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Solar Water Heating in Oregon's Residential Sector: The Current Landscape

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Introduction

It is now broadly understood that rising global temperatures are directly linked to the over-consumption of fossil fuels by our modern industrial society.[i] Potential responses include diversifying the energy mix by integrating a variety of renewable energy technologies (RETs), as current projections suggest it will no longer be possible for simply one or few energy resources to power our society. In Oregon's residential sector, as in the rest of the Pacific Northwest, a significant portion of each household's utility bill comes from electricity generated by hydropower. However, a higher volume of energy consumption comes directly from burning coal and natural gas (40-75%) because these are used both on-site for heating purposes and at generator sites for producing electricity. Given this emphasis on so-called "conventional" energy resources, there is a push to move to alternative energy resources or RETs. Among a variety of these alternatives, solar water heating is a lesser-known option with the potential to

significantly reduce the consumption of fossil fuel energy. To date, solar water heaters, as with many other RETs, lack the economic market maturity of competing energy resources, making them more costly and less enticing. However, there is great potential for reduced energy consumption if the residential sector were to make a large-scale shift to using solar water heaters.

This white paper describes the potential large-scale impacts of SWH adoption, trends in adoption, and relevant policies pertaining to residential solar water heating. It provides a contextual snapshot of SWH in Oregon, and concludes with recommendations and areas for possible future research.

What is Solar Water Heating?

In a domestic application, solar water heating (SWH) is a renewable energy technology (also known as domestic solar hot water systems) that uses thermal energy from the sun to heat a household's hot water supply. SWHs are installed as a complement to conventional heating systems to ensure demand is properly met. SWH systems can account for 40 to 90% of a household's hot water needs, depending upon environmental conditions and system quality. It can also greatly reduce the demand on conventional energy sources used for heating water like electricity or natural gas.

SWHs are very efficient when measured against other RETs. For example, whereas photovoltaic panels (PVs) typically run at about 25% conversion efficiency, solar thermal technology can reach up to about 40% efficiency.[ii, iii] This is because less energy is lost in the transfer from sunlight to heat than there is from sunlight to electricity. In addition, the capital cost of most SWH systems is significantly less than similarly sized systems for PVs. However, despite the relative efficiency and low capital costs of SWH systems, they are far less popular than PV systems overall.

The Potential of Solar Water Heating

As an RET and an efficiency tool, SWH has the potential to greatly reduce the regional demand of electricity and natural gas required for domestic water heating. Even in Oregon where the sun is not always clearly shining, SWH systems can still cover over half of a household's hot water needs. This results not only in regional environmental benefit from the reduction of fossil fuel consumption, but also significant economic savings to the consumer. The following calculations provide a clearer picture of the potential impact of a large-scale adoption of SWH in Oregon's residential sector.

Assume that a residential SWH system will cover 50% of a home's hot water needs (this is a conservative estimate for some systems but comfortably allows for Oregon's weather patterns). Assume for these calculations that the backup system is an electric water heater, and without SWH, would use 4,750 kWh/year for domestic water heating needs.[iv] It is possible to determine exactly how many domestic SWH systems it would take to offset the electricity produced by one average-sized coal power plant. This method of measuring energy efficiency was popularized by Arthur Rosenfeld and detailed in Koomey et al.[v] One Rosenfeld (a unit coined for its creator), is equivalent to offsetting the power produced by one average coal plant of 500MW, and is colloquially termed the "nega-watt." Accounting for capacity and energy conversion factor for the coal plant, the average electricity produced by this plant in one year is about 3,000,000,000 kWh/year.

So the question is how many SWH systems does it take to save this much energy? It is set up as follows:

50% x 4,750 kWh/year = 2,375 kWh/year

3,000,000,000 kWh/year ÷ 2,375 kWh/year = 1,263,158 SWH systems

While 1.2 million may seem like a daunting number, it represents about three quarters of the household units in the state of Oregon according to the 2010 Census.[vi] Thus if SWH systems were in three-fourths of the residential sector, in energy reduction that would equate to turning off one average coal power plant. This number should not be regarded as precise, because of variability in system sizes, backup resources (natural gas), and no accounting for commercial applications (which offer great potential). However, the averages give a clearer picture of the potential.

