THE CADMUS GROUP, INC.

Date: **August 14, 2012**

To: **Don Jones, Eli Morris, and Pete Warnken PacifiCorp**

From: **Heidi Ochsner and Tina Jayaweera, Cadmus**

Re: **Overview of Solar Water Heating Inputs, Data Sources, and Potential Study Results**

Introduction

Cadmus is calculating the total potential and associated levelized cost for solar water heating (SWH) systems projected to be installed in PacifiCorp territory[1] over the next twenty years as part of the Company's 2013 Integrated Resource Plan (IRP). This memo has three purposes: 1) provide an overview of the methodology used in calculating the levelized cost, 2) present our assumptions for the analysis, and 3) present the results of the analysis.

The levelized cost is calculated based on the Total Resource Cost (TRC) perspective for all states except Utah, where the Utility Cost Test (UCT) is the accepted perspective. The levelized cost, which compares the life-cycle costs to the energy savings, is based on a single system and is calculated separately for residential customers, separated into single family and multifamily buildings, and commercial customers, including health, lodging, large office, large retail, and school buildings. Applicable commercial segments were chosen based on average annual hot water consumption of at least 9,000 kWh.

The TRC levelized cost includes:

- The incremental installation cost, which is the installed cost of the SWH.
- The incremental O&M costs, which are the O&M costs for the SWH minus the O&M costs of a standard efficiency electric water heater. The SWH O&M costs include regular system checkups and replacing the heat transfer fluid every three years. The costs are assumed to occur every three years for residential systems and are adjusted to net present value. Costs for commercial and multifamily systems are assumed to occur annually. The O&M costs of a standard efficiency electric water heater are assumed to be zero.
- The federal tax incentive, which is 30% of the installed system cost and is unaffected by utility or state rebates. The federal tax incentive expires December 31, 2016, and this is taken into account in the analysis. The state tax incentive is not included because the TRC sees the incentive as a benefit to the customer who installs the system, but a cost to the state's taxpayers, making the net effect zero.

[1] Potential for Oregon SWH was estimated separately in the Energy Trust of Oregon's potentials assessment and is not included in this memo.

- The program administration costs, including marketing expenses, are assumed to be 20% of the installed measure cost. Utility incentives are not included in the TRC because the TRC sees the incentive as a benefit to the customer who installs the system, but a cost to the ratepayers, making the net effect zero.

The UCT levelized cost includes:

- The utility's cost for administering the program. This cost includes the incentives as well as spending on program administration and marketing. The incentive amount is assumed to be 50% of the installed cost, after the federal tax credit. The administration and marketing costs are assumed to be 20% of the incremental installed cost.

Additionally, a nominal discount rate of 6.88% is used along with an inflation rate of 1.9% to adjust the costs in future years. For both the TRC and the UCT, the costs are then divided by the energy production of the system over its life to obtain the levelized cost of conserved energy.

Sources

In early 2009, Itron released an Interim Evaluation report for the California Center for Sustainable Energy (CCSE) Solar Water Heating Pilot Program (SWHPP), which compiled SWH information from numerous sources, including cost data from incentive programs in the U.S. as well as from contractor interviews.[2] Cadmus reviewed the data in that report for this SWH analysis. The Itron report was supplemented with other sources such as the ENERGY STAR website and information from the National Renewable Energy Laboratory. The most recent California Solar Thermal program data was downloaded from the California Public Utilities Commission to update the installed system costs for residential and nonresidential systems. Energy Trust of Oregon (ETO) also provided average system costs for residential systems.

The solar fraction, which is the percentage of energy used for heating water that is provided by the SWH, was used to calculate energy savings. Solar fractions for each segment and location combination were developed using RETScreen International[3] along with assumptions of gallons of hot water used per day and sector-specific load shapes. The number of collectors was adjusted until the solar fraction was near 70%, as systems are typically designed to reach a solar fraction of 40 to 80%.[4]

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[2] The CCSE SWHPP Interim Report can be downloaded from http://energycenter.org/uploads/CCSE_SWHPP_Interim_Report_Final.pdf

[3] RETScreen International was developed by Natural Resources Canada and can be downloaded for free from http://www.retscreen.net/

[4] National Renewable Energy Laboratory. The Technical Potential of Solar Water Heating to Reduce Fossil Fuel Use and Greenhouse Gas Emissions in the United States. March 2007. Page 5. Accessed August 2, 2010, from http://www.nrel.gov/docs/fy07osti/41157.pdf.

Overview of Installed System Cost Data

Table 1 compares the installed costs for residential retrofit SWH systems in the U.S. Itron reported that SWH system costs increased 72% between 2003 and 2009 due to the price of materials (mainly copper and aluminum) used in manufacturing the equipment as well as oil prices which impacted the shipping costs.[5] Data from the Energy Trust of Oregon showed that system prices have been increasing over the past seven years, and data from the California Solar Thermal program showed prices have increased over the past three years.

