LONG TERM MONITORING AND TRACKING REPORT ON 2005 ACTIVITIES

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EXECUTIVE SUMMARY

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 product is launched. The market progress of Alliance projects is tracked during their implementation phase as part of the project evaluation. However, since market diffusion often occurs after the Alliance funding has ceased, the Alliance 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, the Alliance developed a process and plan for tracking and monitoring the market progress of projects that it no longer funds. The Long-Term Tracking and Monitoring plan focuses on a select group of projects that are expected to have ongoing market impacts in the post-funding period. This report presents the findings from research conducted to track the market progress of ten such Alliance projects.

The goal of long-term monitoring and tracking is to measure and track critical market progress indicators and Alliance Cost-Effectiveness model assumptions in order to estimate long-term electricity savings. Long-term monitoring and tracking methods were selected that provide impact estimates with a satisfactory confidence level 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 some energy savings estimates.

The long term M&T process has three major steps: a review of the Alliance Cost-Effectiveness (ACE) model for each project, the development of an M&T plan, and the incorporation of this plan in the ongoing M&T activities. Each M&T report reviews the project ACE model and, if appropriate, makes recommendations for changes in the model’s assumptions or inputs. Alliance staff meets internally to discuss the recommendations, and prepares a staff recommendation to accept them (completely or in part), or reject them, with the reasons for adopting or not adopting the recommendations outlined. The recommended changes are then documented and presented to the Alliance Cost-Effectiveness Committee.

A Monitoring and Tracking Report for the 2004 program year was delivered to the Alliance in March of 2005 that included the M&T assessment for the *Energy Star Residential Windows* and *Building Operator Certification* programs. The M&T results of the four other programs were completed in spring 2005 (after the 2004 Market Activities Report (MAR) had gone to print), and are included in this 2005 report. M&T efforts for 2005 include:

- *Finalizing* the 2004 monitoring and tracking work on:
    - SAV-AIR
    - Variable Frequency Drives (VFD) in Refrigerated Warehouses
    - Siemens (Shell Solar)
    - Just Enough Air
- *Updating* the Energy Star Residential Windows and Building Operators Certification reports, based on recommendations in the 2004 reports for those projects.
- *Developing and implementing M&T plans* for four additional projects:
    - BacGen
    - EZConserve (Surveyor/Verdiem)
    - Commissioning & Commissioning in Public Buildings
    - Small Commercial HVAC (AirCare Plus)

This report outlines the *methods, findings, and recommendations* for each of these 10 project reviews.

- Table E-1 below provides a summary of the incremental savings estimates for the four 2004 programs reviewed this spring and included in chapters two through five of the report. Total net savings for these programs (0.2 aMW) is minimal.

- Table E-2 shows incremental savings for the programs reviewed or updated for program year 2005. The net incremental savings from these four programs is more significant at 3.1 aMW.

- Both tables include the values reported in the 2004 Market Activities Report (MAR) for comparison.

- Table E-3 provides the cumulative savings estimates for all programs reviewed, including Small Commercial HVAC and Commissioning, where only cumulative savings estimates are available.

Table E-1. Incremental Savings for 2004 Programs Reviewed

Incremental Savings 2004 (aMW)

	2004 MAR Gross Incremental Savings	2004 Gross Savings (A)	2004 Savings Captured By Alliance Baseline (B)	2004 Savings Captured By Utility Incentives (C)	2004 Alliance Net Savings D = (A - B - C)	Notes
SAV-AIR	0.00	0.00	0.00	0.00	**0.00**	- This program achieved no regional savings in 2004.
Evaporator Fan VFDs	0.80	1.08	0.36	0.80	**0.00**	- Incremental savings assume market penetration growth of 6% from 2003 to 2004.
Siemens / Shell	0.00	0.18	0.00	0.00	**0.18**	
Just Enough Air	0.00	0.00	0.00	0.00	**0.00**	- This program achieved no regional savings in 2004.
Total	**0.8**	**1.3**	**0.4**	**0.8**	**0.2**	

* Savings assigned to utility incentives are estimated based on data from the Alliance

Table E-2. Incremental Savings for 2005 Programs

Incremental Savings 2005 (aMW)

	2004 MAR Gross Incremental Savings	2005 Gross Savings (A)	2005 Savings Captured By Alliance Baseline (B)	2005 Savings Captured By Utility Incentives (C)	2005 Alliance Net Savings D = (A - B - C)	Notes
Energy Star Windows	5.20	3.08	0.67	0.23	**2.18**	
Building Operator Certification	2.40	1.12	0.00	0.26	**0.86**	
BacGen	0.14	0.30	0.00	0.58	**0.00**	- Includes savings from wastewater projects only. Including freshwater projects adds 0.33 aMW to savings.
EZConserve / Surveyor	0.77	0.11	0.01	0.00	**0.10**	
Total	**8.5**	**4.6**	**0.7**	**1.1**	**3.1**	

* Savings assigned to utility incentives are estimated based on data from the Alliance

** Neither 'Commissioning in Public Buildings' nor 'Small Commercial HVAC' have been included because the gross incremental savings for 2005 could not be disaggregated from the cumulative savings

Table E-3. Net Cumulative Savings Comparison

Cumulative Savings 2001-2005 (aMW)

	Gross Cumulative Savings (2001-2005) [A]	Cumulative Savings Captured By Alliance Baseline (2001-2005) [B]	Cumulative Savings Captured By Utility Incentives (2001-2005) [C]	LTM&T Net Cumulative Savings (2001-2005) D = [A - B - C]	2004 MAR Net Cumulative Savings (2001-2004)	Notes
SAV-AIR**	3.41	0.00	1.10	2.31	2.38	
Evaporator Fan VFDs**	7.69	1.39	5.67	0.63	1.83	- Assumes that 90% of the gross savings minus the baseline received utility incentives. Also assumes that market penetration of VFDs doubled during the period 2001-2004.
Siemens / Shell**	0.64	0.00	0.00	0.64	0.96	
Just Enough Air**	0.00	0.00	0.00	0.00	0.06	- This program has achieved no savings.
Energy Star Windows	14.57	3.05	0.23	11.29	18.58	- Cumulative savings have been reduced because of an error in the regional savings model that affected all years.
Building Operator Certification	8.50	0.00	1.81	6.69	11.01	- Cumulative savings have been reduced because of an error in the data reporting.
BacGen	1.84	0.00	1.82	0.02	0.76	- Includes savings from wastewater projects only.
EZConserve / Surveyor	0.80	0.08	0.00	0.72	1.24	- Cumulative savings have been reduced due to M&T research.
Commissioning in Public Buildings	1.57	5.74	0.00	0.00	0.32	- Savings in baseline (according to ACE model) are greater than gross savings.
Small Comm HVAC (AirCare Plus)	0.04	0.00	0.04	0.00	NA	- All savings due Small Comm HVAC have utility incentives tied to them.
Total	**39.1**	**10.3**	**10.7**	**22.3**	**37.1**	

* Savings assigned to utility incentives are estimated based on data from the Alliance

** Savings for these programs are actually cumulative from 2001-2004 only.

Summary of Program Findings & Recommendations

Each program review includes recommendations for future data collection, baseline, and attribution studies.

SAV-AIR

- Based on revised energy savings per horsepower of installed compressed air systems treated in the program, and market data provided by the program evaluator, the energy savings from accumulated installations is providing 3.4 aMW of savings to the region.
- No incremental savings were achieved in 2004.
- Although the initiative realized significant energy savings in the industrial compressed air market, it did not achieve a notable market transformation. Other less expensive control schemes have limited *SAV-AIR's* ability to market and install its technologies. Of the estimated 800 compressed air systems in the Northwest, SAV-AIR has implemented its technologies at just 19 sites (2.4%) since its inception in 1997.
- It is recommended that the *program tracking update* for 2006 include: gathering new data on the system capacity of SAV-AIR projects, aggregating energy savings by system type, and determining what spillover impacts may be occurring.

Evaporator Fan VFD

- Based on project data provided by the program implementer and evaluator, and interviews with a sample of refrigeration contractors in the region, it is estimated that market penetration of VFDs in Refrigerated Warehouses has increased from 43% in 2001 to 47% in 2004 (for regular cold storage), and from 18% to 56% for controlled atmosphere (CA) rooms over the same period.
- Total energy savings to the region since program inception is estimated at 15.37 aMW. All (or nearly all) of these savings were provided with utility incentives, and the remainder were considered to be baseline installations. Thus, no net savings is attributed to the Alliance program.
- The initiative was funded by the Alliance for nearly six and a half years, and realized significant energy savings in the Northwest. In addition, the application of VFDs in CA fruit storage rooms has now surpassed that of regular cold storage facilities, indicating that operators are becoming more aware of the importance of the non-energy benefits.
- It is recommended that the *program tracking update* include: quantification of savings from VFDs in potato storage facilities, gathering of NASS[1] data on number of fans in region, interviewing more contractors regarding market penetration, and a review of utility incentive effects on the market.

Shell/Siemens Solar

- Even when the availability of the appropriate polysilicon feedstock limits Shell's ability to employ the recharge process, the company still achieves significant energy savings due to its modification of the hot zone.
- Energy savings attributable to the Shell/Siemens project have increased each year between 2001 and 2004 and incremental savings for 2004 are estimated at approximately 0.18 aMW in 2004, not including any productivity gains due to hot zone modifications and recharge.

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[1] National Agricultural Statistics Service

- The facility continues to operate at virtually full capacity every day of the year, maximizing the amount of time over which the efficiency savings are occurring.
- It is recommended that the *program tracking update* include: annual interviews with Shell personnel regarding production numbers, review attribution of recharge process growth to Alliance efforts, and research ancillary benefits.

Just Enough Air

- The JEA program was useful in raising awareness and consideration of energy efficiency in PCS systems, but that there was little driving force in the market to optimize fan speeds. As a result, there is very little activity that could be considered a direct result of the JEA program, and no savings should be claimed.
- It is recommended that with this report the Alliance conclude its monitoring and tracking effort related to the JEA program. While the trend for reduced fan speeds may continue into the future, there is little indication that significant new activity will occur or that measures adopted will be easily attributed to the program.

Residential Energy Star Windows

- The *Residential Energy Star Windows* project was highly successful in transforming the residential windows market in the Northwest. By working upstream with manufacturers, while at the same time advocating code changes in the region, a significant increase in the sale of efficient windows was achieved.
- Based on updated regional window data, interviews with former implementation staff, and discussion with NWPCC Summit Blue estimates the current market penetration of Energy Star rated windows in the region at 89%. 2004 window sales represent 3.1 aMW incremental energy savings to the region, 2.18 aMW after consideration of baseline sales and utility incentives.
- It is recommended that the *program tracking update* include: an estimate of additional savings for Energy Star windows that are below the U=0.35 standard, explore the possibility of adding the electric savings due to reduced gas heating furnace fan operation to the overall electric savings number, and update the cooling savings on a 4-5 year cycle.

Building Operator Certification

- In 2005, 154 students in the Northwest received their initial certifications, and another 231 previously certified students received their Level 2 certifications or renewed their existing certifications. Due to the high rate of Level 2 certifications and renewals, 82% of all NEEC students in the Northwest certified since 1997 are still considered to be achieving energy savings at the buildings that they manage.
- Based on data from the training programs, and interviews with implementers, incremental energy savings to the region from *new* BOC trainees in 2005 is estimated at 1.12 aMW, 0.86a MW of that after taking out utility incentives. Cumulative electricity savings achieved by BOC-certified students are estimated at 15.1 aMW.
- Gas savings from BOC are estimated at 1.5 million therms in 2001, increasing to 2.6 million therms in 2005.
- *Other observations and recommendations* stemming from the current M&T analysis are as follows:
  - In order to further refine energy savings estimates, a comprehensive study would likely be required that measured building energy consumption over a period of a year or more. The

study would need to measure savings from participant buildings before and after certification of the building operators and/or measure savings from a control group of buildings whose operators did not receive BOC training.

- The number of new Level 1 certifications is the most variable factor affecting the energy savings estimate. As such, it is recommended that certification data be collected annually from both NEEC and NWBOA. It is also recommended that future M&T analyses consider options discussed in the 2004 M&T report for refining estimates of the square footage managed per BOC-certified student.

BacGen

- Based on interviews with program staff, BacGen management, and evaluators, incremental savings to the region for 2005 are estimated at 0.30 aMW for those projects where the Alliance had direct involvement. But, since each of those projects received at least some utility incentives, *NO savings are attributed to the Alliance*.
- Alliance support of this entrepreneurial endeavor was essential in the early success of BacGen.
- Recommendations for analysis during a semi-annual review of the BacGen project include: refine the estimate of savings *attributable to the Alliance,* and determine the extent of the operator "spillover" impacts.

Surveyor Network Energy Manager (Verdiem)

- Based on sales data, interviews with staff, evaluators, and Verdiem management, energy savings to the region attributable to the program was just 0.10 aMW in 2005.
- It appears the Alliance was critical in the success of the Surveyor software, providing vital resources at a critical time in the company's development.
- It is recommended that the *program tracking update* include: investigating the number of licenses deployed and per-unit energy savings by market sector, revisiting energy savings calculation for savings estimates for LCD monitors, and interviewing customers to reduce uncertainty around the number of Surveyor licenses actually achieving savings.

Commissioning in Commercial and Public Buildings

- Based on a review of secondary literature and interviews with state commissioning liaisons, the director of the Building Commissioning Association, PECI, and other stakeholders in the region, Summit Blue estimates current energy savings in the region due to commissioning to be modest, and the estimated baseline activity subsumes any savings due to Alliance activities. *Thus no savings are claimed.*
- It is estimated that at least 187 public buildings have been commissioned in Washington since 2001. Washington has adopted non-binding guidelines for commissioning of all new construction projects managed by the Department of General Administration.
- Staff at state agencies in Washington and Montana directly credit the Alliance for much of the recent commissioning of public buildings in those states and for helping to attract commissioning providers. Oregon and Idaho have not adopted any specific mandates or guidelines to include commissioning in new construction projects.
- The Alliance was the principal reason for the emergence of the BCA.
- It is recommended that next year's M&T effort focus on results of the PECI survey that will characterize the commissioning market in terms of the number and types of providers, the types of buildings commissioned and retro-commissioned, etc. It is recommended that the M&T

analysis be conducted every two years and include: contacting state representatives to obtain updates to existing commissioning databases and identify new state requirements for commissioning of public buildings, a survey of commissioning providers, and detailed interviews with the largest commissioning providers to better understand the market and the factors driving their business.

Small Commercial HVAC (AirCare Plus)

- Based on interviews with the PECI project manager, review of program records, and interviews with AirCare Plus service providers, the overall savings in the Northwest were estimated at only 0.04 aMW in 2004 and 2005.
- Contractors currently participating are satisfied with the program and contractors who participated in the pilot would be willing to participate again, but it is likely that incentives will continue to be required for several years if the program is to continue.
- All Air Care Plus activity in the Northwest is supported through utility incentives. While there are some energy savings to the region, *NO energy savings are claimed*.

Next Steps

Future long term monitoring and tracking efforts will include updates to the programs included in this report, along with several additional Alliance programs that no longer receive funding. Most programs tracked will be on a 2-year update cycle. Exceptions include the Commissioning program, which will benefit in 2006 from a survey being conducted by PECI to provide updated data on commissioning activities in the region. A *tentative schedule* for each of the project tracking efforts for 2006-2010 is shown in Table E-4 below. The list of programs to have reviews conducted in 2006 will be discussed with the Alliance project manager and reviewed by the Cost-effectiveness Committee of the Alliance Board before the 2006 plan is finalized.

Figure E-4. Timeline for Conducting / Updating Long-Term M&T by Program

PROJECT	2004	2005	2006	2007	2008	2009	2010
Energy Star Residential Windows	C	U		U		U	
Building Operator Certification (BOC)	C	U		U		U	
SAV-AIR		C*	U		U		U
Just Enough Air		C*					
Evaporator Fan VFDs		C*	U		U		U
Siemens (Shell Solar)		C*	U		U		U
BacGen		C		U		U	
EZConserve (Surveyor)		C		U		U	
Commissioning in Public Buildings		C	U		U		U
Small Commercial HVAC (AirCare Plus)		C					
Energy Star Home Products			C				
MagnaDrive			C				
Dendritic Polysilicon Production (ASiMi)				C			
Electric Motor Management (Drive Power)				C			
Microelectronics Industry Initiative				C			
SIS/AM400			C	C			

NOTES: C = Conduct initial analysis; C* = Initial analysis for these programs was completed in spring 2005 (after 2004 report delivered), they are included in this 2005 report; 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 product is launched. The market progress of Alliance projects is tracked during their implementation phase as part of the project evaluation. However, since market diffusion often occurs after the Alliance funding has ceased, the Alliance 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, the Alliance developed a process and plan for tracking and monitoring the market progress of projects that it no longer funds. The Long-Term Tracking and Monitoring plan focuses on a select group of projects that are expected to have ongoing market impacts in the post-funding period. This report presents the findings from research conducted to track the market progress of ten such Alliance projects.

1.1 Goal of Monitoring and Tracking

The goal of long-term monitoring and tracking is to measure and track critical market progress indicators and Alliance Cost-Effectiveness (ACE) model assumptions in order to estimate long-term electricity savings. Long-term monitoring and tracking methods have been selected that provide impact estimates with a satisfactory confidence level 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 some energy savings estimates.

1.2 Monitoring and Tracking (M&T) Process

The long term M&T process has three major steps, a review of the Alliance cost-effectiveness (ACE) model for each project, the development of an M&T plan, and the incorporation of this plan in the ongoing M&T activities. The steps are listed below in greater detail.

1. Review the ACE model for each project:
   - Review the critical assumptions and progress indicators for each project
   - Assess the variables on:
     - Confidence in their estimated and forecast values
     - Sensitivity of project savings to changes in the input variable(s)
     - Availability and cost of collecting the data
   - Rank and select critical variables to be tracked
2. Develop M&T plan for each project.
   - Review M&T approach recommended by MPER
   - Review recent market research
   - Review current M&T activities
   - Develop budget and tasks for project M&T
3. Incorporate M&T plans into M&T activities:
   - As projects end incorporate new M&T activities to track these projects
   - Adjust M&T budget as needed on an annual basis
   - Provide annual update on M&T activities, and recalculated energy savings estimates

Each M&T report reviews the project ACE model and, if appropriate, makes recommendations for changes in the model's assumptions or inputs. The Alliance uses the same process to incorporate recommendations from the annual M&T report as it uses to incorporate recommendations from individual project evaluations. Alliance staff meets internally to discuss the recommendations, and prepares a staff recommendation to accept them (completely or in part), or reject them, with the reasons for adopting or not adopting the recommendations outlined. The recommended changes are then documented and incorporated into an updated ACE model, and presented to the Alliance Cost-effectiveness Committee for review.

1.3 M&T for Program Year 2004

In December 2004, the Alliance contracted with Summit Blue to implement the Alliance's monitoring and tracking (M&T) framework for program reporting year 2004. Summit Blue prepared and implemented M&T plans for:

- Energy Star Residential Windows
- Building Operator Certification
- SAV-AIR
- VFDs in Warehouses
- Siemens (Shell Solar)
- Just Enough Air

A Monitoring and Tracking Report for the 2004 program year was delivered to the Alliance in March of 2005 that included the M&T assessment for the *Energy Star Residential Windows* and *Building Operator Certification* programs. The M&T results of the four other programs were completed in spring 2005 (after the 2004 Market Activities Report (MAR) had gone to print), and are included in this 2005 report.

1.4 M&T for Program Year 2005

Shortly after the delivery of results for the 2004 programs, it was determined that the long term M&T efforts for 2005 would include the following activities:

- Finalize the 2004 monitoring and tracking work on:
    - SAV-AIR
    - VFDs in Warehouses
    - Siemens (Shell Solar)
    - Just Enough Air
- Update M&T work on the projects reported on in 2004, based on recommendations in those reports
    - Energy Star Residential Windows
    - Building Operators Certification
- Develop and Implement M&T plans for four additional projects:
    - BacGen
    - EZConserve
    - Commissioning
    - Small Commercial HVAC (AirCare Plus)

This report contains the methodologies employed, findings, and recommendations for each of these 10 project reviews. The M&T work on the remaining 2004 projects was finalized in the spring. A review of the ACE models for the four new projects was completed in August. Then M&T workplans for each new project were developed and reviewed by the Alliance project manager. Soon after, data collection and analysis began.

Chapters two through ten of this report each present the savings approach, data collection methods, and findings for each project noted above, in the order listed.

1.5 Long Term M&T for 2006 and Beyond

Future long term monitoring and tracking efforts will include updates to the programs included in this report, along with several additional Alliance programs that no longer receive funding. A *tentative schedule* for each of the project tracking efforts for 2006-2010 is shown in Figure 1-1 below.

The list of programs to have reviews conducted in 2006 will be discussed with the Alliance project manager and reviewed by the Cost-effectiveness Committee of the Alliance Board before the 2006 plan is finalized.

Figure 1-1. Timeline for Conducting / Updating Long-Term Monitoring & Tracking by Program

PROJECT	2004	2005	2006	2007	2008	2009	2010
Energy Star Residential Windows	C	U		U		U	
Building Operator Certification (BOC)	C	U		U		U	
SAV-AIR	C*		U		U		U
Just Enough Air	C*						
Evaporator Fan VFDs	C*		U		U		U
Siemens (Shell Solar)	C*		U		U		U
BacGen		C		U		U	
EZConserve (Surveyor)		C		U		U	
Commissioning in Public Buildings		C	U		U		U
Small Commercial HVAC (AirCare Plus)		C					
Energy Star Home Products			C				
MagnaDrive			C				
Dendritic Polysilicon Production (ASiMi)				C			
Electric Motor Management (Drive Power)				C			
Microelectronics Industry Initiative				C			
SIS/AM400			C	C			

NOTES: C = Conduct initial analysis;
C* = Initial analysis for these programs was completed in spring 2005 (after 2004 report delivered), they are included in this 2005 report
U = Update to initial analysis

As program monitoring and tracking procedures are initiated for each Alliance 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 Alliance 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 chapter contains recommendations for ongoing data collection activities and frequency.

2. SAV-AIR FINDINGS

2.1 Introduction

The SAV-AIR Market Transformation Initiative was funded from December 1998 to December 2003. Its goal was to develop and launch a self-sustaining business that specializes in optimizing compressed air systems to help industrial facilities achieve energy efficiency benefits and increased system reliability. SAV-AIR, LLC (SAV-AIR) was formed in 1997, and provides comprehensive industrial compressed air management systems and engineering services. The project targets compressed air systems greater than 300 HP in the Northwest, and the technology includes monitoring and control using sensors, computers, and software. The primary project progress indicators included:

- Create a self-sustaining business
- Overcome market barriers that include the lack of technical data and funding as well as the current attitude and lack of accountability for compressed air
- Stakeholders recognize the value of whole system efficiency rather than component-specific efficiency
- Develop an alpha site for product testing and marketing purposes
- Complete six beta test sites and document for further marketing efforts

While SAV-AIR's comprehensive approach to compressed air management appears to offer the greatest energy savings potential, other less capital-intensive control systems have begun making their way into the market. According to Steven Scott of MetaResource Group, SAV-AIR's proprietary technology relies heavily on flow-based measurements, and flow sensors can cost up to $5,000 per sensor. Other control schemes currently in use rely on pressure-based measurements that can produce savings relatively close to those achieved by SAV-AIR's technology at a fraction of the cost (more in the range of $40 per sensor). This long-term monitoring and tracking effort focuses on refining the inputs to the Alliance's Cost-Effectiveness (ACE) model and the subsequent energy savings estimation for SAV-AIR's completed projects.

2.2 Approach to Energy Savings Estimation

According to Summit Blue's review of the ACE model, the energy savings impact of the SAV-AIR Market Transformation Initiative in the Pacific Northwest (NORTHWEST) is based on a few key inputs and assumptions, including the total number of participating sites and an assumed annual savings per facility. Specifically, energy savings for a given calendar year, as calculated in the ACE model, are as follows:

Annual Energy Savings (kWh/year) =

(1) Total number of participating sites
x (2) Estimated per-project energy savings (kWh/unit-year)

where:

Total number of participating sites is defined as the number of projects that SAV-AIR has completed. For the most part, SAV-AIR considers a project to consist of a single company, single location, and single compressed air system as opposed to a single *facility*; consequently, one of SAV-AIR's projects could consist of multiple facilities or buildings.

Estimated per-site energy savings is an assumed value and is equal to the average savings per site that are due to SAV-AIR's services. The current number is based upon measurements from 12 case studies identified in the third and fourth MPER's.

According to Summit Blue's M&T plan[2], one of the recommendations for future tracking efforts is to estimate energy savings as a function of compressed air capacity (HP) instead of by site to reduce the impact of the variability of the industry type on the energy savings calculation. In the course of the data collection effort, we were able to obtain information that would lead to a savings estimation based on capacity. Consequently, *the evaluation team recommends using a revised energy savings calculation*:

Annual Energy Savings (kWh/year) =

(1) Total compressed air capacity of the participating sites (HP)
x (2) Estimated per-capacity energy savings (kWh/HP-year)

where:

Total compressed air capacity of the participating facilities is defined as the sum of the compressed air capacity (HP) for each facility in the Northwest at which SAV-AIR has implemented its integrated compressed air management system.

Estimated per-capacity energy savings is equal to the average savings per HP of compressed air capacity that are due to SAV-AIR's services, and is calculated from sites at which savings were calculated from pre- and post-implementation measurements.

