BPA E3T 2010 HVAC Technical Advisory Group

Final Report

November 2010

This report summarizes the 2010 cycle of the Energy Efficiency Emerging Technology (E3T) Program's Heating, Ventilation, and Air Conditioning (HVAC) Technical Advisory Group (TAG).

This final report and appendices include:

- Narrative putting the 2010 HVAC TAG in context with previous work
- Summaries of key stages of the 2010 HVAC TAG cycle
- Graphics detailing the measure ranking and scoring results from TAG members' surveys
- TAG recommendations for four technologies selected during the 2010 cycle (Appendix A)
- Rosters of TAG members and partners, and participants attending key meetings (Appendices B and C)

The 2009 TAG Cycle

In 2009, the E3T Program recruited highly qualified, experienced HVAC engineers and specialists to serve on the HVAC Technical Advisory Group (TAG). A TAG cycle involving identification, ranking, scoring, and developing recommendations for selected energy technologies was conducted during meetings and webinars taking place on four days over the course of ten months, beginning in May 2009 and concluding February 2010. During those meetings a facilitated brainstorm process was used to create a ranked list of technologies not yet widely adopted in the Northwest. That short list of technologies was scored in detail on a range of characteristics. Four technologies ultimately were selected to advance to the 2009 recommendations stage:

- Demand Controlled Ventilation for Commercial Kitchens
- Variable Refrigerant Flow Heat Pumps
- Demand Controlled Ventilation
- Indirect-Direct Evaporative Cooling

This TAG process is aided by a Framework developed for the E3T process in the summer of 2009 (see below). The Framework further guides the process once TAGs take technologies to the recommendations stage. One part of the post-TAG process involves estimating the potential of the emerging technology or energy saving strategy to be adopted in the region and quantifying potential energy savings region wide.

The current status of the four technologies selected in the 2009 HVAC TAG includes a range of developments. Action on the recommendations for Demand Controlled Ventilation for Commercial Kitchens has not been started. Technology behind Variable Refrigerant Flow (VRF) Heat Pumps is currently the subject of a series of five case studies targeted at local governments and public utilities to help them understand how others have effectively implemented VRF in their facilities. Demand Controlled Ventilation is currently the subject of a feasibility assessment that aims to define specific demand controlled ventilation measures, savings and monitoring and verification protocols through field tests at multiple sites. In its recommendations the 2009 HVAC TAG suggested that Indirect-Direct Evaporative Cooling was not promising enough in the region to warrant further action at this time.

Framework

During the summer of 2009 the E3T Framework was completed. The Framework is used as a guide for the E3T process, with which staff, TAG members, and others identify, rank, score, select, and assess emerging energy

efficiency measures. A process to get input from key partners regarding the original Framework is underway at this time and may result in changes to aspects of the process and the forms and tools used within it.

The 2010 TAG Cycle

The 2010 cycle of the E3T HVAC TAG was operated on a more compressed timeframe than the initial TAG, spanning just over three months. The initial Identification Meeting was convened on June 10, 2010. Subsequent Ranking and Scoring meetings were convened. The 2010 TAG cycle concluded with two Recommendations web conferences, the last one held September 16, 2010, at which the content for the TAG recommendations was finalized.

The 2010 HVAC TAG ultimately selected four emerging energy efficiency technologies to advance in the E3T process to steps that will identify and assess their potential in Bonneville Power Administration's service territory, and lay out steps for funding and implementing greater adoption of these technologies.

Those four technologies are:

- Variable Capacity Compressors
- Air-Side Economizers for Data Centers
- Web-Based Small Commercial Thermostat
- Advanced Design Rooftop HVAC Unit

The TAG's final recommendations for these technologies are appended to this report. The recommendations, along with details on these and other emerging energy efficiency technologies and strategies stored in database records on the E3TNW.org web-based database, represent the final results of the 2010 E3T HVAC TAG.

Identification Meeting

Participants were invited on May 11, 2010 to the initial meeting of the 2010 HVAC TAG held via a four hour GoToWebinar conference held June 10, 2010. The purpose of the session was to establish a list of technologies that would serve as the basis for an online survey that would allow TAG members to indicate their support for technologies, systems, and solutions that made the list. (The term "measure" widely used in the E3T Framework, is an umbrella term referring to individual technologies, physical systems, or methodological approaches. Where possible this report chooses the more specific term, as "measure" has additional connotations in approaches to acquire efficiency in the Northwest). Prior to the Identification (ID) meeting TAG members were encouraged to notify E3T staff of technologies that had come to their attention since the previous TAG cycle's Identification stage. A few were submitted in advance, and several more were suggested during the webinar.

In addition to 15 newly identified technologies, 12 top-ranked items from the previous year's HVAC TAG "vote" which did not go further in the 2009 process were included. Ten additional measures were added at the request of TAG members.

This approach differed from the open brainstorms held at both the initial Lighting and HVAC TAGs, on the premise that the wide net had been cast then, and a returning TAG could use the foundation provided from previous work, allowing more time to hear about newly added items. Top-ranked measures seemed an obvious source for promising measures, and newly identified items are essential to a process dedicated to identify emerging technologies. The other items from the 2009 cycle promoted to the list by individual TAG members allowed for renewed attention to items that might have not been well understood earlier or for which new developments might affect their ranks and scores.

