Bonneville Power Administration

Measure Summary Report:
Web-Enabled Programmable Thermostats

February 2011

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Executive Summary

Web-enabled programmable thermostats (WEPT) allow users to modify temperature set points and HVAC controls remotely using the Internet. Building owners can use WEPT to help optimize heating energy use without having to make physical site visits to manually re-program thermostats. WEPT applies to medium and small commercial buildings without direct digital control (DDC) systems.

A variety of case studies utilizing WEPT have recently been performed in the Northwest. These case studies show that WEPT can save significant amounts of electricity (32-47%) in small commercial building applications. Table ES 1 shows the percent savings for each case study.

ES 1 - WEPT Savings Estimate by Manufacturer

Manufacturer	Percent Savings	Heat Type	Source	Info
Honeywell	30%	Various	Specification Sheet	http://customer.honeywell.com/techlit/pdf/63-0000s/63-9093.pdf
DreamWatts	10-15%	Rooftop units	Portland State Business Accelerator Building	http://PowerMand.com/case-studies
DreamWatts	33%	Rooftop units	MacDonald-Miller Lower Building, Seattle	David Nieman, MMFS
Proliphix	20%	Various	AAA Case Study	http://www.proliphix.com/Collateral/Documents/English-US/case_studies/CSC(AAA)Case%20Study_Rev1.pdf
Proliphix	40-60%	Electric	Evergreen School District	David Cone, Evergreen School District

The Evergreen School District in Vancouver, WA pilot study included web-enabled thermostats installed in 30 electrically heated portable classrooms buildings (60 classrooms). The savings in these school portables were between 40 and 60% of total electricity consumption. This represents about 1900 kWh of savings per portable unit, or about 1.7 kWh per square foot of portable floor space.

In general, installed cost of a WEPT system ranges between $500 and $1000 per thermostat, plus an annual monitoring/maintenance fee of $200-$300 per year. The results show that with these measure assumptions, a measure life of close to 5 years is needed for cost effectiveness. The measure data including benefit cost ratios are shown in Table ES 2.

ES 2 – Cost Effectiveness for WEPT in Portable Classrooms (Units are Per Square Foot of Floor Area)							
Measure	Measure Life	Site Savings (kWh)	Site Savings (therms)	Capital Cost ($/unit)	Annual O&M Cost ($/unit)	TRC B/C Ratio	TRC Net Levelized Cost (Net of All Benefits) in mills/kWh
WEPT	1.0	1.7	0.0	0.64	-0.011	0.2	362.2
WEPT	3.0	1.7	0.0	0.64	-0.011	0.7	83.8
WEPT	5.0	1.7	0.0	0.64	-0.011	1.2	28.2
WEPT	7.0	1.7	0.0	0.64	-0.011	1.6	4.5
WEPT	9.0	1.7	0.0	0.64	-0.011	1.9	-8.6
WEPT	11.0	1.7	0.0	0.64	-0.011	2.3	-16.9

The savings values can be used to estimate regional potential, by applying them to square footage of applicable building floor space. The per-unit savings values range from 0.32 kWh/sf (small office with heat pump) to the 1.7 kWh/sf in school portables. WEPT is applicable to a narrow range of commercial buildings, including school portables, small offices, small retail, lodging, and other health facilities. Methodologies and selected applicability assumptions from the Sixth Power Plan were used to roll up the unit savings into BPA's share of regional potential, shown in Table ES 3.

ES 3 – Total BPA Savings Potential by Commercial Building Type						
	5 Year Potential aMW			**20 Year Potential aMW**		
	Retrofit	New	Total	Retrofit	New	Total
TOTAL	0.65	0.09	0.73	4.17	0.55	4.73

This report summarizes available information regarding WEPT and provides some initial potential and cost-effectiveness estimates. The results of early pilot studies and field test indicate promising energy savings (32-47% in small commercial building applications). However, continued research and evaluation are needed to better understand the savings, applications, and costs for WEPT. As with any controls or commissioning type measure, it is often difficult to ensure reliable savings. WEPT has an advantage of being targeted for small, well defined applications (e.g., single meter) which enable quality M&V.

1 Introduction

Objective

The objective of this report is to provide a summary of available energy efficiency related information regarding the web-enabled programmable thermostat (WEPT). In addition, the total regional energy efficiency potential (and BPA share) is estimated based on available data. These estimates are provided as a proxy to indicate the relative magnitude of the measure's potential.

Background

The WEPT technology makes it possible to adjust HVAC setpoints and schedules from a remote location. This feature can save energy in all geographical locations in small commercial buildings with single zone packaged or split systems. It is a bridge between stand-alone thermostats and a direct digital (DDC) system.

WEPT is a good fit for small commercial buildings with single zone systems where the building owner or maintenance team resides at a remote location. The WEPT technology enables building owners to much more effectively monitor and control temperature setpoints. Benefits of WEPT include cost savings from reduced energy consumption as well as possible maintenance labor savings.

One of the primary applications for the WEPT technology is school classroom portables. These units are often individually metered (or several classrooms on one meter), and they are notorious for having thermostats incorrectly programmed, reset, or set to run full time. Therefore, BPA is conducting research to verify savings for these applications. Other potentially good applications are places of assembly such as movie theaters and small retail spaces remotely by a property management company.

2 WEPT Technology

Technology Description

Web-enabled programmable thermostats (WEPT) are devices that allow users to modify temperature set points and HVAC controls remotely. WEPT applies to medium and small commercial buildings); this type of facility usually doesn't have a digital (DDC) system. Typically, they are buildings less than 100,000 square feet, but vendors and installers generally target buildings less than 40,000 square feet (Neiman, 2011). Note that WEPT are information and control devices that require human input to achieve savings. A diagram of one WEPT configuration is shown in Figure 1.

Figure 1 – WEPT Configuration
(Source: PowerMand)

How It Saves Energy

Thermostats in general can help reduce energy consumption in a building by controlling HVAC systems to run less during unoccupied times. However, because energy savings depend on setting the unoccupied times and occupants are rarely responsible for reducing energy use, these settings are seldom a priority. The WEPT enables much easier access to the thermostat settings and can result in more optimized settings and higher energy savings. However, the persistence of the savings relies on someone monitoring the settings, either through a service contract or an energy manager.

