2006 Long Term Monitoring and Tracking Report

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E. EXECUTIVE SUMMARY

E.1 Introduction

The Northwest Energy Efficiency Alliance (NEEA) tracks the market progress of its projects during their implementation phase through periodic Market Progress Assessment Reports (MPERs). However, since market diffusion often occurs after NEEA funding has ceased, NEEA also needs a mechanism for tracking ongoing market progress and associated aMW savings in the post-funding period. In 2004, NEEA developed a process for tracking and monitoring the market progress of projects that it no longer funds. The goal of this long-term monitoring and tracking (M&T) is to measure and track critical market progress indicators and Alliance Cost-Effectiveness (ACE) model assumptions that are used to estimate on-going and accumulated electricity savings from the market effects.

The seven programs that were reviewed as part of the M&T effort for 2006 include:

- BacGen (updated)
- Evaporator Fan VFDs (updated)
- MagnaDrive
- SAV-AIR (updated)
- Siemens (formerly Shell Solar)
- SIS/AM400
- Commissioning and Commissioning in Public Buildings (updated)[1]

Summit Blue developed a work plan for each M&T program under review for 2006, and these were provided to NEEA's M&T project manager for review in August 2006. Data collection and analysis began shortly thereafter. For each program, the M&T project team focused on tracking current activity in the market, examining NEEA's baseline assumptions, and assessing the likelihood of additional market effects not captured in program accounting. Chapters 2 through 7 of this report present the savings approach, data collection methods, findings, and recommendations for each project listed above.

E.2 Results by Program

BacGen

In tracking BacGen's current market activity, as well as interviewing BacGen and utility staff, findings suggest that savings estimates reported by BacGen are likely the most accurate source of savings data. Therefore, Summit Blue recommends that savings should be aggregated from BacGen-reported data and input into the ACE model each year. The M&T project team concluded that a small level of BacGen's reported savings likely would have occurred in the absence of the BacGen project. This finding was based on a review of the MPERs, other secondary literature, information on wastewater efficiency efforts in other parts of the country, and interviews with seven wastewater treatment operators who are *not* BacGen customers. Although no data exists to substantiate the exact percentage of BacGen's savings that should

[1] The Commissioning update is contingent on results from surveys that had not been fielded by the publication of the 2006 M&T report. The Commissioning report will be provided as part of the 2007 M&T effort.

be attributed to baseline activity, Summit Blue recommends that NEEA adjust its baseline to 5-10% for all projects in 2006.

This M&T effort also examined whether the BacGen project induced market effects not captured in program accounting. Although the M&T project team concluded that BacGen has not influenced operators or other consulting firms to pursue *wastewater process optimization* at this time, Summit Blue *does* recommend that NEEA include savings from *wastewater design consulting services* in its program accounting. The prospects for significant continued market activity in the Northwest is good, and Summit Blue recommends that NEEA continue tracking BacGen projects and reassess market effects in future M&T efforts.

Evaporator Fan VFDs

Cascade Energy Engineering, the implementation contractor for the Evaporator Fan VFD Initiative, provides NEEA with updated data quarterly for energy savings due to evaporator fan VFD installations at various types of cold storage facilities in the region. Cascade determines savings through detailed energy engineering calculations including an analysis of the operating conditions and fan-speed profiles. However, the key metric for determining market effects is the horsepower (HP) capacity of evaporator fans with VFD control, and this was generally not provided by Cascade in their reporting to NEEA after 2001. Without capacity data, no comparisons can be made between the installations that Cascade reports and the total market for evaporator fan VFDs. As such, Summit Blue recommends that NEEA use a small portion of the M&T budget for 2008 to have Cascade review its historical records and input affected motor HP and affected storage space (cubic feet) when available for each of its evaporator fan VFD installations. This will further allow for an updated estimate of per-unit energy savings.

The M&T project team also examined NEEA's assumptions regarding baseline activity in the Northwest. Based on the results of interviews with regional market actors and a secondary literature review, Summit Blue concluded that the baseline is reasonable and recommends no change to the ACE model. The M&T project team also conducted interviews with refrigerated warehouse facility owners, operators, and controls vendors in the Northwest to determine whether any additional market effects could be attributed to the VFD Initiative. Summit Blue found that additional market effects exist through the activities of two companies, and the associated energy savings attributable to the VFD Initiative are estimated at 1.17 MWh/yr. Lastly, Summit Blue recommends that NEEA continue to survey facility owners and operators in future M&T efforts with a focus on determining the market penetration of VFDs on evaporator fans in the Northwest.

MagnaDrive

Summit Blue reviewed MagnaDrive sales data for the Northwest and found that adjustable-speed drive (ASD) sales for 2006 control 6,230 HP of motor capacity, which is a 21% decrease from 2005. Derived from a number of sources, the annual per-unit energy savings for a MagnaDrive ASD as used in the ACE model is based on the average annual operating hours per year and the average energy savings percentage. The M&T project team reviewed these inputs and found that the average annual operating hours should be adjusted every year based on the average motor size (HP) for MagnaDrive sales that year. The average energy savings percentage was also recalculated based on a higher ratio of pump-to-fan applications for the ASD. Therefore, Summit Blue recommends adjusting the per-unit savings *each year* based on the average motor size and the revised energy savings percentage.

The M&T project team also reviewed the ACE model assumptions of zero baseline activity and no market effects beyond those captured by MagnaDrive sales. Specifically, Summit Blue researched the MPERs, reviewed MagnaDrive's website, and interviewed NEEA and MagnaDrive staff. Findings from this research suggest that the baseline condition is not always “no speed control.” In more than one-third of MagnaDrive ASD sales, the appropriate baseline would be a VFD, in which case zero energy savings would be achieved by installing the ASD. However, additional market effects from the MagnaDrive project are currently not being captured in program accounting, including savings from MagnaDrive couplings and the expansion of the speed-control market via direct competition with VFDs. Summit Blue recommends that NEEA assume the baseline and other market effects to ‘net out’ to zero.

SAV-AIR

Findings from tracking SAV-AIR’s current activity in the market suggest that energy savings are based on site-specific M&V, and the M&T project team recommends that savings be aggregated and input into the ACE model each year. Next, Summit Blue concludes that a small level of SAV-AIR’s energy savings likely would have occurred in the absence of the SAV-AIR project. Specifically, Summit Blue recommends that the savings attributable to baseline activity be 5% for the six beta site projects funded by NEEA, 10% for the all other projects completed through 2003, and 14% for projects completed from 2004-2006. This recommendation is based on a thorough review of the market research that was documented during the program’s development. Furthermore, based on findings from the MPER-5 and SAV-AIR’s current status as a licensed technology to a separate company, the M&T project team recommends making no adjustments to account for market effects beyond those captured from SAV-AIR’s projects. Last, Summit Blue recommends continuing to track SAV-AIR’s projects, establishing a current baseline, and reassessing market effects every two years.

Shell Solar

The Shell project led to significant improvements in energy efficiency and productivity that are still producing energy savings at the Shell facility (now owned by SolarWorld). Specifically, since the 2005 M&T report (which covered through 2004), SolarWorld has modified five additional hot zones accounting for 500 kW of capacity, bringing its total capacity of efficient hot zones to 5,250 kW. Based on a review of the MPERs, Summit Blue concludes that the energy saving innovations at SolarWorld likely would not have occurred in the absence of support from NEEA and its sponsors. Furthermore, besides the SolarWorld facility, SEH America is the only remaining crystal growing facility in the region, and there has been no indication through 2006 that the Shell project has influenced any changes in that facility’s production process. Thus, the only savings resulting from the Shell project are those savings achieved at the SolarWorld facility itself, and Summit Blue recommends making no adjustments to the gross savings to account for market effects beyond those captured at the SolarWorld facility. Finally, Summit Blue recommends that NEEA continue a simplified M&T of this project by contacting SolarWorld annually to confirm that operations at the facility are continuing and to identify increased capacity of efficient hot zones and hot zones with recharge.

AM400/Scientific Irrigation Scheduling (SIS)

Based on sales data received from Mike Hansen (the AM400 program proponent), sales of the AM400 soil moisture data logger have been decreasing since 2002, with 127 units sold in 2006. The total market for low-cost scientific irrigation scheduling (SIS) methods in the Northwest was estimated at 1.6 million acres, and the market penetration of the AM400 was approximately 5% at the end of 2006. The M&T project also examined the per-unit energy savings estimate and compared it with data from an SIS study completed for BPA. Summit Blue found the ACE model assumption to be 17% higher than that from the BPA study and recommends that NEEA adjust the per-unit savings estimate to 12,328 kWh/unit/yr. This savings estimate is based on more recent data and thus more likely to reflect current baseline irrigation practices and equipment efficiencies.

Summit Blue also recommends that NEEA maintain the current ACE model assumption of 50 AM400 sales attributable to baseline activity for each year from 2001 to 2006. No evidence exists to suggest a more exact baseline, and the findings from the M&T research are qualitatively consistent with the ACE model assumption. Last, it is very likely that the SIS Initiative influenced manufacturers to offer more low-cost soil moisture equipment, but the impact would be difficult to quantify without significant primary research. As a result, the primary recommendation for continued tracking of the AM400 project is to develop a focused survey instrument and conduct interviews with a significant sample of growers in the Northwest to better estimate the market penetration of SIS methods and the share attributable to the SIS initiative.

E.3 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 NEEA programs that no longer receive funding. A *tentative schedule* for each of the project tracking efforts for 2007-2010 is shown in Table E-1 below. The list of programs to have reviews conducted in 2007 will be discussed with the NEEA project manager and reviewed by the Cost-effectiveness Committee of the NEEA Board before the 2007 plan is finalized.

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

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

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

1. INTRODUCTION

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

In 2004, NEEA developed a process for tracking and monitoring the market progress of projects that it no longer funds. The goal of long-term monitoring and tracking (M&T) is to measure and track critical market progress indicators and Alliance Cost-Effectiveness (ACE) model assumptions that are used to estimate long-term electricity savings. Long term M&T employs methods that provide estimates with a 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 the market effects estimates.

1.1 Monitoring and Tracking Methodology

The long-term M&T process is as follows:

- Review the NEEA 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
- Develop a data collection/analysis plan for each project,
    - Review M&T approach recommended by MPER(s)
    - Review recent market research
    - Review current M&T activities
    - Develop budget and tasks for project M&T
- Execute the plan,
- Report findings & recommendations for changes in the model's assumptions/inputs, as needed

After the long-term M&T report is finalized, NEEA staff presents the recommended changes to the NEEA Cost-Effectiveness Committee and incorporates them into the ACE models once they are approved. As program monitoring and tracking procedures are initiated for each 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.

1.2 M&T for Program Year 2006

The seven programs that were reviewed as part of the M&T effort for 2006 include:

- BacGen (updated)
- Evaporator Fan VFDs (updated)
- MagnaDrive
- SAV-AIR (updated)
- Siemens (Shell Solar)
- SIS/AM400
- Commissioning and Commissioning in Public Buildings (updated)[2]

Summit Blue developed a work plan for each M&T program under review for 2006, and these were provided to NEEA's M&T project manager for review in August 2006. Data collection and analysis began shortly thereafter. For each program, the M&T project team focused on tracking current activity in the market, critically examining NEEA's baseline assumptions, and evaluating the likelihood of additional market effects not captured in program accounting. Chapters two through seven of this report each present the savings approach, data collection methods, and findings for each project in the order listed above.

1.3 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 NEEA programs that no longer receive funding. A *tentative schedule* for each of the project tracking efforts for 2007-2010 is shown in Table 1-1 below. The list of programs to have reviews conducted in 2007 will be discussed with the NEEA project manager and reviewed by the Cost-effectiveness Committee of the NEEA Board before the 2007 plan is finalized.

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[2] The Commissioning update is contingent on results from surveys that had not been fielded by the publication of the 2006 M&T report. The Commissioning report will be provided as part of the 2007 M&T effort.

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Siemens (Shell Solar)	C	U	U		U	
BacGen	C	U		U		U
EZConserve (Surveyor)	C		U		U	
Commissioning in Public Buildings	C		U		U	
Small Commercial HVAC (AirCare Plus)	C	M&T Discontinued				
Energy Star Home Products			C			
MagnaDrive		C		U		U
Dendritic Polysilicon Production (ASiMi)			C		U	
Electric Motor Management (Drive Power)			C		U	
Microelectronics Industry Initiative			C		U	
SIS/AM400		C	U		U	

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

2. BACGEN

2.1 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 with a proprietary mix of micronutrients and process control technologies.[3] 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, HVAC, 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 (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" [9].

The initial BacGen Long-Term Monitoring and Tracking (M&T) effort reviewed activities through 2004, and the findings of that research were presented in the 2005 M&T report [2]. For the 2006 M&T effort, this "update" report will build upon data collection activities undertaken for the 2005 report.

2.2 Indicators and Assumptions for Review

According to Summit Blue's review of the ACE model [4], the cost-effectiveness of the BacGen project is contingent on the total wastewater design capacity of BacGen's projects, the average energy savings per unit capacity, and several key assumptions about the market for wastewater optimization. Specifically, the ACE model determines the *gross* energy savings impact of the BacGen project as the product of the total design capacity (MGD[4]) of BacGen's wastewater optimization projects in the Northwest and the estimated annual energy savings per unit capacity (kWh/MGD/yr). During the course of the data collection effort, however, the M&T project team discovered that energy savings had been estimated for each site in the Northwest and that the total could be calculated by aggregating the reported savings by project. As a result, the gross energy savings impact will be presented as the sum of the individual project savings by year, and the average per-unit savings will be calculated from this sum.

The ACE model currently assumes zero baseline activity and no influence on the wastewater treatment market beyond BacGen's activities. Summit Blue therefore focused its efforts on tracking BacGen's current activity in the market, reassessing the level of baseline activity, and

[3] The BacGen optimization measure is referred to by NEEA as "Process Controls." It consists of continuous monitoring to optimize the aeration process, thereby allowing motor use to be reduced while maintaining or improving effluent quality.

[4] MGD is the wastewater treatment capacity at design conditions, quantified in units of millions of gallons treated per day.

quantifying other market effects that are attributable to the BacGen project.[5] Specifically, the M&T project team assessed the following inputs to the cost-effectiveness calculation:

- BacGen's current market activity in the Northwest, including the total number of wastewater optimization projects, the gross energy savings by project, and total design capacity (MGD) of these projects
- The level of baseline activity in the Northwest
- Wastewater treatment optimization activity outside of BacGen's projects.

In accordance with the M&T work plan for 2006 [3], the project team also investigated the likely magnitude of BacGen's continued market activities in the Northwest and made recommendations for future tracking efforts.

2.3 Methodology

Summit Blue conducted the following data collection activities in support of the BacGen M&T effort:

- **Reviewed project reports and documentation.** Because of the change in scope for the 2006 M&T effort, Summit Blue conducted an in-depth review of the project documentation to acquire a detailed understanding of the program theory and cost-effectiveness assumptions. The literature review served as the foundation for the baseline analysis and helped to focus questions for interviews. The reviewed documentation includes the BacGen ACE model [4], the water and wastewater market research report [10], the municipal wastewater energy baseline study [11], and each of the three MPERs [7,8,9]. A full list of the documentation reviewed for this report can be found in Section 2.6 below.

- **Input design capacity from the EPA wastewater capacity database [5] for BacGen's 2006 projects.** The EPA wastewater capacity database was used for the 2005 M&T effort to determine design capacity and type of waste (municipal or industrial) for each of BacGen's wastewater projects. An update to this database took place in 2004 but the results have not yet been made public.

- **Contacted the Alliance BacGen project coordinator (Andy Ekman) for the BacGen project** to obtain an update to the post-project tracking database [6] provided for the 2005 M&T effort.

- **Contacted the project contractor (Martin Shain of BacGen).** Mr. Shain provided a wealth of information about current projects, future business activities, and historical background on baseline activity. Summit Blue specifically inquired about the following topics [15]:

[5] Summit Blue did not conduct an in-depth review of the per-unit savings assumptions in the ACE model because a) savings have been estimated for each of BacGen's projects, and b) analysis completed for the 2005 M&T report showed the difference between BacGen-reported savings and independently-verified savings to be negligible. Instead, the average per-unit savings was updated based on the aggregate savings to date.

- *Status of BacGen's current service offerings.* The project team also asked Mr. Shain pertinent questions about BacGen's current target markets and the status of their freshwater optimization and design consultation businesses.
- *Historical market for wastewater process controls.* Summit Blue interviewed Mr. Shain for information concerning the historical market for wastewater process controls, to obtain his insights into what the market might be like without BacGen's presence. The team asked Mr. Shain about the existence of any competitors offering similar services around the time of BacGen's contract with the Alliance and whether any competitors had emerged since.
- *Future direction of BacGen.* Summit Blue interviewed Mr. Shain regarding company outlook and future direction, both in the Northwest and other regions. Inquiries were made concerning the number and size of upcoming projects, and about projections of market activity in the industry as a whole.

- **Contacted Phil Degens of the Energy Trust of Oregon and Ken Self of Lockheed Martin Aspen Systems.** On the recommendation of Mr. Shain, Summit Blue contacted Mr. Degens [16] and Mr. Self [17] regarding the third-party measurement and verification (M&V) that their organizations had conducted on BacGen's Oregon projects.

- **Interviewed wastewater treatment facility operators that had not contracted with BacGen for process optimization.** Summit Blue created an interview guide [12] and conducted web searches for wastewater treatment facilities in the Northwest. A total of seven interviews were completed with facilities in the size range of 1.3 MGD design up to 8.8 MGD design. Because of the lack of readily available contact information for operators, two of the completed surveys were for facilities in Wyoming.

2.4 Findings

2.4.1 Current Market Activity

As noted in Section 2.3 above, Andy Ekman supplied Summit Blue with the most up-to-date project tracking database [6] for BacGen's projects, which includes data through 2006. The database is comprehensive and includes fields for state, facility type, service type, treatment type, completion date, and observed savings. According to Martin Shain, the "observed savings" are determined from pre- and post-implementation metering conducted by BacGen for each of their projects [15]. The database also includes savings results from third-party M&V for 10 out of 33 (30%) wastewater optimization projects in the Northwest. Summit Blue further supplemented the database with design capacity data from the 2000 EPA clean water database [5], disaggregated by municipal vs. industrial waste flows.

Most of BacGen's Oregon projects (which comprise 54% of all wastewater optimization savings) are also visually verified by the Energy Trust of Oregon (ETO). Ken Self of Lockheed Martin (the ETO implementation contractor responsible for verifying energy savings from BacGen projects in ETO territory) reported that verified savings often come in at *105% of BacGen-reported savings* [17]. From NEEA's perspective, calculating the energy savings impact of the BacGen project from independently-verified savings data *may* be more defensible to interested third parties, but it will *not necessarily* give more precise savings estimates than using BacGen-reported savings data. The average design capacity for BacGen projects whose savings have been independently-verified is *more than twice as much* as the average for all of BacGen's projects. In addition, the majority of BacGen projects with independently-verified savings data are aerated lagoon (70%), while the percentage of aerated lagoon treatment facilities across *all* of BacGen's projects is just 38%. These variables (facility size and treatment type) have a large impact on the achievable energy savings, and the independently-verified sites are misrepresentative of the population of projects.[6] Although the recommendation from the 2005 M&T report suggested using only independently-verified savings data [2], current research indicates that BacGen-reported savings data are likely the best source for accurate savings data. Furthermore, the use of BacGen-reported savings data provides for a higher level of resolution when disaggregating by treatment type or state. As a result, the M&T project team recommends using BacGen-reported savings data going forward.

As shown in Table 2-1 below, the number of wastewater optimization projects completed by BacGen in the Northwest varies from year-to-year. The energy savings per-unit design capacity also varies year-to-year, from a low of 101,040 kWh/MGD/yr in 2003 to a high of 640,430 kWh/MGD/yr for the two projects completed prior to 2000. The total energy savings from all of BacGen's wastewater optimization projects in the Northwest is 23,533,090 kWh/yr, while the average energy savings per-unit design capacity is 203,540 kWh/MGD/yr. The average design capacity for all of BacGen's wastewater optimizations in the Northwest is 3.50 MGD/facility.

Table 2-1. BacGen Wastewater Optimization Projects in the Northwest by Year

	Number of Projects	Total Design Capacity (MGD)	Annual Energy Savings (kWh/yr)	Per-Unit Savings (kWh/MGD/yr)
Pre-2000	2	3.90	2,497,660	640,430
2000	4	4.49	2,515,260	560,190
2001	4	14.65	2,201,470	150,270
2002	5	14.65	1,920,250	131,080
2003	2	42.18	4,261,830	101,040
2004	2	3.30	1,211,740	367,190
2005	7	21.80	4,143,430	190,070
2006	7	10.64	4,781,460*	449,390*
Total	**33**	**115.62**	**23,533,090**	**203,540**
* These are the projected savings for 2006.				

Although BacGen's contract with the Alliance specified targeting small- to medium-size facilities (those in the range of 0.1-20 MGD design capacity), BacGen has implemented its process optimization strategies at one larger facility in the Northwest. This facility, located in Oregon, is an aerated lagoon treatment facility with a design capacity of 41.00 MGD. Completed in 2003, annual energy savings for this facility are 2,740,000 kWh/yr, and per-unit energy savings are 66,830 kWh/MGD/yr. Table 2-2 below shows the number of projects, total design capacity, and energy savings of BacGen's wastewater optimizations in the Northwest by *facility size*. More than two-thirds (70%) of BacGen's projects *and* total energy savings have been in the medium size range (1-20 MGD).

[6] Analysis completed by Summit Blue for the 2005 M&T report showed that the difference in aggregate savings calculated from BacGen-reported data vs independently-verified data was negligible (less than 2% difference). However, this will likely change as more projects are completed and more data is made available.

