Market Progress Evaluation Report

Evaporator Fan VFD Initiative, No. 2

prepared by

Macro International

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The Northwest Energy Efficiency Alliance

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Executive Summary

A. Background to the VFD Initiative

The use of Variable Frequency Drives (VFDs) on evaporator fans in refrigerated warehouse applications has the potential to produce significant energy savings when compared to other means used to regulate temperature. Estimated energy savings after 10 years is 18.3 aMW[1]. However, very few refrigerated warehouse facilities currently use the VFD technology. The Evaporator Fan VFD Initiative (Initiative) began in early 1998 with the **goal** of making VFDs an industry standard on evaporator fans in refrigerated warehouses in the Pacific Northwest.

In order to make VFDs an industry standard the Initiative will have to overcome several **market barriers** including:

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

The **definition of success** for the Initiative is that by the end of the year 2000 five percent more refrigerated warehouse facilities install evaporator fan VFDs than would have in the absence of the Initiative. By the end of 2007, use of evaporator fan VFDs becomes standard practice.

The Initiative is undertaking several types of activities to accomplish these goals including field trials, information exchange with vendors and contractors, and information dissemination with refrigerated warehouse owners and operators.

Progress indicators include:

- Development of a comprehensive database of refrigerated warehouse facilities in the Northwest;
- Participation in field trials at 30 sites over the first two years of the Initiative and two comprehensive installations;
- Field trials and installations successfully achieve cost-effective savings while maintaining or improving product quality (reducing fruit mass loss and increasing firmness);
- Information on results is disseminated broadly in the industry and to consulting engineers;
- Facilities outside of Initiative participants begin to use the technology.
- Consulting engineers offer and OEMs package VFDs with evaporator fan installations.

B. Evaluation of the Initiative

Macro International (Macro) was hired by the Alliance to perform an evaluation of the Initiative. The main **goals of the evaluation** are:

- Track progress in overcoming market barriers;
- Assess adoption of the VFD technology;

[1]Calculations and assumptions used to estimate energy savings over the 10 year period are included in Appendix B.

- Assess the extent to which VFDs have become an industry standard that will be sustained after the Initiative ends.

To this end, the evaluation consists of several activities, including evaluation of data from field trials, interviews with field trial participants, interviews with vendors and contractors and interviews with facility owners and operators. A table outlining all evaluation activities and indicating the status of each activity is included in Appendix A.

C. Key Findings

1. *Status of Initiative in Meeting Progress Indicators*

- Table 1, below, summarizes the **progress indicators** for the project, the extent to which they have been met and expected future activities. Information on the status of the Initiative with regard to the progress indicators was primarily provided by Cascade, both in their monthly status reports as well as in detailed interviews with Macro.

- Cascade has made reasonable inroads to meeting their progress indicators. The initial goal was participation at 30 sites over the first two years of the initiative. In the first two years of the Initiative they recruited a total of 14 CA facilities to participate in field trials with some facilities participating with more than one room. In addition to the 11 field trials conducted in 1998, another seven were conducted in 1999, or a total of 18 CA field trials. In addition, one regular storage facility was successfully recruited in 1998, another in 1999 and two in 2000.

- All of the 1998 field trials resulted in less mass loss of fruit stored for the VFD rooms and also less energy usage. Mass loss improvement was on average 11%. Results of the pressure tests on the fruit (a measure of fruit firmness) did not show conclusively an improvement or reduction in fruit quality. With regard to energy, the average demand savings in the VFD room range from 0.7 kW versus a control room using a very aggressive fan cycling regime to 7.8 kW versus a room running fans continuously. Energy savings totaled 258,761 kWh for the 11 tests for an overall average annual savings of 50%. Again savings in facilities using a aggressive fan cycling were less (7%) relative to those having the fans on constantly (62%). The results are consistent with the initial goal of demonstrating energy savings while maintaining or improving fruit quality.

Progress towards other indicators, such as information dissemination and installation of VFDs by facilities outside of the Initiative were dependent on finishing tests and ascertaining results. Now that this has been done, progress in those areas should accelerate.

Table 1
Status of Initiative in Meeting Progress Indicators

Progress Indicator	Status	Future Plans
Comprehensive database of refrigerated warehouse facilities developed	Construction of a Microsoft Access database is complete. Data on approximately 60 warehouse facilities has been entered.	Data on additional facilities will be entered as it is collected (typically done when Cascade personnel visit a facility)
Participation in field trials of 30 sites over first two years of Initiative & 2 comprehensive installations	11 CA field trials (a total of 19 tests) were conducted in first year of the Initiative. Another seven field trials are taking place in 1999*. In addition, one regular storage field test is in progress and three more are scheduled. However, as discussed in section II.A.3 below, a program decision was made in 1999 to place less emphasis on regular storage facilities.	Two candidates for comprehensive installations have been identified and negotiations are ongoing.
Field trials & installations successfully demonstrate energy savings while maintaining or improving fruit quality	Results from all 11 1998 field trials are complete, all resulting in energy and mass loss reductions.	Field trials will be completed in spring 2000, at which time data will be analyzed.
Information on results disseminated broadly in the industry	A detailed discussion of information dissemination among facility owners is included in section II.D.	Case studies, based on results of the 1998 field trials, were developed in fall of 1999. It is anticipated that these case studies will be widely disseminated in 2000 and that additional case studies will be developed based on 1999 field trial results.
Facilities outside the Initiative begin to use the technology	Interviews with eighteen facility owners who are not participating in field trials turned up 6 who are currently using VFDs. However, the most recent installation was two years ago. Therefore, none of these installations can be attributed to Initiative activities. Several others indicate that they are considering VFDs (two appear to be directly influenced by the initiative). Cascade has documented 16 recent (1999 and 2000) Alliance area VFD installations (Appendix D)	With the first batch of case studies completed and information dissemination activities continuing it is expected that more VFD installation will be tracked in 2000

* Note that some field trials will result in multiple tests

2. *Vendor and Contractor Interviews*

- Vendors and Contractors believe that demand for VFDs on evaporator fans is still fairly limited.
- It appears that many of the evaporator fan projects done to date are directly related to efforts on the part of Cascade and many or most probably would not have occurred without some form of financial incentive.
- Vendors and contractors do believe that VFDs save energy, although the level of savings may not be sufficient to be cost effective. They are less certain about the benefits with regard to fruit quality and will need to see more data to be convinced.
- Vendors and contractors generally believe that the use of VFDs on evaporator fans will increase in the next few years. Factors that may affect the rate of adoption include profitability in end user markets, continued availability of utility funding and/or tax credits, the price of electricity, and continued decrease in the cost of the drives.
- Vendors and contractors find the information produced by Cascade to be useful and credible. However, they would like to see information covering as many different variables and combinations of variables as possible. For example, different types of fruits, different room configurations, baseline fan-control regimens, etc.
- Participants believe that Cascade has done a good job of disseminating information and that they are reaching a broad audience.
- Cascade is very highly regarded among those participating in the survey.
  There is virtually no recognition of the Initiative or of the Alliance. Most participants in the survey believe that Cascade is funded by the local utilities.

3. *Field Trial Participant Interviews*

- Field trial participants had heard about both potential energy saving benefits and fruit quality benefits prior to their participation in field trials. They were motivated to participate largely out of curiosity, and by the availability of some funding that helped to make the projects pencil out. The decision process usually involves a financial side as well as a technical side and both must be addressed.
- 1998 field trial participants feel that their expectations were met with regard to energy savings realized from installation of VFDs. They are mixed in terms of whether their expectations were met with regard to fruit quality. While most did see some decrease in mass loss, one cited a worry about comparability of results due to a big time difference between opening test and control rooms, one cited a desire for a longer test (he would have liked to see his rooms sealed for another three weeks to a month), and one who had several test rooms cited mixed results for the rooms.
- Overall, two participants indicated that they would probably need to see more significant differences in mass loss to consider future projects, three indicated that results were very promising and that they would like to see more data and two were very enthusiastic about the results and indicated that they have or are installing VFDs in additional rooms.
- Participants did have some concerns going into the field trials, most around potential problems with motors. However, the field trials have convinced them that these problems can be avoided as long as a knowledgeable contractor is involved.
- Cascade's role and participation in the projects was a major factor in selling them internally as well as in their successful completion. Cascade is cited as being very knowledgeable, professional, hard working, reliable, and flexible. They were also commended for solving any problems quickly and satisfactorily.

- Field trial participants felt that the type and level of data being collected was appropriate for making a case with decision makers. They pointed out, however, that presentation of information may need to be varied depending on the audience. More management oriented people will want to see a general overview and will respond more to bottom line messages while operators will be more interested in the technical details and will respond to messages about how this will help them to do a better job and how it will make their job easier.
- Trade shows are a good way to reach facility owners/operators as well as vendors and manufacturers. They are less likely to reach contractors. Trade publications and word of mouth are also important sources of information for facility owners/operators.

4. *Non-participant Facility Owner Interviews*

- One third of those contacted currently use at least some VFDs for evaporator fans. Half use some form of fan cycling.
- Those currently using VFDs do achieve energy savings and also see less shriveling in the fruit. These tend to be qualitative assessments with no formal measurement.
- Facilities tend to be works in progress with changes and upgrades made over time as necessary or as funds are available. Many facilities contain both older and newer sections and a mix of technologies. Therefore, decisions about VFDs are typically part of decisions about a larger upgrade, renovation or retrofit and VFDs must compete for funds with other equipment.
- Facility owners and operators are familiar with the concept of using VFDs in evaporator fan applications and are aware of the potential energy savings and fruit quality benefits. Most have not seen enough information to be able to assess the potential value of these savings. More data would be necessary in order to assess the viability of installing VFDs.
- There are concerns about the VFD technology including cost, potential problems with motors, reliability versus the value of products stored in each room (i.e. risk), and the potential for dead spots in rooms. There is some general concern about motor burnout but there is also a specific concern that has to do with the need to replace older motors when the drives are installed, adding to the cost of the project. Thus, there is more concern with retrofit applications than with new installations since there is a perception that newer motors are made to work with VFDs and that potential problems can be handled if the installation is performed by an experienced contractor.
- Decisions usually involve someone from management and someone from operations (i.e. both a financial and a technical component). Often, trusted contractors are also involved in providing input. It is also the case that vendors and contractors are often the impetus behind projects in the first place. Facility operators are often too busy to get to all of the projects that interest them and find it useful when someone else does a lot of the up-front work and brings it to them.
- The industry has been in a slump recently and funds for capital projects are very tight. There has also been a decline in the availability of outside (utility) funding.
- There is relatively high awareness of Cascade and they have a good reputation for their technical knowledge. They are considered to be a credible source of reasonably unbiased information. There is little awareness of the initiative.
- Conferences and trade shows are good venues for information dissemination as are trade publications and peers. These are considered to be sources for general information. Often, a vendor or contractor is considered to be the best source of information for whether or not a technology is appropriate for an individual facility given its unique properties.

