards is not great enough to attract consumers or manufacturers to Energy Star refrigerators.

- The market baseline estimates were adjusted for clothes washers and dishwashers to reflect market activity in the Northwest relative to national market activity before NEEA's initiative was developed.

- Per-unit energy savings estimates were verified for all three appliances. The methods and input assumptions were found to be reasonable.

Table 6-8 summarizes Summit Blue's findings in the M&T effort, as compared to the values NEEA used in 2006. Cumulative market activity and baseline estimates for all appliance types increased between 2006 and 2007, generally between about 15% and 25%. Cumulative energy savings implied by these values also increased slightly, from 21.8 aMW across the three appliance types through 2006 to 22.5 aMW through 2007.

[113] *Ibid.*

Table 6-8. M&T Recommendations for Key Indicators

Key Indicators Reviewed	2006 NEEA Value(s)	2007 Recommended Value(s)	Source
Current Market Activity			
Clothes Washers	995,707	1,156,159	AHAM sales data; see Section 6.3.1
Dishwashers	1,198,148	1,505,321	
Refrigerators	756,502	907,543	
Current Baseline Activity			
Clothes Washers	544,787	686,547	NEEA baseline values and Summit Blue analysis; see Section 6.3.2
Dishwashers	1,122,892	1,386,088	
Refrigerators	593,732	738,504	
Per-Unit Energy Savings (kWh/unit)*			
Clothes Washers	386.8	369.2	RTF spreadsheets; see Section 6.3.3
Dishwashers	91.8	108	
Refrigerators	61.4	62	
aMW savings (cumulative, 2001 to 2007)			
Clothes Washers	19.9	19.8	aMW=MWh divided by 8760 hours
Dishwasher	0.8	1.5	
Refrigerators	1.1	1.2	
Total	21.8	22.5	

Source: 2006 MAR Cumulative Savings 04-03-07.xls and Summit Blue research and analysis

*Note that all per-unit savings values are weighted averages based on actual units sold; per-unit savings vary by year based on changing federal and Energy Star efficiency standards. Also, clothes washers savings vary by tier; the clothes washer savings value is weighted by tier type and year sold.

** Implied energy savings are presented for comparison purposes only between NEEA's 2006 values and the 2007 M&T findings. NEEA's reported values may not match those presented here since NEEA adjusts for the effect of utility incentives and other factors not taken into account in this M&T analysis.

Summit Blue has found NEEA's methods of tracking the market share and savings calculations to be accurate and recommends the next M&T effort be focused on capturing the change in the market due to changes in federal and Energy Star efficiency standards. As of January 1, 2007, Energy Star standards for clothes washers and dish washers have changed, and federal standards for clothes washers have changed as well. The Energy Star standards for refrigerators are expected to change soon.[114] As discussed in Section 6.3.1, these changes will affect the market for Energy Star home products in the Northwest. Summit Blue recommends that the next M&T effort be held in 2009-10. It is recommended that the future M&T effort focus on the following three activities:

- Updating per-unit savings based on changed federal and Energy Star standards.
- Estimating market share trends due to change in Energy Star standards.
- Updating baseline assumptions based on progress in the national market.

[114] Correspondence with Tom Eckman.

6.5 Bibliography

2006 Annual Savings Report Cost Effectiveness Analysis Key Assumptions: Energy Star Residential Clothes Washers. NEEA. Provided by Ms. Christine Jerko.

"Clothes Washers Key Product Criteria." Energy Star. Available: http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

D&R International. *"Energy Star Appliances – 1998 Sales Data Report."* November 1999.

D&R International. *"Energy Star Appliances – 1999 Sales Data Report."* September 2000.

Dethman and Associates. "*Energy Star Home Products Program Market Progress Evaluation Report, No. 2*." Prepared for NEEA, August 2004.

"*Energy Star Criteria for Clothes Washers – Overview of Energy Star Criteria Setting Process and History of Clothes Washer Criteria"* Richard H. Karney, P.E. August 2004. Available: *http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/clotheswash/4CW083104MeetingKarney_final.ppt*

Energy Star dishwasher program requirements found at "*http://www.energystar.gov/ia/partners/product_specs/program_reqs/dishwash_prog_req.pdf*"

Energy Star refrigerator program requirements found at "*http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/refrig/REF_Program_Requirements2008Proposed.pdf*"

Interview with Ms. Christine Jerko (Senior Analyst, NEEA).

Interview with Ms. Marci Sanders (formerly of NEEA).

McNary, Bill. *"Energy Star Sales Data Collection."* D & R International. October 2004.

NEEA spreadsheets containing AHAM data for ESHP unit sales in the Northwest (2001 to 1007), provided by Ms. Christine Jerko.

Northwest Energy Efficiency Alliance. "*NEEA - 2006 Annual Saving Report.*" Powerpoint presentation provided by Ms. Jerko.

Regional Technical Form (RTF) ESHP savings calculators/spreadsheets provided by Mr. Tom Eckman (RTF).

7 DRIVE POWER INITIATIVE

The Drive Power Initiative (DPI) was an electric motor market transformation effort funded by NEEA and administered by the Electric League of the Pacific Northwest between 1999 and 2004. The main objectives of the DPI were to achieve the following:

- Increase the region's overall motor fleet efficiency.
- Influence end-users' repair/replace decision-making for motors to encourage use of life-cycle costing in investment decision.
- Help motor service centers improve their repair practices and expand their motor management services.

To achieve the aforementioned objectives, the initiative employed the following methods:

- Implementing a broad motor end-user *education program*, including seminars, a newsletter, a toolkit of printed information, motor database software (*EM2*), and a web site.
- Deploying *field consultants* to work with end users throughout the region and to develop success stories, executing a pilot demonstration of motor system optimization. This was supplemented by leveraging program success stories and information through dissemination in various media.
- *Working with motor service centers* on improving repair methods, integrating motor operating costs into repair/replace decisions, and expanding motor management services. Before the initiative started working with motor service centers, only about 4% of the service centers even offered energy efficient rewinds, performed in a controlled environment according to a "best practices method" as specified by the Electrical Apparatus Service Association (EASA).
- Coordinating *promotion of motor management efforts* with trade associations, utilities, government agencies, and organizations promoting energy efficiency.

The primary objective of this M&T effort is to trace back the roots of influence for motor efficiency improvements to identify and isolate the effect that DPI has had on transforming the market. In particular, this effort focuses on 1) new services and changes in practices at motor repair centers, 2) NEEA's role in developing a premium efficiency brand, and 3) impacts resulting from increased use of the EM2 motor management software.

7.1 Assumptions and Indicators for Review

To study the affect of the DPI on the motors market in the Northwest, Summit Blue identified a list of indicators that would help track the progress of the DPI. This section defines these indicators and describes how they support the market transformation effort. Three specific indicators were identified:

1. **Effect of the DPI on formation and requirements of the National Electrical Manufacturers Association (NEMA) Premium motor brand and sales of NEMA Premium™ motors –** NEEA was involved in the formation of a premium efficiency motors brand (NEMA Premium™), which end users were encouraged to buy over standard efficiency motors.

2. **Changes in practices of motor service centers**. Motor service centers in the Northwest are adopting energy efficient repair methods consistent with EASA best practices. This M&T research attempted to ascertain NEEA's role in encouraging them to do so and the extent to which the repair market has been transformed.

3. **Effect of outreach activities, particularly via the following avenues:**

    a. **Distribution of the Energy Motor Management (EM2) database.** The EM2 software helps its users keep track of motors in their facilities and make informed decisions regarding repair and replacements. These objectives are achieved through providing reminders for timely maintenance, advocating efficient rewinds, and providing appropriate information on replacements of motors. This software, which was distributed by Bowns and Company as a part of the EM2 initiative funded by NEEA, helps transform the market by directly influencing end-user decision making.

    b. **Effect of the EM2 software on the Motor Decisions Matter (MDM) effort by the Consortium for Energy Efficiency (CEE).** The MDM software is distributed by CEE to advise end users on decisions regarding replacement and repair of motors. CEE studied the EM2 software prior to developing the MDM product.

7.2 Methodology

This M&T effort assessed trends in different sectors of the motors market in the Northwest, and the factors/programs that were responsible for these trends were identified. Two primary methods were used to obtain data: the first was to interview market actors that have either worked or are currently working closely with the motors industry in the Northwest; and the second was to review secondary sources that have documented savings or evidence of market transformation in the Northwest.

The following specific research tasks were undertaken in this M&T effort:

- **Interviews with NEEA personnel involved with the project –** Summit Blue interviewed Susan Hermenet (Acting Executive Director, who is well-versed in the history of the DPI) and Robert Russell (Project manager, Market research and Evaluation). Ms. Hermenet provided a list of information resources and potential interviewees related to the efficient motors market, while Mr. Russell provided an overview of DPIs' achievements, specifically regarding the effects DPI had on programs that succeeded it such as the Green Motor Practices Group and the Industrial Efficiency Alliance (IEA). Summit Blue also corresponded with Andy Ekman (Project Manager, NEEA) to obtain information on NEMA Premium™ motor sales in the Northwest.

- **Interviews with personnel from the motors industry –** Summit Blue interviewed John Malinowski (Product Manager, Baldor Electric Company) and Jim Williams (JC Williams Consulting, LLC) to get unbiased, third party opinions on the motors market in the Northwest. Mr. Malinowski and Mr. Williams provided Summit Blue with their views on how the motors market had changed in the Northwest and to what extent was NEEA responsible for this transformation.

- **Interviews and correspondence with CEE personnel –** Summit Blue interviewed Ted Jones specifically to gather information on the MDM campaign. Monica Nevius provided

national and regional shipment data on NEMA Premium™ and non- NEMA Premium™ motors.

- **Interviews with other personnel involved with the DPI –** Summit Blue also contacted Phil Degens (formerly of NEEA) and Dennis Bowns (Bowns & Co. and Green Motors Practices Group) as both of them were integrally involved with the DPI. Mr. Degens, who was involved in starting NEEA's motors program, discussed the extent of NEEA's involvement in creating the NEMA Premium™ brand, its activities with motor service centers, and the effect NEEA's efforts had on CEE's MDM campaign. Mr. Bowns is the creator of the EM2 software and has been an active member of the DPI. He provided extensive information regarding NEEA's role in changing practices of motor service centers, developing the EM2 software and in general increasing the fleet efficiency of motors in the Northwest.

- **Review of available secondary sources –** Summit Blue supplemented the information gained by interviews with published reports on various aspects of the motors market in the Northwest to help it quantify per-unit savings and market transformation impacts. Summit Blue reviewed the CEE and NEMA Premium™ websites and other relevant sources through which information was obtained on sales of premium and non-premium motors (from which energy savings could be calculated), the number of efficient rewinds performed, and performance of the MDM and EM2 software.

7.3 Findings

7.3.1 Market Activity

The DPI's impact on the market in the Northwest can be viewed as manifesting itself in three distinct ways, as described by the three indicators in Section 7.1: 1) sales of NEMA Premium™ motors, 2) changes in practices of service centers, and 3) effect of outreach activities using motor management software. These three market activity indicators are discussed below.

Indicator #1: Sales of NEMA Premium™ Motors

Motor *sales data* is not widely collected and is difficult to obtain, but *shipment data* is reasonably available and can be used as a proxy for estimating sales. National shipment data for NEMA Premium™ motors dates back to 2001, with 2005 the most recent year covered.[115] Regional data was not tracked until 2004, so the M&T analysis used national trends and estimated Northwest data prior to 2005 based on the ratio of total motors sold in the region versus all of the United States in 2005. The 2006 and 2007 regional sales figures were extrapolated based on sales growth in the first half of the decade, which the M&T research suggests has continued in recent years.

Shipments of NEMA Premium™ motors, as reported by CEE for 2001 through 2005, are presented in Table 7-1**Error! Reference source not found.**, which indicates that national shipments of premium motors increased steadily between 2001 and 2003. The raw data for 2004 and 2005 are incomplete

[115] NEMA premium motors shipment data was provided to Summit Blue by Ted Jones of the CEE and Andy Ekman of NEEA.

because the records include motors only from original equipment manufacturers (OEMs), and at least one of these manufacturers (it is not known which) pulled out of the motor surveys sometime in 2004.[116]

Table 7-1. Reported Shipments of NEMA Premium™ and Standard Efficiency Motors, 2001-2005

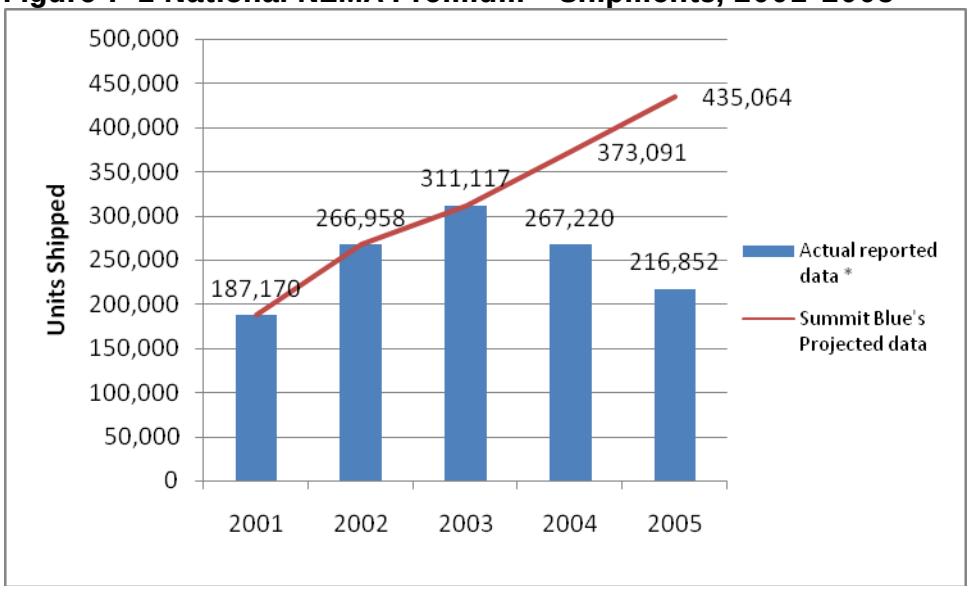
	2001	2002	2003	2004	2005			
	Premium				Premium	Non Premium	Total	% Premium
Idaho	N/A			4,736	8,677	8,223	16,900	51%
Montana				326	(Included in Idaho figure)			
Washington				2,725	1,926	7,787	9,713	20%
Oregon				2,834	1,801	10,020	11,821	15%
Northwest Total	N/A			10,621	12,404	26,030	38,434	32%
National Total	187,170	266,958	311,117	267,220	216,852	668,522	885,374	24%

N/A: Regional data was not collected prior to 2004.
Source: CEE

To account for these deficiencies in the data, Summit Blue extrapolated the total number of NEMA Premium™ units shipped annually by calculating the average annual increase in number of units shipped from 2001 to 2003 to adding this value to each of the subsequent two years. The result is a 2005 national sales estimate of more than 435,000 units (Figure 7-1). The trend of increasing sales was supported by the interviews with Dennis Bowns and correspondence with Ted Jones.

[116] Source: Interviews with Dennis Bowns of the Green Motors Practices Group and John Malinowski of Baldor Electric Company.

Figure 7-1 National NEMA Premium™ Shipments, 2001-2005



* Only non OEM motor shipments were reported in 2004 and 2005;
Source: CEE and Summit Blue projections

Regional shipment data was not tracked until 2004, but market activity in prior years was estimated using the national figures discussed above. The number of NEMA Premium™ units shipped in 2004 and 2005 to the Northwest was reported to be 10,621 and 12,404, respectively. Similar to the national data, the regional data does not include non-OEM motors or shipments from Baldor Electric Co. Therefore, adjustment factors were applied to each year's data for the Northwest. These adjustment factors equaled the ratio of projected shipments to reported shipments for 2004 and 2005, as presented in Figure 7-1. For example, the adjustment factor for 2004 was 1.4 (373,091 divided by 267,220) and resulted in an estimate of more than 14,800 NEMA Premium™ motors shipped in that year.[117]

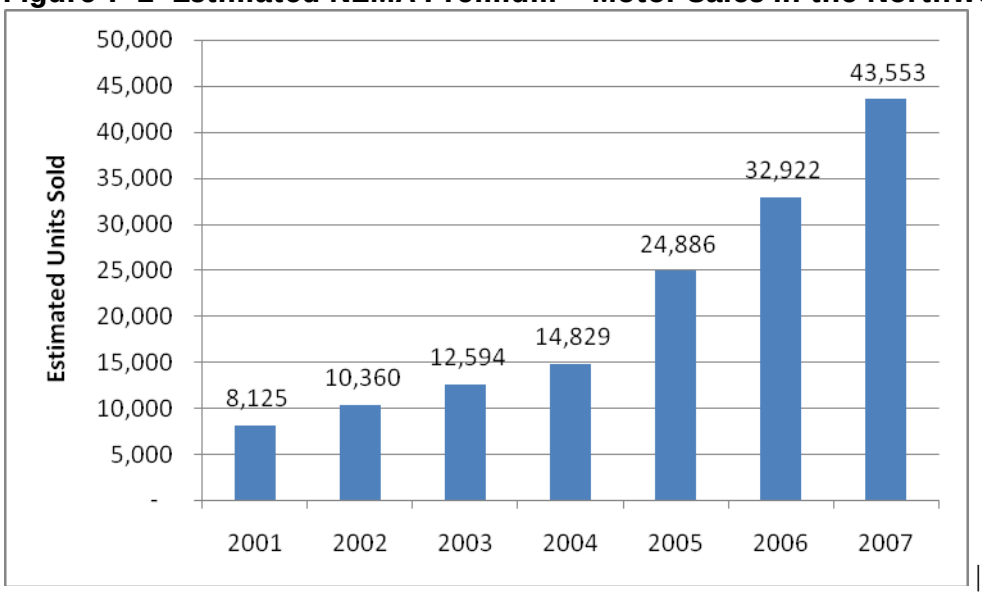
The adjustment factor in 2005 was larger (2.0), owing to the fact that Baldor Electric Company dropped out of the survey in that year. The result is an estimate of more than 24,800 NEMA Premium™ motors shipped in 2005. This relatively large increase is supported by the raw data comparing national and Northwest shipments of premium motors. Whereas national shipments of NEMA Premium™ motors, *as reported by CEE*, dropped by 19% between 2004 and 2005 (owing to the factors discussed previously), reported shipments of premium motors in the Northwest actually *increased* by 17%. This suggests that premium motor sales in the Northwest have been trending upward at a significantly higher rate than they have nationally.