Table 2-2. BacGen Wastewater Optimization Projects in the Northwest by Facility Size[7]

	Number of Projects	Total Design Capacity (MGD)	Annual Energy Savings (kWh/yr)	Per-Unit Savings (kWh/MGD/yr)
Small (<1 MGD)	9	4.31	4,446,690	1,031,710
Medium (1-20 MGD)	23	70.31	16,346,400	232,490
Large (>20 MGD)	1	41.00	2,740,000	66,830
Total	**33**	**115.62**	**23,533,090**	**203,540**

Table 2-3 below shows the number of projects, average design capacity, and average energy savings of BacGen's wastewater optimizations in the Northwest by treatment type for facilities *in BacGen's target market (0.1-20 MGD) only*.[8] More than half of the projects (58%) have been at activated sludge treatment facilities. Table 2-3 also shows that aerated lagoon facilities have achieved the highest per-unit savings (more than 300,000 kWh/MGD/yr), while activated sludge facilities have achieved the lowest (264,170 kWh/MGD/yr). For *all facilities in BacGen's target market*, the average annual per-unit energy savings is 278,650 kWh/MGD/yr, while the average design capacity is 2.33 MGD/facility.

Table 2-3. BacGen Wastewater Optimization Projects in the Northwest by Treatment Type for Facilities in BacGen's Target Market (0.1-20 MGD)

	Number of Projects	Average Design Capacity (MGD)	Per-Unit Savings (kWh/MGD/yr)
Activated Sludge	19	2.29	264,170
Aerated Lagoon	12	2.35	301,030
Biosolids	1	3.00	279,050
Total*	**32***	**2.33***	**278,650***
* BacGen's single large-facility project (aerated lagoon) has been removed to prevent skewing the results for savings by treatment type. If it *were* included, per-unit savings for aerated lagoon treatment facilities would be 162,230 kWh/MGD/yr.			

Table 2-4 below shows the number of projects, average design capacity, and average energy savings of BacGen's wastewater optimizations in the Northwest by state for facilities *in BacGen's target market (0.1-20 MGD) only*[8]. Oregon accounts for 59% of the completed projects for facilities in BacGen's target market. *All* of the projects completed since 2004 have been at facilities in Oregon, which is likely due to the ETO's generous incentives for these projects. Montana achieved the highest energy savings *per-unit* design capacity with 467,860 kWh/MGD/yr, which is more than two-thirds (68%) higher than the regional average of 278,650 kWh/MGD/yr for facilities in BacGen's target market.

[7] The definition for small, medium, and large wastewater treatment plants comes from the water and wastewater market research report [10].

[8] BacGen's single large-facility project (representing 41 MGD and 2,740,000 kWh) has been removed to prevent skewing the results for savings by treatment type and state.

Table 2-4. BacGen Wastewater Optimization Projects in the Northwest by State for Facilities in BacGen's Target Market (0.1-20 MGD)

	Number of Projects	Total Design Capacity (MGD)	Per-Unit Savings (kWh/MGD/yr)
Idaho	3	2.53	203,650
Montana	5	1.10	467,860
Oregon	19	2.02	290,341
Washington	5	4.62	238,920
Total*	**32***	**2.33***	**278,650***

* BacGen's single large-facility project (Oregon) has been removed to prevent skewing the results for savings by state. If it *were* included, per-unit savings for Oregon would be 174,970 kWh/MGD/yr.

Recommendation: The current structure of the ACE model [4] is such that it calculates energy savings (kWh/yr) from the total design capacity of BacGen's wastewater optimizations (MGD) multiplied by the average annual energy savings per unit design capacity (kWh/MGD/yr). As noted earlier in this section, current research suggests that BacGen-reported numbers are likely the most accurate source of savings data. Summit Blue recommends that the savings should be aggregated from BacGen-reported data and input into the ACE model year-by-year.

2.4.2 Baseline Activity

The energy savings attributable to baseline activity are those due to wastewater treatment efficiency measures that would have occurred in the absence of the BacGen project. According to Summit Blue's review of the ACE model [4], NEEA currently assumes that zero savings should be attributed to baseline activity. To determine a reasonable level of savings due to baseline activity, two questions must be answered:

1. *How many projects and what level of energy savings would have been achieved by BacGen on its own without funding from NEEA?*

2. *What level of energy savings due to wastewater treatment efficiency measures would have been achieved by BacGen's customers if BacGen had not existed at all?*

In order to answer these questions, the M&T project team conducted a detailed review of the program reports and other supporting documentation that was written *during the program's development*. Specifically, Summit Blue focused on understanding market conditions for small and medium wastewater treatment plants. This secondary literature review was then supplemented with non-participant operator interviews.

BacGen Activity in the Absence of NEEA Funding

The critical role played by NEEA in the development of BacGen as an entrepreneurial company has been well documented in the three MPERs. NEEA fully funded the first six of BacGen's projects and helped them document the significant energy and non-energy benefits for presentation to other potential third-party funding sources. Feedback from NEEA and the MPERs served to direct and focus BacGen's service offerings; according to Martin Shain, "Our business turned 180 degrees in a different direction after the first MPER" [2]. In the absence of NEEA funding, it seems reasonable to assume that BacGen would have achieved no energy savings.

Wastewater Treatment Process Savings in the Absence of BacGen

Understanding the level of savings due to wastewater treatment efficiency measures that would have been achieved by BacGen's customers *if BacGen hadn't existed at all* requires two separate analyses. First, one must assess the possibility that the customer would have pursued the same strategies (i.e. process optimization through monitoring and control) in the absence of BacGen's involvement. Second, one must consider the possibility that a customer would be pursuing *other* types of process efficiency measures such as motor VFDs or fine bubble aerators. For example, when BacGen contracts with a customer and begins conducting baseline metering for comparison, the customer is unlikely to be concurrently conducting activities that reduce energy consumption. However, if BacGen was not involved at all, the customer *might* be pursuing process efficiency or other O&M measures that have the effect of reducing energy consumption in the treatment process. If this is the case, the baseline energy consumption when the site is metered by BacGen will be higher than it would be if BacGen were not involved at all.

Process Optimization through Monitor and Control

As noted in MPER-2 [8], process control and monitoring technologies are not new to the wastewater industry but have historically been cost-effective only for large facilities. BacGen is *unique*, however, in that it focuses on cost-effective strategies for *small- and medium-sized facilities* which are defined as those in the range of 0.1-20 MGD design capacity. According to the MPERs, *competition* to BacGen's services in the small- to medium-size market segment depends on how the service is defined. Specifically, many companies offer the components of BacGen's services, but none seem to offer all the components in a single, connected package. As noted in MPER-2, "If [BacGen's services are] defined as the full package including diagnosis, installation, and long-term oversight, our research indicates that there is *no direct competition* in the market." According to MPER-3 [9], "Although consulting engineering firms could hone their expertise and compete with BacGen, it would require a significant investment to develop cost-effective technologies for small and medium facilities, and it would represent a substantial departure from their standard business model." Mr. Shain feels that the BacGen projects in small and medium sized facilities were a "pioneering effort," and no other company was specifically targeting this market for process optimization prior to BacGen's contract with the Alliance. He further elaborated that the pursuit of process optimization in markets with very low energy costs (such as the Northwest) is "just not going to happen" without some sort of incentive. [15]

Mr. Shain also indicated that *large* facilities have been pursuing process optimization through monitor and control for some time prior to BacGen entering the market. Specifically, large wastewater treatment operations invest in process optimization in order to make the process better, to reduce overhead costs, and/or to enhance capacity. This investment in process optimization "is for profits only," and energy efficiency is generally considered to be "a secondary benefit." The lone project (St Helens) completed by BacGen at a facility over 20 MGD design capacity was, according to Mr. Shain, "a bit of an anomaly." He was adamant, however, that St Helens would "absolutely not" have pursued process optimization without BacGen's help because of the unusual influent characteristics and physical attributes of the facility. [15] These findings from Mr. Shain suggest that BacGen's customers would not have pursued process optimization in the absence of BacGen's involvement.

To supplement the findings from the interview with Mr. Shain, the M&T project team also interviewed non-participant wastewater treatment facility operators. When asked how they monitor effluent to ensure that it meets EPA standards, six out of seven respondents reported that they manually retrieve samples for testing in a lab. Two of the six respondents that perform manual testing also indicated that they use the results of the testing to adjust and "optimize" excess aeration. The lone respondent that *did not* report manual testing of effluent replied that the treatment process at her facility was fully automated. Representing a 3.1 MGD facility in Montana, this respondent stated that they use PLC controllers with a SCADA system to monitor and control excess aeration and dissolved oxygen (DO) levels. The respondent further reported that BacGen conducted a diagnosis at their facility *after* these process modifications had been implemented and "didn't really find anything to do." The findings from the non-participant operator interviews therefore suggest that a small level of baseline activity is occurring.

Other Process Efficiency Measures

The other consideration when establishing a reasonable baseline for BacGen energy savings is the level of savings that would have been achieved from process efficiency measures in the absence of BacGen. The chief concern for wastewater treatment operators has always been maintaining compliance with environmental regulations, and the pursuit of energy-efficiency *within the treatment process* has always been secondary to maintaining compliance. Still, six out of seven respondents to the M&T interview reported that they actively investigate ways to reduce energy usage in the wastewater treatment process at their facility, and the seventh responded that he "would like to in the future." One operator reported installing "more efficient pumps," and another reported making "some changes to VFDs last year" that saved 125 kWh/day or about $3,000 per year.

According to the water and wastewater market research report, the two most common methods of saving energy in the wastewater treatment process are the installation of VFDs to control motor speed and/or the installation of premium efficiency motors. Results from interviews with 35 facility managers as presented in the report indicate that VFDs are quickly becoming standard practice in the industry. When asked if they would consider installing variable speed drives in their facility, 60% of the respondents replied that VFDs were *already* installed, and another 30% said they would consider installing VFDs. Only 10% of respondents reported that they *would not* consider installing VFDs in their facility. [10]

These findings from the operator interviews and the market research report suggest that energy-efficiency is of importance to operators, and it is likely that some operators actually implement energy-saving measures at their facilities. Summit Blue also finds it somewhat likely that BacGen's *customers* would have implemented some of these *process efficiency measures* in the absence of BacGen's involvement and thus achieved a portion of the energy benefit *already being claimed by BacGen*[9].

Wastewater Efficiency Efforts in Other Regions of the Country

An Internet search conducted by Summit Blue revealed a growing number of organizations and utility programs that focus on efficiency improvements in wastewater treatment facilities across the country. The California Wastewater Process Optimization Program[10], which was initiated in 2000, provides free energy audits to municipal and private water and wastewater treatment facilities, funds up to 100% of the implementation costs for energy saving measures, and provides training for facility operators. The Consortium for Energy Efficiency launched a National

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[9] Some of the energy benefit from these other process efficiency measures would be *in addition to* BacGen savings, but some would likely overlap with the savings being claimed by BacGen.

[10] http://www.calwastewater.com/index.html.

Municipal Water and Wastewater Facility Initiative[11] in 2004 which nationally promoted the opportunities for energy efficiency in water and wastewater treatment facilities and provided an information clearinghouse for facilities and related companies to share best practices. The initiative is also supporting the development of a standardized metric for energy performance of water and wastewater facilities, to allow comparisons over time and across facilities. The U.S. Environmental Protection Agency launched an Energy Star Industrial Water and Wastewater Focus[12] in 2005 as part of a series of Energy Star efforts targeting energy efficiency opportunities in selected industries. As part of this focus, the Energy Star program will develop an energy performance rating system and best practices for energy management in water and wastewater facilities. The New York State Energy Research and Development Authority (NYSERDA),[13] Efficiency Vermont,[14] and Wisconsin Focus on Energy[15] all offer similar funding and technical assistance for water and wastewater treatment facilities.

In addition, Summit Blue researched activity specific to *aeration improvements* and *system optimization* through the use SCADA or other control mechanisms nationally. While there is no direct data for wastewater facilities in the Northwest, there is evidence that suggests the market for these activities/services is moving forward in other parts of the country in the absence of BacGen. A recent edition of the Onsite Water Treatment Journal [13] highlights aeration innovations, including one article focusing on energy cost savings from monitoring and controlling aeration via SCADA system. Another article in the same edition, titled "The SCADA Solution," highlights a facility in municipal wastewater treatment facility in Nevada that installed its SCADA system in 1992. The article further notes that "The cost of the components in SCADA systems – the remote terminal units, the programmable logic computers, and the human-machine interfaces - is dropping."

Baseline Conclusions

BacGen would not have achieved any energy savings through wastewater treatment optimization in the Northwest without NEEA funding. From the research completed, however, it seems likely that a *small* percentage of BacGen's customers would have pursued the same type of strategies (i.e. process optimization through monitoring and control) in the absence of BacGen's involvement. Unfortunately, the level of energy savings achieved from non-BacGen process optimization strategies *relative* to those achieved by BacGen is unknown and would be difficult to quantify. Furthermore, although the likelihood of process optimization increases with facility size, process optimization with regard to energy *does* exist for smaller facilities.

The level of savings that BacGen's customers would have achieved on their own from *other* process efficiency measures in the absence of BacGen's involvement is likely small as well. Although most of these other process efficiency measures are quickly becoming standard practice, it would be difficult to determine which of BacGen's projects had these measures installed prior to the implementation of BacGen's process optimization strategies and which ones *would have* installed them. BacGen measures and reports savings only for the affected motors, so many of these measures would have no impact on BacGen's metered baseline consumption. The

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11 http://www.cee1.org/ind/mot-sys/ww/ww-init-des.pdf.

12 http://www.energystar.gov/ia/business/government/wastewater_fs.pdf.

13 http://www.nyserda.org/Programs/Environment/muniwaterwwt.asp.

14 http://www.efficiencyvermont.com/stella/filelib/WaterWastewaterTechBrief.pdf.

15 http://www.focusonenergy.com/page.jsp?pageId=370.

savings achieved by BacGen's process optimization strategies also would likely dwarf any savings achieved via these other process measures. Lastly, wastewater efficiency efforts have been taking off in other parts of the country in recent years, starting with the California Wastewater Process Optimization Program in 2000.

Baseline Recommendations

Although there does appear to some level of baseline activity, the M&T project team does not think that a large percentage of BacGen's savings would have occurred in the absence of the BacGen project. Since the objective of the BacGen project was to reduce energy consumption at *small- to medium-sized* facilities, the appropriate level of baseline activity should be disaggregated between facilities less than 20 MGD design (small and medium) and facilities over 20 MGD design (large). BacGen has to date completed just one project at a facility larger than 20 MGD design, and the M&T findings indicate that *none* of the savings from this facility should be attributed to baseline activity. For all future projects over 20 MGD, Summit Blue recommends a judicious individual review *of each facility* to determine the appropriate level of savings that should be attributed to the baseline.

For facilities less than 20 MGD design, findings from the M&T research suggest that a small level of BacGen's reported savings likely *would have occurred in the absence of BacGen's involvement.* However, since <u>no data exists to substantiate the exact percentage</u> of savings that should be attributed to baseline activity, Summit Blue thinks a conservative approach would be best. As such, the M&T project team recommends that NEEA attribute 5-10% of BacGen's reported savings to baseline activity. This is consistent with findings from the operator interviews that one out of seven interview respondents reported having process optimization technologies installed. While significant national efforts targeting wastewater efficiency have been on-going since 2000 (for example, the California Wastewater Process Optimization Program), Summit Blue recommends that the estimate of baseline activity for small projects be applied to BacGen's reported savings for 2006, and be re-assessed for the next round of project tracking.

2.4.3 Other Market Effects

As noted in the MPERs, BacGen does not have any significant competition for its full package of services to small- and medium-size wastewater treatment facilities. More than two years after the publication of MPER-3, Mr. Shain still reports *no significant competition* to BacGen's services in the small- to medium-size market in the Northwest. When asked if they were aware of any companies that specialize in the energy optimization of the wastewater treatment process, just two out of six[16] M&T interview respondents replied "Yes." When further asked if they had heard of BacGen, just two out of seven respondents replied "Yes."[17] The findings from the literature review, interview with Mr. Shain, and interviews with non-participant wastewater facility operators suggest that BacGen has not prompted additional market activity outside of that captured by BacGen. On the contrary, the lone interview respondent with BacGen-like process optimization at her facility had implemented it *prior* to BacGen performing facility diagnosis.

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[16] This particular question was added after one interview had already been completed.

[17] Interestingly, one of the respondents that was *not* aware of companies specializing wastewater optimization *had* heard of BacGen, which suggests that BacGen's marketing message is not getting through to all operators. The other respondent that *has* heard of BacGen was the one noted earlier whose treatment process is fully automated.

Although the focus of the BacGen contract with NEEA was process optimization of existing wastewater treatment facilities in the Northwest, BacGen has expanded its offerings to include freshwater process optimization and design consulting services for both wastewater and freshwater facilities. BacGen has also completed one project for irrigation optimization and one project for industrial process optimization in the Northwest. Projects in other regions of the country include 48 wastewater optimization projects in California and one freshwater optimization project in Wyoming. As shown in Table 2-5, most of BacGen's additional projects and achieved energy savings in the Northwest have been for freshwater optimization projects. BacGen has performed design consulting services for 5 wastewater treatment facilities in the Northwest for a gross energy savings of almost 1.8 million kWh/yr.

Table 2-5. Other BacGen Projects in the Northwest

	Number of Projects	**Annual Energy Savings (kWh/yr)**
FW Process Optimization	28	12,007,120
WW Design Consulting	5	1,746,000
FW Design Consulting	1	301,400
Irrigation	1	872,370
Industrial	1	824,000
Total	**36**	**15,750,890**

Recommendation: BacGen does not at this time appear to have influenced operators or other consulting firms to pursue wastewater process optimization, and Summit Blue recommends making no adjustments to account for savings due to additional market effects. Furthermore, while BacGen has achieved significant savings at freshwater facilities in the Northwest, this was not a focus of the NEEA contract. However, savings due to wastewater design consulting services can be reasonably attributed to the BacGen project, and Summit Blue recommends that NEEA include these in their program accounting.

2.4.4 Future Market Activity

BacGen is beginning an expansion both in terms of geography and business focus. Within North America, the company is slowly moving east and north into Canada, and starting to market more aggressively to pulp and paper and larger industrial customers. The company is also starting to perform a lot of work in western Europe, working on elements of wastewater treatment operations outside of process optimization that have large energy impacts. They see a large growth potential with this new work in Europe, and have ramped up a significant research and development effort related to the new business focus.

BacGen completed a total of 20 projects (seven of which were wastewater optimization projects) in 2006, all in Oregon, and all with ETO funding. Martin Shain indicated that Oregon was currently the only state in the Northwest that had program funding that could be leveraged for BacGen projects, and that demand for efficiency is dependent on support from government entities, with the exception of California. However, a new contract with Bonneville Power Administration will keep BacGen active in the Northwest for the next 3-5 years, and the Energy Trust of Oregon will continue to have some level of funding through 2012. Mr. Shain also indicated that due to the ETO's aggressive incentives, market penetration of BacGen's services was quite high in Oregon, and he anticipates that upwards of 50% of wastewater treatment facilities in the state will have been optimized for energy efficiency by 2008, despite the fact that the ETO incentives are decreasing.

2.5 Conclusions/Recommendations

Table 2-6 summarizes Summit Blue's recommendations for the BacGen project.

Table 2-6. BacGen M&T Recommendations

Key Inputs Reviewed	Current ACE Model Value	Recommended Value	Source
Current Market Activity			
Number of Projects	Varies by year	See Table 2-1	• Project tracking database
Energy Savings (kWh/yr)	Varies by year	See Table 2-1	• Project tracking database
Per-Unit Savings (kWh/MGD/yr)	226,950	203,540	• Summit Blue analysis of current market activity • See Table 2-1
Baseline Activity – Percent of BacGen Savings			
Projects over 20 MGD	0%	No change	• Literature review • M&T interviews • See Section 2.4.2
Projects under 20 MGD	0%	5-10%	• Literature review • M&T interviews • See Section 2.4.2
Other Market Effects			
Wastewater Optimization Projects – Percent of BacGen Savings	0%	No change	• Literature review • M&T interviews • See Section 2.4.2
Wastewater Design Consulting (kWh/yr)	0	1,746,000	• Project tracking database • See Section 2.4.2

- **Continue tracking BacGen projects in the Northwest.** With the new BPA contract and continued ETO funding through 2012, BacGen will remain active in the Northwest for the foreseeable future.

- **Track project-specific savings instead of using a common per-capacity multiplier.** BacGen's reported savings are likely the most accurate source of savings data. If this data continues to be available for future projects, there is no need to assume uniform savings rates.

- **Savings attributable to baseline activity should be estimated at 0% for St Helens and 5-10% for all projects less than 20 MGD.** These estimates are based on a review of the program documentation, interviews with project contractor and NEEA staff, and interviews with wastewater operators. All future projects at facilities over 20 MGD design should be judiciously reviewed on an individual basis to determine the appropriate level of savings attributable to the baseline.

- **There do not appear to be any market effects beyond BacGen's projects.** BacGen does not at this time appear to have influenced operators or other consulting firms to pursue wastewater process optimization. Summit Blue recommends that future M&T efforts continue to analyze whether additional market effects can be quantified.

- **Gross program savings should be adjusted to account for savings due to wastewater design consulting.** These savings can reasonably be attributed to the influence of the BacGen project.

2.6 References

1. *2004 Market Activities Report,* Northwest Energy Efficiency Alliance, 2005.

2. *Long Term Monitoring and Tracking Report on 2005 Activities,* Summit Blue Consulting, LLC for Northwest Energy Efficiency Alliance, April 14, 2006.

3. *Long Term Monitoring and Tracking DRAFT Workplan for 2006 Activities,* Summit Blue Consulting, LLC for Northwest Energy Efficiency Alliance, August 21, 2006.

4. "BacGen MAR 2005 04-11-06.xls," Northwest Energy Efficiency Alliance.

5. "1366496094.csv," available from the EPA web site http://www.epa.gov/waters/tmdl/pickadhoc/1366496094.CSV

6. "BacGen – All Installs – Q3 2006.xls," received from Andy Ekman November 28, 2006.

7. *Market Baseline Evaluation Report: BacGen BioWise Project, No. 1,* Quantum Consulting, Inc., and Adolfson Associates, Inc., Report #E00-049, March 2000.

8. *BacGen: Market Progress Evaluation Report, No. 2,* Quantec, LLC, Report #E03-111, April 14, 2003.