2.3 Data Collection Methodology

Data was collected for all the key input variables identified in the Long-Term Monitoring & Tracking Plan; each variable was then scrutinized to determine accuracy and/or reasonableness. Fortunately, the Alliance has a revenue-sharing agreement in place with SAV-AIR that ensures access to sales data for the foreseeable future. The following is a step-by-step description of the data collection process:

1. **Contacted Ned Dempsey of SAV-AIR to gather additional information on the company and market.** Mr. Dempsey supplied the evaluation team with background information on the SAV-AIR project and SAV-AIR company itself. Furthermore, Mr. Dempsey reported that SAV-AIR has completed a total of 19 projects and that two of the plants have since shut down (both in 2002).
2. **Contacted the evaluation contractor (Steven Scott of MetaResource Group) to inquire regarding insights on the market, estimated energy savings, and the potential for spillover.** Mr. Scott discussed in detail the trends in the industrial compressed air market, including the cost-effectiveness of using pressure sensors versus using flow sensors. In addition, Mr. Scott provided the evaluation team with a spreadsheet detailing the accomplishments of 16 of SAV-AIR's 19 projects, and it was critical in our determination of per-capacity savings (kWh/HP).
3. **Reviewed evaluations of other compressed air controls programs** to verify the reasonableness of input assumptions and/or to identify alternative savings estimation methodologies. In particular, the evaluation team examined Ridge & Associate's EM&V report of the Compressed Air Management Program (CAMP) that was run by SBW Consulting[3]. The report detailed M&V activities that were consistent with the International Performance Measurement and Verification

[2] "SAV-AIR Long-Term Monitoring & Tracking Plan"; Summit Blue Consulting; January 31, 2005

[3] "Evaluation, Measurement, and Verification Report for SBW Consulting Inc.'s 2002-03 Compressed Air Management Program"; Ridge & Associates; January 7, 2005

Protocols (IPMVP) for the measurement of savings due to compressed air energy efficiency measures.

2.4 Findings

The following discussion provides a summary of the analysis conducted to determine a best estimate of each key input variable to the energy savings calculations.

2.4.1 Total Number of Participating Sites

One of the key inputs to either of the energy savings calculations outlined in Section 2.2 – Approach to Energy Savings Estimation is the total number facilities at which SAV-AIR has implemented its compressed air optimization strategy. SAV-AIR's Ned Dempsey reported that since SAV-AIR started implementing its technologies in 2001[4], there have been a total of 19 completed projects. Additionally, Mr. Dempsey reported two of the participating facilities have since shut down production, so the net gain of energy savings comes from 17 participating facilities.

2.4.2 Total Compressed Air Capacity of Participating Sites (HP)

The next step in the analysis of energy savings due to the SAV-AIR project was to get an estimate of the total compressed air capacity of each of SAV-AIR's projects. The evaluation team first contacted Steven Scott of MetaResource Group, who was the Alliance's evaluator for the SAV-AIR project. Mr. Scott supplied the evaluation team with a database of SAV-AIR's projects, and it included system type[5], energy cost savings, total compressor HP, installation date, and annual energy savings. Unfortunately, the database provided contains only the first 16 of SAV-AIR's projects, including the two sites which have since shut down production. Table 2-1 below shows the statistics for the compressed air capacities (HP) of the 16 sites in the database.

Table 2-1. Compressed Air Capacity (HP) of Database Sites

Statistic	Value
N	16
Sum	10,265 HP
Average	642 HP/site
Minimum	150 HP
Maximum	3,250 HP
Std Dev	718

In order to get an accurate assessment of the total compressed air capacity of SAV-AIR's projects (not including the two that have been shut down), an estimate has to be made for the three projects not reported in Mr. Scott's database. MPER-3 recommended reducing the original assumption of the size of an industrial compressed air system in the Northwest from 750 HP (average) to 450 HP (average). As shown in Table 2-1 above, the average capacity from the sites provided in the database is 642 HP per site,

[4] Mr. Dempsey reported that SAV-AIR did not start its first project until 2001.

[5] SAV-AIR offers three different compressed air management system types: the PL2000 (which is the most common), the PL1000, and the PL500.

which is in the range of the original assumption and the recommendation from the third MPER. Consequently, the evaluation team used the average value from the database as an estimate of the capacity for the three remaining sites for which we do not have data, and total compressed air capacity of SAV-AIR's projects is estimated to be ***11,291 HP.***[6]

2.4.3 Estimated Per-Capacity Energy Savings (kWh/HP-year)

The final input needed to calculate the energy savings resulting from SAV-AIR's technologies is an estimate of the attainable kWh savings normalized to compressed air capacity (HP). A normalized savings calculation will decrease the variability among different sites; for example, the savings attained by a wood products plant might be significantly different than the savings attained by a mineral processing facility. Fortunately, the database provided by Steven Scott includes the actual savings (in addition to the compressed air capacity) for each project completed.[7] Mr. Scott retained savings data for 12 projects, including for the two sites that have since shut down. All sites for which savings data is available had the PL2000 installed. As shown in Table 2-2 below, the evaluation team used this data to get an estimate of the savings per unit.

Table 2-2. Per-Unit Energy Savings (kWh/HP) of Database Sites

Statistic	Value
N	12
Average	2,644 kWh/HP
Minimum	1,000 kWh/HP
Maximum	6,667 kWh/HP
Std Dev	1,654

In order to retain as many data points as possible, the data for the two sites that have since shut down were included in the estimate of per-unit energy savings. These sites will not, however, be included in the estimate of annual energy savings.

2.4.4 Estimate of Annual Energy Savings

As described in Section 2.2, Summit Blue recommends using a revised energy savings calculation that is normalized to capacity for the estimation of savings due to the SAV-AIR project:

Annual Energy Savings (kWh/year) =

(1) Total compressed air capacity of the participating sites (HP)
x (2) Estimated per-capacity energy savings (kWh/HP-year)

The database provided by Steven Scott includes the date of implementation for 11 of the 17 completed SAV-AIR projects that are still in production (65%), and the evaluation team thinks this is not enough data to accurately characterize the energy savings achieved for each calendar year. A side-by-side

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[6] The value for total compressed air capacity subtracts the two sites which are shut down and no longer in production. These two sites totaled 900 HP, so the corresponding value is equal to 10,265 – 900 + (3*642) = 11,291 HP.

[7] According to Mr. Scott, energy savings were determined using a variety of methods, including the use of SAV-AIR's monitoring equipment, electric utility confirmations, pre-metering, and detailed modeling.

comparison of the energy savings that result from the calculation in the ACE model versus the evaluation team's recommended calculation is presented in Table 2-3 below.

Table 2-3. Per-Unit Energy Savings (kWh/HP) of Database Sites

Method of Calculation	Number of Units	Per-Unit Savings	Annual Energy Savings (kWh)
ACE Model	17 facilities	1,051,304 kWh/facility*	17,872,168
Recommended Approach	11,291 HP	2,644 kWh/HP	29,853,404

* This per-facility savings number is hard-wired into the ACE model and was not investigated for this report due to the evaluation teams alternative savings calculation methodology.

Based on the recommended energy savings calculation, the annual savings currently being achieved by the SAV-AIR project is 29,853 MWh, which is approximately two-thirds (67%) more than the savings calculated using the ACE model assumptions. As the Alliance tracks program impacts in terms of average megawatts (aMW), these MWh numbers can easily be converted to aMW. Table 2-4 below shows the annual energy savings currently being achieved by the SAV-AIR project.

Table 2-4. Annual Energy Savings Attributable to the SAV-AIR Project

Program Savings	
Energy Savings	29,853 MWh
Annual Savings	3.41 aMW

2.5 Conclusions/Recommendations

Although the SAV-AIR Market Transformation Initiative realized significant energy savings in the industrial compressed air market, it did not achieve a notable market transformation. Other less expensive control schemes have limited SAV-AIR's ability to market and install its technologies. Of the estimated 800 compressed air systems in the Northwest, SAV-AIR has implemented its technologies at just 19 sites (2.4%) since its inception in 1997.

Additional data collection and analysis activities beyond the scope of this M&T project may provide a more complete assessment of program impacts and/or reduce the uncertainty surrounding specific indicators. Recommendations for additional analyses include:

- *Obtain a better estimate of the total capacity of SAV-AIR's customers.* The last MPER written by Steven Scott was completed in June 2004, and the data that he was able to provide was limited to projects completed before that time. As a result, he had no data whatsoever for 3 of SAV-AIR's projects. Ned Dempsey might be able to augment the database received from Steven Scott with figures from the additional projects.
- *Aggregate energy savings by system type.* The estimate of per-capacity savings is based on the data from 12 completed projects for which capacity and energy savings is provided, and each of the 12 sites had one PL2000 installed. In the future, and *if* SAV-AIR expands its services, it might be more realistic to estimate savings by system type, i.e. use a different per-capacity savings value for each system, the PL2000, the PL1000, and the PL500.

- *Estimate the share of calculated savings that are attributable to the presence of the SAV-AIR Initiative itself.* In the case of the SAV-AIR Initiative, baseline is probably zero due to the proprietary nature of the technology and its applications – and currently no other firm is actively selling this type of control system in the Northwest.
- *Determine to what degree spillover impacts are occurring.* Programs such as the SAV-AIR Initiative sometimes result in energy savings at facilities beyond those participating in the programs. For example, a "non-participating" facility operator may have heard of the benefits of optimizing their compressed air controls and decided that it was worth pursuing on his/her own, with or without SAV-AIR's technology. The impact of SAV-AIR on the awareness of compressed air control strategies and thus the adoption of other technologies might be quantified with a survey of regional equipment and controls vendors such as Rogers Machinery.
- *Frequency of data collection*
    - Number of participating facilities by calendar year - annually
        - Should be updated and detailed every 2 years
    - Average capacity of participating facilities – every 2 years
        - This simply entails getting the compressed air capacity of each of SAV-AIR's completed projects
    - Updated estimate of per-capacity energy savings – every 2 years
        - If SAV-AIR continues to measure savings from their implemented projects, use these additional sites to update the old data

3. EVAPORATOR FAN VFD

3.1 Introduction

The Evaporator Fan Variable Frequency Drive (VFD) Initiative was funded by the Alliance from January 1998 to June 2004. The effort's initial objective was to make VFDs an industry standard for evaporator fans in all types of refrigerated warehouses in the Northwest, including controlled atmosphere (CA) rooms, food distribution centers, dairy-milk coolers, food-processor blast cells, and other types of common cold storage. This primary objective met with great success, and an additional objective was added in early 2002 to investigate the possibility of making VFD ventilation fans standard practice in potato and onion storage facilities.

The initiative's goal 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. The primary project progress indicators include:

- Conduct field trails at 30 sites in the first two years and achieve two comprehensive installations *(23 field trails and two comprehensive installations were completed).*
- Develop a database of storage facilities
- Increase by 5% the number of refrigerated warehouses and storage facilities that have VFDs by 2000
- Increase market penetration of VFDs to at least 31% of warehouses and 47% of fruit storage facilities by 2007

According to the Initiative's concluding memorandum[8], the effort was by all appearances successful in transforming the market for the application of evaporator fan VFDs in refrigerated warehouses. Additionally, the potato storage VFD effort was also successful in transforming the market for VFDs on ventilation fans in potato storage facilities. Unfortunately, this investigation also uncovered many problems with implementing VFDs on ventilation fans in onion storage facilities, and it concluded that these drawbacks significantly limit the market transformation potential.
This long-term monitoring and tracking effort focuses on refining the inputs to the Alliance's Cost-Effectiveness (ACE) model and the subsequent energy savings estimation for the evaporator fan VFD portion of the Initiative.

3.2 Approach to Energy Savings Estimation

According to Summit Blue's review of the ACE model, the energy savings impact of the Evaporator Fan VFD Initiative is based on a few key assumptions, including the number of evaporator fan units (HP) in the NW at which a VFD control has been installed, an estimation of the number of baseline units installed (HP), and annual per-unit energy savings (kWh/HP-year). Furthermore, each of these input variables must be obtained for each facility type (regular cold storage and CA) in order to accurately calculate and characterize the energy savings from refrigerated warehouses. Specifically, energy savings for a given calendar year are calculated as follows:

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[8] "Evaporator Fan VFD Initiative: Concluding Memorandum"; MetaResource Group, Steven Scott; December 31, 2003

Annual Energy Savings by Facility Type (kWh/year) =

(1) Number of evaporator fan units (HP) in [TYPE CATEGORY] facilities at which a VFD has been installed

\- (2) Estimated baseline evaporator fan units (HP) in [TYPE CATEGORY] facilities at which a VFD has been installed

x (3) Assumed per-unit savings (kWh/HP) for [TYPE CATEGORY] facilities

Where:

Number of evaporator fan units is calculated by multiplying the total number of units (HP) in the market by the estimated market penetration of VFDs for each facility type.

Estimated number of baseline units is the total evaporator fan HP in the NW at which a VFD control has been installed that is attributed to the baseline for each facility type.

Assumed per-unit energy savings is the kWh per evaporator fan HP that is associated with the VFD installation for each facility type.

3.3 Data Collection Methodology

Data was collected for all the key input variables identified in the Long-Term Monitoring & Tracking Plan, and each of the identified key input variables in the ACE model were scrutinized to determine accuracy and/or reasonableness. The M&T approach involves a survey of engineering firms and design/build refrigeration contractors every two to three years to assess the market penetration of VFDs on evaporator fans. The evaluation team incorporated the recommended approach with additional contacts and data collection processes.

The following is a step-by-step description of the data collection process:

1. **Obtained and reviewed project documentation**, including the ACE model, the most recent Market Progress Evaluation Report (MPER), the Initiative's Concluding Memorandum, and other various documents that would provide detailed background on the project and the assumptions used in the savings estimations.

2. **Contacted and interviewed Steven Scott of MetaResource Group**, who was the evaluator of the VFD Initiative. He was able to supply additional project information that could not be found in the MPER's, as well as background information on the industry in general.

3. **Contacted and interviewed Marcus Wilcox of Cascade Energy Engineering**, who was the VFD Initiative's implementation contractor. Mr. Wilcox was exceptionally helpful and knowledgeable about the industrial refrigeration industry, evaporator fan VFD market, and the Initiative itself. In addition, he was able to confirm our per-unit savings assumptions, supply potential sources for information on the market, and provide sources and contact information for several refrigeration contractors and controls vendors in the Northwest.

4. **Contacted a sample of refrigeration contractors and controls vendors** to determine what percentage their customers evaporator fan HP has VFDs installed. Respondents were also asked to disaggregate this information so that we had estimates for both regular cold storage and CA fruit storage rooms.

3.4 Findings

The following discussion provides a summary of the analysis conducted to determine a best estimate of each key input variable to the energy savings calculations.

3.4.1 Number of Evaporator Fan Units

As described above in the Approach to Energy Savings Estimation, there are two main inputs to the calculation of the number of evaporator fan units (HP) in refrigerated warehouses in the Northwest. The first is an in-depth review of the total market size, which is defined as the total evaporator fan HP in market. The second is an accurate assessment of the penetration of VFDs on evaporator fans in the market.

Summit Blue first contacted Marcus Wilcox of Cascade to ask a number of questions related to the current market for evaporator fan VFDs. The conversation yielded many insights about the industry and its major players, and he offered these interesting market anecdotes:

- There are 5 main regions of refrigerated warehouses in the Northwest: the Yakima, Wenatchee, Medford, Hood River, and Milton-Freewater valleys. Each region has varying levels of VFD penetration due to varying electricity rates and other factors.
- The three major categories of market actors include the refrigeration contractors, refrigeration computer controls vendors, and the electrical contractors. Refrigeration contractors are responsible for the custom installation of a built-up refrigerated warehouse and its components. The controls vendors design control schemes for the refrigeration system and ensure that it is operating properly and efficiently after installation. Electrical contractors perform the actual controls installations and necessary wiring to meet the designs of the controls vendors.
- The top 10 fruit companies in the Northwest constitute about 50% of the refrigerated warehouse volume.
- Fruit storage warehouses can be separated into two categories: controlled atmosphere (CA) rooms and common storage rooms. In addition, a CA room can become a common storage room when it is not necessary to store the fruit for a lengthy period of time.

During the interview with Marcus Wilcox, the evaluation team also asked a number of questions related to the total evaporator fan capacity (HP) in refrigerated warehouses in the Northwest. Mr. Wilcox suggested researching Cascade's original proposal to the Alliance, which he believed contained the sources of information and assumptions necessary to make a reasonable judgment about market capacity. After obtaining the pertinent pages from the proposal from Phil Degens of the Alliance, the evaluation team researched the sources listed and to emulate the equations used to determine evaporator fan capacity.

The National Agricultural Statistics Service (NASS) issues a biennial report detailing the capacity (volume) of refrigerated warehouses in the United States, the latest of which was published in January 2004 and contains data for 2003.[9] The first step in determining the total evaporator fan capacity in refrigerated warehouses was to aggregate the data for Washington, Oregon, Idaho, and Montana by storage type (regular or fruit) to estimate the total volume of refrigerated storage space in the Northwest.

[9] "Capacity of Refrigerated Warehouses: 2003 Summary"; United States Department of Agriculture, National Agricultural Statistics Service; January 2004

As shown in Table 3-1 below, the gross storage space of all refrigerated warehouses in the Northwest in 2003 was approximately 902 million cubic feet.

Table 3-1. Gross Refrigerated Storage Space by Warehouse Type and State (2003)

	Regular Storage (ft^3)	Fruit Storage (ft^3)	Total Storage (ft^3)
Idaho	58,587,000	5,840,000	64,427
Montana	976,000	0	976,000
Oregon	103,967,000	51,642,000	155,609,000
Washington	188,961,000	492,326,000	681,287,000
TOTAL	**352,491,000**	**549,808,000**	**902,299,000**

The next step in determining evaporator fan capacity is to estimate the evaporator fan connected load per volume unit (ft^3). Fortunately, Cascade's proposal to the Alliance suggests values based on known installations in the Northwest, and it includes values for regular storage (freezer), regular storage (cooler), and fruit storage evaporator fan energy use. Furthermore, the NASS report divides the data for regular storage into two distinct sections, one for freezer storage and one for cooler storage. According to the data for the states in the Northwest, freezer storage constitutes 95% of the regular storage volume while cooler storage accounts for the other 5%. Using this data, one can calculate a reasonable estimate of the evaporator fan connected load in refrigerated warehouses in the Northwest. As shown in Table 3-2 below, the estimated market size in 2003 was approximately 93,954 HP.

Table 3-2. Evaporator Fan Capacity in Refrigerated Warehouses in the Northwest (2003)

	Gross Volume (ft^3)	Evap Fan Connected Load Per Volume Unit (kW/ ft^3)	kW to HP Conversion	Evap Fan Capacity (HP)
Regular Storage – Freezer	334,760,000	0.00004588	1.34	20,587 HP
Regular Storage – Cooler	17,731,000	0.00002955	1.34	702 HP
Fruit Storage	549,808,000	0.00009860	1.34	72,665 HP
TOTAL				**93,954 HP**

Using national historical data from the NASS report going back to 1985, the evaluation team was able to estimate an annual growth rate of the national gross volume of refrigerated warehouses. The national average annual growth rate was calculated to be 3.34%, which is more than double the growth rate assumed for the Northwest in the ACE model (1.5%). Marcus Wilcox thought that the 1.5% growth rate for the Northwest sounds *reasonable,* as a result, the evaluation team recommends using this number. Since the inputs to the evaporator fan capacity equation are all multiplicative, the growth rate can be applied directly. Table 3-3 below shows the assumptions used in the ACE model compared to the recommended assumptions.

Table 3-3. Evaporator Fan Capacity in Refrigerated Warehouses in the Northwest (HP)

Year	Current ACE Model Assumptions	Recommended Values	Percentage Increase From Current Assumptions
2003	81,977 HP	93,954 HP	14.6%
2004	83,207 HP	95,363 HP	14.6%

The second step in the analysis of the number of evaporator fan units is to determine the market penetration of VFDs on evaporator fans and, fortunately, Mr. Wilcox was able to provide a list of the major refrigeration contractors and controls vendors in the Northwest. Summit Blue called each of the contacts supplied by Mr. Wilcox in an attempt to define the current market penetration of VFDs. Up to 5 attempts were made to contact each contractor and/or controls vendor, and the results were documented via spreadsheet to keep track of the data collection effort. Overall, we attempted to contact 7 different people representing 6 companies, and we received responses from 5 people.[10] In addition, Mr. Wilcox estimated that the 3 controls vendors from whom we received responses represent 80% of the CA fruit storage market and two-thirds of the regular cold storage market in the Northwest. Some anecdotal comments from the survey respondents include:

- *You [the Alliance] really got a movement going – it's just been great!*
- *The Evaporator Fan VFD Initiative was really driving the purchase of VFDs for evaporator fans in refrigerated warehouses. It [VFDs] really works well in cold storage applications.*
- *A lot of plants already have something, and the payback [for VFDs] just isn't good enough. It seems that the only time VFDs are going in is when utilities provide incentives. It was a good program; almost all the VFDs are done through rebates.*
- *VFDs [on evaporator fans] are now the standard in new construction.*

For each of the storage space types, the survey respondents were asked to estimate what percentage of their customers' evaporator fan HP had VFDs installed. The evaluation team initially tried to get this estimate for each calendar year going back to 2002, but that information proved to be too difficult for the contacts to provide reasonable answers. Additionally, some of the survey respondents were only able to answer for one refrigerated warehouse space type since their customers constituted only one space type. Overall, the contractor and control vendor surveys resulted in four data points for the regular cold storage and three data points for the CA rooms.

In addition to contractor/vendor surveys, Summit Blue asked Marcus Wilcox for his impression of the current market for VFDs, and he felt that penetration in regular cold storage was approximately 20% for the entire region and penetration in fruit storage was approximately 45% for the entire region. Since Cascade Energy and Mr. Wilcox himself are such large players in the industrial refrigeration industry in the Northwest, the evaluation team thought it pertinent to include his estimates in the overall average.

According to the third MPER, the market penetration of VFDs in 2001 was 43% for regular cold storage and 18% for CA storage rooms. Currently, the evaluation team estimates penetration to be 47% for regular cold storage and 56% for CA storage rooms, based on the survey of engineering firms. Table 3-4 below shows the results in detail.

Table 3-4. Current Market Penetration of VFDs on Evaporator Fans in Refrigerated Warehouses in the Northwest (2004)

Storage Type	Observations	Mean	Min	Max	Std Dev
Regular Cold Storage	5	47%	20%	75%	0.213
Fruit Storage (CA Rooms)	4	56%	42%	75%	0.152

[10] According to Marcus Wilcox, Double-Kold has two distinct divisions, one of which is a refrigeration contractor and one of which is a controls vendor; he thought it might be beneficial to speak with a contact in each division.

As a result of the preceding analysis, the evaluation team was able to estimate the total number of evaporator fan units (HP) in the refrigerated warehouses in the Northwest that currently have VFDs installed. Table 3-5 below shows the recommended values.

Table 3-5. Number of Evaporator Fans in Refrigerated Warehouses in the Northwest with VFDs Installed (2004)

Storage Type	Total Evap Fan Capacity (HP)	Market Penetration	Evap Fan HP w/ VFDs Installed
Regular Cold Storage	21,608 HP	47%	10,156 HP
Fruit Storage (CA Rooms)	73,755 HP	56%	41,303 HP
TOTAL	**95,363 HP**		**51,459 HP**

3.4.2 Estimated Number of Baseline Units

The ACE model assumes the baseline of evaporator fan units in refrigerated warehouses in the Northwest to be 6,557 HP in 1998, and varying amounts are added to the baseline the next two years. The ACE model then assumes that 1,124 HP is added to the baseline in 2001 and that the amount added each year thereafter grows at a rate of 1.5%. Following this assumption, the combined baseline reaches 13,503 HP (or 16% of the assumed ACE model combined evaporator fan market in the Northwest) by the end of 2004. The ACE model makes no attempt to distribute the baseline between CA fruit storage and regular cold storage – the market for calculation purposes is the total market minus the baseline, and the market distribution is allocated *after* the baseline has been removed. General inquiries were made as to the validity of the baseline assumptions, and Marcus Wilcox of Cascade reported that the annual growth rate of the baseline seemed reasonable.

3.4.3 Per-Unit Energy Savings

As described in Section 3.2 above, a key input to the energy savings calculation is the actual kWh saved per HP of evaporator fan with a VFD installed. Based on values supplied in the third MPER, the ACE model assumes an annual per-unit savings of 2400 kWh/HP for CA fruit storage rooms and 3500 kWh/HP for regular cold storage rooms. These numbers originally came from field trials conducted by Cascade Energy and reported to Steven Scott for inclusion in the MPER's.

Marcus Wilcox reported that Cascade does not normally track savings normalized to HP and that it would be a significant undertaking to go back through a proper sample of projects in order to re-calculate the savings. He did, however, report that the numbers (when calculated for the MPER) might have been conservative and that he believes the numbers are still reasonable and conservative today. As a result, the evaluation team suggests no change to the per-unit savings input assumed in the ACE model.

3.4.4 Estimate of Annual Energy Savings

Annual electricity savings can be estimated for 2004 from the data obtained during the data collection effort As described in Section 3.2 above, the ACE model calculates energy savings according to the following formula:

Annual Energy Savings by Facility Type (kWh/year) =

(1) Number of evaporator fan units (HP) in [TYPE CATEGORY] facilities at which a VFD has been installed

- (2) Estimated baseline evaporator fan units (HP) in [TYPE CATEGORY] facilities at which a VFD has been installed

x (3) Assumed per-unit savings (kWh/HP) for [TYPE CATEGORY] facilities

Based on the values discussed above, the annual energy savings currently being achieved by the Evaporator Fan VFD Initiative is 98,900 MWh. As the Alliance tracks program impacts in terms of average megawatts (aMW), these MWh numbers can easily be converted to aMW. Table 3-6 below shows the annual energy savings currently being achieved by the Evaporator Fan VFD Initiative that is attributable to the Alliance.

Table 3-6. Annual Energy Savings Attributable to the Evaporator Fan VFD Initiative

Program Savings (2004)	
Energy Savings	98,900 MWh
Annual Savings	11.29 aMW
Utility incentives	- 10.16 aMW
Alliance impacts	1.13 aMW

The Alliance showed a cumulative savings of 2.89 aMW 1997-2002[11], a significantly lower a number than the calculated VFD impacts in the region. This is due primarily to the fact that an estimated 90% of all projects accruing savings receive some form of utility incentive. Given that Mr. Wilcox concurred that approximately 90% of projects receive incentives, the Alliance-credited impacts are roughly 10% of the impacts to regional energy use.

3.5 Conclusions/Recommendations

The Evaporator Fan VFD Initiative, funded by the Alliance for nearly six and a half years, realized significant energy savings in refrigerated warehouses in the Northwest. In addition, it appears that the application of VFDs in CA fruit storage rooms has finally surpassed that of regular cold storage facilities, indicating that operators are becoming more aware of the importance of the non-energy benefits.