The M&T research indicated that NEEA's influence on the sale of NEMA Premium™ motors was minimal in 2001, the first year for which data is available. (NEMA premium motor sales only started in 2001, according to Summit Blue's interview with Dennis Bowns. Until that time, the initiative was in a planning stage, and fieldwork was actively conducted only late in the year.) Therefore, motor shipments in the Northwest in 2001 were estimated based on the ratio of total motors (premium and non-premium) shipped in the Northwest in 2005 to total motors shipped in the United States in 2005, the first year for which sales data on all motor is available. This ratio was found to be 4.3%, which translates into an estimate of more than 8000 NEMA Premium™ motors shipped in the Northwest in 2001.

[117] The methodology used to determine adjustment factors implicitly assumes that the ratio of OEM to non-OEM motors and the ratio of Baldor to non-Baldor motors is the same nationally and in the Northwest.

Using this value for 2001 and the previously estimated values for 2004 and 2005, estimates for the Northwest in 2002 and 2003 were linearly interpolated between 2001 and 2004. The values for 2006 and 2007 were estimated using the compound growth rate across all prior years (*i.e.*, 2001 through 2005) as applied to the 2005 estimate. With an annual growth rate of 34.3%, projected sales of NEMA Premium™ motors in the Northwest in 2007 were nearly 45,000 units (Figure 7-2). Total sales since 2001 are estimated to be more than 148,000 units. Results of the extrapolation were submitted to Dennis Bowns of the Green Motors Practices Group and John Malinowski of Baldor Electric Company to obtain outside opinions regarding how realistic these projections were. Mr. Bowns believes that the estimated sales figures are consistent with his views on the current state of the market, while Mr. Malinowski indicated that Summit Blue's methodology appeared somewhat conservative and that actual sales may be higher.

Figure 7-2 Estimated NEMA Premium™ Motor Sales in the Northwest, 2001-2007*



* Values are projected based on 2005 reported regional data and national data from 2001 through 2005. Values are extrapolated for 2006 and 2007 based on M&T research.

Source: CEE; and Summit Blue projections

In 2005 CEE obtained sufficient data from motor manufacturers to publish a national and state motor shipment report for both NEMA Premium™ and non-NEMA Premium™ motors.[118] The market share of NEMA Premium™ motors was 32% in the Northwest, with larger motor sizes tending to have a greater market penetration. Sixty percent of motors between 101 and 200 horsepower are premium efficiency, whereas only 25% of the under-five-horsepower motors are NEMA Premium™ (Table 7-2).

[118] Source: Interview with Monica Nevius (CEE). Summit Blue has requested to be on the e-mail list for release of 2006 data, which Ms. Nevius has agreed to.

Table 7-2. NEMA Premium™ Shipments in the Northwest by Size, 2005

	1-5 HP	6-20 HP	21-50 HP	51 - 100 HP	101 - 200 HP	201-500 HP	Total
NEMA Premium™ Motors	5,690	3,896	1,733	583	361	141	12,404*
Non NEMA Premium™ Motors	17,013	6,105	2,016	453	243	200	26,030
Total Motor Shipments	22,703	10,001	3,749	1,036	604	341	38,434
NEMA Premium™ Share of All Motors	25%	39%	46%	56%	60%	41%	32%

* The figure of 12,404 for total NEMA Premium™ motors shipped in 2005 is taken directly from the CEE data. As discussed above, the M&T analysis has estimated the total to be 24,886, which accounts for missing data for non-OEM motors and those from Baldor Electric Co.

Source: CEE

Indicator #2: Change in Practices of Motor Service Centers

An informal alliance, the Green Motor Practices Group, was formed by Dennis Bowns and four prominent motor service centers in the Northwest to encourage the use of energy efficient rewinds. According to Mr. Bowns, 20 service centers, representing more than 20% of the service centers in the region, are offering energy efficient rewind services and technical assistance to their customers as of 2007. Due to the rising level of awareness, customers are also demanding higher efficiency rewinds, which is indicative of an ongoing transformation in the motor service market. Whereas it is likely that less than 4% of motor service centers offered efficient rewinds and technical assistance in 2001, by the end of 2008, it is expected that one-third or more of the motor service centers will be using these methods.[119]

John Malinowski of Baldor Electric Company offered a different view of the rewind market, suggesting that most service centers are familiar with efficient rewinds. Furthermore, since customers are increasingly demanding this service, it should be a natural process for the majority of the industry to change over to efficient rewinding practices.

It is important to note here that the numbers presented above represent the fraction of the service centers that offer energy efficient rewinds and additional services, not the share of rewinds that are actually performed. The market share of efficient motor repairs and additional customer service may be higher than that of service centers offering such repairs since the DPI initially targeted larger, more prominent service centers. However, it is not clear what share of rewinds at these centers are high efficiency. This issue is raised in the recommendations for future M&T efforts (see Section 7.4) along with a proposed approach to addressing the uncertainty over the market share of efficient rewinds.

Indicator #3: Effect of Outreach Activities (EM2 and MDM)

The rise in awareness and sales of the EM2 and the MDM software are indicative of consumers trying to change their practices, which in turn affects the market for premium efficiency motors. CEE conducted two surveys, in 2003 and 2006, to study the progress made on awareness levels of the MDM campaign. According to Ted Jones of CEE, after studying the results of the surveys, it was decided that the MDM campaign would be revised and shift focus from promoting brand awareness to integration of major

[119] Source: Interview with Dennis Bowns of the Green Motors Practices Group.

players in the Northwest. The survey results showed a slight increase in awareness levels of NEMA Premium™ motors and in the share of respondents indicating that their company has an official policy requiring the purchase of premium efficiency motors. The small magnitude of differences between the two sets of data makes it impossible to draw conclusions regarding trends for the survey questions at this time, other than that there has been little change since 2003[120].

Though sale of the EM2 software was slow at first, sales have steadily risen. As of 2004, (when DPI was ended) 700 copies of the EM2 software had been sold and an additional 1000 copies have sold since that time.

According to John Malinowski of Baldor Electric Company, NEEA's outreach effort has been a success. He credits the effort of NEEA's field consultants, whom he called "Circuit Riders" with this success. Circuit Riders convince companies to change their motor practices. They do so by speaking to the person responsible for making energy related decisions in a company and show them the benefit they can realize through efficient motor practices. Jim Williams of JC Williams Consulting suggested in an interview that the DPI was successful in changing the thought process of end users and even some motor service centers.

7.3.2 Baseline Activity

Due to the unique nature of this program, it is not possible to establish a single market baseline. The baseline discussion below follows the same organization as the previous discussion of market activity, namely: 1) sales of NEMA Premium™ motors, 2) changes in practices of service centers, and 3) effect of outreach activities using motor management software.

Using available resources from the CEE, NEEA, and Green Motors Practices Group, Summit Blue was able to quantify the baseline for sale of premium efficiency motors in the Northwest and make a qualitative assessment for change in end-user management practices and increase in efficient rewinds in the region.

Indicator #1: Sales of NEMA Premium™ Motors

A CEE standard for efficient motors existed prior to NEMA. However, the CEE standard was often reported as unclear and confusing and was never a popular choice with consumers. This gave rise to the need for a new, easily recognizable standard. The NEMA Premium™ brand was established after a summit held with NEEA, CEE, the U.S. Environmental Protection Agency and various motor manufacturers in 1999 and 2000. NEMA Premium™ is an easily recognizable third-party brand that can provide credibility to an efficient motor product.

NEEA was an active participant in all the decisions that led to the formation of the NEMA Premium brand; it also provided the working committee with some case studies. Some responsibility for the savings from the sale of NEMA Premium Motors can reasonably be attributed to NEEA, as it was integrally involved in the process that resulted in the NEMA Premium™ brand being formed.[121] Through other programs that NEEA was integrally involved in, such as one on one consumer outreach activities, EM2 and MDM, the NEMA Premium™ brand awareness grew in the Northwest, leading to higher

[120] Memo to the MDM campaign sponsors by Monica Nevius (CEE), "Results of 2006 survey of *Plant Engineering* readers for MDM evaluation."

[121] Phil Degens indicated that the NEEA was one of the main reasons that NEMA Premium™ brand gained such wide and rapid acceptance.

market penetration. It is expected that federal motor standards will change in 2008 or 2009 to NEMA Premium™ standards.

As previously discussed, the M&T research indicated that NEEA's influence on the sale of NEMA Premium™ motors was minimal in 2001 (see Section 7.3.1). Therefore, the 2001 baseline is the same as the estimated market activity of 8,125 units. Similar to the national market activity projections, the values for baseline activity through 2007 were estimated using the compound growth rate for the nation from 2001 to 2005, which was found to be 23%. This resulted in a 2007 baseline sales estimate of more than 27,000 motors and a cumulative baseline through 2007 of more than 110,084 units.

Table 7-3. Estimated Baseline Sales of NEMA Premium™ Motors in the Northwest, 2001-2007

	2001	2002	2003	2004	2005	2006	2007	Total
NEMA Premium™ Motor Sales	8,125	10,032	12,387	15,295	18,886	23,320	28,794	116,840
Source: CEE and Summit Blue analysis								

Indicator #2: Change in Practices of Motor Service Centers

Initially, most of the influence of the DPI was on the purchase of NEMA Premium™ motors by customers. However, since repairing or rewinding a motor costs significantly less than buying a new motor, customers tend to prefer rewinding. Thus, in its later stages, the DPI promoted energy efficiency rewinds to motor service centers.

At the time, the U.S. Department of Energy (DOE) stated on its website and in its Motor Master Plus software[122] that motor rewinds lead to a loss of at least 3% to 5 % in efficiency. This discouraged the end users from asking for rewinds, and it was widely believed that rewinding could not be performed without significant loss of efficiency. With the backing of NEEA, the Green Motors Practices Group and prominent motor service centers in the region effectively proved that energy efficient rewinds leading to less than a 1% loss in efficiency were possible. The success of this campaign was highlighted by the fact that DOE changed the default decrease in efficiency due from motor rewinds to the values recommended by Dennis Bowns.

During the time that the DPI was active, about a dozen motor service centers claimed to offer energy efficient rewinds and technical assistance to its customers, but only one service center was able to support that claim. Though motor service centers knew about energy efficient rewinds, they did not always practice it. This is due to the fact that, as compared to regular rewinds, efficient rewinds take more time and are more expensive to perform. Moreover, customers were less aware of the benefits of these rewinds than they are today and hence did not demand them. It is likely that without NEEA's influence, energy efficient rewinds and additional technical assistance for customers would not have been so widely accepted in the Northwest and spread to other parts of the country as well. Jim Williams of JC Williams Consulting told Summit Blue that changing the thought process and decision making process of customers and service centers was one of DPI's most notable achievements. Considering these facts it is

[122] Motor Master Plus is a free software package provided by the DOE, which aims to help users better manage their motors. It is a direct competitor of the EM2 software.

safe to say that without the DPI, efficient rewinds and comprehensive customer service including additional technical assistance would not have grown as prevalent as they are today.

Indicator #3: Effect of Outreach Activities (EM2 and MDM)

Initially NEEA thought Motor Master Plus (MM+) was a good choice to help consumers make informed decisions about motor repair and replacement, but customer feedback helped conclude that MM+ was complicated and not easy to use. Hence with the help of Dennis Bowns, the EM2 software was created. Without NEEA's financial and moral help, making of the EM2 software would not have been possible. Once NEEA's program ended, full rights to further develop and sell the software were given to Bowns and Co by NEEA. The EM2 software has sold well considering that it is paid software competing with DOE's free MM+ product.

The CEE studied the EM2 for sometime before developing the MDM software[123]. While the format for the MDM was being finalized, the sponsors of MDM decided that they wanted more financially oriented software. Hence the 1 – 2 – 3[124] approach was finalized, which looks at life cycle costs. Although the EM2 software was a contributing factor to MDM, and NEEA played an integral role in the development of the software, NEEA's contribution was limited to the initial stages of the campaign.

As told to Summit Blue by Jim Williams, DPI representatives managed to change the thought process of end users, so that they make better decisions when it comes to replacing or repairing a motor. The EM2 software did help in this regard as it gave the customers numbers to help make decisions. Motor Service Centers also realized that they would be able to provide better service and help retain, increase its clientele if they aligned themselves with the DPI. All of the field work performed by NEEA's consultants was directly due to the DPI. It is safe to say that in the absence of the DPI, such a systematic and successful field work campaign would not have been carried out in the Northwest.

7.3.3 Per Unit Energy Savings

Per-unit energy savings have been quantified for replacing an existing motor with a NEMA Premium™ motor and performing energy efficient rewinds. To estimate the savings from replacing standard efficiency motors with NEMA Premium™ motors, data was compiled for hours of operation and average efficiency for EPAct and premium efficiency motors.[125] Annual energy consumption for a motor can be calculated as the product of the following factors:

1) motor horsepower times the kW conversion factor of 0.746 kW/hp
2) annual run-time hours,[126]
3) motor loading factor[127]

[123] Interview with Ted Jones of CEE.

[124] The 1 – 2 – 3 approach is a unique approach developed by the CEE for the MDM, which focuses on the financial aspect of decision making rather than the energy aspect.

[125] Data was obtained from CEE. Document title: "CEE Premium Efficiency Motors Initiative – Efficiency Specifications." Undated.

[126] Run-time hours are different for motors of different sizes. Values were obtained from the Green Motors Practices Group's July 2007 submittal to the Northwest Power and Conservation Council's Regional Technical Forum.

[127] Motor loading factor is the percentage of total operation hours that a motor runs on full load. Motor loading factor was assumed to be 0.68. Source: "Quality Motor Rewinding an Energy Efficiency Measure." See RTP submittal from previous footnote.

4) the number 1 divided by motor efficiency.[128]

The savings due to use of a more efficient NEMA Premium™ motor is then the difference in energy consumption between the old motor and the premium efficiency motor. Per-unit savings due to use of premium efficiency motors in the Northwest is presented in Table 7-4. Savings for various motor size categories are weighted according to regional sales volumes, and a single per-unit savings value of 629 kWh per motor is estimated. This value can be applied to NEMA Premium™ motor sales in the Northwest each year to estimate regional savings.

Table 7-4. Average Annual Per-Unit Energy Savings from NEMA Premium™ Motors in the Northwest

Size Category (HP) (A)	Average Annual Hours of Operation (B)	Average EPAct Efficiency* (C)	Average NEMA Efficiency* (D)	Average Per-Unit Savings** *kWh* (E)	Annual Sales in the Northwest*** (F)	Annual Savings in the Northwest *MWh* (E*F/1000)
1 to 5	2,745	84.18%	86.23%	118	5,690	673
6 to 20	3,391	89.77%	91.24%	404	3,896	1,574
21 to 50	4,067	91.87%	93.03%	991	1,733	1,718
51 to 100	5,329	93.42%	94.35%	2,177	583	1,269
101 to 200	5,200	94.39%	95.16%	3,424	361	1,236
201 to 500	6,132	94.39%	95.16%	9,435	141	1,330
Total	**N/A**	**N/A**	**N/A**	**629**	**12,404**	7,800

* Motor Efficiency data were available for different motor sizes (hp). An average efficiency for a particular size range was calculated to estimate per unit energy savings. It was assumed that all sizes had equal weight.

** Per unit energy savings are calculated according to the following formula (using lettered column labels above):
kWh savings = A*(0.746)*B*(0.68)*(1/C – 1/D).

*** Annual NEMA Premium™ sales by motor size are from CEE shipment reports for 2005. See Table 7-2.

Source: CEE; Summit Blue analysis

The energy savings for energy efficient rewinds can be calculated in a similar manner to savings from use of premium efficiency motors. The only difference is in the "before" and "after" efficiencies. Rather than using efficiencies of standard vs. NEMA Premium™ motors, the calculation is based on efficiencies after a *standard, inefficient rewind* vs. an *efficient rewind*. Based on the relative efficiencies presented by the Green Motors Practices Group, per-unit savings from efficient rewinds of motors of various sizes are calculated and presented in Table 7-5. A single, weighted average value that would apply to regional rewinds has not been calculate since data is not available on the number and motor size of efficient rewinds.

[128] For each motor size, efficiency figures are averaged across the values for three RPM levels as well as both open and drip-proof motors. Base efficiency assumptions were for efficiencies of federal standard (EPAct) efficiency motors. NEMA Premium™ efficiencies were obtained from CEE. See Footnote 125.

Table 7-5 Average Annual Per Unit Energy Savings from Efficient Motor Rewinds

HP	Average Annual Savings (kWh)	HP	Average Annual Savings (kWh)
1	16	60	1,046
1.5	25	75	1,097
2	33	100	1,456
3	48	125	1,771
5	80	150	2,116
7.5	146	200	2,809
10	196	250	4,136
15	291	300	4,952
20	385	350	5,732
25	573	400	6,542
30	621	450	7,349
40	732	500	8,165
50	796	-	-
Source: Green Motors Practices Group			

At the conclusion of NEEA's Electric Motor Management (EMM) Program, the EMM field consultants asked their customers to provide copies of their EM2Solutions™ databases for purposes of estimating energy savings potential.[129] In this survey, 22 customers provided databases containing a total of 3,952 motors. Out of these motors, 1,356 had sufficient data for savings estimation and 510 were of a type that was replaceable by NEMA Premium™ motors. Two analyses were done, one where existing motors were replaced by NEMA Premium™ motors immediately, other where NEMA Premium™ motors were replaced only after existing motors failed. The savings potential was found to be 8.53 aMW and 11.54 aMW respectively. Though these numbers look encouraging, it must be considered that motors are likely only to be replaced only after their full lifetime of 8 to 10 years, and many motor will be rewound instead of replaced since rewinding costs significantly less than replacement.

7.4 Conclusions and Recommendations

NEEA projects focusing on motors have led to a significant market transformation in the Northwest. The sale of NEMA Premium ™ motors has increased nearly six-fold since 2001, and *regional growth in sales of premium efficiency motors has been at approximately 34% per year, versus 23% nationally*. Furthermore, it is estimated that more than 20% of all motor service centers in the Northwest now offer energy efficient rewinds, and end users appear to be using more efficient practices and demanding more efficient services. The result is an increase in the overall fleet efficiency of motors in the Northwest. Additional findings from the 2007 M&T effort include the following:

[129] Drive Power evaluation memorandum, Currents Consulting, March 2005.