9. *BacGen: Market Progress Evaluation Report, No. 3,* Quantec, LLC, Report #E04-132, October 4, 2004.

10. *Market Research Report: Pacific Northwest Water and Wastewater Market Assessment,* Quantum Consulting, Inc., and Adolfson Associates, Inc., Report #01-079, May 2001

11. *Municipal Wastewater Treatment Plant Energy Baseline Study,* M/J Industrial Solutions for Pacific Gas & Electric Company, June 2003.

12. "Operator Interview Questions.doc," Summit Blue Consulting, LLC, January 2007

13. *Onsite Water Treatment: The Journal for Decentralized Wastewater Treatment Solutions,* Aeration Innovations: Advances in Treatment Solutions, March/April 2007.

14. *Personal communications with Andy Ekman,* Northwest Energy Efficiency Alliance, October 2006.

15. *Personal communications with Martin Shain,* Northwest Energy Efficiency Alliance, October 2006 and February 2007.

16. *Personal communications with Phil Degens,* Energy Trust of Oregon, December 2006.

17. *Personal communications with Ken Self,* Lockheed Martin Aspen Systems, December 2006.

3. EVAPORATOR FAN VFD

3.1 Introduction

In January 1998, NEEA contracted with Cascade Energy Engineering to implement the Evaporator Fan Variable Frequency Drive (VFD) Initiative, which was funded for 6 years until the program's end in January 2004 [8]. The initial objective was to make VFDs the industry standard for evaporator fans in all types of refrigerated warehouses in the Northwest, including controlled atmosphere (CA) rooms, regular fruit storage, food distribution centers, dairy-milk coolers, food-processor blast cells, and other types of common cold storage. This objective was very successful, and an additional objective was added in early 2002 to investigate 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 included:

- Conducting field trials at 30 sites in the first two years and achieving two comprehensive installations *(23 field trials and two comprehensive installations were completed).*
- Developing a database of refrigerated storage facilities in order to characterize the market.
- Increasing the number of refrigerated warehouses and cold storage facilities with evaporator fans controlled by VFDs by 5%, by 2000.
- Increasing market penetration of VFDs to at least 31% of cold storage warehouses and 47% of fruit storage facilities by 2007.

According to the Initiative's concluding memorandum [12], the effort was 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. Onion storage facilities have limited market transformation potential, however, as onions can only be stored in CA facilities for short periods of time, and this effort was subsequently discontinued.

3.2 Indicators and Assumptions for Review

According to Summit Blue's review of the ACE model [9], the *gross* energy savings of the VFD Initiative is based on evaporator fan capacity in refrigerated warehouses with VFD control, annual energy savings per unit capacity, and storage type (controlled atmosphere or common cold storage). According to MPER-3 [17], VFDs installed on evaporator fans in CA rooms will achieve different savings than the same measure in common cold storage rooms because of different cooling requirements for long-term fruit storage.[18] The ACE model also assumes a small

[18] "Fruit storage" is not the same as "controlled atmosphere." Most fruit storage facilities will have some CA rooms and some regular cold storage rooms. In general, the CA rooms are used as long-term storage

level of baseline activity and no influence on evaporator fan VFD installations beyond what is captured by Cascade. Summit Blue therefore focused its efforts on tracking Cascade's current activity in the market, re-assessing the baseline activity, and quantifying other market effects that are attributable to the VFD Initiative. Specifically, the M&T project team assessed the following inputs to the cost-effectiveness calculation:

- Cascade's current market activity in the Northwest, including the number of refrigerated warehouses with evaporator fan VFDs and the capacity of the motors (HP) on which they are installed.
- The level of baseline activity in the Northwest.
- Market effects beyond what is being captured by Cascade.

In accordance with the M&T work plan for 2006 [14], Summit Blue also investigated the likely magnitude of continued market effects and made recommendations for future tracking efforts.

3.3 Methodology

Summit Blue conducted the following data collection and research activities in support of tracking the market for evaporator fan VFDs in refrigerated warehouses:

- **Contacted NEEA project manager (Andy Ekman) for the VFD Initiative [22].** The project manager was contacted to provide data for evaporator fan VFD installations in the region as reported by Cascade. He also supplied insights into the refrigerated storage market and the Initiative.

- **Reviewed updated USDA report on refrigerated warehouse capacity [1].** The 2005 USDA report, released in January 2006, was used to help determine evaporator fan capacity for the 2006 M&T report. Previous reports, dating back to 1999, were used to assess the growth in the market for all types of refrigerated facilities in the Northwest.

- **Contacted the implementation contractor (Marcus Wilcox of Cascade Energy Engineering) for input on current, baseline, and future market activities [20].** Mr. Wilcox was contacted by telephone to get his insights on current activity in the market by type of facility, what the market might have been like in the absence of the NEEA Initiative, and the future direction of the market. Another engineer at Cascade (Mike McDevitt) also supplied critical information regarding VFD installations that may have occurred outside of Cascade's purview.

- **Contacted Dan Black of Techni-Systems, a major regional controls vendor in the Northwest [23].** Techni-Systems has control systems in at least 96 fruit storage warehouses in the Northwest, most of which are located in Washington. Mr. Black provided information regarding baseline activity, as well as his thoughts on the penetration of VFDs on evaporator fans in the refrigerated storage market.

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and the regular cold storage rooms are used while the fruit is being transitioned from the field to long-term storage. The per-unit savings values are thus dependent on whether the VFD is installed in CA rooms or regular cold storage, ***not*** whether it is *fruit storage* or regular cold storage.

- **Interviewed John Cockrum from Doubl-Kold, a refrigeration and controls vendor in Washington [24].** Mr. Cockrum stated that Doubl-Kold gets its "bread and butter" from the fruit industry, and they have 100 control systems in place in the Northwest. Mr. Cockrum noted that VFDs for new projects are very common and that customers "always save more than what they're told." He also suggested that Cascade is involved in nearly all of the fruit storage market and that competitors to Cascade are rare.

- **Interviewed facility owners to determine whether market effects were occurring.** Summit Blue completed five interviews with refrigerated storage operators or their controls vendors in the Northwest. Interview results suggest that market effects beyond those captured by Cascade *do exist*.

- **Researched secondary sources for information regarding market penetration of evaporator fan VFDs in industrial refrigeration applications in other parts of the country.** The M&T project team searched the internet and evaluation databases, including the CALMAC database (www.calmac.org) and the CEE evaluation clearinghouse (www.cee1.org), for implementation and evaluation of evaporator fan VFD programs around the country. This research was aimed at determining what might be happening in the Northwest without the VFD Initiative.

3.4 Findings

3.4.1 Current Market Activity

According to Andy Ekman, Cascade Energy Engineering provides NEEA with quarterly updates of the evaporator fan VFD installations with which they have been involved [22]. NEEA maintains historical records of each installation going back to 2000, and Mr. Ekman provided the M&T project team with a rollup of his project tracker relating the energy savings associated with each installation from 2000-2006 [10]. The average annual energy savings per site for all years is 603,279 kWh/year, and the majority of installations (79%) and energy savings (86%) have occurred at sites in Washington. Table 3-1 presents a rollup of the data from Mr. Ekman's tracker; it shows the number of sites,[19] average energy savings per site, and the gross energy savings of evaporator fan VFD installations with Cascade involvement in the Northwest by year. Table 3-2 shows the same data by state.[20]

[19] A "site" is *one location* where evaporator fan VFDs have been installed. Each site could have several refrigerated warehouses, each of which could have several rooms. Furthermore, a site does *not* indicate whether *all* the evaporator fans have VFDs or only a portion of them. As a result, using the number of sites with evaporator fan VFDs as a metric for market effects would not be practical. These data are shown in Table 3-1 and Table 3-2 for comparative purposes only.

[20] Cascade also reported involvement in the installation of evaporator fan VFDs at eight sites *not* in the Northwest between 2000 and 2005. These installations resulted in annual energy savings of approximately 10,125,000 kWh/yr. [10]

Table 3-1. Evaporator Fan VFD Installations in Refrigerated Warehouses in the Northwest with Cascade Involvement by Year

	Number of Sites	Average Energy Savings Per Site (kWh/yr)	Gross Energy Savings (kWh/yr)
2000*	19	487,689	9,266,100
2001	24	537,773	12,906,548
2002	8	1,331,054	10,648,433
2003	20	521,460	10,429,199
2004	13	540,715	7,029,295
2005	12	607,811	7,293,734
2006**	14	627,667	8,787,334
Total	**110**	**603,279**	**66,360,643**

* Two sites (line items) in the tracker did not have associated savings, and these have not been counted in the number of sites for 2000.
** 2006 does not include data for the 4th quarter.

Table 3-2. Evaporator Fan VFD Installations in Refrigerated Warehouses in the Northwest with Cascade Involvement by State*

	Number of Sites	Average Energy Savings Per Site (kWh/yr)	Gross Energy Savings (kWh/yr)
Idaho	4	370,815	1,483,259
Montana	0	0	0
Oregon	19	393,583	7,478,071
Washington	87	659,762	57,399,313
Total	**110**	**603,279**	**66,360,643**

* 2006 does not include data for the 4th quarter.

Although the savings tracker includes data for annual energy savings, the ACE model [9] tracks market effects as the evaporator fan capacity (HP) with VFD control multiplied by the average energy savings per-unit capacity (kWh/HP/yr). Market effects are further disaggregated in the ACE model by refrigerated facility type (fruit storage or regular cold storage). This tracking method allows for a comparison of the "converted" evaporator fan capacity to the total evaporator fan capacity in the Northwest and thus an assessment of VFD market penetration. The savings tracker, however, does not include data for evaporator fan VFD HP, refrigerated facility type, or storage type (CA or regular). Upon request, Mr. Ekman supplied the M&T project team with the raw data files provided by Cascade to NEEA. Although the raw files included data for refrigerated facility type, number of VFDs installed, and annual energy savings per site, these files were *not available* for all years and quarters. Some of the older files (for the years 2000 and 2001) included data for affected motor HP, but the majority did not.

Since HP data was generally not available, Summit Blue contacted Mike McDevitt at Cascade to see if it would be possible to "back-out" the HP data from the energy savings using the per-unit savings values. Mr. McDevitt reported that Cascade usually determines savings through detailed energy engineering calculations including an analysis of the operating conditions and speed profiles. He further felt that these calculations "would be pretty accurate," because they are often conducted as part of the M&V protocol for sites receiving utility incentives. [21] Since the savings reported by Cascade to NEEA were determined via site-specific M&V and ***not*** as evaporator fan VFD capacity multiplied by the per-unit savings, it would not be practical to determine HP data from the savings data.

Recommendation: The key metric for determining market effects is the evaporator fan capacity (HP) with VFD control, and this was generally not provided by Cascade in their reporting to NEEA after 2001. As such, Summit Blue recommends that NEEA use a small portion of the M&T budget to have Cascade go back through their historical records and input affected motor HP and/or affected storage space (cubic feet) for each evaporator fan VFD installation with which they have been involved. Cascade should also include data for refrigerated facility type (fruit storage or regular cold storage, for determining market penetration) and storage type (CA or regular, for further analysis of savings due to market effects beyond those captured by Cascade). NEEA should also require that future reporting from Cascade include these data in addition to the energy savings determined from site-specific M&V. The alternative would be to "back-out" HP data from the reported energy savings using the per-unit multipliers *even though* the savings were not calculated this way. Since the VFD Initiative appears to have generated considerable market effects beyond those captured by Cascade (see Section 3.4.3 below), Summit Blue finds it to be worthwhile to get a more detailed estimate of the historical and future impacts.

3.4.2 Baseline Activity

The initial estimates of baseline activity were provided by Cascade in the early phases of the VFD Initiative and were based on Cascade's significant involvement in industrial refrigeration activities. Cascade and NEEA together estimated the evaporator fan VFD capacity (HP) already in place at the start of the project in 1998 at approximately 9% of the total market,[21] and they further estimated the amount that was added to the baseline in 1999, 2000, and 2001. Starting in 2002, the *incremental* evaporator fan VFD capacity due to baseline activity was assumed to grow at 1.5% per year until 2010, and these assumptions are reflected in the ACE model [9]. In order to assess these assumptions, the M&T project team reviewed the project documentation [15,16,17,18], interviewed the implementation contractor [20,21], interviewed various controls vendors in the region, and reviewed reports from the National Agricultural Statistics Service (NASS) detailing the growth of refrigerated warehouses [1,2,3,4].

According to Dan Black of Techni-Systems, the market for VFD-controlled evaporator fans "took off about ten years ago," which was right around the beginning of the VFD Initiative [23]. The market baseline report, which was published near the beginning of the Initiative in April 1999, states "very few refrigerated warehouse facilities currently use the VFD technology" [15]. These findings indicate that a small level of baseline activity *did exist* at the beginning of the Initiative, and this is qualitatively consistent with the ACE model assumption that less than 10% of the evaporator fan market had VFD control in 1998. Next, Marcus Wilcox suggested that the market would have been "very poor" without the Initiative. The market at that time was dominated by a few key players who were very negative about the use of VFDs on evaporator fans [20]. Low regional energy costs also hindered the cost-effectiveness of adopting VFDs based on energy cost savings alone, but the NEEA case studies documenting the positive impacts of VFDs on fruit quality helped to assuage the primary concern of many facility owners. Utilities in other jurisdictions, including California, do offer incentives for the installation of VFDs, but these are generally for applications other than evaporator fans in refrigerated warehouses. Furthermore,

[21] The total market was estimated for 2005 using gross storage space data from the NASS report [1] and Cascade estimates of evaporator fan connected load per cubic foot of storage space. See Section 3.4.3 for more details on the total market.

most of the United States fruit storage market is in the Northwest, and it is also the second largest in the US for regular storage. It is therefore more likely that the Northwest would *lead* the country in refrigerated warehouse technologies than follow it.

The above findings suggest that *there would not have been a **significant** increase* in the use of VFDs on evaporator fans in refrigerated warehouses in the Northwest without the VFD Initiative. Analysis of data from the biennial NASS reports [1,2,3,4] further shows that the average annual growth in gross refrigerated warehouse storage in the Northwest was 0.9% over the 6-year period from 1999 to 2005. Given that the estimated growth in baseline activity is fairly consistent with the actual growth in the total market, Summit Blue finds the estimate of 1.5% annual growth in baseline activity to be reasonable.

Recommendation: Based on findings from the interviews and secondary literature review, Summit Blue recommends no change to the ACE model assumptions regarding baseline activity.

3.4.3 Other Market Effects

Total Market for Evaporator Fan VFDs

The NASS report [1] referenced in Section 3.4.2 above was also used to determine the *total market* for evaporator fan VFDs in refrigerated warehouses in the Northwest in 2005. The data for Washington, Oregon, Idaho, and Montana were aggregated by facility type (fruit or regular) to estimate the total volume of refrigerated storage space in the Northwest. As shown in Table 3-3, the Northwest dominates the fruit storage market with 76% of the U.S. capacity for fruit storage. In terms of regular storage, the Northwest has 11% of capacity (3% for cooler space and 14% for freezer space), second only to California at 12%, and followed by Florida at 8%. Table 3-3 also shows that the gross storage space of all refrigerated warehouses in the Northwest was approximately 916 million cubic feet (mcf) in 2005. The conversion of this gross storage space into evaporator fan capacity in horsepower (HP) is also provided, and Marcus Wilcox confirmed that the conversion factors from cubic feet to horsepower as shown below are still appropriate [20]. The market penetration of VFD control for evaporator fans cannot be determined, however, because of the lack of capacity data for the VFD installations reported by Cascade (see Section 3.4.1 above). Table 3-4 shows the historical market size dating back to 1998 using the same calculation methodology as illustrated in Table 3-3.

Table 3-3. Gross Refrigerated Storage Space and Evaporator Fan Capacity in 2005

Location	Regular Storage (mcf)		Fruit Storage (mcf)	Total Storage (mcf)
	Cooler Space	Freezer Space		
Idaho	4,885	56,887	4,777	66,548
Montana	49	938	0	987
Oregon	5,290	103,417	55,672	164,379
Washington	10,435	184,989	488,733	684,157
Total Northwest	**20,659**	**346,231**	**549,182**	**916,071**
Total United States	716,615	2,490,883	721,221	3,928,718
% Northwest	**3%**	**14%**	**76%**	**23%**
Evap Fan Connected Load Per Volume Unit (kW/ft^3)[22]	0.00002925	0.00004588	0.00009860	
Evap Fan Capacity (HP[23])	**809**	**21,286**	**72,560**	**94,655**

Table 3-4. Refrigerated Warehouses in the Northwest by Year and Storage Type 1998-2006

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006
Fruit Storage									
Number of Facilities		231		236		232		227	
Evaporator Fan Capacity (HP)	65,737	67,607	69,478	71,348	72,007	72,665	72,613	72,560	73,386
Regular Storage									
Number of Facilities		137		138		136		147	
Evaporator Fan Capacity (HP)	21,618	21,492	21,367	21,241	21,265	21,289	21,663	22,036	22,127
Total Storage									
Number of Facilities		368		374		368		374	
Evaporator Fan Capacity (HP)	87,354	89,099	90,844	92,589	93,272	93,954	94,275	94,655	95,512

Determination of Market Effects Beyond Those Captured by Cascade

To determine whether the Evaporator Fan VFD Initiative generated market effects beyond those captured by Cascade, Summit Blue interviewed Cascade staff, representatives from two major refrigeration controls vendors in the region, and several regional facility owners and operators. According to Dan Black at Techni-Systems, approximately half of the existing facilities in the Northwest have been retrofit with evaporator fan VFDs. He specifically noted that utility incentives have helped increase the penetration of VFDs and, in the case of CA rooms, make the choice a "no-brainer" [23]. John Cockrum of Doubl-Kold stated that Cascade is involved with

[22] Provided by Cascade Engineering as part of their original proposal to NEEA.
[23] HP is calculated by multiplying kW by 1.34.

"virtually 100% of the [fruit storage] market" in the Northwest. Mr. Cockrum also reported that it is very common for new projects to include VFDs but that they are "very driven by electricity costs" [24]. Mr. Black took this notion even further, stating that it is now ***standard** practice* to include VFDs on evaporator fans in refrigerated warehouses. He specifically cited the example of one new refrigerated warehouse in Wenatchee County in Washington, saying "almost no one puts in a new refrigerated facility without VFDs" [23]. Given these notes from two prominent market actors, the M&T project team found it likely that some evaporator fan VFD installations in the region were going in without Cascade's involvement. Summit Blue contacted Mike McDevitt at Cascade, and he said that he is "aware of several VFD installations that went in without any Cascade involvement including" Dovex, Underwood Fruit, Stadelman's Fruit, and Washington Fruit. He also said, "There are likely others" [21].

Next, Summit Blue endeavored to interview facility owners and operators to determine (a) whether additional market effects not captured by Cascade were being generated in the region, and (b) what portion, if any, could be attributed to the VFD Initiative. The interview questions were designed to quantify the amount of refrigerated storage space with evaporator fan VFD control, to determine the influences on the decision to install VFDs, to determine the VFD installations with which Cascade had been involved, and to ascertain how much had been done with utility incentives. The questions were also set up to disaggregate the results by refrigerated facility type and storage type. Starting with the suggestions from Mr. McDevitt, the M&T project team made many calls over the course of several days, and a total of five interviews were completed. Table 3-5 shows the interview attempts and completions, as well as whether additional market effects are likely; all completed interviews were with operators of fruit storage facilities.[24]

Table 3-5. Interview Completions

Interview No.	Company	State(s) Represented	Facility Type	Interview Completed?	Additional Market Effects Likely?
1	Evans Fruit	WA	Fruit Storage	Yes	Yes
2	Washington Fruit	WA	Fruit Storage	Yes	No
3	Underwood Fruit	WA	Fruit Storage	Yes	Yes
4	Dovex	WA	Fruit Storage	Yes	Yes w/ Incentives
5	Stadelman's Fruit	OR	Fruit Storage	Yes	No
6	Stadelman's Fruit	WA	Fruit Storage	No	
7	Wal-Mart	NW	Regular Storage	No	

Attribution of Additional Market Effects to the VFD Initiative

Of the five completed interviews, the operators at two (Washington Fruit and Stadelman's Fruit Oregon) reported that all of their evaporator fan VFD installations had been installed with Cascade's involvement. Summit Blue checked this against the project tracking database [10] and found that Cascade had indeed reported VFD installations for these two storage operators. The facility operator for Dovex reported that they operate 5 regular cold storage rooms and about 100 CA rooms. He further reported that 40% of the regular cold storage space and 75% of the CA storage space had been retrofit with evaporator fan VFDs. In addition, according to this operator,

[24] Summit Blue made several attempts to contact Wal-Mart, but multiple emails and phone calls led to no results.

Cascade was involved in *none* of the VFD installations, but all of the installations received utility incentives. Summit Blue checked these findings against the project tracking database and found that *one* installation had been reported for Dovex in 2001. Although market effects beyond those captured by Cascade *are likely for this facility*, not enough information was available from the interview to determine the portion of VFD installations for Dovex that had been installed without Cascade's involvement.

According to Mr. McDevitt, Evans Fruit installed evaporator fan VFDs at many of their facilities with Cascade's direct involvement and one at Mattawa without Cascade's involvement at all. Mr. McDevitt also thought that the VFDs were installed without any utility incentives, though he personally felt that it was probably not cost-effective for them to do so [21]. Summit Blue checked this against the project tracking database and found *no installation* at Mattawa for Evans Fruit. The M&T project team subsequently contacted the controls vendor for Evans Fruit (Mark Desoulier at Doubl-Kold) to determine the capacity of the Mattawa facility.[25] Mr. Desoulier reported that Evans Fruit had indeed built a "nine room CA complex" in Mattawa with a storage capacity of 30,000 bins. He also confirmed Cascade was not involved in this particular installation but was involved in all of the others and that this involvement *likely influenced the Mattawa installations*. Last, he confirmed that the Mattawa facility VFDs had gone in without any utility incentives at all. Given the history of Evans Fruit installing evaporator fan VFDs with Cascade, *it seems likely that the savings from VFD installations at the Mattawa facility are attributable to the VFD Initiative.*

The facilities operated by Underwood Fruit in Washington also appear to have generated additional market effects. Specifically, the operator representing these facilities reported that half to two-thirds of his CA storage capacity had been retrofit with evaporator fan VFDs, and 20% of his regular cold storage had been retrofit. When asked what influenced his company to install VFDs on their evaporator fans, this operator said the primary reason was improved fruit quality and the secondary reason was energy savings. When asked whether the VFD Initiative and case studies were an influence, the operator reported nothing about NEEA specifically but instead said that they "may have seen some literature" regarding improvements in fruit quality and energy savings. He also noted that Cascade was "involved in the beginning, but we did them all on our own." He further clarified this statement by saying that none of the evaporator fan VFD installations went in with Cascade involvement, but that they may have been influenced by Cascade. Last, he stated that none of the VFDs had been installed with utility incentives. Summit Blue checked these findings against the project tracking database and found that *no installations* had been reported for Underwood Fruit. Given this respondent's emphasis on fruit quality and energy savings, which were the primary benefits documented in the NEEA case studies, as well as Cascade's direct influence, *it seems likely that the savings from the VFD installations for this storage operator are attributable to the VFD Initiative*.