What about monetary savings? Using the same assumptions, in which an average SWH system is saving about 2,375 kWh/year, at Oregon's average price of 7.63¢/kWh the economic savings are as follows:

2,375 kWh/year x $0.0763/kWh = $181.22

$181.22 x 1,263,158 systems = $228,900,019

If three-fourths of the residential sector adopted SWHs, there would be savings of over $180 per household and almost $230 million statewide. Again these back-of-the-envelope calculations are crude, but they successfully paint the picture of the potential of this technology. It is unrealistic to expect adoption of SWH to reach such a level of saturation, but the potential remains.

Households that adopt SWHs would also realize monetary savings in the long run because their utility bills would decrease as a result of their reduced energy consumption required for conventional water heating. With these savings from the regular utility bills, simple cost-benefit analysis shows a 5-7 year payback period. When this is taken into account with the 20-30 year life of the system, having the system installed makes the owner money. Every year after the system is paid back will be a positive gain.

Lastly, utilities would reap the benefits of widespread SWH adoption in the state because they would be able to more easily manage the regional peak-load demand of their consumer base. To adequately meet the demand of the region during high-consumption times, large-scale utilities are required to ramp up expensive peak-load generators. This is not only a financial drain on utilities, but on ratepayers (customers) who see those costs reflected on their own utility bill with higher rates. Even in Oregon's climate, the regional load benefit is significant.

A Rocky Past

Despite the environmental and economic potential of SWH, in Oregon it has had a variable history. Installations of SWHs typically occur when users can take advantage of tax credits to support their purchase. This was apparent in the late 1970s/early 1980s with a spike in demand (see Figure 1). However, lack of regulation (resulting in low quality equipment on the market) and the cancellation of incentive programs caused the SWH industry to nearly die out by the end of the decade. Tax credits were reinstated in the early 2000s with stricter certifications for systems required to qualify for tax credits (meaning much higher quality equipment), but popularity has remained low for this RET. In the five-year span from 2007-2011, fewer than 1,500 tax-credit-certified SWH systems were installed. To go back to the potential of this technology, this amounts to less than .1% of an average coal plant.

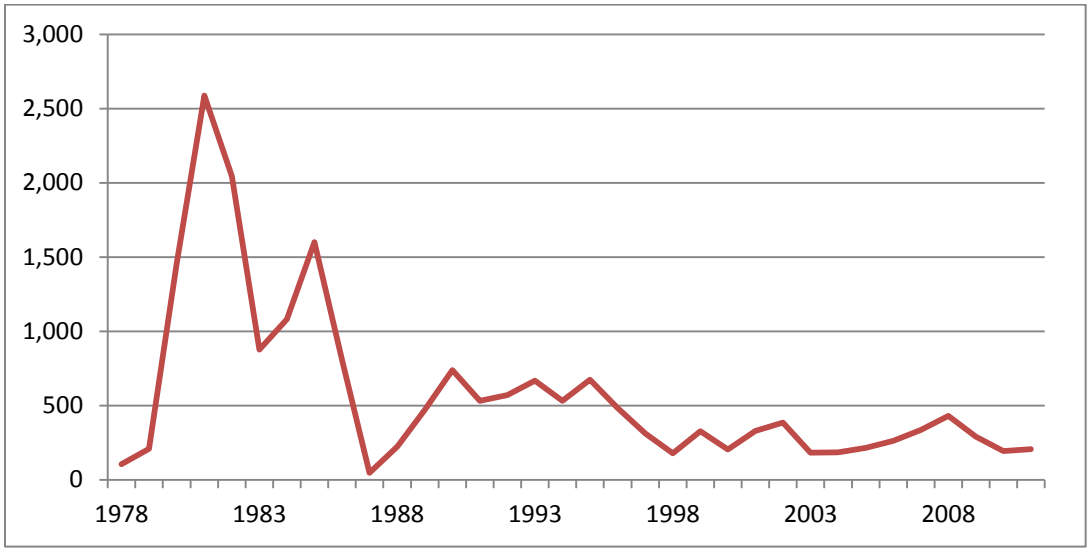

Figure 1: Solar Water Heating Tax Credit Installations (1978-2011)[vii]