- NEEA has played an active and important role in the creation and adoption of ultra high efficiency motor standard, NEMA Premium ™. It is also important to note that federal motor standards may change to NEMA Premium™, marking a noteworthy accomplishment for all parties involved in creating a NEMA Premium™ brand.

- Only recently has sufficient data been released to establish a regional baseline for premium efficiency motor sales. The first release of statewide NEMA and non-NEMA Premium™ data was in 2006 (of 2005 data). Future data has yet to be released, but will provide additional opportunity to study the market transformation in the Northwest.

- The EM2 software would not have been widely adopted without NEEA's support. The EM2 is being regularly updated and continuing sales of this software result in better management and higher sale of premium efficiency motors.

- NEEA's achievements regarding motor service centers are noteworthy. They not only started the process of market transformation in the Northwest, but the effects are also being felt in other parts of the country.

Table 7-6 summarizes **recommendations for the values of key indicators**. Through 2007, estimated sales of NEMA Premium™ motors in the Northwest had reached more than 148,000 units. Baseline sales are estimated at approximately 117,000, or nearly 80% of the total market activity. The cumulative energy savings implied by these figures is 2.2 aMW in 2007. As noted below, due to limited data availability, these estimated energy savings only cover the savings resulting from the replacement of standard efficiency motors with premium efficiency motors, and not any savings resulting from changes in motor service center practices or adoption of the EM2 software.

Table 7-6. M&T Recommendations for Key Indicators

Key Indicators Reviewed	2006 NEEA Value(s)	2007 Recommended Value(s)	Source
Current Market Activity			
NEMA Premium™ motors sold in the Northwest, cumulative 2001-2007	N/A	147,268	CEE motor shipment data and interviews with motor industry professionals. See Section 7.3.1.
Share of motor service centers offering energy efficient services		20 %*	
Units sold of NEEA sponsored EM2 software		1000	
Current Baseline Activity			
NEMA Premium motors sold in the Northwest	N/A	116,840	CEE motor shipment data and interviews with motor industry professionals. See Section 7.3.2.
Share of motor service centers offering energy efficient services and additional customer support.		1 to 4%	
Units sold of NEEA sponsored EM2 software		0	
Per-Unit Energy Savings			
Replacing existing motors with NEMA premium motors (kWh/motor per year)	N/A	629	CEE and Green Motors Practices Group. See Section 7.3.3.
Energy efficient motor rewinds.		Per unit savings are defined for different motor sizes.	
Implied Energy Savings (aMW).			
Replacing standard efficiency motors with NEMA premium efficiency motors.	N/A	2.2	Table 7-7.

N/A: NEEA has not previously performed a comprehensive assessment of market activity or savings from this initiative.

* The M&T analysis generated an estimate of the share of motor service centers providing efficiency rewinds. However, the share (and number) of motors being serviced is not known.

Source: CEE and Summit Blue analysis

Because this is the first M&T assessment of DPI, detailed data and savings calculations for each year since 2001 are presented in Table 7-7. The cumulative annual savings can be seen to grow from less than 1 aMW through 2005 to an estimated 2.2 aMW by 2007.

Table 7-7. Energy Savings from NEMA Premium™ Motor Sales in the Northwest, 2001-2007

	2001	2002	2003	2004	2005	2006	2007	Cumulative through 2007
NEMA Premium™ motor sales	8,125	10,360	12,594	14,829	24,886	32,922	43,553	147,268
Baseline NEMA Premium™ motor sales	8,125	10,032	12,387	15,295	18,886	23,320	28,794	116,840
Non-Baseline Sales of NEMA Premium™ motors	-	328	207	(466)	6,000	9,602	14,759	30,428
Per unit savings (kWh/motor per year)	629							
Incremental annual MWh savings	-	206	130	-	3,772	6,038	9,281	19,428
Incremental annual aMW savings	-	0.02	0.01	-	0.43	0.69	1.06	2.2
Cumulative annual aMW savings	0	0.02	0.03	0.03	0.46	1.2	2.2	2.2
Source: CEE and Summit Blue analysis								

It is important to reiterate that the estimated 2.2 aMW of energy savings are only due to *replacement* of standard efficiency motors by NEMA Premium™ motors. With available data it is only possible to quantify savings attributable to new NEMA Premium™ motors entering the market, but not any savings due to the adoption of energy efficient rewinds or the EM2 software. These savings could be significant since rewinding costs less than replacement and many motors are rewound instead of replaced. Furthermore, considering the long lifetime of a motor, market transformation may only be fully recognized after 8 to 10 years, which is the average lifetime of an installed motor.

Future M&T efforts should be based on better understanding NEEA's influence on the end user and changes in practices of service centers. This will give NEEA a more complete understanding of how the market has been transformed. Specifically, the following steps are recommended for future M&T efforts:

- **Interview prominent motor service centers in the Northwest** to better understand what percentage of their services are energy efficient, how much effect did the DPI have on their practices and procedures, and the awareness levels of consumers that use their services.
- **Estimate annual energy savings as a result of efficient rewinds.** The Green Motors Practices Group is currently tracking keeping track of the rewinds (energy efficient and regular) in motor service centers that are a part of this organization, and by the end of 2008 it is expected that there will be sufficient data to make initial savings estimates.
- **Develop a more robust projection of NEMA Premium™ motor sales in the Northwest.** CEE has only released regional motor shipment data for 2005. The 2006 data is expected later this year, which would provide data for two full years and would allow better trend estimation. An additional year of data will also allow for a more extensive comparison of regional versus national sales, which can be used to refine the baseline estimate.

Summit Blue recommends that an M&T effort be held next year to address the recommendations mentioned above.

7.5 Bibliography

Currents Consulting. "Analysis of EM2 motor management database" *Drive power evaluation memorandum.* March 2005.

Nevius, Monica. *"Results of Survey of Plant Engineering Readers for MDM Evaluation, Final Report"* CEE.

"National NEMA premium sales report 2001 – 2004", CEE.

Consortium of Energy Efficiency. "State level national shipment data for 2005 – NEMA", CEE.

Consortium of Energy Efficiency. *"Summer 2007 News letter – CEE"*

The Green Motors Practices Group, *"Quality Motor Rewinding, an Energy Efficiency Measure"*. Regional technical forum submittal 1.0

Electrical Apparatus Service Association (EASA) *"The effect of repair/rewinding on motor efficiency"*.

Consortium of Energy Efficiency *"CEE premium efficiency initiative, efficiency specifications"*

Consortium of Energy Efficiency *"Motor Decisions Matter"* (Factsheet/Brochure)

U.S Department of Energy *"When to purchase NEMA premium motors / Energy tips – motor systems"*

NEMA press release *"NEMA premium motor sales show increase – 4 Nov 2004"*

Interview with Dennis Bowns, December 2007, and January 2008 (Bowns & Co. and the Green Motors Practices Group)

Interview with John Malinowski, March 2008 (Baldor Electric Company)

Interview with Jim Williams, March 2008 (JC Williams Consulting, LLC)

Correspondence with Monica Nevius, January 2008 (CEE)

Interview with Susan Hermenet. December 2007

Interview with Robert Russell, December 2007

Interview with Phil Degens, December 2007 (Energy Trust of Oregon; formerly NEEA)

Interview with Ted Jones, December 2007, January 2008 (CEE)

Email correspondence with Andy Ekman, January 2008 (NEEA)

8 VERDIEM NETWORK ENERGY MANAGEMENT SOFTWARE

From 2001 until December 2003, the Northwest Energy Efficiency Alliance (NEEA) provided funding to Verdiem to introduce a software product that manages energy in computer network environments. The product is a network software tool that enables network administrators to remotely control the power management functions of personal computers (PCs) linked to the central network. The program was designed to lower the projected growth in energy consumption caused by the rapid expansion of computers and associated technology in the workplace. By creating brand awareness of a product that could create energy savings and by identifying strategies to overcome network administrators' reluctance to introduce additional software into their networks, the NEEA-Verdiem partnership sought to create a viable commercial venture with sales of at least 18,000 licenses in NEEA's territory by the end of 2003. As of mid-2004, Verdiem had outpaced that target by over 50 percent, with 27,263 licenses sold in the Pacific Northwest.[130]

NEEA invested nearly $1 million in the effort through its investment in Verdiem, associated evaluation studies, and general administration of the program. Private investors sunk more than $22 million into Verdiem since its founding in 2001. An initial monitoring and tracking (M&T) project was undertaken in 2005 to begin to uncover the answers to questions about the per-unit energy savings and sales data; now, an update is needed to determine the accuracy of those data for updated products and whether or not the NEEA-Verdiem partnership spurred innovation by additional companies and created broader market transformation.

8.1 Assumptions and Indicators for Review

In assessing the energy savings attributable to the NEEA-Verdiem partnership, Summit Blue took a top-down approach, classifying the market and then determining Verdiem's impact on energy consumption in that market. The Alliance's Cost-Effectiveness (ACE) model will be used as a foundation for conducting this evaluation. The M&T will focus on verifying the ACE model's assumptions about the following inputs:

- market size, [131]
- market penetration rate for Surveyor
- market penetration of similar network power management software, and
- per-unit energy savings.

A more formal equation for the network power management software's energy savings calculation:

[130] Quantec, LLC. January 15, 2005. "Market Progress Evaluation Report 2: Surveyor Software." Prepared for NEEA.

[131] The relevant *market* definition is the total number of commercial PCs in the Northwest with compatible operating systems, less one-third of the PCs operating in environments (i.e., companies) with fewer than five people.; MPER#2 assumes that this fraction (one-third) of the smallest companies are not networked, and this M&T effort will continue to use that assumption. (MPER #2)

Annual Energy Savings (kWh/year) =

(1) Market size

x (2) Market penetration of network power management software

x (2) Per-unit energy savings (kWh/year)

where:

- **Market size** is the total number computers that are eligible to have the Surveyor technology applied to them in the Northwest, and
- **Market penetration of network power management software** is the percentage of those computers included in market size that are actually using power management software; and
- **Per-unit capacity energy savings** is the annual energy savings per network power management software license sold.

Other indicators of success will reflect the broader market impacts of the NEEA-Verdiem partnership. One key indicator in this category would be the entrance of additional network power management software firms into the market. If appropriate, these market effects may also be considered.

8.2 Methodology

The 2005 M&T effort for the NEEA-Verdiem partnership focused on determining energy savings from network energy management software using a "bottom-up" approach; evaluating the assumptions regarding baseline activity; and validating the per-unit savings values. This research led the M&T project team to conclude that the baseline and per-unit savings assumptions were reasonable.

The 2007 M&T team operated on the premise that the bottom-up approach to determining regional energy savings from network energy management software based on data from Verdiem alone would not create a comprehensive picture of the market for this service in the region. Thus, the team took a top-down approach, examining the market and seeking to calculate the market penetration of network energy management software in the region.

Research for the 2007 M&T effort focused in the following areas:

- Review of the 2005 Market Progress Evaluation Report;[132]
- Review of the 2005 M&T findings;
- Contact with Denise Masters, Chief Financial Officer at Verdiem, to obtain updated sales data and other relevant product information;
- Mining of publicly available sources of data on personal computer (PC) sales in the United States, primarily from IDC;[133]

[132] Dimetrosky, S. and J. Steiner Luedtke and K. Seiden. *Market Progress Evaluation Report 2: Surveyor Software.* Prepared for NEEA, Report #E05-136. January 19, 2005.

[133] A comprehensive list of these sources is included in the Bibliography.

- Studying the results of a 2004 U.S. Department of Energy (DOE) report that examined the energy saving potential of several technologies, including network energy management software;[134] and

- Surveying trade publications for information about Verdiem, its competitors, and the PC market at large.

- Interview with Braden Cave, Marketing and Brand Specialist, at Faronics, Verdiem's primary competitor.

8.3 Findings

In 2007, several changing market trends collided, requiring a second look at some of the assumptions in the Verdiem ACE model. Though these trends were gaining traction during the entire two-year period that this M&T effort considers, they only hit the market in the latter half of 2007 and are continuing into 2008. Thus, some of the assumptions in the ACE model will remain stable for this M&T period but will need revision in future years; other assumptions will be examined in closer detail in this report.

8.3.1 Market Activity

Using the top-down approach to considering energy savings requires examining two types of market activity:

- activity in the market for networked commercial PCs and

- activity in the market for network energy management software products, like Verdiem's.

First, the activity in the market for commercial PCs has seen a faster rate of growth than that anticipated in the ACE model. While the ACE model anticipates an average annual growth rate of just 1.3% from 2005-2011, IDC forecasts indicate an average annual growth rate of 4.6%.[135] The market share for commercial PCs is expected to remain virtually constant, which means that this 4.6% gross growth rate could be applied to the overall market size for Verdiem's product.

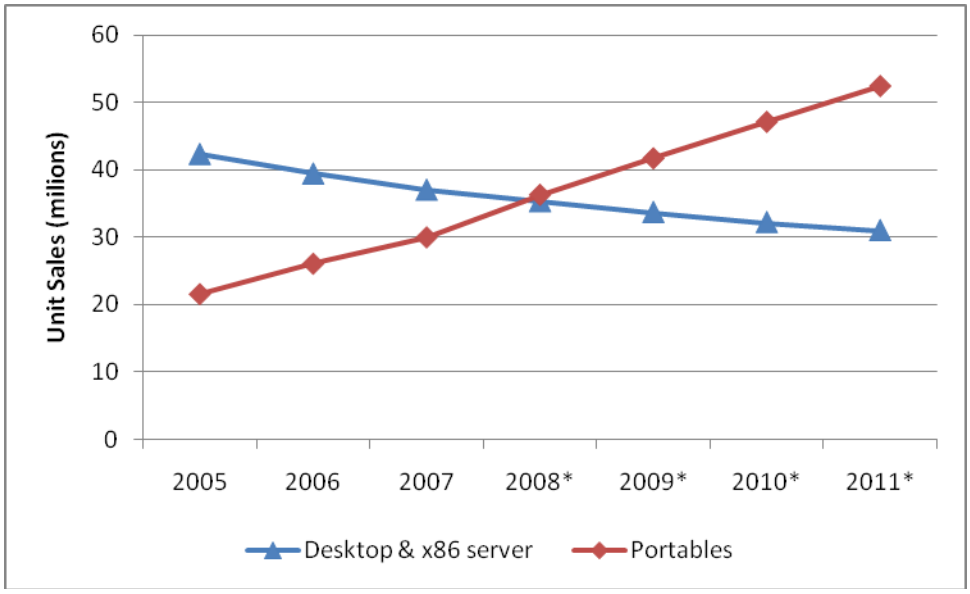
---

[134] Roth, K.W. and G.R. Larocque and J. Kleinman. *Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings: Volume II: Energy Savings Potential.* Prepared for Building Technologies Program, U.S. Department of Energy. December 2004.

[135] "Portable PC Adoption Accelerates, Lifting the Market Despite a Conservative Outlook for the United States, According To IDC." IDC. June 12, 2007. Available: http://www.idc.com/getdoc.jsp?containerId=prUS20729407
"PC Market Outlook Remains Strong, While The Shift To Emerging Regions Accelerates, According To IDC." IDC. September 13, 2007. Available: http://www.idc.com/getdoc.jsp?containerId=prUS20870407
"PC Market Is Expected To Continue Double-Digit Growth Despite Increasing Economic Concerns, According to IDC." IDC. March 12, 2008. Available: http://www.idc.com/getdoc.jsp?containerId=prUS21138308
Note that these estimates are for *shipments* of new PCs to the region, but these can be considered a conservative estimates of growth in the region since it is unlikely that the number of retirements will exceed the number of new computers added in the region.

Further, the U.S. PC market has seen a significant shift in the sales of new PCs away from desktop units and toward portable devices, specifically laptops, but this will not adversely affect the potential market size for network energy management software. Figure 8-1 shows that IDC anticipates sales of portable PCs to exceed those of desktop and server units for the first time in 2008. Since MPER#2 suggested that Verdiem's target market would only be desktop units, this could mean that the potential market size for Verdiem's product would begin to shrink as this shift becomes evident in the marketplace with the retirement of existing desktop units in the coming years. As a venture capital-backed firm, however, Verdiem will need to look for alternative market strategies in this new context; it can be safely assumed that Verdiem – and its competitors – will develop strategies to target both the portable and desktop segments of the market.

Figure 8-1. Actual and Forecasted Growth in Sales of PCs by Type[136]



The second part of the market activity for the NEEA-Verdiem partnership is to determine the number of computers in the target market which have installed network energy management software, i.e., its market penetration rate. Currently, only two companies market network energy management software, and only Verdiem has a substantial presence in the Northwest. The M&T team compiled sales data from Verdiem. examined publicly available documents about its major competitor, Faronics, and spoke with a representative of the firm. These data were analyzed to assess current market activity in the Northwest market for energy management software.

Verdiem achieved several major milestones in 2007 that will contribute to increased market penetration moving forward. In addition to securing an infusion of $15 million from a collection of major venture capital and other investors,[137] Verdiem secured a major client in the Northwest.[138] It also signed an OEM agreement with Hewlett Packard (HP), which will include the Verdiem software as a standard feature on a

[136] Ibid.

[137] "Kleiner Perkins Invests in Energy Efficiency." July 13, 2007. Verdiem. Available: http://www.verdiem.com/news/pr_20070713.asp

[138] Verdiem sales data, provided by Denise Masters, CFO, Verdiem.

subset of the HP computers.[139] This will significantly increase Verdiem's reach, though it is unclear how often those energy saving options will be enabled on a network.

Faronics has taken a strategic approach that involves targeting early adopters of network energy management software in markets with incentives for the technology.[140] With its relatively new technology, Power Save, only on the market for a year, the bulk of Faronics' sales have come in areas where utilities offer rebates for the technology and drive demand. In these unique situations, says Faronics' Braden Cave, "There is a triple win. Utilities benefit by meeting their energy efficiency resource acquisition goals. The end user benefits from cost savings created by a product that is typically cost-free after the rebates. The vendor (Faronics) benefits because it is still compensated for its product." In the absence of current rebates for energy management software in the Northwest, Faronics has not seen the early adopters in this market. Since Faronics did not have a significant market presence in the Northwest during the period on which this M&T effort focuses, the M&T team felt that it was overly aggressive to include market activity from the Faronics software in this assessment of NEEA's market effects.