Additional data collection and analysis activities beyond the scope of this M&T project may provide a more complete assessment of program impacts and/or reduce the uncertainty surrounding specific indicators. Recommendations for additional analyses include:

- *The Alliance could take at least partial credit for those sites that received a utility DSM incentive.* According to Marcus Wilcox, 90% of the VFDs installed are done so with a utility incentive, but it is unlikely that this was the only reason for installation. An attempt should be made to quantify the Alliance's role in the process and provide some additional credit to the Alliance for its role in instigating these efforts.

- *Obtain more data points for the estimate of penetration.* Although Marcus Wilcox felt that the contractors and controls vendors that were interviewed represented a large part of the market in

[11] Alliance reported impacts are pulled from a spreadsheet file (Program Savings.xls) received March 9, 2005, that contains previous adjustments to impacts reported in annual Market Activity Reports.

the Northwest, there were many that could not be reached. Additional interviews would only add to the robustness of the estimates.

- *Quantify the savings from VFDs on evaporator fans in potato storage facilities.* According to Steven Scott's Concluding Memorandum, the potato storage VFD project was a success. Although the market is limited and influence of the University of Idaho is very large, the Alliance played an important part in increasing VFD applications in potato storage facilities.

- *Frequency of data collection*
  - Number of evaporator fan units – every two years
    - Should be updated with each output of NASS data
  - Number of baseline units – every two years
    - Should be updated with the number of evaporator fan units
  - Per-unit energy savings – every two years
    - This is unlikely to change much, can be verified at the same time as all the other inputs
  - Analysis of utility incentives – every two years
    - A survey of regional utilities to determine which projects they actually provide incentives for might alter the amount of savings attributable to the Alliance

4. SIEMENS/SHELL

4.1 Introduction

Shell (formerly Siemens) Solar submitted a proposal to the Northwest Energy Efficiency Alliance 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 introduction of an external feeder system to recharge the hot zone with 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, Siemens 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 the Alliance, there were about 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. Besides the Shell facility, SEH America is the only remaining crystal growing facility in the region, and there has been no indication through 2004 that the Shell project has influenced any changes in that facility's production process. Thus, the Shell plant is considered the only facility in the Northwest influenced by the program. Future Alliance efforts to improve efficiency in silicon crystal growing facilities will be handled within the ASiMi project.

4.2 Approach to Energy Savings Estimation

According to Summit Blue's review of the ACE model, 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. 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.

4.3 Data Collection Methodology

The following is a step-by-step description of the data collection process:

1. Obtained ACE model documentation, the latest Market Progress Evaluation Report, and the research report prepared by Siemens in 2000. These documents provided detailed background on the project and assumptions used in the savings estimations.

2. Interviewed the Shell Solar facility manager (Greg Mihalik) in February 2005 to obtain information on the installed capacity and operation levels of efficient hot zones and to verify electricity savings estimates. This interview and subsequent email correspondence confirmed the following information:

    a. **The number of currently operating hot zones that use the efficient growing process, and their heater capacity (in kW).**
    In addition to the current number and capacity, information was obtained on the operational capacities in each year from 2001 through 2004, accounting for new conversions, new additions, and any removals of efficient hot zones.

    b. **Estimated electricity savings per kW per day.**
    Estimates of savings in the last MPER were based on engineering estimates included by Siemens in its 1999 Annual Report to the Alliance.[12] Mr. Mihalik confirmed that the estimates provided in that report are still appropriate for current operations.

    c. **Production days per year.**
    The assumption used in previous savings estimates was that the efficient hot zones operate 24 hours per day for 360 days per year. This assumption was revisited during the interview, and a distinction was made between production days with the efficient hot zones and production days where recharge was also employed.

    d. **Assumption of measure life.**
    The current assumption is a ten-year lifetime. Mr. Mihalik offered that hot zone furnaces may last for 30 years or more.

    e. **Information on other crystal growers in the region.**
    Since there are only two known growers as of 2004, the addition of any new growers to the market can significantly impact the market penetration rate and, if these facilities use the Shell process, electricity savings estimates as well. The Shell interview explored the crystal-growing and feedstock-production practices of other companies to help determine whether the project's influence has spread beyond the Shell facility.

3. Reviewed USGS Minerals Report and Journal of Crystal Growth for additional, relevant information on crystal growing facilities and the technologies they are employing.

[12] Mihalik, Greg and Bryan Fickett, Siemens Solar Industries, *Efficiency Opportunities in Silicon Crystal Growing Facilities: Redesign of Crystal Grower Hot Zones 1999 Annual Report*, April 2000.

4.4 Findings

The following discussion provides a summary of the analysis conducted to determine a best estimate of each key input variable to the energy savings calculations. For confidentiality reasons, production data and calculation details are not available for publication.

The ACE model utilizes electricity savings assumptions reported by Shell (then Siemens) in its original project application and confirmed by Shell's Greg Mihalik during the interview conducted for this report. Electricity savings—from the direct hot zone modifications (i.e., improved insulation and related modifications)— provide approximately a 40% savings). Shell also reported productivity gains of approximately 22% that are directly attributable to the efficient hot zones. The combined effect of the reduced energy consumption and the increased productivity resulted in a decrease in the energy intensity of production of 51% as measured in kWh per kilogram of usable silicon ingot. Actual electricity savings—relative to what would have been consumed to produce the same amount of silicon product without the hot zone modifications—are roughly 55% greater than the initial savings estimate.

Since Shell's original project application, the company has received support from the Alliance that was instrumental in the development of the polysilicon feedstock recharge system now used in most of Shell's operations.[13] Recharge provides productivity gains that are estimated to provide about 25% of additional electricity savings on top of what is achieved from the efficient hot zone alone.

4.4.1 Estimate of Annual Energy Savings

Annual electricity savings are estimated for each calendar year since the last year for which an estimate was derived. Since the 2001 MPER contained a savings estimate through February 2001, this report presents savings estimates for 2001 through 2004. As described in Section 4.2, the ACE model calculates electricity savings according to the following formula:

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

Based on the discussion above, electricity savings can be determined by the following three approaches:

1. Realized reductions in electricity consumption at the Shell facility from energy efficient hot zones.
2. Production-adjusted reductions that account for increased productivity resulting from the efficient hot zone modifications.
3. Production-adjusted reductions that account for both efficient hot zone modifications *and* increased productivity due to recharge.

[13] Shell's Greg Mihalik confirmed in a telephone interview that Shell "would not have undertaken the recharge process" without Alliance support. Existing recharge methods were too expensive to justify the risk of applying the technology to Shell's operations; however, through the Alliance's sharing of some of the financial risk, Shell was able to pursue and develop the less expensive system that is in use today.

Based on the values discussed above, realized energy savings (i.e., actual reductions in electricity use) attributable to the Siemens/Shell project are estimated at approximately 0.71 aMW in 2001 rising to 1.12 aMW in 2004 (see Table 4-1).

Table 4-1. Realized Electric Savings *from Efficient Hot Zones Only*, 2001-2004

		2001	**2002**	**2003**	**2004**
Annual Savings	***aMW***	**0.71**	**0.86**	**1.01**	**1.12**
Note: Savings figures represent realized electricity savings *from hot zone modifications only*. Savings do not account for productivity gains from either the hot zone modifications or from recharge.					

Accounting for increased productivity from the hot zone modifications increases the estimated electricity savings by 55% (see Section 4.2). This results in production-adjusted reductions of 1.10 aMW in 2001 rising to 1.74 aMW in 2004 (see Table 4-2).

Table 4-2. Production-Adjusted Electric Savings *from Efficient Hot Zones Only*, 2001-2004

		2001	**2002**	**2003**	**2004**
Energy Savings	***aMW***	**1.10**	**1.33**	**1.56**	**1.74**
Note: Savings figures account for productivity gains from the hot zone modifications, but not from recharge. Savings are calculated as the realized savings from Table 4-1 multiplied by 1.55.					

Incremental savings from productivity gains associated with recharge are estimated at 2.23 kWh/kW per day (see Section 4.2). Savings that include recharge benefits are presented as “incremental” daily savings because the Shell facility has not been able to employ recharge for all of its recent production. Therefore, annual savings including recharge benefits are calculated by adding the incremental annual savings from recharge to the annual savings from the efficient hot zones only (see Table 4-3). Based on the incremental savings rate of 2.23 kWh/kW per day and the estimate of annual production days employing recharge, incremental savings range from 0.28 aMW to 0.35 aMW per year. Total production-adjusted reductions (including electricity savings from the efficient hot zones and productivity gains from the efficient hot zones and from recharge) are estimated at 1.38 aMW in 2001 rising to 2.09 aMW in 2004.

Table 4-3. Production-Adjusted Electric Savings *from Efficient Hot Zones and Recharge*, 2001-2004

		2001	2002	2003	2004
***Incremental* Savings from Recharge**	***aMW***	**0.28**	**0.33**	**0.35**	**0.35**
Savings *without* Recharge (from Table 4-2)	*aMW*	1.10	1.33	1.56	1.74
	aMW	**1.38**	**1.66**	**1.91**	**2.09**
Note: Savings figures account both for realized electricity savings from the efficient hot zones and for productivity gains from the efficient hot zones and from recharge.					

- A summary of the savings estimates under the three approaches is presented in Table 4.5 along with estimates from the Alliance.[14] The savings figures representing realized savings from efficient hot zones only are slightly lower than the savings estimated by the Alliance, by approximately 0.3 to 0.5 aMW in each year. It is not clear why the two sets of numbers are different, although it appears that the Alliance assumed a large jump in the number of efficient hot zones between 2001 and 2002, and then virtually no change between 2002 and 2004.
- When the productivity gains from the efficient hot zones are considered, the savings estimates very nearly match those of the Alliance. Over the four years, the difference between the two sets of estimates is generally 0.1 aMW or less, with the exception of 2004 in which the estimate from this M&T work is greater by approximately 0.2 aMW. When all productivity gains are considered (including from recharge), the M&T estimates are greater than those from the Alliance by at least 0.2 aMW in each year and by more than 0.5 aMW in 2004.

Table 4-4. Comparison of Energy Savings Estimates

	Realized Savings from Efficient Hot Zones Only	Production-Adjusted Savings from Efficient Hot Zones Only	Production-Adjusted Savings Including Recharge	Northwest Alliance Estimate
2001	0.71	1.10	1.38	1.04
2002	0.86	1.33	1.66	1.44
2003	1.01	1.56	1.91	1.52
2004	1.12	1.74	2.09	1.52

The “realized savings” approach is the most conservative, in that it reflects actual reductions in electricity consumption at the Shell facility. That is to say, the savings represent the measured decrease in electricity consumed by each of the crystal growers. On the other hand, the productivity gains reflect real decreases in the amount of electricity used to produce each kilogram of silicon ingot. Given that the Shell facility has been steadily increasing capacity and production over the past four years, it is reasonable to assume that—even in the absence of support for the Alliance—Shell would have increased production to current levels using the conventional hot zones and crystal-growing processes. In this case, the “production-

[14] Alliance reported impacts were taken from a spreadsheet file (Program Savings.xls) received March 9, 2005, that contains previous adjustments made to impacts reported in annual Market Activities Reports.

adjusted" savings estimate (including recharge) most accurately reflects the reduction in energy use attributable to the Alliance.

4.5 Conclusions/Recommendations

4.5.1 Conclusions

The Shell/Siemens project that the Alliance supported in the late 1990s and into 2001 has continued to yield electricity savings in the years after the project was completed. Some of the key findings from this study include the following:

- Even when the availability of the appropriate polysilicon feedstock limits Shell's ability to employ the recharge process, the company still achieves significant energy savings on account of its modification of the hot zone.
- Energy savings attributable to the Shell/Siemens project have increased each year between 2001 and 2004 and are estimated at approximately 1.1 aMW in 2004, not including any productivity gains due to hot zone modifications and recharge. If it is assumed that Shell would have increased production to current levels even without equipment and process modifications, then the 2004 savings estimate rise to approximately 2.1 aMW.

4.5.2 Recommendations and Considerations for Future Monitoring and Tracking

- Interviews with Shell are recommended annually since the facility has steadily been adding efficient hot zone capacity over the past several years. New capacity may be developed due to global demand for crystal silicon. This could result in additional crystal-growing capacity at the facility or the conversion of some of the smaller hot zones to the more efficient configuration.
- The project may have ancillary energy-saving benefits in addition to the direct savings at the Shell facility. According to Shell's 1999 Annual Report to the Alliance (p.12), the granular silicon used during recharge requires 50% to 75% less energy to manufacture than do the polysilicon rods used under the conventional crystal-growing method. Thus, the use of recharge at Shell (and other facilities that have adopted the recharge process) represents additional, if unquantified, savings. [this will be part of the ASiMi M&T]
- Shell's Greg Mihalik believes that other crystal-growing facilities are benefiting from the work done by Siemens/Shell through the Alliance, although he cannot attribute specific changes to the program. According to Mr. Mihalik, the industry is moving toward recharge as a standard practice. To the extent that this transformation would have happened even in the absence of the Siemens/Shell project, one could argue that energy savings from recharge should not be attributed to the Alliance, at least not after some unspecified date in the near future.

5. JUST ENOUGH AIR (JEA)

Summary: Summit Blue completed five interviews with JEA service providers and program implementers. There appears to be little activity that can directly be attributed to the program, although reports of changes over the past few years in the operation of low-pressure pneumatic conveying systems (PCS) suggest that fan speed has been declining and facility operators are more interested in assessing opportunities to improve PCS efficiency. Interviewees were able to provide anecdotal evidence of program influence, but no solid data in terms of the number of facilities or the percent of the market affected. Consequently, energy savings have not been calculated.

Much of the activity reported has been studies only (no implementation) or part of system reconfigurations, rather than specific efforts to optimize fan speed. As a result, this M&T report does not report on the fan-speed-optimization activity, but rather characterizes current general trends in the secondary wood products industry, as reported by interviewees, with respect to adoption of efficiency improvements in PCS systems.

5.1 Introduction

The objective of the Just Enough Air initiative, funded by the Alliance from April 1999 to February 2002, was to increase the energy efficiency of industrial (PCS) systems, with an initial focus on the secondary wood products industry. These systems use the suction provided by centrifugal fans to remove wood waste generated in the manufacturing process or to transfer materials from one location to another. The energy efficiency optimization strategy involves adjusting motors and fans to an optimum speed, usually a lower speed than previously set, for removing sawdust and wood chips to a collection system. Additionally, the project aimed to build awareness by marketing case studies and a Best Practices Guide to utilities and interested contractors. Other industries, including agriculture, food processing, primary metals, and concrete/aggregates, use PCS for dust collection and removal of air-borne pollutants.

5.2 Approach to Measuring Program Impact

The initial intent of this M&T report was to track continuing program impacts and market transformation by estimating the total energy savings resulting from fan speed reductions in secondary wood products facilities. However, due to the limited direct impact of the program and the lack of available data on fan optimizations, energy savings have not been calculated.

Instead, the indicators of program success are anecdotal accounts from participating contractors and engineers of broad changes in the operation of PCS systems in the wood products industry. These changes address issues including:

- PCS fan speeds
- Awareness of energy consumption and efficiency opportunities
- Use of the Best Practices Guide developed through the program

The original key indicators and the formula for determining energy savings (based on the ACE model) are presented as an Appendix at the end of this document.

5.3 Data Collection Methodology

The M&T approach involved surveying JEA service providers (engineering firms/contractors) to assess the market penetration of JEA practices. As part of this effort, the demand for the Best Practices Guide was also reviewed.

Following are the steps conducted for data collection:

1. **Contacted the program evaluator (Jennifer Stout)** to obtain the following information, with documentation as appropriate:
   - **a. Sources of data for the key input variables**
     Ms. Stout concurred with Summit Blue's conjecture that data on facilities was contained in the market baseline evaluation reported conducted in 1999.[15] However, as discussed above, there was insufficient program-related activity to quantify savings. Therefore, the facility information and other energy-savings input data was not utilized.
   - **b. Database of JEA service providers**
     Ms. Stout provided Excel spreadsheets containing contact information for utilities, engineering firms, and contractors who provide JEA services and who were surveyed for the earlier MPERs. This information was used to conduct a survey of half a dozen contractors for this M&T report.
2. **Conducted a survey of six engineering firms and contractors who provided JEA services**
   Interviewees were asked about their experience with PCS optimization and about their views on the market for PCS-related energy efficiency services. The interview guide used by Summit Blue addressed the following subjects:
   - **a. Activity related to optimization of PCS systems, including contractor experience and percent of market affected**
     It was intended that this information would help determine if the ACE model assumption of market penetration is reasonable. However, none of the interviewees could quantify PCS optimization activity other than, in a few cases, to list two or three projects in which they had been involved in the past few years.
   - **b. Demand for the Best Practices Guide**
   - **c. Role of utility incentives**

   The following people were interviewed (organization in italics):

   1. Tim Dugan (*Compression Engineering*)
   2. Craig Meredith (*Riverbend Group*)
   3. Dan Parker (*Parker, Messana, & Associates*)
   4. John Shinn (*QEI Energy Management*)
   5. Bing Tso (*SBW*)
   6. John Vranizan (*Carroll-Hatch*)

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[15] See *Fan Speed Reduction in Pneumatic Conveying Systems in the Secondary Woods Products Industry, No. 1 (12/99)*, Report #99-045, prepared for the Alliance by SBW Consulting, Inc., December 1999.

5.4 Findings

The general view conveyed by the contractors interviewed is that the JEA program was useful in raising awareness and consideration of energy efficiency in PCS systems, but that there was little driving force in the market to optimize fan speeds. As a result, there is very little activity that could be considered a direct result of the JEA program. Furthermore, it would be appropriate to share some of the credit for the resulting energy savings with the local utilities since most of the studies to determine the potential savings from fan speed optimization have been funded by utilities as part of broader facility audit programs.

Fan speed adjustment is viewed as a possible measure that can be taken as part of a whole-system modification or facility-wide audit. However, the perceived benefits are not significant enough to attract much attention on their own. In fact, one contractor indicated that his customers typically look for “bigger hitting projects” relating to steam or compressed air. Another called JEA a “niche market program” that provided a useful “tool in the toolbox” for ESCOs and consultants, but that did not have a greater place in the market for energy efficiency. It is worth noting that interviewees universally regarded the program as well-run and supportive of energy efficiency efforts despite the fact that the program’s target market apparently was not ripe for substantial adoption of program concepts.

Some of the specific barriers to implementation of fan speed optimization, as identified during the interviews, are as follows:

- Facilities don’t want to think about such a small part of their operations, so changes are more likely to occur during whole system upgrades/reconfigurations.
- Facilities don’t do PCS optimization just for energy reasons.
- Due to existing design problems, sometimes higher fan speeds are required to get around a “bad leg” or other poorly designed aspect of the ducting system.
- Most systems are too big in terms of the duct systems, so they have oversized fans, but they can’t reduce fan size unless they reconfigure the entire system.

5.4.1 Market changes

Several contractors reported changes over the past several years regarding more efficient operation of PCS systems. The JEA program was credited with influencing some of these changes, but none of the interviewees could specifically link the program to these changes. Among the market effects observed are the following:

- Operating costs are now a part of vendor proposals to service facilities, including PCS systems.
- One contractor reported seeing a “decrease in air velocities from when the program was started to now” (e.g., from 5000 ft./min. to 4000 ft. min.). The decrease is mostly evident in new systems, as opposed to optimization of existing systems.
- Another contractor has seen a reduction in fan speeds overall, and expanded use of VFDs. Yet another noted that some facility managers (although well under half) are more aware than in the past regarding how much fan speed is required to meet their facilities’ needs.
- It was also noted that the wood products industry took a big economic hit since the program was initiated, and the market for JEA measures is smaller than originally projected.

5.4.2 Specific activity reported by contractors

Most of the contractors reported that they had conducted at least some activity in the past five years related to fan speed optimization. However, they could generally recount the projects on one hand, and the activity was primarily studies/audits, with virtually no known implementation. JEA activities cited by contractors include the following:

- One interviewee has consulted to 25 facilities in past five years, and in two or three of them he reconfigured systems to lower air flow. These facilities each had several hundred horsepower of fan motors.
- One of the big industry players has worked to drop pressure through the baghouse. They retrofitted to cut the pressure drop in half, which was remarkable in that traditionally only first cost has been considered in designing PCS systems.
- Three of the contractors tried unsuccessfully to encourage clients to do fan speed optimizations. One could recall three specific facilities, none of which implemented the recommended changes. The customers' reaction was that the systems work, so they didn't want to invest in any changes. Another contractor conducted studies at several sites to see if JEA concepts were applicable, but none of them worked out due to technical reasons/barriers cited by the customers. Yet another has done several overall facility audit projects in which he pointed out the possibility of reducing fan speeds. There has been some interest, but none of the facilities has taken action.

5.4.3 Best Practices Guide

Through the JEA program, a Best Practice Guide was developed that explained the "Just Enough Air" concept and offered energy savings estimates. The Guide was intended as a tool for contractors and utilities to assist them in conducting fan speed optimization studies and in encouraging customers to implement related measures. Most of the contractors interviewed have used the Guide in the past as a reference and they generally regard it as a useful tool, although none report that the Guide has played a major role in their work. John Shinn, one of the program implementers has provided the guide to clients and has received positive comments from people who come across the guide on the Alliance web site or by other means.

5.5 Conclusions and Recommendations

There appears to be little activity that can directly be attributed to the program, although reports of changes over the past few years in the operation of PCS systems suggest that fan speed has been declining and facility operators are more interested in assessing opportunities to improve PCS efficiency. Due to the limited activity related to fan speed optimization, especially activity that can be directly linked to the JEA program, it is not possible to estimate energy savings. However, the Alliance can take credit for the program playing an important role in increasing PCS operators' awareness of energy efficiency opportunities and the shift in the industry toward lower fan speeds.

It is recommended that with this report the Alliance conclude its monitoring and tracking effort related to the JEA program. While the trend for reduced fan speeds may continue into the future, there is little indication that significant new activity will occur or that measures adopted will be easily attributed to the program.

5.5.1 Addendum: KEY SAVINGS INDICATORS

When developing the M&T plan, the team initially reviewed the key indicators of energy savings. While no savings is currently being tracked for JEA, according to the Alliance's ACE model, total energy savings is categorized by facility size (large, medium, and small), and is based on an estimation of the average number of fans, the average horsepower of those fans, annual operating hours, and percentage savings. Table 5-1 below shows the input assumptions used in the ACE model.

Table 5-1. Key Input Assumptions

Facility Size	Total fans	HP of fans	Hours/year
Large	6.8	86	6,010
Medium	1.3	69	4,375
Small	2.1	9	1,480

1. **Average number of fans by facility size**

   The ACE model assumes that the average number of fans varies by the size of the facility.

2. **Average horsepower of fans by facility size**

   The ACE model also assumes that the average HP of the fans varies by the size of the facility, and it varies from 9 to 86 HP, on average.

3. **Annual operating hours by facility size**

   The ACE model assumes that larger facilities operate more hours per year, on average, than smaller facilities.

4. **Estimated energy savings rate**

   The ACE model assumes an annual energy savings of 47% for all facility sizes.

Original "Data Analysis" (Energy Savings) Approach from M&T Plan

The energy savings impact of the Just Enough Air Initiative is a function of the input variables described under Key Indicators above, and it should be estimated for each calendar year since the last estimate was derived. The following energy savings calculation should be aggregated for each facility size category and then summed to obtain total JEA savings for the year:

Annual Energy Savings by Facility Size (kWh/year) =
(1) Number of [SIZE CATEGORY] facilities at which a PCS optimization has occurred
x (2) Average number of fans per facility
x (3) Average HP per fan
x (4) Average annual operating hours
x (5) kW per HP conversion (considered consistent)
x (6) Assumed savings rate (as a percentage of energy consumption).

6. ENERGY STAR WINDOWS UPDATE

6.1 Introduction

The Energy Star (ES) Residential Windows Program (Program) was funded by the Alliance from February 1998 to June 2001 to build product image and brand association to encourage consumers to demand more energy-efficient windows for their homes than were typically available. The goals of the project were 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. The Alliance adjusted regional standards for energy-efficient 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 immediate results as the market penetration of ES windows jumped significantly from just 13% in 1997 to 70% by 2002.

The Alliance contracted with Summit Blue Consulting (Summit Blue) at the end of 2004 to develop and implement long-term monitoring and tracking (M&T) protocols that would be the basis for estimating the continuing energy savings in the initiative's post-funding period. In March 2005, Summit Blue provided the Alliance the results of the M&T effort and made recommendations for additional data collection and analysis activities beyond the scope of the original effort to provide a more complete assessment of program impacts. Upon review, the Alliance tasked Summit Blue with implementing two of the recommendations from the findings report:

- **"Estimate gas savings from gas-heated residences.** Since the windows market in the Northwest has been transformed for both electric and gas heated homes, the Alliance should include gas savings in its energy savings estimates as well."
- **"Account for savings due to reduced *cooling* loads.** The current approach to calculating savings accounts only for electric savings due to reduced heating loads. Although cooling is not a huge energy component in residential markets in the Northwest, it is growing, and calculating the savings due to reduced cooling loads could potentially add a significant percentage of energy savings to the project."

In December 2005, Summit Blue learned that a "bug" had been discovered in the residential windows savings model that was originally used to determine the per-unit electric-heating savings for the 2004 M&T report.[16] This bug in the model has subsequently been fixed, and the per-unit savings values have been re-calculated. This ES Residential Windows Program "update" report builds upon the data collection activities undertaken for the 2004 M&T report to:

- Revise the electric-heating savings from the 2004 M&T report
- Estimate gas-heating savings
- Estimate electric-cooling savings

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[16] *NW Alliance Residential Energy Star Windows Program M&T Findings*, Summit Blue Consulting, March 2005

6.2 Approach to Energy Savings Estimation

Summit Blue's initial review of the ACE model for the 2004 M&T report revealed that the electric-heating energy savings impact of the Program is based on several key assumptions, including per-unit electric-heating savings (kWh/SF-year), the number of ES window units (SF) installed each year, market penetration of ES windows, and electric-heating saturation levels. Furthermore, this review showed that the input variables and subsequent savings are categorized by home type (single-family, multi-family, and manufactured) and vintage (new vs. existing). Consequently, Summit Blue used the results from this review to develop the savings calculation framework around which the data collection activities would be focused. Specifically, the electric-heating energy savings for a given calendar year were calculated for the 2004 report as follows:

Annual Electric-Heating kWh Savings by Home Type and Vintage (kWh/year) =

(1) Per-unit electric-heating savings (kWh/SF-year) by [TYPE AND VINTAGE CATEGORY]
x (2) Total window units (SF) sold in the Northwest
x (3) Market penetration of ES windows sold in the Northwest attributable to the Alliance
x (4) Market share of electrically-heated homes in the Northwest by [TYPE AND VINTAGE CATEGORY]

1. **Per-unit electric-heating savings (kWh/SF-year)** is defined as the annual kWh savings due to reduced heating loads per square foot of installed glazing. Furthermore, these savings values are a function of many factors, including weather, heating system type, home size, window area, home type, and vintage. For simplicity in the ACE model, they were disaggregated by home type and vintage only.