D. Conclusions and Recommendations

- Results of the field trials to date show promise, although a more data may be needed to address the range of issues that will be brought up by facility owners and operators. This is in response to a number of vendors, contractors, and facility owners who said that there are so many factors that each situation is essentially unique, and therefore it is difficult to make generalizations. The more that results from different mixes of variables are available, the easier it will be to find some that most closely mirror an individual situation, and therefore to convince people that the results are applicable to them and that they can draw conclusions about their own situation. Results of the 1999 field trials will help. It is important that, to the extent possible, these field trials be closely controlled, thus eliminating concerns about the methodology (primarily tests not running long enough or big differences between opening of the control and test rooms).
- Cascade will need to be able to address those field trials that did not achieve significant results. Are there remedies or is it possible that in some cases VFDs simply are not going to result in sufficient energy savings and/or fruit quality improvements to justify expenditures on them? In either case, Cascade should be prepared to provide answers.
- Field trial results should help to address concerns in the market about the cost of VFDs versus the benefits. However, there are still lingering concerns about the technology, primarily potential motor problems. Most people believe that the problems have been fixed or that they can be addressed but they need to be reassured. It might be worthwhile to address this issue head on in communications pieces.
- Both fruit quality and energy savings are important to controlled-atmosphere facility owners/operators. Energy savings are better understood at this point in terms of the magnitude of potential savings and confidence that VFDs will achieve energy savings. There is much less certainty about the effect of VFDs on fruit quality. Therefore, the most interest is on data about the effect of VFDs on fruit quality. It is unclear how possible it is to collect data on the dollar sales value of the crops. However, if possible, this data should be collected.
- As the program moves through its final year, there should be a shift in emphasis from data collection to information dissemination.
- Vendors and contractors are important points of leverage in the market and should be recruited as allies to help disseminate information. Vendors often play the role of generating interest or of fueling a latent interest that has not been acted upon because of the workload of facility owners/operators. Contractors often have significant input into the ultimate decision process. Therefore, it is important to ensure that information dissemination among vendors and contractors is stepped up. It might be worthwhile to spend some time working with vendors to develop a format for the information that will be most useful to them in working with their customers. It may be that the case studies will suffice, but there may still be other considerations. For example, it may be useful to have both a general version as well as a more detailed technical version depending on the audience. Or, since the pieces will be used as “leave behinds” it may be worthwhile providing vendors with a template that would allow them to add their own logo and contact information while being unable to change the body of the file. Some time spent up front with vendors will help to maximize the usefulness and use of the information.
- Word of mouth is important, therefore it is crucial that any installations that are done be as free as possible from technical problems so as not to reinforce concerns about the technology. It appears that most installations done by inexperienced contractors do run into some problems. It may be worth exploring whether or not there is a way to help ensure that inexperienced contractors get the help that they need. Perhaps the Alliance would want to explore finding funds for a training program.
- Trade shows and conferences are considered to be good sources of information and a good way to reach facility owners/operators and vendors. Cascade should continue their efforts at

providing a presence at the major shows. Trade shows and conferences are not as good a vehicle for reaching contractors, particularly electrical contractors. It is unclear whether there is a single event at which one could reach a large number of them. Cascade should consider other means of reaching contractors. A direct mail piece may work if a suitable database of contacts can be located or developed (possibly through trade associations). Perhaps an event for contractors could be developed, depending on the size of the pool of qualified contractors. Ultimately, the size of the pool should be used as a factor in determining what type of marketing makes sense.

- Peers are also considered to be a good source of information and seeing is believing. If possible, it might be worthwhile to explore the possibility of setting up tours of facilities that are successfully using VFDs. Obviously, this will require some incentive for the facilities and any proprietary issues will need to be addressed. The most likely candidate for an incentive would be some form of publicity or recognition among potential customers or perhaps within the industry. Proprietary issues may be able to be addressed if it is possible to find facilities that don't compete directly with each other (for example those who only have facilities in Washington might be able to tour a facility in Oregon and Vice-versa).
- A few organizations and/or individuals such as Duckwall-Pooley, Central Washington Refrigeration and Dan Black were mentioned on a number of occasions as being good proponents of VFD use. If possible, it may be worthwhile trying to find ways to work with or through them.
- It is important to have repetition of messages since facilities are constantly evolving and one must reach facility owners and operators in the proper part of their capital cycle, which may last for several years. For example, owners and operators may be leery of using VFDs with older motors because of the perception that there is a higher likelihood of motor failure. Even if these concerns are unjustified, owners may be unwilling or unable to justify replacing older motors that are still operable in order to install VFDs as long as this perception remains. However, at the point in time when they make the decision to change out the motors, they may willing to consider installation of VFDs as part of the project.
- The biggest hurdle with regard to market transformation will continue to be the perception of cost. Until benefits are fully understood, initial cost will be perceived to be high. Even with cost savings from reduced energy use and reduced mass loss in fruit, it will be difficult to make some projects pencil out in the two to three year time frame that many organizations employ when evaluating projects. Slumps in the industry and reduced funding from utilities have contributed to a lack of available capital. However, the cost of drives is continually decreasing, the quality of drives is continually increasing and there is a perception that energy prices will increase over time. Therefore, having good, reliable information in the marketplace will help to ensure that VFDs are in the purchase decision mix when conditions are right.

A. Background to the VFD Initiative

The use of Variable Frequency Drives (VFDs) on evaporator fans in refrigerated warehouse applications has the potential to produce significant energy savings when compared to other means used to regulate temperature. Estimated energy savings after 10 years is 18.3 aMW[2]. However, very few refrigerated warehouse facilities currently use the VFD technology. The Evaporator Fan VFD Initiative (Initiative) began in early 1998 with the **goal** of making VFDs an industry standard on evaporator fans in refrigerated warehouses in the Pacific Northwest.

In order to make VFDs an industry standard the Initiative will have to overcome several **market barriers** including:

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

The **definition of success** for the Initiative is that by the end of the year 2000 five percent more refrigerated warehouse facilities install evaporator fan VFDs than would have in the absence of the Initiative. By the end of 2007, use of evaporator fan VFDs becomes standard practice. This is defined as having 50% of regular storage facilities use VFDs compared to an initial estimate of 10% of such facilities currently using VFDs (this would represent a 31% increase in the number using VFDs versus the number who would be using them in the absence of the Initiative) and 70% of fruit storage facilities would be using VFDs compared to an initial estimate of 5% currently using them (an increase of 47% versus those that would use them in the absence of the Initiative).

The Initiative is undertaking several types of activities to accomplish these goals including field trials, information exchange with vendors and contractors, and information dissemination with refrigerated warehouse owners and operators.

One of the key elements of the Initiative is that it is designed to result in sustainable market transformation, meaning that the Initiative will set market forces in motion which in turn will make VFDs an industry standard and that this will continue even after Initiative activities have ceased. Experience with refrigeration control systems suggests that the types of activities being undertaken by the Initiative have a good chance of success. Ten to fifteen years ago penetration of control systems was virtually non-existent. Academic research on fan cycling was conducted and demonstrated lower energy usage and a positive impact on fruit quality. This information was disseminated among key refrigeration contractors who became convinced of the merits and began to promote such systems. Within ten years, an estimated 80% of facilities had gone to computer controls. In addition, Cascade points out that the economics of computer controls and VFDs are similar. Therefore, it is reasonable to expect that by conducting well documented field trials and then disseminating information among vendors, contractors, and facility owners a similar type of transformation in evaporator fan VFD technology will likely occur.

Progress indicators include:

- Development of a comprehensive database of refrigerated warehouse facilities in the Northwest;

[2]Calculations and assumptions used to estimate energy savings over the 10 year period are included in Appendix B.

- Participation in field trials at 30 sites over the first two years of the Initiative and two comprehensive installations;
- Field trials and installations successfully achieve cost-effective savings while maintaining or improving product quality (fruit mass loss and firmness);
- Information on results is disseminated broadly in the industry and to consulting engineers;
- Facilities outside of Initiative participants begin to use the technology.
- Consulting engineers offer and OEMs package VFDs with evaporator fan installations.

B. Evaluation of the Initiative

Macro International (Macro) was hired by the Alliance to perform an evaluation of the Initiative. The main **goals of the evaluation** are:

- Track progress in overcoming market barriers;
- Assess adoption of the VFD technology;
- Assess the extent to which VFDs have become an industry standard that will be sustained after the Initiative ends.

To this end, the evaluation consists of several activities, including evaluation of data from field trials, interviews with field trial participants, interviews with vendors and contractors and interviews with facility owners and operators. A table outlining all evaluation activities and indicating the status of each activity is included in Appendix A.

C. Purpose of the Report

This report represents the second of three Market Progress Evaluation Reports (MPER) on the Variable Frequency Drive Initiative (Initiative) sponsored by the Northwest Energy Efficiency Alliance (Alliance) and implemented by Cascade Energy Engineering (Cascade). Evaluation reporting includes an MPER at the end of each of the three years of the Initiative. Each MPER represents a periodic, structured assessment designed to track and document performance and progress made by the program in reaching its overall goals as well intermediate progress indicators. Each MPER is meant to build on and extend information from the previous MPER(s). Taken together, the three MPERs constitute the overall evaluation of the project.

D. Summary of first MPER

The first MPER was conducted in 1998 and results were published in March 1999 in a document titled “Baseline Market Assessment of the Evaporator Fan VFD Initiative: Market Progress Evaluation Report #1”. Electronic copies of this document are available from the Alliance Web site (www.nwalliance.org).

The Initiative’s activities during 1998 were largely confined to recruiting field trial participants and setting up the field trials. The field trials consisted of actual experiments in which VFD’s were installed in one room (the test room) while they were not installed in another, similar room (the control room). In order to examine fruit quality issues, the same type of fruit was stored in both rooms, with specific test bags or bins assigned to the test in each room. The bags or bins were placed at various locations within the rooms (high and low, front, middle and back). Measurements were taken both before the room was sealed and after it was opened in order to assess the difference (if any) between the two rooms. Other measurements were taken as well in order to test for difference in energy usage. Examples of measurements include energy consumption, room temperature, fruit mass loss, and pressure tests (a measure of fruit firmness).

In addition, two levels of field trial were conducted: simple field trials and detailed field trials. Information from simple field trials is geared more towards the facility owner/manager who is likely to be more interested in and able to understand general results. Detailed trials result in information that is more geared towards a technical audience that might be interested in precise details.

The basic difference between a simple field trial and a detailed field trial is the degree of rigor associated with the trials. The simple trials involve comparative tests, which address the main issues of fruit quality and energy savings, but do not include the degree of rigor associated with academic work. Detailed trials, which involve equipment that allows one to more closely monitor conditions inside the room while it is sealed, allow for more frequent and sophisticated measurements that approach an academic degree of rigor. For example, a detailed field trial provides information on air flow and temperature distributions within the room, information that is important for understanding the subtleties of the system but which is too complex for a layman.

Cascade recruited a total of 10 controlled atmosphere facilities. Nine of the ten facilities conducted a simple field trial. One of those nine also conducted a detailed field trial. The other facility conducted only a detailed field trial. Therefore, a total of 11 field trials were conducted for the ten facilities (nine simple and two detailed). Most of the field trials consisted of one test (meaning that one VFD room, one control room and one sample set of fruit were used). However, one of the facility's simple field trial consisted of three tests, meaning that although only one VFD room and one control room were used, three different sample sets of fruit, representing three different grades of apples were put into the rooms. In addition, another facility (which conducted both a simple and a detailed field trial) conducted a total of four tests for the simple field trial and four tests for the detailed field trial. Again, only one VFD room and one control room were used for each field trial. However, four sample sets of Golden apples from four different growers and four sample sets of Red apples from four different growers were used in the tests. Thus, ten facilities participated in 11 controlled atmosphere field trials (nine simple and two detailed) consisting of 19 tests (fourteen simple and five detailed). The breakout is as follows:

Table 2
Summary of 1998 CA Field Trials

Facility	Rank in Size (total SQFT)	# of Simple Field Trials	# of Detailed Field Trials	# of Simple Tests	# of Detailed Tests
1. Stemilt Growers	1	1	1	4	4
2. Columbia Reach	46	1	0	1	0
3. Hansen	21	1	0	1	0
4. C.M. Holtzinger Fruit	11	1	0	1	0
5. McDougall &Sons	27	1	0	1	0
6. Olympic Fruit	55	1	0	1	0
7. Valley Fruit	34	1	0	3	0
8. Blue Star Growers	18	1	0	1	0
9. Blue Bird	9	1	0	1	0
10. Trout Blue Chelan	2	0	1	0	1
Total		9	2	14	5

Recruitment generally involved offering financial and technical assistance for installing VFDs in exchange for access to the rooms for conducting tests and collecting data. The ability to use the data in information dissemination activities was also included. All of the details were spelled out in a document that the facility was required to sign.