Table 1. Comparison of Installed Costs for U.S. Residential Single-Family SWH Systems

Program	Average Residential System Cost (2012 $)	Typical System Type
California Solar Thermal Program 2012	$8,401*	Active glycol and drainback systems
Eugene Water and Electric Board 2008	$7,607	Active glycol and drainback systems
Energy Trust of Oregon 2011 - 2012	$8,688	Active glycol and drainback systems

*Adjusted to remove sales tax

[5] See the CCSE SWHPP Interim Evaluation Report page 6-5

Residential, Multifamily, and Commercial Inputs

A summary of the inputs for the analysis are provided in the tables below. Table 2 and Table 3 list the assumptions for residential and commercial systems, respectively.

Table 2. Residential Single-Family Assumptions

Input	Value	Reasoning
Average size	48 square feet	Assumes two collectors. Typical collector area for a home is 40 to 60 square feet.
Measure Life	20 years	Minimum collector lifetime from warranty claims in Hawaii See SWHPP Interim Report Table 5-3; ENERGY STAR also lists a 20 year lifetime. See website: http://www.energystar.gov/index.cfm?c=solar_wheat.pr_savings_benefits
Installed Cost for Retrofit Systems	$8,500	Average cost (rounded) reported by the CA Solar Thermal Program and Energy Trust of Oregon
Annual change in nominal installed cost	0%	Costs have increased steadily over the past six years due to increases in material costs. We assume that costs will stabilize over the next 20 years
O&M Cost	$120 every 3 years (nominal)	Assumes customers have the system inspected every three years and have the heat transfer fluid flushed and replaced. (SWHPP Interim Evaluation Report Table 7-6)
Tilt	32 degrees	Average residential system tilt in the Utah Solar PV Incentive Pilot Program from 2010 - 2011
Azimuth	South	Average residential system azimuth in the Utah Solar PV Incentive Pilot Program
Annual Change in Efficiency	0%	Solar thermal is a mature technology and no improvements in efficiency are expected
Annual Performance Degradation	1%	Assumption used in the NREL Solar Advisor Model which can be downloaded for free from https://www.nrel.gov/analysis/sam/
Solar Fraction	Varies by Location.	Modeled using RETScreen International

Table 3. Commercial and Multifamily Assumptions

Input	Value	Reasoning
Average size	Varies by sector and location	Size was calculated based on gallons of hot water used per day in each segment within each state.
Measure Life	20 years	Minimum collector lifetime from warranty claims in Hawaii See SWHPP Interim Report Table 5-3; ENERGY STAR also lists a 20 year lifetime. See website: http://www.energystar.gov/index.cfm?c=solar_wheat.pr_savings_benefits
Installed Cost for Retrofit Systems	$106 per square foot	Average cost per square foot for commercial and multifamily systems in the California Solar Thermal program in 2012
Annual change in nominal installed cost	0%	We assume that costs will remain stable over the next 20 years
Annual O&M Cost	10% of installation cost divided by 20 years	Assumes customers have the system inspected and have the glycol flushed and replaced periodically. (SWHPP Interim Evaluation Report Table 7-11)
Tilt	25 degrees	Average commercial system tilt in the Utah Solar PV Incentive Pilot Program from 2010 - 2011
Azimuth	South	Average commercial system azimuth in the Utah Solar PV Incentive Pilot Program from 2010 - 2011
Annual Change in Efficiency	0%	Solar thermal is a mature technology and no improvements in efficiency are expected
Annual Performance Degradation	1%	Assumption used in the NREL Solar Advisor Model which can be downloaded for free from https://www.nrel.gov/analysis/sam/
Solar Fraction	Varies by location and sector.	Modeled using RETScreen International
Federal Tax Incentive	30% of installed cost. No cap.	This is the current federal tax incentive for renewable energy measures, set to expire on December 31, 2016.

Market Penetration Methodology

It was assumed that the maximum market penetration was 25% for all segments except manufactured housing, which was 15%. To avoid double-counting of savings with Class 2 resources, these percentage are in addition to those water heaters assumed to be converted to high efficiency units (e.g. heat pump water heaters). The percentage was based on the Northwest Power and Conservation Council's (Council's) potential for the Northwest.[6] Cadmus also used

[6] http://www.nwcouncil.org/energy/powerplan/6/default.htm

the same lost opportunity ramp rate as the Council to determine how many systems would be installed each year. [7]

Results

Table 4 shows the results of the analysis and summarizes the cumulative achievable potential by year 20 by state and technology..

Table 4. Cumulative Achievable Potential by Year 20 by State and Technology

Technology	Achievable Potential by Year 20 (aMW)				
	CA	ID	UT	WA	WY
SWH	0.70	0.78	2.80	0.89	0.75

Table 5 shows the levelized cost of energy for SWH systems before and after the expiration of the ITC. The levelized cost was calculated based on the TRC perspective for all states except Utah, which is based on the UCT perspective.

Table 5. Levelized Cost of Energy Before and After the ITC Expiration

Year	Levelized Cost of Energy ($/kWh)				
	CA	ID	UT	WA	WY
2013 through 2016	$0.45	$0.41	$0.15	$0.51	$0.44
2017 forward	$0.64	$0.59	$0.21	$0.71	$0.62

[7] The Council's potential does not include manufactured homes.