Ranking Survey and Meeting

TAG members were invited on June 21 to attend a one hour Ranking Review meeting held on June 29, 2010. The list emerging from the ID meeting was developed into a survey asking TAG members to rate their support for as many of the 37 measures listed as they wished on a 0-5 scale:

0- I do not support this measure
1- I support this technology with significant reservations
2- I mildly support this technology
3- I support this technology
4- I strongly support this technology
5- My support for this technology is enthusiastic and unqualified

General comments were also encouraged. Instructions regarding the ratings included this message:

Consider these First Round Emerging Technology Screening Criteria when indicating your preference and the strength of your support:

1. **Emerging** – Degree to which this technology is newly developing and currently ready for attention
2. **Energy Efficiency** – Degree to which this technology has potential to provide quantifiable, reliable, and cost effective electric energy savings for end-users in the Northwest region
3. **Customer Need** – Degree to which this technology is a clear and distinct solution to a customer need
4. **Technically Sound** – Degree to which this technology is expected to deliver its intended performance

Between June 15 and June 25, 17 TAG members recorded responses to the online Ranking survey, including TAG members who were unable to attend the Identification webinar. The rating approach differed from the previous HVAC and Lighting TAGs in several significant ways (starting with the way the list was developed) as described in the "Identification Meeting" section above.

The results of the Ranking survey are depicted in Figures 1 and 2. Because members were not limited to the number of measures they could rate, two rankings emerged. One was a rank by average points, with the total points divided by the number or responses. The other was simply the total points. In general the two rankings differed little, usually by only one position. The top ranked technology, Variable Capacity Compressors (VCC), was at the top of both lists with an average of 4.2, well above the 3.7 average for the next highest technology, Premium Ventilation Package for Rooftop Units. VCC also topped the list of measures ranked by total points, garnering a total of 50 points, three points ahead of the second place technology on that list, Air-Side Economizers for Data Centers.

Because of very close ratings among six of the top-ranked measures, two technologies in the list differed by five positions between the two ranking lists. Occupancy Sensor HVAC Controls enjoyed a 6th place ranking by average points (3.18) but was in 11th place by total points (35), with a total of 11 respondents. Dedicated Outside Air System was in 8th place by average points (3.0) but fell to 13th place when ranked by total points (33), also with 11 respondents.

These discrepancies did not affect the selection of measures by E3T staff to advance to the Scoring stage of the TAG process. The accompanying table is ranked by average score, showing also the highest and lowest ratings given by TAG members for each item, and the total points garnered.