For measurement and verification purposes, it is best if the WEPT measure is utilized with single-zoned systems without sensors or variable air volume systems.

Competing or Overlapping Technologies

The Pacific Northwest has a variety of efforts underway to improve the energy performance of rooftop HVAC systems. Better thermostat control, including the WEPT technology, can be an important aspect of optimizing rooftop system energy use. Measures such as Demand Controlled Ventilation, Energy Star rating, or other efforts that impact the HVAC energy consumption could impact the total savings available to WEPT. Regional savings potential for rooftop units are outlined in the Northwest Power and Conservation Council's 6th Power Plan (Sixth Plan) as 51 average megawatts[1].

Additionally, a well-monitored standalone programmable thermostat has the potential to compete with WEPT. For both, energy savings are a result of temperature setbacks. However, the web-enabled component of WEPT allows a resource manager to correct programming in real time and as needed from a remote location, which could result in deeper and more persistent savings.

Based on U.S. Department of Energy estimates, programmable thermostats save one percent of energy consumption per degree set-back per eight hours. Therefore, a thermostat set back by 10° each night, or up by 10° for eight hours each day during the cooling season, can be expected to produce a 10 percent annual energy savings (Karr, 2010). Higher savings will occur in more extreme climates.

The WEPT thermostats covered in this report do not include wireless pneumatic thermostats (WPT). WPT is a viable option for HVAC setback savings in larger commercial buildings with pneumatic control systems.

Commercial Availability

There are a variety of components associated with WEPT, from the thermostat alone to a full package that includes the thermostat as well as all communicating equipment, data storage, and monitoring services. Two key cost drivers are the number of gateways that are installed and data hosting fee; this system design not only affects the cost, but it can also affect how easy it is to program the thermostats remotely. A few of these options are summarized below:

- DreamWatts
- Honeywell – T7300
- Proliphix – Uniphy Professional Series

Dreamwatts

PowerMand, Inc. offers a packaged called DreamWatts that includes software, hardware, and service for automating small commercial building HVAC. DreamWatts is able to support any communicating thermostat (WEPT), but primarily supports the Robertshaw 9825I2 and the Temco Controls Tstat5 thermostats. The DreamWatts Solution provides the following:

[1] This value comes from the "*Summary Tables"* Sixth Plan commercial supply curve file.

- ZigBee(R) radio-enabled thermostats
- Internet gateway (called DreamWay)
- Commercially hosted data center
- Any client device with web access (PC / MAC, laptop, smart-phone etc) can be used to access a DreamWatts account, modify settings, create and maintain custom energy management profiles, examine monitored data and manage alerts.
- All communication is bi-directional

Supported Thermostats

RobertShaw 9825I2 Deluxe Programmable Thermostat

Temco Controls Tstat5 Communicating Thermostat

Honeywell T7350

The Honeywell T7350 thermostat is very common and is installed in many Northwest commercial buildings. The newest version of the T7350H includes remote communication features. This is the premium model of the 7350D, which does not include internet cabailities. Honeywell plans to offer web communication on more inexpensive models in the future. Communicating Thermostat can be accessed on a network through your PC, via modem. The LonStat® software allows remote adjustment to schedules, set points and overrides through the WebStat controller.

The T7350H is well suited to retrofit applications. It can function as a standalone programmable thermostat initially, or can be upgraded to web control in the future if WebStat gateways are installed. Some building, specifically Beaverton Public Schools, are approaching WEPT in this manner to minimize the initial cost.

Proliphix

Proliphix offers their Energy Control Solution (ECS) which is comprised of three components:

- Energy Manager Software

- Internet-Managed Thermostats
- Monitoring Services

IMT550c/w

The IMT 550 is the newest version of the Proliphix Network Thermostat. The IMT550w connects to a data network through 802.11b/g WiFi. The IMT550c can also connect via wired Ethernet for traditional installation or in areas where WiFi signal strength may be degraded by environmental influences. The IMT550 Network Thermostats provide remote monitoring and control of temperature and humidity. The IMT550 thermostats can handle up to 3 stages of heat and 2 stages of A/C.

The IMT550 supports three external wired sensors which can be used to sense temperature or dry contact closures from external equipment. Each of these sensors can provide independent alarms via email or text message notification when pre-set threshold conditions are exceeded. Two auxiliary relays are also supported to enable customers to control additional equipment.

Model	**Price**
IMT550c	$545
IMT550w	$595

Uniphy Professional Series

Un*ip*hy Professional Series, models NT120, NT130, NT150, and NT160, are the original Proliphix web-enabled thermostats for commercial applications. Facility managers can remotely manage network thermostats over the Internet using a Web browser. The thermostats support dual-stage, fossil fuel or heat pump (with auxiliary heat) HVAC systems and derive power via Ethernet ("e" designation) or via HVAC system ("h" designation). The thermostat can support two external wired sensors.

These thermostats feature internet browser-based configuration and control over a secure Ethernet connection (no wi-fi). In addition to remote configuring and monitoring, the thermostats have the ability to deliver e-mail status alerts.

There are numerous other brands and manufacturers of WEPT devices and supporting systems, including Ecobee, Bay Controlls, LLC, and X300 (ControByWeb.com). Most of these are being marketed to the residential market but could also be used or adapted for small commercial applications.

3 Measure Data

Measure Savings

Savings estimates are provided in Table 1. The range of savings is 10-60% of space conditioning energy consumption, which is both a large magnitude and range of potential savings. While these savings are not based on rigorous whole building modeling studies, they have been validated by individual pilot programs.

Table 1 - WEPT Savings Estimate by Manufacturer

Manufacturer	Percent Savings	Heat Type	Source	Info
Honeywell	30%	Various	Specification Sheet	http://customer.honeywell.com/techlit/pdf/63-0000s/63-9093.pdf
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Proliphix	40-60%	Electric	Evergreen School District	David Cone, Evergreen School District

One of the best pilot studies for WEPT in the Northwest was the Evergreen School District in Vancouver, Washington. The school district installed web-enabled thermostats on 30 electrically heated portable classrooms buildings (60 classrooms). Based on a Measurement and Verification calculator, savings in these school portables were between 40 and 60% of total electricity consumption. This represents about 1900 kWh per portable unit, or about 1.7 kWh per square foot of portable floor space.