Thus, Verdiem's sales can be used as a proxy for sales of network energy management software in the Northwest. Verdiem's sales have been inconsistent over the past few years, but these trends converged to create a major increase in 2007. Verdiems' sales in the Northwest increased by nearly 2500% from 2006 to 2007, which is higher than the company expects in future years but should be considered as an indication that this technology is gaining traction. Verdiem's anticipated rate of future sales growth[141] should be incorporated into the ACE model for at least the next few years; Verdiem is in a period of rapid growth driven mainly by the venture capital backing the company.

In order to use Verdiem's sales data[142] as a proxy for market activity, its Northwest sales figures need to be adjusted for two factors, as discussed in the last M&T report:

- *The number of licenses that are actually deployed in the Northwest.* Some clients that purchase network energy management software have operations outside of Northwest but purchase the software for workstations in all states. Where relevant, the Verdiem sales were decreased according to an estimated proportion of personnel in the Northwest versus other regions.[143]

- *Timing of deployment.* There can be some lag between the purchase and installation (deployment) of the technology. An adjustment was made when considering deployment dates for units sold in 2006 and 2007; it was assumed that deployment was at least one month after the purchase date, which caused a large portion of the 2007 sales to be pushed into 2008. Sales prior to 2006 were assumed to be fully deployed at this time.

---

[139] "Verdiem gives you more power over your power consumption. And, inquiring minds wonder whether power management might not be Vista's holy grail?" ZDNET. January 27, 2008. Available: http://blogs.zdnet.com/green/?p=732

[140] Unless otherwise noted, all information about Faronics originates in an interview with Braden Cave, Marketing and Brand Specialist, at Faronics.

[141] This data is confidential and was provided to NEEA separately in order to calculate savings.

[142] This data is confidential and was provided to NEEA separately in order to calculate savings.

[143] For the most part, these estimates were created using data available on the clients' websites.

8.3.2 Baseline Activity

While market activity for the growth of the overall market for commercial PCs is unrelated to NEEA's efforts, activity in the network energy management software market will be examined in closer detail.

NEEA's efforts were just one force that enabled network energy management software sales to take off. The IT industry is in the midst of a major sea change, which has recently and will continue to create new opportunities for network energy management software. The cost of energy associated with IT has become more visible in corporate America and is being considered as a variable, rather than a fixed, cost in many corporate settings. As IT has become a more critical foundation for American business, the scale of those costs has escalated, and C-level executives are starting to take notice. A recent survey showed that 81% of respondents consider green products' cost reduction potential as the most important reason for considering a supplier's "greenness."[144] Products that prove their value in this arena are getting noticed.

This awareness did not translate into action, however, until the bottom line impacts – in dollar terms – were quantified. Other companies in the IT space have begun to capitalize on this fact; chip manufacturers ADM and Intel, server and systems manufacturer Sun, and computer manufacturer HP have been on the leading edge of this movement. Yet, the energy savings originating from *centrally controlled* IT networks, like those generated by Surveyor and Power Save, have not been aggressively targeted, except by Verdiem and, more recently, Faronics.

Although the other market forces accelerated market acceptance of this technology, NEEA's efforts ensured that a product was indeed available. Since NEEA contributed while the technology was still very early in its market adoption curve, NEEA helped prove it technical viability and facilitated its development into a market-ready product. Faronics is the only real competitor to Verdiem, and its product is not yet producing energy savings in the Northwest. In the absence of NEEA's partnership with Verdiem, network energy management software would not be generating energy savings in the Northwest.

The current ACE model uses an estimated baseline of 10% of current market activity that would have taken place without the NEEA funding. As discussed in the last M&T report, this was a ballpark estimate and was not based on primary data collection. Without any evidence to the contrary, the M&T team recommends maintaining this baseline at this time. This figure should be re-examined in the next M&T effort by surveying end users about their decisions to employ network energy management software. This will be an important component of future M&T efforts because of the new focus on energy used by information technology systems that may have driven the creation of a separate network energy management software tool even without NEEA's participation in the market.

8.3.3 Per-Unit Energy Savings

As discussed in the 2005 M&T report, per-unit energy savings for network energy management software are dependent on many factors, making it difficult to develop an "average" per-unit energy savings estimate. The volatility in the per-unit energy savings estimate is caused by significant differences in

[144] "Green IT a Natural Fit for Enterprise Executives, IDC Says." IDC. October 31, 2007. Available: http://www.idc.com/getdoc.jsp?containerId=prUS20932407

savings based on the type of technology used (e.g., CRT vs. LCD monitors, desktops vs. laptops), baseline user habits and company policies, and aggressiveness of the energy management savings applied. These vary significantly from one context to another.

The best basis for creating a per-unit energy savings estimate is the data reported by Verdiem. The previous M&T report found that energy savings reported by Surveyor accurately reflected actual savings based on monitoring of actual energy usage. Verdiem reported actual per-unit savings for its 2006 and 2007 unit sales to Northwest clients, which were combined with a database of savings data compiled during the 2005 M&T effort. In the absence of a comprehensive breakdown of license sales by customer in the older dataset, creating weighted calculations was not possible; instead, a straightforward approach was taken to develop a statistical understanding of the per-unit energy savings data.

The ACE model uses an average of 200 kWh savings per unit as an initial input, which should remain constant for the 2006-07 savings calculation. As seen in Table 8-1, the addition of data from units sold in 2006 and 2007 increased both the average (mean) and the volatility (standard deviation) of the per-unit energy savings realized by this sample of Verdiem's clients. Since there is no "average" unit, the 200 kWh/unit/year estimate remains a fair value. This may underestimate the savings in the future because the client that accounted for a significant amount of Verdiem's 2007 sales had per-unit savings roughly 30% higher than this estimate; since the bulk of these units will be deployed in 2008, however, it will not have a significant impact on this M&T effort. Future M&T efforts should seek to collect additional data on the actual and reported savings in order to determine if a higher value is warranted.

Table 8-1. Statistical Summary of Per-Unit Energy Savings Data from Verdiem

	Number in sample	Minimum value	Maximum Value	Standard Deviation	Mean
Using 2002-2007 data	60	34	695	130	249
Using 2002-2005 data	37	34	695	116	228

The ACE model's downward adjustment of the per-unit savings estimate by 37.5% should be decreased to a 5% reduction. The 37.5% adjustment was based on a recommendation from the 2005 M&T effort, but information collected as part of this 2007 M&T effort revealed that decrease to be too high. The adjustment accounts for the fact that some clients purchase more licenses than they immediately need in order to plan for expansion and never deploy some units. In other cases, clients delay implementation of power management settings, affecting overall savings. Since Verdiem reports that 95% of the licenses sold in 2006 and 2007 have been deployed as of March 2008,[145] only 5% of the licenses are not generating energy savings. Thus, the adjustment to per-unit energy savings should be reduced from the 37.5% recommended in 2005 to 5%. As a result, per-unit energy savings of 190 kWh per year should be applied to all sales.

Looking ahead, another energy-saving technology, 80 PLUS power supplies, will also affect per-unit energy consumption for PCs. As part of a nationwide effort, NEEA has sponsored the 80 PLUS program since the middle of 2005. 80 PLUS power supplies for servers and computers have efficiencies of 80% or greater at 20%, 50% and 100% of rated load.[146] These power supplies represent at least a 33% increase in

[145] Communication with Denise Masters, Verdiem, March 2008.

[146] "What is 80 PLUS?" Available: http://www.80plus.org/80what.htm

efficiency over current power supplies.[147] Althought they have only captured 1.5-3% market share in the Northwest to date, it is anticipated that their market share will increase since they were adopted as part of the Energy Star 4.0 Computer Specification in May 2007. [148] As that occurs, baseline per-unit energy consumption will decrease, and it is anticipated that Verdiem will have a somewhat lower per-unit energy savings, even at higher penetration levels. As the stock of computers in the Northwest turns over during the next few years, the per-unit energy savings estimate for Verdiem will need to be re-evaluated to consider this effect.

8.4 Pricing Information in the ACE Model

While investigating energy savings, the M&T team identified one other assumption in the ACE model that should be updated. The ACE model's assumption about per-unit and annual maintenance prices should be updated to reflect current market prices. Although these values are not directly related to energy savings, they do provide important information about NEEA's benefit to the region. Table 8-2 compares the M&T team's recommended values with the ACE model's current values.

Table 8-2. Per Unit Pricing Information[149]

	ACE Model	Current Prices
First cost to consumer (per unit)	$13.25	$25
Maintenance to consumer (per unit per year)	$1	$5

8.5 Conclusions/Recommendations

NEEA's partnership with Verdiem helped develop a market-ready product with proven energy savings data. When market forces converged to raise awareness about the energy use of networked information technology systems, Verdiem's technology was able to achieve significant market penetration and create energy savings. The IT industry is in the midst of a major sea change, which has recently and will continue to create new opportunities for network energy management software.

Although implementation of the Verdiem Surveyor technology in the Northwest stalled during 2006 and 2007, a significant sale at the end of 2007 positioned 2008 for a significant growth in implementation, even before 2008 sales began. Further, a competitor, Faronics' Power Save software, emerged in 2006; although it has not pursued the Northwest market as much as other markets where utilities offer incentives for the technology, its presence in the marketplace creates additional opportunities for energy savings.

Table 8-3 summarizes the calculation of implied energy savings from NEEA's partnership with Verdiem. Between NEEA's 2006 values and the 2007 findings, market penetration and baseline estimates of Surveyor licenses remained relatively constant. However, the per unit energy savings estimate increased from 125 to 190 kWh/unit per year, resulting in an increase in the cumulative implied energy savings from 0.8 aMW through 2006 to 1.2 aMW through 2007.

[147] 80 PLUS. "Energy Efficient Computers Run with 80 PLUS™." Available: http://www.80plus.org/docs/broch/80PLUS_brochurepages.pdf

[148] Conversation with Andy Ekman, NEEA. May 23, 2008.

[149] "Want to Save the Planet? Turn off that PC." November 5, 2007. Richard Martin. *Information Week*.

Table 8-3. Recommended values for Verdiem Surveyor

Key Indicators Reviewed	NEEA 2006 Cumulative Values*	2007 Recommended Cumulative Values	Source
Current Market Activity (most recent 5 years)			
Overall commercial PCs in use (units)	3,130,706	3,554,169	IDC market reports
Surveyor licenses sold	62,679	61,415	Verdiem data
Market Penetration	1.8%	1.7%	Calculated
Current Baseline Activity (most recent 5 years)			
Surveyor licenses sold	6,269	6,141	Baseline discussed in Section 8.3.2
Market Penetration	0.2%	0.2%	Calculated
Per-Unit Energy Savings			
kWh/unit/year	125	190	Verdiem actual unit savings (Section 8.3.3)
Implied Energy Savings**			
Surveyor licenses sold (aMW)	0.8	1.2	Calculated

*NEEA 2006 values from Excel file "2006 MAR Cumulative Savings 04-03-07.xls"

** Implied energy savings are presented for comparison purposes only between NEEA's 2006 values and the 2007 M&T findings. NEEA's reported values may not match those presented here since NEEA adjusts for the effect of utility incentives and other factors not taken into account in this M&T analysis.

To summarize, the major recommendations of the 2007 M&T effort are as follows:

- Modify sales data to account for 2006 and 2007 sales, adjusted for estimated timing of deployment;
- Maintain baseline market activity at 10% of total market activity
- Increase the per-unit energy savings estimate from 125 kWh/unit/year to 190 kWh/unit/year to reflect increased deployment rates.
- Summit Blue recommends that NEEA continue the M&T effort for the market for network energy management software in two years. Due to the strengths of other market forces, a survey of new competitors to Verdiem should be a critical component of this analysis. Determining how they developed their products would lend insight into the lasting impacts of NEEA's effort in the market; this activity would create a baseline estimate with a stronger tie to the data. Assuming that Verdiem's competitors will have a more prominent role in the market by the end of 2009, Summit Blue recommends undertaking a survey of the target market (including both known and potential users of network energy management software) in order to create a top-down market assessment.
- The unique market conditions that have heightened the attention paid to network energy management software have created an opportunity for the Northwest to leverage NEEA's investment in Verdiem. Markets in which utilities are offering financial incentives for purchasing network energy management software (e.g., California and Madison, Wisconsin) are currently receiving the most attention from vendors like NEEA and Verdiem. NEEA could encourage Bonneville Power Administration or a subset of the utilities in the region to build on NEEA's

initial work with Verdiem in the Northwest. In doing so, the region could leverage the ratepayers' initial investment, capitalize on the fact that Verdiem is actually located *in* the Northwest, and take advantage of market forces that are making companies think seriously about the energy costs associated with their information technology systems. Additional energy savings could be realized through such an effort.

8.6 References

Communication with Denise Masters, Verdiem, January – March 2008.

Dimetrosky, S. and J. Steiner Luedtke and K. Seiden. *Market Progress Evaluation Report 2: Surveyor Software.* Prepared for NEEA, Report #E05-136. January 19, 2005.

"Green IT a Natural Fit for Enterprise Executives, IDC Says." IDC. October 31, 2007. Available: http://www.idc.com/getdoc.jsp?containerId=prUS20932407

Interview with Braden Cave, Marketing and Brand Specialist, at Faronics.

"Kleiner Perkins Invests in Energy Efficiency." July 13, 2007. Verdiem. Available: http://www.verdiem.com/news/pr_20070713.asp

"PC Market Outlook Remains Strong, While The Shift To Emerging Regions Accelerates, According To IDC." IDC. September 13, 2007. Available: http://www.idc.com/getdoc.jsp?containerId=prUS20870407

"PC Market Is Expected To Continue Double-Digit Growth Despite Increasing Economic Concerns, According to IDC." IDC. March 12, 2008. Available: http://www.idc.com/getdoc.jsp?containerId=prUS21138308

"Portable PC Adoption Accelerates, Lifting the Market Despite a Conservative Outlook for the United States, According To IDC**."** IDC. June 12, 2007. Available: http://www.idc.com/getdoc.jsp?containerId=prUS20729407

Quantec, LLC. January 15, 2005. "Market Progress Evaluation Report 2: Surveyor Software." Prepared for NEEA.

Roth, K.W. and G.R. Larocque and J. Kleinman. *Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings: Volume II: Energy Savings Potential.* Prepared for Building Technologies Program, U.S. Department of Energy. December 2004.

"Verdiem gives you more power over your power consumption. And, inquiring minds wonder whether power management might not be Vista's holy grail?" ZDNET. January 27, 2008. Available: http://blogs.zdnet.com/green/?p=732

"Want to Save the Planet? Turn off that PC." November 5, 2007. Richard Martin. *Information Week.*

9 ASiMI

The NEEA-ASiMI partnership, named after Advanced Silicon Materials (ASiMI), was created to develop a reliable dendritic polysilicon feedstock that could be used in continuous side recharge devices for silicon crystal growing. Prior to formation of the initiative, NEEA had supported Shell Solar (formerly Siemens and now owned by SolarWorld) in developing a more energy efficient process for growing silicon crystals, which included use of granular polysilicon feedstock for continuous recharge of the crystal-growing hot zone. However, only one granular feedstock supplier, Monsanto Electronic Materials Company (MEMC), existed in the marketplace at the time, and MEMC's feedstock was in short supply as the company often made the strategic decision to use it in-house rather than sell it to competitors. As a result, continuous recharge was difficult to use on a consistent basis and consequently NEEA began funding the project with ASiMI to develop a new feedstock.

At the time of the project, ASiMI had two production facilities, one at Moses Lake, WA, and the other at Butte, MT. At different times, Moses Lake produced a feedstock called Teardrop™, and the Butte facility produced a product called Teardrop™Plus. The Teardrop™Plus product was a modified version of the Teardrop™ technology, designed to run in the reactors located in Butte instead of those at the Moses Lake facility; both feedstocks created energy savings at the silicon crystal manufacturing facilities that used them, and both were compatible with continuous side recharge, which reduces energy intensity at the site of silicon crystal growing operations. By 2005, a Norwegian company, REC Group (REC), had acquired both production facilities.

The NEEA-ASiMI partnership was a part of the Microelectronics Initiative, a market transformation effort funded by NEEA and was targeted at the semi-conductor manufacturers in the region. Using the new feedstocks, NEEA began the demonstration project with Shell Solar because, as the only U.S. solar manufacturer at the time, Shell Solar was open to sharing knowledge about advances in the efficient production of silicon cyrstals. Shell Solar's experience could be used as an example for the semi-conductor industry, which could also generate energy savings by using a continuous recharge process. In addition to Shell Solar, SEH-America, a local semiconductor-grade silicon crystal-growing company, was recruited for the demonstration project.

The 2007 long-term monitoring and tracking effort is directed at determining the extent to which the advances in feedstock supply and silicon production efficiency enabled by the NEEA-ASiMI partnership are still in use in the silicon industry in the Northwest and the extent to which the NEEA-funded project is responsible for the benefits created by the technology.

9.1 Assumptions and Indicators for Review

Due to the nature and developments of this effort, this M&T effort focuses on a market progress assessment as well as a review of savings assumptions. Indicators of impact of NEEA's efforts on the silicon manufacturing and silicon crystal growing industries include the following:

1. *Use of continuous side recharge technology and/or ASiMI feedstock in semiconductor or solar crystal-growing facilities in the region, such as the SEH-A facility in Vancouver, WA.*

2. *Production of silicon feedstock at the Butte facility using ASiMI technology.* While in the process of purchasing the Butte facility, REC intended to use the plant's production capacity for its own solar products and anticipated maintaining its semiconductors customers, at least until existing

contracts expired.[150] If the Butte facility still produces silicon using the ASiMI technology, it would result in energy savings similar to those at the Siemens-Shell facility.

3. *Connection between NEEA's efforts and REC's investment decisions regarding Northwest facilities.* REC purchased the Moses Lake Plant in 2005 in order to secure a stable supply of feedstock for its U.S. operations. To what extent did the ASiMI technology make that purchase happen? Moreover, in 2006, REC announced the construction of a third solar-grade silicon facility in Moses Lake, and it appears that it will use an energy efficient manufacturing process. If that is the case, the energy savings using this method could be a direct result of NEEA's efforts with ASiMI.

4. *Development of more flowable products by other polysilicon producers.* MPER #3 states, "there are strong indications that the market is moving in the direction of desiring more flowable materials, which could ultimately result in more [continuous] recharge." If that were still the case today, it could point to additional energy savings in the region.

In short, there are two ways that energy savings are generated from the ASiMI feedstock. First, the process used to produce the feedstock is less energy intensive than the process used to manufacture traditional silicon feedstocks; thus, energy is saved in manufacturing the feedstock (#2 and #4 above). Second, energy is saved when the feedstock is used to grow silicon crystals *if and only if* the feedstock is input using the side recharge technology (#1 above); if an ASiMI-like feedstock is used in traditional batch processing for silicon growth, energy savings are not realized.