Figure 1. Graphical Representation of Measure Ranking Results

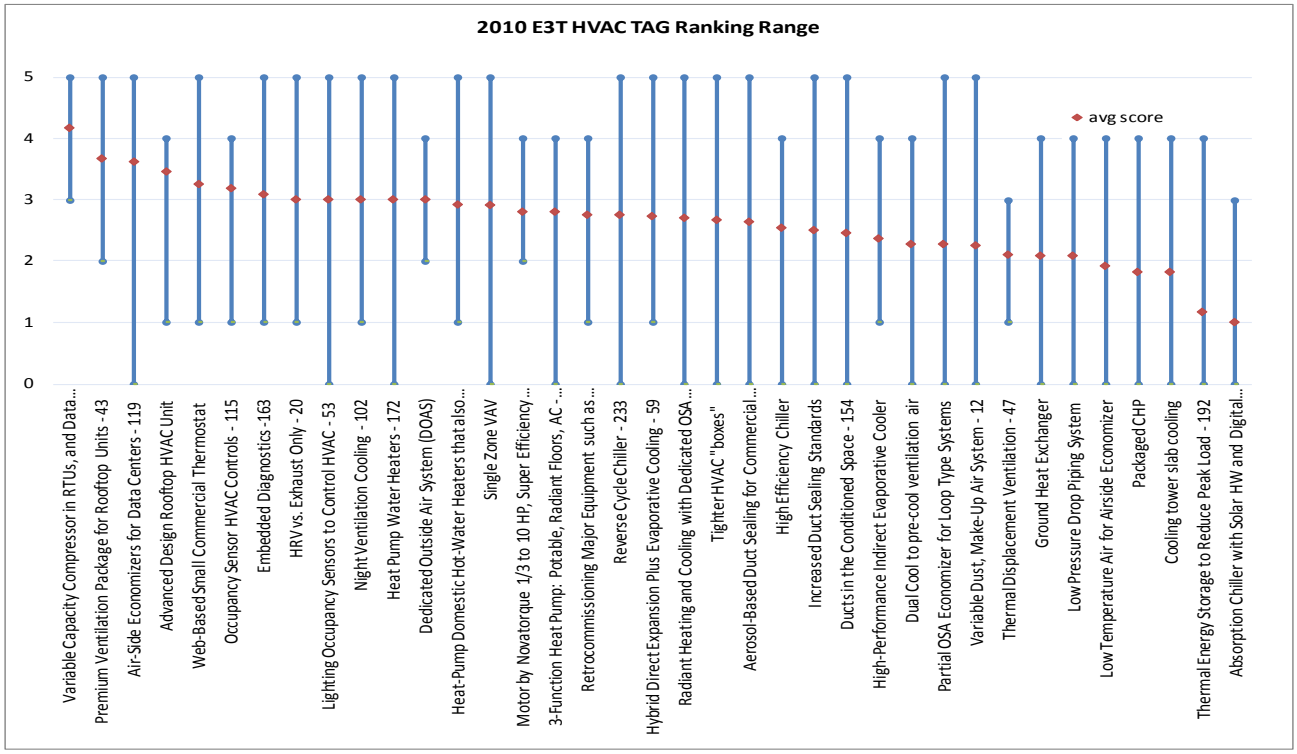


Figure 2. Tabular Measure Ranking Results

2010 E3T HVAC TAG Weighted Rankings							
measure title - E3TNW.org record number	highest rating	avg points	lowest rating	total points	number of respondents	rank by avg pts	rank by tot pts
Variable Capacity Compressor in Packaged Rooftop Units - 6	5	4.2	3	50	*12*	1	1
Premium Ventilation Package for Rooftop Units - 43	5	3.7	2	44	*12*	2	3
Air-Side Economizers for Data Centers - 119	5	3.6	0	47	*13*	3	2
Advanced Design Rooftop HVAC Unit - 246	4	3.5	1	38	*11*	4	5
Web-Based Small Commercial Thermostat -247	5	3.3	1	39	*12*	5	4
Occupancy Sensor HVAC Controls - 115	4	3.2	1	35	*11*	6	11
Embedded Diagnostics -163	5	3.1	1	37	*12*	7	6
Heat Recovery Venitilators - 20	5	3.0	1	36	*12*	8	7
Use Lighting Occupancy Sensors for Offices to Control HVAC - 53	5	3.0	0	36	*12*	8	7
Integrated Night Ventilation Cooling - 102	5	3.0	1	36	*12*	8	7
Heat Pump Water Heaters - 172	5	3.0	0	36	*12*	8	7
Dedicated Outside Air System (DOAS) - 248	4	3.0	2	33	*11*	8	13
Heat-Pump Domestic Hot-Water Heaters Providing Air Conditioning -	5	2.9	1	35	*12*	13	11
Single Zone VAV - 249	5	2.9	0	32	*11*	14	17
Motor by Nova Torque 1/3 to 10 HP, Super Efficiency - 101	4	2.8	2	28	*10*	15	22
3-Function Heat Pump: Potable, Radiant Floors, AC - 156	4	2.8	0	28	*10*	15	22
Reverse Cycle Chiller - 233	5	2.8	0	33	*12*	17	13
Retrocommissioning Major Equipment such as Chillers - 87	4	2.8	1	33	*12*	17	13
Hybrid Direct Expansion Plus Evaporative Cooling - 59	5	2.7	1	30	*11*	19	19
Radiant Heating & Cooling with Dedicated OSA Ventilation - 74	5	2.7	0	27	*10*	20	24
Tighter HVAC boxes - 250	5	2.7	0	32	*12*	21	17
Aerosol-Based Duct Sealing for Commercial Buildings -178	5	2.6	0	29	*11*	22	21
High Efficiency Chiller - 251	4	2.5	0	33	*13*	23	13
Increased Duct Sealing Standards - 253	5	2.5	0	30	*12*	24	19
Ducts in the Conditioned Space - 154	5	2.5	0	27	*11*	25	24
High-Performance Indirect Evaporative Cooler - 252	4	2.4	1	26	*11*	26	27
Partial OSA Economizer for Loop Type Systems - 254	5	2.3	0	25	*11*	27	28
Dual Cool to Pre-Cool Ventilation air - 255	4	2.3	0	25	*11*	27	28
Variable Volume Dust Collection System - 12	5	2.3	0	27	*12*	29	24
Thermal Displacement Ventilation - 47	3	2.1	1	21	*10*	30	33
Ground Heat Exchanger - 256	4	2.1	0	25	*12*	31	28
Low Pressure Drop Piping System -257	4	2.1	0	25	*12*	31	28
Low Temperature Air for Airside Economizer - 258	4	1.9	0	23	*12*	33	32
Packaged CHP - 259	4	1.8	0	20	*11*	34	34
Cooling Tower Slab Cooling - 260	4	1.8	0	20	*11*	34	34
Thermal Energy Storage (to Reduce Peak Load) - 192	4	1.2	0	14	*12*	36	36
Absorption Chiller with Solar HW and Digital Controls - 202	3	1.0	0	11	*11*	37	37
Legend: 2009 top 12	Newly identified 2010			Other 2009			

Scoring Meeting

TAG members were invited on July 23, 2010 to attend a three hour Scoring session held on August 10, 2010. TAG Scoring sessions invite the most detail about technologies and solutions, and typically have engaged, enthusiastic participation. During this webinar presentations were made on four technologies chosen by E3T staff to advance in the process.

Jared Sheeks from MacDonald Miller Engineers presented on Variable Capacity Compressors, contrasting them with multiple fixed-capacity compressors, multiple stage compressors, and inverter-driven variable capacity compressors. Discussion included perspectives and information on savings calculations, cost, prospects for expansion beyond a single manufacturer, peak load performance, compressor operation, and applicability to retrofit situations.