A more detailed description of the program and its results is included in a subsequent section.

Figure 2 shows estimated energy savings for WEPT installation in different climate regions on a nationwide basis (source: Honeywell). These graphs show that WEPT can save up to 13% of heating energy and up to 18% of cooling energy in the Northwest.

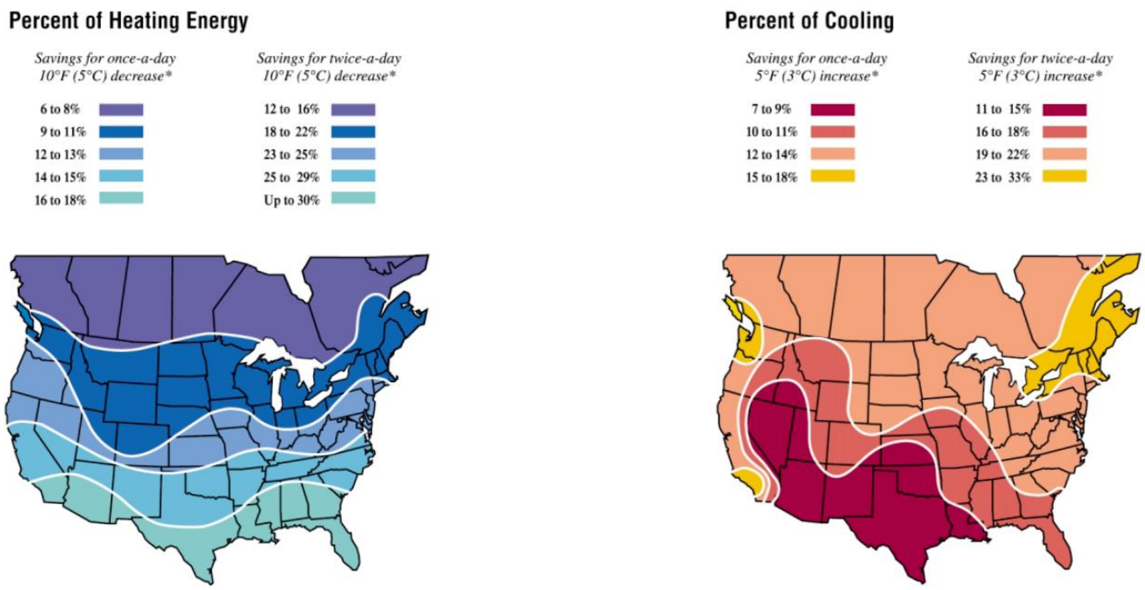

Figure 2 – Heating and Cooling Savings from WEPT
(Source: Honeywell)

Measure Life

The thermostat will last about 15 years. However, since this measure includes a heavy behavioral and monitoring component, the measure life will depend more on utility program design or the long term monitoring contract, rather than the equipment life. An estimated minimum 4-5 year measure life may be required for cost effectiveness.

Measure Costs

Potential costs for WEPT installation vary not only by vendor and model, but also by building type, dealer markup, contractor and volume pricing. Below are equipment cost estimates from three primary vendors, Proliphix, PowerMand and Honeywell. Based on the data from these three manufacturers, the installed cost of a WEPT system ranges between $500 and $1000 per thermostat, plus an annual monitoring/maintenance fee of $200-$300 per year. Table 2 summarizes the price points for major manufactures included in this report. Note that most web-enabled system requires a centralized gateway, with the exception of the Proliphix system.

Table 2 - WEPT Cost Estimate by Manufacturer

Manufacturer	Thermostat Model	Thermostat Cost	Gateway Cost	Thermostats per Gateway	Per Unit Installed Cast	Annual Subscription (Per Installation)
Powermand/ DreamWatts	RobertShaw 9825i2	$200	$300	10	$500-$765	$200-$300
Proliphix	IMT550c, IMT550w	$545-$595	N/A	N/A	$500-$1000	$200-$300
Honeywell	7350H	$500	$1,000	20	$500-$1000	$0

Below is a more detailed description of specifics and installed cost for each manufacturer.

PowerMand/DreamWatts

PowerMand's DreamWatt system consists of three main components: a thermostat, an Internet Gateway (DreamWay) that collects thermostat data using the ZigBee platform and PowerMand's commercially hosted data center services. Each component of the WEPT system has an associated base cost:

- PowerMand predominantly uses a RobertShaw 9825i2 communicating thermostat at a cost of $200.
- The Internet Gateway costs $300 and can operate up to 10 thermostats.
- The annual subscription fee for the total installation costs an average of $200-$300 per year.

Installation costs are highly variable and must consider factors specific to each building. However, PowerMand provided the following cost information for two recent installations:

1) 14 thermostats and two DreamWay gateways were installed for a total cost of roughly $7000, for an installed cost of $500 per unit.

2) 23 thermostats and two DreamWay gateways were installed for a total cost of roughly $17,541, for an installed cost of $765 per unit.

Proliphix

Proliphix thermostats have an internal gateway and can be wired directly to an Ethernet connection. Proliphix thermostats were used in the Evergreen Public Schools, where estimated installed costs were $625 per unit. However, final installed cost was roughly $1,150 per thermostat. Thermostat-only prices are shown below:

- IMT550c – $545
- IMT550w – $595

Based on the data from these two manufacturers, the installed cost of a WEPT system ranges between $500 and $1000 per thermostat, plus an annual monitoring/maintenance fee of $200-$300 per year.

Honeywell

Honeywell manufactures the 7350H that is capable of web communication. This is the web-enabled version of the 7350D model. The estimated cost for the equipment is $500 per thermostat, which is a $100 cost premium over the 7350D. A WebStat gateway is required ($1000) and can be connected to 20 thermostats. Honeywell differs from other vendors in that there is no annual service fee and the software for building management is included (Nieman, 2011).

Other Cost-Effectiveness Parameters

Measure cost-effectiveness depends primarily on incremental capital cost, savings, and life. Below are brief descriptions of the other cost-effectiveness parameters used in the Council's ProCost model to determine regional (Total Resource Cost) cost effectiveness.