Energy Savings from Additional Market Effects

In addition to asking the respondents about the percentage of storage space with VFD control, Summit Blue also asked about the total refrigerated storage space that the operators represent. All of the operators found this question most easily answered in terms of the number of bins of fruit storage. When asked about the dimensions of the fruit storage bins, all operators reported using 25-bushel bins with approximate outside dimensions of 48"x48"x28" or about 37.3 cubic feet of

[25] Summit Blue first contacted Bill Evans (the owner of Evans Fruit), but he directed us to his controls vendor.

volume.[26] The space consumed by these bins is the "usable" storage volume, and this was converted to gross storage volume using the ratio of gross-to-usable space for the Northwest states from the most recent NASS report [1]. Once the storage volume was determined, Summit Blue used the evaporator fan connected load values from Cascade's original proposal to determine the evaporator fan capacity for each of these operators. Last, Summit Blue used the per-unit savings values from MPER-3 [17] to determine the annual energy savings due to evaporator fan VFDs at these sites.[27] Table 3-6 shows the calculation of the other market effects from the available data. The market effects from Evans Fruit and Underwood Fruit that is attributable to the VFD Initiative are 1,171,000 kWh/yr.

Table 3-6. Calculation of Additional Market Effects Attributable to VFD Initiative

	Source	Evans Fruit		Underwood Fruit	
		CA Storage	Regular Fruit Storage	CA Storage	Regular Fruit Storage
Storage Capacity (Bins)	Operators	30,000	0	65,000	35,000
Cubic Feet Per Bin – Usable Volume	Operators	37	37	37	37
Conversion to Gross Storage Space	NASS data	1.2	1.2	1.2	1.2
Gross Storage Capacity (Cubic Feet)	Calculation	1,348,000	0	2,921,000	1,573,000
Evap Fan Connected Load Per Unit Volume (kW per Cubic Feet)	Cascade	9.86×10^{-5}	9.86×10^{-5}	9.86×10^{-5}	9.86×10^{-5}
Evaporator Fan Capacity (HP)	Calculation	133	0	288	46
Per-Unit Savings (kWh/HP/year)	MPER-3	2,400	3,500	2,400	3,500
Annual Energy Savings (kWh/year)	Calculation	319,000	0	691,000	161,000

Recommendation: Summit Blue recommends that NEEA attribute additional market effects beyond those captured by Cascade for the two companies outlined in Table 3-6. As Mike McDevitt reported, however, "there are likely others." Summit Blue therefore recommends continuing to survey facility owners and operators in future M&T efforts with a focus on determining the market penetration of VFDs on evaporator fans in the Northwest.

[26] The volume of 25 bushels is approximately 31.1 cubic feet, leaving approximately 6.2 cubic feet (37.3 minus 31.1) for actual bin *material*.

[27] Summit Blue also reviewed the per-unit savings values for use in determining market effects beyond that captured by Cascade. The data was based on information from the field trials provided by Cascade Energy Engineering and research conducted in 2002 for MPER-3 [17], and Mr. Wilcox stated that the numbers (when calculated for the MPER) might have been conservative and that he considers them reasonable [20]. A search of literature related to VFD initiatives and reports did not provide any data that could be used to adjust the savings multiplier. VFD applications are either specifically targeted, as in the Evaporator Fan VFD Initiative, or included as part of custom project applications such as the Energy Trust of Oregon's Industrial Transition Initiative. Thus Summit Blue finds these values to be reasonable for determining additional market effects.

3.4.4 Future Market Activity

It is likely that the growth in evaporator fan VFD penetration in refrigerated warehouses will continue to be strong in future years. Marcus Wilcox said that using VFDs to control evaporator fan load in refrigerated facilities is increasingly becoming common practice [20]. Dan Black of Techni-Systems submits that it is *standard practice* in new construction and existing facilities are constantly being retrofitted [23]. *All* of the survey respondents reported that 100% of their new construction projects, both for CA rooms and regular storage, are being built with VFDs on the evaporator fans. Additional evidence for continued growth includes:

- the industry is small (fewer than 400 facilities) and relies heavily on sharing of information.
- the influence of consultants and contractors who are opposed to VFDs has diminished.
- new facility owners and controls vendors favoring VFDs.

Incremental baseline activity is likely to grow at the rate predicted in the ACE model (1.5% per year), and Summit Blue recommends no change to these values. Last, based on findings from the research completed for Section 3.4.3 above, market effects beyond those captured by Cascade are likely to be significant. A concerted effort should be made to quantify and separate these effects from those reported by Cascade.

3.5 Conclusions/Recommendations

Table 3-7 summarizes Summit Blue's recommendations for the Evaporator Fan VFD project:

Table 3-7. Evaporator Fan VFD Initiative M&T Recommendations

Key Inputs Reviewed	Current ACE Model Value(s)	Recommended Value(s)	Sources
Current Market Activity			
Number of Sites	Varies by year	See Table 3-1	• Project tracking database [33] • See Section 3.4.1
Energy Savings (kWh/yr)	Varies by year	See Table 3-1	• Project tracking database [33] • See Section 3.4.1
Baseline Activity			
Evaporator Fan Capacity (HP) w/ VFD Control	1.5% annual growth from 2002-2010	No change	• Literature review • M&T interviews • See Section 3.4.2
Other Market Effects – Fruit Storage Market			
Total Evaporator Fan Capacity in Market (HP)	Varies by year	See Table 3-4	• NASS Reports [1,2,3,4,5] • See Section 3.4.3
Evaporator Fan Capacity (HP) w/ VFD Control	0	467 HP	• M&T Interviews • See Section 3.4.3
Energy Savings (kWh/yr)	0	1,171,000	• M&T Interviews • See Section 3.4.3

- **Continue tracking Cascade's involvement in evaporator fan VFD installations.** In addition to energy savings, future tracking requirements should include data for evaporator fan capacity (HP), facility type (fruit or regular storage), and storage type (CA or regular).

- **Use a small portion of the M&T budget to have Cascade go through their historical records and input evaporator fan capacity data for the VFD installations to date.** This data was generally not available after 2001, and it is the key metric for determining market effects. This data should also be disaggregated by refrigerated facility type (fruit storage or regular cold storage, for determining market penetration) and storage type (CA or regular, for further analysis of savings due to market effects beyond those captured by Cascade).

- **Continue to use the current ACE model data for estimates of baseline activity.** Findings from literature review, M&T interviews, and NASS reports indicate that the values estimated in the ACE model are reasonable, even conservative. At the start of the project in 1998, the market had been dominated by key players—consultants, contractors, controls vendors—most of whom were opposed to the use of VFDs for evaporator fans. Little growth was expected to happen at the time.

- **Revise the estimates of the total market going back to 1998 as illustrated in Table 3-4.** The M&T estimate of the total evaporator fan capacity (HP) for refrigerated warehouses is based on actual data from the biennial NASS reports. The conversion from storage space to evaporator fan HP uses the same methodology as Cascade in their original proposal to NEEA.

- **Gross program savings should be adjusted to account for market effects beyond those captured by Cascade.** The M&T interviews of facility owners and operators revealed the presence of additional market effects that can be reasonably attributed to the VFD Initiative.

The gross program savings should be adjusted to capture these additional impacts as illustrated in Table 3-6.

- **Continue interviews with facility operators and controls vendors to assess the extent of additional market effects.** The VFD Initiative generated considerable market effects not captured by Cascade. Future M&T efforts should focus on determining market penetration of VFDs on evaporator fans in the Northwest. Constructing a database of facilities in the region from Cascade's knowledge and as operator interviews are completed would help facilitate this process.

- **Package and present results as an example of market transformation of VFD applications.** The Evaporator Fan VFD Initiative resulted in a well-documented set of materials such as case studies, databases, etc., that could be used to demonstrate the transformation of niche market applications for variable frequency drives as well as an example of the value of cooperation between NEEA and the utilities. The results could be used as part of the package to demonstrate market transformation of VFD applications.

3.6 References

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4. MAGNADRIVE

4.1 Introduction

In 1999, the Northwest Energy Efficiency Alliance (NEEA) formed a partnership with MagnaDrive Corporation (MagnaDrive) to accelerate the development and commercialization of MagnaDrive's proprietary adjustable-speed drive (ASD) for motors. MagnaDrive's technology is a coupling device that uses powerful rare-earth permanent magnets to transmit torque through an air gap from the motor drive to the load shaft. By varying the air gap spacing, the speed of the motor can be controlled to match the load, thereby reducing energy usage in low-load situations. With no mechanical connection between the motor drive and the load shaft, the MagnaDrive ASD also eliminates vibration transfer and harmonics; allows for soft starting and stopping; reduces maintenance costs; and improves safety [5].[28]

The market transformation goal of the MagnaDrive project was not to replace VFDs, but instead to expand the motor speed-control market into applications where VFDs are not well suited [1]. During the first phase of the project, NEEA funded performance and comparison testing between the MagnaDrive ASD and conventional VFDs [9], market research and assessment studies [10,11,12,13], and four industrial case studies. The second phase of the project focused on increasing MagnaDrive ASD sales in targeted market sectors, expanding the technology into the larger motor market, and penetrating the irrigation market [5]. According to the 2004 Market Activities Report (MAR), MagnaDrive successfully completed its goals, and NEEA ceased funding in December 2004 [1].

This is the first Long-Term Monitoring and Tracking (M&T) report for the MagnaDrive venture.

4.2 Indicators and Assumptions for Review

According to Summit Blue's review of the ACE model [4], the cost-effectiveness of the MagnaDrive project is contingent on the level of MagnaDrive ASD sales in the Northwest, as well as several key assumptions concerning the savings potential of the technology and the speed-control market. Specifically, the *gross* energy savings impact of the MagnaDrive project is the product of the total motor capacity (HP) controlled by MagnaDrive ASDs and the annual energy savings per unit capacity (kWh/HP/yr). The ACE model currently assumes zero baseline activity and no influence on the broader speed-control market beyond that captured by MagnaDrive sales. Summit Blue therefore focused its efforts on tracking current activity in the market, validating the per-unit savings assumptions, reassessing baseline activity, and quantifying market effects beyond Magna Drive sales that are attributable to the MagnaDrive project. Specifically, the following inputs to the cost-effectiveness calculation were assessed:

- MagnaDrive's current market activity in the Northwest, including the number of ASDs and couplings sold and the capacity (HP) of the motors on which they are installed.
- The per-unit savings assumption (kWh/HP/yr), which is a function of several other assumptions.
- The level of baseline activity in the Northwest.
- Market effects beyond Magna Drive sales that are attributable to the MagnaDrive project.

[28] MagnaDrive also sells constant-speed magnetic couplings as part of their product line, which offer the same non-energy benefits as the ASD but no speed control.

In accordance with the M&T work plan for 2006 [4], the project team also investigated the likely magnitude of MagnaDrive's continued market activities in the Northwest and made recommendations for future tracking efforts. Finally, Summit Blue assessed the reasonableness of providing a *precise* update to overall market size and the market penetration of the MagnaDrive ASD in a manner that is not cost-prohibitive.

4.3 Methodology

Summit Blue conducted the following data collection activities in support of the MagnaDrive M&T effort:

- **Reviewed project reports and documentation.** Since this is the first M&T report for the MagnaDrive project, Summit Blue conducted an in-depth review of the project documentation to obtain a detailed understanding of the program theory and the savings assumptions. The reviewed documentation includes the MagnaDrive ACE model [4], each of the four MPERs [5,6,7,8], the motor market research reports [11,12,13], and many others. A full list of the documentation reviewed for this report can be found in Section 4.6 below.

- **Reviewed secondary sources of data.** The project team also reviewed secondary market research completed with respect to motor markets in general, including the US DOE motor market opportunities report [10]. This research was completed with a focus on understanding the level of effort required to update market size, market projections, and the market penetration of MagnaDrive ASDs in the Northwest. This research also provided inputs to the validation of the per-unit savings multiplier.

- **Interviewed NEEA staff familiar with the MagnaDrive project.** The M&T project team spoke with both Bob Helm [15] and Jeff Harris [16] and gathered the following information:
  - *MagnaDrive ASD sales data.* Mr. Helm provided a spreadsheet of MagnaDrive sales in the Northwest from 2004-2005. Mr. Harris supplemented the sales data with a separate spreadsheet listing MagnaDrive sales from 2001-2003. Sales for the period 1999-2000 were corroborated through several sources, including old data from Mr. Helm's spreadsheet, the MPERs, and a separate NEEA savings spreadsheet.
  - *Contact information for MagnaDrive staff.* Mr. Helm provided contact information for both Don Jacques and Steve Manwell at MagnaDrive.
  - *Project background and program theory.* The M&T project team spoke with Mr. Helm about the history of the project and the current status of MagnaDrive's activities in the Northwest. Summit Blue also spoke at length with Mr. Harris concerning the impetus for the project, assumptions regarding the baseline, and sources for the savings estimate.

- **Interviewed MagnaDrive staff.** Summit Blue interviewed Don Jacques at MagnaDrive for the following information [17]:
  - *MagnaDrive ASD sales data.* Mr. Jacques provided an update of MagnaDrive sales in the Northwest, including both ASDs and couplings, for the period of January 1, 2006 through October 31, 2006. Mr. Jacques also reviewed and revised some of the HP estimates for 2005 that were apparently entered incorrectly.
  - *Additional case studies.* Mr. Jacques sent the project team four new case studies, now called Quantified Business Results (QBRs), which were not available on the MagnaDrive website.

- *Company information and sales anecdotes.* Mr. Jacques discussed current sales methods and the market for MagnaDrive ASDs and couplings. He also discussed the relationship between the ASD and VFDs, as well as the competition for sales between the two technologies.

- **Interviewed the project evaluation contractor.** Summit Blue also contacted key personnel from Quantec that worked closely in the evaluation of the MagnaDrive project. They provided the source for the energy savings percentage that was recommended in MPERs 2 [6] and 3 [7], as well as additional thoughts concerning project theory and the role of the MagnaDrive ASD in the motor speed control market [18].

4.4 Findings

4.4.1 Current Market Activity

As described in Section 4.2 above, a key input to the gross energy savings calculation is the motor capacity (HP) in the Northwest that is controlled by a MagnaDrive ASD. While sales of the coupling have generally been increasing, sales of the ASD have varied significantly from year to year. As noted in MPER-3 [7], the decline in quantity of ASD sales from 2001-2003 was "primarily due to the ongoing recession in 2001 and 2002." In 2003, MagnaDrive converted its business model from a focus on direct sales to a focus on distributor and Original Equipment Manufacturer (OEM) sales. This transition also involved training those in its distributor network to sell the ASDs based on a "total cost of ownership" analysis instead of focusing on the capital cost. This modified approach to sales focused on *cost savings* achieved through (a) energy savings (for the ASD) and (b) reduced maintenance due to MagnaDrive's significant non-energy benefits (for both the ASD and the coupling) [7,17].

Furthermore, according to Mr. Jacques, the energy savings achieved by a MagnaDrive ASD are not the "basis for sales." For most customers, the non-energy benefits of having a disconnected coupling far outweigh the energy savings. As a result, the distributors are now "leading" with couplings in their sales pitch because they include all of the non-energy benefits of an ASD at a lower cost. Once the customer has been satisfied that they will receive significant cost savings due to reduced maintenance, it requires less effort to convince them that speed control would add to the cost savings via reduced energy consumption. According to Mr. Jacques, the new approach of leading with couplings when making a sales pitch has in turn "helped to sell more ASDs" [17]. Table 4-1 shows MagnaDrive sales in the Northwest, including the average motor HP per ASD sold and the total motor HP of ASD sales.[29]

[29] Because of the relatively large capital cost of a MagnaDrive ASD, it can be reasonably assumed that the purchaser conducted some level of research concerning the costs and benefits of a MagnaDrive for the intended application. Consequently, the percentage of sold units that were never installed or were subsequently removed is likely zero or otherwise very small. As a result, the project team considers it prudent to assume that all MagnaDrive ASDs that are sold are also installed and achieving energy savings.

Table 4-1. MagnaDrive ASD Sales in the Northwest by Year

	MagnaDrive ASDs	
	Average Motor HP Per ASD Sold	**Total Motor HP of ASD Sales**
Pre-2001	100	2,994
2001	85	3,823
2002	124	4,726
2003	218	2,184
2004	159	3,680
2005	189	7,935
YTD-2006*	215	6,230
All Years	**141**	**31,572**
* Data for 2006 includes ASD sales through Oct 31, 2006.		

As shown in Table 4-1, the average motor size for MagnaDrive ASD installations in the Northwest is 141 HP. This is much lower than was anticipated during planning stages of the project, at which time the market assessment report [13] analyzing MagnaDrive's market opportunities predicted that the large horsepower ASD market (those over 500 HP) would represent the start-up's "principal opportunity." To date, however, only one ASD has been sold for motors in this category. However, with the notable exception of 2003 to 2004, the average motor size per ASD installation has increased steadily year-by-year since 2001, and the project team expects that it will remain on the increase as MagnaDrive continues to establish the benefits of its technology to large horsepower customers.

4.4.2 Per-Unit Savings Assumptions

Another key input to the gross energy savings equation is the estimate of energy savings per-unit capacity. The value of 1,186 kWh/HP currently used in the ACE model [4] was derived from a combination of sources and was calculated according to the following formula:

Per-Unit Annual Energy Savings (1,186 kWh/HP/yr) =

(1) Average annual operating hours (6,466 hours/year)
x (2) Average energy savings percentage (24.6%)
x (3) Conversion factor (0.746 kW/HP)

where:

- **Average annual operating hours** is the assumed average full-load hours for motors on which MagnaDrive ASDs would be installed in the Northwest.
- **Average energy savings percentage** is the average energy savings achieved by installing a MagnaDrive ASD in the place of no speed control.
- **Conversion factor** is the standard HP-to-kW conversion, equal to 0.746 kW/HP.

Another method for determining a reasonable per-unit savings value would be to average the results from the MagnaDrive case studies. This methodology could potentially introduce some bias, however, in that MagnaDrive uses the case studies as sales tools and thus is not likely to make available those case studies that might show low energy savings. Nevertheless, the case studies do provide a "sanity check" for the final recommended energy savings value. In the absence of M&V for each MagnaDrive ASD installation, the equation approach offers a practical method to estimate the gross savings achieved by the MagnaDrive project within a reasonable range.

Furthermore, although the equation includes three inputs, one is simply a placeholder. Only variations in the annual operating hours and the energy savings percentage actually affect the annual per-unit savings. The assessment of these variables is presented in the following subsections.

Average Annual Operating Hours

According to the cost-effectiveness analysis key assumptions document [14], the annual operating hours came from “the Easton and Associates” report. A thorough review of each Easton and Associates report [11,12,13], however, revealed no explicit reference to 6,466 annual operating hours. Follow-up conversations with NEEA staff revealed that the value actually came from an internal analysis completed for the ACE model that used data from the Easton reports [16]. NEEA arrived at the value of 6,466 by analyzing the potential applications for the MagnaDrive ASD specific to the Northwest and the typical operating hours of those applications. The result of the analysis was intended to represent the *average* annual operating hours for motors in MagnaDrive’s target markets and applications. Specifically, it was chosen to represent large motors in heavy- and rough-duty industrial applications where multiple shifts or continuous operation is common.

In order to assess the reasonableness of this assumption, the M&T project team compared data from NEEA’s internal analysis to the data from the “U.S. Industrial Electrical Motor Systems Market Opportunities Assessment” [10]. Sponsored by the DOE’s Motor Challenge Program, this report appears to have formed the foundation for much of the market research completed for NEEA. It presents data concerning the stock of motor-driven equipment by industrial SIC code, including number of motors by size category and application. More specifically, the report includes tables illustrating the *average operating hours* for each manufacturing SIC code by motor size category and end-use application. Table 4-2 has been reprinted from the report and shows the average annual operating hours across all manufacturing SIC codes (20-39) by size and application.

Table 4-2. Average Hours of Operation by Application and Horsepower

Size Category	Fans	Pumps	Air Compressor	Other	Total
1 – 5 HP	4,550	3,380	1,257	2,435	**2,745**
6 – 20 HP	4,316	4,121	2,131	2,939	**3,391**
21 – 50 HP	5,101	4,889	3,528	3,488	**4,067**
51 – 100 HP	6,151	5,667	4,520	5,079	**5,329**
101 – 200 HP	5,964	5,126	4,685	5,137	**5,200**
201 – 500 HP	7,044	5,968	6,148	6,102	**6,132**
501 – 1,000 HP	8,013	6,829	6,156	7,328	**7,186**
1,000+ HP	8,167	6,955	7,485	7,173	**7,436**
All Motor Sizes	**5,988**	**5,211**	**5,476**	**4,692**	**5,083**
* Source: US Industrial Electrical Motor Systems Market Opportunities Assessment [10]					

As a first step in the comparative analysis, Summit Blue reviewed the average hours of operation from Table 4-2 for all motor uses. Across all SIC codes, all motor sizes, and all applications, the average annual operating hours are 5,083, which is 21% less than NEEA’s assumption of 6,466. Table 4-2 also suggests that, as motor size increases, so do the annual operating hours; that is, larger motors are typically run more in a year than the smaller ones.