The Current Policy Landscape

The difficulty facing homeowners is the upfront capital investment in the system. According to a report released by the Gotham Research Group in early 2012, the largest barrier standing the way of installing solar water heaters throughout the country is the cost of installation. When materials and labor are taken into consideration, residential solar water heaters can cost between $1,500 and $10,000. This wide range exists because there are a variety of system styles that the consumer can take advantage of, ranging from short-life DIY kits to the professionally installed and regulated longer-life systems.[viii] In comparison, the average cost of an electric or gas heater ranges from $150 to $1,000. Federal and state funding addresses the financial burden on the consumer, to help overcome the initial hurdle of installation.

Available Incentive Programs for Residential Solar Water Heating			
Residential Renewable Energy Tax Credit (Federal)	Residential Energy Tax Credit (State*)	Small-Scale Energy Loan Program (State*)	Solar Water Heating Incentive Program (Energy Trust of Oregon)
30%[ix]	$0.60/kwh saved / $1,500	Amount Varies[x]	$550-$1,200[xi]

* Cannot use simultaneously

The incentive structures in place to promote adoption in the residential sector are varied, but the most commonly used are the Federal and state tax credits and the Energy Trust of Oregon rebate. The Federal tax credit amounts to 30% of the initial capital investment that can be claimed as a personal deduction the following year on Federal tax returns. The state credit is of a similar structure, but instead of a flat percentage it is a dollar value credit per kilowatt hour (kwh) saved, meaning the size of the credit is contingent upon the size of the system, up to a limit of $1,500. The Small-Scale Energy Loan Program (SELP) offered through the state is eligible for a variety of technologies, including SWH, and loan amounts will vary based on the size of the system. Terms will typically be between 5-15 years, but will not exceed the projected life of the system. Consumer limitations for taking advantage of the state incentives are that they must choose one or the other; they cannot be paired. The final common incentive program is a rebate offered through the Energy Trust of Oregon (ETO), which varies between $550-$1,200, depending on the style of backup system (gas or electric) and the regional site location in the state. The requirement for consumers taking advantage of the state incentives or the ETO rebate is that all systems must be OG-300 certified by the Solar Rating and Certification Cooperation (SRCC), meaning they are independently evaluated and regulated, and therefore held to a higher standard of installation, material, and overall longevity and quality.

Where Does Policy Help and Hinder Adoption?

The current incentive structure allows consumers to take advantage of a variety of financial resources to aid in the installation of a solar water heater for their home. The majority of consumers who install the appropriate OG-300 certified systems take advantage of the federal tax credit, the state RETC, and the Energy Trust rebate, all of which can amount to a substantial credit. If a system costs $10,000, a consumer could save $3,000 with the federal credit, and $1,500 with each of the state credit and Energy Trust rebate, for a final net cost of only $4,000. The limit of the credits is that the most they can reduce the consumer's tax liability is to zero, and no further, meaning you can't get any money back in the form of a rebate from the government, and the Energy Trust rebate is only awarded upon completion and inspection of the installed system.

When incentives can only be taken advantage of after the installation of the system, consumers are left to front its entire capital investment, which limits the customer base to those with large amounts of disposable income. Additionally, for households already eligible for significant tax credits to reduce their tax liability (such as large families with multiple children),

the incentive structure of tax credits is not very enticing. This poses a problem to the industry because the target populations of users are precisely those households that use a large amount of hot water. These households would not only have the largest energy savings, but would also realize the quickest payback period compared to lower hot-water users.