Phoebe Warren of Seattle City Light presented on Air-Side Economizers for Data Centers. Presentation points included installation dependencies as a built-up configuration, user behavior in current installations with economizers, barriers, supply air temperature, evaporative cooling, cost, and identifying regional experts. During the discussion it was noted that this application is best suited for large data centers. Several aspects of the presentation points were clarified, including the ability to use relatively high temperature supply air. The technology was contrasted with other approaches that data center operators might use,.

Mark Firestone with PAE Engineers presented on Advanced Design Rooftop Units, pointing out that this approach combines many smaller technologies. Noting that rooftop units (RTUs) are ubiquitous, he suggested that most new units are designed only to meet codes, not exceed them. First costs are offset by much longer typical life in units with advanced components, with most of the energy savings coming from heating energy, fan power, and refrigeration in Northwest applications. Discussion points included limited competition leading to higher prices, the confirmed availability of prescriptive specifications, potential benefits of performance specifications, and the value of establishing LEED points for premium units.

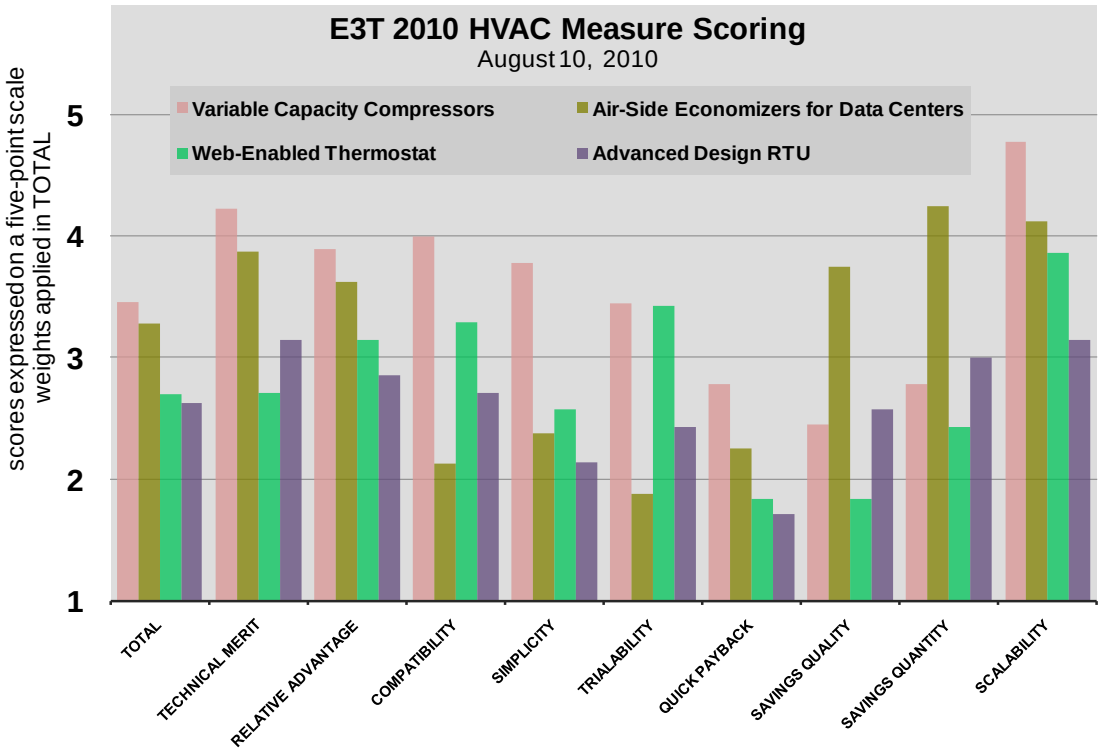
Jack Callahan of Bonneville Power Administration Energy Efficiency and Reid Hart of PECI presented on Web-Enabled Commercial Thermostats. The presentation introduced core features of such thermostats, typically used with packaged rooftop units in small commercial applications. Features of various brands' products were covered, such as DreamWatts dashboard and Emme's wireless product. Benefits would accrue mostly to smaller commercial applications, rather than large applications that likely already use direct digital controls. Benefits include illustrating how systems are running, providing more information to operators. Noted during discussion is the very recent emergence of these products.

TAG members were encouraged to respond to the online survey following the webinar to score the selected technologies. The survey was based directly on the Measure Benefits TAG Scorecard – the "D3" – which uses a 1 to 5 scale for respondents to rate nine separate characteristics of individual emerging technologies. The first group of characteristics is based on the user's perspective regarding Technical Merit, Relative Advantage, Compatibility, Simplicity, Trialability, and Quick Payback. The second group of characteristics, from the perspective of BPA Energy Efficiency, covers Energy Savings Quality, Energy Savings Quantity, and Scalability. Quick Payback and all the characteristics in the second group are double weighted in the final score.

Seven respondents scored the selected technologies between August 10 and August 19. E3T staff from WSU Energy Program and lead staff from Bonneville typically do not score E3T measures. The results of the E3T 2010 HVAC Scoring are graphically depicted in Figure 3.

Details of the presentations and discussion are in draft notes taken during the session and are available to TAG members and partners. Most Webinars are recorded as well, enabling unedited review of screen presentations and audio content.

Figure 3. Graphical Representation of Measure Scoring



Scored measures are also ranked, both in aggregate and by characteristic. Those ranks are depicted in Figure 4.