These issues were explored to help determine the market effects and changes in practice that continue today due to NEEA's efforts.

9.2 Methodology

In order to determine the long-term impacts of NEEA's funding of the NEEA-ASiMI partnership, Summit Blue reviewed the MPERs, interviewed individuals involved with the project and other relevant industry players, conducted internet research where appropriate, and reviewed other industry literature. While the industry literature review and internet research served as background, the interviews with individuals who were involved in developing the ASiMI feedstock or implementing it in the SEH-A and Shell Solar facilities provided the bulk of the content for this report. Interviewees included the following.

- **Phil Degens,** Energy Trust of Oregon, who was the Evaluation Manager at NEEA for the NEEA-ASiMI partnership;

- **Bryan Fickett,** Solaicx, who developed the Fickett Universal Recharge System and worked closely with Shell Solar during NEEA-ASiMI partnership;

- **Bob Helm,** contractor for NEEA, who was the Senior Manager for the Agricultural and Industrial Sectors group at NEEA during the preparation of the MPER for the NEEA-ASiMI partnership;

[150] Research Into Action and MetaResource Group. October 24, 2005. *Market Progress Evaluation Report.* Prepared for NEEA. Report #E05-150.

- **Jane Peters,** Research into Action, who prepared the final MPER on the NEEA-ASiMI partnership and participated in the development of the previous MPER;

- **Ron Reis,** REC, who was the main contact at ASiMI during the NEEA-ASiMI partnership and is now the Director of Technology at REC;

- **Steven Scott,** MetaResource Group, who assisted in preparing the most recent MPER;

- **Darren Taie,** SEH-America, who was the contact person at SEH-A during the NEEA-ASiMI partnership.

9.3 Findings

9.3.1 Market Activity

For the NEEA-ASiMI partnership, market activity in the Northwest can be assessed with respect to each of the four indicators discussed in section 9.1:

1. Use of ASiMI feedstock in the semi-conductor and solar industries in the Northwest;

2. Production of the feedstock at REC facilities;

3. Connection to REC's investment decisions regarding Northwest facilities;

4. Other industry activity.

1) Use of ASiMI feedstock in the Northwest semi-conductor and solar markets

The only semi-conductor manufacturer in the Northwest currently using ASiMI's flowable feedstock is SEH-A. Without specifying an amount of TearDrop™Plus that it purchases each year, SEH-A states that it is using a "significant amount" of the feedstock in its operations in Vancouver, WA.[151] The company is satisfied with the feedstock's performance and plans to continue using the feedstock at least until its current supply agreement with REC expires. SEH-A believes that REC would like to continue doing business together, though SEH-A is not certain how much feedstock REC would be willing to supply. Thus, future market activity for ASiMI in the semi-conductor industry is uncertain.

Although the semi-conductor industry was the main target of the NEEA funding, circumstances have changed in the Northwest. The semi-conductor industry went through a major contraction in the Northwest during the early part of this decade. Many silicon manufacturers closed or were mothballed. In the meantime, the solar industry has experienced rapid growth: Shell Solar was acquired by Siemens and then by SolarWorld, which recently announced plans to locate the largest solar plant on the North

[151] Interview with Darren Taie, SEH-A.

American continent in Hillsboro, OR;[152] REC is a vertically integrated global solar company, that acquired the two former ASiMI facilities; Solaicx, a solar wafer manufacturer, has located its new facility in Portland;[153] and Peak Sun Silicon, a polysilicon manufacturer, has recently decided to locate in the Northwest.[154]

As a result of this sector shift in the Northwest, the ASiMI feedstock could have a greater impact if used in the solar industry than in the semi-conductor industry. According to REC, however, its only Teardrop™Plus customer in the Northwest is SEH-A.[155] (Shell Solar never purchased the product from REC.)

2) Production of the Teardrop™Plus feedstock at REC facilities in the Northwest

REC is still manufacturing the Teardrop™Plus feedstock, using part of the capacity at both the Butte and Moses Lake facilities to do so. However, it is a smaller portion of its overall product mix at these facilities than it was during the ASiMI project's operation. Today, less than 10% of the facilities' combined capacity is used to manufacture Teardrop™Plus. Given the imprecise nature of this estimate, initial calculations were based on a range of 5% to 10% of total capacity being used to produce Teardrop™Plus. This results in an estimate of roughly 290-580 metric tons of annual Teardrop™Plus production at the combined facilities.[156] The midpoint estimate of roughly 440 metric tons per year is within a few percent of NEEA's 2005 estimate, which is withheld on NEEA's behalf to maintain confidentiality. Thus, the NEEA assumption appears to be supported by the M&T research and is adopted for this analysis.

When REC acquired the Moses Lake and Butte facilities, it had to make strategic decisions about how to use the new capacity. As a vertically integrated solar manufacturer, some of REC's capacity in Moses Lake and Butte would need to be used to supply its own wafer manufacturing subsidiary. As a result, REC produces other types of silicon feedstock at these facilities. One of them is also an energy efficient process, though it is not directly connected to the Teardrop™Plus product.

Future production levels of Teardrop™Plus at REC's Northwest facilities is uncertain. The company committed to fulfilling the supply agreements that Advanced Silicon Materials had signed with SEH-A and other firms prior to the acquisition. Those agreements will expire in the next few years, however, and REC has not made a firm decision about whether or not to renew them or at what levels they might be renewed. One thing is for certain: the amount of capacity dedicated to the Teardrop™Plus product will not increase from its current level.[157]

---

[152] SolarWorld. March 1, 2007. "SolarWorld Group to Build America's Largest Solar Facility." Available: http://www.solarworld-usa.com/America-s-Largest-Sola.579.0.html

[153] Solaicx. November 20, 2007. "Oregon Governor Kulongoski Cuts Ribbon for Solaicx Solar Manufacturing Plant." Available: http://www.solaicx.com/pages/news12.htm

[154] Paul, A. November 8, 2008. Silicon Maker Peak Sun Picks Millersburg, OR Site." *Corvallis Gazette-Times*. Available: http://www.solaroregon.org/about/news_folder/silicon-maker-picks-millersburg-site/

[155] Interview with Ron Reis, REC. All information on REC in the Market Activity section was provided by Mr. Reis unless otherwise noted.

[156] REC reported that its combined operations in Moses Lake and Butte produced 5,760 metric tons of polysilicon in 2007. "Presentation of Interim Results: 4th Quarter 2007." Renewable Energy Corporation. February 12, 2008.

[157] Ron Reis, REC.

3) REC's investment decisions regarding Northwest facilities

REC purchased a stake in the Moses Lake plant in 2002 and acquired the remainder of that plant and a full stake in the Butte plant in 2005. REC recently reported that it had or would invest $1.2 billion in the Butte and Moses Lake facilities in 2007-2009 in order to expand capacity. These investments would more than double the combined capacity of the Butte and Moses Lake facilities.

Just over half of that expansion would stem from plans to build another production facility at Moses Lake based on a highly efficient technology called fluidized bed reactor (FBR). The FBR technology uses about 10% of the energy that the traditional alternative uses.[158] This FBR technology is a cutting edge technology in silicon feedstock production, and it uses an entirely different process than either ASiMI or the traditional process. This technology represents a revolutionary transformation of the silicon manufacturing process, rather than the incremental change.

4) Other industry activity

According to SEH-A, REC and MEMC are the only companies producing a flowable feedstock for the semi-conductor industry.[159] MEMC's product was being manufactured prior to the NEEA-ASiMI partnership and is not consistently available on the market. This leaves REC as the only reliable source of the flowable feedstock in the Northwest. Since REC operates the facilities originally owned by ASiMI, it appears that the NEEA project did not stimulate additional manufacture of flowable feedstock in the semi-conductor industry.

However, the nature of silicon feedstocks for the solar industry is different from those for semi-conductors, and there has been significant market activity in solar-grade silicon wafer manufacturing. Until recently, no other polysilicon suppliers in the Northwest produced flowable feedstock for the solar industry except REC. That changed when Peak Sun Silicon decided to locate in Millersburg, OR. Peak Sun Silicon produces a granular feedstock using the same FBR technology that REC uses.

With the global demand for solar growing and manufacturers' need to maintain low prices in order to stay competitive, growth in the use of flowable feedstocks in the solar manufacturing process can be expected to continue. Total polysilicon production (for semi-conductors and solar combined) in the United States is anticipated to grow from 31,000 metric tons in 2005 to 77,000 metric tons in 2010.[160] Given the strength of the Northwest's skilled labor market, support of green businesses through business tax credits, and low energy prices, it can be expected that some of this activity will be located in the Northwest. As more market players emerge, however, it is not clear what share of that activity the Northwest can expect.

One of the desired outcomes of the NEEA-ASiMI partnership was to stimulate interest in using continuous side recharge. At this time, Solaicx is using continuous recharge at its Portland, OR,

[158] Sources: a) "Presentation of Interim Results: 3rd Quarter 2007." Renewable Energy Corporation. October 26, 2007; b) "Presentation of Interim Results: 2nd Quarter 2007." Renewable Energy Corporation. July 27, 2007; c) "Capital Markets Day: Fluidized Bed Reactor." Ron Reis. November 22, 2006. All available at http://www.recgroup.com/default.asp?V_ITEM_ID=610

[159] Interview with Darren Taie, SEH-A.

[160] Flynn, H. and T. Bradford. *Polysilicon: Supply, Demand and Implications for the PV Industry." Prometheus Institute.* 2006. Available: http://www.prometheus.org/research/polysilicon2006

facility.[161] The development of Solaicx's proprietary side recharge technology was an outgrowth of the NEEA-ASiMI partnership.[162] One of the primary engineers responsible for developing the Solaicx technology worked at Siemens during the NEEA-ASiMI partnership and was able to apply the lessons learned to the new Solaicx technology.

Since the technical details of the Solaicx technology are closely held, it is not possible to determine the amount of energy savings generated at this facility. Additionally, the plant only began operating in November 2007 and only at a fraction of its potential capacity. The facility anticipates generating 100 jobs and producing silicon wafers sufficient for 32 MW of photovoltaic power in its first year of operations and ramping up to 180 jobs and 100 MW at full capacity.[163] This is a tangible demonstration of market transformation in the Northwest market for crystal growing processes.

9.3.2 Baseline Activity

The baseline represents the market activity that could have been expected without the investment made by NEEA in the ASiMI partnership. This section will follow the same structure as the Market Activity discussion above.

1) Use of ASiMI feedstock in the Northwest semi-conductor and solar markets

Without the NEEA-ASiMI partnership, it is unlikely that the semi-conductor industry would have used the Teardrop™ or Teardrop™Plus feedstocks. The NEEA-ASiMI partnership created a forum in which suppliers and customers were able to discuss concerns about the feedstock and develop strategies for addressing those concerns. Most relevant was the qualification process, which provided critical data points for the semi-conductor industry. Since semi-conductors are built to rigid specifications, there is a reluctance to use alternative feedstocks that may or may not replicate the status quo. SEH-A was able to overcome these issues through the qualification process, enabling the firm to make the decision to use the alternative feedstock. SEH-A's positive experience with ASiMI's products led to additional business for REC in the semi-conductor industry outside of the Northwest.

Thus, the baseline for SEH-A's use of Teardrop™Plus is 0% of current market activity.

2) Production of the Teardrop™Plus feedstock at REC facilities in the Northwest

The NEEA-ASiMI partnership enabled REC to interact with customers to address concerns and to optimize and replicate the process for manufacturing Teardrop™ and Teardrop™Plus . The quality improvements that resulted from the qualification process with SEH-A had a dramatic effect on the feedstock's market viability.[164] Further, the partnership enabled Advanced Silicon Materials to investigate

[161] "Creating a Revolution." Solaicx. Undated. Available: http://www.solaicx.com/pages/pv.htm Also, interview with Bryan Fickett, Solaicx.

[162] Interview with Brian Fickett, April 2, 2008.

[163] "Oregon Governor Kulongoski Cuts Ribbon for Solaicx Solar Manufacturing Plant." November 20, 2007. Solaicx. Available: http://www.solaicx.com/pages/news12.htm

[164] Interview with Ron Reis, REC.

the manufacturing process and determine how to replicate the process most effectively.[165] This enabled the transfer of operations from Moses Lake to Butte in 2002. Without the NEEA-ASiMI partnership, it is fair to say that baseline market activity in the Northwest would have been 0% of current market activity.

Regardless of the impact of the NEEA-ASiMI partnership, the acquisitions in the Northwest had a significant impact on the production at the Moses Lake and Butte facilities. Once the acquisition occurred, REC had to make strategic decisions about how to use that production capacity to supply the other parts of the vertically integrated organization. Those decisions resulted in a decrease in the amount of Teardrop™Plus produced in the Northwest that had nothing to do with NEEA's effort.

3) REC's investment decisions regarding Northwest facilities

REC reports that its decision to acquire the Moses Lake and Butte facilities was based on production capacity alone, rather than the types of products being manufactured in the facilities.[166] This is supported by the fact that REC only uses less than 10% of the plants' combined capacity to produce the Teardrop™Plus product today. In other words, in the absence of the NEEA-ASiMI partnership, the acquisition still would have happened; the baseline is 100% of the market activity.

Similarly, the development of the FBR facility would have occurred with or without the NEEA-ASiMI partnership.[167] REC's broader corporate goals target cost reduction for the manufacturing of photovoltaic equipment, which is the driver behind the FBR development.[168]

ASiMI would have maintained roughly the same market share during the downturn even without the NEEA-ASiMI partnership.[169] During the market downturn, customers typically reduced orders equally among their suppliers; that is, ASiMI's customers purchased about the same share of their supply from the company during the downturn as they did before it. As a result, it is reasonable to conclude that the fact that the Butte and Moses Lake facilities remained in operation during the downturn is independent of the NEEA-ASiMI partnership.

4) Other Industry Activity

The baseline for the broader silicon industry should be examined carefully. The NEEA-ASiMI project targeted the semi-conductor industry because of its dominant presence in the region when the Microelectronics Initiative began. The solar industry, manifested by Shell Solar, was used as a vehicle for reaching the semi-conductor industry. Over the long-term, most of the activity around energy efficient polysilicon manufacturing techniques has targeted the solar industry, however. The NEEA-ASiMI partnership may have generated spillover effects into the solar industry.

That said, the baseline for energy efficient polysilicon market activity in the solar industry is quite high. Since the early 2000s, government incentives for solar have permeated the globe. Concern over carbon dioxide emissions from electricity production has captured the public's attention not only in Europe and Japan but in the United States as well. The "green revolution" has sparked market interest in residential

---

[165] Interview with Steven Scott, MetaResource Group.

[166] Interview with Ron Reis, REC.

[167] Interview with Ron Reis, REC.

[168] "Presentation of Interim Results: 4th Quarter 2006." Renewable Energy Corporation. February 13, 2007. Available: http://www.recgroup.com/default.asp?V_ITEM_ID=610

[169] Personal communication with Ron Reis, REC.

and commercial PV systems. Due to surging demand, the solar industry has witnessed significant increases in the cost of raw materials. In order to capitalize on market demand, solar manufacturers have looked to cut costs wherever possible. The development of the continuous recharge and FBR technologies by different solar manufacturers are two examples of this driver at work; both technologies reduce costs through lower energy costs, shorter process times, and reduced materials waste.

Calculating a baseline for Solacix, the company that is now using continuous side recharge to grow crystals in Portland, is complex. These market drivers created a need for cost-effective solar manufacturing techniques, and the Solaicx technology was one response to that demand. Although the technology may not have existed without the NEEA-ASiMI partnership, the market would have. Any potential energy savings for 2006 and 2007 would be minimal because of the timing and scale of Solaicx's initial manufacturing operations in the region. Recognizing that NEEA would only take a fraction of those savings generated, this M&T effort concludes that the baseline for this activity is immaterial at this time.

9.3.3 Per-Unit Energy Savings

At SEH-A, energy savings created by using Teardrop™Plus are reported to be insignificant.[170] In large part, this is due to SEH-A's use of the feedstock in regular batch processing rather than through a continuous recharge process. (In the semi-conductor manufacturing industry, the batch manufacturing process is standard operating procedure.) SEH-A reports a per-unit energy savings of 0 kWh/ton Teardrop™Plus used in its process.

REC's per-unit energy savings remain the same as those reported in the 2005 MPER.[171] Each ton of TeardropPlus produced saves about 22% of the energy that would otherwise be used to produce silicon through the traditional process.[172] Since the traditional process uses between 70 and 120 kWh per kilogram produced, the range of savings is roughly between 15 and 26 kWh/kg.[173]

9.4 Conclusions/Recommendations

The NEEA-ASiMI partnership had a dramatic effect on the market viability of continuous flow silicon feedstock using the Teardrop™ method. The partnership also enabled ASiMI to investigate the manufacturing process and determine how to replicate the process most effectively, thus enabling the transfer of operations from Moses Lake to Butte in 2002. REC, the current owner of the ASiMI facilities, is still manufacturing the Teardrop™Plus feedstock. However, it is a smaller portion of its overall product mix at these facilities than it was during the NEEA-ASiMI partnership, and the precise production levels (tons per year) are considered proprietary information by the company.

Without the NEEA-ASiMI partnership, it is unlikely that the semi-conductor industry would have used the Teardrop™ or Teardrop™Plus feedstocks in the process of manufacturing silicon crystals. SEH-A is

[170] Interview, Darren Taie.

[171] Personal communication with Ron Reis, REC.

[172] This savings estimate was cited in the most recent MPER (Research Into Action and MetaResource Group. October 24, 2005. *Market Progress Evaluation Report.* Prepared for NEEA. Report #E05-150.), and Ron Reis (REC) indicated that no process changes have been made since that report that would affect that estimate.

[173] "Analyst Silicon Field Trip." Renewable Energy Corporation. March 28, 2007. Available: http://www.recgroup.com/default.asp?V_ITEM_ID=610

the only silicon crystal grower in the Northwest using the Teardrop™ feedstock, however, and the facility is using the feedstock in the standard batch process common for semi-conductor crystal growth. Thus, SEH-A is not realizing the potential savings that would result from continuous recharge.