Because results of these field trials would not be available until the middle of 1999, the first MPER primarily focused on establishment of baseline information and development of a market characterization. Interviews were conducted with one person who chose not to participate in field trials as well as some facilities for which Cascade had installed VFDs prior to the creation of the Initiative. Results from these interviews were also included in the report.

Results indicated that Cascade facilities that had installed VFDs were satisfied with the results both in terms of product quality as well as energy savings. Most reported that the installation process required a big learning curve, particularly for the electricians, and that the initial set up was not problem-free. However, that they felt certain that having gone through the process once, the next time would be much smoother.

The one facility that chose not to participate in a field trial after being offered the opportunity said that their reason had to do with circumstances at their facility at the time and that they were still very interested in the technology and in being kept up to date on the results of the field trials.

E. 1998 Field Trial Results

Cascade reached agreement for field trials with 10 facilities in 1998. Each of the facilities agreed to a simple field trial (although one of these field trials did not have the proper controls and Cascade has not used the results in their findings). Two of the facilities also agreed to detailed field trials. The field trials included several different varieties of apples (Golden and Red). In addition, two trials were conducted on rooms storing pears (Anjou).

Measurements were made to ascertain the effects of the use of VFDs on fruit quality. The primary measurement used to quantify the effect is mass loss. As indicated in Table 3, Mass loss improvements were observed in each of the bin field trials (the Blue Bird field trial used boxed fruit versus storing the fruit in bins so the results are not comparable). Results for the Trout-Blue Chelan test are not included in the table because there was too big a time difference between opening of the VFD and control rooms. The other measure of fruit quality was a pressure test used to measure the firmness of the fruit. As shown in Table 3, the majority of tests showed a slight advantage for the VFD rooms.

All of the 1998 field trials resulted in less mass loss for the VFD rooms and also less energy usage. With regard to mass loss, the improvement was on average 11% where the point decrease ranged from 0.12% to 0.58% (although the 0.58% was recorded at a facility where the VFD room was opened much sooner than the control room, so the actual improvement was probably somewhat less). In practical terms, a very simple calculation of the dollar value of an improvement in mass loss suggests that a 0.1% improvement would be worth $500 (assuming that a typical room might contain 1,500 bins with 900 pounds of fruit per bin and a wholesale value of $500,000 for all 1,500 bins). An improvement in the 0.50% could be worth $2,500.

Results of the pressure tests on the fruit (a measure of fruit firmness) were mixed, with the majority of the rooms showing slightly higher firmness in the control room. However, unless the pressure is near the minimum for packing purposes this likely does not present a big problem. The results are consistent with the initial goal of demonstrating energy savings while maintaining or improving fruit quality.

Table 3.
Fruit Quality Results of 1998 Field Trials

			Baseline	Control Room	VFD Room	Improvement	Control Room	VFD Room	Improvement
Facility	**Fruit**	**Variety**	**Fan Control**	**% Mass Loss**	**% Mass Loss**	**w/VFD**	**Pressure**	**Pressure**	**w/VFD**
Stemilt* 1	Apples	Goldens	Full Speed – All Fans	1.59%	1.47%	0.12%	13.1	12.5	-0.6
Stemilt* 2	Apples	Goldens	Full Speed – All Fans	2.59%	2.27%	0.32%	11.4	10.9	-0.5
Stemilt* 3	Apples	Goldens	Full Speed – All Fans	1.87%	1.74%	0.13%	13.3	13.3	0.0
Stemilt* 4	Apples	Goldens	Full Speed – All Fans	1.95%	1.70%	0.25%	10.9	10.3	-0.6
Columbia Reach 1	Apples	Goldens	Full Speed – All Fans	3.75%	3.43%	0.32%	14.8	14.4	-0.4
Hansen 1	Apples	Goldens	Full Speed – All Fans	3.05%	2.83%	0.23%	14.5	13.8	-0.7
Holtzinger 1	Apples	Goldens	Full Speed – 50% Fans	4.14%	3.56%	0.58%	12.8	13.2	0.4
McDougall & Sons 1	Apples	Goldens	Aggressive Fan Cycling	3.88%	3.53%	0.35%	12.7	12.6	-0.1
Stemilt** 1	Apples	Reds	Full Speed – All Fans	1.83%	1.65%	0.18%	15.5	15.4	-0.1
Stemilt** 2	Apples	Reds	Full Speed – All Fans	1.54%	1.32%	0.22%	12.4	12.8	0.4
Stemilt** 3	Apples	Reds	Full Speed – All Fans	1.44%	1.23%	0.21%	13.1	13.9	0.8
Stemilt** 4	Apples	Reds	Full Speed – All Fans	1.45%	1.21%	0.24%	12.4	12.7	0.3
Olympic 1	Apples	Reds	Aggressive Fan Cycling	1.95%	1.66%	0.29%	14.9	14.8	-0.1
Valley Fruit***	Apples	Reds	Full Speed – All Fans	2.24%	1.99%	0.25%	12.5	14.0	1.4
Valley Fruit***	Apples	Reds	Full Speed – All Fans	2.12%	2.06%	0.06%	12.8	12.4	-0.4
Valley Fruit***	Apples	Reds	Full Speed – All Fans	2.62%	2.39%	0.24%	12.4	10.7	-1.7
Blue Star 1	Pears	Anjou	Full Speed – All Fans	2.45%	2.18%	0.27%	12.5	12.1	-0.4

Source: Cascade Energy Engineering
Holtzinger - Full Speed 50% alternating fans: The improvement of 0.58% needs to be adjusted to account for the fact that the VFD room opened 45 days earlier than the control room.
We are still working on the tools to reasonably account for differences in storage duration. It is likely that the advantage of the VFD at Holtzinger would be considerably reduced when storage duration is normalized.
Conversely, the savings at Columbia Reach, Hansen, and McDougall and Sons need to be increased to account for the longer storage periods in the VFD rooms.
* Sample sets were created from four separate growers. The test on these samples were conducted using only one VFD and one Control room
** Sample sets were created from four separate growers. The test on these samples were conducted using only one VFD and one Control room
*** Sample sets were created from three separate grades of apples. The test on these samples were conducted using only one VFD and one Control room.
**** Some trials included fruit from different growers. Each set of fruit from a grower is referred to as a test. If only one test was conducted at the facility the grower is simply referred to as "Grower 1"

Results from the boxed fruit field trials conducted on pears as the Blue Bird Facility showed a significant advantage for the control room. It is possible that the test was flawed due to holes in the box liner.

With regard to energy, the average demand savings in the VFD room range from 0.7 kW versus a control room using a very aggressive fan cycling regime to 7.8 kW versus a room running fans continuously. Energy savings totaled 258,761 kWh for the 11 tests for an overall average annual savings of 50%. Again savings in facilities using a aggressive fan cycling were less (7%) relative to those having the fans on constantly (62%). The results are consistent with the initial goal of demonstrating energy savings while maintaining or improving fruit quality.

Table 4
Energy Savings Results of 1998 Field Trials

		Reduced Load	Rated Full Speed	Average - VFD	Energy Use	Savings
	Facility	Evaporator	Fan Power	Savings	Savings	Relative to
Facility	Type	Control	(kW)	(kW)	(kWh)	Rated Fan Power
Blue Bird	CA Storage (Pears)	Constant – All Fans	6.8	4.3	21,869	63.3%
Blue Star	CA Storage (Pears)	Constant – All Fans	9.2	6.5	33,395	71.3%
Columbia Reach	CA Storage (Apples)	Constant – All Fans	5.7	3.7	18,860	64.7%
Hansen	CA Storage (Apples)	Constant – All Fans	12.6	7.8	40,087	62.2%
Holtzinger	CA Storage (Apples)	Constant – 50% Fans	11.1	3.6	18,308	32.2%
McDougall	CA Storage (Apples)	Fan Cycling – Very Aggressive (20% Duty Cycle)	11.5	0.7	3,702	6.3%
Olympic	CA Storage (Apples)	Fan Cycling – Aggressive (33% Duty Cycle)	7.5	0.6	2,910	7.6%
Stemilt - Detailed	CA Storage (Apples)	Constant – All Fans	7.5	4.8	24,735	64.3%
Stemilt - Simple	CA Storage (Apples)	Constant – All Fans	7.8	5.1	25,954	65.4%
Trout - Detailed	CA Storage (Apples)	Constant – 50% Fans on Limited Basis	12.2	7.7	39,153	62.8%
Valley	CA Storage (Apples)	Constant – All Fans	8.7	5.8	29,789	67.3%
Totals			100.6	50.6	258,761	50.4%

Source: Cascade Energy Engineering

F. 1998 Field Trial Participant Interviews

a. Methodology

Telephone interviews were conducted with seven of the ten facilities that were involved in the 1998 field trials. The interviews were conducted in late 1999 and early 2000. Field trial participants would have had their equipment installed for over one year and would have received results of measurements made on the test rooms. It was felt that a one-year window would allow sufficient time for facility owners and operators to fully evaluate the technology.

A discussion guide for the interviews was developed by Macro with input from the Alliance and Cascade. A copy of the interview guide is included in Appendix B. The interviews averaged 25 minutes in length.

b. Findings

What led the participant to be interested in participating in a field trial?

Most of the interviewees report that they had heard of the use of VFDs on evaporator fans and had heard of the potential for energy savings. Five of the seven had also heard about the potential benefits on fruit quality. For the most part, the information that they had received was not very specific about the magnitude of the possible benefits and was mixed with cautions about potential problems, primarily with motor burnout.

There are several sources cited for having heard about VFDs in evaporator fan applications. Five of the seven mentioned that they had heard about them from peers. Two mentioned that they had actually toured facilities in which VFDs were installed. The overall impression from these interviewees is that although there is some guarding of trade secrets, for the most part, it is a fairly common practice to share information with peers and to tour each other's facilities. In addition, three interviewees cited trade magazines as being sources for their knowledge and awareness of VFDs and two participants cited seeing Cascade make a presentation at the Post Harvest Show, the major, regional industry tradeshow, as being a source. Both of the people who saw Cascade present at the Post Harvest Show indicated that they found the presentation to be very compelling and that this, as much as anything else, fueled their curiosity and desire to participate in a field trial.

Two of the interviewees indicate that they had tried to get more information from their electrical and/or refrigeration contractors on costs, potential benefits, and potential problems. Neither of the two had done a formal payback analysis nor had gone very far towards thinking about actually pursuing a project. The primary reasons given for not pursuing VFDs more vigorously was perceived expense and lack of time to really evaluate such a project. Both interviewees indicate that they are always very busy with routine maintenance of their facilities and that often, innovations or new technologies have a better chance when someone else comes to them with information or a proposal. Often, this is a good way to lend impetus to something that they had already thought about but didn't have time to pursue.

All of the interviewees indicate that curiosity was one of the main drivers behind their interest in the field trial. They saw the field trial as a relatively low-risk way to find out for themselves just what the VFDs were capable of. This was particularly so in cases where Cascade was able to help them find additional funding. In any case, all interviewees cite the fact that Cascade was able to provide them with data and conduct analyses (including payback analyses) as helping to lower the risk and to sell the projects.

Six of the seven interviewees indicate that Cascade approached them about doing a project while one indicates that he approached Cascade after seeing them make a presentation at the Post Harvest Show.

Expectations

None of the interviewees report that they had very specific or concrete expectations. As stated above, for the most part they were driven to participate by curiosity. In a general sense, all indicate that they did expect to see energy savings but did not have firm expectations about the magnitude.