Additionally, in the market of competing renewable energy technologies, SWH systems are at a disadvantage because of a policy definition for specific alternative energy devices. According to Oregon Revised Statute (ORS) 316.116, alternative energy devices can be defined as category one or category two devices. A category one alternative energy device is eligible for up to $1,500 in credits, where a category two is eligible for up to $6,000 in credits. Because the state defines a solar water heater as a conservation tool or efficiency measure, it falls under category one, where the popular alternative photovoltaic panels fall under category two. This makes PVs much more enticing than SWHs and, indeed, they are currently more popular.

Finally, the structure of incentives only caters to those who are already both knowledgeable about SWH and willing to pursue it. There is no formal promotion of the technology in the form of education, or even leading by example, despite the potential for Solar Water Heating across multiple sectors. The residential market might be stimulated if the technology had a greater prevalence in other areas.

Recommendations

Revise Definitions of Alternative Energy Devices

There is a misconception about the definition of "renewable energy" leading many people to believe it is *electricity* generated by a renewable resource, when in fact we can harness thermal energy from a renewable resource with much greater efficiency. Amending the definition of Solar Water Heating to be considered a renewable energy technology and not just an efficiency tool would not only level the incentives and therefore the playing field, but it would also play a role in educating the public about the potential of solar water heating, which has largely been overshadowed in the public eye by photovoltaic panels.

Design and Implement Alternative Financing Methods

The existing incentive structures should be altered to better cater to those who already have low tax liability and little need for additional tax credits. This could include the state partnering with banks, credit unions, utilities, and even the Federal government, to provide a soft-loan financing scheme to cover the capital investment of the system, but still provide a financial benefit to the lender. In these cases, the target population for SWH consumers could be expanded and households would repay their loan just like any other bill while also realizing

immediate savings on their utilities. Moreover, each of these partnered institutions would reap the benefit of positive public relations for participating in a renewable program.

Expand Policy Targets

Policy targets should be expanded beyond those in the residential sector to take full advantage of this technology in every sector of society. There are significant commercial applications that are enabled by a variety of SWH system sizes.

Lead by Example

The state could lead by example to promote the image of SWH and display its effectiveness as a renewable technology by installing SWH systems in public buildings, such as government offices, schools, hospitals, and emergency response facilities. The benefit of this would be twofold: immediate energy and monetary savings at each location, and ongoing rising awareness. Finally, a state or Federal mandate for shifting to SWHs, in new constructions or otherwise, would go a long way to not only increasing the adoption, but also legitimately affecting the regional impact of Solar Water Heating technology.

Conclusion

Solar Water Heating is an effective RET and energy efficiency tool that has great potential for environmental and economic benefit. Oregon has had a highly varied history with SWH adoption, and despite current incentive structures, adoption remains low. There is significant opportunity for policy design to address the issues faced by SWH to help increase adoption, including revising the state definition of Alternative Energy Devices, designing and implementing alternative financing methods, expanding policy targets to promote adoption in multiple sectors, and leading by example by adopting SWH public buildings. If these changes occur then the environmental and economic potential of SWH can be realized.

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[i] http://www.ipcc.ch/publications_and_data/ar4/wg3/en/contents.html
[ii] http://www.eere.energy.gov/basics/renewable_energy/pv_cell_conversion_efficiency.html
[iii] http://www.nrel.gov/docs/fy12osti/54793.pdf
[iv] http://www1.eere.energy.gov/femp/technologies/eep_waterheaters_calc.html#output
[v] Koomey, Jonathan, *et al*. (2010). Defining a Standard Metric for Electricity Savings. *Environmental Research Letters 5 014017.*
[vi] 2010 United States Census
[vii] Data courtesy of the Oregon Department of Energy
[viii] http://www.solar-rating.org/facts/system_ratings.html#AboutSRCC
[ix] http://www.dsireusa.org/incentives/index.cfm?state=us
[x] http://www.dsireusa.org/incentives/index.cfm?re=0&ee=0&spv=0&st=0&srp=1&state=OR
[xi] http://energytrust.org/residential/incentives/solar-water-heating/SolarWater