Figure 4. Measure Scoring Detail and Ranks

SCORES	Variable Capacity Compressors	Air-Side Economizers for Data Centers	Web-Enabled Thermostat	Advanced Design RTU
TOTAL	**3.5**	**3.3**	**2.7**	**2.6**
TECHNICAL MERIT	4.2	3.9	2.7	3.1
RELATIVE ADVANTAGE	3.9	3.6	3.1	2.9
COMPATIBILITY	4.0	2.1	3.3	2.7
SIMPLICITY	3.8	2.4	2.6	2.1
TRIALABILITY	3.4	1.9	3.4	2.4
QUICK PAYBACK	2.8	2.3	1.8	1.7
SAVINGS QUALITY	2.4	3.8	1.8	2.6
SAVINGS QUANTITY	2.8	4.3	2.4	3.0
SCALABILITY	4.8	4.1	3.9	3.1
legend	weight = 1x	weight = 2x		
	scores are all expressed on a five-point scale; weights applied in TOTAL			

RANKS	Variable Capacity Compressors	Air-Side Economizers for Data Centers	Web-Enabled Thermostat	Advanced Design RTU
OVERALL	1	2	3	4
TECHNICAL MERIT	1	2	4	3
RELATIVE ADVANTAGE	1	2	3	4
COMPATIBILITY	1	4	2	3
SIMPLICITY	1	3	2	4
TRIALABILITY	1	4	2	3
QUICK PAYBACK	1	2	3	4
ENERGY SAVINGS QUALITY	3	1	4	2
ENERGY SAVINGS QUANTITY	3	1	4	2
SCALABILITY	1	2	3	4
legend	1st place	2nd place	3rd place	other

Recommendations Confirmation Meetings

TAG members and participants were invited on August 23, 2010 to attend a one hour Recommendations Confirmation session held on August 26, 2010. The original intent was to review and confirm recommendations developed by E3T staff from materials developed throughout the 2010 HVAC TAG cycle. Discussion of each of the items averaged just under half an hour, requiring a second session scheduled on September 16, 2010.

Recommendations meetings are distinct from other sessions in that the focus is on the path forward for the selected items. In both parts of the Recommendations phase of the 2010 HVAC TAG, it was noted that many measures share a common set of actions important to progress in the E3T process after the TAG recommendations are made, and that perhaps a template including common elements could be a starting point for recommendations, adding and deleting as necessary.

Recommendations represent the final product of each TAG cycle. Recommendations from the E3T 2010 HVAC TAG follow in Appendix A.

E3T 2010 HVAC TAG Recommendations

September 2010

These are recommendations for technologies presented and scored at the scoring session August 10, 2010, which were confirmed and discussed further during the E3T 2010 HVAC TAG Measure Recommendations confirmation calls, held August 26 and September 16, 2010.

The numbers following the technologies' titles refer to their record number in the E3TNW database.

Variable Capacity Compressors-6	**Overall Score: 3.5**

Description:

Variable capacity compressors operate in a pulsating fashion to vary the mass flow rate of refrigerant. This allows direct expansion (DX) air conditioning or heat pump equipment to be operated as a variable capacity device.

Recommendations:

1. Develop a staged research plan for the recommendations below.
2. Perform a literature search for previous lab and field testing, and contact appropriate organizations such as manufacturers for their literature and assistance.
3. Define appropriate baseline systems for various applications.
4. Estimate distribution of cooling loads in representative regional applications.
5. Perform lab testing as needed, including studying the effects of various types of economizers and variable-speed fans, and the affect of this strategy on maintenance, possibly partnering with other regional efforts.
6. Perform field testing to measure actual performance in the Pacific Northwest to include economizer savings, if any. Include both retrofit and new construction as well as appropriate baseline systems.
7. Explore new competing technologies, such as inverter-driven compressors and Carrier two-stage systems.
8. Develop criteria for estimating savings in a wide variety of different settings (e.g., different building types, sizes, and configurations, and different climate zones) using modeling tools.
9. Compare field and lab data with standard ratings and modeling results.
10. Estimate potential regional savings.
11. Identify key variables for good applications, including non-energy savings and market characteristics.
12. Provide training for designers and code officials so they may better understand rating systems.
13. Evaluate performance from field and lab testing and develop Integrated Energy Efficiency Ratio (IEER) guidelines.
14. Provide IEER performance information and application and implementation guidelines.
15. Provide utility incentives for new construction and retrofit based on the outcome of the field and lab tests.
16. Share research results with RTU Working Group.

Air-Side Economizers for Data Centers-119	Overall Score: 3.3

Description:

Install 100% outside-air cooling capability in data centers to provide free cooling where outside air was previously provided only to satisfy the minimum ventilation requirements. Because data centers require air conditioning year-round, significant energy savings can be realized by using outside air for cooling.