2. **Total window units (SF) sold in the Northwest** incorporates the total number of windows, skylights, and patio doors sold in the Northwest with an estimate for the average area of each of these types of windows to calculate the total square footage of residential fenestration sold.

3. **Market penetration of ES windows sold in the Northwest attributable to the Alliance** is the percentage of all window sales in the Northwest that are ES-rated minus the baseline units sold.

4. **Market share of electrically-heated homes in the Northwest** is the percentage of homes whose heating fuel is electric.

Fortunately, many of the inputs used to calculate electric-heating savings can be used to calculate gas-heating and electric-cooling savings as well, and the analysis methodology is the same. In fact, the only variables that change from the original calculation are the per-unit savings estimate and the market share of homes in the Northwest. Specifically, these variables will change to accommodate the newly calculated savings in the following ways:

Annual Gas-Heating kBtu Savings:

1. **Per-unit gas-heating savings (kBtu/SF-year)** is defined as the annual kBtu savings due to reduced heating loads per square foot of installed glass and is disaggregated by home type and vintage only.

4. **Market share of gas-heated homes in the Northwest** is the percentage of homes whose heating fuel is gas and is disaggregated by home type and vintage.

Annual Electric-Cooling kWh Savings:

1. **Per-unit electric-cooling savings (kWh/SF-year)** is defined as the annual kWh savings due to reduced cooling loads per square foot of installed glass and is disaggregated by home type and vintage only.

4. **Market share of homes in the Northwest with CAC** is the percentage of homes that have central air conditioning and is disaggregated by home type and vintage.

6.3 Data Collection Methodology

Data for the key input variables to the electric savings due to reduced heating loads was collected for the 2004 M&T report according to the protocols outlined in the long-term M&T plan.[17] Since many of the input variables to the gas and cooling savings calculations remain unchanged, the evaluation team was tasked only with gathering the key additional information needed to estimate gas and cooling savings.[18] The following is a step-by-step description of the data collection process for this "update" report:

1. **Contacted Ducker Research Company to inquire about an update to the 2004 window and door study.[19]** After performing a general Internet search for a new Ducker report and searching the Ducker web site for new information, the evaluation team contacted Ducker directly to inquire if a new report was available. A Ducker representative reported that they put out smaller and more general reports every year, but the next comprehensive report containing the level of disaggregation needed for the M&T effort would not be made available until 2006.

2. **Contacted Tom Eckman of the Northwest Power and Conservation Council.** Mr. Eckman supplied the basic data for the per-unit energy savings estimate and market share information required by the original savings analysis. For this update report, Mr. Eckman helped clarify a few issues regarding the market share estimates; he also provided the following information for each section of this update:

    a. **Revised electric-heating savings analysis.** Mr. Eckman informed the project team that a bug had been discovered in his residential windows savings model, and he re-calculated the per-unit electric-heating savings values.

    b. **Gas-heating savings analysis.** Mr. Eckman was able to provide a reasonable estimate for gas-furnace efficiency in the region, and he suggested a simple conversion to go from electric to gas units.

    c. **Electric-cooling savings analysis.** Mr. Eckman also supplied several residential spreadsheet models indicating the savings due to reduced cooling loads for the average Northwest climate.

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[17] *Energy Star Windows Long-Term Monitoring & Tracking Plan,* Summit Blue Consulting, January 31, 2005.

[18] The data collection methodology for the unchanged calculation variables can be found in the original Summit Blue report [1].

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

6.4 Findings

The following discussion provides a summary of the analysis conducted to determine a best estimate of each key input variable to the energy savings calculations.

6.4.1 Annual Per-Unit Heating, and Electric-Cooling Savings

As stated in the Approach to Energy Savings Estimation section above, a key input to the aggregate savings calculations is the assumption about energy savings per installed window, normalized to glazing area (square feet). The evaluation team originally derived per-unit electric-heating savings estimates by home type and vintage for use in the 2004 M&T report from data provided by Tom Eckman.[20] The following three sub-sections present the methodology and results from the per-unit savings research.

Annual Per-Unit Electric-Heating Savings (kWh/SF-year) [REVISED]

In December 2005, Tom Eckman contacted the Alliance and Summit Blue to report that a "bug" had been discovered in his residential ES windows savings model. The net effect of the error was to inflate the per-unit electric-heating savings values for the existing single-family and new manufactured housing sectors (as described in the 2004 M&T report) by more than 200% beyond their actual values. Fortunately, the bug did not propagate itself into all housing sectors or into the cooling savings model. Table 6-1 below illustrates the discrepancy between the values used for the 2004 report and the actual values.

Table 6-1. Comparison of Per-Unit Electric-Heating Savings Values From the 2004 M&T Report to the Revised Values (kWh/SF-year)

	2004 M&T Report	Revised Values	Percentage Difference From 2004 Report
New Construction			
Single Family	0.86	0.86	0%
Multi Family	1.50	1.50	0%
Manufactured	5.11	1.53	-70%
Existing Homes			
Single Family	5.08	1.62	-68%
Multi Family	1.51	1.51	0%
Manufactured	1.74	1.74	0%

Annual Per-Unit Gas-Heating Savings (kBtu/SF-year)

The recent discussion with Mr. Eckman indicated that he does not maintain or even possess a reliable model for gas-heating savings due to ES windows installations in the Northwest. Fortunately, however, Mr. Eckman confirmed that the values from his electric-heating savings model can be converted to gas savings with the standard unit conversion and an assumption about electric and gas furnace efficiencies.

[20] Please see the original M&T findings report for details on how these values were calculated.

The first task in deriving gas-heating savings from the electric-heating savings estimates is to understand what assumptions and variables went into the electric model. Mr. Eckman reported that the electric forced-air furnace efficiency is assumed to be 100% in his model; furthermore, duct losses and other distribution inefficiencies are embedded in the model and are reflected in the final savings values. Next, Mr. Eckman reported a reasonable assumption for regional gas-furnace efficiency to lie in the range of 70-78%. The final task for the evaluation team in obtaining a good estimate for per-unit gas-heating savings was to apply the standard conversion between kWh and kBtu. The overall conversion for using the electric-heating savings to estimate gas-heating savings can be illustrated by the following equation:

$$\frac{kBtu}{SF * year} = \frac{kWh}{SF * year} * \frac{3.412 kBtu}{kWh} * \frac{eff_{electric}}{eff_{gas}}$$

Table 6-2 below shows the per-unit electric-heating savings estimates as well as converted gas values for the range of gas furnace efficiencies as specified by Tom Eckman.

Table 6-2. Annual Per-Unit Gas-Heating Savings Due to ES Windows

	Per-Unit Electric Savings (kWh/SF-year)	Per-Unit Gas Savings (kBtu/SF-year)			
		Low Savings (Gas-eff = 70%)	High Savings (Gas-eff = 78%)	Avg Savings (Gas-eff = 74%)	Recommended Savings Values
New Construction					
Single Family	0.86	4.19	3.76	3.97	**3.97**
Multi Family	1.50	7.31	6.56	6.92	**6.92**
Manufactured	1.53	7.46	6.69	7.05	**7.05**
Existing Homes					
Single Family	1.62	7.90	7.09	7.47	**7.47**
Multi Family	1.51	7.36	6.61	6.96	**6.96**
Manufactured	1.74	8.48	7.61	8.02	**8.02**

Annual Per-Unit Electric-Cooling Savings (kWh/SF-year)

During Summit Blue's initial data collection period and subsequent conversations with Tom Eckman, he mentioned that he was in the process of working on a model to estimate the energy savings due to reduced cooling loads from the installation of ES windows in the Northwest. In preparing this update report, the project team contacted Mr. Eckman to inquire whether he had completed this cooling-savings model. Mr. Eckman reported that he had indeed completed modeling the electric savings due to reduced cooling loads for all single-family and manufactured housing applications. According to Mr. Eckman, the percentage of units in the multi-family housing sector with central cooling was insignificant, and he chose not to model the savings from this market sector. In the absence of better data, and to avoid assigning zero savings for the entire multi-family market sector, the evaluation team recommends using the minimum savings value from the other two home types within each vintage category as the savings for the multi-family sector. The evaluation team believes this approach to be reasonable if not conservative. Table 6-3 below indicates the per-unit electric savings values due to reduced cooling loads with the installation of ES windows by home type and vintage category.

Table 6-3. Annual Per-Unit Electric-Cooling Savings Due to ES Windows (kWh/SF-year)

	New Construction	Existing Construction
Single Family	0.05	0.04
Multi Family*	0.05	0.04
Manufactured	0.06	0.07
* Multi Family savings values have been set, as a proxy, to the lowest known value within each vintage category.		

6.4.2 Total Window Units (SF) Sold in the Northwest

The determination of total square feet of residential window units sold in the Northwest for the 2004 M&T report required the collection of many data points, including total number of windows sold, population data to use as a proxy, and an assumption about the size of an average window in each window category. As explained above in the Data Collection Methodology section of this report, a comprehensive update to the number of window units sold in the Northwest isn't due out until 2006. Since no new data is available, the total square feet of installed residential glazing in the Northwest uses the forecast values of the 2004 report. Furthermore, the population ratio of the entire Northwest to that of Washington and Oregon is assumed to be the same, and the values for average window square footage by window type is also assumed to be the same.[21] Table 6-4 below shows the total square feet of installed glass by year for both new and existing construction applications from 2001 through 2005.[22] Table 6-5 uses the population ratio for each state to disaggregate the same data by year and state.

Table 6-4. Total Square Footage of Installed Glass in the Northwest by Year and Vintage (x 000,000 sf)

Vintage	2001	2002	2003	2004*	2005*
New Construction	22.32	21.53	21.05	23.91	21.38
Existing Construction	26.05	27.49	29.05	29.08	28.63
TOTAL	**48.37**	**49.03**	**50.09**	**53.00**	**50.02**
* The values for 2004 and 2005 are forecasted.					

[21] Please see the original M&T findings report for the details of this analysis.

[22] The forecasted value for window sales drops considerably from 2004 to 2005. Unfortunately, the evaluation team received only an excerpt of the Ducker report, and it contained all of the tables but none of the text describing the numbers. As such, it remains unclear why sales dropped so significantly.

Table 6-5. Total Square Footage of Installed Glass by Year and State (x 000,000 sf)

State	2001	2002	2003	2004	2005
Washington	24.77	25.10	25.65	27.13	25.61
Oregon	14.38	14.57	14.89	15.75	14.87
Idaho	5.52	5.59	5.72	6.05	5.71
Montana	3.71	3.76	3.84	4.06	3.83
TOTAL	**48.37**	**49.03**	**50.09**	**53.00**	**50.02**

6.4.3 Market Penetration of ES Windows Attributable to the Alliance

The evaluation team performed a wide variety of research for the original M&T findings report in order to understand current and past market penetration of ES windows sold in the Northwest, including:

- Determining if the 0.35 U-value of Energy Star had been adopted as part of any regional building codes.
- Speaking with Gary Curtis of the West Wall Group to obtain pertinent market insights and to get the names and contact information for the largest window manufacturers in the region.
- Interviewing a small sample of regional and national manufacturers for an accurate characterization of market penetration in the Northwest by year from 2001 through 2004.

The research into whether the Energy Star standard had been adopted into regional building codes revealed that it was not consistent across the region; consequently, it was deemed unreasonable to assume that all the windows sold in the region were ES-rated because of building codes. In addition, besides getting a substantive sample and contact information for window manufacturers in the region, the conversation with Gary Curtis served to further augment and verify the results from the manufacturer interviews. The results of the manufacturer surveys were the basis for the overall market penetration estimates of ES windows in the Northwest, and the Alliance provided the evaluation team with their accepted estimate of baseline units. Table 6-6 below presents the results of the manufacturer surveys along with the estimate of the percentage of ES window units sold that are attributable to the presence of the Alliance's Residential ES Windows program from 2001 through 2005.[23,24]

Table 6-6. Market Penetration of ES Windows Sold in the Northwest Attributable to the Alliance

	2001	2002	2003	2004	2005
Market Penetration Rate	75.0%	81.0%	88.0%	89.0%	89.0%
Alliance-Accepted Baseline	16.0%	16.8%	17.6%	18.5%	19.5%
Attributable to Alliance Program	59.0%	64.2%	70.4%	70.5%	69.5%

[23] Please see the original M&T findings report for the details of this analysis.

[24] The market penetration in 2005 is assumed to be the same as in 2004.

6.4.4 Market Share of Homes by Heating and Cooling Type

For the original M&T findings report, in addition to providing a per-unit electric savings estimate, Tom Eckman also supplied a summary spreadsheet of the market share of electrically-heated homes in the Northwest as a percentage of the total units in each home type and vintage category. Unfortunately, because of the way the sales data was reported in the Ducker report [3], the energy savings calculation requires knowing market share as a percentage of the total units in each vintage category only. The project team subsequently contacted Mr. Eckman again, and he provided via telephone the percentages requisite to the analysis.

In preparing this update report, the project team recognized that the original summary spreadsheet sent by Mr. Eckman would not suffice, so we contacted him directly to obtain the market share of gas-heated and centrally-cooled homes. In lieu of reporting the numbers directly over the phone, Mr. Eckman sent via email the very detailed residential spreadsheet model so that the project team could calculate the necessary percentages directly. In comparing the calculated values for market share of electrically-heated homes to those reported in the 2004 M&T report, however, the project team discovered a slight discrepancy between the two sets of values.[25] Mr. Eckman explained that he did not include in his first estimate of market share those homes whose heating type was "Electric Other" because it was such a small percentage of the total and because it was not included in the model to determine per-unit savings. Since this analysis assumes that *all* electrically-heated homes at which ES windows have been installed are achieving electric savings, this heating type was included in the market share estimates for this update report. Table 6-7 below shows the revised electric-heating saturation levels by home type and vintage as well as the percentage of homes with gas-heat and central air.

Table 6-7. Market Share of Electrically-Heated, Gas-Heated, and Centrally-Cooled Homes in the Northwest by Home Type and Vintage

	ELEC-HEATED HOMES		GAS-HEATED HOMES		CAC HOMES	
	New Construction	Existing Construction	New Construction	Existing Construction	New Construction	Existing Construction
Single Family	9.1%	25.1%	53.6%	41.0%	26.6%	17.2%
Multi Family	15.1%	12.0%	10.2%	1.5%	6.7%	1.6%
Manufactured	9.1%	6.6%	1.5%	0.7%	4.5%	2.0%
TOTALS	**33.3%**	**43.6%**	**65.3%**	**43.2%**	**37.8%**	**20.8%**

6.4.5 Estimate of Annual Energy Savings

Annual heating and cooling energy savings can be estimated for each calendar year from 2001-2005. As described in Section 6.2, the savings calculation is dependent on the four inputs described above and is illustrated by the following formula:

Annual Energy Savings by Home Type and Vintage =

(1) Per-unit energy savings by [TYPE AND VINTAGE CATEGORY]
x (2) Total window units (SF) sold in the Northwest by [VINTAGE CATEGORY]

[25] The market shares for the new construction market segment did not change. The market shares for the existing construction market segment changed by approximately 2 percentage points in each home type category.

- (3) Market penetration of ES windows sold in the Northwest attributable to the Alliance
- (4) Market share of homes in the Northwest by [TYPE AND VINTAGE CATEGORY]

The following three sub-sections illustrate the annual aggregate electric-heating, gas-heating, and electric-cooling savings attributable to the presence of the Alliance's Residential Energy Star Windows Program.

Savings Due to Reduced Electric-Heating Loads [REVISED]

Based on the revised per-unit electric-heating savings estimates as described in Section 6.4.1, aggregate electric-heating savings attributable to the Residential Energy Star Windows program are estimated at approximately 16,646 MWh in 2001 and rise to 20,595 MWh in 2005. As can be seen in Table 6-8 below, the reduction in per-unit electric-heating savings from the 2004 M&T report had a drastic effect on the aggregate energy savings. The savings in the existing housing market sector were particularly reduced due to the high market share of single-family electrically-heated homes in the Northwest and the slight reduction in market share from the 2004 report.

Table 6-8. Comparison of Revised Annual Electric-Heating MWh Savings to Previously-Reported Savings

	NEW CONSTRUCTION		EXISTING CONSTRUCTION		TOTAL	
	2004 M&T Report	**Revised Savings**	**2004 M&T Report**	**Revised Savings**	**2004 M&T Report**	**Revised Savings**
2001	10,117	5,846	24,467	10,800	34,583	16,646
2002	10,622	6,137	28,095	12,402	38,717	18,540
2003	11,378	6,574	32,532	14,361	43,910	20,935
2004	12,949	7,482	32,625	14,402	45,575	21,884
2005	NA	6,603	NA	13,991	NA	20,595

As the Alliance tracks program impacts in terms of average megawatts (aMW), these calculated MWh numbers are converted to aMW and compared to the previously-reported values in Table 6-9 below. In all years, the revised savings are lower than were reported in the 2004 M&T report; however, comparing the actual (revised) savings to those initially reported by the Alliance[26] shows that the actual savings are lower in 2001 and 2002 but slightly higher in 2003 and 2004.

[26] Alliance reported impacts are derived from a spreadsheet file (Program Savings.xls) that Summit Blue received March 9, 2005. The file contains previous adjustments made to impacts reported in the annual Market Activity Reports.

Table 6-9. Comparison of Revised aMW Savings to Previously-Reported Savings

	Alliance Reported	2004 M&T Report	Revised Estimates
2001	4.078	3.948	1.900
2002	3.388	4.420	2.116
2003	1.796	5.013	2.390
2004	1.796	5.203	2.498
2005	NA	NA	2.351

The savings were also disaggregated by state and by year using the population ratio for each state to the entire region, as shown in Table 6-10.

Table 6-10. Annual Electric-Heating aMW Savings by State and Year

	Washington	Oregon	Idaho	Montana	Total
2001	0.973	0.565	0.217	0.146	1.900
2002	1.084	0.629	0.241	0.162	2.116
2003	1.224	0.710	0.273	0.183	2.390
2004	1.279	0.743	0.285	0.191	2.498
2005	1.204	0.699	0.268	0.180	2.351

Savings Due to Reduced Gas-Heating Loads

Based on the values discussed above, gas savings attributable to the Residential Energy Star Windows program are estimated at approximately 88,205 MMBtu in 2001, rising to 115,551 MMBtu in 2004; the slight dip in savings from 2004 to 2005 can be directly attributed to the forecast of windows sold in 2005, taken from the Ducker report [4]. Table 6-11 shows the annual gas-heating energy savings attributable to the Alliance's Residential Energy Star Windows Program.

Table 6-11. Annual Gas-Heating MMBtu Savings Attributable to the Energy Star Windows Program

	New Construction	Existing Construction	Total
2001	38,664	49,541	88,205
2002	40,595	56,888	97,483
2003	43,484	65,872	109,356
2004	49,490	66,061	115,551
2005	43,676	64,179	107,855

The savings were also disaggregated by state and by year using the population ratio for each state to the entire region, as shown in Table 6-12.

Table 6-12. Annual Gas-Heating MMBtu Savings Attributable to the Energy Star Windows Program by State

	Washington	Oregon	Idaho	Montana	Total
2001	45,163	26,219	10,064	6,759	88,205
2002	49,913	28,977	11,123	7,470	97,483
2003	55,993	32,506	12,477	8,380	109,356
2004	59,165	34,348	13,184	8,854	115,551
2005	55,224	32,060	12,306	8,265	107,855

Savings Due to Reduced Electric-Cooling Loads

Based on the values discussed above, the electric-cooling energy savings attributable to the Residential Energy Star Windows program are estimated at approximately 392 MWh in 2001, rising to 510 MWh in 2004; again, the slight dip in savings from 2004 to 2005 can be directly attributed to the forecast of windows sold in 2005. Table 6-13 shows the annual electric-cooling energy savings attributable to the Alliance's Residential Energy Star Windows Program, while Table 6-14 shows the aMW savings.

Table 6-13. Annual Electric-Cooling MWh Savings Attributable to the Energy Star Windows Program

	New Construction	Existing Construction	Total
2001	243	150	392
2002	255	172	427
2003	273	199	472
2004	311	200	510
2005	274	194	468

Table 6-14. Annual Electric-Cooling aMW Savings Attributable to the Energy Star Windows Program

	New Construction	Existing Construction	Total
2001	0.028	0.017	0.045
2002	0.029	0.020	0.049
2003	0.031	0.023	0.054
2004	0.036	0.023	0.058
2005	0.031	0.022	0.053

The savings were also disaggregated by state and by year using the population ratio for each state to the entire region, as shown in Table 6-15.

Table 6-15. Annual Electric-Cooling aMW Savings by State and Year

	Washington	Oregon	Idaho	Montana	Total
2001	0.023	0.013	0.005	0.003	0.045
2002	0.025	0.014	0.006	0.004	0.049
2003	0.028	0.016	0.006	0.004	0.054
2004	0.030	0.017	0.007	0.004	0.058
2005	0.027	0.016	0.006	0.004	0.053

Total Electric and Gas Savings Attributable to the Program

The total electric and gas energy savings impact due to the presence of the Alliance's Residential Energy Star Windows Program is presented by calendar year in Table 6-16. The electric savings impact is due to reduced heating and cooling loads across all housing sectors, while the gas savings impact is due to reduced heating loads only. Table 6-17 shows the same results by state.

Table 6-16. Aggregate Annual Electric and Gas Energy Savings Impact

	Electric Savings (aMW)	Gas Savings (MMBtu)
2001	1.945	88,205
2002	2.165	97,483
2003	2.444	109,356
2004	2.556	115,551
2005	2.404	107,855

Table 6-17. Aggregate Annual Electric and Gas Energy Savings Impact by State

	Washington		Oregon		Idaho		Montana	
	Elec Savings (aMW)	Gas Savings (MMBtu)	Elec Savings (aMW)	Gas Savings (MMBtu)	Elec Savings (aMW)	Gas Savings (MMBtu)	Elec Savings (aMW)	Gas Savings (MMBtu)
2001	0.996	45,163	0.578	26,219	0.222	10,064	0.149	6,759
2002	1.109	49,913	0.644	28,977	0.247	11,123	0.166	7,470
2003	1.251	55,993	0.726	32,506	0.279	12,477	0.187	8,380
2004	1.309	59,165	0.760	34,348	0.292	13,184	0.196	8,854
2005	1.231	55,224	0.715	32,060	0.274	12,306	0.184	8,265

6.5 Conclusions/Recommendations

The Residential Energy Star Windows project was highly successful in transforming the residential windows market in the Northwest. By working upstream with manufacturers, while at the same time advocating code changes in the region, a significant increase in the sale of efficient windows was achieved. At an estimated 89% market penetration of Energy Star rated windows in the region, the market is essentially transformed. Recommendations for future M&T update reports include:

- Estimate savings for Energy Star windows that are below U=0.35, (i.e. U=0.30 windows, etc). Additional market research would be required to analyze the additional savings attributable to window sales that exceed the Energy Star specification (as savings are now calculated to represent the difference between U=0.40 and U=0.35 windows only). A more extensive review of window sales data to gather actual U-values for windows sold in the region may be beneficial in future years, and, if undertaken, should also include an adjustment to the baseline to reflect changes in the national market.

- Explore the possibility of adding the electric savings due to reduced gas heating furnace fan operation to the overall electric savings number. A report published by the Florida Solar Energy Center (FSEC) found that furnace fan motor power draw related to air conditioner operation reached 511 watts per 1000 CFM, which is 40% higher than the value assumed by the Department of Energy (DOE).[27] Similar research regarding fan motor power consumption for heating in the Northwest could reveal significant savings. Research on this issue was initiated for the 2004 M&T report, but was not extensive enough to draw conclusions.

- Update the cooling savings on a 4-5 year cycle. Although the percentage of homes in the Northwest with central cooling is increasing, the savings associated with reduced cooling are only 2% of the total electric impact of the Windows program due to the short cooling season and moderate summer weather west of the Cascades. As such, the cooling savings should be updated less frequently than the heating savings.

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[27] *Hidden Power Drains: Trends in Residential Heating and Cooling Fan Watt Power Demand;* Procter, John and Parker, Danny; http://www.fsec.ucf.edu/bldg/pubs/pf361

7. BUILDING OPERATOR CERTIFICATION

7.1 Introduction

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. Now that the BOC curriculum and delivery mechanism have been established, BOC continues to be offered *without* Alliance assistance through the Northwest Energy Efficiency Council (NEEC) and the Northwest Building Operators Association (NWBOA). The program offerings include an initial set of courses that constitute Level 1 curriculum, while Level 2 is comprised of a second set of somewhat more advanced courses.

7.2 Approach to Energy Savings Estimation

According to Summit Blue's review of the 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 or therms/year) =
(1) Number of operators certified within the past five years
x (2) Square footage per operator
x (3) Electricity or gas consumption per square foot of participating facilities
x (4) Savings from certification (as a percentage of electricity or gas 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.[28] 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.

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 a 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.

[28] The five year measure life is taken from the ACE model and is the same as that used in a recent evaluation of the Northeast Energy Efficiency Partnerships' BOC program. See *Impact and Process Evaluation Building Operator Training and Certification (BOC) Program*, RLW Analytics, June 2005.

7.3 Findings

This M&T update report is based on certification records from NEEC and NWBOA through 2005.[29] NEEC continues to record the names, basic contact information, square footage, and certification dates (including Level 1, Level 2, and renewal). The following discussion provides a summary of the analysis conducted to determine a best estimate of each key input variable to the energy savings calculations.