Load Shapes

The following load shapes were used in PROCOST for retrofit and new measures:

- EXCOMM - Existing Shell and HVAC Measures
- NEWCOMM – New Shell and HVAC Measures

Operation and Maintenance Cost or Savings

As indicated in Table 2, WEPT requires (in some cases) an annual subscription fee. For this analysis we used the average of the range, or $250 per year.

There is also a maintenance cost savings for using WEPT by avoiding trips by an off-site maintenance person to visit the site and re-set the thermostats. For this analysis it is assumed that two trips can be saved at a cost of $200 per trip (total = $400 per year). This results in a net O&M savings of $150 per year.

Non-Energy Benefits

There were no non-energy benefits quantified for this analysis.

Periodic Replacement Costs

There were no periodic replacement costs quantified for this analysis.

Gas Savings

The initial and best applications for WEPT are electrically heated, single-zone small commercial buildings. Therefore, gas savings are not quantified in this analysis. It is possible that future applications could include facilities with high cooling loads and gas heat, which would result in a need to quantify the gas savings.

Avoided Cost

The avoided cost used is the "Sixth Plan Mid-C Final" price forecast used in the Sixth Plan and approved by the RTF. In addition, the Risk Mitigation Credit of $43/MWh was used. This credit is added to the avoided cost and is representative of retrofit measures.

Cost Effectiveness

The Council's ProCost model was used to gain some initial insight into possible cost effectiveness ranges for WEPT. Table 3 summarizes cost-effectiveness for the WEPT measure in portable classrooms. In this example, the site savings are 1.7 kWh/sf per year, the cost is 0.64 $/sf, and the annual O&M savings is 0.011 $/sf per year. In this example, a range of measure life years was selected. The results show that with these measure assumptions, a measure life of close to 5 years is needed for cost effectiveness.

Table 3 – Cost Effectiveness for WEPT in Portable Classrooms
(Units are Per Square Foot of Floor Area)

Measure	Measure Life	Site Savings (kWh)	Site Savings (therms)	Capital Cost ($/unit)	Annual O&M Cost ($/unit)	TRC B/C Ratio	TRC Net Levelized Cost (Net of All Benefits) in mills/kWh
WEPT	1.0	1.7	0.0	0.64	-0.011	0.2	362.2
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WEPT	5.0	1.7	0.0	0.64	-0.011	1.2	28.2
WEPT	7.0	1.7	0.0	0.64	-0.011	1.6	4.5
WEPT	9.0	1.7	0.0	0.64	-0.011	1.9	-8.6
WEPT	11.0	1.7	0.0	0.64	-0.011	2.3	-16.9

This example was selected since the school portables case study carries the highest degree of confidence. In other applications, the preliminary estimates of savings are significantly lower, and would require a longer measure life for cost-effectiveness. Also consider that the cost estimate of $1150 per thermostat was used, which reflects the actual installed costs for the pilot study (Evergreen). However the projected costs are likely to be slightly lower, which will improve the cost-effectiveness. Other factors including increased value of avoided O&M would also increase the value of this measure.

4 Market

Applications

WEPT applies specifically to small to medium (less than 100,000 square feet) commercial facilities without direct digital (DDC) systems or variable air volume (VAV). Additionally, WEPT devices can only be installed in single zone applications with an existing wall thermostat Larger buildings with many zones could also be applicable, but must have individual zones with their own thermostat (Nieman, 2011, Needman, 2010). Electric savings are greatest in buildings with electric heat.

School portables and small-medium office buildings are the most logical applications for WEPT devices. Most case studies in the region are in these two building types. However, there are other buildings that meet the criteria outlined above from the Sixth Plan.

- Small retail
  - Strip malls
  - Small stores within larger enclosed mall environments
  - Space managed by an off-site property manager
  - Bank branch locations
- Assembly
  - Assembly common spaces
- Assembly
  - Common areas of nursing homes, doctor's offices

Specific applicability assumptions for the potential calculation are outlined in the Energy Efficiency Potential Section.

Market Barriers and Opportunities

WEPT devices are commercially available. The market channel is from the manufacturer to controls companies, to contractors, to the building owner. There are few barriers for obtaining the product. For example, Powermand is the vendor for the DreamWatts control system. They have distribution contracts with several contractors to design and install the system in buildings.

However, there is a barrier in terms of consumer acceptance and persistent savings. Many building owners do not see the inherent value in the web-enabled component of a thermostat. It is unclear if this is because building managers are uninterested in managing the setpoints, or simply unaware of the difference between a web-enabled thermostat and a programmable thermostat. Also, regular monitoring of settings is required for optimal savings. MacDonald Miller Facility Solutions is pioneering the business model of an HVAC service contractor actively marketing WEPT for persistent energy savings, improved comfort and remote trouble-shooting of rooftop units.

5 Energy Efficiency Potential

Codes and Standards

Programmable thermostats capable of nighttime setbacks are required by code for new construction or major retrofits in the Northwest. Similarly, in larger commercial spaces, DDC systems are required.

Codes are consistent between states in the Northwest. Below is an excerpt from the State of Washington non-residential building code, applicable in 2010:

> *1412.4 Setback and Shutoff: HVAC systems shall be equipped with automatic controls capable of accomplishing a reduction of energy use through control setback or equipment shutdown during periods of nonuse or alternate use of the spaces served by the system. The automatic controls shall:*
>
> *a. Have a minimum seven-day clock and be capable of being set for seven different day types per week,*
>
> *b. Be capable of retaining programming and time setting during loss of power for a period of at least ten hours, and*
>
> *c. Include an accessible manual override, or equivalent function (e.g., telephone interface), that allows temporary operation of the system for up to two hours.*

Codes do not require permanent setback operation or web-enabled capability. Therefore, all savings from WEPT are above current codes, or will result in capturing a higher degree of the savings intended by the code.

Applicability

WEPT is potentially applicable to a wide range of small commercial spaces. There are four main criteria for determining the best spaces for maximum electricity savings:

- Less <100,000 square feet (although most vendors believe <40,000 square feet is ideal)
- Single zone
- Existing wall thermostat
- Electric or heat pump heating

Additionally, measure savings come from effective management and are most effective when staff regularly monitors settings for optimal savings. Examples include, school portable classrooms, small retail spaces that are managed by a property company and theater chains with a resource manager. Specific applicability factors are addressed in the potential section.

