DRAFT REPORT TO THE LEGISLATIVE ASSEMBLY

Investigation into the Effectiveness of Solar Programs in Oregon

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Public Utility Commission of Oregon

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I. Introduction

The 2013 Oregon Legislature passed House Bill 2893 directing the Oregon Public Utility Commission to study the effectiveness of the state's solar energy incentive programs and report to the Legislature on its findings. Specifically, HB 2893 directs the PUC to:

a) Investigate the resource value of solar energy,
b) Investigate the costs and benefits of the existing solar incentive programs,
c) Forecast future costs for solar energy systems,
d) Identify barriers to the development of solar energy systems, and
e) Recommend new programs or program modifications that encourage solar development in a way that is cost effective and protects ratepayers.

The report is organized into seven chapters.

Chapter 1 is an introduction.

Chapter 2 describes solar photovoltaic (PV) systems and their characteristics as an energy resource. It also examines trends in solar development in Oregon.

Chapter 3 describes Oregon's solar incentive programs and new programs being offered elsewhere in the U.S.

Chapter 4 examines the current and future cost of solar PV systems. It describes the major cost components and the factors affecting solar costs, and shows the trends in costs over time.

Chapter 5 discusses the value of solar power to the energy system and society as a whole. It examines the components of value, methods for valuing those components, and estimates of value that have been produced.

Chapter 6 evaluates the costs and benefits of Oregon's solar incentive programs and compares the different programs. It also identifies barriers to solar development.

Chapter 7 examines three issues surrounding the development of solar in Oregon – recovery of utility fixed costs, integration of distributed solar generation into local distribution systems using "smart inverters," and efforts to reduce the non-hardware "soft" costs of solar.

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II. Solar Development in Oregon

Oregon has promoted the development of solar PV projects for nearly 35 years. Since 1980, Oregon households and businesses have been eligible for tax credits to offset part of the costs of solar projects. In 1999, the legislature passed a law requiring Oregon utilities to offer net metering to customers with on-site systems. Some utilities have supplemented the net metering incentives with direct incentives for projects. Since 2003, the Energy Trust of Oregon (ETO) has offered incentives for the installation of solar PV projects by Oregon customers of PacifiCorp and Portland General Electric (PGE). This program is funded through a charge on the bills of PGE and PacifiCorp customers. In 2007, the legislature adopted the Renewable Portfolio Standard (RPS) requiring Oregon's electric utilities to meet a percentage of their loads with renewable resources. In 2009 the legislature directed the Commission to establish a pilot program to examine the effectiveness of a volumetric incentive rate (feed-in tariff) in developing solar PV systems. It also created a Solar Capacity Standard directing utilities to meet specific targets for the development of solar PV systems exceeding 500 kilowatts.

Solar Energy Basics

In solar PV generation, thin plate-like panels convert sunlight directly into electricity. The panels can be mounted directly on a building roof or on the ground in large arrays.

Solar generation is completely dependent on sunlight. The more sunlight striking the photovoltaic panel, the more electricity is produced. Solar electricity generation varies by hour, by day, and by season. As a result, buildings with solar PV generation must still be connected to the power grid to access power from other resources at night and on cloudy days, to make up for the variability of power produced by the solar panels. Utilities must have resources at the ready to ramp up and down with the varying solar generation.

Residential systems average about 5 kilowatts (kW) in size, and range from 1 kW to 10 kW. These systems are typically mounted on the building roof and are "fixed," so they face the same direction at all times. Since solar generation requires that the roof have good sun and face either south or west, not all residences are suitable. Typical residential systems installed in 2013 cost between $20,000 and $30,000.

Commercial systems range widely in size, from 5 kW up to 500 kW or more. Since 2012, the average commercial system installed in Oregon cost approximately $50,000, but costs have ranged from $3,000 to more than $1 million. These larger systems can be installed on building rooftops or on the ground. Large ground-mounted systems can be installed with tracking mechanisms that enable the solar panels to follow the sun as it travels, providing more consistent solar generation throughout the day.