Participants were less sure about the fruit quality benefits. While all of them hoped to see less mass loss, they were really taking a wait and see attitude. Again, most participants had heard about potential benefits but really wanted to have some first hand experience and saw the field trial as a good way to get it. Several also mentioned that they largely consider the information that

they had received to be anecdotal and they were very interested in seeing something more "scientific" and/or "controlled".

Concerns about the Technology

Five of the seven interviewees indicate that they did have concerns about the technology going into the project. They had heard from peers who had used VFDs for evaporator fans that there can be problems with damage to motors if the installation is not done correctly. However, each of the interviewees cited Cascade's participation as a major factor in allaying any such concerns. Cascade personnel bring such technical and practical experience to the project that the risks seemed to be minimized.

Two interviewees indicate that that they also had some concerns about the effect that the installations might have on their operations, but that discussions with Cascade personnel and their willingness to be flexible helped to ease those concerns.

The only other concern, voiced by one interviewee, was that if there were a major problem he could lose a whole crop and suffer a significant financial loss. However, he indicated that this was not a major concern and obviously did not prevent him from participating in the trial.

Who was involved in the decision process/ What were the main factors?

In all cases both the facility owner and the facility operator (if different) were involved in the decision to participate in the field trials. The potential for both energy savings and improvement in fruit quality were cited as being the primary factors in the decision process.

However, several interviewees indicate that there is some difference in terms of the relative importance of the benefits between facility owners and operators. Facility owners are more likely to be interested in the energy savings while the operators are more likely to be interested in the improvements in fruit quality. The reason is that at the current time, energy savings are perceived to be more tangible and likely to contribute to the bottom line since there is not enough evidence to confirm improvements in fruit quality, suggest the magnitude of improvements, or assign a firm value to them. Operators, however, tend to be more curious about the potential for fruit quality improvements regardless of the results.

One interviewee (a facility operator) summed up an impression that was given by several of the others. He said that there is as much art as science involved in storing apples with regard to the quality of the product. Operators tend to know a lot about their individual rooms, about specific areas within their rooms, about how long to store different types of apples, about the content of different gases in the rooms, temperatures, and about the myriad other factors which can affect the ultimate fruit quality. He pointed out that individual crops differ year to year depending on numerous growth conditions. He went on to say that there are so many factors that it is impossible to come up with any kind of formal model. It is just something that one gets a feel for when they have been involved in the industry for a long time. The operators tend to take a great deal of pride in their knowledge and their ability to weigh all of the variables to produce a really good apple when the rooms are opened. Therefore, any technology that might give them an edge in this effort is important not only from an economic standpoint, but also from the standpoint of helping them to be better at what they do.

Five of seven also cite the availability of additional funds to help offset costs as being an important factor. The typical feeling is that without the additional funds it is very difficult to make a project like this pencil out in a reasonable time frame. All of the interviewees indicate that a project with a two to three year payback is highly likely to be approved but that anything over that will receive serious scrutiny and is much less likely to receive approval. For these projects, the only up-front savings that could be included in the return calculations are energy savings since there is no

guarantee of improvements in fruit quality. With energy prices being so low, the energy savings alone often are not very compelling.

Working with Cascade/ Installation process

Interviewees had nothing but positive things to say about all aspects of their experience working with Cascade. Each one mentioned that Cascade's staff is extremely proficient at what they do. They thoroughly understand the technology and are able to answer questions in a way that is understandable. Four interviewees specifically noted that they learned quite a bit from Cascade about other parts of the system in the process of completing the project. Three interviewees cited Cascade's patience in taking the time to explain things to them and to make sure that they understood and were comfortable with all aspects of the project.

Five of the interviewees cited Cascade's analysis and proposals as being very thorough and high quality and mentioned that this was a factor in helping to make the decision to proceed. All interviewees stated that Cascade interfaced extremely well with their staff and contractors. Two mentioned that Cascade was present so often that they seemed like a part of the staff.

Other positives that were mentioned by at least one interviewee include that Cascade's staff is very professional and hard working, that they do what they say they are going to do when they say that they are going to do it, that they follow through on promises and that they are very accessible.

Even among those who experienced problems, Cascade's performance was deemed to be exemplary in that they addressed the problems quickly and satisfactorily. Non-technical problems included one person who had a problem with billing and two people who said that there were problems with scheduling (in those cases the problem did not originate with Cascade but were the result of changes in the facilities' schedules). In the case of the billing problem, Cascade was cited for stepping in and getting it straightened out immediately. In the case of the scheduling problems, Cascade was cited for being flexible and for a willingness to work around the facilities' schedules.

One person also mentioned some problems on the technical side. He indicated that there was a slightly higher incidence of motor problems after installation of the VFDs but that he wasn't sure whether or not the VFDs were the cause and also feels that it if were, his electrical contractor probably had more to do with it than Cascade. In this case, he says that he spoke with Cascade about filters and other possible remedies to eliminate voltage spikes. He also indicated that after installation there was a one degree rise in temperature when his fan speed was cut in half (from 1800 RPM to 900 RPM) but that he was able to compensate by lowering the temperature. He reports that it took three days to get back to a stable thirty degrees from thirty-one degrees. However, despite these "minor problems", the interviewee stated that he was happy with the process overall and he never expected it to be totally trouble free to begin with. He reports that he would definitely do it again, although if he had it to do over again he would want a contractor who had previous experience installing VFDs or who had talked to someone who had such experience.

Overall, all interviewees report that their projects went as smoothly as possible and that Cascade made very positive contributions.

Results

Six of the seven interviewees report that the energy savings results either met or exceeded their expectations. The other interviewee stated that the results were a little bit lower than what he had hoped for, although he did not elaborate on what his expectations had been or how he had arrived at them. One participant cited work that he had done with the capacitors and said that the energy savings were more significant.

Reactions were more mixed with regard to fruit quality. All of the interviewees to whom we spoke report that the VFD rooms did show less mass loss (or as several put it, less shrivel). However one of the interviewees reports that there may be problems in comparability of the results due to the fact that the VFD room was opened much sooner than the control room. Another interviewee stated that he would have liked to see the rooms sealed for another three weeks to a month but had to open up the rooms for market reasons. A third interviewee indicated that he had mixed results (he had more than one test) and that it was still unclear to him exactly what accounted for the differences, and therefore might like to see results from more tests.

Beyond the issue of whether or not there was an improvement in mass loss and in the overall quality of the fruit, interviewees were mixed in terms of whether or not they believe that the results were significant. Two of the seven indicate that they would probably need to see a bigger difference than they had seen before it would be compelling enough to justify future projects, although they did not specify what they would consider to be a bigger difference. Three of the seven stated that the results are very promising but that there are a lot of factors involved and they would like to see more data. Two of the seven are very enthusiastic about the results and state that they either have converted or are planning to convert additional rooms.

Several interviewees mention other potential benefits that resulted from use of the VFDs. They concede that these will be harder to quantify and therefore might not figure into strict payback calculations, but that they may be a factor in a close decision. These factors include the potential for less wear and tear on the equipment and, therefore, lower maintenance costs; the fact that the software automatically adjusts fan speed to load, and therefore less need for monitoring; and for those who spend a lot of time in or around the rooms a potentially quieter environment.

Information Dissemination

All of the interviewees state that they believe the type and level of data being collected in the field trials is appropriate with regard to the kind of information which will be compelling to facility owners and operators. For the most part, their main recommendation concerning data collection is to collect more data in order to provide a more robust baseline. As one interviewee put it, “there are a lot of old dogs out there and it will take a lot to convince them – the more data the better”.

All of the interviewees feel that case studies are an appropriate and effective way to summarize and communicate results of field studies. However, several mention that there are differences with regard to the type of information that a facility owner will be interested in and that which will interest a facility operator. The owner is more likely to be interested in a broad piece which speaks to bottom line issues but are unlikely to want a lot of technical detail. Operators will be more interested in the question of how this will make their life easier and help them to do a better job. They will also be more interested in the technical details or more of a “how to” piece. The suggestion is that a broad piece might be a good way to get attention focused on the issue, but that it might make sense to have some more in-depth information available for those who want it.

Several interviewees point out that it will be very important to be sure to communicate information to contractors and vendors. They cite the fact that the contractors, often a trusted electrical or refrigeration contractor, and sometimes vendors are involved in the decision process in a consultative role and can have a significant impact on decisions.

With regard to communication vehicles, all of the interviewees mention trade shows and conferences (six mentioned the Post Harvest Show) as being a good way to reach facility owners and operators as well as vendors (contractors, particularly electrical contractors, are not as likely to be at the show unless they have something specific to push). Five mention trade journals and publications. Five also cite word of mouth and visits to other facilities as a good source of information. Four of the interviewees state that they get a lot of information from manufacturers, vendors, and contractors.

Summary

Overall, the participants in the first year are probably quite representative of CA facility owners and operators in general. They had heard of VFDs and of their potential use in evaporator fan applications. They had heard about possible benefits in terms of energy consumption and fruit quality, but hadn't seen any formal data. They had also heard about potential problems, primarily damage to motors. Always on the look out for ways to improve their operations, and in particular their bottom line, they were very curious. When the Initiative approached them and gave them what they perceived to be a relatively low risk way to satisfy their curiosity, they decided to participate in field trials. There were few specific expectations going into the trials but there was a general expectation that energy savings would occur and a hope that fruit quality would either be unaffected or would improve. The results were in line with these expectations. Reaction to the magnitude of improvement is mixed, with some feeling that they will probably go ahead and install more VFDs on their own and some taking a wait and see attitude. No one appears to feel that they definitely would not use VFDs in the future. So, the good news is that the results were positive, if not overwhelming, and it is likely that this type of information will help to convince others in the marketplace to at least take a look at VFDs.

G. 1999 Field Trials

In June of 1999 Cascade and the Alliance reviewed the strategy of trying to include a specified number of regular storage facilities in field trials. In the 1998 field trials Cascade had experienced significant problems finding regular storage participants. A number of factors were cited including the perception that the projects are viewed as small capital projects, larger hierarchy of decision makers who must approve a project (as opposed to CA facilities which are more likely to be family owned) leading projects to bog down, and underestimation of the current practice (many facilities currently employing fan cycling or two speed motors) among others. The Alliance and Cascade concluded that the regular field marketplace may offer less potential for transformation and agreed to shift emphasis away from regular field trials while still looking for opportunities where they present themselves.

Subsequently, Cascade has signed up one non-CA facility and several more are in the pipeline. The reason for this is that there appears to be a much longer timeframe for the decision makers to commit than for CA facilities. Therefore, work that Cascade had been since the beginning of the Initiative is just now showing results

In 1999, Cascade reached agreement on seven CA field trials, including an agreement with the largest CA organization, Stemilt (who also participated in 1998). In addition, the Washington Apple commission is participating in a field trial, which may indicate the level of interest that the preliminary results are generating. These are summarized in Table 5.

Table 5.
Summary of 1999 CA Field Trials

Facility	Utility	Participant Status	Field Trial Type	Test Status Harvest Activities Complete?
Stemilt Growers	Chelan County PUD	Repeat Participant	Detailed	Yes
Columbia Reach	Pacificorp	Repeat Participant	Detailed	Yes
Larson Fruit	Pacificorp	New Participant	Simple	Yes
Snokist Growers	Pacificorp	New Participant	Detailed	Yes
Henggeler Packing	Idaho Power	New Participant	Simple	Yes
Magi	Okanogan PUD	New Participant	Detailed	Yes
Washington Apple Commission Research Rooms	Chelan County PUD	New Participant	Detailed	Yes

Source: Cascade Energy Engineering

H. **Vendor and Contractor Interviews**

1. Methodology

Seven Interviews were conducted with personnel from vendors and contractors and a trade association during the spring and summer of 1999. Table 6, below, shows the distribution of interviews.