Recent Experience

Evergreen Public Schools – Vancouver, WA

Evergreen Public School district installed WEPT devices in 60 portable classrooms in 2009. The district was initially leaning towards Honeywell as their vendor, but chose Proliphix. The primary benefit was a global controller and access to data from each device. Savings were estimated at 45-65% based on a linear regression forecast tool. There is no record of the model or settings of the thermostats previously in the building. In this example, the savings were 91,917 kWh per year (47% of consumption) in 30 portables with a total of 60 classrooms. Figure 3 shows the plot of baseline data (average kWh per day, vs. HDD per day) compared with the post data.

While the District considers the program a great success, there were several key lessons learned. First, there were installation problems coordinating between the internal IT department and HVAC technicians doing the installation. Also, costs were higher than initially budgeted. The initial cost was estimated at $625 per unit, but the actual cost was about $1,150. There were large energy savings, but a spike in morning in demand resulted from all units being programmed with the same start time. After this was discovered, staggering the start times solved this problem.

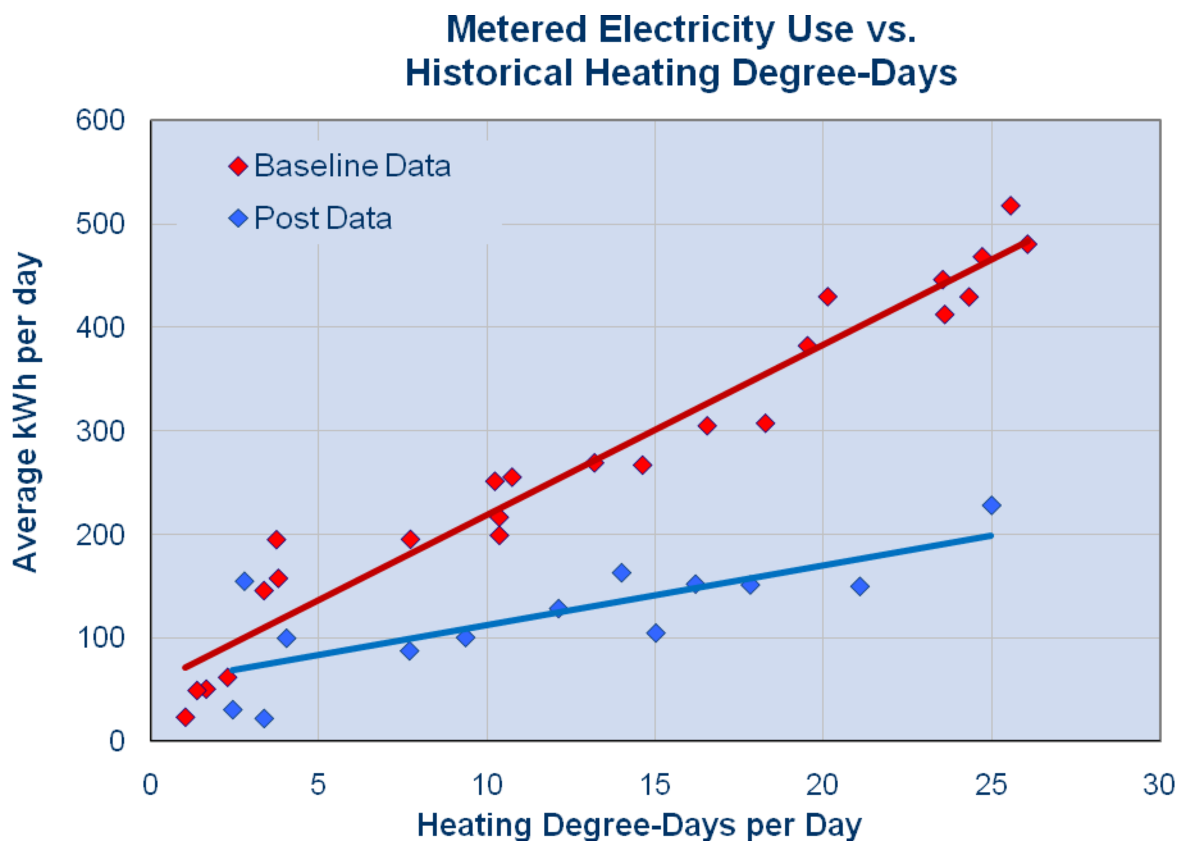

Figure 3 – Energy Consumption per HDD Regression for Evergreen Schools
(Koran, 2010)

Portland State Business Accelerator – Portland, OR

A recent Portland State University WEPT application includes 47,000 square feet of office space for 30 tenants. At the time of the pilot program, there were 30 individual rooftop units and 65 programmable thermostats.

Robertshaw 9825i2 web-enabled thermostats and two DreamWay gateways were installed on 14 common area thermostats, which represented 22% of the total building square footage. Two HVAC technicians installed the units in half a day and the total installed cost was roughly $7000.

Areas were defined with different temperature setpoints depending on usage. Two different general modes were created, one for occupied and unoccupied areas. Occupied areas were also sub-divided, with differing setpoints given to hallways, conference rooms and other common areas. Work holidays were scheduled and updated using unoccupied modes. Real-time temperature monitoring allowed management to adjust setpoints and schedules based on verified system run-times. Manually overrides in shared conference rooms were possible to adjust for thermal comfort, but only for two hours at a time.

According to PowerMand, the energy related costs were reduced 13% in the first 6 months using DreamWatts, or $.02 a square foot per month. It was also estimated that the building management saved an additional day of staff time in not having to reprogram thermostats.

MacDonald-Miller – Seattle, WA

MacDonald-Miller Facility Solutions installed the DreamWatts system in the Lower Building in Seattle, WA. 14 thermostats controlled single zone rooftop units and produced a 33% annual electric savings.

Market Saturation

Market saturation of WEPT is low in the Northwest, primarily due to low consumer acceptance and cost barrier for DDC retrofits in larger commercial buildings. While there are likely some WEPT devices installed in the region, for estimates of potential, saturations in applicable buildings are assumed to be zero.

Achievable Potential Estimates

While manufacturers claim large savings and wide applicability, savings from WEPT installations are difficult to verify and deem indefinitely. A responsible energy manager or service contract is necessary, so savings potential estimates for the region rely on the limited program experience in the Northwest. The calculated regional savings assumes that there is regular monitoring of settings for persistent savings over the measure life.