Next, Summit Blue reviewed the operating hours *by industry and application* from the motor systems report and compared them to the operating hours from NEEA’s internal analysis. For the industries in which a comparison could be made (such as Pulp & Paper, Primary Metals, and Chemicals), the operating hours used by NEEA were generally within a few percent of those shown in the motor systems report. Furthermore, although typical motor applications and industries in the Northwest are likely somewhat different from those nationally, the general relationship of increasing operating hours with increasing motor size appears to hold true *regardless of the industry*. This finding seems to indicate that motor size generally has a significant impact on operating hours.

As noted in Section 4.4.1 above, the MagnaDrive market assessment report [13] projected that the MagnaDrive ASD would be installed on larger HP motors. As a result, the internal savings analysis completed by NEEA actually yields a melded motor size of 512 HP, which is more than 3 times the average motor size of 141 HP for actual ASD sales (see Section 4.4.1 above). According to Table 4-2, the average annual operating hours for a 512 HP motor would be 7,186, as compared to 5,200 hours for a 141 HP motor. With the advantage of having actual MagnaDrive sales data, Summit Blue estimated the annual operating hours of MagnaDrive ASD installations using the data from the motor systems report. Table 4-3 shows the estimated operating hours for MagnaDrive's ASD sales in the Northwest by year.

Table 4-3. Estimated Operating Hours for MagnaDrive ASD Sales in the Northwest by Year

	Average Motor HP Per Unit	Average Annual Operating Hours (from Table 4-2)
Pre-2001	100	5,329
2001	85	5,329
2002	124	5,200
2003	218	6,132
2004	159	5,200
2005	189	5,200
YTD-2006	215	6,132
Average All Years*	**141**	**5,461**

* The average value for all years was weighted by total HP installed to convert it to a per-HP basis instead of just pulling the number from Table 4-2

Recommendation: Although Table 4-2 includes operating hour values for several industries to which MagnaDrive has made no sales, it *does* include industries where sales have been made that were *not* accounted for in NEEA's internal analysis. Since motor size was found to have a substantial impact on typical operating hours, Summit Blue recommends adjusting the annual operating hours for the per-unit savings calculation *by year* based on the average motor size and the corresponding value from the motor systems report as shown in Table 4-3.

Average Energy Savings Percentage

The energy savings percentage of 24.6% is an estimate of achievable savings over the population of MagnaDrive ASD installations when the baseline condition is no speed control at all [18]. The actual savings achieved are highly dependent on the load itself, including the type of load and the load's variability within the duty cycle. Motors that consistently run at 100% load may actually receive an energy penalty from the installation of the MagnaDrive ASD due to the inherently higher slippage. [9] However, it is reasonable to assume that the customer would not buy an ASD for motors running at 100% load all the time and that all of MagnaDrive's ASD sales are for variable-load applications.

The savings percentage itself was calculated by Quantec (the project's evaluation contractor) using data from the OSU product testing report [9]. The analysis compared energy usage of baffled fans and throttled pumps to that of speed-controlled fans and pumps over various flow ranges using the graphical output from the OSU report. Summit Blue reviewed Quantec's assumptions, as well as the data from the OSU report, and found the analysis to be reasonably representative of loads likely to be seen by the MagnaDrive ASD. The assumptions used in Quantec's analysis are presented in Appendix A to this chapter.

The results of the analysis were that the installation of a MagnaDrive ASD would save an average of 30% on pumps and an average of 23% on fans. The value of 24.6% was chosen as a conservative estimate of savings. Of the 93 ASDs sold from 2001-2003, however, more than three-quarters (76%) were for pump applications.[30] This finding is corroborated by anecdotal evidence that suggests that pumps are more likely to be installed than fans because of their significant vibration problems as compared to fans. Using the actual sales data, the project team computed the weighted average savings for pump and fan installations to be 29.1%, which is more probable than the conservative value of 24.6% currently used to determine savings.

Recommendation: Although data disaggregated by application and industry were not available after 2003, Mr. Jacques reported that the distribution of sales for 2004-2006 was likely the same as the distribution in the years 2001-2003 [17]. Since pump applications represent the vast majority of MagnaDrive ASD sales and achieve different energy savings than the fans, the M&T project team recommends revising the energy saving percentage to 29.1 %.

Revised Per-Unit Savings

As discussed above, the project team recommends changes to both of the critical variables used to determine the per-unit energy savings value. Surprisingly, the revised per-unit savings percentage for all years is nearly exactly the same as that currently assumed in the ACE model [4]. A review of the case studies available on the MagnaDrive website, and those provided by Mr. Jacques, indicates that actual savings in the field vary significantly, from a low of 288 kWh/HP/yr to a high of 3,504 kWh/HP/yr. Evaluating the case studies as a whole seems to indicate that the range of per-unit savings values in Table 4-4 is indeed reasonable.

Table 4-4. Revised Per-Unit Savings for MagnaDrive ASD Sales in the Northwest by Year

	Average Motor Size	Estimated Operating Hours (A)	Energy Savings Percentage (B)	Per-Unit Savings (kWh/HP/yr) A * B * 0.746 = C
Pre-2001	100	5,329	29.1%	1,157
2001	85	5,329	29.1%	1,157
2002	124	5,200	29.1%	1,129
2003	218	6,132	29.1%	1,331
2004	159	5,200	29.1%	1,129
2005	189	5,200	29.1%	1,129
YTD-2006	215	6,132	29.1%	1,331
Average All Years	**141**	**5,461**	**29.1%**	**1,185**

Recommendation: Summit Blue recommends adjusting the per-unit savings *by year* (Table 4-4) based on the average motor size and the corresponding operating hours value from the motor systems report [10] (Table 4-2).

[30] Data disaggregated by application and industry was not available after 2003.

4.4.3 Baseline Activity and Other Market Effects

The task of determining the net energy impact for any effort is difficult, but doing so for a venture aimed at transforming a market can be especially complicated. The critical role played by NEEA in the development of MagnaDrive as an entrepreneurial company has been well documented in the four MPERs. As such, the uncertainty in estimating energy savings is primarily a function of the assumed baseline condition. According to the 2004 MAR [1], "The market transformation goal is to expand the speed control market – rather than replace variable frequency drives (VFDs) – by introducing the MagnaDrive coupling in applications where VFDs have not penetrated or are not ideal/applicable." The implicit assumption is therefore that the MagnaDrive ASD is being installed in applications where the baseline condition is no speed control at all because VFDs cannot be used. Since the OSU product testing report [9] concluded that, on average, the MagnaDrive ASD saves approximately two-thirds of the energy saved by a VFD, any condition where the baseline might be a VFD would actually result in an energy penalty. Currently, NEEA assumes the baseline condition for all reported MagnaDrive ASD sales in the Northwest to be no speed control.

To assess the reasonableness of this assumption, the project team researched the MPERs, reviewed MagnaDrive's website [19], and spoke directly with Jeff Harris [16] and Don Jacques [17] about the issue. The MPERs, in particular, seem to contradict the notion that MagnaDrive may only be competitive in niche markets where VFDs have not penetrated:

- **MPER-2, pg IV-1 [6]:** *Since the ASD and competitive VFDs have similar pricing structures, the MagnaDrive is, on the surface, competitive only in sub-markets where speed control is not currently being used. Non-energy benefits, however, may make the ASD economically viable relative to VFDs and other speed-control devices in certain cases.*

- **MPER-3, pg ES-4 [7]:** *The MagnaDrive is still widely viewed as competitive technology to the VFD.*

- **MPER-4, pg ES-2 [8]:** *…MagnaDrive's marketing approach and message appear to be as much directed at going after the existing VFD market as increasing the overall speed control market.*

MPER-2 develops a model that compares the life cycle cost of a MagnaDrive ASD, a VFD, and no speed control. In all cases, the model shows that the MagnaDrive ASD achieves the lowest overall cost and a better payback than the VFD. A review of the MagnaDrive website, as well as conversations with Mr. Jacques, indicate that MagnaDrive is now focusing their sales pitch on the "total cost of ownership" model so that they can compete with VFDs. While this is good for MagnaDrive and its customers, a motor's energy consumption might actually *increase* if a customer was going to install a VFD but decided to go with a MagnaDrive ASD because of the lower life cycle costs. While this focus on life cycle cost does not necessarily suggest that the baseline would be a VFD, documentation from MPER-3 indicates that the significant non-energy benefits of the MagnaDrive ASD are leading to the removal of VFDs in at least some cases. The following is a reprint of a quote by one of MagnaDrive's OEM customers:

- **MPER-3, pg II-5 [7]:** *…With the addition of the MagnaDrive ASDs and couplings, we expect to be able to modify our centrifuges and easily operate them at variable speeds, which is currently being achieved with either sophisticated hydraulic or variable frequency drives. The implementation of MagnaDrive technology will yield much simpler systems, resulting in a reduction in maintenance costs as well as an increase in reliability and safety…*

When asked if there had been instances where a customer was going to install a VFD but sales staff was able to convince the customer to go with a MagnaDrive ASD instead due to the life cycle cost analysis, Mr. Jacques replied, “Absolutely. Yes.” He also reported that the MagnaDrive ASD competes head-to-head against VFDs in about 40-50% of sales, and in more than two-thirds of these cases, the customer was either (a) decided on installing a VFD or (b) deciding between an ASD and VFD. Because of this research, the M&T project team considers it unreasonable to assume the baseline condition to be no speed control *in all cases*.

Several factors exist, however, to mitigate the apparent non-zero baseline. The first is a restatement of the results of the OSU product testing report that says VFDs will save more energy than the MagnaDrive ASD. In reality, the MagnaDrive ASD performs more efficiently in some flow ranges while the VFD performs more efficiently in others. As long as they are not applied to a motor running at 100% all the time, both will save considerable amounts of energy over no speed control. Second, when asked if they had made sales where a customer had a VFD installed but was having such significant problems that they were going to go back to no speed control, Mr. Jacques replied, “Quite a few.” In these cases, the MagnaDrive ASD was able to keep motors under speed control where VFDs had failed.

Third, Mr. Jacques pointed out that the MagnaDrive *couplings* are achieving mostly small energy savings that are not being captured by NEEA. The couplings achieve savings simply by providing a disconnect between the load shaft and motor shaft, thereby reducing the stress caused by misalignment. Even slight misalignment or off-center loading can lead to increased motor load (and thus wasted energy) needed to overcome system losses from bent shafts. This phenomenon was the focus of one of the case studies provided by Mr. Jacques, and it indicated *energy savings of 35%* simply from the installation of the disconnected coupling. While most installations would likely not achieve savings anywhere close to this level, more than 130 couplings have been sold to date. Even small energy savings from these components would add up quickly and could potentially offset any reduction in savings due to a non-zero baseline.

Finally, according to conversations with both Mr. Harris and the evaluation contractor, a big component of the MagnaDrive venture was to push the overall speed control market, to “expand the pie.” This sentiment was echoed in the 2004 MAR as well: “It is believed that this product introduction [MagnaDrive] will stimulate the development of a new generation of VFDs, which will provide improved energy efficiency and non-energy benefits.” While MPER-4 expresses doubt about how well NEEA’s objective of transforming the speed control market is being accomplished, the competition with VFDs does seem to be promoting increased opportunities for motor speed control. In particular, MPER-4 states “…some VFD distributors have been lowering the first cost of VFDs in order to keep MagnaDrive out the market…” This information was corroborated by Mr. Jacques during the M&T interview as well.

Recommendation: While there does not seem to be any doubt that the baseline condition for MagnaDrive ASD sales is not always “no speed control,” there also seems to be no doubt that additional market effects are not being captured. Quantifying these variables, however, would be difficult and would require significant primary research, the cost of which would not be commensurate with the increased precision. As such, Summit Blue recommends that NEEA assume that the baseline and other market effects ‘net out’ to zero. If savings from MagnaDrive ASD sales begin to accelerate, however, it may be worthwhile to research these variables in more detail.

4.4.4 Future Market Activity

The outlook for MagnaDrive is good. Mr. Jacques reported that MagnaDrive is currently trying to get beyond the borders of North America and into markets in Europe and elsewhere. He also reported that they have been having “problems” with distributors in the Northwest, in particular that the distributors are “not prolific” in terms of sales compared with other regions. Although sales are likely to continue in the Northwest, Mr. Jacques was uncertain of the sales magnitude. As he put it, “We’re working on it.” [17]

The project team also assessed the reasonableness of providing an accurate update to market size and market penetration of the MagnaDrive ASD. Summit Blue reviewed the data from the Easton and Associates reports [11,12] and conducted many web searches for secondary data regarding the motor market in the United States. Unfortunately, it appears that no publicly available research has been conducted since the 1998 motor systems report. Summit Blue also contacted staff at Drives Research Corporation to see if they knew of any publicly available motor research that had been done in the United States. They replied that they have been doing continuing research but that the information was proprietary and could not be given away. The cost of conducting primary research would be significant. As such, the project team considers the research completed by Easton and Associates concerning the overall market, the market in the Northwest, and the market for variable speed applications in the Northwest continues to be the best available estimate for market size.

4.5 Conclusions/Recommendations

Table 4-5 summarizes Summit Blue's recommendations for the MagnaDrive project:

Table 4-5. MagnaDrive M&T Recommendations

Key Inputs Reviewed	Current ACE Model Value	Recommended Value	Sources
Current Market Activity and Per-Unit Savings			
Installed HP with MagnaDrive ASD	Varies by year	See Table 4-1	• Don Jacques of MagnaDrive [17] • See Section 4.4.1
Annual Operating Hours	6,466	See Table 4-3	• US DOE Motor Systems Report [10] • See Section 4.4.2
Energy Savings Percentage	24.6%	29.1%	• Quantec savings analysis • OSU product testing report [9] • MagnaDrive sales data 2001-2003 • See Section 4.4.2
Per-Unit Savings (kWh/HP/yr)	1,186	See Table 4-4	• Summit Blue analysis of annual operating hours and energy savings percentage • See Section 4.4.2
Baseline Activity			
Percent of Installed HP with MagnaDrive ASD	0%	No change	• MPERs 1-4 [5,6,7,8] • Market research reports [11,12,13] • Interview with Jeff Harris [16] • Interview with Don Jacques [17] • See Section 4.4.3
Other Market Effects			
Market Effects Not Captured By MagnaDrive ASD Sales (kWh/yr)	0	No change	• MPERs 1-4 • Market research reports • Interview with Jeff Harris • Interview with Don Jacques • See Section 4.4.3

- **Continue tracking ASD sales in the Northwest.** Not including OEM sales, MagnaDrive sold 22 ASDs from the period of January 1, 2006 through October 31, 2006. Although the magnitude of sales in the Northwest going forward is somewhat uncertain at this point, tracking the sales data requires little effort and is the key indicator of MagnaDrive's success in the Northwest.

- **Revise the per-unit savings assumption based on average motor size for MagnaDrive's ASD sales by year.** The review of actual sales data led to changes in both the average annual operating hours and the energy savings percentage. Recalculating the per-unit savings value based on average motor size (see Table 4-3) will provide for increased resolution and less uncertainty.

- **No adjustments should be made for the baseline or to account for other market effects.** While a non-zero baseline is likely, other market effects and energy savings from couplings are not currently being captured. Quantifying these variables, however, would be difficult and would require significant primary research, the cost of which would not be commensurate with the increased precision. As such, Summit Blue recommends that NEEA assume that the baseline and other market effects 'net out' to zero. If savings from MagnaDrive ASD sales begin to accelerate, however, it may be worthwhile to research these variables in more detail.

4.6 References

1. *2004 Market Activities Report,* Northwest Energy Efficiency Alliance, 2005.

2. *Long Term Monitoring and Tracking Report on 2005 Activities,* Summit Blue Consulting for Northwest Energy Efficiency Alliance, April 14, 2006.

3. *Long Term Monitoring and Tracking DRAFT Workplan for 2006 Activities,* Summit Blue Consulting for Northwest Energy Efficiency Alliance, August 21, 2006.

4. "MagnaDrive MAR 2005.xls," Northwest Energy Efficiency Alliance.

5. *Market Progress Evaluation Report: MagnaDrive, No. 1,* Quantec, Report #01-080, May 2001.

6. *Market Progress Evaluation Report: MagnaDrive, No. 2,* Quantec, Report #02-099, May 2002.

7. *Market Progress Evaluation Report: MagnaDrive, No. 3,* Quantec; Report #03-018, July 10, 2003.

8. *Market Progress Evaluation Report: MagnaDrive, No.4*; Quantec, Report #05-149, October 20, 2005.

9. *Product Testing: Magna Drive, Report No. 1,* Motor Systems Resource Facility, Oregon State University, Report #00-048, March 2000.

10. *United States Industrial Electric Motor Systems Market Opportunities Assessment,* Xenergy, Inc., December 1998.

11. *Market Research Report: Variable Frequency Drives,* Easton Consultants, Inc, Report #00-054, June 2000.

12. *Market Assessment: Summary of Energy Savings Opportunities,* Easton Consultants, Inc, Report #99-044, December 1999.

13. *MagnaDrive Corporation: Market Assessment and Marketing Strategy for the MagnaDrive ASD, A New Speed Control Technology,* Easton Consultants, Inc., January 24, 2000.

14. *MagnaDrive Variable Speed Drive: Cost-Effectiveness Analysis Key Assumptions – Converted,* Northwest Energy Efficiency Alliance, January 27, 2005.

15. *Personal communications with Bob Helm,* Northwest Energy Efficiency Alliance, October 2006.

16. *Personal communications with Jeff Harris,* Northwest Energy Efficiency Alliance, December 2006.

17. *Personal communications with Don Jacques*, MagnaDrive Corporation, December 2006.

18. *Personal communications with Scott Dimetrosky, Ken Seiden, and Allen Lee,* Quantec, LLC, December 2006.

19. www.magnadrive.com.

4.7 Appendix A

Table 4-6. Input Assumptions to Energy Savings Analysis (from Quantec)

Input Name	Notes
Motor Loading	This value equals the load driven by the motor. In these worksheets the load is either the movement of liquid for pumps or the movement of air for fans. The load distribution is given in % of max fluid flow required for each hour in a sixteen hour (two shift) time period and can be seen in the worksheet labeled load distribution. It is assumed that the flow is being controlled by a throttle valve in the pump input sheets and baffles in the fan input sheets. Data from an Oregon State University (OSU) report (1) was used to correlate % flow to power used by the motor. The resulting column of data was used to calculate average motor loading.
Energy Savings W/VFD	Using the same load distribution as discussed above, percent fluid flows (pff) were correlated to the power draw of a motor being controlled by a VFD. Data from the OSU report was used in the correlation. The difference between the VFD controlled motor and throttle controlled motor was divided by the max power rating of the motor to determine a percentage of energy savings at each pff. The resulting value was multiplied by the time duration of the flow level (1 hour for all flows in this load distribution). The resulting column of data was summed and then divided by the total hours the motor was on to arrive at an average energy savings. This is the value used in the input sheet. Due to time constraints, this was only done for the 50HP pump scenario. It was assumed that the difference in motor sizes are negligible and that there is less energy saving for the fan application. 50, 250, 500 HP pump VFD savings 42% 50, 250, 500 HP fan VFD savings 35%
Energy Savings W/ MD	The same procedure outlined above was used in calculating the average savings associated with motor operation using a MagnaDrive Coupling. The data for both VFD and MD are shown in the worksheet entitled Load Distribution. Due to time constraints, this was only done for the 50HP pump scenario. It was assumed that the difference in motor sizes are negligible and that there is less energy saving for the fan application 50, 250, 500 HP pump MD savings 30% 50, 250, 500 HP fan MD savings 23%

5. SAV-AIR

5.1 Introduction

Formed in 1997, SAV-AIR, LLC (SAV-AIR) provides comprehensive industrial compressed air management systems and engineering services to end-users and service providers. In 1998, the Northwest Energy Efficiency Alliance decided to provide funding for the upstart company as part of its portfolio of market transformation initiatives. The result was the SAV-AIR Market Transformation Initiative (SAV-AIR Initiative, or Initiative), which was funded by NEEA from December 1998 to December 2003. The project's goal was to develop SAV-AIR into a self-sustaining business specializing in the optimization of compressed air systems to help industrial facilities achieve energy benefits and increased system reliability. The project targeted compressed air systems in the Northwest with capacity greater than 300 HP, while the technology included monitoring and control with sensors, computers, and software [1].[31]

The initial SAV-AIR Long-Term Monitoring & Tracking (M&T) effort reviewed activities through 2004, and the findings of that research were presented in the 2005 M&T report [2]. For the 2006 M&T effort, this "update" report will build upon data collection activities undertaken for the 2005 report.

5.2 Indicators and Assumptions for Review

According to Summit Blue's review of the ACE model [4], the cost-effectiveness of the SAV-AIR Initiative is contingent on the number of SAV-AIR projects completed, average energy savings per project, and several key assumptions about the market for compressed air efficiency. Specifically, the ACE model determines the *gross* energy savings impact of the Initiative as the product of the total number of projects and the estimated annual energy savings per project (kWh/project/yr). During the course of the data collection effort, however, the M&T project team discovered that energy savings had been estimated for each site in the Northwest via site-specific M&V,[32] and that the total could be calculated by aggregating the reported savings by project. As a result, the gross energy savings impact will be presented as the sum of the individual project savings by year, and the average per-project savings will be calculated from this sum.

The current ACE model assumes zero baseline activity and zero influence on the broader compressed air efficiency market beyond that captured by SAV-AIR. Follow-up conversations with NEEA staff indicate that they have recently begun assuming a non-zero baseline due to the recommendation of MPER-5 and that the ACE model has not yet been updated to reflect the new baseline [10]. Based on the results of the ACE model review, Summit Blue focused its efforts on tracking SAV-AIR's current activity in the market, reassessing the baseline activity, and quantifying market effects beyond SAV-AIR projects that are attributable to the SAV-AIR

[31] The SAV-AIR optimization measure, consisting of the monitoring and controlling of compressed air systems using sensors, computers, and software, is referred to by NEEA as "Optimize" and is input in the ACE model as a single measure.

[32] See Section 5.4.1 for more details about the site-specific M&V completed.