Table 6
Distribution of Completed Interviews

Type of Organization	Number of Interviews
Evaporator Coil Manufacturer	1
Refrigeration Contractor	2
Electrical Contractor	2
Refrigeration Control Vendor	1
Trade Association	1

Cascade provided a list of contacts from which the study participants were drawn (with the exception of the trade association for which contact was made through information provided on their web site).

Interviews were conducted by phone using a topic guide developed by Macro, reviewed by Cascade and the Alliance and approved by the Alliance. A copy of the guide is included in Appendix B. On average, interviews lasted thirty minutes.

2. Findings

Familiarity and experience with VFDs in evaporator fan applications

All of the participants are familiar with the use of VFDs in evaporator fans and have first hand experience with projects that included installation of VFDs. This includes the person from the industry association who is also a facility owner. All of the participants are also familiar with the use of VFDs in other applications, primarily compressors, and in most cases first became familiar with VFDs from these other applications rather than from the evaporator fan application.

Their level of experience with evaporator fan VFDs (EFVFDs) varies. One of the refrigeration contractors described his experience as being in its “infancy” and has just completed his first project. The control system vendor claimed to have “pioneered” the use of EFVFDs almost five years ago and has done many jobs since. The experience of the rest of the participants falls somewhere in between with each participant claiming to have done several jobs over at least two years.

The types of applications with which they have experience include controlled atmosphere warehouses, regular cold storage warehouses and food processing. Most of this experience is limited to the Pacific Northwest. However, the coil manufacturer has also looked at potential applications in Arizona.

Customers, Market Structure and Level of Influence

The refrigeration contractors and electrical contractors cite the end user as their primary customer. Both indicate that they have a fair amount of influence on the end user. The coil manufacturer cites refrigeration manufacturers as their main customers, although they do occasionally get involved with the end user in specialized applications. The coil manufacturer indicated that he has a moderate amount of influence with refrigeration contractors and end users. The control system vendor works with refrigeration contractors, electrical contractors and end users, who often function as their own general contractor on a project. The control system vendor says that he has "some sway" with customers. The trade association representative indicates that his association works with all of the vendors and contractors involved in refrigeration systems and also has some influence with end users.

All of the vendors and contractors have worked with energy consultants in that they have worked with Cascade. In most cases it appears that they worked with Cascade prior to the inception of the Initiative as well as since the Initiative began (as reported below, vendors and contractors are unfamiliar with the Initiative and therefore are not aware of the distinction). It appears that all of the EFVFD applications in which the vendors and contractors have been involved were driven by Cascade and that Cascade has a great deal of influence with end users. Cascade also has a fair amount of influence with vendors and contractors with whom they work since they are often the catalysts for the project. Participants indicate that Cascade works with the end user to conduct analyses, perform payback calculations, helps secure utility funding, and to generally provide information that helps the end user to make a decision.

Other market actors that were cited as having influence on end users as well as with other vendors and contractors are drive manufacturers and motor manufacturers. The coil manufacturer and a refrigeration contractor cited motor manufacturers as having made presentations to them as well as to end users. One of the electrical contractors indicated that drive manufacturers have been very aggressively marketing to their customer base. Several participants stated that the larger the end user, the more likely that they are aware of the technology and have the capacity to understand and evaluate its merits. To some extent this is a function of their level of technical expertise. However, to some extent it is also due to the fact that they simply get more attention from vendors and contractors.

Vendor and Contractor Market Share

Interview participants were not asked about their market share. However, Cascade provided qualitative assessments of the market share for each of the vendors and contractors who were included in the sampling frame. The coil manufacturer and control system vendor were listed as major suppliers in the region. Cascade estimates that there are fewer than five significant control system vendors and fewer than ten key coil manufacturers in the region.

Cascade lists one of the refrigeration contractors as being a major contractor in the Northwest while the other is listed as one of three major contractors to the central Washington fruit industry. Overall, it is believed that there are fewer than ten major refrigeration contractors in the region. One of the electrical contractors is listed as being prominent in the Yakima area while the other is prominent in Oregon. The population of electrical contractors is large. Therefore it is unclear how well these two contractors represent the overall population.

Each of the vendors and contractors attends conferences and other functions held by the industry trade group and cite such functions as one of the main occasions where vendors and contractors as well end users are likely to be together. They also cite such functions as being very important for the dissemination of information.

Efficacy of the Technology

All of the participants indicate that they believe that EFVFDs are effective with regard to saving energy. They base this on their direct experience with customers. In some cases participants report that their customers have actually measured the energy savings. Such measurements are often required when utility funding is involved. In addition, since Cascade has been involved in most installations so far a lot of measurement data (whether for utilities or for the Alliance) is generated by Cascade. Participants also indicate that in cases where no formal measurements were done, they base their conclusions on the qualitative assessments of their customers, which are always positive. Finally, beyond their own direct experience participants have seen presentations by Cascade and are aware of the data contained within the presentations.

While vendors and contractors all believe that EFVFDs do save energy, they are less sure about the magnitude of the savings. They point out that there are many different variables to consider, enough so that each application is essentially unique. Therefore, they find it difficult to generalize from recorded results. Examples of the types of factors that might affect savings range from macro considerations, such as the type of application (CA versus regular storage versus processing), the configuration of the room, current equipment and current practices (such as fan cycling) to micro considerations such as how the product is stacked in the room.

Participants are aware that there is a potential product quality benefit in CA applications but appear to consider the data more preliminary than the energy savings data. This is due to the fact that there is less data available and the data only covers a limited range of products (participants were only aware of studies done with red and golden apples). Another reason that many cite for being less comfortable with the fruit quality issues is that it simply isn't an area of expertise for them. They understand energy, they have far less of an understanding of fruit quality. As with energy savings, participants believe that there are a large number of variables that might affect fruit quality including inherent characteristics of a particular crop.

Reliability Aspects of the Technology

All of the participants cite cases where there have been problems with the functionality of EFVFD. The most commonly cited problem is motor burn out. However, these problems were all associated with early efforts. Participants indicate that a number of steps have been taken to solve the problems (in particular they cite the fact that motors are now designed and specified as VFD rated) and they now have absolutely no reservations about recommending the technology.

Market potential

None of the participants felt that they could give an accurate estimate of current EFVFD usage. When asked to give a qualitative sense of the market, most simply said that use of VFDs for evaporator fans is still very limited. Several participants also pointed out that "the market" is actually several markets including CA facilities, regular cold storage facilities, and processing facilities. They believe that CA applications are more common than either of the others.

When asked about perceived trends, all of the participants state that they believe that use of the technology will continue to grow. Estimates of how much and how fast vary. The coil manufacturer stated that in the last two years "everything has been moving in that direction" and that within five years he expects EFVFDs to be an industry standard. On the other end of the spectrum, one of the refrigeration contractors said only that he is "cautiously optimistic". Although all of the participants expect use of the technology to grow, they cite a number of qualifications (covered in – "Factors That Will Influence Adoption of the Technology" - below).

Participants feel that there is more potential for new applications than for retrofits. One reason is that in a retrofit job one may have to replace equipment which still functions properly and which may not even have been fully depreciated on the books. Participants also feel that there is more

potential for CA applications that for regular cold storage or for processing because of the potential product quality benefit in addition to energy savings and because of the relative size of the industry.

Barriers

Vendors and contractors identify several barriers to adoption of the EFVFD technology. The barriers include:

- Cost – the cost of an EFVFD installation (materials and labor) is too expensive versus the return (particularly if the return is only energy savings) to get payback within an acceptable time frame;
- Lack of Expertise – there is a lack of expertise on the part of vendors, contractors and facility owners to calculate return on investment;
- Lack of Information – there are two aspects to this. The first is that some people are unaware of the information that is available. The second is that the available information is insufficient to address uncertainty around fruit quality benefits as well as to address enough variables to be able to extrapolate results;
- Conservative Nature of the Industry – vendors and contractors believe that the industry is conservative and they believe that there are still a number of people who are "waiting on the sidelines" until the benefits are more clearly established.

Factors That Will Influence Adoption of the Technology

Vendors and contractors cite a number of factors that may impact the rate of adoption of the EFVFD technology. Perhaps the most important is the continued availability of utility funding and, in Oregon, tax credits to offset some of the costs. The general sentiment is that without financial incentives it would be extremely difficult if not impossible to sell EFVFD projects. Participants cite two ways in which utility funding currently offsets costs. One is direct. For example, the utility may cover the cost of the control system and drive. The second is indirect. Participants believe that Cascade is funded directly by utilities and therefore the utility is offsetting up front costs that are incurred by all of the analysis that Cascade does. The contractors are quick to point out that most if not all of the EFVFD jobs in which they have been involved would not have occurred without Cascade's participation. They believe that the initial cost of these projects is such that without financial incentives they simply don't "pencil out" within the timeframes that most facility owners have for return (usually two to three years maximum).

The availability of more data, a better information baseline and more extensive track record are also cited as being important factors. As noted above, participants feel that there are a large number of variables to take into consideration in field trials. Therefore, the more that these can be addressed, the better. For CA applications, participants would also like to see results for a wider variety of types of apples. In addition, the extent to which fruit quality results can be replicated (recall that participants believe that the characteristics of a particular crop may be significant) is also considered to be important. The bottom line, as one electrical contractor put it, is that "farmers are 'show me' people". The more information that is available, the more industry people will be able to understand the potential benefits and make the case for individual projects.

Another factor is the overall health of the target industries. The coil manufacturer noted that apple prices have been "in the tank". One of the refrigeration contractors also pointed to problems in the apple industry and indicated that the problems may mean that funds for capital projects may dry up. He also noted the cold storage industry has been flat and that recent consolidations in the grocery industry (such as the Fred Meyer acquisition of QFC) may lead to more centralization and therefore over capacity in facilities. The control system vendor noted that China has been aggressively planting apple orchards and that may cut off a large potential market. However, one of the electrical contractors viewed the problems in the apple industry as potentially being a positive. He noted that with prices depressed, facility owners might have to do everything they

can with regard to their operating costs to stay competitive and that they may be inclined to look at energy expenditures more critically.

Almost everyone mentioned energy prices as being an important factor. Vendors and contractors state that energy prices are very low in the region, which is one of the reasons that it is very difficult to get the projects to pencil out without financial incentives. All of the participants believe that energy prices are likely to increase in the mid-term. They most commonly cite deregulation as the reason for this belief. The idea is that prices will come down in areas that are currently expensive while they will go up in areas where they are cheap, ultimately reaching some kind of equilibrium. Participants are somewhat divided on the effect this may have on EFVFDs. Several believe that rising energy costs will make the technology more attractive and may even make projects pencil out without financial incentives. A few, however, believe that higher costs may cut into funds that facilities have available for capital projects. Participants worry that deregulation in the electric utility industry may also dry up funds that utilities currently have available for energy efficiency projects. One participant, however, had a different take on it, claiming that utilities will increase funding of energy efficiency projects because they will want to have more energy available to sell into markets where they can get a higher price for it.

Finally, participants indicate that the price of EFVFD equipment has already dropped some and expect that it will drop more. As equipment prices come down, projects will become more attractive.

Competition for Capital

Participants indicate that there are several types of activities with which EFVFDs typically compete for capital and for attention from facility owners. The most frequently mentioned competition comes from improvements to compressor systems. Other types of things that were mentioned include improvements to condenser systems and basic equipment such as purchasing plastic bins.

The Initiative

None of the participants had heard of the Initiative nor had they heard of The Alliance. For the most part they assume that Cascade is funded directly by utilities, probably because most of the projects do involve some direct utility funding. Participants indicate that they don't really care who is funding Cascade or why. They are not very curious about Cascade's mission, assuming that they are generally part of utility energy efficiency efforts. None are familiar with the term market transformation. What matters to them is that Cascade is providing a service to their customers that may lead to work. Participants generally insist that they would not have the technical expertise to do what Cascade does anyway.