Based on the analysis conducted for this long-term monitoring and tracking effort, annual energy savings associated with the NEEA-ASiMI partnership is estimated at between 0.8 aMW and 1.3 aMW, all due to the *production* of TearDrop™Plus at REC facilities in the Northwest (Table 9-1). Due to the imprecise nature of this range, however, an estimate of 1 aMW best represents the possible savings from the manufacture of Teardrop™Plus. No savings have accrued from the *use* of TearDrop™Plus at silicon crystal growing facilities.

The implied energy savings are higher than those calculated by NEEA for 2006 because NEEA did not report any savings from this project in 2006. This 2007 M&T analysis does suggest a change to the ACE model, however, since the M&T calculation estimates per-unit savings that range from one-half to two-thirds of the NEEA's most recent (2005) estimated energy savings.[174] It is not clear how the NEEA estimate was developed.

[174] NEEA savings estimates derived from "2006 MAR Cumulative Savings 04-03-07." Provided by NEEA. The specific estimates are treated as confidential.

Table 9-1. M&T Recommendations for Key Indicators

Key Indicators Reviewed	Discussion and Estimated Values*
Market Activity	
Use of ASiMI feedstock in the Northwest	SEH-A is the only crystal growing facility using the ASiMI feedstock. Quantities are confidential, but estimating them is unncecessary since its use is not contributing to energy savings.
Production of TearDrop™Plus at REC facilities in the Northwest	456 metric tons per year in 2006 and 2007.**
REC's investment decisions regarding northwest facilities	Activity included the acquisition itself, the resulting job creation, and the plants' continued operation during the market downturn.
Other industry activity	New manufacturing facilities in the Northwest include 1) Peak Sun Silicon's granular feedstock plant, 2) Solaicx's silicon wafer plant, and (3) SolarWorld's wafer/solar cell expansion. The proprietary nature of technology at Solaicx prevents quantification of savings.
Total Market Activity	*Approximately 440 metric tons of TearDrop™Plus production per year*
Baseline Activity	
Use of ASiMI feedstock in the Northwest	Zero baseline. No activity would have occurred in the absence of the NEEA-ASiMI partnership.
Production of TearDrop™Plus at REC facilities in the Northwest	Zero baseline. No activity would have occurred in the absence of the NEEA-ASiMI partnership.
REC's investment decisions regarding northwest facilities	100% of market activity. All identified activity likely would have occurred even in the absence of the NEEA-ASiMI partnership.
Other industry activity	Baseline is about 50% of market activity. The forces shaping the market were as important as the development of the side recharge technology through the NEEA-ASiMI partnership.
Total Baseline Activity	*Varies. Zero baseline for quantifiable market activity.*
Per-Unit Energy Savings	
Use of ASiMI feedstock in the Northwest (kWh/kg of crystal growth)	Zero. SEH-A is not using the ASiMI feedstock for continuous recharge.
TearDrop™Plus production (kWh/kg)	Between 15 and 26 kWh/kg Teardrop™Plus produced**
REC's investment decisions regarding northwest facilities	Not applicable
Other industry activity	Negligible for 2007, though formal calculations are not possible due to the proprietary nature of the technology.
Implied Energy Savings	
Use of ASiMI feedstock in the Northwest	0 aMW
Production of TearDrop™Plus at REC facilities in the Northwest	Approximately 1 aMW each year in 2006 and 2007***
REC's investment decisions regarding northwest facilities	0 aMW
Other industry activity	Unable to quantify
Total Implied Energy Savings	*1.0 aMW*

* The M&T assessment of the NEEA-ASiMI partnership includes a variety of activities, some of which cannot easily be quantified in terms of cumulative market activity and energy savings. Therefore, results are presented in a different format than for other 2007 M&T assessments.

** The production of TearDrop™Plus at REC's facilities, as well as the associated energy savings, was estimated using cited sources (see Sections 9.3.1 and 9.3.3).

*** Due to the imprecise nature of the data underlying this calculation, only one signficiant figure is recommended for the implied energy savings, which were calculated to be between 0.8 aMW and 1.3 aMW.

It appears likely that market transformation in future crystal growing activity by Solaicx and any other new entrants into the Northwest market will capture the lasting effect of the NEEA-ASiMI partnership on the region. Because REC is focusing its growth efforts in the new FBR technology, it is likely that the role of the Teardrop™Plus product will continue to decrease relative to other energy efficiency efforts in the industry. It is unclear if REC will even continue to produce the Teardrop™Plus product when existing supply agreements expire. On the other hand Solaicx is using the continuous side recharge technique that was developed through the NEEA-ASiMI partnership. Energy savings from those operations are at least partially related to the NEEA-ASiMI partnership.

If Solaicx relaxes its policy on sharing information about its proprietary technology, NEEA may consider undertaking future M&T efforts in this market. Without information from Solaicx about the technology, however, it will not be possible to calculate energy savings from its operations. If that information is available, future M&T efforts could look to quantify savings from Solaicx and gauge the relative importance of outside market forces in enabling the application of the continuous side recharge technology.

At a higher level, the solar industry in the Northwest does present tremendous opportunity for future energy efficiency efforts. With the introduction of FBR technology, significant gains can be made in the energy efficiency of polysilicon manufacturing. Other efficiencies may be possible in the manufacture of solar wafers, cells, and panels. Because the industry is in a period of intense price sensitivity, it is likely that manufacturers will seek out such opportunities, to the extent that they cut costs. Although it is likely that the simple rules of supply and demand will generate much of the energy efficiency gains, NEEA may assess the extent to which it could add value in this market. If a facilitator's role would enhance the efficiencies of the market, then NEEA could carve out a role for future involvement.

9.5 Bibliography

"Analyst Silicon Field Trip." Renewable Energy Corporation. March 28, 2007. Available: http://www.recgroup.com/default.asp?V_ITEM_ID=610

"Capital Markets Day: Fluidized Bed Reactor." Ron Reis. November 22, 2006. Available: http://www.recgroup.com/default.asp?V_ITEM_ID=610

Interviews with Bryan Fickett, Solaicx, December 18, 2007 and April 2, 2008.

"Creating a Revolution." Undated. Solaicx. Available: http://www.solaicx.com/pages/pv.htm

Interview with Phil Degens, Energy Trust of Oregon, December 17, 2007.

Interview with Bob Helm, contractor for NEEA, December 6, 2007.

Interview with Jane Peters, Research into Action, December 11, 2007.

Interview with Ron Reis, REC, January 9, 2008.

Interview with Steven Scott, MetaResource Group, December 7, 2007.

Interview with Darren Taie, SEH-America, January 3, 2008.

"Oregon Governor Kulongoski Cuts Ribbon for Solaicx Solar Manufacturing Plant." November 20, 2007. Solaicx. Available: http://www.solaicx.com/pages/news12.htm

Paul, A. November 8, 2008. Silicon Maker Peak Sun Picks Millersburg, OR Site." *Corvallis Gazette-Times*. Available: http://www.solaroregon.org/about/news_folder/silicon-maker-picks-millersburg-site/

"Presentation of Interim Results: 4th Quarter 2007." Renewable Energy Corporation. February 12, 2008. Available: http://www.recgroup.com/default.asp?V_ITEM_ID=610

"Presentation of Interim Results: 3rd Quarter 2007." Renewable Energy Corporation. October 26, 2007. Available: http://www.recgroup.com/default.asp?V_ITEM_ID=610

"Presentation of Interim Results: 2nd Quarter 2007." Renewable Energy Corporation. July 27, 2007. Available: http://www.recgroup.com/default.asp?V_ITEM_ID=610

"Presentation of Interim Results: 4th Quarter 2006." Renewable Energy Corporation. February 13, 2007. Available: http://www.recgroup.com/default.asp?V_ITEM_ID=610

SolarWorld. March 1, 2007. "SolarWorld Group to Build America's Largest Solar Facility." Available: http://www.solarworld-usa.com/America-s-Largest-Sola.579.0.html

Solaicx. November 20, 2007. "Oregon Governor Kulongoski Cuts Ribbon for Solaicx Solar Manufacturing Plant." Available: http://www.solaicx.com/pages/news12.htm

10 SHELL SOLAR

Shell Solar (formerly Siemens and now owned by SolarWorld) submitted a proposal to NEEA in 1997 to develop an innovative process for growing silicon crystals by modifying the crystal-growing hot zones. This process includes both a redesign of the hot zone itself (improved insulation and heating elements) and the introduction of an external feeder system to recharge the hot zone with granular polysilicon feedstock, while maintaining a vacuum and without losing the heat built up during the initial production run.

As the only US grower of silicon crystals for the solar industry, Shell was willing and able to publish the results of its experience in industry forums, thus potentially influencing silicon crystal growing firms throughout the photovoltaic industry. The company successfully met all internal objectives in its proposal and saved six million kWh between February 1999 and February 2001. Significant non-energy benefits included reduced production time, reduced Argon consumption, and higher quality solar cell panels. At the time the project was funded by NEEA, there were about a half a dozen other facilities in the region, including those operated by SEH America, Sumitomo/Mitsubuishi, and Wacker. However, many of these facilities have since shut down. In fact, until recently, SEH America was the only other crystal growing facility in the region besides the Shell (SolarWorld)[175] facility, and there has been no indication through 2006 that the Shell project has influenced any changes in that facility's production process.

Recently, Solar World announced that it was opening an integrated solar silicon wafer and solar cell production plan in the Northwest, which could require higher volumes of crystal growth than in the recent past.[176] In addition, several other companies have located facilities in the Northwest to manufacture polysilicon feedstock and grow crystals for solar silicon wafers. This new activity may be related in some manner to the advances of the Shell project, although it is likely that market forces and the economics of photovoltaic wafers are the driving force.

This 2007 M&T effort will update production and energy savings data from the original Vancouver, WA Solar World facility and assess whether the new Hillsboro, OR facility has produced silicon crystals using the energy efficiency methods from the original Shell project. The scope of this review is limited due to the fact that subsequent efforts by NEEA to improve efficiency in silicon crystal growing facilities have been handled within the ASiMi project, which is receiving an independent M&T assessment.

10.1 Indicators and Assumptions for Review

According to Summit Blue's review of the ACE model, and as documented in the 2005 M&T report, the electricity savings impact of the Shell project is based on the capacity of efficient hot zones used for production, the related electricity savings relative to the conventional hot zones, and the number of production days per year. The ACE model also assumes zero baseline activity and zero market effects beyond those captured by Shell.

[175] For purposes of clarity and consistency, "SolarWorld" will be used to refer to the company and the facility where the efficiency innovations occurred. "Shell" will be used to refer to the project funded through NEEA.

[176] SolarWorld press release, March 1, 2007, "SolarWorld Group to Build America's Largest Solar Factory," http://www.solarworld-usa.com/SolarWorld-Group-to-Bu.299.0.html.

Specifically, savings for a given calendar year are calculated as follows:

Annual Electricity Savings (kWh/year) =

(1) Heater capacity (in kW) of efficient hot zones that were converted or developed within the past [Measure Life] years

x (2) Electricity savings per kW of hot zone production per day

x (3) Production days per year

where:

Hot zone heater capacity is based on the rated capacity of the grower units. Total capacity is the sum of the capacities of the individual units using the more efficient process.

Electricity savings per kW of heater capacity is a measure of the increased efficiency of production in terms of electricity savings generated for each kW of grower capacity.

Production days per year is the number of 24-hour days that the efficient hot zones are used each year.

The original savings estimates reported by Shell and NEEA were based on 125-kW hot zones. In 2006 SolarWorld began retrofitting some of its idle 100 kW hot zones, which have only about 60% of the savings of the larger units. Thus, the indicators of interest are not just the heater capacity (in kW), but the actual number of 125 kW and 100 kW units used in production at the Vancouver facility and, if applicable, at the new Hillsboro plant.

10.2 Methodology

The original intent was to contact Greg Mihalik of SolarWorld for an update on the manufacturing process and equipment usage at the Vancouver facility. However, Mr. Mihalik no longer works for SolarWorld and was not available to comment on changes in production. Bob Beisner of SolarWorld, who was familiar with Summit Blue's 2006 M&T research, served as a liaison between the technical staff and Summit Blue. Through several email exchanges and telephone conversations, Summit Blue was able to obtain some general information about production in Vancouver and about plans for the new Hillsboro facility.

SolarWorld was not as forthcoming with detailed information as in the past. Factors contributing to the difficulty in gaining specific production data include the acquisition of Shell by SolarWorld, the loss of the M&T team's principal contact in Greg Mihalik, and the growing competition in the region for silicon crystal growing and wafer manufacturing.

10.3 Findings

10.3.1 Market Activity

As discussed above the focus of this M&T assessment is on the SolarWorld facility in Vancouver and its new manufacturing plant in Hillsboro. It can be broadly stated that SolarWorld's crystal growing activity in 2007 remained roughly stable, and production at the new facility was not yet underway. These findings, discussed briefly below, are based on previous M&T research, an interview with Bob Beisner of SolarWorld, and the company's March 1, 2007 press release.

Silicon Crystal Growing at the Vancouver, WA Facility

SolarWorld's crystal growing plant in Vancouver is equipped with a total of 69 hot zones. Thirty-eight hot zones are of the larger, 125-kW size, and all have been retrofitted to become "efficient" hot zones and have been in operation since 2004. (Shell had 24 hot zones in operation in 2001 and increased the number until all were being used by 2004.) In addition, the facility has 31 100-kW hot zones, which were not initially retrofitted and were not being used until 2006, at which time five units were retrofitted and in operation.

For this 2007 M&T update, SolarWorld did not provide specific information on its use of the 100-kW hot zones. However, previous interviews with Greg Mihalik did not indicate that these smaller hot zones were likely to be used in a large way. Furthermore, SolarWorld intends to begin growing crystals in the new facility, which would lessen the need to expand production using the less efficient, smaller hot zones in Vancouver. Thus, the research suggests that production at the facility is little changed from 2006. The best estimate is that 38 125-kW hot zones are in use, and five 100-kW hot zones. Continuous recharge is not being used, except in small testing applications.

Activity at the New Hillsboro, OR Facility

Through the end of 2007, production had not yet begun at the Hillsboro plant, in part due to delays in receiving the necessary equipment from manufacturers. Production is expected to begin in mid-2008. According to the company press release, the facility will be "integrated solar silicon and solar cell production which will reach a capacity of 500 MW by the year 2009," making it the largest solar factory in the United States. In short, SolarWorld will be producing both the silicon wafers (cut from ingots produced in Vancouver) and the solar cells used for photovoltaic panels. According to Mr. Beisner of SolarWorld, by the end of 2008 the Hillsboro facility may also be used to grow the silicon ingots (crystals). The company plans to continue production in Vancouver for the foreseeable future.

None of the sources of information identified by Summit Blue indicated the type of crystal growing process or feedstock that would be used at the new facility. However, even if the Shell technology is employed, the benefits would not begin accruing substantially until 2009.

10.3.2 Baseline Activity

Investigation of the baseline was not an explicit part of the 2007 M&T assessment, and there was nothing to indicate any change. As such, the assumed baseline of zero still applies. It is unlikely that baseline will change, especially given that the scope of the market activity is limited to SolarWorld facilities. (Other market effects, if any, are being assessed via the ASiMI M&T effort.) If the Vancouver facility replaces its hot zone equipment in the future, then perhaps the changeover could be considered a baseline activity that would have provided energy savings not linked to the original Shell project. Similarly, crystal growing at the new Hillsboro plant may not represent incremental energy savings stemming from the original Shell project since industry innovations not linked to Shell have allowed for more efficient crystal growing without the modifications pioneered by Shell.

As noted in the 2006 M&T report, "Since the time of SolarWorld's innovations, the quality and characteristics of crucibles have improved such that the additional insulation developed through the project is no longer necessary to allow for continuous recharge. While these new crucibles may be more

energy efficient than their predecessors, the advancement cannot be attributed to SolarWorld, as recharge was employed in crystal-growing operations prior to the Shell project…."[177]

10.3.3 Per-Unit Energy Savings

Energy savings from individual hot zones were not a subject of the 2007 M&T assessment, and there is nothing to indicate that previously established assumptions should be changed. Savings per unit are based on days of operation and on type of hot zone. Some of this data is considered confidential by SolarWorld and detailed information is not presented here.

10.4 Conclusions and Recommendations

The SolarWorld facility in Vancouver continues to operate using the energy efficient technology developed through the original NEEA collaboration with Shell. The number of operating hot zones appears to be similar to the number found to be in operation in 2006 M&T report, although detailed information was not available from SolarWorld to confirm these figures (and NEEA did not update the ACE model from the 2006 M&T report). Based on these findings, the implied energy savings remains the same as recommended in the 2006 M&T report at 1.8 aMW (Table 10-1). It is important to note that NEEA did not report any change in savings in 2005 or 2006; therefore a reduction in savings of 0.3 aMW is recommended for 2007, based on the 2006 M&T recommendations.

Table 10-1. Shell Solar M&T Recommendations

Key Indicators Reviewed	NEEA 2006 Values*	2007 Recommended Values	Source
Market Activity			
125-kW hot zones	38	38	Interview with Bob Beisner; see Section 10.3.1
100-kW hot zones	0	5	
Baseline Activity			
125-kW hot zones	0	0	ACE model and previous M&T reports
100-kW hot zones	0	0	
Per-Unit Energy Savings			
kWh/kW hot zone capacity	3,856	3,000 (implied)	2006 M&T analysis
Implied Energy Savings**			
Implied Energy Savings (aMW)	2.1	1.8	2006 M&T analysis and finding of no change in 2007.

*NEEA did not report any change in market activity in 2006. However, the cumulative activity through 2006 is used for comparison to the M&T assessment's 2007 values. Source: Excel file "2006 MAR Cumulative Savings 04-03-07.xls"

** Implied energy savings are presented for comparison purposes only between NEEA's 2006 values and the 2007 M&T findings. NEEA's reported values may not match those presented here since NEEA adjusts for the effect of utility incentives and other factors not taken into account in this M&T analysis.

[177] *Long Term Monitoring and Tracking Report on 2006 Activities*, Summit Blue Consulting for the Northwest Energy Efficiency Alliance, April 2007.

Future M&T assessment of the Shell Solar project may not be necessary, depending on whether there is a major change at the Vancouver facility. If crystal growing shifts to Hillsboro and the Vancouver plant shuts down, then savings would be reduced to zero. On other hand, if production increases significantly in Vancouver or if a feedstock is found that can be used for continuous recharge, then higher savings than at present may be possible.

It is unlikely that savings at the Vancouver facility will increase significantly, however, and it is likely to be difficult to obtain the information necessary from SolarWorld to quantify it. The current savings of 1.8 aMW is likely to be sustained into the future barring a shutdown or major reduction in production at the facility. NEEA staff is likely to be aware of major changes, and at that time a decision can be made whether to conduct an additional M&T assessment or to reduce savings to zero.