7.3.1 Number of Operators Certified within the Past Five Years

7.3.1.1 Measure Life

As described in the Approach to Energy Savings Estimation above, a key input to the energy savings calculation for a given calendar year is the number of operators who received certification within five years (i.e., the assumed measure life) of the year in question. The current measure-life assumption of five years is regarded by the Summit Blue team to be a reasonable figure (see Footnote). Furthermore, as discussed in the 2004 M&T report, Summit Blue has concluded that it is appropriate to extend the energy savings benefits attributable to a student's involvement in the program for five years from the date of the most recent certification/renewal activity.

7.3.1.2 Number of Certified Operators Contributing to Savings Estimates

Given the assumption of a five-year measure life, the number of certified operators for whom savings are counted for 2005 can be determined by reviewing the latest certification or renewal date on record. All students who received their initial certifications in 2001 or later are automatically considered "within the measure life" of the program during 2005.[30] Additionally, any student who received initial certification prior to 2001 but who received a Level 2 certification or a certification renewal during or after 2001 is also considered to contribute to on-going energy savings.

According to NEEC records, 118 students in the Northwest received their initial certifications in 2005, and 419 new students were certified between 2001 and 2004. Furthermore, more than half of the 298 NEEC students who received their initial certification between 1997 and 2000 subsequently obtained a Level 2 certification, or a renewal, or both during or after 2001. In fact, 688 students, or 82% of the 835 students receiving certification from NEEC, received their latest certification or renewal during or after 2001. Given the assumed five-year "measure life," this means that 835 NEEC students are considered to still be contributing to energy savings at their facilities.

Assuming a similar rate of secondary certifications, it is estimated that 244 out of the 324 NWBOA students (75%) received their latest certification or renewal since 2001.[31] Between the two programs,

[29] NEEC maintains a database of new and renewed certifications that was provided directly to Summit Blue Consulting for this analysis. Certification tallies for NWBOA were obtained from Andy Eckman of the Alliance via email February 9, 2006.

[30] Initial certification for the vast majority of students was Level 1. However, 30 students received Level 2 certification between 2000 and 2005 without having first completed the Level 1 coursework.

[31] It is assumed that the percentage of students receiving Level 2 certification or certification renewal is the same for NWBOA students as it is for NEEC students (actual determinations are only possible for NEEC, which has data specific to individual students, rather than just annual totals). The fact that only 75% of NWBOA students received their latest certification/renewal since 2001, compared to 82% of NEEC students, reflects that fact that a greater percentage of NWBOA students participated prior to 2000 and thus a greater percentage are now beyond the five-year measure lifetime.

energy savings are being achieved by 932 students in 2005. Table 7-1 presents figures for both NEEC and NWBOA,[32] disaggregated according to the following:

- New student certifications in 2005
- New student certifications between 2001 and 2004
- Students who received initial certification prior to 2001 but who received a renewal and/or Level 2 certification between 2001 and 2005.

Table 7-1. Number of Certified Operators for Whom Energy Savings are Counted for 2005

Category	NEEC	NWBOA	Total
New student certifications in 2005	118	36	154
New student certifications between 2001 and 2004	419	178	597
Students with initial certification prior to 2001 who renewed or received Level 2 certification between 2001 and 2005	151	30	181
Total	**688**	**244**	**932**
These numbers reflect all certified operators who are still within the five-year measure life in 2005.			

The same method described above was used to determine the number of certified operators for whom energy savings can be counted in each year from 2001 to 2004 (see Table 7-2).

Table 7-2. Number of Certified Operators for Whom Energy Savings are Counted, 2001-2004

	2001	2002	2003	2004
Number of Operators	541	748	853	863

7.3.2 Other Inputs to Energy Savings Estimation

As described above in Section 7.2, the inputs to the calculation of energy savings include not only the number of students certified in recent years, but also the following:

- Square footage of building space managed by BOC students
- Electricity and gas consumption per square foot of buildings managed by BOC students
- Savings achieved through operator certification.

A summary of the assumptions used for these parameters is presented below. For a discussion of how these assumptions were derived, see *Long-Term Monitoring and Tracking of Building Operator Certification and Energy Star Residential Windows*, Summit Blue Consulting for the Northwest Energy Efficiency Alliance, March 2005.

[32] Data for NEEC certifications was provided by Teresa Squillace. Data for NWBOA certifications for 2001 through 2005 were provided by Andy Ekman of the Alliance; NWBOA certification data for 1997 through 2000 were presented in aggregate in Market Progress Evaluation Report, Regional Building Operator Certification, No. 7, Research Into Action, Inc. for Northwest Energy Efficiency Alliance, September 2001, p. 96.

Square Footage per Operator

The review of BOC program data for the 2004 M&T Report and in the final MPER both suggest that a facility size of 355,000 square feet (ft^2) per operator receiving certification is appropriate for the energy savings analysis. Analysis of the updated data through 2005 supports the continued use of this figure, which applies to all operators receiving certification, regardless of the year in which they were certified.[33]

Energy Consumption per Square Foot of Participating Facilities

The most recent ACE model 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. 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. Annual gas consumption at participating facilities is assumed to be 0.32 therms/ft^2.[34]

Savings from Operator Certification

The current ACE model input value of 0.4 kWh/ft^2 for the annual electricity savings resulting from operator certification is based on estimated savings of 2.5% of a facility's total electricity consumption and on the annual consumption rate of 16 kWh/ft^2 (discussed above). This savings rate is reasonable, and may even be a bit conservative. A 2002 evaluation of the BOC program in the Northeast used a value of 0.5 kWh/ft^2, and a 2003 "retrospective" evaluation of Alliance programs by Summit Blue Consulting recommended use of a savings rate of 1.2 kWh/ft^2.[35] A more recent evaluation in the Northeast, based on a survey of BOC participants, found savings of 0.35 kWh/ft^2.[36] Other recent evaluations of BOC programs in California and Wisconsin were focused more on process issues and did not address explicit savings impacts.[37] Given the available information, the savings rate of 0.4 kWh/ft^2 is used in this analysis.

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[33] According to the raw data provided by students, the average square footage per facility is slightly higher through 2005 (492,000 ft^2) than it was through 2004 (446,000 ft^2). However, as discussed in detail in the 2004 M&T report, the raw data "exclude size data for many large organizations and facilities for which operators were not able to provide estimates." In recognition of this fact, the current analysis uses the MPER value of roughly 645,000 ft^2 per facility, the same as that used for the 2004 M&T report. Furthermore, through 2005 there were roughly 1.8 students per unique facility, virtually unchanged from the value through 2004. Therefore, the square footage managed *per student* (as opposed to *per facility)* remains at approximately 355,000 ft^2.

[34] For discussion the electricity usage assumption, see *Long-Term Monitoring and Tracking of Building Operator Certification and Energy Star Residential Windows,* Summit Blue Consulting for the Northwest Energy Efficiency Alliance, March 2005. The gas usage assumption of 0.32 therms/ft^2 is the average of the weighted normalized energy-use intensities derived from data from *Assessment of the Commercial Building Stock in the Pacific Northwest: Market Research Report,* Report #04-125, Kema-Xenergy, Inc. for Northwest Energy Efficiency Alliance, March 8, 2004. The EUI figure and accompanying analysis were provided by Jeff Harris, Northwest Energy Efficiency Alliance, via email with spreadsheet attachment, January 30, 2006.

[35] See *Evaluation of the Building Operator Training and Certification (BOC) Program in the Northeast*, Research Into Action, Inc. for Northeast Energy Efficiency Partnerships, Inc., September 6, 2002, p. 57. Also see *Findings and Report: Retrospective Assessment of the Northwest Energy Efficiency Alliance, Final Report,* Summit Blue Consulting for Northwest Energy Efficiency Alliance, October 2003, p. 5-4.

[36] RLW Analytics for NEEP; see Footnote 35.

[37] See *Evaluation of the 2002 Statewide Building Operator Certification and Training Program,* Study ID #428, Research Into Action, Inc. for Pacific Gas & Electric Company, November 30, 2003. Information on the Wisconsin BOC evaluation is from personal communication with Ingo Bensch, Senior Project Manager, Energy Center of Wisconsin, February 25, 2005.

Analogous to electricity savings, gas savings from operator certification are assumed to be 2.5% of a facility's total gas consumption. Based on the assumed energy-use intensity of 0.32 therms/ft^2, discussed above, average annual gas savings are estimated at 0.0080 therms/ft^2 (0.80 MBtu/ft^2). The recent evaluation of the BOC program in the Northeast assumes a similar savings value of 0.74 MBtu/ft^2, accounting for savings from both natural gas and oil.[38]

7.3.3 Estimate of Annual Energy Savings

As described in Section 7.2, the ACE model calculates energy savings as follows:

Annual Energy Savings (kWh/year or therms/year) =

(1) Number of operators certified within the past five years
x (2) Square footage per operator
x (3) Electricity or gas consumption per square foot of participating facilities
x (4) Savings from certification (as a percentage of electricity or gas consumption).

Based on the values discussed above, cumulative electricity savings in the Northwest from BOC-certified students are estimated to be growing steadily, from approximately 77 GWh in 2001 to 132 GWh in 2005. Based on these figures, average megawatt savings have increased from roughly 8.8 aMW in 2001 to 15.1 aMW in 2005 (see Table 7-3). Incremental savings in 2005 were approximately 1.1 aMW.

Table 7-3. Electricity Savings from BOC-Certified Students, 2001-2005

	2001	2002	2003	2004	2005
Number of Certified Operators[a] (A)	541	748	853	863	932
Square Feet per Operator (B)	355,000 ft^2				
Electricity Consumption (C)	16 kWh/ft^2				
Savings Percentage (D)	2.5%				
Cumulative Electricity Savings (MWh) E= (A*B*C*D)	76,858	106,250	121,159	122,575	132,320
Cumulative Electricity Savings (aMW) (E / 8760 hours)	8.8	12.1	13.8	14.0	15.1
Incremental Electricity Savings (aMW) ($E_{Year} - E_{(Year-1)}$)	8.8[b]	3.4	1.7	0.2	1.1

[a] The value for Number of Certified Operators is a cumulative value that reflects all operators receiving initial certification within the prior five years, plus those certified more than five years prior but who subsequently received Level 2 or renewal certification within the prior five years.

[b] The value for incremental savings in 2001 reflects all savings from program inception through 2001.

[38] The NEEP BOC program evaluation (see Footnote 35) assumes savings of 5% and 10% for boiler maintenance and HVAC control, respectively, much higher than the 2.5% assumed in this M&T analysis. However, the NEEP evaluation is based on a survey of participants, not all of whom performed each possible activity. As a result, the overall savings rates across all participants are very similar between the two programs.

The increase in savings from 2004 to 2005 is due to the fact that 154 new students based in the Northwest were certified in 2005, and 231 were recertified (via Level 2 or renewal). Seventy-one of the students receiving these secondary certifications received their initial Level 1 certifications prior to 2001, and many therefore would have been considered beyond the "measure life" of their BOC training were it not for the secondary certification.[39] All of these certifications are accounted for above in Table 7-1 and Table 7-2, which show the 932 certified operators for whom energy savings are counted in 2005.

Using the energy savings equation and the assumptions discussed above, cumulative gas savings from BOC-certified students are estimated at 1.5 million therms in 2001, increasing to 2.6 million therms in 2005 (Table 7-4).

Table 7-4. Gas Savings from BOC-Certified Students, 2001-2005

	2001	2002	2003	2004	2005
Number of Certified Operators[a] **(A)**	541	748	853	863	932
Square Feet per Operator (B)	355,000 ft^2				
Electricity Consumption (C)	0.32 therms/ft^2				
Savings Percentage (D)	2.5%				
Cumulative Gas Savings (millions of therms) $E = (A*B*C*D) / 10^6$	1.5	2.1	2.4	2.5	2.6
Incremental Gas Savings (millions of therms) $(E_{Year} - E_{(Year-1)})$	1.5[b]	0.6	0.3	0.1	0.1

[a] The value for Number of Certified Operators is a cumulative value that reflects all operators receiving initial certification within the prior five years, plus those certified more than five years prior but who subsequently received Level 2 or renewal certification within the prior five years.

[b] The value for incremental savings in 2001 reflects all savings from program inception through 2001.

7.4 Conclusions/Recommendations

The BOC programs that the Alliance supported in the late 1990s and into 2000 have continued to train building operators in the Pacific Northwest, resulting in increased energy efficiency of facility operations. As new students complete the certification requirements, the cumulative impact of the program continues to grow. This growth is supported by the fact that half of all students receiving Level 1 certification subsequently attain their Level 2 certification or demonstrate their continued commitment to the BOC principles through continuing education and certification renewal.

[39] NEEC records the dates of Level 1 and Level 2 certification, plus the most recent renewal. Fifteen of the 71 students who were beyond their initial five-year measure life in 2005 had received their Level 2 certifications between 2001 and 2004, and so their savings would still be counted in 2005 even if they did not subsequently renew their certifications in 2005. Some of the others may have renewed between 2001 and 2004, but the NEEC database would have replaced these records with their 2005 renewals. There were no reported Level 2 certfications or renewals in the NWBOA program.

Some of the key findings from this 2005 update include the following:

- In 2005, 154 students in the Northwest received their initial certifications, and another 231 previously certified students received their Level 2 certifications or renewed their existing certifications.
- Due to the high rate of Level 2 certifications and renewals, 82% of all NEEC students in the Northwest certified since 1997 are still considered to be achieving energy savings at the buildings that they manage (i.e., 82% have received certification or renewal since 2001, which is the most distant year for which the five-year "measure life" would still apply in 2005). Using the same criteria, it is estimated that 75% of all NWBOA students are still within their "measure life."
- Electricity savings achieved by BOC-certified students are estimated at 8.8 aMW in 2001, increasing to 15.1 aMW in 2005. Gas savings from BOC are estimated at 1.5 million therms in 2001, increasing to 2.6 million therms in 2005.

The 2004 M&T Report discusses a variety of considerations for future M&T analysis, including refinement of the square footage estimate, treatment of Level 1 versus Level 2 certification, and a variety of other issues. Specific observations and recommendations stemming from the current M&T analysis are as follows:

- In order to further refine energy savings estimates, a comprehensive study would likely be required that measured building energy consumption over a period of a year or more. The study would need to measure savings from participant buildings before and after certification of the building operators and/or measure savings from a control group of buildings whose operators did not receive BOC training. Such a study would be more costly than what the Alliance has been allocating to the M&T efforts thus far. However, it might be worth investigating jointly funding a BOC savings study with other organizations operating BOC programs.
- Energy savings resulting from Level 1 and Level 2 certifications are treated the same in the ACE model and in this M&T analysis. There is little data to suggest how dual savings estimates might be employed to better refine the estimates. An evaluation of the BOC program in the Northeast suggests that "somewhere in the range of 75%-85%" of the total savings is generated as a result of the Level 1 training. The evaluation also highlights some of the non-energy benefits from the BOC program such as improved occupant comfort and indoor air quality that might be worth investigating.
- The number of new Level 1 certifications is the most variable factor affecting the energy savings estimate. As such, it is recommended that certification data be collected annually from both NEEC and NWBOA. It is also recommended that future M&T analyses consider some of the options, discussed in the 2004 M&T report, for refining estimates of the square footage managed per BOC-certified student.

8. BACGEN

8.1 Introduction

In 1997, BacGen Technologies, Inc (BacGen) approached the Alliance with a proposal to reduce the energy consumption of small- to medium-sized wastewater treatment facilities (WWTFs) with a proprietary mix of micronutrients and process control technologies. BacGen's proposal differed from previous energy efficiency efforts in the wastewater market in that it focused exclusively on optimizing the wastewater treatment process instead of improving building performance (lighting, heating, etc). BacGen and the Alliance signed an initial 3-year project contract to develop and demonstrate the technologies' capabilities beginning in January 1999, and the contract was extended in 2001 with a renewed focus on aeration process control. The goal of the project was for BacGen to succeed as a business serving the wastewater treatment market and for potential competitors to show interest in BacGen's technical approach. According to the BacGen Market Progress Evaluation Report[40] (MPER) No. 3, "…BacGen is indeed on its path to being a profitable, self-sustaining business and the initial foundations for a market transformation have been firmly established."

This long-term monitoring and tracking effort focuses on refining the inputs to the Alliance's Cost-Effectiveness (ACE) model and the subsequent energy savings impact of the BacGen project.

8.2 Approach to Energy Savings Estimation

According to Summit Blue's review of the ACE model, the energy savings impact of the BacGen project in the Northwest is based on several key assumptions, including the total number of wastewater treatment facilities, the average design capacity of those facilities, and the annual per-unit energy savings. The evaluation team recommends a slight modification to this approach in that savings should be based on the total design capacity of the affected facilities and the per-unit savings only. Specifically, energy savings for a given calendar year should be calculated as follows:

Annual Energy Savings (kWh/year) =

(1) Total design capacity of affected facilities (MGD)
x (2) Per-unit energy savings (kWh/MGD-year)

Where:

Total design capacity of affected facilities (MGD) is defined as the sum of the design capacity in millions of gallons treated per day for each wastewater treatment facility at which BacGen has implemented its optimization strategies.

Per-unit energy savings (kWh/MGD-year) is defined as the annual kWh savings from BacGen's wastewater process optimization services per unit of design capacity in millions of gallons treated per day.

[40] *BacGen: Market Progress Evaluation Report, No. 3,* Quantec, LLC, October 4, 2004.

In addition, the above core energy savings calculation can be disaggregated to include differences in facility size (small, medium, or large), market type (municipal vs. agricultural/industrial) and treatment type (aerated lagoon vs. activated sludge).

8.3 Data Collection Methodology

Data was collected for all the key input variables identified in the M&T plan[41]; each variable was then scrutinized to determine accuracy and/or reasonableness. The following is a step-by-step description of the data collection process:

1. **Contacted the Alliance's M&T project coordinator (Phil Degens)** to obtain data and results from previous ACE modeling efforts. Mr. Degens also offered ideas for research to be completed and clearly defined the evaluation team's scope of work to consider energy savings from wastewater facilities only. Finally, Mr. Degens supplied the draft BacGen confidential business review[42] for additional information before the evaluation team's conversation with Martin Shain.

2. **Contacted the BacGen evaluation contractor (Lauren Miller Gage of Quantec)** to inquire about general project background and market insights. Ms. Gage also recommended researching the CALMAC website for additional information and/or evaluations completed for BacGen projects in California.

3. **Contacted the Alliance's BacGen project coordinator (Andy Ekman)** to obtain the following information:

    a. **Project background, company information, and market insights.** Mr. Ekman provided much of the critical project background information that was used as the basis for this report, including anecdotal information about measure life and persistence of savings.

    b. **Post-project tracking database for completed BacGen projects.** Upon request, Mr. Ekman passed along a database that the Alliance had received from BacGen detailing all of BacGen's installations to date. The database included data crucial to this analysis, such as site name, state, facility type, treatment type, date of installation, design capacity, energy savings, and funding utility.

    c. **Additional sources of M&V for BacGen projects.** Mr. Ekman reported that, in addition to the M&V completed by the Bonneville Power Administration (BPA), the Energy Trust of Oregon (ETO) had conducted some M&V of BacGen projects. He also provided contact information for the ETO's project implementation contractor at Aspen Systems.

4. **Contacted the BacGen project contractor (Martin Shain of BacGen)** to obtain the following information:

    a. **Updates to the project database.** The post-project tracking database provided by Mr. Ekman contained many missing fields and, upon request, Mr. Shain filled in the missing data for all completed projects in the Northwest, as well as many of BacGen's California projects.

[41] *BacGen: Long-Term Monitoring & Tracking Plan,* Summit Blue Consulting, August 2005.

[42] *Business Review of BacGen Technologies, Inc. (M10068),* LaunchBox, LLC, June 2005 (draft).

b. **Additional sources of M&V for BacGen projects.** Mr. Shain reported that the BPA and the ETO are the only outside entities who have conducted any sort of M&V for BacGen projects and that none has been performed for any California projects. He explained further that the M&V conducted by the ETO consisted solely of verifying the installations in the field and that no savings estimates were produced. Consequently, the only independent M&V conducted to produce savings estimates was that completed by the BPA.

c. **Methodology for internal M&V completed.** According to Mr. Shain, BacGen performs some form of internal M&V for each of their projects. He explained further that BacGen often conducts pre- and post-implementation metering of the affected equipment and uses the results to estimate energy savings. In cases where they are not able to conduct metering, BacGen collects pre- and post-implementation billing data from their clients to calculate savings and thus supplement their database.

d. **Other miscellaneous and anecdotal information.** During the course of Summit Blue's conversation with Mr. Shain, he went on to discuss issues such as measure life and persistence of savings, BacGen's design consultation services, the challenges inherent with implementing savings at larger facilities, savings potential by facility and treatment type, and the impact of the Alliance in the success of BacGen as a company.

5. **Reviewed secondary sources of data** for general information about the market and inputs to the energy savings calculation. A number of secondary data resources were identified and searched for relevant inputs, baseline reference data, and/or additional information to augment our key indicators:

    a. **BacGen MPER Number 3 [see footnote 1].** The evaluation team reviewed the third MPER for critical project background and to obtain sources for additional secondary information.

    b. **PG&E WWTF Energy Baseline Study.**[43] This report provided a great summary of the overall wastewater treatment process and the potential for energy efficiency within each part of the process. The evaluation team also searched within this report for baseline consumption benchmarking data.

    c. **PNW Water and Wastewater Market Assessment.**[44] The evaluation team reviewed this report for baseline consumption data and market inputs.

8.4 Findings

Since the project's initiation to save energy at wastewater treatment facilities in the Northwest, BacGen has extended its service offerings to include freshwater treatment facility optimizations and consulting design services for new or updating facilities. BacGen has also expanded its service territory to include California and Wyoming, and it has moved cautiously into optimization services for larger facilities. Table 8-1 below shows the breakdown of facilities by region and type of services implemented for all of BacGen's projects regardless of size.

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[43] *Municipal Wastewater Treatment Plant Energy Baseline Study*, M/J Industrial Solutions, June 2003.

[44] *Market Research Report: Pacific Northwest Water and Wastewater Market Assessment*, Quantum Consulting Inc. with Adolfson Associates, May 2001.

Table 8-1. Number of Sites by Region and Implementation Service Type

	WW Optimizations	WW Design Consultations	FW Optimizations	TOTAL
Northwest	24	2	14	40
Other*	48	0	1	49
TOTAL	**72**	**2**	**15**	**89**
* All the WW optimizations in the 'Other' category occurred in California, while the single FW optimization occurred in Wyoming.				

In accordance with the Alliance's request, Summit Blue has structured this evaluation to focus on refining the savings estimates from wastewater projects only.[45] The end of this report does, however, provide a short discussion of savings from freshwater optimization projects.

8.4.1 Energy Savings from Wastewater Treatment Facility Projects

The project savings database provided by Andy Ekman and later updated by Martin Shain lists savings for each of BacGen's 24 WW optimization projects as the observed savings reported on by BacGen. Additionally, 10 of the 24 projects (42%) also have an independently-verified savings value associated with them. The easiest and most obvious way to determine aggregate regional savings from BacGen's WW optimizations would be to sum the project savings values (as reported by BacGen) for each of the 24 projects. The authors of MPER-3 warn against using data that has not been independently verified, however, stating "As BacGen completes additional sites, the ideal tracking mechanism will be to use only third-party-verified numbers. In the absence of these, the Alliance should cautiously use the savings reported by BacGen."

In light of the recommendation from MPER-3, the significant challenge for the evaluation team lay in determining whether to use the data reported by BacGen or to calculate an average savings value from the independent M&V completed and extrapolate the per-unit savings to the population for an aggregate value. As such, the evaluation team conducted rigorous research and analysis to determine which category of savings (independently-verified or BacGen-reported) would be best suited to give a reasonable and conservative estimate for the regional energy savings achieved by BacGen. In the discussion with Andy Ekman, he advised sticking to only that data that had been independently-verified. Furthermore, a statistical comparison between the two groups of data revealed a statistically significant difference at the 95% confidence level. In the end, the evaluation team agrees with Mr. Ekman that the most defensible method for determining savings lie in using independently-verified data.[46]

The next task was to choose a common denominator across all wastewater facilities in the Northwest to which the savings impact could be normalized. The easiest and most obvious choice (from a data collection standpoint) would be to normalize by facility. In order to provide a slightly higher level of resolution, the authors of MPER-3 used treatment capacity in MGD as the normalization factor. Other potential normalization factors include concentration of contaminants in the influent, concentration of contaminants in the effluent, and pounds of contaminants removed. Martin Shain indicated reservations with this approach, however, stating that normalizing savings by *any* variable would not necessarily give the most accurate results because each facility is unique according to its equipment and operating

[45] Wastewater projects include both optimizations and design consulting services for wastewater facilities.

[46] It was later determined (as shown in Table 3 below) that the difference was negligible for the aggregate savings from the independently-verified versus the BacGen-reported data.

protocols, and savings for two identically sized facilities can be dramatically different. Ultimately, since it is necessary to use independently verified data to ensure integrity, the evaluation team believes the most cost-effective variable for normalization is treatment capacity.

MPER-3 recommends, and the evaluation team agrees with, using design capacity as reported in the EPA database as the unit factor for calculating aggregate savings for two main reasons:

- It is difficult to accurately measure flows because of daily and seasonal changes.
- There are substantial differences between the BacGen database and the EPA database.

In addition to normalizing savings by design capacity, value may be added by disaggregating the population savings by market type and/or treatment type. MPER-3 reports, "The primary recommendation for the ACE model is to separately assess the agricultural/industrial and municipal markets." The energy savings potential will generally be higher for industrial waste treatment because, according to Martin Shain, it has a biochemical oxygen demand (BOD) that is one or even two orders of magnitude higher than that of municipal waste streams and, as illustrated in the PG&E baseline study [4], higher levels of BOD removal require higher levels of energy input. Unfortunately, the distinction between municipal waste streams and industrial waste streams is frequently blurred, with a single plant often serving both waste stream types. In fact, of the 64 wastewater treatment projects completed by BacGen with reliable design capacity data, fully 18 of them (28%) served both a municipal and an industrial waste stream. Furthermore, of the 10 sites in the Northwest whose savings were independently verified, just 2 of them were fed by both waste stream types, which is not enough to justify disaggregating savings by market type at this time.