Initiative.[33] Specifically, the following key inputs to the cost-effectiveness calculation were assessed:

- SAV-AIR's current market activity in the Northwest, including the total number of projects and the gross energy savings by project
- The level of baseline activity in the Northwest
- Market effects other than SAV-AIR projects that are attributable to the SAV-AIR Initiative.

In accordance with the M&T work plan for 2006 [3], the project team also investigated the likely magnitude of SAV-AIR's continued market activities in the Northwest and made recommendations for future tracking efforts.

5.3 Methodology

Summit Blue conducted the following data collection activities in support of the SAV-AIR M&T effort:

- **Reviewed project reports and documentation.** Because of the change in scope for the 2006 M&T effort, Summit Blue conducted an in-depth review of the project documentation to acquire a detailed understanding of the program theory and cost-effectiveness assumptions. The literature review served as the foundation for the baseline analysis and helped to focus questions for the interviews. The reviewed documentation includes the SAV-AIR ACE model [4], compressed air efficiency market research report [5], and each of the five MPERs [6,7,8,9,10]. Summit Blue conducted a thorough review of the customer and non-participant interviews from the MPERs with a focus on understanding the impact of the program relative to what might have happened without the program. A full list of the documentation reviewed for this report can be found in Section 5.6.

- **Interviewed NEEA staff familiar with the SAV-AIR project.** The M&T project team spoke with Bob Helm [11], Christine Jerko [12], and Jeff Harris [13] about the SAV-AIR Initiative, and they were able to provide cumulative savings data for SAV-AIR projects. Mr. Harris also reported that the ACE model reviewed by the project team was not up-to-date with NEEA's latest baseline assumptions and that NEEA is now assuming a non-zero baseline.

- **Interviewed SAV-AIR staff.** Summit Blue interviewed Ned Dempsey at SAV-AIR for the following information [14]:
    - *SAV-AIR projects and savings.* Mr. Dempsey reported that no projects had been completed in the Northwest in 2006 due to a company restructuring. However, he did provide annual energy savings for all projects completed in the Northwest to date.

[33] Because each and every SAV-AIR project to date has had site-specific M&V to determine savings, the M&T project team did not review the per-unit savings assumption. Instead, the average per-project savings was updated based on the aggregate savings to date.

- *Company information and sales anecdotes.* Mr. Dempsey discussed current sales arrangements and the market for compressed air efficiency. He provided an estimate of SAV-AIR projects in the Northwest going forward, as well as the outlook for projects worldwide. He also spoke about the importance of NEEA funding in the success of SAV-AIR as a company.

- **Interviewed the project evaluation contractor.** Summit Blue also interviewed Steven Scott of MetaResource Group for additional project background, information concerning the baseline and market transformation effects, savings data, and the relationship of the SAV-AIR Initiative to the Compressed Air Challenge [15].

5.4 Findings

5.4.1 Current Market Activity

The year 2006 was one of major restructuring for SAV-AIR. In January 2006, the owners of SAV-AIR created a new, distinct company to license the software product from SAV-AIR and sell it under the new company name of Pneu-Logic Corporation. The purpose of this restructuring was to separate the technology and future sales prospects from the financial challenges faced by SAV-AIR and documented in the MPERs. With a renewed focus, Pneu-Logic hired a full sales staff in June 2006 and contracted with resellers worldwide in order to expand their product offerings to other regions of the globe. Pneu-Logic also now offers two licensing agreements, one in which customers pay an upfront fee and an annual renewal fee, and another in which customers pay a lower upfront fee and agree to “share” or “give back” to Pneu-Logic a portion of the cost savings resulting from reduced energy usage. According to Mr. Dempsey, the shared energy savings sales approach has been popular with customers and profitable for Pneu-Logic [14].

Although these activities have had positive outcomes, the focus on restructuring led to no new projects being completed in the Northwest in 2006. Table 5-1 shows the number of projects completed and the associated annual energy savings by year through 2006.[34] According to Mr. Dempsey, at least 16 out of the 17 completed projects received utility incentives or funding from NEEA, and each of these projects also received site-specific M&V to determine the actual energy impact of the SAV-AIR controls software. Savings for the other project were taken from a report issued by Washington State University for BPA; as such, all of the savings reported in Table 5-1 are based on site-specific data. The total energy savings from all installed projects in the Northwest is 35,373,000 kWh/yr, while the average energy savings per project is 2,080,765 kWh/project/yr.

[34] Summit Blue also attempted to retrieve compressed air capacity data (HP) for each of SAV-AIRs past projects, but Ned Dempsey reported that he did not maintain historical records of compressed air system size.

Table 5-1. SAV-AIR Projects in the Northwest by Year

	SAV-AIR Projects	
	Number of Projects	**Annual Energy Savings (MWh/yr)**
Pre-2002	8	12,920
2002	4	9,243
2003	2	1,233
2004	1	896
2005	2	11,081
2006	0	0
Total Installed Projects	**17**	**35,373**
Total Operational Projects*	**15**	**32,679**
* Two of the sites for which SAV-AIR completed projects have since shut down and are no longer in operation. One facility, representing savings of 1,243,000 kWh/yr, was in operation from Jan-01 through Jan-02. The other facility, representing savings of 1,451,000 kWh/yr, was in operation from Jan-02 through Oct-02.		

Recommendation: The current structure of the ACE model [4] is such that it calculates savings from the number of completed projects multiplied by the average energy savings per project. The M&T project team recommended in the 2005 M&T report [2] that NEEA consider normalizing savings by compressed air capacity in order to minimize the effect of system size and industry type when extrapolated to the population of projects. However, if project-specific data continues to be available for future projects, Summit Blue recommends that the savings should simply be aggregated and input into the ACE model as a single number.

5.4.2 Baseline Activity

The energy savings attributable to baseline activity are those due to compressed air efficiency measures that would have occurred in the absence of the SAV-AIR Initiative. According to Jeff Harris, NEEA currently assumes that 64% of the reported gross energy savings should be attributed to baseline activity [13]. To determine a reasonable level for savings due to baseline activity, two questions must be answered:

1. *How many projects and what level of energy savings would have been achieved by SAV-AIR, on its own, without funding from NEEA?*
2. *What level of energy savings due to compressed air efficiency measures would have been achieved by SAV-AIR's customers if SAV-AIR had not existed at all?*

The critical role played by NEEA in the development of SAV-AIR as an entrepreneurial company has been well documented in the five MPERs. When asked about the importance of NEEA funding in the success of SAV-AIR as a company, Ned Dempsey replied that NEEA funding "is what created SAV-AIR." Specifically, NEEA funding provided SAV-AIR with "the ability to develop the technology and the company" [14]. From these responses, it seems reasonable to assume that SAV-AIR would have achieved no energy savings without NEEA funding.

Obtaining a reasonable understanding of the compressed air savings that would have been achieved by SAV-AIR's customers *if SAV-AIR hadn't existed at all* is a more difficult task. First, one must assess the possibility that some other entity would have provided *the same or similar* service (i.e., compressed air monitoring and control) for SAV-AIR's customers in the absence of SAV-AIR's involvement. This assessment must also indicate the level of savings achieved by another entity compared to that achieved by SAV-AIR. Second, one must consider the possibility that a customer would be pursuing *other* types of compressed air efficiency measures such as leak detection and repair. This second consideration specifically affects the baseline condition against which SAV-AIR measures energy savings. For example, when SAV-AIR contracts with a customer and begins conducting baseline metering for comparison, the customer is unlikely to be concurrently conducting activities that reduce energy consumption. However, if SAV-AIR was not involved at all, the customer *might* be pursuing compressed air efficiency or other O&M measures that have the effect of reducing usage. If that were true, the baseline energy consumption when the site is metered by SAV-AIR would be higher than it would be if SAV-AIR were not metering the site.

To assess these variables, the M&T project team conducted a detailed review of the market research that was documented *during the program's development*. Specifically, Summit Blue focused on the market actor, end-user, and customer interview results from the MPERs and the market research report [5]. Since the research was conducted at the beginning of and throughout the program's development, it is likely to be the most accurate representation of market conditions at the program's genesis and, consequently, the best foundation for establishing a reasonable baseline.

Importance of Compressed Air Efficiency to End-Users

A review of the early program documentation suggests that system efficiency was not of primary importance to compressed air end-users. Remarks from the market research report [5] include:

- **Pg. II:** *Most customers spend little time thinking about compressed air system efficiency.*
- **Pg. II:** *Most customers and contractors are not currently acting to optimize the efficiency of compressed air systems.*
- **Pg. VII:** *Generally speaking… compressed air O&M is largely neglected and system efficiency is rarely considered.*

End-user interviews were conducted for MPER-2 [7], and these further corroborate the lack of attention given to compressed air energy efficiency that was documented in the market research report. Among the primary conclusions from the interviews was the statement that "awareness and action to address compressed air efficiency among customers are relatively rare." Only 6% of end-users from these interviews indicated that controlling or reducing energy use was one of their top two compressed air system *management* objectives, as compared to 29% that indicated maintaining continuous operation was a management objective. This lack of awareness and priority given to system efficiency in the early years of the program suggests that SAV-AIR's customers would not have been actively pursuing system optimization in the absence of SAV-AIR.

Availability of Compressed Air Controls and Efficiency Services

Lack of awareness does not *by itself* indicate that SAV-AIR's customers would not have had a similar service performed by another consultant in the absence of SAV-AIR. However, findings from the market research report [5] suggest that the volume of compressed air services *being offered in the Northwest* was small in 2000 and that most market actors would *not pursue compressed air efficiency* until changes in customer interest were evident. MPER-1 states, "Many service providers *say* they are doing 'system optimization,' but at the same time do not offer the *key service elements* of true system optimization. In general, compressed air services remain fragmented, while customer needs are integrated" [6].

Concerning the market baseline, MPER-2 [7] found that "The market characterization conducted in MPER-1 and in this report (MPER-2) suggested that there is no significant competition to the unique SAV-AIR System Optimization product in the Northwest region at this time." Findings from interviews conducted for MPER-3 [8] suggest that even three and a half years after SAV-AIR contracted with NEEA, few other firms were offering the same or similar services in the Northwest. Remarks from MPER-3 include:

- **Pg VI:** *...potential competitors with comparable compressed air control systems are not particularly active in the Northwest market…*
- **Pg VI:** *Without NEEA being involved in SAV-AIR, no other firm would likely be offering the services that SAV-AIR provides in the Northwest over the next few years.*

Compressed Air Controls Sales in the Northwest

MPER-4 [9], published when SAV-AIR had completed 12 system optimization projects in the Northwest, roughly quantifies *other* high-end compressed air controls sales in the region at "one or two systems per year – perhaps five in the past two and a half years" for a total of 17 in the Northwest from 2001-2003. This finding suggests that (a) at least a few other firms were providing compressed air controls in the Northwest at the same time as SAV-AIR, and (b) SAV-AIR dominated the market in the Northwest with a 71% market share (12 divided by 17). If SAV-AIR had *not* been in the market, it seems reasonable that at least a portion of SAV-AIR projects would have been completed by other entities.[35] However, SAV-AIR must solicit its customers to stay active, so it is *unlikely that this portion of projects would represent a majority*. Assuming that SAV-AIR's competitors would have completed no more than twice as many projects without SAV-AIR in the market (5 additional projects), then it also seems reasonable to assume, on the high end, that 42% (5 additional projects out of SAV-AIR's 12 completed projects) of SAV-AIR's completed projects by 2003 would have been completed *by other entities.* The findings from MPER-5 [10], however, tell a different story. Specifically, MPER-5 states that "…sales of medium-to-large compressed air control systems in the Northwest region have typically been on the order of about ten systems per year…" MPER-5 further estimates that 40 compressed air control systems had been sold in the region from about 2000-2004, and 16 of these (40%) were completed by SAV-AIR.

Since this apparent discrepancy in findings is not clarified in the text of the fifth MPER, the M&T project team is led to two likely possibilities: (a) the conclusions that were presented in the first four MPERs and that were consistent across each are erroneous, or (b) the market actors interviewed for the final MPER incorrectly attributed the significant increase in compressed air controls as having occurred over several years instead of within a year or two. The latter scenario is much more probable than the former, as it is *very unlikely* that several rounds of interviews

[35] Since *significant* sales of other compressed air controls were not documented until MPER-4, an argument could be made that the *SAV-AIR Initiative* prompted competition that otherwise would not have existed. If this were true, then at least a portion of the impacts from these other market actors would be attributable to the Initiative. However, findings from earlier MPERs suggest that there was a *small* amount of fragmented services available, and assessing attribution of additional compressed air controls projects to the SAV-AIR Initiative would be difficult. This is discussed in more detail in Section 5.4.3 "Indirect SAV-AIR Impacts" below.

with market actors and end-users were consistently misinterpreted across four MPERs and a market research report [5]. Summit Blue therefore concludes that compressed air monitoring and control activities were small during the program's early years, that they began accelerating when MPER-4 was published (2003), and that this increase was erroneously captured as a multi-year effect in MPER-5 instead of as having occurred since MPER-4.

Other Compressed Air Efficiency Measures

The final consideration when establishing a reasonable baseline for SAV-AIR energy savings is the level of savings that would have been achieved from compressed air efficiency measures in the absence of SAV-AIR. These other measures could include buying newer, more efficient compressors, better control strategies, long- or short-term monitoring, leak detection and repair, and many others. Almost half (48%) of the end-users surveyed for MPER-2 [7] indicated that they have a regular leak detection routine, and 80% of these also indicated that there is a subsequent leak *repair* routine as well. More than two-thirds of respondents (68%) also indicated that they use long- or short-term monitoring to help manage their compressed air system.

These interview results suggest that end-users are at least moderately aware of compressed air management strategies. The link between these activities and *energy-efficiency*, however, was never established, and it is likely that the respondents view these actions as regular O&M. The focus does not appear to be on reducing energy usage, so the expected reduction as compared to SAV-AIR's control scheme is likely small.

However, MPER-4 [9] and MPER-5 [10] *do* indicate that an increased use of microprocessor technology in new air compressors "makes SAV-AIR's approach less cutting-edge" and that this technology has "closed the gap" between what SAV-AIR offers and what is available from compressor manufacturers. This finding suggests that *new* compressor installations might achieve a large portion of the savings achieved by SAV-AIR. New compressors are a highly capital-intensive investment though, and SAV-AIR's technologies are likely to continue being relevant for customers who want to avoid a large capital expenditure.

Compressed Air Challenge

The Compressed Air Challenge (CAC) is a nationwide collaboration of compressed air end-users, manufacturers, distributors, consultants, energy-efficiency organizations, and utilities devoted to improving compressed air system performance. Established at around the same time as the SAV-AIR Initiative, the CAC features workshops, trainings, and a "best practices" manual dedicated to helping those in the industry recognize "opportunities to increase net profits through compressed air system optimization" [16]. In 2004, the USDOE and Xenergy completed an evaluation of the Compressed Air Challenge and concluded that participants in the CAC trainings save, on average, 7.5% of the pre-project system energy [17]. The study further elaborated that 30% of system energy usage for a typical compressed air system can be saved through "cost-effective measures."

Based on the review of the Compressed Air Challenge evaluation, it is *unlikely* that the CAC prompted end-users to pursue *compressed air control strategies similar to or the same as those provided by SAV-AIR*. In fact, the CAC evaluation found that "the most common capital improvements made were the replacement of current compressors with more efficient models (18%), reconfiguring system piping (10%), and adding air storage capacity (8%)" [17]. Although the CAC is a national effort, NEEA was a major contributor for activities in the Northwest, including funding trainings and serving on the board of directors [13]. In fact, the first three SAV-AIR MPERs all included a chapter assessing the CAC trainings in the Northwest as a means of analyzing shifts in end-user attitudes. Although NEEA played a significant role in CAC activities in the Northwest, they have not historically assigned any savings to the CAC trainings. Consequently, to the extent that CAC activities might have impacted the baseline for SAV-AIR savings, it is not critical to make the distinction between market effects attributable to the CAC and market effects attributable to SAV-AIR.

Baseline Conclusions

From the research completed, Summit Blue thinks that it is *unlikely* that another entity would have provided the same or similar service for SAV-AIR's customers in the absence of SAV-AIR's involvement, particularly for SAV-AIR's initial projects. Projects completed after 2003 have a higher likelihood that they might have been conducted by another firm, but this percentage is still likely to be small. The first six projects completed by SAV-AIR (beta sites for NEEA) likely would not have been done at all without SAV-AIR's solicitation, and this is confirmed in MPER-4 [9]: "…at least six of the SAV-AIR installations are systems that would not have been installed without their involvement…"

Given the small percentage of SAV-AIR's projects that might have been completed in SAV-AIR's absence, they likely would not have achieved the same level of energy savings as the SAV-AIR proprietary approach. During the project evaluator interview, Steven Scott reinforced the idea of the SAV-AIR method as truly comprehensive, integrated, and different from all other approaches. In fact, he estimated that SAV-AIR's approach would save approximately 5-10% more compressed air energy than the *next-best* compressed air optimization strategy available in the market today [15].[36] Energy savings from other compressed air efficiency measures are likely to be small, and the baseline condition against which SAV-AIR measures savings may only be slightly more energy intensive than conditions would be in the absence of SAV-AIR's involvement.

Baseline Recommendations

Summit Blue subsequently devised a baseline calculation methodology in which the aforementioned variables were given a range and bounded by high and low values. The percentage of SAV-AIR's energy savings that is due to baseline activity was determined from the following formula:

Savings Attributable to Baseline Activity (%) =

(A) Baseline Systems *with* Controls (%)
x (B) Relative Savings *with* Controls (%)

+

(C) Baseline Systems *without* Controls (%)
x (D) Relative Savings *without* Controls (%)

[36] The SAV-AIR approach to system optimization relies on *flow-based* measurements, which are much more accurate than traditional *pressure-based* measurements. This focus on airflow allows for more precise monitoring and better control which, in turn, alleviates the need to "oversize" the airflow and pressure. The result is higher energy savings and a *truly* optimized system. Mr. Scott indicated that if the next-best compressed air control strategy saved 10% of energy consumed based on pressure measurements, then SAV-AIR's flow-based approach would likely save around 15%. If the next-best strategy saved closer to 25-30%, then SAV-AIR would likely save around 35-40%. He also said that it is *unlikely* that SAV-AIR would actually save *twice as much* as the *next-best* strategy.

where:

A. **Baseline Systems *with* Controls** – This is the percentage of SAV-AIR's customers that would have received the same or similar compressed air control scheme in the absence of SAV-AIR's involvement.

B. **Relative Savings *with* Controls** – This is the relative savings of other control schemes as compared to SAV-AIR.

C. **Baseline Systems *without* Controls** – This is the percentage of SAV-AIR's customers that would *not* have received the same or similar compressed air control scheme in the absence of SAV-AIR's involvement, and it is equal to one minus "Baseline Systems *with* Controls".

D. **Relative Savings *without* Controls** – This is the relative savings of other compressed air control measures that might have been implemented in the absence of SAV-AIR's involvement.

Because of the differences in baseline energy savings among the MPERs and due to the increased activity in the region, Summit Blue recommends a graduated baseline. The six beta projects funded by NEEA should have a baseline due *only* to savings from other compressed air efficiency measures. Other projects through *2003* should have a slightly higher baseline due to both savings from controls and savings from other compressed air efficiency measures, and projects completed from 2004-2006 would have a moderately higher baseline due to controls and other measures. Table 5-2 shows the high, low, and recommended values for each of the four variables defined above, as well as the final recommended baseline percentage for each subset of projects. Summit Blue recommends that the savings attributable to baseline activity be 5% for the six beta site projects, 10% for the all other projects completed through 2003, and 14% for projects completed from 2004-2006. The rationale behind each of the recommended values is provided immediately below Table 5-2.

Table 5-2. Savings Attributable to Baseline Activity

	Baseline Systems *with* Controls (A)			Relative Savings *with* Controls (B)			Baseline Systems *without* Controls (C)			Relative Savings *without* Controls (D)			Savings Attributable to Baseline Activity A*B + C*D = E		
	High	***Low***	***Rec'd****	***High***	***Low***	***Rec'd****	***High***	***Low***	***Rec'd****	***High***	***Low***	***Rec'd****	***High***	***Low***	***Rec'd****
Six NEEA Beta Projects	0%	0%	0%	75%	25%	50%	100%	100%	100%	30%	0%	5%	30%	0%	5%
Other Projects Through 2003	42%	0%	10%	75%	25%	50%	71%	100%	90%	30%	0%	5%	49%	0%	10%
Projects 2004-2006	64%	0%	20%	75%	25%	50%	36%	100%	80%	60%	0%	5%	70%	0%	14%

* "Rec'd" in the table above represent Summit Blue's recommended baseline values.

A. Baseline Systems *with* Controls:

- ***Beta Projects*** – These were NEEA projects, and they would not have had any controls implemented without SAV-AIR's solicitation.
- ***Other Projects Through 2003*** **–** The high value (42%) was based on data from MPER-4 [9] and assumes that no more than 5 of SAV-AIR's 12 completed projects would have been completed by other entities. The low value assumes that no other entity would have completed projects with SAV-AIR's customers, and the recommended value is a judgment based on the documentation review.
- ***Project 2004-2006*** – The high value is the same as that used by NEEA and is based on data from MPER-5 that suggests that 90 out of 140 (64%) systems would be installed by "other" entities from 2001-2010. The low value assumes that no other entity would have completed projects with SAV-AIR's customers, and the recommended value is a judgment based on the documentation review.

B. Relative Savings *with* Controls: The high value (75%) is based on the example from Steven Scott where if the next-best strategy saves 30% of compressed air usage, then SAV-AIR might save 40% (30% divided by 40% equals 75% *relative* savings). The low value (25%) assumes that the *worst* compressed air control scheme would save no less than one-quarter of SAV-AIR savings, and the recommended value is the midpoint of these (50%).

C. Baseline Systems *without* Controls: These values are equal to one minus the "Baseline Systems *with* Controls" percentage.