Recommendations:

1. Investigate market penetration, estimating how many economizer systems are currently installed and in use.
2. Perform a comprehensive literature search for relevant research and contact appropriate organizations for additional resources and information.
3. Identify savings potential predictions for various temperature allowances.
4. Provide guidelines on filtration issues to address outside air quality concerns.
5. Provide funding for energy modeling for designers and owners.
6. Identify a number of existing projects, new or retrofit, where economizers are utilized and develop a few case studies.
7. Provide designers, specifiers, and data center owner/operators with technical assistance and application information, training, best practices, and guidelines for sequences of operation and control integration. Include some criteria for server temperature and humidity tolerance.
8. Promote the use of robust servers that can tolerate a wider range of temperatures and humidity.
9. Share research results with the RTU Working Group, ASHRAE, and other organizations.
10. Train data center designers through a seminar series, possibly through BetterBricks.
11. Check the building codes in the major jurisdictions in the Northwest to determine which ones already require economizers. If the codes are in place, but economizers are not being installed, why not? If the codes are not being enforced, provide training to local code officials, if necessary.

Web-Based Small Commercial Thermostat-247	**Overall Score: 2.7**

Description:

The proposed measure includes a package of hardware, software, and operation and maintenance practices that include:

- Digital "smart thermostats" with a variety of programmable control capabilities.
- An internet connection.
- The internet interface is used by someone who has HVAC optimization knowledge and an interest in the energy efficient operation of the facility.

The focus of this measure is for applications where packaged HVAC equipment is used in small commercial facilities.

Recommendations:

1. Identify competing products, including those from Cooper Industries; attend ASHRAE trade show typically held in the month of January to explore manufacturers' latest relevant products.
2. Perform a comprehensive literature search of previous research on these products and their performance.
3. Pacific Gas & Electric (PG&E) currently funds the use of this technology and Puget Sound Energy (PSE) may be considering it. Find out what convinced them to do that and what their experience has been.
4. Solicit feedback on benefits (energy and non-energy) and issues from a small group of building operators managing multiple buildings.
5. Survey how the technology is currently being applied.
6. Estimate when this technology will be ready to be incentivized.
7. Clarify issues and gaps to be addressed in future research.

Remaining Questions:

- What are the real costs? They are currently high but should drop as the application becomes more widespread.
- Are these smart enough to avoid using strip heat on heat pumps?
- How can these be benchmarked?
- BPA is doing some field trials. Are they considering an incentive?
- Do the thermostats cycle fan off or slow the fan down to gain fan energy savings? Will that impact indoor air quality; are CO2 sensors needed?

Advanced Design Rooftop HVAC Unit-246	**Overall Score: 2.6**

Description:

The Advanced Design Rooftop HVAC Unit offers improved energy performance over the typical commercial rooftop unit by enhancing the performance of individual components and configurations, including fans, coils, filters, dampers, compressors, condensers, controls, and airflow path.

Recommendations:

1. Perform the following tasks with a prioritized, staged approach or perform a scoping study to clarify needed research and develop a prioritized, staged plan for future research within budget guidelines of BPA.
2. Clarify specific advanced features that should be considered as part of advanced RTUs or performance specifications that should be met for the research below.
3. Perform a market survey of product availability and sales data for various IEER levels and features.
4. Perform literature search for previous lab and field testing, making calls to appropriate organizations such as manufacturers, utilities, and research organizations.
5. Estimate distribution of cooling loads in representative regional applications.
6. Define appropriate baseline systems for variable applications.
7. Clarify variables and research questions; how much savings can be expected, how well do economizer integrated controls impact savings, how are economizers being controlled, etc. Establish priorities for limited research funding.
8. Perform simulation of energy savings potential, improving models, and partnering with California Energy Commission (CEC) or Western Cooling Efficiency Center.
9. Develop a lab test standard specific to the Pacific Northwest; investigate and build on work done previously by the Advanced Energy Corporation (AEC), Consortium for Energy Efficiency (CEE), the US Department of Energy, the US Environmental Protection Agency, American Council for an Energy-Efficient Economy, and CEC's Public Interest Energy Research (PIER).
10. Explore and quantify persistence of energy savings and user impacts on persistence, such as control settings.
11. Identify or develop a recognized performance labeling system (i.e. similar to Energy Star) that provides flexibility for manufacturers to demonstrate compliance.
12. Explore and clarify non-energy benefits as well as impacts on equipment life and maintenance; quantify as possible.
13. Analyze savings potential beyond Energy Efficiency Rating (EER) and IEER using lab testing, possibly partnering with labs at California utilities or elsewhere to measure performance at base loads. Then take field measurements, do simulations using expected value method for expected savings potential with various building types and at a range of loads.
14. Clarify which advanced features are responsible for energy savings and how feature impacts interact.
15. Provide a prescriptive specification with compliance paths that can be incentivized.
16. Based on the results of the savings analysis, provide utility incentives for new construction and replacement applications.

Remaining Question:

- What happened with the work in this area done by AEC, CEE, and PIER and why were they apparently not successful?