Moreover, both Andy Ekman and Martin Shain pointed out significant differences in savings potential between *aerated lagoon* facilities and *activated sludge* facilities. They each indicated separately that aerated lagoons are typically smaller facilities (in terms of design capacity) and that the percentage savings associated with these projects is often higher than that associated with the activated sludge projects. Conversely, activated sludge facilities often show higher absolute savings potential because they are typically larger and thus process more total waste. In the end, however, the problem is the same as it is with segmenting by market type; it is unreasonable to attempt to disaggregate savings by treatment type because of the relative lack of data.

Table 8-2 below details the normalized savings for 9 of the 10 independently verified wastewater treatment optimization projects completed by BacGen in the Northwest.[47] Although BacGen has moved gradually into providing optimization services for larger facilities, the Alliance's project was focused on small-to-medium sized facilities which, according to MPER-3, range in size from 0.1 MGD design to 20 MGD design. As such, the analysis to determine per-unit savings includes only those sites within the Alliance's target market.

[47] The remaining site (St. Helens, design capacity = 41.0 MGD) was removed from the analysis so that only facilities meeting the Alliance's definition of small-to-medium sized facilities would be considered.

Table 8-2. Independently Verified Energy Savings for WW Optimizations in the Northwest Within the Alliance's Target Market (0.1 – 20 MGD Design)

Facility Name	Design Flow (MGD)	Energy Savings (kWh/year)	Normalized Savings (kWh/MGD-year)
Bandon	0.45	461,620	1,025,822
Reedsport	1.90	368,572	193,985
Burley	3.90	503,391	129,075
Polson	1.65	406,344	246,269
Ronan	0.20	157,104	777,743
Richland	11.40	1,083,170	95,015
Whitefish	2.20	461,310	209,686
Daishowa	6.70	392,098	58,522
Sunnyside	1.18	1,521,829	1,289,686
Sum	29.58	5,355,438	
Facility Average	3.29	595,049	447,311
Avg Savings Per MGD			181,037

As shown above, the average savings for all analyzed facilities normalized to design flow was 181,037 kWh/MGD-year, which is 32% higher than the value currently used in the ACE model.[48] This value was then applied to all projects to calculate aggregate savings and compared to the aggregate savings calculated from the BacGen-reported data. Table 8-3 below shows the aggregate savings for all of BacGen's wastewater optimization projects in the Northwest, regardless of size, and compares it to the value calculated from the BacGen-reported data.

Table 8-3. Annual kWh Savings From BacGen's WW Optimizations in the Northwest

Variable	Value
Total Design Capacity (MGD)	96.97
Avg Savings Per MGD (kWh/MGD-year)	181,037
Aggregate Savings Calculated From Independently verified Data (kWh/year)	17,555,525
Aggregate Savings Calculated From BacGen-Reported Data (kWh/year)	17,224,789
Difference in Savings (kWh/year)	330,736
Percentage Difference in Savings (%)	1.9%

As expected, the difference between the aggregate savings values from the two separate methods of calculation is small (less than 2%). Since the comparison between the BacGen-reported aggregate savings and the independently verified aggregate savings was so close, the evaluation team next endeavored to compare the average savings per MGD from BacGen's Northwest projects to the average savings per

[48] The current ACE model assumes 137,000 kWh/MGD-year savings.

MGD from BacGen's California projects. Although none of BacGen's California wastewater optimization projects had any independent M&V conducted for them, each of them had a BacGen-reported savings value associated with it. After removing those sites outside of the Alliance's target market and those whose design flow could not be determined, the project team calculated the average savings per MGD for the California projects to be 180,560 kWh/MGD-year, which is just 477 kWh/MGD-year (or less than 0.3% different) less than the average savings per MGD for the Northwest projects and serves to confirm the authenticity of the recommended per-unit savings value.

In addition to the wastewater optimization projects, BacGen has begun offering design consultation services for new or updating facilities. Martin Shain reported that BacGen has been hired to provide recommendations to facility management for installing energy-efficient equipment to reduce consumption in new plants. Determining energy savings for these projects is a challenge because no baseline system actually exists. In the process of making recommendations, however, BacGen often builds a simulation model for the plant to show facility management the effects of certain energy-saving measures. These unverified savings from the model are the basis for BacGen's reported savings, and although BacGen has conducted about a dozen design consultations, they have reported savings for this long-term M&T project for only two of them. As such, the evaluation team believes it is reasonable and prudent to include the BacGen-reported savings from the two design consultations in the analysis of BacGen's overall impact in the wastewater treatment market in the Northwest (total savings from these two projects was estimated at 908,291 kWh/year).

Table 8-4 below shows the annual energy savings from all 26 of BacGen's wastewater projects in the Northwest, as well as the savings from the Alliance-funded projects. Based on the recommended energy savings calculation, the annual energy savings currently being achieved by BacGen's wastewater projects in the Northwest is 17,676 MWh (or 2.02 aMW).

Table 8-4. Annual MWh and aMW Savings From BacGen's Wastewater Projects in the Northwest

	All WW Projects		**Alliance-Funded WW Projects***	
	MWh Savings	**aMW Savings**	**MWh Savings**	**aMW Savings**
Pre-2002	4,171	0.48	1,175	0.13
2002	2,652	0.30	0	0.00
2003	7,636	0.87	0	0.00
2004	597	0.07	0	0.00
YTD 2005	2,620	0.30	0	0.00
TOTAL	**17,676**	**2.02**	**1,175**	**0.13**
* Based on 6 projects that were fully funded by the Alliance (Dillon, Roundup, Emmett, Hubbard, Westport, and Hayden).				

Additional Notes and Anecdotes About BacGen's Wastewater Projects

The research completed by the evaluation team yielded several significant notes and anecdotes related to energy savings from BacGen projects that are not direct inputs to the savings calculation. At the commencement of the project, the Alliance expressed interest in determining whether BacGen was basing their savings on an inflated baseline, and the project team was asked to investigate the possibility of overstated savings. The results of this analysis are presented below in bullet format:

- It is virtually impossible to establish a baseline for energy consumption in wastewater treatment facilities due to differences that impact consumption much more than design capacity. The PG&E energy baseline study [see footnote 4] underlined this volatility especially well, stating "There is enormous variability from plant to plant in wastewater flow rates, concentration of contaminants, type of process used, the discharge regulations the effluent must meet, disinfection method used, and the wet weather flows the plant must treat. This lack of standardization and site-specific regulatory requirements make it impractical to establish a definitive wastewater treatment baseline in terms of a system configuration or a universal performance metric for wastewater treatment facilities."
- As reported above, Martin Shain indicated that BacGen does indeed conduct pre- and post-implementation metering to determine energy savings. However, BacGen meters only the equipment that will be affected by their process control technologies. As a result, comparing the consumption data for specific pieces of equipment to a benchmarked value (even if one existed) is completely impractical.
- The savings calculated from the independently verified data is within 2% of that calculated using the BacGen-reported data; in fact, they are actually higher than BacGen's reported savings.
- The aggregate savings calculated for the M&T effort was based on independently verified savings data. Consequently, the possibility of BacGen basing their own savings on an exaggerated baseline is immaterial for this report.

As a result of the above analysis, the evaluation team believes that modifying BacGen's savings impact because of the possibility of BacGen basing savings on an inflated baseline is impractical, unnecessary, and irrelevant.

Both Andy Ekman and Martin Shain indicated that money remains the largest barrier to facility management undertaking energy-saving measures such as those provided by BacGen. Mr. Shain further expounded this opinion by saying that, currently, incentives from utilities and other interested parties apply only to direct conservation off of existing plants. He argued that a push needs to be made to include BacGen's design consultations as a viable energy-saving measure to be funded. In addition, he reported that working with larger facilities requires getting approval from many different organizations and that the politics and red tape associated with making changes can be frustrating. He stated that the focus of the company was to make changes in the market, and they can more easily attain this goal working with smaller municipalities than with larger facilities.

Another concern of the Alliance was in getting an estimate for persistence of savings and measure lifetimes. Andy Ekman reported that BacGen is generally putting in good quality equipment and training the operators; he went on to say that because of BacGen's continuing involvement after the initial installations, facility operators are beginning to take more ownership of the process and are looking for additional savings opportunities. In a separate conversation with Martin Shain, he reported increasing operator involvement at wastewater treatment facilities. He said that operator education from BacGen extends persistence and opens opportunities for additional savings in other areas (*spillover*). Concerning the equipment itself, Mr. Ekman said that the BPA uses 10 years as the measure life, the Alliance uses 12 years, the ETO used 12-15 years, and BacGen says it is at *least* 15 years. Martin Shain indicated that the equipment lifetime is often more than 20 years.

8.4.2 Energy Savings from Freshwater Treatment Facility Projects

Although the core of BacGen's business lies in providing process optimization strategies to wastewater customers, they have continued to adapt their technologies for implementation in freshwater and irrigation facilities. To date, BacGen has conducted 14 freshwater optimization projects in the Northwest and 1 in Wyoming. Of these, the BPA has independently verified the energy savings at 8 facilities, while BacGen has reported savings from their own internal M&V for all of them. The evaluation team used the same methodology outlined for calculating savings from wastewater projects to assess freshwater project savings; freshwater facilities, however, are not sized according to treatment capacity, and the unit factor for the analysis is per-facility. Table 8-5 below shows that once again the BacGen reported savings in aggregate are less than those calculated from the independently verified data. The annual energy savings currently being achieved by BacGen's freshwater projects in the Northwest is 5,849 MWh (or 0.67 aMW).

Table 8-5. Annual kWh Savings From BacGen's FW Optimizations in the Northwest

Variable	**Value**
Total Number of Affected Freshwater Facilities in the Northwest	14
Avg Savings Per Facility (kWh/Facility-year)*	417,804
Savings Calculated From Independently verified Data (kWh/year)	5,849,256
Savings Calculated From BacGen-Reported Data (kWh/year)	5,527,617
Difference (kWh/year)	321,639
Percentage Difference (%)	5.5%
* The average savings per facility was calculated from the 8 sites with independently verified data.	

8.5 Conclusions/Recommendations

The Alliance's BacGen Initiative achieved significant savings at wastewater treatment facilities in the Northwest by introducing process optimization technologies and techniques to reduce the consumption of critical equipment. Furthermore, it appears the Alliance was essential in the success of BacGen; as the BacGen project contractor, Martin Shain, put it: "Our business turned 180 degrees in a different direction after the first MPER."

Additional data collection and analysis activities beyond the scope of this original M&T project may provide a more complete assessment of program impacts and/or reduce the uncertainty surrounding specific indicators. Recommendations for additional analyses include:

- **Refine the estimate of savings *attributable to the Alliance.*** The Alliance played a key role in the success of BacGen as an entrepreneurial firm, and it may be reasonable to assign greater savings to the presence of the Alliance initiative than that for only the fully funded implementations. The Alliance claims no credit for any project that receives ANY utility incentives, even when those incentives account for a small portion of the overall savings at the site attributable to BacGen activities. A review of project incentives, and overall savings for some individual projects may be warranted.

- **Determine the extent of the operator "spillover" impacts.** As stated above, both Andy Ekman and Martin Shain agreed that operator education from BacGen was motivating facility operators to look for additional savings opportunities. The Alliance might consider interviewing a sample of operators to determine what additional energy savings measures they've taken as a result of their BacGen experience.

- **Frequency of data collection.**
    - Obtain an updated database every two years.

9. EZCONSERVE/SURVEYOR NETWORK ENERGY MANAGER

9.1 Introduction

In 2001, the Northwest Energy Efficiency Alliance (Alliance) and Verdiem, Inc (formerly EZConserve, Inc.) formed a partnership to help commercialize Verdiem's software product, the Surveyor Network Energy Manager (Surveyor). The product is a network software tool that enables network administrators to remotely control the power management functions of personal computers (PC's) linked to the central network. Furthermore, Surveyor can monitor computer usage during baseline conditions and simulate how much energy would be saved with the implementation of various power management schemes. The goal of the Surveyor project was a market transformation to make power management software an industry standard in all computers networked to servers in commercial Northwest businesses. According to the Surveyor Market Progress Evaluation Report[49] (MPER) No. 2, "Verdiem offers an innovative product and continues a steady pattern of growth and acceptance by the marketplace, fulfilling an important 'niche' in energy savings potential and functioning as an important market transformation project."

This long-term monitoring and tracking effort focuses on refining the inputs to the Alliance's Cost-Effectiveness (ACE) model and the subsequent energy savings impact of the Surveyor initiative. The following discussion considers only energy savings that are achieved at commercial entities in the Northwest.

9.2 Approach to Energy Savings Estimation

According to Summit Blue's review of the ACE model, the energy savings impact of the Surveyor initiative in the Northwest should be based on three fundamental inputs: total number of Surveyor licenses achieving savings at commercial businesses in the Northwest; an estimation of per-unit energy savings for each license; and an estimate of the baseline. Specifically, energy savings for a given calendar year can be calculated as follows:

Annual Energy Savings (kWh/year) =

(1) Number of Surveyor licenses achieving savings
x (2) Estimated per-unit savings (kWh/license-year)
x (3) Percentage of units NOT included in the baseline

Where:

Number of Surveyor licenses achieving savings is defined as the total number of workstations at commercial businesses in the Northwest at which Surveyor is deployed and achieving energy savings.

Estimated per-unit savings is the annual electric (kWh) savings attained per Surveyor license achieving savings.

[49] *Surveyor Network Energy Manager: Market Progress Evaluation Report, No. 2;* Quantec, LLC; January 2005

Percentage of units NOT included in the baseline accounts for those units that would be achieving savings anyway in the absence of the Alliance's initiative and is set within the ACE model to 10% of all units sold.

9.3 Data Collection Methodology

Data was collected for all the key input variables identified in the M&T plan[50]; each variable was then scrutinized to determine accuracy and/or reasonableness. Fortunately, the Alliance has a revenue-sharing agreement in place with Verdiem that ensures access to sales data for the foreseeable future. The following is a step-by-step description of the data collection process:

1. **Contacted the Alliance project coordinator (Phil Degens)** to obtain data and results from previous ACE modeling efforts. In addition, Mr. Degens offered ideas and resources for secondary research to be conducted and provided the evaluation team with the E Source report by Dan Greenberg regarding network power management software.[51]

2. **Contacted the Surveyor evaluation contractor (Scott Dimetrosky of Quantec)** to inquire about general project background and market insights, as well as to gather supplementary project information. Mr. Dimetrosky also discussed the volatility of the per-unit savings estimate and its dependence on PC type, monitor type, baseline user habits, baseline company policy, the aggressiveness of power-management settings, and the percentage of licenses sold that are actually deployed.

3. **Contacted the Surveyor project contractor (James Tatham of Verdiem)** to obtain the following information:

    a. **Sales data for licenses sold in the Northwest.** Upon request, Mr. Tatham provided a database of units sold and revenues by year from January 2002 to September 2005 for each state in the Northwest.

    b. **Secondary sources of information.** Mr. Tatham mentioned several potential sources of additional information for the Surveyor product, including the aforementioned E Source report [4] and a detailed M&V report completed by Southern California Edison.

    c. **Other miscellaneous and anecdotal information.** During the course of Summit Blue's conversation with Mr. Tatham, he went on to discuss issues such as business regions, percentage of sold licenses that actually get deployed, user habits with Surveyor, and a new guarantee of savings that Verdiem is offering for its product.

4. **Reviewed secondary sources of data** for general information about the market and inputs to the energy savings calculation. A number of secondary data resources were identified and searched for relevant inputs and/or additional information to augment our key indicators:

    a. **Surveyor MPER Number 2 [1].** The evaluation team reviewed the second MPER for general project background and to obtain sources of additional secondary information.

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[50] *Surveyor Network Energy Manager Long-Term Monitoring & Tracking Plan;* Summit Blue Consulting, LLC; August 2005

[51] *Network Power Management Software: Saving Energy by Remote Control;* E Source, Dan Greenberg; November 2004

Furthermore, the MPER provided a good starting point for understanding user habits and per-unit energy savings estimates.

b. **E Source technical brief regarding power management software [4].** This report provided a great summary of Surveyor installations at businesses around the country and offered a comparison of per-unit energy savings by M&V study completed.

9.4 Findings

The following discussion provides a summary of the analysis conducted to determine a best estimate of each key input variable to the energy savings calculations.

9.4.1 Number of Surveyor Licenses Deployed

Several methods exist to quantify the number of workstations at which Surveyor is affecting energy consumption. By far the simplest method, and the one employed by the current ACE model, is to say that all licenses sold to commercial businesses in the Northwest are achieving savings. The uncertainty surrounding this method is high, however, because of a few pervading issues:

- A significant delay may exist between purchase and deployment on client workstations
- Some licenses may have been deployed but have never been set to enforcement (i.e., do not have their power settings controlled by the central server)
- Some licenses that are sold are *never* actually deployed

In fact, according to the results of the customer interviews completed for and presented in MPER-2, only half of the sold licenses had been installed. Furthermore, of the licenses that *had* been installed on client workstations, fully 20% had not been set to any sort of enforcement scheme at the time the surveys were conducted. The evaluation team also queried James Tatham of Verdiem about the idea that licenses sold do not always equal licenses deployed, and he reported that some licenses are never deployed and that there will *always* be some that are not deployed. As a result of this research and ACE model review, the evaluation team believes a more robust method is needed to accurately characterize the number of client workstations at which Surveyor is affecting energy consumption.

Quantifying the time-delay between purchase and deployment, as well as the delay between deployment and enforcement, presents a number of intensive problems because most customers buy the licenses in bulk and deploy/enforce only small subsets of the population at a time. MPER-2 reports that 70% of Verdiem customers were behind schedule in both installation on client workstations and implementation of power management settings due to the need to conduct comprehensive user profiling and internal communications. The report goes on to further illustrate the problem by stating “Four of ten of the responding organizations indicated that they had obtained enough licenses for their anticipated growth over the next two to three years. Based on expected organizational growth and increased saturation of technology, as many as 10% of the licenses obtained to date may be reserved for future use.”

As a result, the evaluation team believes the most cost-effective method for estimating the number of workstations at which Surveyor is achieving savings is to make an assumption about the percentage of sold licenses that have actually been deployed at the time of evaluation. This method has its limitations, though, in that it does not account for those licenses that have been deployed but are not set to enforcement.[52] This variable, then, is a function of two sub-inputs and can be calculated as follows:

Number of Surveyor Licenses Deployed =
(1) Number of Surveyor licenses sold
x (2) Percentage of licenses that have actually been deployed at the time of evaluation

At Summit Blue's request, James Tatham supplied the evaluation team with a database of the number of Surveyor licenses sold to commercial businesses in the Northwest, broken out by year and by state. The evaluation team then asked him to estimate the percentage of licenses sold in the Northwest that have actually been deployed and to bound this estimate with an absolute lowest and absolute highest value. Although he didn't have any hard numbers to report, Mr. Tatham thought the absolute lowest deployment percentage to be 50% and the absolute highest deployment percentage to be 70%. In the end, his best guess for deployment percentage in the Northwest was 60-65%.[53] Table 9-1 below shows the breakdown of the number of licenses sold and deployed by year from 2002 through YTD 2005.

Table 9-1. Number of Surveyor Licenses Deployed in the Northwest*

	Licenses Sold	Low Boundary (Deployed = 50%)	High Boundary (Deployed = 70%)	Average Value (Deployed = 60%)	Recommended Value (Deployed = 62.5%)
2002	1,546	773	1,082	928	966
2003	22,500	11,250	15,750	13,500	14,063
2004	24,100	12,050	16,870	14,460	15,063
2005	7,900	3,950	4,480	5,530	4,740
TOTAL	**56,046**	**28,023**	**39,232**	**33,628**	**35,029**
*All the Surveyor licenses sold in the Northwest have gone to businesses in Washington and Oregon.					

As a result of the above analysis, the evaluation team recommends using 35,029 as the number of client workstations at which Surveyor is achieving energy savings at commercial businesses in the Northwest.

9.4.2 Per-Unit Energy Savings (kWh/license-year)

As stated in the Approach to Energy Savings Estimation section above, a key input to the energy savings calculation is the assumption about kWh savings per Surveyor license deployed. Unfortunately, the per-unit energy savings is exceptionally volatile and sensitive to influences such as PC type, monitor type, baseline user habits and/or company policy, and the aggressiveness of the power-management settings. Scott Dimetrosky (project evaluator) was asked how all these variables affect the per-unit savings

[52] A short survey of Verdiem's customers would be the best way to reduce the uncertainty around the number of Surveyor licenses achieving savings, and this is presented as a recommendation in Section 5 below. Overall, however, the evaluation team believes the method outlined above is a good way to characterize the population of achieved energy savings.

[53] Mr. Tatham qualified this estimate by saying that most of the sold licenses that have not been deployed belong to older clients and that the more recently sold licenses have a higher deployment rate. He also noted one school district that bought a significant number of licenses but decided to deploy only 50% of them, and they do not plan to deploy any more. Another client bought a block of licenses but has deployed none of them.

estimate, and he reported "All of these have significant impacts on the savings." Due to the difficult nature of estimating the impact of these influences, however, the value currently used in the ACE model (200 kWh/license-year) is held constant regardless of variations in the aforementioned variables. The following discussion of per-unit energy savings focuses specifically on reducing the uncertainty inherent in the estimate and is divided into three sub-sections:

- Surveyor Case Studies, Reports, and M&V
- Other Power Management Software Savings Claims
- Recommended Per-Unit Energy Savings

Surveyor Case Studies, Reports, and M&V

Several organizations have conducted case studies based on Surveyor installations, including schools, government organizations, colleges and universities, commercial businesses, utilities, and independent consulting firms. Two of these studies included outfitting the various pieces of equipment with power monitors and dataloggers to physically measure the power states and the time spent in each state. The results from this M&V method were then compared with the results from the Surveyor reports; both evaluations showed that the energy savings estimates were within a few percentage points of one another, which seems to validate the software as an accurate tool for reporting savings.

The evaluation team collected the results of several case studies from a variety of independent entities. In addition, Verdiem maintains on its website a list of customers and the energy savings results of their implementations, and the evaluation team compiled the claimed savings results from each. Table 9-2 below shows the mean and median per-unit savings estimates based on the compilation of results by source 'group' and by market sector.

Table 9-2. Annual Electric Energy Savings Per Workstation (kWh/workstation-year)

Market Sector	N	Min	Max	Std Dev	Median	Mean
Independent Evaluations						
School Districts	2	211	254	30.4	233	233
Colleges / Universities	2	129	317	132.9	223	223
Government Agencies	3	34	330	148.0	176	180
All Market Sectors	7	34	330	105.2	211	207
Verdiem Website						
School Districts	10	90	695	176.0	201	260
Colleges / Universities	6	141	237	42.1	181	187
Government Agencies	5	145	301	63.0	169	190
All Market Sectors	21	90	695	128.5	181	222
All Savings Estimates*						
School Districts	12	90	695	159.8	213	255
Colleges / Universities	8	129	317	63.8	181	196
Government Agencies	8	34	330	92.5	169	186
All Market Sectors	28	34	695	121.4	182	219
* This is the average between all savings estimates, not the average between the two groups.						

As illustrated in Table 9-2, the per-unit savings mean value for the independent evaluations was 207 kWh/workstation-yr, while the mean value from those case studies posted on the Verdiem website was 222 kWh/workstation-yr, a difference of only 15 kWh. The median value, however, was quite different between the two source groups at 211 for the independent evaluations and 181 for the those from Verdiem. The overall statistics for all sites considered were 219 for the mean and 182 for the median. In addition, school districts in all cases seem to have more savings potential on a per-unit basis than other market sectors.

Other Power Management Software Savings Claims

Summit Blue also conducted basic Internet research for savings claims from the other power management software products mentioned in MPER-2 and the E Source report. Many of the private software products such as Energy Saver Pro, NightWatchman, Energy Management Option, and RSHUT Pro did not specify a per-unit energy savings potential on their product literature web pages. One of these sites did, however, offer a gross savings estimate based on a block of workstations and an assumed rate, and the evaluation team was able to interpret the data for a per-unit energy savings estimate.

Other websites such as the one for Blue Owl's Wattsavvy CE and the Energy Star products EZ Save and EZ GPO offered a calculator to determine cost and/or energy savings. The homepage for the Wattsavvy CE software asks for certain parameters such as number of workstations, electricity rate, PC energy consumption, and monitor energy consumption to estimate potential cost savings from the product. The Energy Star website for power management makes it even easier to estimate savings by asking only for the number of PCs, the number of monitors, and the electricity rate. Based on the initial assumptions given on the websites, savings estimates were much higher for these other products and the evaluation team believes the assumptions going into these calculations are inflated and unrealistic.

Table 9-3 below shows the breakdown of per-unit energy savings claims by product.

Table 9-3. Per-Unit Energy Savings Estimates For Other Power Management Software Products

Product	Website	Analysis Method	Annual Per-Unit Savings (kWh)	Assumptions
EZ Save	energystar.gov	Direct	381 kWh/yr	Controls monitors only Monitor power draw = 73w active
EZ GPO	energystar.gov	Direct	675 kWh/yr	Controls monitors and PCs Monitor power draw = 73w active PC power draw = 57w active
Wattsavvy CE	wattsavvy.com	Indirect	240 kWh/yr	$28.76 saved @ $0.12/kWh Monitor power draw = 55w PC power draw = 70w
Energy Saver Pro	edubusinesssolutions.com	Indirect	200 kWh/yr	200,000 kWh saved per 1,000 monitors Has capability but does not include PC savings
NightWatchman	1E.com	NA	NA	
Energy Management Option	fastware.com.au	NA	NA	
RSHUT Pro	rtsecurity.com	NA	NA	

Recommended Per-Unit Energy Savings

Overall, the evaluation team places more faith in the per-unit savings estimates from Verdiem's own specific case studies and M&V than the estimates of savings from other power-management software products. Generally, the estimates found on websites for other products seemed to be inflated and based on unrealistic baseline conditions. If nothing else, however, the exercise of researching savings claims from other software product companies serves to corroborate the conservativeness of the Alliance estimate of 200 kWh/yr. Additionally, Verdiem is so confident that their customers will see some level of savings that they have recently begun offering a ***guarantee*** of 120 kWh saved per workstation per year if the client installs within 6 months of purchase.