One exception is an electrical contractor who feels that Cascade does compete with him in some areas. He indicates that it might be useful know more about Cascade's mission so that there would be a clear line where their functions stop and his would begin. He stated that Cascade's work should be confined more to the very front end of the projects and that they should come out of the loop sooner. He also felt that in some cases Cascade does too many engineering studies and too much analysis, which doesn't leave as much funding for the actual systems. As a result, he ends up bidding for general contractor work when he could have been providing some of the higher value services. Ultimately, he feels that he has been pushed out of some projects. He emphasized, however, that his experiences with Cascade have been positive in general and that they have done a good job of promoting the technology.

The only other concern about Cascade's activities was expressed by the control system vendor who stated that if energy savings are the goal, EFVFDs seem to be a high cost, high tech solution. He indicated that if one were to look at the system a whole there are lower cost, lower tech solutions might be able to achieve as great or greater energy savings. However, he was quick to

point out that he was looking at it from the perspective of the funding organization and how they might get the biggest "bang for the buck". As far as his business is concerned, he has no problem with someone promoting the EFVFD technology.

Interactions with Cascade

All of the participants appear to have begun their relationship with Cascade before the beginning of the Initiative. Therefore, they tend to think of Cascade's activities in a continuous sense, rather than as pre- and post-Alliance program – which is probably one of the reasons that they don't recognize the existence of a specific program. All of the vendors and contractors had nothing but very positive things to say about Cascade. They paint a picture of a group of people who are extremely talented, bright, technically expert, hard working and easy to work with. Other comments include the fact that Cascade is "very ethical", "fair", and "informative". In addition, they believe that Cascade has done a great deal to promote the EFVFD technology and that the market for the technology would be nowhere near what it is today without their efforts.

Information Dissemination

Participants indicate that they believe Cascade is doing a good job of disseminating results. They mention seeing Cascade present papers or results at RETA (Refrigeration Engineers and Technicians Association) and IIAR (International Institute of Ammonia Refrigeration) meetings as well as regional harvest and food related events, conventions and trade shows. They believe that Cascade has done a good job of maintaining visibility at all of the significant events.

One suggestion for improving on information dissemination activities comes from one of the refrigeration contractors. He suggested that someone develop a white paper on the subject. He envisions a twenty-page paper that he could take to show his customers and use as a leave behind.

Suggestions for Improvements

One of the refrigeration contractors cautioned about how results have been presented. He indicated that one can show tremendous savings depending on the comparisons that they choose to make for the baseline condition. For example, use of VFDs versus different fan cycling regimens will appear to achieve greater or lesser savings. He called for a balanced approach and said that he didn't want Cascade to "over-sell" the technology since that might raise unrealistic expectations among customers.

The control system vendor indicated that Cascade is not necessarily a "third" or "disinterested" party. He believes that they are not trying to push any one product, but that they are an advocate of the technology. He suggested that it might help to have results come from such a third party, then added that he couldn't think of any such third party that has the combination of technical expertise and credibility that Cascade has. So, as a practical problem he didn't have any ideas for who might play that role.

Summary

In summary, vendors and contractors tend to be familiar with the technology and the application. In most cases, they are much more familiar with and comfortable talking about the energy savings benefits. Yet, they believe that it will be necessary to demonstrate fruit quality benefits to make VFD projects attractive to facility owners and operators. Most feel that the current market is very limited because of the actual cost versus benefits that are hard to quantify. Most also feel that there is potential for VFDs, some feeling that the potential is great while others are less sure. All do feel that the market will grow. Therefore, they are very interested in the work that the Initiative is doing and also in having positive results put into a format that they can use to communicate them in the market place (most feel that given the right tools, they have a great deal of influence

on the buyer). Along with data from trials, they feel that, as with any new technology or application of an existing technology, the more a solid track record can be established, the easier it will be to overcome concerns of buyers. So it is important to find ways to sell projects now and start developing that track record.

I. Non-Participant Facility Owner Interviews

1. Methodology

Telephone interviews were conducted with eighteen facilities that are not involved in field trials. Names of facilities were taken from a database provided by Cascade that provided contact information for facilities and also provided information about facility size. For sampling purposes, facilities were categorized as large (over 500,000 square feet), medium (300,000-500,000 square feet) or small (less than 300,000 square feet). The distribution of completed interviews is shown in Table 7.

Table 7
Distribution of Interviews by Size of Facility

Facility Size	Number of Completed Interviews	Percent
Large	9	50%
Medium	5	37%
Small	4	22%
Total	18	100%

It is important to note that the facility size refers to the company as a whole. In many cases only a portion of the total is dedicated to controlled atmosphere storage. Also, in a number of cases the company has facilities located at more than one location and the person to whom we spoke could only answer for their location.

All completed interviews were conducted with facilities in Washington State. Attempts were made to conduct a portion of the interviews with facilities in Oregon. However, an inability to locate a database or other source of information about facilities in Oregon with a similar level of detail to the database provided by Cascade for facilities in Washington made this impractical.

A topic guide for the interviews was developed by Macro with input from the Alliance and Cascade. A Copy of the topic guide is included in Appendix B. Interviews lasted about a half-hour on average.

2. Findings

Facility characteristics/Current practices

The facilities included in the study range in age from one which includes sections that are up to 49 years old (some sections are only 9 years old due to remodels and upgrades) to a two year-old facility. Most of the facilities have both older and newer sections due to renovation and upgrades. None of the organizations indicate that they plan to build a new facility within the next two to three years and with the exception of the organization with the two-year-old facility, all others are at least five years old. It appears that most of the facilities (information was not explicitly collected from all interviewees) contain both CA and regular storage sections.

Most (sixteen of eighteen) facilities store apples. Although explicit information was not collected from all interviewees, at least six said that they store multiple varieties of apples. Four of the facilities store pears. Four of the facilities indicated that they also store cherries.

Many facilities employ a mix of methods since their facilities contain older as well as newer sections and they tend to make changes and upgrades over time. One third (six of eighteen) of the facilities currently have some VFDs installed on evaporator fans. None has installed VFDs on all evaporator fans. Four of the facilities use VFDs for compressors. One facility was recently involved in a VFD project with Cascade, although not as part of Alliance activities. Another fifty percent (nine of eighteen) use some form of fan cycling. Although not explicitly asked, it appears that the majority of those employing fan cycling use computers to control the cycling (one person said that they use microprocessor chips). Five facilities run at least some of their fans at full speed.

Current awareness, perception and use of VFDs

All of the interviewees are familiar with the concept of using VFDs on evaporator fans and two-thirds (twelve of eighteen) state that they have considered using VFDs at one time or another (note that six of them report that they are using some VFDs).

Those who considered VFDs but decided not to use them state that they were cost prohibitive and that there were concerns about their reliability. Several also mentioned that they believed that they would have to change out older motors and that would have added to the cost of the project. Typically, the decision was not being made in a vacuum but was being made as part of larger upgrade, renovation and retrofitting projects, meaning that the VFDs were competing for funds with other capital improvements.

Two interviewees report that the VFDs appeared to make financial sense and that they were prepared to recommend using them in a few rooms. However, the industry has been having a tough time over the past few years and funds for VFDs as well as for other capital improvements have "vanished". One Interviewee states that he had done some analysis based on the availability of utility funding, but that by the time he made his decision the utility was out of funds and the utility program was subsequently cancelled.

Benefits of the technology

All of the interviewees report that they believe VFDs will save energy. However, most say that they do not believe that the energy saving benefits alone will result in a short enough payback period to justify installation. All of the participants also report that they are familiar with the concept that VFDs can help to reduce dehydration in fruit.

Interviewees who are currently using VFDs claim that they are achieving energy savings and that they feel that there is less shriveling in the fruit. However, only two stated that they have quantified the energy savings, largely because the installations were done as part of utility projects, but didn't have the information readily available. None have quantified the fruit quality benefits.

Current users also point out some less easily quantified or tangible benefits. Two current users cite the ability to monitor the system from home computers (although they probably meant that the refrigeration control system allows them to do so.). Two current users also report that they believe they will require less maintenance in the long run. One current user claims that troubleshooting is much easier and one cites a quieter work environment. Also, one current user said that it is a potential marketing point with his customers. He said that customers like to tour his facility and he likes to point out that it is state of the art. He goes on to tell customers that if he

is willing to go to such lengths to take care of the facility then they can be assured that he can take care of their crop.

Concerns with the technology

Interviewees who are not currently using VFDs report that they have a number of concerns about the technology. Ten interviewees mention cost as a big concern. VFDs require a relatively large initial outlay and the payback period may be too long. They are uncertain of how much value they will see from fruit quality improvements and it is difficult to make projects pencil out based solely on energy savings.

Nine interviewees cite worries about motor burnout. One interviewee wondered whether motor manufacturers would honor warranties for motors used to run the drives. In addition, several interviewees bring up reliability, as a general issue.

Another general area of concern has to do with uncertainty. The crux of the issues is that there is a lot of value in each room. Facility owners and operators are wary of committing to a new technology until they are sure that all of the bugs are worked out. As one interviewee stated, "I would hate to be an innovator on VFDs."

Four interviewees report that they have heard about problems with dead spots in rooms when fans are turned down.

Among those who are using VFDs, three of six report that they did actually experience problems with motor burnout when they first installed VFDs. In each case, they feel that their contractor probably did not have the proper experience and that this contributed significantly to the problems. Since getting the initial problems worked out they have not experienced any major problems. Therefore, they recommend that anyone considering installing VFDs use an experienced contractor. Other current users mentioned a number of minor problems and adjustments that had to be made to get their systems operating properly.

One interviewee stated that the biggest difficulty he has is programming the VFD when something goes wrong. He mentioned that the VFD needs to be programmed for amp draw and for cycling and that it is pretty technical. Sometimes he has to call the electrician who is able to solve the problem over the phone.

One current VFD user reports that since installation, two VFDs have broken down and require new boards. He believes that the boards are very expensive, probably as expensive as a new drive. Partly because of this, the company has moved away from VFDs (the other part of the equation is that in the meantime a computer system with the capability of fan cycling had been installed and, therefore, fan cycling requires no additional investment).

Awareness of the Initiative and The Alliance

There is relatively high awareness of Cascade, although it is unclear how much of this is through the Initiative since there is very low awareness of the Initiative. Eleven interviewees said that they had heard of Cascade and several report that they have had discussions with Cascade (and as mentioned above at least one recently completed a project with Cascade). Only one interviewee claimed to be familiar with the Initiative. He said that he had been approached by Cascade about participating in a field trial but that it had not worked out. Two others state that they are familiar with the studies that Cascade is doing, but do not seem to be aware that this is part of the Initiative or that a specific Initiative exists. Ten of the interviewees say that they have seen Cascade present at a conference or show or saw their name on the agenda for an individual session.

Only one of the interviewees claims to have any awareness of the Alliance.

Factors that are important in the decision process

Decisions typically involve both a facility owner as well as a facility operator (in some cases this is one person). About half of the interviewees also indicate that contractors tend to play a significant role in the decision process. Contractors are relied upon to provide a technical opinion about new technologies and are often considered to be good sources of up-to-date information. Three of those who had considered using VFDs but ultimately decided not to indicate they were discouraged from doing so by their contractors. Two of those currently using VFDs indicate that it was a vendor or contractor who came to them with the idea and helped to spur their interest.

Cost, energy savings, and improvements in fruit quality are most often mentioned as major factors in the decision process. Availability of funding is also frequently cited with regard to the issue of cost. In general, a project such as this must "pencil out" in two or three years to be considered viable.