D. Relative Savings *without* Controls:

- ***Beta Projects and Other Projects Through 2003*** **–**The low value (0%) represents those customers who would not be doing any sort of regular maintenance or other energy-saving activities with respect to compressed air. The high value (30%) is based on the finding from the CAC evaluation [17] that says 30% of a typical compressed air system's energy can be saved via "cost effective measures." The recommended value (5%) is a judgment based on the documentation review and benchmarked against the finding from the CAC evaluation that claims 7.5% savings for participants in CAC trainings.
- ***Projects 2004-2006*** **–** The high value (60%) is a judgment based on the finding from the MPERs that new microprocessor technology is "closing the gap" between SAV-AIR savings and what is commonly embedded in new air compressors today.

5.4.3 Other Market Effects

Direct SAV-AIR Impacts Not Captured in Program Accounting

Direct SAV-AIR impacts represent energy savings achieved from compressed air efficiency measures that are not captured by program accounting but that are directly influenced by the SAV-AIR Initiative. Findings from non-participant interviews conducted for MPER-3 [8] suggest that SAV-AIR had worked with potential customers only to have them decline SAV-AIR's monitoring and controls. This was described further in MPER-4 [9]:

- *The non-participants interviewed for the previous MPER cited financial reasons and communications difficulties with the SAV-AIR team, but did not indicate they had chosen other service providers. However, both of the non-participants interviewed for the MPER are going forward with less expensive control approaches offered by other providers.*

During the interview with the program evaluation contractor [15], Steven Scott further explicated this finding. He stated that he was "aware of two specific instances" in which SAV-AIR had recommended a package of compressed air measures only to have the customer take SAV-AIR's proposal to a lower bidder. This situation is a prime example of direct program impacts not captured in program accounting. If SAV-AIR solicited these customers and proposed ways for them to optimize their system that were subsequently *implemented* by another contractor, then at least a portion of these savings could be attributable to SAV-AIR. It is unclear from the documentation, however, whether these measures were ever implemented or how much energy would be saved.

Recommendation: Although it is likely that SAV-AIR had some direct program impacts go unaccounted, Summit Blue recommends the conservative approach of claiming no additional savings for these occurrences. The impact would be impossible to quantify, and this will also avoid the possibility that savings might be "double-counted" in the region if compressed air controls from other entities are receiving utility funding.

Indirect SAV-AIR Impacts

Indirect SAV-AIR impacts represent energy savings from compressed air efficiency measures that have occurred in the market external to the Initiative and are an indirect result of the Initiative's influence. While MPERs 1-3 suggest only slight competition to SAV-AIR regionally, both MPER-4 and MPER-5 indicate that significant sales of other high-end compressed air control schemes were occurring in the region from 2000-2004 (see Section 5.4.2 "Compressed Air Controls Sales in the Northwest"). These findings suggest *a possibility* that the SAV-AIR Initiative might have influenced competitors to enter and make sales in the Northwest market, but this link was never established in the MPERs. While MPER-5 notes that the SAV-AIR Initiative *did* make "definite and valuable progress towards market transformation," the *conclusion* of the evaluators as stated in MPER-5 is that "… [SAV-AIR's] efforts have not yet sustainably transformed the regional compressed air controls market…" In addition, based on interviews completed with regional market actors, MPER-5 notes:

- *Despite its contribution to increasing the total regional sales of comprehensive systems, SAV-AIR's impact on the broader market has been modest. The evaluators' research indicates that customer demand for monitoring and control in compressed air has not* *increased dramatically. Based on market actor interviews, SAV-AIR itself has not driven a substantial change to competitors' approaches, services, or products.*

If SAV-AIR had not changed competitors' approaches, services, and products as of the publication of MPER-5 in 2004, it is even less likely that it has influenced regional sales *since* MPER-5. SAV-AIR completed just two projects in the region in 2005 and zero in 2006. Its status as a company was such that the owners created a new, distinct company (Pneu-Logic) under which they could sell SAV-AIR *the product* and thus separate it from SAV-AIR *the company*. Future efforts at determining market effects beyond those captured by SAV-AIR will need to track the influence of Pneu-Logic.

Recommendation: Based on the findings from MPER-5 and SAV-AIR's current status, Summit Blue recommends making no adjustments to account for market effects beyond those captured from SAV-AIR's projects.

5.4.4 Future Market Activity and Baseline Projection

Future Market Activity

SAV-AIR's outlook for continued market activity is very good. The restructuring effort carried out in 2006 was extremely positive, and the owners of Pneu-Logic (SAV-AIR's licensee) are enthusiastic about increased activity going forward, particularly in other regions of the world. Specifically, Ned Dempsey cited the Kyoto Protocols (not effective in the United States) as a major driver behind interest in SAV-AIR's technologies. He also reported that Pneu-Logic is to be profiled as the feature company in the January 2007 edition of "Compressed Air Best Practices" magazine. When asked about future projects in the Northwest, Mr. Dempsey reported that they had 24 slated for 2007 and "lots more in the pipeline." If 24 projects are indeed completed in 2007 as suggested by Mr. Dempsey, this represents an increase of 140% in a single year over those completed in the previous eight years [14]. As a result, the M&T project team recommends continuing to track gross savings from SAV-AIR projects.

Baseline Projection

In the final recommendations for changes to the ACE model, MPER-5 [10] suggests that 140 compressed air controls systems would be sold in the Northwest from 2001-2010 if SAV-AIR remains in the market. It also suggested that 90 compressed air controls systems would be sold in the Northwest in the same timeframe, if SAV-AIR does not continue to be active. As noted above, this estimate formed the basis for NEEA's current baseline assumption. Based on the documentation review and analysis, however, Summit Blue thinks that the strict interpretation and translation of these numbers into a baseline percentage of 64% (90 units sold by other companies divided by 140 total units) may be inaccurate. Instead, the M&T project team recommends that NEEA use a baseline of 14% for 2006 (see Table 5-2) and periodically update the baseline from secondary and primary research concerning regional activity and changes to the market structure.

5.5 Conclusions/Recommendations

Table 5-3 summarizes Summit Blue's recommendations for the SAV-AIR Initiative:

Table 5-3. SAV-AIR M&T Recommendations

Key Inputs Reviewed	Current ACE Model Value	Recommended Value	Source
Current Market Activity			
Number of Projects	Varies by year	See Table 5-1	• Ned Dempsey of SAV-AIR • See Section 5.4.1
Energy Savings (kWh/yr)	Varies by year	See Table 5-1	• Ned Dempsey of SAV-AIR • See Section 5.4.1
Per-Unit Savings (kWh/project/yr)	1,051,304	2,080,765	• See Section 5.4.1
Baseline Activity – Percent of SAV-AIR Savings			
Six NEEA Beta Projects	64%	5%	• See Table 5-2 • See Section 5.4.2
Other Projects Through 2003	64%	10%	• See Table 5-2 • See Section 5.4.2
Projects 2004-2006	64%	14%	• See Table 5-2 • See Section 5.4.2
Other Market Effects – Percent of SAV-AIR Savings			
Other Direct Program Impacts	0%	No change	• See Section 5.4.3
Market Transformation Effects	0%	No change	• See Section 5.4.3

- **Continue tracking SAV-AIR projects in the Northwest.** According to Ned Dempsey, SAV-AIR projects will greatly accelerate in the Northwest in coming years, with 24 scheduled to begin in 2007.
- **Track project-specific savings instead of using a common per-project or per-capacity multiplier.** All of SAV-AIR's projects to date have received M&V to determine site-specific energy savings. If this data continues to be available for future projects, there is no need to assume uniform savings rates.
- **Savings attributable to the baseline should be 5% for the six beta site projects, 10% for the all other projects completed through 2003, and 14% for projects completed from 2004-2006.** These estimates are based on a detailed review of the program documentation that was researched and written *during the program's development,* which provide the best foundation for establishing a reasonable baseline.
- **No savings adjustments should be made for direct SAV-AIR impacts.** Although SAV-AIR appears to have directly influenced the installation of compressed air controls that are not captured in program accounting, the impact would be impossible to quantify. Claiming no savings for these incidents will also avoid the possibility of double-counting in the region.
- **No savings adjustments should be made for indirect SAV-AIR impacts at this time.** The opinion of the evaluators and the M&T project team is that SAV-AIR did not influence competitors' products and services.
- **Establish a current baseline and reassess market effects every two years.** The M&T project team recommends that NEEA use the baseline of 14% for 2006 (see Table 5-2) and periodically update the baseline from secondary and primary research, including any available data from the IEA, concerning regional activity and changes to the market structure. This data, along with any from Pneu-Logic, should also be used to carefully

determine the relationship between what would have happened in the absence of the Initiative and any market effects that it generated.

5.6 References

1. *2003 Market Activities Report,* Northwest Energy Efficiency Alliance, 2004.

2. *Long Term Monitoring and Tracking Report on 2005 Activities,* Summit Blue Consulting for Northwest Energy Efficiency Alliance, April 14, 2006.

3. *Long Term Monitoring and Tracking DRAFT Workplan for 2006 Activities,* Summit Blue Consulting for Northwest Energy Efficiency Alliance, August 21, 2006.

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5. *Market Research Report: Compressed Air Efficiency,* Pacific Energy Associates, Inc, Report #00-058, August 2000.

6. *Market Progress Evaluation Report: SAV-AIR Market Transformation Initiative,* Pacific Energy Associates, Inc, Report #E00-053, June 2000.

7. *Market Progress Evaluation Report: SAV-AIR Market Transformation Initiative, No. 2,* Pacific Energy Associates, Inc, Report #E01-076, February 2001.

8. *Market Progress Evaluation Report: SAV-AIR, No. 3,* Pacific Energy Associates, Inc, Report #E02-098, March 2002.

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15. *Personal communications with Steven Scott.* MetaResource Group, December 2006 and January 2007.

16. www.compressedairchallenge.org.

17. *Evaluation of the Compressed Air Challenge Training Program,* Xenergy for the US Department of Energy, 2004.

6. SHELL SOLAR

6.1 Introduction

Shell Solar (formerly Siemens and now owned by SolarWorld) submitted a proposal to NEEA in 1997 to develop an innovative process for growing silicon crystals by modifying the crystal-growing hot zones. This process includes both a redesign of the hot zone itself (improved insulation and heating elements) and the introduction of an external feeder system to recharge the hot zone with granular polysilicon feedstock, while maintaining a vacuum and without losing the heat built up during the initial production run.

As the only US grower of silicon crystals for the solar industry, Shell was willing and able to publish the results of its experience in industry forums, thus potentially influencing silicon crystal growing firms throughout the photovoltaic industry. The company successfully met all internal objectives in its proposal and saved six million kWh between February 1999 and February 2001. Significant non-energy benefits included reduced production time, reduced Argon consumption, and higher quality solar cell panels. At the time the project was funded by NEEA, there were about a half a dozen other facilities in the region, including those operated by SEH America, Sumitomo/Mitsubuishi, and Wacker. However, many of these facilities have since shut down. Besides the Shell (SolarWorld)[37] facility, SEH America is the only remaining crystal growing facility in the region, and there has been no indication through 2006 that the Shell project has influenced any changes in that facility's production process. Thus, the SolarWorld plant is considered the only facility in the Northwest influenced by the program. Future NEEA efforts to improve efficiency in silicon crystal growing facilities will be handled within the ASiMi project.

6.2 Indicators and Assumptions for Review

According to Summit Blue's review of the ACE model as described in the 2005 M&T report [9], the electricity savings impact of the Shell project is based on the capacity of efficient hot zones used for production, the related electricity savings relative to the conventional hot zones, and the number of production days per year. The ACE model also assumes zero baseline activity and zero market effects beyond those captured by Shell. Summit Blue therefore focused its efforts on tracking the current status of Shell's efficient hot zones, reassessing the baseline activity, and quantifying additional market effects attributable to the Shell project. Specifically, the M&T project team assessed the following key inputs to the cost-effectiveness calculation:

- The current status of Shell's production, including the hot zone heater capacity, the electricity savings per kW of heater capacity, and the number of production days per year
- The level of baseline activity in the Northwest
- Market effects beyond those captured by Shell.

Research conducted by Summit Blue for the 2005 M&T report quantified each of these energy savings inputs and determined that the SolarWorld facility itself was the sole facility generating energy savings as a result of the project. In accordance with the M&T work plan for 2006, the project team updated the

[37] For purposes of clarity and consistency, "SolarWorld" will be used to refer to the company and the facility where the efficiency innovations occurred. "Shell" will be used to refer to the project funded through NEEA.

indicator values for the SolarWorld facility and investigated whether additional efficient hot zone capacity had been developed that could reasonably be the result of advances from the Shell project.

6.3 Methodology

Data collection for the M&T effort built on the two primary research activities conducted for the 2005 M&T report:

1. Review of key documents, including ACE model documentation, the final Market Progress Evaluation Report [2], and the research report prepared by Siemens in 2000 [4]. These documents provided detailed background on the project and assumptions used in the savings estimations.

2. Interviews with the SolarWorld 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.

The principal source of information for this year's effort was a follow-up interview with SolarWorld's Greg Mihalik [5], who provided an update of the facility's hot zone capacity and discussed changes in operations over the past two years. Contextual information on the crystal growing industry and the impact of the Shell project was obtained from the following sources:

- **Research report [8]:** *Polysilicon: Supply, Demand, and Implications for the PV Industry*, published by the Prometheus Institute in 2006. This report reviewed methods of polysilicon production and profiled the major producers and uses. The report included a discussion of the granular polysilicon used by SolarWorld for continuous recharge in its efficient hot zones.

- **Interview with John Holder [6],** Monsanto Electronic Materials Company (MEMC). Mr. Holder worked directly with Shell in the late 1990s to modify the hot zones to incorporate MEMC's granular feedstock.

- **Interview with Ted Ciszek [7]**, president of Siliconsultant and former group leader for the Silicon Materials Research Task at the National Renewable Energy Laboratory. Mr. Ciszek provided an independent expert assessment of hot zone technology and the use of granular feedstock for recharge.

- **Journal article by Greg Mihalik [1].** Additional context for how the technological advances from the Shell project related to crystal growth was obtained from a 2001 article not previously reviewed by Summit Blue: "Multiple Batch Recharging for Industrial CZ Silicon Growth," published in the *Journal of Crystal Growth*.

6.4 Findings

6.4.1 Current Market Activity

As previously reported, the only savings resulting from the Shell project are those savings achieved at the SolarWorld facility itself. These savings result from three aspects of the process improvements:

1. Increased energy efficiency of the hot zones.

2. Increased productivity from the reconfigured hot zones.

3. Improved yield due to application of the recharge process.

Since the time of the last M&T report (which covered 2001 through 2004), the SolarWorld facility has expanded the number of efficient hot zones in operation from 38 to 43. However, the newly modified hot zones are somewhat smaller than the 38 previously reported (100 kW versus 125 kW) and the corresponding energy savings are somewhat less as well. Furthermore, SolarWorld has made temporary changes in its process that have resulted in fewer savings from each efficient hot zone in operation. The net result is that savings in 2005 were approximately 90% of the 2.09 aMW estimated for 2004, and savings in 2006 are estimated at 85% of the 2004 figure, or approximately 1.77 aMW.[38] In other words, there has been a small net loss in savings each of the past two years.

6.4.2 Baseline Activity and Other Market Effects

The 2005 M&T report [9] and the Market Progress Evaluation Reports [2] completed for the project have documented that the energy saving innovations at the SolarWorld facility likely would not have occurred in the absence of support from NEEA and its sponsors. This suggests a baseline of zero savings, meaning that all savings reported above are a result of the project. The potential for market effects, or additional savings resulting from the project's influence on other crystal growing facilities in the region, has been an open question.

A major rationale for the original Siemens (Shell) project was to develop "an innovative process for growing silicon crystals that could provide energy and non-energy benefits to Siemens and to other silicon crystal-growing firms in the solar, semiconductor and microelectronics industries."[39] However, there is little direct evidence of quantifiable energy savings because of two overriding factors:

1. The crystal growing industry in the Northwest has retracted considerably since the Shell project, with only one manufacturer remaining besides SolarWorld.

2. It is virtually impossible to get detailed information needed to support calculations of market effects due to the confidential nature of the industry.

Furthermore, there are several specific reasons why the efficiency improvements at SolarWorld have not spread beyond the SolarWorld facility. As mentioned above, the two primary innovations developed at the facility were the modified crystal-growing hot zones (including improved insulation) and the continuous recharge of polysilicon feedstock. These innovations are interdependent in that the insulated hotzones were necessary in order to lower temperatures of the crucible walls, thereby extending crucible lifetime and allowing for the continuous addition of fresh feedstock, [40] and the additional insulation likely would not have been cost-effective or operationally desirable if it did not provide for the benefits of continuous recharge. This interdependence suggests that if the process improvements were to be adopted by others in the industry, they would likely be adopted together. However, this has not been the case due in part to the following circumstances:

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[38] Greg Mihalik of SolarWorld agreed to share information on the facility's recent production with the caveat that this information would be used only to estimate energy savings and that specific details would not be included for publication.

[39] *Market Progress Evaluation Report, Silicon Crystal Growing Facilities, No. 2* (MPER 2), Research Into Action for NEEA, November 2001.

[40] Ficket, B. and G. Mihalik. "Multiple Batch Recharging for Industrial CZ Silicon Growth." *Journal of Crystal Growth*. 225 (2001). pp. 580-585.

1. **Lack of supply of the granular polysilicon needed for recharge.** There is only one industrial-scale manufacturer of granular polysilicon in the world—Monsanto Electronic Materials Company (MEMC), with facilities located in Texas and Italy.[41] At the time of then-Siemens' application to NEEA, MEMC was actively marketing its patented granular polysilicon product to crystal growers and, in fact, SolarWorld was and still is one of its principal customers. However, MEMC soon improved its methods of using this feedstock for its own crystal-growing operations, so it reserved the majority of its polysilicon for in-house use, thus limiting supply in the market.[42] Two other polysilicon producers have been attempting to manufacture granular polysilicon, but have so far been unsuccessful in producing commercial-grade feedstock on a large scale. Companies that rely on granular polysilicon in their crystal growing processes—such as Evergreen Solar and Schott Solar, which use proprietary ribbon/sheet growth processes—have even resorted to crushing polysilicon chunks in efforts to produce a feedstock that can be used in their recharge processes.
2. **Advances in crucible design have alleviated the need for Shell's insulation improvements.** Since the time of SolarWorld's innovations, the quality and characteristics of crucibles have improved such that the additional insulation developed through the project is no longer necessary to allow for continuous recharge. While these new crucibles may be more energy efficient than their predecessors, the advancement cannot be attributed to SolarWorld, as recharge was employed in crystal-growing operations prior to the Shell project, albeit perhaps not as efficiently as at the SolarWorld facility.
3. **Crystal growth is very facility-specific.** Unlike many other industries, crystal growing is an extremely delicate process susceptible to the most minute deviations in temperature, feedstock characteristics, input rates, and other factors. As such, the innovations at SolarWorld cannot easily be replicated elsewhere. Another facility would likely have to conduct extensive testing of alternative hot zone designs, feeder systems, etc., before a reliable process could be developed to produce crystals of the quality required by the market.
4. **The potential market is limited.** Crystals produced from granular silicon are generally not of sufficient quality to be used for semiconductors, as opposed to solar panels. Furthermore, less than half of silicon crystals manufactured worldwide are used in solar panels (although this is changing), suggesting that only a minority of crystal growers have been in a position to employ the SolarWorld process, even if it were possible given the constraints discussed above.

While the specific technology improvements deployed at SolarWorld may not have been directly adopted by the chip industry, there is evidence that the Shell project has had a positive effect on industry attitudes toward energy efficiency. For example, the three staff persons from silicon crystal manufacturers who were interviewed for MPER-2 [2] all believed that Shell's experience "provides a benchmark and will inspire semiconductor-grade silicon growers to attempt to do the same thing in order both to keep energy costs down and to increase the material that can be manufactured in one pull." Additionally, John Holder, the MEMC engineer who assisted SolarWorld during the project, suggested that the innovations allowed the company to realize the benefits of the more efficient manufacturing processes before other companies. SolarWorld's leadership in this area may have facilitated and accelerated the adoption of energy efficient equipment and practices, even if these changes would have eventually occurred anyway.

6.5 Conclusions/Recommendations

Table 6-1 summarizes Summit Blue's recommendations for the SAV-AIR Initiative:

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[41] The Prometheus Institute. *Polysilicon: Supply, Demand, and Implications for the PV Industry.* 2006.

[42] Personal communication with John Holder, MEMC, who worked directly with Shell in modifying the hot zones to incorporate MEMC's granular feedstock.

Table 6-1. Shell Solar M&T Recommendations

Key Inputs Reviewed	Current ACE Model Value	Recommended Value	Source
Current Market Activity			
Heater capacity (kW)	4,750	5,250	• Interview with Greg Mihalik of SolarWorld [5]
Electricity savings per kW of hot zone production per day (kWh/kW-day production)	11.2	Varies by production process (*confidential*)	• Interview with Greg Mihalik [5]
Production days per year (days)	360	Varies by year and hot zone type (*confidential*)	• Interview with Greg Mihalik [5]
Baseline Activity			
Efficient hot zone capacity (kW)	0	No change	• Interviews with Greg Mihalik [5] and industry experts [6,7]
Other Market Effects			
Efficiency hot zone capacity (kW)	0	No change	• Interviews with industry experts [6,7] • Prometheus Institute report on polysilicon [8]

Current Market Activity and Per-Unit Savings

The Shell project led to significant improvements in energy efficiency and productivity that are still producing energy savings at the SolarWorld facility. Furthermore, it appears that SolarWorld will continue to operate at least as many efficient hot zones as it has in the recent past.

Detailed information on the energy savings indicators is not presented in this report due to SolarWorld's concerns over the confidentiality of the data. However, as discussed in the Findings above, since the 2005 M&T report (which covered through 2004) SolarWorld has modified five additional hot zones accounting for 500 kW of capacity, bringing its total capacity of efficient hot zones to 5,250. However, relative to the original 125 kW furnaces, the savings per kW from these smaller hot zones is less than proportional to their size. Additionally, temporary changes in SolarWorld's production processes have altered some of the assumptions used in the previous M&T energy savings calculations. As a result, savings have declined from 2004 estimates by roughly 10% in 2005 and 15% in 2006.[43]

Baseline Activity and Other Market Effects

The energy saving innovations at SolarWorld likely would not have occurred in the absence of support from NEEA and its sponsors. This suggests a baseline of zero savings, meaning that all savings at the SolarWorld facility can be considered a result of the original Siemens initiative. However, it appears that the project's direct impact on the crystal growing industry was fairly small—particularly in the Northwest where there is only one remaining grower besides SolarWorld. The project's success did draw industry attention, but more for its innovation in recharge than in the insulation of the hot zones. Recharge has been used since at least the mid-1990s by MEMC, which manufactures the granular feedstock that is most appropriate.