The best program example is Evergreen Public school district. In conjunction with Clark Public Utilities, Evergreen installed WEPT in 30 portable buildings (two classrooms per building, 60 classrooms). Based on a weather-adjusted linear regression model, there was a 47% savings among all sites (91,917 kWh)[2]. Note that these savings are for electric heating units, which are common in portable classrooms (Cone, 2010). The average size of the portable classrooms in this pilot study is 900 sf per classroom[3]. Therefore, the total conditioned space is 54,000 square feet, which makes the total savings 1.7 kWh/sq ft for electrically heated portable classrooms.

The savings estimates generated from Evergreen Public Schools test can be used to help estimate the regional potential, by applying it to square footage of portable buildings in the region. The potential savings are large on a square footage basis, but only applicable to a very narrow range of commercial buildings, and require a dedicated resource manager that can control the WEPT devices and monitor their status. Therefore, for this analysis, it is assumed that savings seen in the Evergreen Public Schools are applicable to school portables only.

In other building types, a percentage savings from baseline was used to calculate potential savings. Electric and heat pump systems maximize electric WEPT savings. Energy Use Intensity

[2] Source: "Evergreen School District Portable Classroom Thermostats Analysis-10-5-10.xlsx"

[3] On average, a portable classroom is 900 square feet (Holden, 2005, Tanner, 2000).

(EUI) is shown in Table 4 for each commercial building category in the Sixth Plan[4]. Retrofit savings in school portables are custom based on the Evergreen Public Schools data, while other building types use a 32% savings from the Dreamwatts installation in the MacDonald-Miller Building in Seattle[5].

Table 4 – Savings by Building Type, Retrofit

	Baseline Consumption (kWh/sq.ft.)		Percentage Savings Assumption	Savings (kWh/sq. ft.)	
	Electric Heat	Heat Pump		**Electric Heat**	**Heat Pump**
Large Office	2	1		**0**	**0**
Medium Office	2	1		**0**	**0**
Small Office	2	1	32%	**0.64**	**0.32**
Big Box	2	1		**0**	**0**
Small Box	2.2	1.1	32%	**0.704**	**0.352**
High End	3	1.5	32%	**0.96**	**0.48**
Anchor	3	1.5		**0**	**0**
K-12	3	1.5	CUSTOM	**1.7**	**0.71**
University	4	2		**0**	**0**
Warehouse	2	1		**0**	**0**
Supermarket	5	2.5		**0**	**0**
Mini Mart	4	2		**0**	**0**
Restaurant	4	2		**0**	**0**
Lodging	4	2	32%	**1.28**	**0.64**
Hospital	6	3		**0**	**0**
Other Health	5	2.5	32%	**1.6**	**0.8**
Assembly	4	2		**0**	**0**
Other	4	2		**0**	**0**

[4] These values come from the *"Commercial Master"* supply curve file.

[5] Source: "Lower Building Report 2010.xls"

Table 5 shows WEPT savings for new construction, separated by commercial building type. A lower percentage savings is assumed for new buildings (15%) as compared to retrofit project. This is based on the Portland State Business Accelerator Building case study. Again, savings for school portables are custom.

Table 5 – Savings by Building Type, New Construction					
	Baseline Consumption (kWh/sq.ft.)		Percentage Savings Assumption	**Savings (kWh/sq. ft.)**	
	Electric Heat	Heat Pump		**Electric Heat**	**Heat Pump**
Large Office	2	1		**0**	**0**
Medium Office	2	1		**0**	**0**
Small Office	2	1	15%	**0.3**	**0.15**
Big Box	2	1		**0**	**0**
Small Box	2.2	1.1	15%	**0.33**	**0.165**
High End	3	1.5	15%	**0.45**	**0.225**
Anchor	3	1.5		**0**	**0**
K-12	3	1.5	CUSTOM	**1.7**	**0.71**
University	4	2		**0**	**0**
Warehouse	2	1		**0**	**0**
Supermarket	5	2.5		**0**	**0**
Mini Mart	4	2		**0**	**0**
Restaurant	4	2		**0**	**0**
Lodging	4	2	15%	**0.6**	**0.3**
Hospital	6	3		**0**	**0**
Other Health	5	2.5	15%	**0.75**	**0.375**
Assembly	4	2		**0**	**0**
Other	4	2		**0**	**0**

Table 6 shows percentages in each of the Sixth Plan commercial building categories that are applicable to WEPT savings. There are separate applicabilities for electric and heat pump heat baseline consumption. Applicability refers to the percentage of square footage in that building category that is applicable to the shown savings. For example, 5.3% of Small Box Retail square footage in the region can technically achieve savings from WEPT using heat pumps as a baseline (0.352 kWh/sq.ft.).

These percentages are calculated using heat type percentage from the Sixth Plan[6] and single zone and thermostat percentages from NEEA's 2006 *Baseline Characteristics of the 2002-2004*

[6] These values come from the Characteristics tab in the "*Commercial Master"* commercial supply curve file.

Nonresidential Sector: Idaho, Montana, Oregon, and Washington. The percent thermostats refers to the percentage of floor space that is not controlled by DDC systems (NEEA, 2006). As stated previously, commercial spaces must be electrically heated, single zoned, and controlled by a thermostat to be applicable to WEPT savings. Therefore, the applicability factor is calculated by:

Heat Type % **x** Thermostat % **x** Single Zone % **=** Applicability Factor

K-12 applicability factors differ slightly from this formula. The applicability factors represent the percentage of school square footage that is in portable classrooms only. It was calculated that 8.3% of school square footage in the region is in school portable. This assumption reflexes the high applicability for WEPT in schools and is confirmed by discussions with school facility managers in the Northwest (Cone, 2010; Miller, 2010; Tyler, 2010).