Concerns with potential problems were also cited as being a factor in the decision process, primarily with regard to potential motor problems. Several interviewees expressed the opinion that there would probably be few problems if the installation is entirely new since they believe that manufacturers now make motors that are compatible with VFDs and that any other potential sources of problems can be addressed in the design. However, they are less certain about the ability to control problems in retrofit applications. A few interviewees expressed the opinion that in the case where older motors are being used, they would have to be switched out. It is unclear whether or not this belief is true. Therefore, whether the installation is new or is a retrofit application is a factor.

Sources of Information

Conferences and shows are considered to be good sources of information. The Post Harvest Show, one of the largest and best attended trade shows, is most frequently cited. However, the Northwest Food Processor Show and the Washington State Horticultural Association Conference were also mentioned by name.

Trade journals, publications and newsletters are also considered to be good sources of information. Some of the publications that are mentioned include "Refrigeration and Engineering", "Good Fruit Grower", and "Grocery Distribution". Other types of publications such as engineering studies or academic studies and case studies are also mentioned. These are reported to be available from utilities. In general, though, utilities are viewed as being somewhat inconsistent sources of information. At times they have money to spend on efficiency and are promoting a program and then they tend to be around a lot. At other times, they don't have much going on and then one never sees them. However, if one wants to contact them they can generally provide some information or contacts.

Although publications are considered to be good sources of basic information about new technologies, the information is often not written about a specific industry or product. Vendors, contractors and consultants are often mentioned as being the most trusted source for getting specific information, including information on how the technology would or would not fit into an individual facility given the current equipment, type of fruit stored and other factors. Several organizations or individuals were mentioned by name by at least three interviewees: Double-Kold, Central Washington Refrigeration, Dan Black.

Peers are also considered to be a good source of information. In addition to discussions with peers, three interviewees mentioned Duckwall-Pooley as being a facility which they had toured and several others mentioned that Duckwall-Pooley seems to constantly have some type of study going on (not necessarily on VFDs but on topics of interest).

Message which is likely to be compelling

Interviewees are roughly split with regard to whether the energy savings benefits or fruit quality benefits are of the most interest to them. Four interviewees said that they are primarily interested in saving energy, four indicate that they are most interested in the fruit quality benefits and ten say that they are interested in both equally.

Other general messages that are likely garner attention include saving money, information about ease of operation and how VFDs can make the job easier, and whether the VFDs will work within the parameters of a specific facility.

Several interviewees also reiterated that one should keep the audience in mind. Some people will be more interested in a general overview and will not be able to interpret very technical information while others will want to have detailed technical information.

Finally, a number of interviewees stated that unbiased information, or at least information that is perceived to be unbiased is more likely to be compelling.

Summary

In summary, most facility owners and operators are familiar with VFDs and with the fact that they can be sued in evaporator fan applications. One third claim to be using EFVFDs and another third claim to have considered using them. The main factors in the decision for those who decided not to use them are cost and concerns about reliability. All believe that they will save energy, although most believe that the energy savings alone don't justify the payback (typically they are looking for a two to three year payback). They have heard about the potential for fruit quality benefits but not seen any hard or reliable data. Even those who use EFVFDs and believe that there is less "shrivel" don't know how to measure and quantify it. Therefore, the work of the Initiative is very important since it will help to fill this void and potentially overcome concerns about projects not penciling out. Helping to establish a track record through these projects will also help to address concerns about reliability, especially since peers are considered to be an important source of information. Once information is available it should be disseminated in several ways. First, it is important to get it into the trade press, which owners and operators see as being a good source of general information. Second, it needs to get to vendors and contractors, to whom owners and operators often look for more specific information. Two levels of information should be available. A general level of information and a more detailed or technical level since it is likely to be scrutinized by management level people as well as technical level people. Finally, it is important that whether the information is in the trade press, comes from a vendor or contractor, or is disseminated in some other way that it is perceived to have been developed by a third party or an objective party.

J. Information Dissemination

Cascade undertook a number of information dissemination activities in 1999. In addition to individual meetings with facility owners/operators and vendors and contractors they had a booth and made a presentation at the Post Harvest Show, they prepared Case Studies for 1998 field trials (copies are included in Appendix C) as well as a brochure that summarizes results for all sites, and they had a letter published in the RETA National newsletter.

These types of activities appear to be covering the main bases with regard to the best avenues for information dissemination. The key will be to continue to extend the activities. For example, it will be important to try to get more exposure in the trade press and to continue to expand the network of vendors, contractors and facility owners

Appendix A

Summary of Evaluation Activities

Task	Activities	Projected Date	Status
1998			
Field Trials Assessment	- Summary of facilities participating in field trials; - Interviews with facilities which chose not to participate in the Initiative.	December, 1998 December, 1998	Complete Complete
Supplemental Interviews	Interviews with 5 facilities which are using VFD technology but not as part of the Initiative	NA	Complete
Interviews with Vendors & Contractors	11 interviews with vendors & contractors (sampling outlined in work plan)	March-May, 1999 Date changed from Dec. 1998 in order to allow enough time for program to have an effect.	Complete
Market Assessment	Development of Market Progress Evaluation Report	February, 1999	Complete
1999			
Field Trials Assessment	- Summarize technical data on 1998 -99 field trials; - Conduct interviews with personnel at participating 1998 facilities; - Conduct Interviews with personnel at non-participating facilities for 1999 field trials.	June/July, 1999 December ,1999-February, 2000 Task eliminated because reasons for non-participation well enough understood.	Completed Completed NA
Interviews with Vendors & Contractors	19 Interviews (sampling outlined in work plan)	Task moved to fall of 2000	TBC
Interviews with Non-Participating Facility Owners	20-30 interviews to determine extent of information dissemination	December, 1999-February, 2000	Complete
Market Assessment	Development of Market Progress Evaluation Report	February, 2000	Draft Complete and submitted to Alliance

2000			
Field Trials Assessment	- Summarize technical data on 1998 -99 field trials; - Conduct interviews with personnel at participating 1999 facilities;	June/July, 2000 October/November, 2000	TBC TBC
Interviews with Vendors & Contractors	20 Interviews (sampling outlined in work plan)	July/August, 2000 Task changed to development of a recommendation on the future of the program when current commitment runs out	TBC
Interviews with Non-Participating Facility Owners	20-30 interviews to determine extent of information dissemination	November/December, 2000	TBC
Market Assessment	Development of final Market Progress Evaluation Report	January, 2001	TBC

Appendix B

Interview Guides

K. EVAPORATOR COIL MANUFACTURERS…

manufacture and sell evaporator coils that go into refrigeration and controlled atmosphere systems. They do not produce a component that is part of the control system; rather, they produce a part of the system that is controlled. The evaporator manufacturer can influence the systems that are specified by the refrigeration contractor.

Topics to Cover:

- Who are their customers (refrigeration contractors, electricians, etc.)? What products and services do they provide to customers?
- Familiarity with Evaporative Fan technology? What are the perceived benefits or drawbacks? On what do they base these opinions (i.e. direct experience, heard stories from customers or peers, etc.)?
- Experience with the technology? Are they aware of any installations? Have they heard any (even anecdotal) results from use of the technology in terms of energy use, product quality, or any other benefits? Have they heard of any problems or drawbacks that are related to use of the technology?
- What are the perceived trends in terms of use of EFVFD technology (increase, decrease, or stay the same? What kind of time frame?)
- What kinds of trends have they seen in technology, in the industry, in the business environment that relate to the level of use of the EFVFD technology?
- To what extent are coils used in VFD applications a separate product versus a generic component used for various refrigeration applications (i.e. have they adapted their products or created new types of products in response to EFVFD technology)?
- Do they produce any other components related to controlled atmosphere?
- To what extent (If any) do they influence other market actors (i.e. refrigeration contractors, electrical engineers, etc.)?
- To what extent do they influence end users?
- What factors do they think will have the greatest influence on the future of the technology?
- What kind of priority are refrigeration/CA facilities placing on this technology?
- What are some of the other investment priorities that you see being made?
- What kind of an impact, if any, would growth of EFVFD have on their business?
- What other types of investment are refrigeration/CA companies making in their facilities?
- Have they heard of the EFVFD Initiative? What have they heard? What are the Initiative's goals? How are they funded? What are the different elements of the Initiative's efforts?
- Have they had direct experience dealing with Initiative personnel? What was the nature of the interaction? What was the result?
- How effective will Initiative activities be in promoting the use of EFVFD technology (note that if they are unfamiliar with the initiative we provide a synopsis of the Initiative which explains the field demonstrations and information dissemination activities)
- Are there any other types of activities or information that they think would be important for the Initiative to pursue?

L. REFRIGERATION CONTRACTORS…

design industrial refrigeration systems. They are in a four-way relationship with electrical contractors, evaporator manufacturers, and the customer. Since the refrigeration contractor is responsible for designing the refrigeration system they can have a significant impact on the ultimate technology that is chosen. It is not necessarily the case that new refrigeration systems

are put into place as a result of the technology; in some cases, existing evaporative fans are retrofitted to be run by VFD's. In cases where EFVFDs are installed in existing refrigeration/CA systems, some modification to the refrigeration systems may be required.

A premium is placed on the ability of the refrigeration contractors and the other contractors to work together in putting the new technology in place with no disruption to facility operation.

Topics to Cover:

- Who are their customers (end users? electricians? others?) Who else do they generally interact with (i.e. suppliers such as evaporator manufacturers, electricians, energy design consultants, etc.)? What products and services do they provide to customers?
- What is their level of familiarity/experience with Evaporative Fan technology (i.e., years, and level of service, training, level of involvement in installation efforts?) How familiar are they with EFVFD technology? Have they designed any systems that use the technology (if so how many)?
- What are the perceived benefits or drawbacks? On what do they base these opinions (i.e. direct experience, heard stories from peers, etc.)?
- What has been the impact of EFVFD installation on their business?
- Have they heard of any (even anecdotal) results from use of the technology in terms of energy use, product quality, or any other benefits? Have they heard of any problems or drawbacks that are related to use of the technology?
- What role do they play in promotion of EFVFD technology? In the installation of EFVFDs?
- Have they developed and/or offered different products or services in response to EFVFD activity? How are existing services/products applied in addressing consumer demand for EFVFD?
- What other products or services do they offer to refrigerated/controlled atmosphere facilities?
- What are the main factors which end users typically consider when buying a refrigeration system? Do these differ between retrofit and new applications? How?
- Who is most likely to consider installing an EFVFD system? How does the idea typically come up (i.e. request by the customer versus suggestion from contractor)? To what extent can/do they (the contractor) influence the ultimate decision? To what extent does new versus retrofit make a difference?
- What are the perceived trends in terms of use of EFVFD technology (increase, decrease, or stay the same? What kind of time frame?)
- What kinds of trends have they seen in technology, in the industry, in the business environment that relate to the level of use of the EFVFD technology?
- Where do they tend to get information or how do they tend to form opinions about new technologies such as this?
- What kind of priority are refrigeration/CA facilities placing on this technology?
- What are some of the other investment priorities that they see being made?
- Have they adapted their products/services in response to EFVFD technology?
- Have they created new types of products/services?
- What would be the impact of expanded use of the technology on their business?
- What factors do they think will have the greatest influence on the future of the technology?
- Have they heard of the EFVFD Initiative? What have they heard? What are the Initiative's goals? How are they funded? What are the different elements of the Initiative's efforts?
- Have they had direct experience dealing with Initiative personnel? What was the nature of the interaction? What was the result?
- How effective will Initiative activities be in promoting the use of EFVFD technology (note that if they are unfamiliar with the initiative we provide a synopsis of the Initiative which explains the field demonstrations and information dissemination activities)
- Are there any other types of activities or information that they think would be important for the Initiative to pursue?