[43] Summit Blue has provided a confidential memo to NEEA discussing the new assumptions and explaining the energy savings calculations.

For the foreseeable future, the limited availability of granular silicon may prevent significant expansion of crystal growth with recharge, pending the success of Wacker and other companies in either manufacturing the granular silicon or crushing polysilicon chunks into a usable feedstock for recharge. Even if innovations prove successful, it would be difficult to attribute adoption of the recharge process directly to the project, although there is strong evidence to suggest that the project increased awareness of opportunities for energy efficiency in the crystal growing process.

Recommendations for Future M&T

Summit Blue recommends that NEEA continue a simplified M&T of the this project by contacting SolarWorld annually to confirm that operations at the facility are continuing and to identify increased capacity of efficient hot zones and hot zones with recharge. The savings quantified to date have been significant, but indications are that they are not likely to grow significantly. Also, it should be noted that the information needed to estimate energy savings will likely be increasingly difficult to obtain, as the company is sensitive to providing information on its operations.

Regarding greater market effects, it is *not recommended* that future M&T efforts for the Shell project attempt to identify market effects beyond the SolarWorld facility. The project itself is now just one of nine components under the umbrella of NEEA's Microelectronics Initiative [3], and market effects may best be viewed in the context of this broader effort or more specifically through tracking of the ASiMI project.

6.6 References

1. Ficket, B. and G. Mihalik. "Multiple Batch Recharging for Industrial CZ Silicon Growth." *Journal of Crystal Growth*. 225 (2001). pp. 580-585.
2. *Market Progress Evaluation Report, Silicon Crystal Growing Facilities, No. 2* (MPER-2), Research Into Action for NEEA, November 2001.
3. *Microelectronics: Market Progress Evaluation Report*, Research Into Action for NEEA, October 2005.
4. Mihalik, Greg and Bryan Fickett. *Efficiency Opportunities in Silicon Crystal Growing Facilities: Redesign of Crystal Grower Hot Zones 1999 Annual Report*. Siemens Solar Industries: 2000.
5. Personal Communication with Greg Mihalik, SolarWorld, January 2007.
6. Personal Communication with John Holder, Monsanto Electronic Materials Company (MEMC), December 2006.
7. Personal Communication with Ted Ciszek, Siliconsultant and former group leader for the Silicon Materials Research Task at the National Renewable Energy Laboratory, December 2006.
8. The Prometheus Institute. *Polysilicon: Supply, Demand, and Implications for the PV Industry.* 2006.
9. Summit Blue Consulting for Northwest Energy Efficiency Alliance, *Long Term Monitoring and Tracking Report on 2005 Activities,* April 2006.

7. AM400/SCIENTIFIC IRRIGATION SCHEDULING (SIS)

7.1 Introduction

The Scientific Irrigation Scheduling (SIS) project, funded by the Alliance from 1997 to 2000, encouraged irrigation practices that supply the right amount of water at the right time to crops using enhanced information about weather and improved water delivery technology, where applicable and available. The program generally involved field demonstration of SIS with irrigation opinion leaders, promotion and education activities to encourage growers to adopt SIS, and training to encourage consultants to offer SIS services. SIS generally reduces water and energy consumption by reducing unnecessary irrigation and correspondingly reducing demand and energy to pump water. However, the project was not continued, as analysis of the Farm and Ranch Irrigation Survey (FRIS) results for 1994 and 1998 demonstrated that SIS was already increasing on larger farms that produce energy intensive, high value crops at a rate sufficient to meet the Alliance 2010 goals. [10]

Subsequent funding included marketing support for a lower cost moisture meter (the AM400) with a built-in graphic display, unlike most such devices which require downloading the data into a computer. The AM400 project (2002-2004) was designed to increase the reach of SIS to growers of low-value crops by demonstrating the effectiveness of the technology. SIS means that acres that were once irrigated by using a manual pump control based on a spade full of soil at sampling points are now automated based on metering of soil moisture as shown by readings from sensors buried in the soil and sending data to a central receiver and data logger for storage. This soil moisture data plus weather data from the local AgriMet station allows the AM-400 to predict how much water would be needed over the next couple days. In this way, over-watering is avoided. AgriMet is a satellite-based network of automated agricultural weather stations operated and maintained by the Bureau of Reclamation. The stations are located in irrigated agricultural areas throughout the Northwest and are dedicated to regional crop water-use modeling, agricultural research, frost monitoring, and integrated pest and fertility management. The SIS Initiative aimed to increase user fees for AgriMet, which was funded by BPA until 1998. Several new AgriMet sites were developed over the course of the SIS Initiative.

This is the first Long-Term Monitoring and Tracking report for the SIS project and is focused on the sales of the AM400.

7.2 Indicators and Assumptions for Review

According to Summit Blue's review of the ACE model [4], the only energy savings that have been tracked for the SIS Initiative are those attributed to the AM400 moisture meter, since SIS was found to be standard practice on larger farms and those growing higher value crops. The *gross* energy savings impact of the AM400 project is based on the total number of AM400 loggers sold in the Northwest and the estimated annual energy savings per logger. The ACE model also assumes a small level of baseline activity that would have happened in the absence of the AM400 project. Last, the ACE model assumes that the AM400 project had *no influence* on the adoption of SIS by growers of low-value crops outside of that captured by AM400 sales. Summit Blue therefore focused its efforts on tracking current sales of the AM400, defining the market for low-cost SIS methods, evaluating the per-unit savings estimate, reassessing the baseline activity, and quantifying other market effects that are attributable to the AM400 project. Specifically, the M&T project team assessed the following inputs to the cost-effectiveness calculation:

- Current sales of the AM400 low-cost soil moisture data logger in the Northwest

- The market for low-cost SIS methods in the Northwest and the penetration of the AM400 product
- The energy savings of 14,800 kWh/yr for each AM400 sold in the Northwest
- The level of baseline activity in the Northwest
- Market effects beyond what is being captured in project accounting.

In accordance with the M&T work plan for 2006 [2], Summit Blue also investigated the likely magnitude of continued market effects and made recommendations for future tracking efforts.

7.3 Methodology

Summit Blue conducted the following data collection activities in support of the AM400 M&T effort:

- **Contacted the Alliance project manager for the SIS and AM400 projects, Mr. Andy Ekman,** to obtain current and historical market activity data for AM400 sales (2001 through the third quarter of 2006) and for insights into the market for low-cost SIS options [15].

- **Contacted the AM 400 project proponent, Mr. Mike Hansen** for thoughts on what would have happened without the NEEA initiative and to better understand the market for soil moisture loggers and the influence of the Alliance SIS Initiative [16].

- **Contacted Mr. Mike Morris of the National Center for Appropriate Technology [17]** to discuss the impact of the SIS Initiative on sales of the AM400 through NCAT.

- **Located and reviewed Farm and Ranch Irrigation Survey (FRIS) data from the U.S. Census Bureau [9].** The 2003 FRIS was analyzed to enable calibration against the shifting data of farmed acreage in the Northwest and to assess the total market potential for the AM400, which was developed to increase the use of irrigation scheduling on smaller farms where it is not cost-effective to use normal SIS methods.

- **Reviewed a 2005 study on the water and electricity impact of SIS completed for BPA [1].** The data provided in the study on electricity savings from irrigation practices was combined with data from the 2003 FRIS to calculate a revised estimate of energy savings from the AM400 unit.

- **Interviewed market actors and manufacturers of soil moisture sensors and data loggers** to determine if additional market effects beyond those captured by AM400 sales were likely.

- **Reviewed secondary sources of data for inputs to the savings multiplier.** The project team searched evaluation databases, including the CALMAC database (www.calmac.org) and the CEE evaluation clearinghouse (www.cee1.org), as well as the internet, for evaluations of SIS and AM400 projects. Several projects related to the AM400 were obtained through the internet search[44,45,46] as well as an ACEEE report in 2005 by Elizabeth Brown , R. Neal Elliott, and Steven Nadel called “Energy Efficiency Programs in Agriculture: Design, Success, and Lessons Learned.”

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[44] Morris, Mike. Soil Moisture Monitoring: Low-Cost Tools and Methods, 2006.
[45] Shock, C. et al. Evaluation of the AM400 Soil Moisture Data Logger to Aid Irrigation Scheduling, Malhuer Experiment Station, Oregon State University, Oregon, 2001 and 2004.
[46] Morris, Mike. Water and Energy Conservation with the AM400 Soil Moisture Monitor, NCAT, 2004.

7.4 Findings

7.4.1 Current Market Activity

Sales of the AM400

Summit Blue obtained a project tracking database listing sales of the AM400 soil moisture data logger from Andy Ekman. Table 7-1 below shows AM400 sales from 2001 to 2006. Sales have declined since 2002, with unit sales in the Northwest leveling off at about 150 units per year. In addition, 251 AM400 units were sold in regions other than the Northwest over this same timeframe, about 40 per year.

Table 7-1 Actual Sales of AM400 in the Northwest

Year	2001	2002	2003	2004	2005	2006*
Annual AM400 Sales	211	232	166	147	149	127
Cumulative AM400 Sales	211	443	609	756	905	1,032
*Sales data for 2006 includes only the first three quarters.						

Total Market for Low-Cost SIS Methods

According to the irrigation scheduling practices study [1], the market for low-cost SIS methods, such as the AM400 data logger, is considered to be farmers growing low value crops and smaller farms. However, based on discussions with Andy Ekman, the program manager, Summit Blue focused on assessing the irrigated acreage of low-value crops in the Northwest because it would not be cost-effective for even large farms growing low-value crops like alfalfa for feedstock to implement sophisticated SIS methods.

Summit Blue obtained the number of acres irrigated by sprinkler systems—thus eligible for the use of SIS—for each state in the Northwest from the Farm Ranch and Irrigation Survey 2003. The National Agricultural Statistics Service website [13] provided data by crop and state, including the value of the crops. Low value crops were considered to be less than $300 per acre and included wheat, barley, alfalfa, oats and corn; high value crops are potatoes, dry hay, and field crops. A irrigation scheduling practices study [1] found that "*alfalfa was the dominant crop in the region. Fifty-six percent of all surveyed farms reported planting alfalfa; in 38% of cases, it was the primary crop. Alfalfa accounted for nearly one-third of the planted acreage, followed by corn (15%), potatoes (7%), and grass seed.*" Table 7-2 below shows the calculation of the percentage of acreage growing low-value crops in the Northwest in 2005 and Table 7-3 shows the application of these percentages to the acreage in each state that is irrigated by sprinkler systems.

Table 7-2. Low-Value Crops by State 2005

State	Low-Value Crop Acreage [A]	Total Acreage [B]	% Low-Value Crops [C] = [A] / [B]
Idaho	2,578,000	10,433,887	25%
Montana	6,960,000	19,583,600	36%
Oregon	1,169,500	4,453,163	26%
Washington	2,964,000	8,448,294	35%
TOTAL	**13,671,500**	**42,918,944**	**32%**

Table 7-3. Market Potential for Low Cost SIS Methods in the Northwest (2005)

State	Total Irrigated Acres	Irrigated with Sprinkler Systems [D]	% Low Value Crops [C]	Acres Suitable for Low Cost SIS Methods [E] = [D]*[C]
Idaho	3,126,857	2,202,917	25%	544,296
Montana	2,131,956	773,008	36%	274,727
Oregon	1,731,660	1,048,211	26%	275,284
Washington	1,805,692	1,490,274	35%	522,848
TOTAL	**8,796,165**	**5,514,410**		**1,617,155**

Since one AM400 unit covers 80 acres, the potential market for AM400 *sales* in the Northwest would be 20,214 units (1,617,155 acres divided by 80) in 2005. Total cumulative sales of AM400 data loggers to the end of 2006 was 1,032, or approximately 5% of the total potential market.

Recommendation**:** Use 20,214 units in the ACE model as the estimate of the total potential for low-cost SIS units similar to the AM400 data logger. This number is based on the most up-to-date information available and is adjusted for the value of crops.

7.4.2 Per-Unit Energy Savings

Revise the estimate of per-unit energy savings based on more recent data. The ACE model assumes per-unit energy savings of 14,800 kWh per unit (185 kWh per acre per year), as described in the Alliance's cost-effectiveness analysis assumptions. This estimate was based on 1994 FRIS data and assumes electricity reduction of 15.8% based on a study completed by Washington State University (WSU) [5]. Phase II of a study conducted for BPA in 2005, which derived estimates of water and electricity savings through monitoring actual water use in a sample of fields, provides an updated and more rigorous estimate. The study used 19 *paired samples* (a total of 38 samples) of farms using SIS methods and farms not using these methods, matched on the basis of geographical area, crops grown, and comparable soils. Both large and small operations were included with field acreage ranging from very small half circles to relatively large 200 acre fields. The researchers found "*that reductions in water use resulting from the application of SIS in the study sample result in net electricity savings of 13.1 per cent,"* or 154 kWh/acre-year or 12,328 kWh/year. [1] By comparison, the data from the WSU was obtained during 1992-1994 and includes only 15 irrigators total without a matched-pair analysis.[47]

Recommendation: Summit Blue recommends changing the per-unit savings estimate for AM400 sales from 14,800 kWh/yr to 12,328 kWh/year. The data supporting this savings estimate is much more recent than that from the WSU study and thus more likely to reflect current baseline irrigation practices and equipment efficiencies. Furthermore, by using a robust matched-pair analysis, the study analysts were able to compare savings from similar geographic areas, crops, and soils.

7.4.3 Baseline Activity

At the start of the NEEA funding for the AM400 project in May 2002 [3], the AM400 was already being sold in the market. The original ACE model assumptions regarding baseline activity thus reflected the actual sales for 2001 and 2002, and the baseline was set to grow by 1% per year thereafter [5]. By 2005, however, the projected baseline sales had exceeded actual sales in the region, and NEEA revised the baseline downward to 50 units per year from 2001-2006 to better reflect market conditions. Table 7-4

[47] http://sis.prosser.wsu.edu/brochure.htm

below shows revised estimates of baseline activity from 2001 to 2006 compared to the original baseline sales projections [4].

Table 7-4. Original and Revised Baseline Sales of AM400

Year	2001	2002	2003	2004	2005	2006
Original Baseline	146	192	194	196	198	199
Revised Baseline	50	50	50	50	50	50

Sales of the AM400 in the Northwest were influenced by the NEEA SIS Initiative. Between 2001 and 2004, about 40% of AM400 units were installed in the Northwest as part of a National Center for Appropriate Technology (NCAT) initiative, but it is likely that a significant share of these sales were a result of the NEEA SIS Initiative started in 1997. In fact, it was at an NEEA information session on SIS that NCAT heard about the AM400. [17] MPER-3 reports that "*manufacturers perceive increasing growth and a strong future for irrigation management among large-scale growers. However, market conditions are less optimal for growth among small and medium scale growers in the Pacific Northwest*:" The following additional quotes from MPER-3 further emphasize the impact of SIS on awareness of and interest in AM400 units: [10]

- *"…SIS… was instrumental in encouraging the developer of the AM400 to pursue his idea and then provided an opportunity to demonstrate the equipment…the project facilitated the development and introduction of a new irrigation management tool (AM400) and dissemination of valuable information comparing different soil moisture sensors."*
- *"In 2000 …the (field) agents tested 13 AM400s… (which) were very well received. Several growers asked how to purchase them. This was quite different than the experience with farmers using other soil moisture sensing equipment, who tended to rely on the agents and stated they were unlikely to continue on their own without the agent's assistance."*
- *"…growers who have had exposure to SIS are enthused about the AM400 as a low-cost and effective tool for doing SIS on their own. Access to the AM400 and training in its use are the major limits to its adoption."* However, an agricultural supplier approached by the SIS team to carry the AM400 was not willing to do so due to a "*perceived need for support services, which would not be available."*

The findings from MPER-3 indicate that although NEEA did not begin funding the AM400 project until mid-2002, the SIS Initiative had a positive impact on the awareness of and interest in the AM400 as early as 2000. However, since the AM400 was being sold in the market prior to NEEA funding, it seems likely that some level of baseline sales would have occurred in the absence of the AM400 project.

Recommendation: Summit Blue recommends that NEEA maintain the current ACE model assumption of 50 AM400 sales attributable to baseline activity for each year from 2001 to 2006. No evidence exists to suggest a more exact baseline, and the findings from the M&T research are qualitatively consistent with the ACE model assumption.

7.4.4 Other Market Effects

NEEA's goal was to increase the availability of low-cost SIS equipment (e.g. AM400) in the market. There is evidence that this has occurred, for example, a recent article by Mike Morris of NCAT noted that growers would be "*surprised to learn how easy and inexpensive it has become to purchase, install, and use a state-of-the-art monitoring system. More devices are coming on the market all the time, and prices* *continue to fall*."[48] In addition, Mike Hansen said that there were many fewer competitors for his AM400 product *before* the NEEA program [16].

Using the list of 25 manufacturers from MPER-3 [10] as a starting point, Summit Blue conducted web searches for manufacturers, distributors, and retailers that sell low-cost equipment that could be used for scientific irrigation scheduling. The search results were varied, but the market for a low-cost data logger with capabilities similar to AM400 appears to be very fragmented. Some manufacturers sell moisture sensors, some sell data loggers, some sell both, and a few sell them as a package. Irrometer, for example, now offers data loggers in addition to soil moisture sensor equipment. This company initially used the AM400 to complement their soil moisture sensors, and then added their own product when it became evident that the demand existed. In a separate conversation, a representative from Spectrum Technologies reported that they sell packages of soil moisture data loggers plus sensors all over the United States, including the Northwest. He stated that they have been selling the individual equipment pieces for years, but that three years ago they started selling them as a package because of demand out of California. He also confirmed that the true differentiator in whether a grower pursues scientific irrigation scheduling is whether the crops are of high or low value. He further felt that SIS for high-value crops nationwide was quickly becoming standard practice, whereas SIS for low-value crop growers was more dependent on the region and the availability and cost of water. Mike Morris of NCAT said that the soil moisture market, which is "very crowded," had to improve technology and lower costs to compete with the AM400 because of its "great features" and low cost. He said that it is not the *lack* of tools that is the barrier to using SIS but rather getting people to *use* the tools. In his opinion, the AM400 demonstrated in the field was much more effective than education sessions in getting growers to change firmly entrenched behavior of growers. [17]

The interviews with market actors and equipment manufacturers suggest that it is very likely that the NEEA SIS Initiative, including the promotion of the AM400 product, has influenced competitors to enter the market with low-cost data loggers. However, Summit Blue does not think it reasonable to attribute additional market effects to the Initiative on the basis of increased competition alone. While increased competition likely means increased implementation of these technologies, it would be premature to declare that energy savings are being achieved beyond what is being captured by program accounting.

Recommendation: Summit Blue recommends that NEEA does not count market effects beyond SIS sales at this time. It is very likely, however, that the SIS Initiative influenced manufacturers to offer more low-cost soil moisture equipment. Quantifying the *energy impact* of this increased competition and *definitively attributing it to the SIS Initiative* would be difficult to substantiate without significant primary research with Northwest growers. Summit Blue thinks the potential market effects due to increased scientific irrigation scheduling among low-value crop growers because of the SIS Initiative is worth the cost. Therefore, the primary recommendation for continued tracking of the AM400 project is to develop a focused survey instrument and conduct interviews with a significant sample of growers in the Northwest to better estimate the market penetration of SIS methods and the share attributable to the SIS initiative.

7.5 Conclusions/Recommendations

Table 7-5 summarizes Summit Blue's recommendations for the SIS project.

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[48] NCAT 2006.

Table 7-5. SIS (AM400) M&T Recommendations

Key Inputs Reviewed	Current ACE Model Value	Recommended Value	Sources
Current Market Activity and Per-Unit Savings			
AM400 Sales	Varies by year	See Table 7-1	• See Section 7.4.1
Total market for AM400	25,015 units	20,214 units	• FRIS 2003 [6] • NASS 2005 [12] • MPER 3 [7] • See Section 7.4.1
Unit savings for AM400	14,800 kWh/year	12,328 kWh/year	• Irrigation Practices Study [1] • FRIS 2003 [6] • See Section 7.4.1
Baseline Activity			
AM400 sales not influenced by SIS Initiative.	50 units per year	No change	• MPER 3 [7] • Interview with Mike Hansen [16] • See Section 7.4.3
Other Market Effects			
Market share of low cost options for SIS other than the AM400 product.	0%	No change	• See Section 7.4.4

- **Continue tracking AM400 sales in the Northwest.** Sales of AM400 units have reached 5% of the total market potential by 2006. Although the magnitude of sales in the Northwest going forward is somewhat uncertain at this point, tracking the sales data requires little effort and is a key indicator of success of the SIS Initiative.

- **Revise the total market potential for low-cost options for SIS such as the AM400.** A revised estimate was calculated based on the most recent data available the market potential for units.

- **Revise the per-unit savings assumption for AM400 units based on recent research results.** Recalculating the per unit savings based on the new estimates of 13.1% decrease in energy use will provide for increased resolution and less uncertainty.

- **No change should be made to the estimate of baseline activity.** No evidence exists to suggest a more exact baseline, and the findings from the M&T research are qualitatively consistent with the ACE model assumption.

- **Conduct primary research with in the Northwest growers to determine other market effects.** Summit Blue thinks the potential market effects due to increased scientific irrigation scheduling among low-value crop growers because of the SIS Initiative is worth the cost of primary research. Therefore, the *primary recommendation* for continued tracking of the AM400 project is to develop a focused survey instrument and conduct interviews with a significant sample of growers in the Northwest to better estimate the market penetration of SIS methods and the share attributable to the SIS initiative.

7.6 References

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