E3T 2010 HVAC Technical Advisory Group Members, Partners, and Staff

First Name	Last Name	Organization	City	Status
Carrie	Nelson	BPA Energy Efficiency, Planning & Evaluation	Portland, OR	BPA Partner
Charlie	Grist	Northwest Power and Conservation Council	Portland, OR	Member
Danielle	Gidding	BPA Energy Efficiency, Planning & Evaluation	Portland, OR	BPA Partner
David	Hatfield	Sacramento Municipal Utility District	Sacramento, CA	Member, joined Aug 2010
David	Springer	Davis Energy Group	Davis, CA	Member
Jack	Callahan	BPA Energy Efficiency, Engineering Services	Portland, OR	Member, BPA E3T Lead
Jared	Sheeks	MacDonald Miller Engineers	Seattle, WA	Member
Jeff	Harris	Northwest Energy Efficiency Alliance	Portland, OR	NEEA Partner
Joel	Jackman	Puget Sound Energy	Bellevue, WA	Member
KC	Spivey	Pacific Gas & Electric	San Francisco, CA	Member
Keith	Elder	Coffman Engineers, Inc.	Seattle, WA	Member
Mark	Cherniack	New Buildings Institute	White Salmon, WA	Member, joined Jun 2010
Mark	Firestone	PAE Consulting Engineers	Portland, OR	Member
Mark	Rehley	Northwest Energy Efficiency Alliance	Portland, OR	NEEA Partner
Mary Ann	Piette	Lawrence Berkeley National Lab	Berkeley, CA	Member
Michael	Lubliner	WSU Energy Program	Olympia, WA	Member
Mira	Vowles	BPA Energy Efficiency, Engineering Services	Portland, OR	Member, BPA E3T Staff
Paul	Delaney	Southern California Edison	Irwindale, CA	Member
Peter	Alspach	Arup	Seattle, WA	Member
Phoebe	Warren	Seattle City Light	Seattle, WA	Member
Reid	Hart	PECI, Inc.	Portland, OR	Member, joined Jun 2010
Robert	Carver	NYSERDA	Troy, NY	Member
Tom	Yim	BC Hydro	Burnaby, BC	Member
Xudong	Wang	Air-Conditioning, Heating & Refrigeration Inst.	Arlington, VA	Member
Alan	Mountjoy-Venning	WSU Energy Program	Olympia, WA	E3T staff
Doug	Koenen	WSU Energy Program	Olympia, WA	E3T staff
Jack	Zeiger	WSU Energy Program	Olympia, WA	E3T TAG Lead
Rob	Penney	WSU Energy Program	Olympia, WA	E3T Manager

Unless otherwise indicated, HVAC TAG members joined in March of 2009

E3T 2010 HVAC TAG Meeting Rosters

TAG members include busy professionals with tight schedules. The E3T program appreciates the work done by all TAG members, and understands that it is often difficult to select a date for meetings that work for all members.

Listed in this section are rosters for those participating in TAG sessions, and indications of survey participation. Note that most E3T staff members are not expected to participate in the Ranking or Scoring surveys. Unless otherwise indicated Doug Koenen served as the facilitator for E3T 2010 HVAC TAG meetings and Rob Penney served as recorder.

There are numerous ways for members to participate in addition to the scheduled meetings, chief among them developing the information in the E3TNW.org database of emerging energy efficiency technologies. We also greatly appreciate those who bring new technologies to our attention and those willing to serve as presenters during TAG sessions.

E3T 2010 HVAC Technical Advisory Group

June 10, 2010 Identification Meeting Participants and Guests

NAME	ORGANIZATION	LOCATION	JUNE 10, 2010
Jack Callahan	BPA Energy Efficiency, Engineering Services	Portland, OR	Web conference
Robert Carver	NYSERDA	Troy, NY	Web conference
Mark Cherniack	New Buildings Institute	White Salmon, WA	Web conference
Paul Delaney	Southern California Edison	Irwindale, CA	Web conference
Mark Firestone	PAE Consulting Engineers	Portland, OR	Web conference
Charlie Grist	Northwest Power and Conservation Council	Portland, OR	Web conference
Reid Hart	PECI, Inc.	Portland, OR	Web conference
Joel Jackman	Puget Sound Energy	Bellevue, WA	In person
Doug Koenen	WSU Energy Program; E3T staff	Olympia, WA	In person
Michael Lubliner	WSU Energy Program	Olympia, WA	Web conference
Alan Mountjoy-Venning	WSU Energy Program; E3T staff	Olympia, WA	In person
Rob Penney	WSU Energy Program; E3T staff	Olympia, WA	In person
Mark Rehley	NEEA	Portland, OR	Web conference
Jared Sheeks	MacDonald Miller Engineers	Seattle, WA	In person
KC Spivey	Pacific Gas & Electric	San Francisco, CA	Web conference
David Springer	Davis Energy Group	Davis, CA	Web conference
Mira Vowles	BPA Energy Efficiency, Engineering Services	Portland, OR	Web conference
Phoebe Warren	Seattle City Light	Seattle, WA	In person
Jack Zeiger	WSU Energy Program; E3T staff	Olympia, WA	In person