M. ELECTRICAL CONTRACTORS…

purchase and install VFDs for customers. Electrical contractors are responsible for meeting the power and wiring requirements of the system. They also involved in adapting the existing electrical systems to support the electrical needs of the new system. While the refrigeration contractor may be responsible for the design, it is the electrical contractor who is responsible for the actual installation. They typically have a relationship with the end user, VFD vendors, control system vendors, and motor protection vendors. In new construction situations they are likely to be subcontracted by the refrigeration contractor. In retrofit situations, they may contract directly with the facility.

Topics to Cover:

- Who are their customers (end users? refrigeration contractors? others?) Who else do they generally interact with (i.e. suppliers such as control vendors, motor protection vendors, VFD manufacturers, energy design consultants, etc.)? What products and services do they provide to customers?
- What is their level of familiarity/experience with Evaporative Fan technology (i.e., years, and level of service, training, level of involvement in installation efforts?) How does this differ depending on new versus retrofit situations? How familiar are they with EFVFD technology? Have they installed any systems that use the technology (if so how many)?
- What kinds of challenges, if any, did they run into in installing the technology? What factors are most important for a successful installation? Who else in generally involved and what is their role?
- What are the perceived benefits or drawbacks? On what do they base these opinions (i.e. direct experience, heard stories from peers, etc.)?
- What has been the impact of EFVFD installation on their business?
- Have they heard of any (even anecdotal) results from use of the technology in terms of energy use, product quality, or any other benefits? Have they heard of any problems or drawbacks that are related to use of the technology?
- What role do they play in promotion of EFVFD technology?
- Have they developed and/or offered different products or services in response to EFVFD activity? How are existing services/products applied in addressing consumer demand for EFVFD?
- What other products or services do they offer to refrigerated/controlled atmosphere facilities?
- What are the main factors which end users typically consider when buying a refrigeration system? Do these differ between retrofit and new applications? How?
- Who is most likely to consider installing an EFVFD system? How does the idea typically come up (i.e. request by the customer versus suggestion from contractor)? To what extent can/do they (the contractor) influence the ultimate decision? How does this differ between new and retrofit applications?
- What are the perceived trends in terms of use of EFVFD technology (increase, decrease, or stay the same? What kind of time frame?)
- What kinds of trends have they seen in technology, in the industry, in the business environment that relate to the level of use of the EFVFD technology?
- Where do they tend to get information or how do they tend to form opinions about new technologies such as this?
- What kind of priority are refrigeration/CA facilities placing on this technology?
- What are some of the other investment priorities that they see being made?
- Have they adapted their products/services in response to EFVFD technology?
- Have they created new types of products/services?
- What would be the impact of expanded use of the technology on their business?
- What factors do they think will have the greatest influence on the future of the technology?

- Have they heard of the EFVFD Initiative? What have they heard? What are the Initiative's goals? How are they funded? What are the different elements of the Initiative's efforts?
- Have they had direct experience dealing with Initiative personnel? What was the nature of the interaction? What was the result?
- How effective will Initiative activities be in promoting the use of EFVFD technology (note that if they are unfamiliar with the initiative we provide a synopsis of the Initiative which explains the field demonstrations and information dissemination activities)
- Are there any other types of activities or information that they think would be important for the Initiative to pursue?

REFRIGERATION COMPUTER CONTROL VENDORS….

Design and provide the computer systems that control VFDs. They are responsible for getting the operating hardware and software in place and in sync. Their efforts are frequently part of larger automation efforts. The work is complex and technical; the refrigeration computer control vendors are providing the existing system with a new brain. As with the other contractors, Refrigeration Computer Control Vendors work on site to customize the system and adjust it to meet the needs of a given facility.

Topics to Cover:

- Who are their customers (end users? refrigeration contractors? electricians? others?) Who else do they generally interact with (i.e. suppliers such as evaporator fan manufacturers, energy design consultants, etc.)? What products and services do they provide to customers?
- What is their level of familiarity/experience with Evaporative Fan technology (i.e., years, and level of service, training, level of involvement in installation efforts?) How familiar are they with EFVFD technology? Have they installed any systems that use the technology (if so how many)?
- What kinds of challenges, if any, did they run into in installing the technology? What factors are most important for a successful installation? Who else in generally involved and what is their role?
- What are the perceived benefits or drawbacks? On what do they base these opinions (i.e. direct experience, heard stories from peers, etc.)?
- What has been the impact of EFVFD installation on their business?
- Have they heard of any (even anecdotal) results from use of the technology in terms of energy use, product quality, or any other benefits? Have they heard of any problems or drawbacks that are related to use of the technology?
- What role do they play in promotion of EFVFD technology? In the installation of EFVFDs?
- Have they developed and/or offered different products or services in response to EFVFD activity? How are existing services/products applied in addressing consumer demand for EFVFD?
- What other products or services do they offer to refrigerated/controlled atmosphere facilities?
- What are the main factors which end users typically consider when buying a refrigeration system? Do these differ between retrofit and new applications? How?
- Who is most likely to consider installing an EFVFD system? How does the idea typically come up (i.e. request by the customer versus suggestion from contractor)? To what extent can/do they (the contractor) influence the ultimate decision?
- What are the perceived trends in terms of use of EFVFD technology (increase, decrease, or stay the same? What kind of time frame?)
- What kinds of trends have they seen in technology, in the industry, in the business environment that relate to the level of use of the EFVFD technology?
- Where do they tend to get information or how do they tend to form opinions about new technologies such as this?
- What kind of priority are refrigeration/CA facilities placing on this technology?
- What are some of the other investment priorities that they see being made?
- Have they adapted their products/services in response to EFVFD technology?
- Have they created new types of products/services?
- What would be the impact of expanded use of the technology on their business?
- What factors do they think will have the greatest influence on the future of the technology?
- Have they heard of the EFVFD Initiative? What have they heard? What are the Initiative's goals? How are they funded? What are the different elements of the Initiative's efforts?
- Have they had direct experience dealing with Initiative personnel? What was the nature of the interaction? What was the result?

- How effective will Initiative activities be in promoting the use of EFVFD technology (note that if they are unfamiliar with the initiative we provide a synopsis of the Initiative which explains the field demonstrations and information dissemination activities)
- Are there any other types of activities or information that they think would be important for the Initiative to pursue?

1. Field Trial Participant Interviews

I. Introduction

I will introduce myself and convey the following information:

I work for Macro International;
Macro has been hired by The Alliance with regard to an ongoing VFD initiative and that as part of that I want to try to understand the experiences of those who are using them;
That I am calling them because their name was given to me by Cascade Engineering as being someone for whom they installed a VFD system as part of the Initiative;
That their input will be very useful in helping to guide program development;
That I expect the interview to last about 30 minutes;
That their comments will be confidential [in that no specific comments will be attributed to them].

II. Interview

I will check to make sure that the person to whom I am speaking was involved in the decision to instal a VFD and/or has enough knowledge to answer questions about that decision. If not, I will ask to speak to someone who can and then start over with the introduction. Once I have the right person on the phone I will cover the following topics:

What is the interviewee's title and role within the company?
What type of storage facility do they have, how many rooms, what types of products do they typically store? Which rooms have had the VFDs installed and for how long? [Note: if Cascade can give me this information ahead of time I will probably not go into much depth but will still talk about a little bit as a lead into the discussion]
How did they hear about VFDs?
What lead them to be interested in VFD's? [probe for specific expectations] Did they have any concerns? [probe for specific concerns]
How did they follow up on this interest (i.e. did they seek out more information? from whom? what type of information? did they visit a site that already had one installed? did they seek a demonstration? Etc.)
Who was involved in the decision process? What are their roles within the organization? Did expectations/concerns differ among these people?
What were the major factors that were considered in the decision process? What types of barriers or hurdles were there and how were these addressed? What were their expectations (probe here for whether or not they had developed specific goals versus general ones and whether they had developed a plan for evaluating results to see whether expectations were met)?
How did the installation actually occur (for example, did they install in one or two rooms as an experiment and then later convert more rooms?)
Now that they have had time to gain experience with the systems how, have they measured up to expectations? Were there unexpected benefits? Were there any problems (expected or unexpected)? How were they resolved?

Do they believe that their results are generalizable to other facilities? Would they recommend the technology to other facilities? What do they think would be the best way to generate interest?
Finally, I will give them a chance to talk about anything that they think is pertinent but that did not come up in our discussion.

2. Non-Participating Facility Owner Interviews

Introduction

In some cases the database will provide a contact name. In those cases we will ask to speak to the contact person, explain what we are doing and then try to ascertain whether or not they are the correct person to speak to. If not, we will ask them to direct us to the appropriate person. If there is no contact name Macro will call the facility and ask to speak to the person who would make decisions regarding refrigeration equipment. If the person answering the phone is unsure about whom we should speak to then we will ask to speak to the owner or facility manager. We will then explain what we are doing and try to ascertain who is the correct person to speak to

When explaining what we are doing we will introduce ourselves as calling from Macro International, a consulting firm, that has been hired by the Northwest Energy Efficiency Alliance to perform research to assess the use of variable frequency drive technology in refrigerated warehouse applications.

We will explain that the Alliance is a non-profit consortium of utilities, Bonneville Power Administration, Northwest state governments, energy efficiency industry and public interest groups whose goal is to improve the efficiency of electricity use in the region.

We will tell participants that the interviews should take no more than fifteen minutes and that their responses will be confidential in that we will not attribute any specific comments to an individual.

Topic Areas

a) Facility Characteristics - What are the size and age of the facility? What products do they store there? [Note that in some cases we will already have this information in the database. However, we will probably ask these questions anyway in order to confirm our information and as a natural lead in to the rest of the topics]
b) Knowledge and Use of VFDs - Do they currently use VFDs in evaporator fan applications? If so, how many? How long have they used them? How did they first get interested in the technology (probe for vendors, contractors, consultants, manufacturers, colleagues, peers, trade publications, conferences, etc)? What motivated them to use them (probe for potential benefits, expectations)? What factors were considered in the decision process? Who had input into the process (probe for colleagues, vendors, contractors, consultants, manufacturers) If not, What do they know about the use of VFDs in EF applications? What have they heard about potential benefits and drawbacks? Have they ever had experience using them?
c) Results/Experience – For those who currently use VFDs or who have had experience using them in the past even if they currently aren't, do/did the VFDs meet expectations? Do they have any quantifiable results? What kinds of problems or drawbacks if any have/did they run into? What are their future plans with regard to VFDs (i.e. install them in more rooms/new facilities. If so, when? Don't plan to use them in the future. If so, why not?) Are there some applications for which they make more sense than for others? Would they recommend them to others?

d) Sources of information – Where do they typically get information about products like this or new technologies in general (probe for vendors, contractors, consultants, manufacturers, colleagues, peers, trade publications, trade groups, conferences, Internet/WWW, etc.)? More specifically, if they are aware of the use of VFDs in EF applications, where did they get that information? What type of information is most compelling to them when evaluating new products/technologies (probe for case studies, academic studies, etc.)? What sources do they most trust (probe for vendors, contractors, consultants, manufacturers, colleagues, peers, trade publications, trade groups, conferences, marketing materials, internet/WWW, etc.)?
e) Data – What type of data would they need to see in order to convince them of the efficacy of the technology (probe for factors such as the variety of products tested, testing in different room configurations or parts of the room, length of the study, the way in which results are measured, etc)? How detailed does the study need to be? How detailed does the data presented to them need to be?
f) Message – What type of message is most likely to appeal to them (probe for different themes such as energy efficiency, reduction in operating costs, better product quality, etc?) Who, beside themselves, typically has input into the decision making process? What type of message is likely to be most appealing to that person or those people?
g) Other – Is there anything else that they want to tell us?

Closing

We will thank participants for their time and help on this project and will provide them with the Alliance web address in case they are interested in learning more about the program or are interested in reading about the results of this study. We will let them know that the results will be contained in the second market progress report which will be posted on the site sometime in the first quarter of 2000.