Table 6 – Applicability Factors by Building Type

	Percent of Buildings				**TOTAL**	
	Electric Heat	Heat Pump	Thermostat Control	Single Zone	**Electric Heat**	**Heat Pump**
Large Office	52.1%	9.5%	45.0%	48.3%		
Medium Office	26.3%	23.0%	45.0%	48.3%		
Small Office	21.3%	21.6%	45.0%	48.3%	**5%**	**5%**
Big Box	2.3%	18.3%	45.0%	84.7%		
Small Box	18.9%	13.9%	45.0%	84.7%	**7%**	**5%**
High End	16.8%	9.4%	45.0%	84.7%	**6%**	**4%**
Anchor	18.8%	28.8%	45.0%	84.7%		
K-12	CUSTOM		CUSTOM		**8.3%**	
University	9.3%	9.3%	45.0%	27.7%		
Warehouse	9.5%	8.1%	45.0%	46.2%		
Supermarket	14.0%	17.6%	45.0%	88.2%		
Mini Mart	12.4%	5.6%	45.0%	88.2%		
Restaurant	8.6%	10.5%	45.0%	100.0%		
Lodging	38.6%	24.3%	45.0%	63.2%	**11%**	**7%**
Hospital	3.0%	1.0%	45.0%	5.0%		
Other Health	32.8%	7.6%	45.0%	28.7%	**4%**	**1%**
Assembly	12.8%	13.1%	45.0%	74.0%		
Other	12.7%	13.0%	45.0%	85.8%		

Table 7 shows a matrix of savings, life and applicability factors for WEPT in retrofit projects under different heat types. Table 8 is a similar matrix for new construction. As programs improve, data from other sectors can be added.

Table 7 – WEPT Matrix, Retrofit

		Electric Heat			Heat Pump		
		Life	Savings (kWh/sq. ft.)	% Applicability	Life	Savings (kWh/sq. ft.)	% Applicability
Large Office	Retrofit	15	0	0.0%	15	0	0.0%
Medium Office	Retrofit	15	0	0.0%	15	0	0.0%
Small Office	Retrofit	15	0.64	4.6%	15	0.32	4.7%
Big Box	Retrofit	15	0	0.0%	15	0	0.0%
Small Box	Retrofit	15	0.704	7.2%	15	0.352	5.3%
High End	Retrofit	15	0.96	6.4%	15	0.48	3.6%
Anchor	Retrofit	15	0	0.0%	15	0	0.0%
K-12	Retrofit	15	1.7	4.2%	15	0.71	4.2%
University	Retrofit	15	0	0.0%	15	0	0.0%
Warehouse	Retrofit	15	0	0.0%	15	0	0.0%
Supermarket	Retrofit	15	0	0.0%	15	0	0.0%
Mini Mart	Retrofit	15	0	0.0%	15	0	0.0%
Restaurant	Retrofit	15	0	0.0%	15	0	0.0%
Lodging	Retrofit	15	1.28	11.0%	15	0.64	6.9%
Hospital	Retrofit	15	0	0.0%	15	0	0.0%
Other Health	Retrofit	15	1.6	4.2%	15	0.8	1.0%
Assembly	Retrofit	15	0	0.0%	15	0	0.0%
Other	Retrofit	15	0	0.0%	15	0	0.0%

Table 8 – WEPT Matrix, New Construction

		Electric Heat			Heat Pump		
		Life	Savings (kWh/sq. ft.)	% Applicability	Life	Savings (kWh/sq. ft.)	% Applicability
Large Office	New	15	0	0.0%	15	0	0.0%
Medium Office	New	15	0	0.0%	15	0	0.0%
Small Office	New	15	0.3	4.6%	15	0.15	4.7%
Big Box	New	15	0	0.0%	15	0	0.0%
Small Box	New	15	0.33	7.2%	15	0.165	5.3%
High End	New	15	0.45	6.4%	15	0.225	3.6%
Anchor	New	15	0	0.0%	15	0	0.0%
K-12	New	15	1.7	4.2%	15	0.71	4.2%
University	New	15	0	0.0%	15	0	0.0%
Warehouse	New	15	0	0.0%	15	0	0.0%
Supermarket	New	15	0	0.0%	15	0	0.0%
Mini Mart	New	15	0	0.0%	15	0	0.0%
Restaurant	New	15	0	0.0%	15	0	0.0%
Lodging	New	15	0.6	11.0%	15	0.3	6.9%
Hospital	New	15	0	0.0%	15	0	0.0%
Other Health	New	15	0.75	4.2%	15	0.375	1.0%
Assembly	New	15	0	0.0%	15	0	0.0%
Other	New	15	0	0.0%	15	0	0.0%

Sixth Plan estimates of total square footage were applied to the measure matrix in Tables 7 and 8. Table 9 shows the 20 year savings potential by building type. Note that these are estimates of Technical Potential. The potential is also the BPA share of regional potential, which is assumed to be 42% for commercial measures. The Council often uses an 85% achievability factor, which is not included in this estimate. Figures 4 and 5 show annual technical potential using a ramp rate similar to the Sixth Plan Emerging Technologies ramp rate. In this case the ramp rate is applied as a percent of the total potential acquired each year.

Table 9 – Total BPA Savings Potential by Commercial Building Type

	5 Year Potential aMW			20 Year Potential aMW		
	Retrofit	**New**	**Total**	**Retrofit**	**New**	**Total**
Large Office	0.00	0.00	0.00	0.00	0.00	0.00
Medium Office	0.00	0.00	0.00	0.00	0.00	0.00
Small Office	0.04	0.01	0.05	0.29	0.05	0.33
Big Box	0.00	0.00	0.00	0.00	0.00	0.00
Small Box	0.11	0.01	0.12	0.72	0.06	0.78
High End	0.03	0.00	0.03	0.20	0.02	0.22
Anchor	0.00	0.00	0.00	0.00	0.00	0.00
K-12	0.17	0.04	0.21	1.10	0.25	1.34
University	0.00	0.00	0.00	0.00	0.00	0.00
Warehouse	0.00	0.00	0.00	0.00	0.00	0.00
Supermarket	0.00	0.00	0.00	0.00	0.00	0.00
Mini Mart	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	0.00	0.00	0.00	0.00	0.00	0.00
Lodging	0.21	0.01	0.22	1.36	0.08	1.44
Hospital	0.00	0.00	0.00	0.00	0.00	0.00
Other Health	0.08	0.02	0.09	0.51	0.10	0.61
Assembly	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**0.65**	**0.09**	**0.73**	**4.17**	**0.55**	**4.73**