E3T 2010 HVAC Technical Advisory Group

June 29, 2010 Ranking Review Meeting Participants and Guests

NAME	ORGANIZATION	LOCATION	AUGUST 26, 2010	SURVEY PARTICIPANT
Peter Alspach	Arup	Seattle, WA	Unable to attend	y
Jack Callahan	BPA Energy Efficiency, Engineering Services	Portland, OR	Web conference	y
Robert Carver	NYSERDA	Troy, NY	Web conference	y
Mark Cherniack	New Buildings Institute	White Salmon, WA	Web conference	y
Keith Elder	Coffman Engineers, Inc.	Seattle, WA	Unable to attend	y
Mark Firestone	PAE Consulting Engineers	Portland, OR	Web conference	y
Reid Hart	PECI, Inc.	Portland, OR	Web conference	y
Joel Jackman	Puget Sound Energy	Bellevue, WA	In person	y
Doug Koenen	WSU Energy Program; E3T staff	Olympia, WA	In person	
Michael Lubliner	WSU Energy Program	Olympia, WA	Web conference	y
Alan Mountjoy-Venning	WSU Energy Program; E3T staff	Olympia, WA	In person	
Rob Penney	WSU Energy Program; E3T staff	Olympia, WA	In person	
Mark Rehley	NEEA	Portland, OR	Web conference	y
Jared Sheeks	MacDonald Miller Engineers	Seattle, WA	In person	y
KC Spivey	PG&E	San Francisco, CA	Web conference	y
David Springer	Davis Energy Group	Davis, CA	Web conference	y
Mira Vowles	BPA Energy Efficiency, Engineering Services	Portland, OR	Web conference	y
Phoebe Warren	Seattle City Light	Seattle, WA	In person	y
Tom Yim	BC Hydro	Burnaby, BC	Unable to attend	y
Jack Zeiger	WSU Energy Program; E3T staff	Olympia, WA	In person	

E3T 2010 HVAC Technical Advisory Group

August 10, 2010 Scoring Meeting Participants

NAME	ORGANIZATION	LOCATION	AUG 10, 2010	SURVEY PARTICIPANT?
Jack Callahan	BPA Energy Efficiency, Engineering Services	Portland, OR	Web conference	
Robert Carver	NYSERDA	Troy, NY	Web conference	y
Mark Cherniack	New Buildings Institute	White Salmon, WA	Web conference	
Paul Delaney	Southern California Edison	Irwindale, CA	Web conference	y
Tom Yim	BC Hydro	Burnaby, BC	Unable to attend	
Mark Firestone	PAE Consulting Engineers	Portland, OR	Web conference	y
Reid Hart	PECI, Inc.	Portland, OR	Web conference	y
Joel Jackman	Puget Sound Energy	Bellevue, WA	Web conference	y
Doug Koenen	WSU Energy Program; E3T staff	Olympia, WA	In person	
Alan Mountjoy-Venning	WSU Energy Program; E3T staff	Olympia, WA	In person	
Rob Penney	WSU Energy Program; E3T staff	Olympia, WA	In person	
Jared Sheeks	MacDonald Miller Engineers	Seattle, WA	Web conference	
KC Spivey	PG&E	San Francisco, CA	Web conference	
David Springer	Davis Energy Group	Davis, CA	Web conference	y
Mira Vowles	BPA Energy Efficiency, Engineering Services	Portland, OR	Web conference	y
Phoebe Warren	Seattle City Light	Seattle, WA	Web conference	y
Jack Zeiger	WSU Energy Program; E3T staff	Olympia, WA	In person	

E3T 2010 HVAC TAG Meeting Rosters

E3T 2010 HVAC Technical Advisory Group

August 26, 2010 Recommendations Meeting #1 Participants

NAME	ORGANIZATION	LOCATION	AUG 26, 2010
Peter Alspach	Arup	Seattle, WA	Web conference
Jack Callahan	BPA Energy Efficiency, Engineering Services	Portland, OR	Web conference
Robert Carver	NYSERDA	Troy, NY	Web conference
Mark Cherniack	New Buildings Institute	White Salmon, WA	Web conference
Paul Delaney	Southern California Edison	Irwindale, CA	Unable to attend
Charlie Grist	Northwest Power and Conservation Council	Portland, OR	Web conference
Reid Hart	PECI, Inc.	Portland, OR	Web conference
David Hatfield	Sacramento Municipal Utility District	Sacramento, CA	Web conference
Joel Jackman	Puget Sound Energy	Bellevue, WA	Web conference
Doug Koenen	WSU Energy Program; E3T staff	Olympia, WA	In person
Alan Mountjoy-Venning	WSU Energy Program; E3T staff	Olympia, WA	In person
Rob Penney	WSU Energy Program; E3T staff	Olympia, WA	In person
KC Spivey	PG&E	San Francisco, CA	Web conference
Mira Vowles	BPA Energy Efficiency, Engineering Services	Portland, OR	Web conference
Phoebe Warren	Seattle City Light	Seattle, WA	Web conference
Jack Zeiger	WSU Energy Program; E3T staff	Olympia, WA	In person

E3T 2010 HVAC Technical Advisory Group

September 16, 2010 Recommendations Meeting #2 Participants

NAME	ORGANIZATION	LOCATION	SEP 16, 2010
Doug Koenen	WSU Energy Program; E3T staff	Olympia, WA	In person
Alan Mountjoy-Venning	WSU Energy Program; E3T staff	Olympia, WA	In person
Rob Penney	WSU Energy Program; E3T staff	Olympia, WA	In person
Jack Zeiger	WSU Energy Program; E3T staff	Olympia, WA	In person
Robert Carver	NYSERDA	Troy, NY	Web conference
Reid Hart	PECI, Inc.	Portland, OR	Web conference
Joel Jackman	Puget Sound Energy	Bellevue, WA	Web conference
Michael Lubliner	WSU Energy Program	Olympia, WA	Web conference
KC Spivey	Pacific Gas & Electric	San Francisco, CA	Web conference
Phoebe Warren	Seattle City Light	Seattle, WA	Web conference