On a case-by-case basis, the per-unit savings estimate of 200 kWh/workstation-yr is subject to too many extraneous variables to be considered accurate in every single situation. In the end, however, the evaluation team believes that 200 kWh/workstation-year functions as a good middle ground to project the energy savings ***in aggregate*** for all Verdiem projects. As Scott Dimetrosky put it, "Few companies are 'average' – many users show very little to no savings, while others show savings well above the 200 kWh [per workstation-yr]. Generally, the 200 kWh [value] is a good middle ground to use."

9.4.3 Percentage of Units NOT Included in the Baseline

According to the project memo received from the Alliance[54], "The baseline is assumed to be zero in 2001 but then 10% of all Verdiem units sold are assumed to be baseline units that are not counted in the Alliance savings." The evaluation team made a follow-up phone call to Phil Degens at the Alliance to inquire about the basis for the baseline assumption, and he reported that the 10% value was mostly to be conservative is estimating project impacts. He explained further that as the market becomes more saturated with other power-management software products it is likely that some of the sales made would have been done anyway without the presence of the Verdiem project. Consequently, in the absence of conducting additional primary research, the evaluation team believes a 10% baseline to be reasonable if not conservative. Therefore, the percentage of units NOT included in the baseline is assumed to 90% for all years after 2001.

9.4.4 Estimate of Annual Energy Savings

Annual energy savings are estimated for each calendar year 2002-2005. As described in Section 9.2, the ACE model calculates energy savings according to the following formula:

Annual Energy Savings (kWh/year) =

(1) Number of Surveyor licenses achieving savings
x (2) Estimated per-unit savings (kWh/license-year)
x (3) Percentage of units NOT included in the baseline

As stated in Section 9.4.1, the current ACE model bases the number of workstations at which Surveyor is achieving energy savings solely on the number of licenses sold to commercial businesses in the Northwest. As discussed, the evaluation team believes this method may lead to overvaluing project achievements and we suggest using the number of workstations at which Surveyor has been deployed to calculate savings. A side-by-side comparison of the energy savings that result from the calculation in the ACE model versus the evaluation team's recommended calculation is presented in Table 9-4 below.

Table 9-4. Annual Savings Attributable to the Surveyor Project

	MWh Savings		**aMW Savings**	
	Current ACE Model	**Recommended**	**Current ACE Model**	**Recommended**
2002	278	174	0.03	0.02
2003	4,050	2,531	0.46	0.29
2004	4,338	2,711	0.50	0.31
YTD 2005	1,152	889	0.13	0.10
TOTAL	**9,818**	**6,305**	**1.12**	**0.72**

[54] *Verdiem's Surveyor Network Energy Manager: Cost-Effectiveness Analysis Key Assumptions;* Kenneth Anderson, Northwest Energy Efficiency Alliance; October 29, 2004

Based on the recommended energy savings calculation, the annual savings currently being achieved by the Surveyor project is 6,305 MWh, which is equal to 0.72 aMW and is approximately 64% of the savings calculated using the ACE model assumptions.

9.5 Conclusions/Recommendations

The Alliance's Surveyor Network Energy Manager Project achieved significant savings at commercial businesses in the Northwest by reducing the energy consumption of networked PCs and monitors through remote power management. Furthermore, it appears the Alliance was critical in the success of the Surveyor software; as the project evaluator, Scott Dimetrosky, put it: "…the Alliance funding and support gave them [Verdiem] vital resources at a critical time in their development."

Additional data collection and analysis activities beyond the scope of this original M&T project may provide a more complete assessment of program impacts and/or reduce the uncertainty surrounding specific indicators. Recommendations for additional analyses include:

- *Disaggregate the number of licenses deployed and per-unit energy savings by market sector.* As shown in Table 9-2 above, the difference in per-unit savings varied widely by market sector, especially for school districts. Since per-unit savings by market sector is already known, the only remaining task is to get sales data from Verdiem by market sector. Disaggregating this information could greatly reduce the uncertainty in the ***aggregate*** energy savings estimate, and this cost-effective task should give greatly improved results for minimal additional effort.

- *Revisit the original energy savings calculation for savings estimates for LCD monitors.* The PSE metering study completed for MPER-2 was done for workstations which all had LCD monitors, and the authors computed a total workstation savings value of 176 kWh/year. Before any M&V had been completed or Surveyor reports had been compiled, however, the initial energy savings estimate came directly from a calculation, and this original calculation assumed that all PCs were desktops and all monitors were CRT. James Tatham estimated that, currently, nearly 40% of all workstations with Surveyor installed have LCD monitors that draw much less power than their CRT counterparts, which suggests that the current per-unit savings estimates might not be reasonable for the coming years. Conversely, the size of monitors is growing, as is the addition of "performance" equipment in the PC itself (such as high-resolution graphics cards), which suggests that aggregate consumption might actually be growing even as the equipment itself is becoming more energy-efficient. In the end, it may be best to use case studies and M&V as the basis for the per-unit savings estimate, but revisiting the original calculation with updated assumptions might provide a peak into future savings.

- *Interview customers to further reduce uncertainty around the number of Surveyor licenses achieving savings and the per-unit energy savings estimate.* As explained above, the per-unit energy savings estimate is volatile and influenced by many factors. Conducting interviews with some of Verdiem's customers might help reduce the uncertainty surrounding these variables and inherent in the overall savings estimate. Due to the relatively low aMW savings as compared to the Alliance's other initiatives, however, this action item might only be justified if Verdiem's sales, and hence energy savings, increase dramatically enough to substantiate the additional effort. Some topics of conversation might include:
    - What percentage of the licenses purchased have not been deployed?
    - Do you plan on deploying all of the licenses bought?
    - How much of a delay exists between puchase and deployment?

    - How aggressive are the power management settings?

- *Frequency of data collection:*
    - Sales data concerning the number of licenses sold – annually
    - Update the per-unit energy savings estimates – biennially
    - Update the baseline assumption - biennially

10. COMMISSIONING AND COMMISSIONING IN PUBLIC BUILDINGS

10.1 Introduction

In recent years the Alliance 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. With coordinators in each of the four participating states (Oregon, Washington, Idaho, and Montana), the project included the following specific 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, the Alliance 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. The two Alliance-sponsored commissioning efforts took different approaches to achieve a common objective of increasing commercial building commissioning in the region.

10.2 Approach to Energy Savings Estimation

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 building space (in square feet) in the Northwest and the savings from commissioning (in kWh per square foot).[55] With the addition of the Commissioning industry project (supporting the BCA), it is appropriate to expand the energy savings analysis beyond the public sector to include all commercial buildings as well as public buildings. The savings can be expressed as follows:

[55] The Alliance recognizes that some commissioning activity would have occurred even in the absence of the Alliance's efforts to promote commissioning. However, this report is intended to address the *gross impact* of commissioning, not just the incremental impact of Alliance activities. The Alliance is developing a separate baseline estimate against which total commissioning activity will be measured to determine attribution to Alliance projects.

Electricity Savings (kWh/year) =

(1) Commercial and public building space commissioned within the past five years[56] (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 discussions with select commissioning agents who were referred through the interviews.

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., retro-commissioning), based on median data from a meta-analysis of commercial-building commissioning conducted by Lawrence Berkeley National Laboratory.[57]

10.3 Data Collection

The long-term monitoring and tracking (M&T) approach involved initial contact with the Alliance's project manager, then a series of interviews with state coordinators and other government officials familiar with commissioning activity at public buildings. At the suggestion of several interviewees, calls were also made to individual commissioning agents active in the Northwest. The results of these efforts suggested that the best, and perhaps only reliable, way to quantify commissioning activity would be to survey individual contractors who perform commissioning services.

Discussions with the head of the Building Commissioning Association revealed that the BCA does not have data on the number or size of commissioned buildings. However, in early 2006 Portland Energy Conservation, Inc. (PECI) will be fielding a survey of BCA members and other commissioning providers that will include specific questions aimed at quantifying commissioning activity in both public and private buildings. Results of this effort are expected to be made available to the Alliance by spring 2006. Limited secondary research was also conducted to lend additional credibility to the per-square-foot energy savings estimates from the LBNL study that were used in the energy savings calculations.

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[56] The five year measure life is based on the ACE model. See *Commissioning in Public Buildings: Cost-Effectiveness Analysis Key Assumptions*, prepared by Ken Anderson of the Northwest Energy Efficiency Alliance, September 17, 2004. This is the same measure-life assumption used by Puget Sound Energy (see Tariff Schedule 250, Electricity Conservation Program). The state of Texas allows commissioning savings to persist indefinitely "provided that appropriate programmatic elements are included in the design" of the program, such as adoption of measures with long lifetimes, building operator certification for key personnel, etc. See Texas Administrative Code, Title 16, Part II, Chapter 25 Section 184(c)(12).

[57] 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 Commissioning: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States*, LBNL, December 15, 2004.

The following is a step-by-step description of the data collection process related to M&T for the Alliance's Commissioning and Commissioning in Public Buildings projects:

1. **Held discussion with the Alliance project manager (John Jennings)** to obtain feedback on the approach and specific ideas for additional contacts and for estimating commissioning activities data. Mr. Jennings provided a brief background on the role of key state liaisons and offered suggestions on what programs or issues to inquire about.
2. **Contacted each of the state representatives who coordinated the Alliance's commissioning efforts** under contract to either the Alliance itself or to the Oregon Office of Energy (the Alliance'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 many 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), Toby Benson, who referred us to Mark Hines and Georgia Brensdal, both from the DEQ
    d. Idaho Department of Water Resources (Energy Division), Sue Seifert, who referred us to Tim O'Leary of her department.
3. **Discussed commissioning activity with Michael Ivanovich, who at the time was head of the Building Commissioning Association**. Mr. Ivanovich was not able to provide data, but he indicated that PECI was planning to conduct a survey of commissioning providers, and he offered references to several prominent private-sector providers.
4. **Interviewed a variety of people associated with building commissioning in the Northwest,** including Rick Kunkle of Washington State University, who authored a study on state and local building commissioning code provisions; Michael Weiss, a past president of the BCA; Kent Barber, a past president of the Northwest regional chapter of the BCA; and various commissioning providers referred to Summit Blue through previous interviews.
5. **Reviewed secondary sources of data** for information on commissioning activity and energy savings estimates. Documents included:
    a. *The Cost-Effectiveness of Commercial Buildings Commissioning: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States***,** Lawrence Berkeley National Laboratory *et al.*, December 2004.
    b. *Cost-Benefit Analysis for the Commissioning in Public Buildings Project,* SBW Consulting for Northwest Energy Efficiency Alliance, undated (June 2003?).
    c. *Enhanced Baseline Assessment of Public Building Commissioning in the Pacific Northwest,* Quantum Consulting for Northwest Energy Efficiency Alliance, July 1999.
    d. *Local newspapers and business periodicals through electronic searches. This effort provided an indication of interest in commissioning, whether through press releases from companies commissioning buildings, announcements of training seminars, or other activity that may or may not be directly related to the number of buildings commissioned in the region.*
6. **Coordinated with PECI in developing and a survey of commissioning providers** that will provide information on commissioning activity in the region. Results may be available by spring 2006.

10.4 Findings

10.4.1 Commissioned Space in Commercial and Public Buildings

Estimates of commissioned space in commercial and public buildings are derived from three sources:

1. Data from the demonstration sites that were part of the Commissioning in Public Buildings project[58]
2. Project summary information from the LBNL study referenced above
3. Interviews conducted with state government employees and commissioning providers.

Only those projects commissioned in 2001 and later are included in the current estimates, since projects prior to 2001 would be beyond their five-year "measure life" in 2005. Out of the 33 demonstration projects, 12 were commissioned after 2000 and are included in the summary table below. Out of the LBNL report's 175 projects, several dozen are in the Pacific Northwest. However, most of these were commissioned prior to 2001, and most of the remainder were Alliance demonstration projects. Therefore, only three additional projects from the LBNL report are included in this analysis.

The interviews with state employees revealed the difficulty in estimating the number of commercial buildings, and the related floor space, that are commissioned in the Northwest. The final MPER for the Commissioning in Public Buildings project suggests that the best source for information on buildings in the Northwest receiving commissioning services would be commissioning providers themselves (i.e., BCA members).[59] However, the initial assessment by the Alliance and Summit Blue was that surveying a reasonable sample of agents was beyond the scope of this effort given the modest M&T budget. Furthermore, it was believed that state agencies would be able to provide reasonable estimates of commissioning in public buildings and that the BCA and its local chapter (of which a majority of commissioning agents are members) were likely to provide information on commissioning of both public and private buildings.

Unfortunately, there are few records available of public building commissioning activity outside of the demonstration projects done for the Alliance, and even fewer databases that have already consolidated the information. Also, the BCA has never collected records of commissioning activity, although it is planning a survey in late 2005 that could provide essential information for this M&T analysis. Prior to contacting the state liaisons, it was anticipated that a feasible alternative to a "bottom-up" accounting of public commissioning projects would be to get estimates of the percentage of new public construction that is commissioned. This estimate could then be multiplied by a measure of new construction activity obtained from the CBSA report or from Dodge data. However, none of the state employees was able to provide a firm estimate of the share of new buildings that are commissioned.

Through interviews with state liaisons to the Alliance, Summit Blue has identified records of commissioning of public buildings only in **Washington.** These records cover 33 projects since 2003, but they do not include public universities or local school districts. A DEQ employee in **Montana** indicated that limited commissioning of some state buildings has occurred, but he was unable to locate specific records. Other DEQ employees provided information that supports perhaps 10 retro-commissioning

[58] See *Market Progress Evaluation Report: Commissioning in Public Buildings Project, No. 3*, prepared for the Northwest Energy Efficiency Alliance by Quantum Consulting, Inc., February 2003.

[59] *Commissioning in Public Buildings: Market Progress Evaluation Report*, prepared by Quantum Consulting for Northwest Energy Efficiency Alliance, June 2005, p. 5-4.

projects and an unknown number of new commissioning projects. Compared to Washington and Montana, the Alliance was much less successful in encouraging Oregon and Idaho to adopt mandates to include commissioning in new construction of public buildings. The Alliance liaison in **Oregon** wrote that “the state does not carry any records which state buildings have been commissioned or not,” and he suggested that Summit Blue contact individual commissioning providers. An interview with a prominent commissioning provider in Washington identified about a dozen projects conducted in Oregon in recent years. **Idaho** does not track commissioning activity, and a state contact suggested that commissioning is not common.

Table 10-1 presents a breakdown of the 224 commissioning and retro-commissioning projects completed since 2001, as estimated from each of the three sources used for this analysis. Table 10-2 then presents estimates of the floor space covered by these projects, which amounts to more than 14 million square feet. Floor space is based on project-specific data for the demonstration projects and the LBNL data and on an assumed average of 60,000 square feet per project for commissioning activity identified through interviews with state employees and commissioning providers.[60]

Table 10-1. Number of Commissioning Projects between 2001 and 2005

Source	**Commissioning of New Buildings**	**Retro-Commissioning of Existing Buildings**	**Total (All Buildings)**
Alliance Demonstration Projects*	4	8	12
LBNL Study ** (not including overlap with demonstration projects)	1	2	3
Summit Blue Interviews	146	63	209
Total	**151**	**73**	**224**

* There were a total of 33 demonstration projects, but 21 were begun prior to 2001 and are not assumed to contribute to savings in 2005.

** Several dozen projects in the Northwest were evaluated in the LBNL study, but most of these were commissioned prior to 2001, and most of the remainder were Alliance demonstration projects.

Table 10-2. Floor Space Covered by Commissioning Projects between 2001 and 2005

Figures in square feet	**Commissioning of New Buildings**	**Retro-Commissioning of Existing Buildings**	**Total (All Buildings)**
Alliance Demonstration Projects*	728,000	500,466	1,228,466
LBNL Study ** (not including overlap with demonstration projects)	180,000	675,200	855,200
Summit Blue Interviews	8,760,000	3,780,000	12,540,000
Total	**9,668,000**	**4,955,666**	**14,623,666**

[60] The estimate of 60,000 square feet per commissioning project is based on states records from Washington and on interviews with state employees and commissioning providers. Some of the specific comments are included in the state-specific discussions below.

10.4.2 Washington

Washington appears to be the state with the most commissioning activity among the four states included in this assessment, largely as a result of the state's non-binding guidelines calling for commissioning of all new construction projects managed by the Department of General Administration (GA), which is responsible for projects for most state agencies and community colleges. According to Roger Wigfield, an energy system engineer with GA and the state liaison to the Alliance, the state maintains a database for most, but not all, state-owned buildings that have undergone commissioning (e.g., records do not include state-owned universities). The first recorded projects occurred in 2003.

As of September 2005, there were 33 unique commissioning projects in the state database, nearly all of them at community colleges and 30 of them commissioning of new buildings. Mr. Wigfield could not provide records of the square footage of the commissioned buildings, but he indicated that the size generally ranged from 30,000 ft^2 to 100,000 ft^2, with a conservative estimate of 60,000 ft^2 on average.

Table 10-3. Commissioning of State-owned Buildings in Washington, 2003-2005*

Year	Commissioning of New Buildings	Retro-commissioning of Existing Buildings	Total
2003	15	2	17
2004	12	1	13
2005	3	0	3
Total	**30**	**3**	**33**

* These figures do not include any commissioning that may have occurred at state-owned universities.

Source: Roger Wigfield, Washington Department of General Administration

Mr. Wigfield believes that most of the 33 buildings commissioned since 2003 were a direct result of the state's work with the Alliance to promote commissioning. State program efforts grew out of GA's involvement with the Alliance, which "helped move the market" for commissioning by helping to make the benefits of commissioning apparent to decision makers.

While the state does not have records of commissioning activity as the local level, Mr. Wigfield remarked that local school districts have been adopting commissioning. He routinely fields phone calls from school district officials seeking assistance after hearing about the state's commissioning work or visiting the commissioning web site. According to Wigfield, at least 30 and perhaps as many as 50 school districts have contacted him, and based on the discussions he estimates that a majority would have since completed commissioning projects. He suggested that contacting individual commissioning providers—such as through a survey with BCA members—would be the best way to quantify commissioning activity, and he specifically cited one firm as having conducted a majority of the K-12 commissioning projects in the state.

Summit Blue subsequently interviewed a former partner in the firm to obtain estimates of the number and size of commissioning projects completed. According to the interview, the firm has done commissioning projects at approximately 200 K-12 school districts on the West Coast (Washington, Oregon, and

California) over the past eight years.[61] The vast majority have been in Washington, with perhaps as many as 15 in California and 12 in Oregon. The average size of the projects was between 60,000 and 70,000 ft^2, and approximately 70% of the jobs were for new construction. The volume of the firm's commissioning projects has remained fairly steady over the years, suggesting that roughly 108 projects have been completed over the past five years in school districts in Washington. Perhaps 76 projects were new construction, and 32 were retro-commissioning of existing structures.[62] The partner interviewed estimates that the firm accounts for between 50% and 70% of the market in Washington; even assuming the higher number of 70%, this suggests that other firms have performed approximately 46 K-12 commissioning projects in the state. Thus, it is estimated that 154 school districts have been commissioned in Washington since 2001, with perhaps 108 new construction commissioning and 46 retro-commissioning projects.

Based on the information available from the state government (Department of General Administration) and from what is perhaps the state's most active commissioning firm, at least 187 public-building commissioning projects have been performed since 2001 (33 at state facilities and 154 at local school districts). The best estimate is that 138 projects were new buildings and 49 were existing buildings. The average size is approximately 60,000 ft^2.

10.4.3 Oregon

It appears that Oregon has had some commissioning activity, but Summit Blue has not yet been able to quantify it beyond the modest estimate provided for one of the prominent firms of perhaps 12 school district commissioning projects over the past eight years (see discussion for Washington, above). According to Andrej Pekalski, the state liaison for the Alliance, commissioning is still not required for new construction and is performed entirely on a voluntarily basis. Furthermore, "the state does not carry any records which state buildings have been commissioned or not. Some of the buildings may have been partially commissioned, depending on fiscal constraints. Individual agencies may consider commissioning but it is not mandated. Some state programs like SEED contain some elements of commissioning, but again, their execution is left to the agencies concerned." He added that he could provide little direct assistance in quantifying commissioning activity other than to provide references to providers of commissioning services. He suggested, "You'll be probably better advised to contact individual commissioning providers, or contractors who offer that type of services." (The PECI-sponsored survey of commissioning providers to be performed in early 2006 is expected to gather information on commissioning activity from individual providers.)

10.4.4 Montana

Unlike Washington, Montana does not have a centralized database of state building commissioning activity. Toby Benson, who is with the Department of Environmental Quality and was the Alliance commissioning liaison in Montana, believes that there were three commissioning projects performed several years ago that were not selected by the Alliance as case studies for the Commissioning in Public Buildings project. Additionally, 44 projects covering 5 million square feet may be in state records for the Rebuild America program, and some of these projects may have been commissioned. Mr. Benson was

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[61] The partner also estimates that the firm completed approximately 50 commissioning projects at universities, but it is not clear how many are community/state colleges that are included in the figures from the GA.

[62] According to the partner, the firm completed approximately 173 commissioning projects in Washington (200 on the West Coast minus 15 in California minus 12 in Oregon). Evenly spread across eight years, the past five years would have seen roughly 5/8 of 173, or 108 projects. Given that approximately 70% of the projects were new construction, about 76 (70% times 108) were new-building commissioning projects, and 32 were retro-commissioning.

unable to locate the specific information, but he referred Summit Blue to two other employees at DEQ who are familiar with commissioning: Mark Hines, an engineer in the architecture and engineering group who is responsible for commissioning of new state buildings, and Georgia Brensdal, the engineer from DEQ who is responsible for retro-commissioning projects. Both work on state construction only, and their comments below are limited to that sector.

Ms. Brensdal provided Summit Blue with some quantifiable and anecdotal evidence of retro-commissioning in Montana. Last year approximately three contracts were let, while three have already been let in the first six months of this fiscal year (July 1 start) and it is anticipated that another three are likely. Ms.Brensdal sums up that commissioning is probably increasing in Montana, and the state is really just getting started. There are approximately 100 existing buildings that are practical to do, and the state has retro-commissioned perhaps 15% of these in recent years. As a conservative estimate, this analysis assumes that 10 projects have been retro-commissioned since 2001. Ms. Brensdal typically looks at systems in buildings in the range of 30,000 to 70,000 square feet.

Mr. Hines generally concurs on the status of commissioning in Montana, and he says that most new buildings for the state are commissioned, but the extent varies depending on the funding for the project. Mr. Hines explained that funding typically follows a two year cycle in the Montana legislature and that funding can vary, in part because the University of Montana and Montana State University are sometimes able to obtain grant money to assist in commissioning. Without specific new construction figures, and given the uncertainty over how extensive the new building commissioning is, this analysis does not include new building commissioning in the energy savings estimations, other than projects done as demonstration projects.

Both Brensdal and Hines agree that the efforts of the Alliance came at just the right time for commissioning in their state. Brensdal comments,

> "We utilized [Alliance] case studies, and their experiences to justify our investments. They helped us get commissioning providers into the state. I think they were real important. Especially the case studies and the credibility it lends the process. I'm not sure that we would have gotten off the ground without it. We had grants in place, but we wouldn't have had the money to do the verification of savings that the Alliance did."

On the future of commissioning in Montana, Brensdal is somewhat optimistic, and Hines a bit more cautious. He is concerned that there is little money available to spend on retro-commissioning, especially for small obviously needed building tune-ups. The 10 year bond-mechanism is not a good option for paying for short term investments. Also, he notes, that assistance in building benchmarking would be of great help to him in discussing building energy consumption with facility managers. With benchmarked data in hand, he could help over come the somewhat natural defensive posture that facility managers are often placed in when defending their buildings' energy consumption.

10.4.5 Idaho

Idaho simply does not have the staff or resources to track commissioning in their state on a square footage basis or otherwise. At this time, the state cannot provide sufficient information to document specific commissioning project other than those commissioned as demonstration projects. In general, Idaho ties retro-commissioning more closely to the LEED process than either Montana or Oregon. Summit Blue spoke to Tim O'Leary of the Department of Water Resources, Energy Division. He explained that the popularity of LEED and the included requirement of commissioning helps pull in architects and engineers who may not have been initially "on board" with commissioning. According to O'Leary, LEED appears to be gaining ground in Idaho, and commissioning is riding in on the coat tails. This is important because commissioning is not generally required in the state of Idaho. A requirement to commission buildings over a certain size was watered down to by the legislature to "strongly recommend" commissioning. There is however a stronghold in the county of Ada, where they have adopted a requirement to commission buildings in the municipalities and school districts of the county.

Performance contracting is exploding in Idaho. In particular, school districts are feeling the pinch of rising energy costs where, according to the American Society of Civil Engineers, 56% of Idaho's schools have at least one inadequate building feature and 64% of Idaho's schools have at least one unsatisfactory environmental condition.[63] Performance contracting, while not truly building commissioning, is one measure of attention paid to the energy performance of a building. O'Leary explains, "we use performance contracting to market commissioning. If there is a guarantee, so much the better." O'Leary sees the rising fuel prices as fertilizer to the seed of commissioning the Alliance helped to plant.

> "Programs such as Performance Contracting and LEED are the water that will continually sustain the Commissioning industry [seed] and spread the plant until it becomes an industry standard. It seems as though rising fuel prices and commercial energy efficiency are not yet significantly important issues within the commercial industry in this state but I am certain their importance will grow over time. When that happens, we will be ready with concepts such as Commissioning to help them maximize the efficiency of their built environments."

10.4.6 Estimate of Annual Energy Savings

As described in Section 10.2, the ACE model calculates energy savings according to the following formula:

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 (kWh/ft^2 per year)

Across the four Northwest states, it is estimated that over the past five years (2001 through 2005) 9.7 million square feet of new building space has been commissioned and 5.0 million square feet of existing building space has been retro-commissioned. Based on the savings assumptions of 0.55 kWh/ft^2 per year for newly commissioned buildings and 1.7 kwh/ft^2 per year for retro-commissioned buildings, electricity savings in 2005 are 5.3 GWh from commissioning and 8.4 GWh from retro-commissioning.