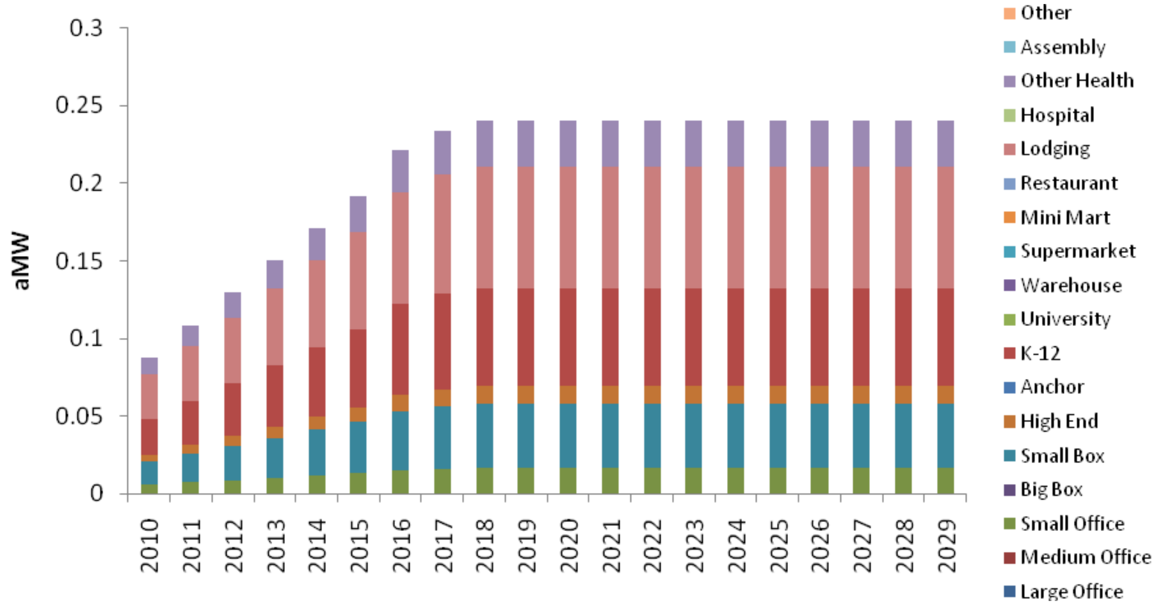

Figure 4 – Annual BPA WEPT Savings, Retrofit

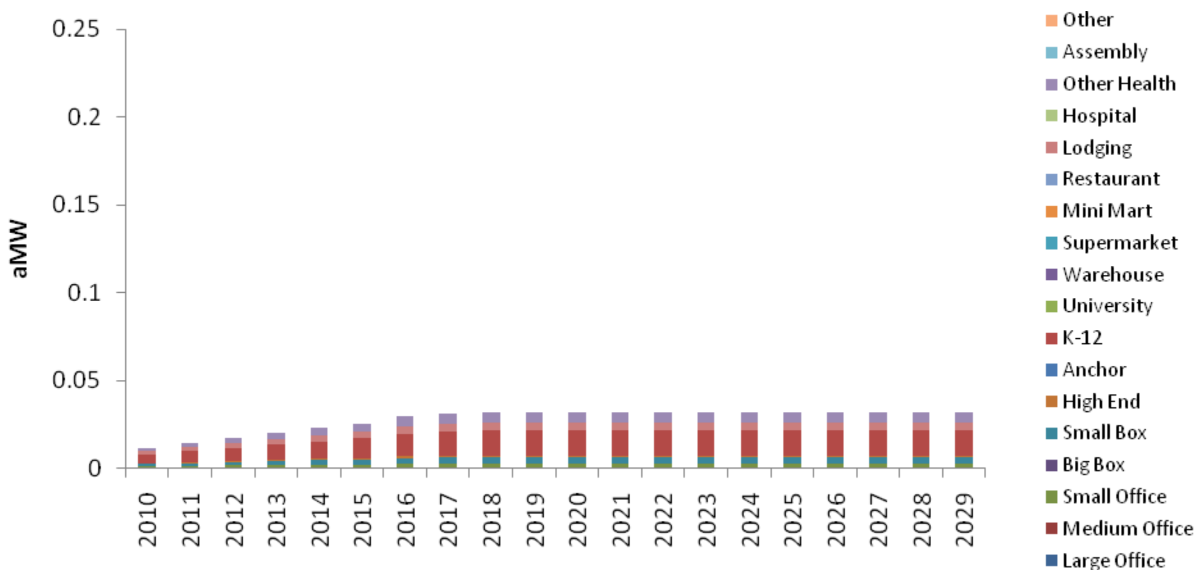

Figure 5 – Annual BPA WEPT Savings, New Construction

The total 20 year regional potential for HVAC measures in the Sixth Plan is 304 aMW. Assuming BPA share of 42% (128 aMW), WEPT savings represents 3.7% of HVAC potential in the region.

6. Summary

The use of Web Enabled Programmable Thermostats can save significant amounts of electricity (32-47%) in small commercial building applications, based on recent case studies. As with any controls or commissioning type measure, it is often difficult to ensure reliable savings. WEPT has an advantage of being targeted for small, well defined applications (e.g., single meter) which enable quality M&V.

Research Needs

This report summarizes available information regarding WEPT and provides some initial potential and cost-effectiveness estimates. The results of early pilot studies and field test indicate promising energy savings. However, continued research and evaluation are needed to better understand the savings, applications, and costs for WEPT. These research areas may include:

- Total BPA share of regional potential for WEPT is estimated to be 5.6 aMW. This is small relative compared to total HVAC potential in the Sixth Plan. However, niche applications such as school portable are viable and cost effective.

- Calculators – WEPT is not likely to become a “deemed” measure. The best approach is to continue to develop and support calculators that utilize pre and post data.

- Persistence of Savings and Measure Life - The definition of this measure will also depend on the program specifications and requirements, specifically that the consumption be continuously monitored over its life. This could possibly require a maintenance contract.

- Baseline Data – Baseline data for other portable classrooms could be obtained to improve the confidence in evaluating pre and post energy consumption.

- Additional Markets – A limited set of market applications were evaluated in this review. It is possible that addition building sectors, or portions of these sectors are good applications and will need evaluation.

- Additional Climates - The savings values in this review are based on cased studies in heating zone 1. However, it is likely that savings values would be higher in the other heating zones.

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