10.5 Bibliography

Interview with Bob Beisner, SolarWorld, January 2008.

SolarWorld press release, March 1, 2007, "SolarWorld Group to Build America's Largest Solar Factory," http://www.solarworld-usa.com/SolarWorld-Group-to-Bu.299.0.html.

Interview with Greg Mihalik, SolarWorld, January 2007.

Summit Blue Consulting for Northwest Energy Efficiency Alliance, *Long Term Monitoring and Tracking Report on 2005 Activities*, April 2006.

11 SCIENTIFIC IRRIGATION SCHEDULING (SIS)/AM400

The Scientific Irrigation Scheduling (SIS) project, funded by NEEA from 1997 to 2000, encouraged irrigation practices that supply the right amount of water at the right time to crops using enhanced information about weather and improved water delivery technology. For pressurized irrigation systems using electric pumps, SIS practices can significantly reduce the amount of electricity consumed for pumping water to the fields. SIS practices use moisture data plus weather data from the local AgriMet station[178] to allow growers to predict water needs over the next few days, avoiding over-watering and associated energy use for pumping. Moisture sensors can be used without data loggers but data from the sensors needs to be put into perspective with previous readings, expected weather, and other relevant factors.

NEEA discontinued the education and outreach part of the project in response to the 2001 Market Progress and Evaluation Report No. 3 (MPER #3),[179] which concluded that SIS was already standard practice on farms growing high value crops. The initiative then focused on increasing the use of SIS for low-value crops using low-cost methods, and NEEA supported a specific low cost irrigation product (AM400) to help stimulate the use of SIS for low value crops. NEEA funded the AM400 from 2002 to 2004 to demonstrate the effectiveness of the technology and stimulate the market for similar technologies.

The first M&T assessment of the SIS initiative, which appeared in the 2006 M&T report, addressed sales of the AM400 and provided an estimate of the total market potential for SIS options such as the AM400. The assessment recommended a revision to the per units savings of the AM400 as well as primary research with growers to better assess market activity for a broader range of SIS products. This second M&T assessment uses interviews with growers of irrigated low-value crops to estimate the penetration of low-cost equipment to track moisture needs, establish an SIS market activity baseline, and assess any trends in the use of SIS for low-value crops.

11.1 Assumptions and Indicators for Review

Gross energy savings from SIS are based on the number of acres of low-value crops irrigated with pressurized systems and using SIS methods. There are two types of irrigation systems—pressurized and gravity. Pressurized systems include a variety of sprinkler and low-flow irrigation techniques to distribute water across a field; with rare exceptions, the pressure to distribute water involves electric pumping. Gravity flow systems distribute water via land treatments and do not involve pumping.[180] For pressurized systems SIS generally reduces water and energy consumption by reducing unnecessary irrigation and thus

[178] AgriMet is a satellite-based network of automated agricultural weather stations operated and maintained by the Bureau of Reclamation. The stations are located in irrigated agricultural areas throughout the Northwest and are dedicated to regional crop water-use modeling, agricultural research, frost monitoring, and integrated pest and fertility management.

[179] *Market Progress Evaluation Report Scientific Irrigation Scheduling, No. 3,* report #E01-091, Research Into Action, Inc., November 2001.

[180] Schaible, G. and Aillery, M. Agricultural Resources and Environmental Indicators, 2006 Edition / EIB-16 Economic Research Service/USDA, 2007.

demand and energy to pump water. Energy savings estimates are based on annual savings per acre, calculated for a given calendar year as follows:

Annual Energy Savings (kWh/year) =

(1) Number of acres of low-value crops irrigated with pressurized systems

x (2) Percentage irrigated using SIS equipment such as moisture sensors

x (3) Annual energy savings per acre due to SIS

where:

- **Number of irrigated acres of low-value crops** is based on the most recent Farm & Ranch Irrigation Survey (FRIS) data and National Agricultural Statistics Service (NASS)data;
- **Percentage using SIS** is based on an estimate from surveys with growers; and
- **Per-acre energy savings** are annual energy savings per irrigated acre and are estimated from research on savings from the use of SIS.[181]

11.2 Methodology

In-depth interviews with a sample of growers in the Northwest were used to estimate market penetration of SIS methods including the use of moisture-sensing equipment and data loggers for low-value crops. Data collection activities are described below.

Determined sampling frame for low-value crop growers. The first step was to determine what crops would be of interest, which was done by examining the distribution of low-value crops by state from the NASS data. However, a list of growers appropriate for the survey was difficult to identify. NEEA program manager Andy Eckman, indicated that most AM400 data loggers were distributed through universities and county extension agents, which may be able to provide information on growers. This route was not pursued because of the time and effort required to contact all counties in each state to get a reasonably comprehensive list, and because of the probable difficulties in obtaining sample lists due to confidentiality issues.

An extensive internet search was performed for online sources of growers of low-value crops such as barley, alfalfa and other hay, and corn for grain[182]. The best source for contact information on growers was found to be the member directories of hay grower associations which were available for each state.[183]

[181] A Study of Irrigation Scheduling Practices in the Northwest. Phase II: Measurement of Water and Electricity Impacts, Haeri, H. et al. June 30, 2005.

[182] Low value crops were identified from the FRIS 2003 on the basis of average production value per acres of crops. Crops such as sugar beets, tobacco and potatoes had average production values per acre of over $1000. Other crops, considered "low-value" had much lower values, usually under $300/acre.

[183] Idaho Hay & Forage Assoc. www.idahohay.com/directory.htm; Oregon Hay & Forage Assoc. http://forages.oregonstate.edu/organizations/ohfa; Montana Hay Hotline, http://agr.mt.gov/crops/hayFirst.asp; Washington State Hay Grower's Assoc. www.wa-hay.org/directory/.

As alfalfa hay is one of the top irrigated crops in the United States[184], and the hay directories covered several types of hay, these directories were considered a good source of representative growers of low value crops. Alfalfa and other hay crops account for about 45% of irrigated acres in the Pacific Northwest.[185] Through these associations, over 400 growers were identified (Table 11-1).

Table 11-1. Sources of Grower Contact Information

State	Source	Member Growers	Type of Crops
Idaho	Idaho Hay & Forage Assoc.	97	Alfafa, grass, straw, corn silage, oat hay, triticale hay, grass, haylage, timothy
Montana	Montana Hay Hotline	48	Alfalfa, grass hay, barley/alfalfa/grass mix, timothy, barley straw, wheat straw,
Oregon	Oregon Hay & Forage Assoc.	148	Alfalfa, grass, triticale hay, straw, rye, orchard grass, forage, blue grass straw, cereal hay, wheat straw, oat, wheat, barley, silage, mixgrass hay, quackgrass, grain hay, timothy, grain, blue grass straw
Washington	Washington State Hay Grower's Assoc.	163	Alfalfa, orchard grass, timothy, grass hay, haylage, straw, straw, oat hay, triticale, bluegrass straw, oats, barley hay

Selected sample of growers to interview. Sampling was performed by segmenting growers by state since the data indicated differences between states in percentage of low value crops and types of crops. Random samples for each state were selected from the hay grower association lists and telephone interviews were completed with 35 growers who used irrigation for their low-value hay crops. (Those who did not irrigate were screened out of the survey.) The intent was to sample roughly evenly across each state and then weight by the acreage of irrigated low value crops. Table 11-2 below shows the sample disposition.

Table 11-2. Sampling Information for Grower Survey

	Idaho	Montana	Oregon	Washington	Total
Total member growers	97	48	148	163	**456**
Unique growers contacted	18	19	18	25	**80**
Completed surveys with growers irrigating low-value crops	10	7	10	8	**35**
Source: Summit Blue survey research					

Designed and conducted interviews. The questionnaire developed for this assessment screened for growers who irrigated crops, since some low-value crops are not irrigated. Questions addressed irrigated acreage, awareness of SIS methods and the source of this information, and the use of SIS methods both currently and in the future. The survey questions are shown in the Appendix in Section 11.6.1.

[184] FRIS 2003 noted that "*the top irrigated crops in the United States in 2003 were corn for grain or seed, alfalfa hay, soybeans, land in orchards, and cotton. These crops accounted for 56 percent of all irrigated land*."

[185] FRIS 2003, Table 27.

11.3 Findings

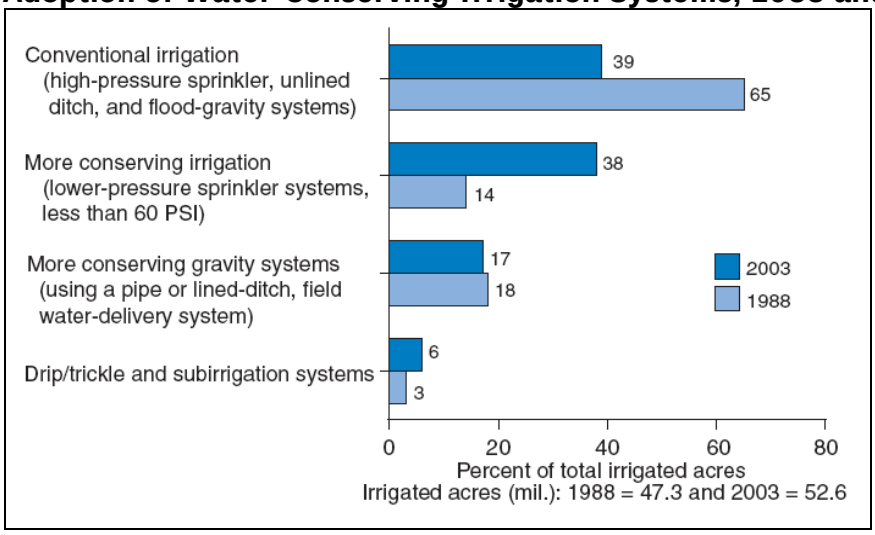
Summit Blue used literature reviews and the interview data to construct a scenario for current market activity and baseline activity for the use of SIS practices for low value crops.

11.3.1 Market Activity

The target market for the SIS initiative consists of farms growing *low-value crops that are irrigated by pressurized systems*. Market activity is defined as the *use of SIS for these crops*. Although secondary sources do not provide direct information on the use of SIS, there are indications of increased activity:

- There has been a steady increase in the use of pressurized systems for irrigation. According to FRIS 1998 and 2003 surveys, the number of acres irrigated by pressurized systems has been increasing by 1.8 per cent per year since 1979, reaching 51% of irrigated acres in 2002.
- In addition, the trend in irrigation in the Western states over the last 15 years has been an increase in the use of water-conserving/higher efficiency irrigation as shown in Figure 11-1.[186]

Figure 11-1. Adoption of Water-Conserving Irrigation Systems, 1988 and 2003



Source: USDA

The M&T research focused on assessing if these trends apply to the use of SIS for low-value crops. The following steps were taken to estimate market activity in 2007:

1. Estimate the size of the market
2. Determine the use of pressurize irrigation systems in the sample
3. Assess the use of SIS methods by those growers using pressurized irrigation.

[186] Wiebe, K. Y Gollehon, N. Eds *Irrigation and Water Management.* Agricultural Resources and Environmental Indicators, 2006 Edition, Economic Information Bulletin No. (EIB-16) , July 2006 *Agricultural Resources and Environmental Indicators, 2006 Edition / EIB-16* Economic Research Service/USDA

These steps are described below.

1) ***Estimate the size of the 2007 market, based on acres of low value crops by state from NASS data.*** The acreage of low-value crops from the publicly available data was adjusted first for percentage irrigated and then for percentage irrigated with pressurized systems (Table 11-3). The last column in the table (percentage of acres of low-value crops irrigated with pressurized systems) was used to weight sample results and account for the variation across state. The total market was estimated as 3.5 million acres, mainly in Idaho, which has the highest rate of irrigation and use of pressurized systems.

Table 11-3. Calculating the Total Market for SIS for Low-Value Crops

State	Low Value Crops (acres) (A)	% Irrigated (B)	% Pressurized (C)	Low-Value Crops Using Pressurized Irrigation (acres) (A*B*C)	% of Market by State
Idaho	12,939,000	28%	70%	2,546,000	72%
Montana	20,885,000	3%	36%	226,000	6%
Oregon	5,295,000	11%	60%	352,000	10%
Washington	9,590,000	12%	36%	415,000	12%
TOTAL	**48,708,000**	7% use pressurized irrigation		**3,539,000**	**100%**
Sources: NASS 2007, FRIS 2003					

2) ***Determine the use of pressurized irrigation systems in the sample.*** Twenty of the 35 growers interviewed irrigated with pressurized systems. Montana had a low saturation of pressurized irrigation which was also found in the 2003 FRIS survey. Survey results are also consistent with the MPER #3 (2001) which noted that Montana had difficulties with the quality of irrigation hardware on the market. Table 11-4 summarizes results regarding use of pressurized irrigation systems.

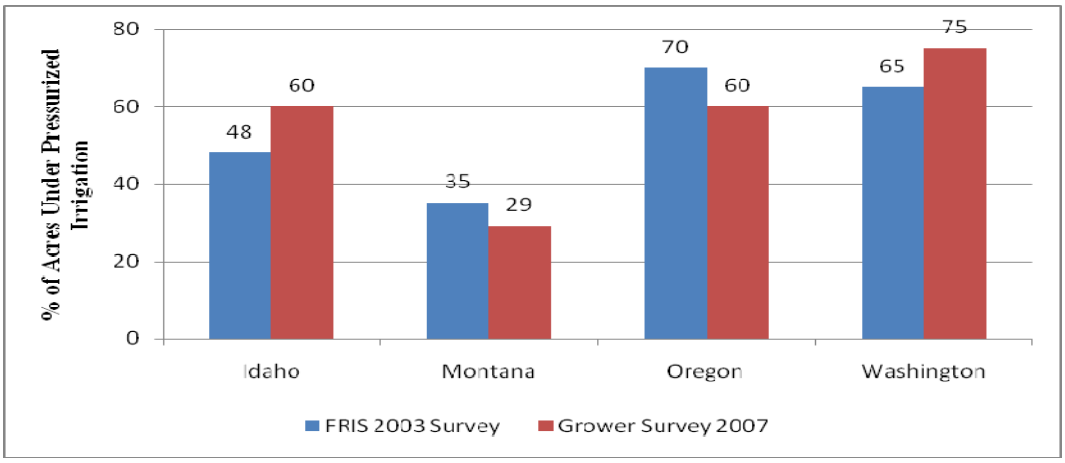
Table 11-4. Survey Results: Use of Pressurized Irrigation by Grower's Irrigating Low-Value Crops

Sample Results		Idaho	Montana	Oregon	Washington	Total
Growers (farms)	Total	10	7	10	8	35
	Pressurized Systems	6	2	6	6	20
	Percentage Pressurized	60%	29%	60%	75%	57%
Acres	Total	20,834	4,108	8,970	3,230	37,142
	Pressurized Systems	17,850	648	8,310	2,730	29,538
	Percentage Pressurized	86%	16%	93%	85%	80%

Source: Summit Blue survey of growers

Figure 11-2 compares sample results to the FRIS 2003 data for the share of irrigated farms using sprinkler irrigation (the most common form of pressurized irrigation). Survey results indicate that the sample reasonably reflects the population of growers using pressurized irrigation.

Figure 11-2. Use of Pressurized Irrigation (FRIS 2003 & M&T Sample)



Source: USDA and Summit Blue grower survey

3) ***Assess the use of SIS methods by those growers using pressurized irrigation***. Of the 20 growers who use pressurized irrigation, eight (40%) reported using SIS methods. These farms account for 30% of the acreage in the sample. Half of those not using SIS (six out of 12) would consider using SIS if it were shown to be cost-effective. Results are shown in Table 11-5 below. Survey results are intended to be viewed in aggregate across the four states, as sample sizes for individual states are too small to draw meaningful conclusions. However, the Appendix in Section 0 presents a brief description of state-specific results, including notes from the grower interviews.[187]

Table 11-5. Use of SIS in the Grower Sample

Sample Results		Idaho	Montana	Oregon	Washington	Total
Growers (farms)	Pressurized Systems	6	2	6	6	20
	Use of SIS	1	0	3	4	8
	Percentage	17 %	0 %	50 %	67 %	40 %
Acres	Pressurized Systems	17,850	648	8,310	2,730	29,538
	Use of SIS	250	0	7,000	1,520	8,770
	Percentage	1 %	0 %	84 %	56 %	30 %

Source: Summit Blue survey of Growers

Extrapolation of the survey results was performed separately based on both the share of sample growers using SIS and on the share of sample acres using SIS. This dual estimation approach provides a range of results and avoids the false precision that may otherwise be indicated from the small sample of 20

[187] Based on the limited sample sizes, it appears that there may be a difference across states in use of SIS, with Idaho and Montana showing virtually no use of SIS. MPER # 3 also noted the higher use of SIS in Oregon and Washington which was partially attributed to education efforts in those states. Lower use in Idaho could be attributed to a Power Credit for irrigation only recently removed and in Montana the use of irrigation including pressurized systems, is very low.

growers using pressurized irrigation.[188] Based on the share of growers in the sample who use SIS, the total area of low-value crops employing SIS is approximately 887,000 acres, or 25% of all low-value crops using pressurized irrigation. Based on the share of acreage in the sample for which SIS is used, the estimated area using SIS is somewhat lower—roughly 554,000 acres, or 16% of all low-value crops using pressurized irrigation (Table 11-6). These figures can be viewed as a "weighted average" share of SIS usage across the four states.

Table 11-6. Estimating Use of SIS in the Northwest from the Grower Survey

State	Low-Value Crops Using Pressurized Irrigation (acres) (A)	Extrapolation Based on Growers in Sample*		Extrapolation Based on Acreage in Sample*	
		% of Growers Using SIS (B)	Acres Using SIS (A*B)	% of Acres Using SIS (C)	Acres Using SIS (A*C)
Idaho	2,546,000	17%	432,820	1%	25,460
Montana**	226,000	0%	0	0%	0
Oregon	352,000	50%	176,000	84%	295,680
Washington	415,000	67%	278,050	56%	232,400
Total	**3,539,000**	**25%**	**886,870**	**16%**	**553,540**

* The percent of growers and acres using SIS is based on the sample and taken from Table 11-5.