[63] American Society of Civil Engineers, Report Card for America's Infrastructure, at http://www.asce.org/reportcard/2005/page.cfm?id=52

Table 10-4. Electricity Savings from Commissioned Buildings in 2005

	Commissioning of New Buildings	Retro-Commissioning of Existing Buildings	Total (All Buildings)
Commissioned Space (*Ft²*) (A)	9,668,000	4,955,666	14,623,666
Electricity Savings (*kWh/ft² per year*) (B)	0.55	1.7	Not Applicable
Electricity Savings (*MWh/yr*) C= (A * B)	5,317	8,425	13,742
Electricity Savings (*aMW*) (C / 8760 hours)	0.61	0.96	1.57

10.5 Conclusions and Recommendations

10.5.1 Conclusions

Alliance projects supporting public building commissioning and the BCA 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. The following are major conclusions of this M&T research:

Centralized records of commissioning activity are available only for Washington. Between these records and interviews with a prominent commissioning provider, it is estimated that at least 187 public buildings have been commissioned in Washington since 2001, with a large majority new buildings. Notably, these records do not include city buildings or state universities. Other states may have limited records of commissioning projects, but the information is not centralized and could not be easily located.

Staff at state agencies in Washington and Montana directly credit the Alliance for much of the recent commissioning of public buildings in those states and for helping to attract commissioning providers. However, anecdotal evidence suggests that commissioning of K-12 schools has remained roughly steady, at least in Washington, and any increase in activity may be offset by less comprehensive commissioning services for the average project.

Washington has adopted non-binding guidelines for commissioning of all new construction projects managed by the Department of General Administration (which is responsible for projects for most state agencies and community colleges) that have a value of more than $5 million, and this has likely been a catalyst for much of the commissioning activity reported above. Montana has included commissioning as a line item for all new construction projects in the state's Long Range Building Plan, although the limited amount of new construction in the state is likely keeping commissioning activity modest. Oregon and Idaho have not adopted any specific mandates or guidelines to include commissioning in new construction projects. As a result, it is assumed that commissioning activity in these states is relatively low.

The Alliance was the principal reason for the emergence of the BCA, according to Kent Barber, a recent president of the Northwest chapter. Michael Weiss, a former president of the BCA, believes that the volume of commissioning activity has definitely increased in the past four or five years, and that the BCA has been a driving factor. Weiss called the Alliance "incredibly instrumental in getting the commissioning market kicked off," citing the development of training materials and other resources used by commissioning providers to quantify savings and convince building owners to invest in the process. Barber is uncertain how much direct influence the BCA has had in the Northwest, but he credits the Alliance with an increase in commissioning activity (such as through the Commissioning of Public Buildings program), and he sees momentum building in the local BCA chapter. Barber also cited numerous RFPs in recent years that require commissioning providers to comply with "BCA attributes," ensuring that commissioning meets minimum standards. This is especially important as the number of commissioning providers and the volume of commissioning activity grow since he believes that market forces have steered commissioning toward lowest-priced services that may not qualify as "commissioning" as defined by the BCA and supported by the Alliance.

10.5.2 Recommendations

Absent a detailed survey of commissioning providers, Summit Blue is able to estimate only a limited number of commissioned buildings in some, but not all, sectors of the public arena. Even less information can easily be obtained for private buildings. As a result, this report presents an initial, conservative estimate of commissioning activity and corresponding electricity savings. Later in 2006 PECI is expected to complete a survey of commissioning providers that provides more comprehensive information on commissioning activity than can be gained through interviews alone. Once the survey results are available, an estimate will be possible for the market penetration for commissioning in new and existing buildings in the Northwest, and a revised estimate of electricity savings can be made.[64]

At this time, market penetration figures can be assessed in relation to the baseline assumptions of roughly 11 million square feet commissioned per year. If the baseline assumptions no longer appear valid, it is recommended that an attribution analysis be conducted to estimate the share of commissioning activity that occurred as a direct result of Alliance efforts in support of commissioning.

Summit Blue recommends that next year's M&T effort focus on results of the PECI survey, characterizing the commissioning market in terms of the number and types of providers, the types of buildings commissioned and retro-commissioned, and other attributes available from the data. On a continuing basis, it is recommended that the M&T analysis be conducted every two years and include the following activities:

Contact with state representatives 1) to obtain updates to existing commissioning databases or identify new sources of state records, and 2) identify new state requirements or guidelines for commissioning of public buildings.

Survey of commissioning providers, coordinated through PECI if necessary to ensure consistency of questions and to allow for collection of time-series data.

Interviews with some of the largest commissioning providers to better understand the market and the factors driving their business.

[64] A recent study conducted for the Alliance found that 36% of the floor space designed by architects in the Northwest in 2003 was commissioned, as self-reported by architects surveyed. See *Commercial Sector Initiative Baseline Study: Architects*, Research Into Action, November 2004.

11. Small Commercial HVAC (AirCare Plus)

11.1 Introduction

In October of 2001, in response to an unsolicited proposal from Portland Energy Conservation Inc. (PECI) in fall 2001, the Alliance funded a small HVAC pilot effort under the Efficient Solutions component of its Commercial Sector Initiative. The pilot targeted 5-15 ton RTUs packaged rooftop units (RTUs) on commercial buildings. The program, called ***AirCare Plus,*** was designed to create a sustainable market for premium energy-efficiency tune-up services. Existing HVAC service providers would market the service as a supplement to their standard service contract providing superficial maintenance.

As stated in the Market Progress Evaluation Report No. 1 on the Small Commercial HVAC Program in November 2004, *"The market transformation theory underlying this program hypothesizes that, once proven, the additional revenue stream available from this service would provide a significant incentive for service contractors to market and sell the service."* PECI implemented the pilot program between February 2003 and February 2004, training 20 contractors and marketing it to limited markets in Washington, Idaho, and Montana. The pilot program confirmed that significant energy savings opportunities exist but the service was costly, received only moderate acceptance by contractors and customers, and could not deliver predictable energy savings. The Alliance discontinued funding as of February 2004, and no resources are currently being invested outside of periodic monitoring and tracking of residual program impacts.

11.2 Approach to Energy Savings Estimation

The AirCare Plus program *did not get beyond the pilot stage*, and energy savings were minimal and difficult to quantify, with cumulative energy savings of 0.02 aMW (2003 Market Activities Report). Given this history, the initial intent of this long-term M&T report did not include an explicit calculation of energy savings for the AirCare Plus program. However, since the program continues to be offered and there are quantifiable savings from programs in California and Idaho, this report presents findings for energy savings related to premium RTU tune-up services. It should be noted, however, that since *all identified activity is supported by utility incentives, none of the savings are credited to the Alliance*.

Energy savings for a given measure are calculated as follows:

Electricity savings (kWh) =

(1) Number of RTUs serviced with the measure

x (2) kWh savings per RTU for the measure

where:

Number of RTUs serviced with the measure is based on PECI program records.

kWh savings per RTU for the measure is based on PECI estimates of electricity consumption pre- and post-implementation of the measure, calibrated to annual energy use based on billing data. This is done for all measures except for refrigerant tune-up, which is based on data collected over the past three years.[65]

Measure types include basic inspections, airflow service retrofits, economizer adjustment retrofits, refrigeration compressor retrofits, thermostat replacements, and thermostat medication retrofits.

11.3 Data Collection Methodology

The M&T approach involved initial discussions with the Alliance's project manager and program contractor, then a series of interviews with original contractors from the pilot program and some currently offering the AirCare Plus service. Further discussions were held with the program contractor to obtain data to estimate measure savings. Specifically, the data collection included the following steps:

1. **Contacted the Alliance project manager (John Jennings)** to gain additional perspective on the program and its impacts and to identify the service contractors offering the AirCare Plus service.
2. **Contacted the Portland Energy Conservation, Inc. project manager (Dianne Levin)** to identify additional providers of AirCare Plus and to get input on current program activities, participating service contractors, and savings. PECI, after obtaining permission from Avista and Southern California Edison (SCE), provided summary data for 2005 as follows:
    - Savings per RTU for each measure
        i. Avista calibrated data
        ii. SCE deemed savings
    - # of RTUs by measure
    - Average size (tons) of RTUs by measure
    - # of sites/customers by measure
3. **Interviewed 16 of the 20 original services providers and 5 of the 16 active AirCare Plus service providers,** including those identified by the Alliance and PECI during initial contacts, to determine current activities related to the services.
4. **Contacted the program evaluation contractor, Stellar Processes,** to better understand the energy savings impacts from the pilot phase, their use by PECI, and to adjust savings estimates.
5. **Reviewed other literature sources such as the California DEER database and CALMAC** to determine if there are other estimates to help assess the accuracy of savings estimates per measure.

11.4 Findings

Program Delivery

Since February 2004, PECI has implemented the AirCare Plus program for Avista Utilities in Idaho and Southern California Edison (SCE) in California, targeting RTUs between 4 and 20 tons. AirCare Plus uses a hand-held computer and other technology to provide HVAC technicians a comprehensive diagnosis of a roof top unit's refrigerant charge, airflow and economizer functions. The program offers technical training and assistance and sales and marketing tools. A website (http://www.aircare-plus.com) provides information on the service, tools and technology, components of the service inspection, a list of

[65] Source: Spreadsheet with Supporting Calculations provided by PECI.

16 certified service contractors, and resources for contractors. All but three contractors are based in California; two are based in Idaho and one in Washington.

Puget Sound Energy (PSE) in Washington offers a similar program—Premium HVAC Service for Rooftop Units[66] that have an economizer. The program has been incorporated as a general offering under the Commercial Energy Efficiency Rebates program[67], which is targeting only 14 MWh in annual savings[68]. The pilot trained contractors to provide enhanced maintenance services which focus on energy savings measures, and provided three rebate levels; from $350 to $750 per unit, depending on the level of Premium Services and amount of equipment repair or service required.

All three utilities provide incentives for the measures; half of SCE's 2005 program budget of $1.5 million was for incentives[69]. Table 11-1 shows incentives offered in 2005 by Avista and SCE. [70]

Table 11-1. Avista and SCE Incentives for Premium HVAC Tune-Ups

Measure	Incentive
Air Flow71	$100
Basic Package (inspection)	$60
Economizer control package	$85
Economizer adjustment	$50
Programmable thermostat adjustment	$30
Thermostat upgrade & economizer adjustment	$150
Refrigerant tune-up – one compressor	$10072
– two compressors	$15073
Premium HVAC Services for Rooftop Units	$350-750

11.4.1 Energy savings

Since the Alliance is charged with achieving market transformation in the Pacific Northwest, only those activities within the region (i.e., in the Avista and PSE service territories) are considered. In fact, the only documented savings from the AirCare program are from those projects receiving incentives from Avista. Since the Alliance does not take credit for savings achieved with the support of utility incentives, no savings are credited to the Alliance. However, the savings from the AirCare program are real and are a

[66] PSE Efficiency Programs and Rebates http://www.pse.com/solutions/ForBusiness_EfficiencyPrograms.aspx

[67] Source: Puget Sound Energy website. Program Descriptions. http://www.pse.com/energyEnvironment/rfpFiles/App%20A%20Pgm%20Descriptions.pdf

[68] Source: PSE website Program Targets & Budget http://www.pse.com/energyEnvironment/rfpFiles/App%20B%20Pgm%20Targets%20Budgets.pdf

[69] Personal correspondence from D. Levin, PECI, November 2005.

[70] Southern California Edison AirCare Plus – Enhanced HVAC Service Program Participation Agreement, AirCare Plus website, November 2005.

[71] PECI to combine with Refrigerant tune-up next year

[72] Will be raised to $150

[73] Will be raised to $200

direct effect of the Alliance's support for the initiative. Therefore, savings are quantified below in order to gauge the impact of AirCare Plus and the potential for future savings throughout the region.

As described in Section 2, electricity savings for a given measure are estimated according to the following formula:

Electricity savings (kWh) =

(1) Number of RTUs serviced with the measure

x (2) kWh savings per RTU for the measure

11.4.2 Number of RTUs Serviced with Each Type of Measure

As discussed above, the quantifiable energy savings from the AirCare Plus service in the Northwest are all a result of the program supported by Avista. Under the program, contractors take pre- and post-measurements using a hand-held computer and upload the data to the PECI database once the service is completed. This database captures site information, including the size of each RTU in tons and the measures implemented. Findings presented in this section are based on the data from 2005.

The average size of RTU in tons is relatively small (4.2 to 6.7 tons/RTU) for all measures but the Refrigerant 2 compressor retrofit which had an average of 12.5 tons per RTU for the two RTUs that had this measure implemented. The average size of RTUs for all measures was only 5.5, indicating that most of the RTUs are at the bottom of the range eligible for the program. In total 440 measures were performed on 308 RTUs, with two measure types—basic retrofits and thermostat modifications—accounting for close to 90% of the activity. Table 11-2 shows the number of RTUs and average size of RTU for each measure covered by the program.

Table 11-2. Number of RTUs by Measure Implemented (2005)

Measure	#RTUs	Average Size of RTU (ton)
Airflow Service	33	4.2
Basic Inspection	307	5.7
Economizer Control Package	16	5.8
Refrigerant Tune up (1 compressor)t	3	6.7
Refrigerant Tune up (2 compressors)	2	12.5
Thermostat Modification	79	5.0
TOTAL	**See note below**	**5.5**
A total of 440 measures were performed on the 308 RTUs serviced through the program in 2005.		

11.4.3 Savings per RTU by Measure

In 2002 protocols (diagnostic & maintenance steps) were developed for thermostats, airflow, refrigerant charge and economizers. In 2003 Stellar Processes, Inc. conducted technical monitoring and verification to provide an estimate of energy savings for program measures and to determine if the savings estimates calculated by the PECI model were valid. They used a case study approach for several reasons including that "*high variability is to be expected in the observation of savings.*" Stellar Processes did short-term monitoring and applied a calibrated energy simulation model which compared energy savings during the monitoring period to the rest of the year according by weather-adjusting historical billing consumption. Conclusions of the M&V work were as follows: 1) There were an insufficient number of cases to adequately test refrigerant charge; 2) Airflow adjustments did not appear to provide substantial savings; 3) Economizer savings were much higher than PECI estimates; and 4) Thermostat savings were slightly lower than PECI estimates.

PECI calculates energy savings by measure for Avista customers using a simulation model, taking pre- and post-measurements on each RTU and using these data to estimate annual savings for each measure, except for refrigeration savings. These savings are based on average kWh savings per RTU for refrigeration units with one compressor and refrigeration units with two compressors for the previous three years[74]. The table below shows the average kWh savings by measure for Avista participants in 2005.

Table 11-3. Estimates of Energy Savings (kWh per RTU) by Measure for Avista

Measure	Average kWh Savings per RTU
Airflow Service	1.9
Basic Inspection	270
Economizer Adjustment	1,573
Refrigerant Tune-up (1 compressor)	919*
Refrigerant Tune-up (2 compressors)	1,135*
Thermostat Modification	1,633
* Based on average kWh/RTU for program participants over three years.	

PECI estimates of savings by measure are based on the actual savings for each RTU except for refrigerant measures which are based on data compiled over the last three years, likely due to the small number of measures implemented in 2005. The current estimates are reasonably consistent with Stellar Resources findings, except for refrigerant savings as no measures were done in the pilot. Estimates for refrigerant may be high or low for individual sites, depending of the size of RTUs.

A search of the literature for other comparable savings estimates did not yield any applicable insights, as databases of measures such as the DEER database focus on replacing technologies rather than on services such the AirCare Plus.[75] Savings are expected to persist for three years with the Premium RTU service required to be repeated every three years.

11.4.4 Electricity Savings

Total savings were estimated by multiplying the number of RTUs receiving a particular measure by the unit savings (kWh per RTU) for that measure, and summing across all measures. As shown in Table 11-4

[74] Source: PECI Spreadsheet of program assumptions.

[75] Other references, while not providing specific savings for AirCare plus efforts, did look at achievable savings from improvements to RTUs, including; *Upstream Solutions to Downstream Problems: Working with the HVAC and Efficiency Communities to Improve Field Performance of Small Commercial Rooftop Units* by Peter C. Jacobs, Architectural Energy Corporation, Cathy Higgins, New Buildings Institute, and Rachael Shwom, Consortium for Energy Efficiency; ACEEE Summer Study on Energy Efficiency, 2004.

and Figure 11-1 below, most savings came from two measures—over half (53%) from thermostat modifications, with another third (34%) from the over 300 basic inspections. Economizer adjustments saved 25 MWh for 16 RTUs, and refrigerant measures, though seldom implemented, saved 5 MWh from 5 projects alone. Savings from airflow service were minimal; PECI now combines it with the refrigerant measures.

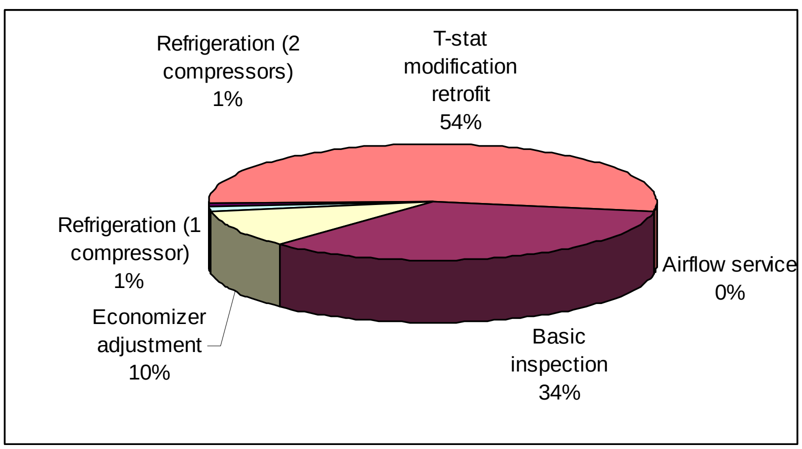
Table 11-4. Energy Savings from Avista AirCare Plus Program 2005

Measure	**#RTUs (A)**	**kWh Savings/RTU (B)**	**kWh Savings* (A * B)**
Airflow Service	33	1.9	62
Basic Inspection	307	270	82,947
Economizer Adjustment	16	1,573	25,171
Refrigerant Tune-up (1 compressor)	3	919	2,757
Refrigerant Tune-up (2 compressors)	2	1,135	2,270
Thermostat Modification	79	1,633	128,977
TOTAL	**308****	**-**	**242,184 (0.028 aMW)**

* Estimated savings are attributable to the AirCare program. However, the Alliance does not claim credit for the savings since the AirCare services were supported by Avista incentives. kWh savings may not exactly equal the number of RTUs multiplied by the unit savings due to rounding in the unit savings figures.

** Multiple measures were performed on some RTUs.

Figure 11-1 2005 Avista Savings by Measure (242 MWh Total)



PECI also provided 2004 AirCare results, however savings for each RTU were not broken out by measure. Instead, total kWh savings were provided for each RTU, some of which had several measures implemented. Table 11-5 shows total RTUs, measures, and energy savings for Avista for 2004 and 2005. The number of RTUs serviced increased by a factor of roughly 4.0 between 2004 and 2005. However, since there were more than three measures per RTU in 2004 compared to less than 1.5 measures per RTU in 2004, the number of measures and the kWh savings roughly doubled from one year to the next. Total savings over the two years is estimated at 369 MWh, or 0.04 aMW.

Table 11-5. Avista Results (2004 & 2005)

Year	# of RTUs	# of Measures	kWh Savings	aMW
2004	74	250	127,061	0.028
2005	308	440	242,184	0.015
Total	**382**	**690**	**369,245**	**0.04**

11.4.5 Interviews with Market Actors

Summit Blue interviewed several market players in order to find out about current contractor market activity for premium HVAC services for rooftop units. These interviews included:

- PECI staff to determine whether they continued the program, identify changes made since the pilot, and obtain information on contractor participation, incentives, and energy savings;
- Contractors who had participated in the original Alliance-funded pilot to see if they were continuing to provide such services; and
- Contractors currently providing AirCare Plus services in Idaho and California to determine activity and solicit their opinions on the programs.

11.4.5.1 Portland Energy Conservation Inc.

Interviews with PECI provided an update on the AirCare Service since Alliance funding ended in February 2003. PECI delivered this program for Avista Utilities in Idaho in 2004 and 2005 and for SCE in 2005, providing training and other resources for contractors, and administering incentives for the utilities.

PECI made program changes to deal with issues identified in the pilot—specifically, the time required to complete the service and the lack of reliability in savings estimates. The first issue was resolved by using a hand held computer to diagnose savings and capture data. Once the service is completed, data is downloaded to a secure website, available immediately, and a customer summary report automatically generated showing unit specifications, findings, actions, and estimated gas and electric savings. Measurements are calibrated to billing data to get better estimates of savings.

Other program changes included: turning the screening into an audit—promoted as an "inspection"—which also identifies energy savings that can be rebated, adapting to seasonal business cycles, and providing high incentives to encourage contractors to participate. Many contractors have

> - Each technician is expected to perform AirCare Plus services on 16 RTUs per month during the swing season in spring and fall. If they do this they keep the equipment and got a free year of licensing.
> - Technicians who serviced 13 RTUs per month between February and December 2005 could buy the equipment and an additional year of licensing for $500.
> - The program was designed so most services would take place March though May and October through December, avoiding conflict with busier corrective maintenance work during high season.
>
> AirCare Plus Website

difficulty covering even the training costs.

11.4.5.2 Original Contractors

Summit Blue interviewed 16 out of the original 20 contractors; only two were providing premium HVAC tune-up services, one with a program similar to Avista's that is being offered by Puget Sound Energy in Washington. The contractor participating in the PSE program had serviced 50 units and had a backlog of 50 more. The program involves measures such as an airflow monitoring device, cleaning coils, servicing economizers. The contractor said that the goal of 5-15% energy savings is being exceeded. The other contractor was based in Oregon and did not provide details. The general view of the contractors interviewed is that if incentives were offered, and appropriate changes made to the pilot such as decreasing the length of time to complete the services, they would participate in AirCare Services again.

Two major themes emerged from the interviews, suggesting that AirCare Plus is a useful service valued by contractors, but that the market is still not mature enough to sustain the service without financial incentives. The themes are:

- Contractors liked the AirCare program, and they value the skills they learned.
- Customers see value in the premium tune ups, but few will invest the incremental cost.

11.4.5.3 Current Contractors

Summit Blue interviewed five of the 16 active contractors – two out of the three contractors in Avista territory and three contractors in SCE territory. One of the Avista contractors is very satisfied but said that he had lost money in the first year; the other contractor dropped out because Avista did not provide the rebates in the timeframe that they had promised. The participating contractor serviced 200 units in the previous six months. The three SCE contractors interviewed were all active in the program.

Overall the contractors were very satisfied with the value of the program to their business and to customers, but incentives are still critical to market the program. Several themes emerged:

- Contractors believe there is a market for AirCare Plus services and want to see the program continued and expanded to other markets.

- Contractors use the program to differentiate themselves from competitors and to find opportunities with the customers.

- Incentives are extremely important.

- Program timing has been significantly improved. According to contractors it sometimes required up to three site visits before the PDA was introduced; now results are approved instantaneously.

11.4.6 Lessons Learned from California

As shown in Table 11-6below, participation and savings in California were roughly four times higher than in Idaho, with contractors in SCE territory servicing 1,788 units compared to 440 in Idaho. All types of measures were implemented.

Table 11-6. 2005 Energy Savings (CA & ID)

Measure	California		Idaho	
	# of RTUs	**kWh**	**# of RTUs**	**kWh**
Airflow Service	33	12,210	33	62
Basic Inspection	1,306	522,400	307	82,947
Economizer Adjustment	53	49,025	16	25,171
Economizer Control Package	38	43,700	0	0
Refrigerant Tune-up (1 compressor)	13	22,750	3	2,757
Refrigerant Tune-up (2 compressors)	10	22,000	2	2,270
Thermostat Modification	296	213,120	79	128,977
Thermostat Replacement	39	140,400	0	0
Total	**1,788**	**1,025,605**	**440**	**242,184**

There are several lessons learned from California that could be applied to the Northwest.

- **Extend the market for AirCare Services beyond Idaho**. There were only three contractors participating in the Avista program, and one noted that he had saturated the market in northern Idaho in the spring. With a larger market and more contractors participating, results would likely be much higher.

- **The calibrated model provides more accurate estimates of savings.** SCE used deemed savings per RTU rather than the calibrated model, used by PECI and supported by Stellar Resources research, that was applied to activity in Avista's territory. As seen in Table 7, kWh savings per measure, where calibrated, can be significantly different, even accounting for climate differences.

- **Thermostat replacement can provide significant savings.** In Idaho, no thermostats were replaced; inspections and thermostat modifications accounted for 87% of savings. In California, three measures—inspections, thermostat modifications, and thermostat replacements—account for 86% of energy savings.

Table 11-7. 2005 SCE vs Avista Savings by Measure

Measure	Savings (kWh per RTU)	
	SCE	Avista
Airflow Service	370	0-1.9
Basic Inspection	400	270
Economizer Adjustment	925	1,573
Economizer Control Package	1,150	n/a
Refrigerant Tune-up (1 compressor)	1,750	919*
Refrigerant Tune-up (2 compressors)	2,200	1,135*
Thermostat Modification	720	1,633
Thermostat Replacement	3,600	n/a
* Based on average savings by RTU over last 3 years.		

11.5 Conclusions

Programs offering premium tune-up services for rooftop units (e.g. AirCare Plus Services) have been offered in the Northwest and California over the last two years. Although all activity in the Northwest is supported by utility rebates, thus the Alliance will not claim credit, there are real energy savings achieved by such services.

- Overall savings in the Northwest were quite small, achieving an estimated 369 MWh (0.04 aMW) in 2004 and 2005;
- California achieved much higher program participation and savings (1,026 MWh or 0.12 aMW), likely due to the much larger size of the market;
- Estimates of savings in the Northwest were based on a calibrated model for most measures and are more accurate than if they were based on deemed savings.
- Contractors currently participating are satisfied with the program and contractors who participated in the pilot would be willing to participate again; and,
- It is likely that incentives will continue to be required for several years if the program is to continue.

11.5.1 References

Small Commercial HVAC Pilot Program: Market Progress Evaluation Report, No. 1, prepared by Energy Market Innovations, Inc. for Northwest Energy Efficiency Alliance, November 2004.

Excerpts from AirCare Plus database, program assumptions, and progress reports, personal correspondence between Summit Blue Consulting by Dianne Levin, PECI, January 2006.