** It is likely that SIS methods are employed in Montana. However, secondary research indicated that SIS is not commonly used, and the small state-specific sample size did not identify any SIS activity. This finding does not significantly affect the results since Montana only constitutes 6% of the potential market for SIS for low-value crops using pressurized irrigation (see Table 11-3)

Sources: NASS 2007, FRIS 2003, Summit Blue grower survey

Given the uncertainty associated with the small sample, the more conservative 16% value (554,000 acres) is adopted for this M&T assessment. This appears to be a higher percentage of SIS usage than reported by the USDA in 2004, which found that "*most irrigated farms do not use the more advanced, information-intensive methods to schedule irrigation; less than 8 percent of irrigated farms use soil and/or plant moisture sensing devices, commercial or government-sponsored irrigation scheduling services, or computer simulation models.*"[189] The findings suggest that the SIS initiative may be increasing use of SIS in low-value crops. However, it should be noted that the USDA figures are for all irrigated farms, not just low-value crops using pressurized irrigation. Furthermore, the M&T research presents SIS usage as a share of *acreage*, whereas the USDA results are for the share of *farms.*

11.3.2 Baseline Activity

The use of SIS in low-value crops appears to be the result of many market influences, but the grower interviews did not indicate any direct link to the NEEA initiative. Although NEEA may well have influenced the use of SIS by increasing awareness (60% of the total sample of 35 were aware of SIS), this

[188] Ideally, extensive information on the population of growers and size of farms would be available, and a large sample could be used to stratify by state and size of farm. In that case, using acreage instead of number of growers, would provide the most appropriate estimate. However, given the limitations of the population data and sample, the high variance in the acreage of respondents' farms suggests extrapolation based only of size could be misleading.

[189] Figure 4.6.3 Irrigation & Water Management, USDA, 2006, p. 139.

influence could not be firmly established or quantified. Primary sources of awareness of SIS noted by growers interviewed were other farmers, universities, the Hay Association, and vendors. In Idaho, the key source noted was the University of Idaho. In Oregon, one respondent became aware of SIS through research on his own, another through a fertilizer store over ten years ago and another through the USDA. Any possible link between NEEA's SIS initiative and the awareness in the market outside of the specific AM400 technology cannot be substantiated based on the research conducted for this M&T assessment.

Therefore, since we cannot substantiate any market effects due to NEEA's initiative, it is assumed that all the market activity estimated above (554,000 acres) except for AM400 sales attributed to NEEA's influence would have occurred anyway even without market intervention. In the 2006 M&T report, AM400 market activity was estimated through the third quarter of 2006. These figures are extrapolated through 2007 as follows:

- From 2001 to the end of Q3 2006 1,032 AM400 units were sold in the Northwest, with 443 installed to the end of 2002. For 2003 through 2005 sales were lower, at 154 per year, and sales in 2006 were on a similar pace, with 127 units sold through the third quarter.[190] Assuming steady sales of 154 per year in 2006 and 2007, it is estimated that a total of 1,186 AM400 units were sold in the Northwest through 2007.[191]
- Baseline sales of AM400 are assumed to be 50 units per year, as discussed in the 2006 M&T report. Over seven years, this results in baseline AM400 sales of 350 units. AM400 sales *not* in the baseline through 2007 are the difference between total sales and baseline sales, or 836 units (1,186 units minus 350 units).
- Since each AM400 covers an estimated 80 acres, the total acreage *not* in the baseline through 2007 is approximately 67,000 acres (836 units multiplied by 80 acres/unit).
- Thus, **the total baseline activity of SIS products and services for low-value crops is approximately 487,000 acres** (554,000 acres of SIS market activity minus 67,000 acres from non-baseline usage of AM400 units).

11.3.3 Per-Unit Energy Savings

The 2006 M&T report addressed annual energy savings per acre and recommended reducing previously assumed values from 185 kWh per acre to 154 kWh per acre. This recommendation was based on a study conducted for BPA in 2005, which derived estimates of water and electricity savings through monitoring actual water use in a sample of fields, provides an updated and more rigorous estimate. The study used 19 *paired samples* (a total of 38 samples) of farms using SIS methods and farms not using these methods, matched on the basis of geographical area, crops grown, and comparable soils. Both large and small operations were included with field acreage ranging from very small half circles to relatively large 200 acre fields. The researchers found "*that reductions in water use resulting from the application of SIS in the study sample result in net electricity savings of 13.1 per cent,"* or 154 kWh/acre-year. This second M&T assessment for 2007 was not aimed at assessing the per unit savings and did not find any information that would indicate the need for changes to the previously recommended value of 154 kWh per acre.

[190] Source: 2006 Long-Term M&T Tracking Report. Additional sales in fourth quarter 2006 of 27 units would have been sufficient to maintain the steady annual sales rate of 154 units.

[191] Discussion with Mike Hansen, the owner of the AM400 product, indicated that sales of the units in 2007 were similar to those in previous years.

11.4 Conclusions/Recommendations

The purpose of this research was to find out if the NEEA SIS initiative has influenced the use of SIS methods for low value crops beyond the promotion of the AM400 product. The following are major conclusions of this M&T research:

- The total market for SIS in low-value crops in the Northwest is approximately 3.6 million acres.
- SIS methods (including AM400 applications) are used on approximately 16% of the acreage of low-value crops irrigated with pressurized systems.
- Most of the market for energy savings through the use of SIS for low-value crops is in Idaho, which has the highest percentage of low value crops as a share of all crops (30%), the highest percentage of low-value acres that are irrigated (28%) as well as the highest use of pressurized irrigation for low-value crops (70%). And, although it appears that use is currently low, there is interest if the methods are shown to be cost-effective.

Cumulative market activity through 2007 is estimated at an order of magnitude larger compared to figures used by NEEA in 2006. This difference (554,000 acres versus 65,680 acres) is because NEEA did not previously have information on total acreage of low-value crops using pressurized irrigation and was tracking only the impact of sales of AM400s. On the other hand, the 2007 M&T research targeted the market for all SIS equipment for low-value crops irrigated with pressurized systems. The estimate of baseline activity increased by nearly the same amount as total market activity—and is approximately 88% of market activity—owing to the fact that the research did not identify any direct influence of the SIS initiative on the market, outside of the AM400. Per-unit energy savings figures have not changed since the 2006 M&T report, when it was recommended that the savings rate be reduced from 185 kWh per acre per year to 154 kWh per acre per year; however, it does not appear that NEEA adopted this recommendation in its calculations.

The net result of the increases in market activity and baseline activity, and the reduction in per-unit savings, is that the implied cumulative energy savings through 2007 (1.2 aMW) are slightly higher than NEEA's 2006 figure (1.0 aMW), as shown in Table 11-7.

Table 11-7. M&T Recommendations for Key Indicators

Key Indicators Reviewed	NEEA 2006 Cumulative Value(s)*	2007 Recommended Value(s)	Source
Market Activity			
Use of SIS, including AM400 (acres)	65,680	554,000	USDA; see Section 11.3.1
Baseline Activity			
Use of SIS, including AM400 (acres)	20,000	487,000	2006 M&T report; see Section 11.3.2
Per-Unit Energy Savings			
kWh/acre	185	154	2006 M&T report and BPA; see Section 11.3.3
Implied Energy Savings**			
aMW	1.0 aMW	1.2 aMW	aMW = MWh divided by 8760 hours

* NEEA 2006 values were obtained from Excel file "2006 MAR Cumulative Savings 04-03-07.xls". NEEA reported market activity and baseline in terms of units (loggers). Acreage presented here is based on an assumed 80 acres per unit.

** Implied energy savings are presented for comparison purposes only between NEEA's 2006 values and the 2007 M&T findings. NEEA's reported values may not match those presented here since NEEA adjusts for the effect of utility incentives and other factors not taken into account in this M&T analysis.

Source: 2006 Long-term M&T Report and Summit Blue research and analysis

Possible avenues for future M&T research include:

- A larger survey of growers, possibly outsourced for greater economies of scale, that could provide greater statistical precision and more significant state-specific findings.

- More detailed investigation into the market activity baseline, which remains highly uncertain. The 2007 grower survey did not indicate obvious linkages between the NEEA SIS initiative and increased market activity. M&T research based on structured, in-depth interviews with hay grower associations, university agricultural departments, USDA personnel, equipment vendors, and other market players could provide the necessary support to reduce the baseline estimate and link NEEA activities to increased use of SIS equipment and procedures.

Additional M&T research may not be warranted, however, since the implied energy savings in 2007 are only 1.2 aMW and establishing a linkage to NEEA activities would likely prove tenuous. Furthermore, nearly three-quarters of the market for SIS in low-value crop applications is in Idaho, and indications are that Idaho has seen relatively little adoption of SIS to date.

11.5 Bibliography

Farm and Ranch Irrigation Survey (2003), Volume 3, Special Studies, Part 1, 2002 Census of Agriculture, November, 2004.

Haeri, H. et al. *A Study of Irrigation Scheduling Practices in the Northwest. Phase II: Measurement of Water and Electricity Impacts*, June 30, 2005.

Long Term Monitoring and Tracking Report for 2006 Activities, Summit Blue Consulting, 2006.

Long Term Monitoring and Tracking Workplan for 2007 Activities, Summit Blue Consulting, 2007.

Market Progress Evaluation Report Scientific Irrigation Scheduling, No. 3, report #E01-091, Research Into Action, Inc., November 2001.

Wiebe, K. & Gollehon, N. Editors *Irrigation and Water Management.* Agricultural Resources and Environmental Indicators, 2006 Edition, Economic Information Bulletin No. (EIB-16) , July 2006 *Agricultural Resources and Environmental Indicators, 2006 Edition / EIB-16* Economic Research Service/USDA.

Interview with Mike Hansen of the M.K. Hansen Company, which manufacturers the AM400 product.

11.6 APPENDIX - Grower Survey and Summary of Comments

11.6.1 Appendix A: Grower Survey

Screening question: Do you irrigate? If no, the survey was terminated.

1. Are you aware of scientific irrigation scheduling (SIS) methods?
2. Do you use any SIS methods or services?

   2.1 If yes, probe.

   a. Can you describe, e.g. SIS services, implemented by other agency such as university, AM400, other.

   b. How did you find out about this technology/method?

   2.2 If no.

   a. Why don't you use SIS?

   b. Would you consider using these technologies?

   c. Do you have plans to do so in the future?

3. Can you please describe the crops you grow?
4. How many acres do you irrigate?
5. Could you recommend anyone else we could talk to, such as growers you know who are using SIS methods or associations/universities or such?
6. Do you have any other comments or questions on SIS or efficient irrigation practices in general.

11.6.2 APPENDIX B: Comments from Growers

Idaho: Four of 6 growers irrigating with pressurized systems would be interested in SIS if "*it worked and saved money*". None had plans to use SIS but expressed interest because "*if SIS were economically feasible, then a lot of use would be using it around here. The cost of our irrigation went up 70% last year, because they took away our Power Credits.*" Another grower said "*I would like to see more site specific information on the soil fertility - water calibration. Basically that would give me information on how much nitrogen to apply to the crops with a limited supply of water to produce the desired protein yield based on the site specific ground soil.*"

Montana: There are issues about water rights and subsidization of big farmers. One grower noted "*the main issue in this area that needs to be addressed is the lack of maintenance for the irrigation ditches. The corporate farm around here gets all the subsidizing funds and that leaves no funds to improve the basic infrastructure*." Another said "*the Farm Service Agency has destroyed the economy in this area. They have subsidized the large farmers and almost ruined the smaller ones.*"

Oregon: One grower aware of but not using SIS said "*most of the moisture systems are not accurate or do not work well*", but would be interested "*if they were improved and were cost effective"*. Another noted that *"Pacific Power did a study a few years ago where they sent out people to probe the ground for moisture, but we didn't start using it because it was too costly to maintain for us."* One SIS user said that "*…almost everyone is doing it around here*" but another had "*to use FLOOD irrigation because the pressure is so low. If they were to increase the pressure of the water, then the entire area would save 30-45% of the water used. We would then be able to use the moisture probes and save money and electrical energy used by the pumps."*

Washington: One respondent said "*most everyone in this area are doing the same thing as we are with the moisture probes.*" Others noted "*something needs to be done about the energy cost. I use wheel and hand lines to irrigate and I pump from a deep well. The energy cost to get the water to the surface is almost cost prohibitive;*"and "*I would like to see more effort to educate the American farmers so that they can conserve water and increase production. The farmers would need to know actual statistics and the amount of water or energy they save and the amount of production increase. My CIRCLE (pivot irrigation) paid for itself in five years and gave me a 20-35% increase in production without an increase in water usage or energy costs."*

12 OPTI-CHILL CHILLER OPTIMIZATION

Implementation of the Opti-Chill project began in 2000 and finished in late 2003. NEEA funded the partnership between Willis Energy Services of Vancouver, BC, and two of Intel Corporation's Oregon manufacturing facilities to pilot this approach to achieving energy savings in chiller operations. The Opti-Chill approach can be likened to commissioning in the building industry: Opti-Chill enables system operators to analyze the system under actual operating conditions, rather than conditions anticipated by the design engineer. The Opti-Chill approach monitors, measures, models, and validates equipment performance and uses the results to make recommendations for generating energy savings.

The Opti-Chill project was one of three chiller efficiency projects that NEEA funded as part of the Microelectronics Initiative. Another consultant, EN-WISE, worked with Hewlett Packard to identify energy efficiency opportunities in its chillers by using a series of sensors and facility control system information as a means to perform additional data monitoring and develop system metrics. A third consultant, Rumsey Engineers, worked with another chip manufacturer, ZiLOG, on a walk-through audit, benchmarking, and analysis of its chiller system.

For the purposes of this report, only the Opti-Chill project will be considered. The goal of the long-term monitoring and tracking of the Opti-Chill project is to determine the extent to which this project led to other chiller efficiency projects in the Northwest that used the Opti-Chill approach.

12.1 Assumptions and Indicators for Review

Since no ACE model exists for this effort, proxy indicators of market transformation are used for this analysis. The focus is on qualitative measures since MPER #2 quantified the energy savings achieved through measures implemented at Intel's facilities. Anticipated indicators of market change include the following:

- The development of more business using the Opti-Chill software as a result of the Intel project;
- Changes in practice and decision making at Intel's Northwest facilities due to recommendations resulting from Opti-Chill; and
- Other energy efficiency measures adopted by Intel as a result of the demonstration of potential efficiencies by Opti-Chill.

12.2 Methodology

As the first long-term monitoring and tracking effort on the Opti-Chill approach, the research for this report focused on interviews with relevant players and the MPERs prepared for NEEA. Based on recommendations from NEEA, Summit Blue interviewed the authors of the most recent MPER (Jane Peters of Research into Action and Steven Scott of MetaResource Group) and Bob Helm, who was the sector manager for the Agriculture and Industry Group at NEEA at the time of the project. These three references provided some input and directed the research team to four additional contacts:

- Paul Willis, Willis Energy Services – Mr. Willis was the consultant that partnered with Intel to implement this project;

- Bill Sarikas, Intel – Mr. Sarikas was the lead on Intel's side of this project;

- Peter Rumsey, Rumsey Engineers – Mr. Rumsey implemented the ZiLOG chiller efficiency project and is regarded as an expert in energy efficient design; and

- Phil Degens, Energy Trust of Oregon – Mr. Degens was the Evaluation Manager at NEEA when Opti-Chill was implemented.

Summit Blue followed up with these four individuals and spoke with all of them except for Mr. Sarikas. Several calls to Mr. Sarikas went unreturned.

12.3 Findings

By all accounts, the Opti-Chill approach to chiller efficiency has not been used since the NEEA-funded project with Intel, and there have been no other approaches like it that have gained traction in the industry.[192] One of the major barriers to the technology was that it required a significant staff commitment on the facility side, which was often difficult to obtain. The technology required an internal champion at the host site, and it is difficult to secure the required staff without one. With minimal marketing committed to the Opti-Chill approach, it has been difficult to identify these champions within the microelectronics industry.

That said, however, Mr. Degens believes that the Opti-Chill project may be one of the building blocks in the pursuit of "free cooling" in the microelectronics industry in the Northwest.[193] By bringing awareness to the issue of energy use in the manufacture of semi-conductors, Opti-Chill and the other chiller efficiency projects opened the conversation about how to reduce energy use. Though it is not necessarily a one-to-one correlation, the Opti-Chill project may have been one element (in addition to rising energy prices and environmental issues, for example) affecting the attention to energy efficiency in chillers in the Northwest's microelectronics industry.

Identifying any long-term impacts on Intel's operations beyond the findings in the last MPER was not possible due to a lack of communication with Intel.

12.4 Conclusions/Recommendations

Beyond this long-term monitoring and tracking effort, it does not appear practical to commit additional resources to tracking the effects of this project. NEEA's funding of the Opti-Chill project may have played a minor role in the microelectronics industry's attention to energy efficient chillers, but it was a one-off project that was not replicated. Since the semi-conductor industry in the Northwest has contracted

[192] The finding that software-based chiller efficiency efforts have not gained traction in the industry is based on conversations with Jane Peters, Paul Willis, Phil Degens, and Peter Rumsey.

[193] Free cooling enables facilities to utilize the outside air to cool water when the outside ambient air temperature is lower than the required chilled water set-point.

since the project's inception, it is not likely that other opportunities to apply this approach to other semi-conductor facilities in the Northwest are feasible at this time.

The Opti-Chill technology could be applied in other industries, however. It could be used in large central chilling systems in other large building complexes, such as corporate campuses or convention centers. If the barriers to using the technology could be overcome, it may be resurrected and applied elsewhere. If chiller efficiency fits into other NEEA programs, this could be considered as a component of future efforts. The barriers are significant, however, and it would require the commitment of a substantial amount of up-front resources to address them in order to move forward.

12.5 Bibliography

- Research Into Action. *Microelectronics Industry Energy Efficiency Initiative: Market Progress Evaluation Report, No. 2.* Prepared for the Northwest Energy Efficiency Alliance. Report #E03-117. June 26, 2003.
- Research Into Action. *Microelectronics Market Progress Evaluation Report.* Prepared for the Northwest Energy Efficiency Alliance. Report #E05-150. October 24, 2005.
- Interview with Phil Degens, Energy Trust of Oregon. December 17, 2007.
- Interview with Bob Helm, formerly of NEEA. December 6, 2007.
- Interview with Jane Peters, Research Into Action. December 11, 2007.
- Interview with Peter Rumsey, Rumsey Engineers. December 17, 2007.
- Interview with Steven Scott, MetaResource Group. December 7, 2007.
- Interview with Peter Willis, Willis Energy Services, December 17, 2007.