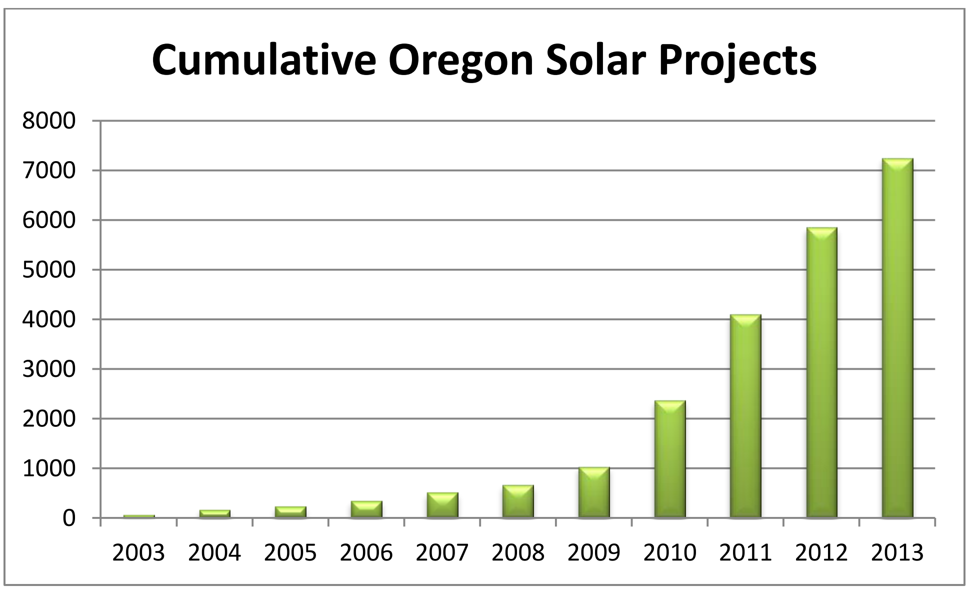
Trends in Solar Development

Before 2003, few solar PV systems were installed in Oregon. After 2003, the number of solar installations increased largely due to net metering, ETO incentives, and tax credits. Since the beginning of the feed-in-tariff pilot and the Solar Capacity Standard, the number of solar systems has increased from about 1,000 systems in 2009 to more than 8,000 systems at the end of 2013.

Through 2013, about 77 megawatts of solar photovoltaic capacity has been installed in Oregon. For comparison, Oregon's peak load is about 8,200 megawatts.[1] About 37 percent of the generating capacity is from residential systems and 48 percent from systems for commercial businesses. The remaining 15 percent is from large scale projects built or purchased directly by the utilities to comply with the solar capacity target mandated by the legislature in 2009.

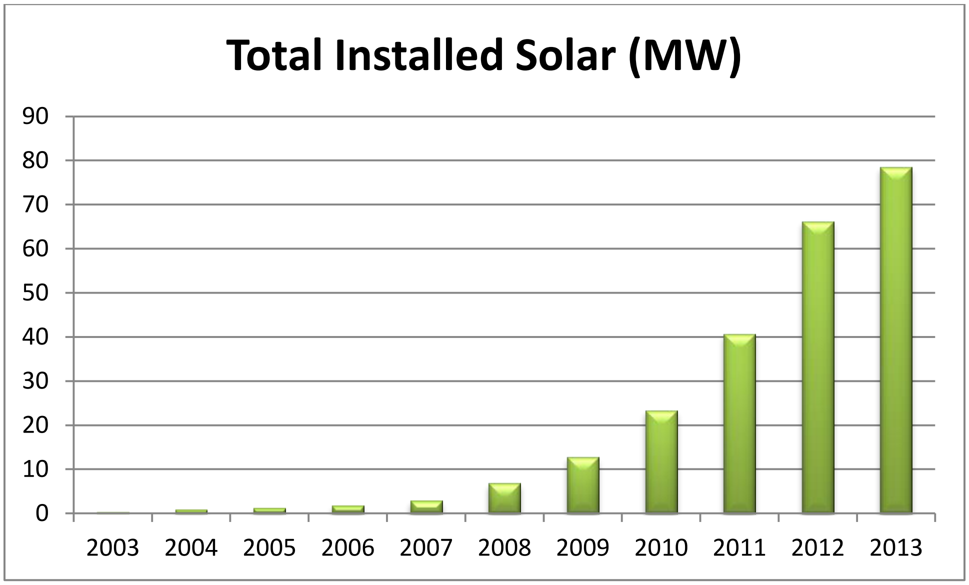
Figures 1 and 2 below, show the trends in the cumulative number of solar projects and capacity of those projects:

Figure 1: Cumulative Number of Solar Installations in Oregon



[1] Email from M. Jourabchi, NW Planning and Conservation Council, to Adam Bless/OPUC, April 18, 2014

Figure 2: Total Solar Capacity in Oregon



Role of Third Party Solar Companies

Since 2011, the majority of solar projects in Oregon have been developed and financed by third party companies, such as Solar City, Sun Run, and Lite Solar, Inc. These companies install, own, and operate the solar PV systems on their clients' property. The companies either lease the equipment to the client, or sell the electricity to the client at rates contracted for 10 to 20 years. For end-users, this eliminates up-front adoption costs. Using federal and state incentives, the third party companies can price solar energy contracts at or below the utility's retail rate.[2] Third party companies manage the solar PV systems as a unified asset and bundle the various financial incentives in a way that enables them to effectively raise capital.

The third party model is used in conjunction with other incentives. PGE reports that in 2013, 68 percent of participants in its feed-in tariff program chose the third party model, accounting for 57 percent of reserved capacity. The ETO also reported an increasing share of rebate applicants using the third party model in 2012 and 2013.

[2] *See* "Distributed Solar Power: A Path Forward," Solar City, December 5, 2013.

DRAFT REPORT TO THE LEGISLATIVE ASSEMBLY

III. Solar Programs

Oregon offers a wide array of solar PV incentive programs. They include:

- Net Metering
- Cash rebates offered through the ETO and individual utilities
- The Renewable Portfolio Standard
- The Solar Capacity Standard
- Avoided cost pricing for Qualifying Facilities under the federal Public Utility Regulatory Policy Act (PURPA)
- Feed-In Tariff
- State and federal tax credits

We describe each of these programs below.

Net Metering

Net Metering has been available in Oregon since 1999, to promote the installation of solar PV panels on homes and small businesses. With net metering, customers use on-site solar PV generation to offset electricity supplied to them by their utility. The customer enters into an agreement with their utility to interconnect their solar generation with the utility's distribution system. Effectively, the customer is paid the retail rate for the power generated by the solar photovoltaic system and offset by their own usage. If the customer generates more power than they use over the course of the month, they receive kWh credits that they can apply towards charges in future months. Oregon statute prohibits net metering participants from receiving credit for generation in excess of what they use over the course of a year. At the end of each annual billing cycle, any excess credits for generation that exceeded annual usage are donated to the utility's low-income assistance program.

Oregon statute limits the size of individual net metering systems to 25 kW, but allows the Commission to set a higher size limit for investor owned utilities. The Commission has retained the 25 kW size limit for residential systems, and set a limit of 2 MW for commercial systems. There is no limit on the cumulative generating capacity of net metering systems in Oregon.

Net metering is available to residential and commercial customers of all Oregon electric utilities. About 7,000 net-metered systems have been installed in Oregon. About 6,000 are residential and the remaining 1,000 are commercial.

Note: Net metering customers can also receive rebates and tax credits towards the cost of their solar installation. Nearly all net metering participants in Oregon received rebates from the ETO, state tax credits through the Oregon Department of Energy, or both. Those programs are described below.

Energy Trust of Oregon and Utility Rebates

Since 2003, the ETO has offered rebates for solar PV installations at homes and businesses served by PGE and PacifiCorp. Funding for the incentives comes from a "Public Purpose Charge" on PGE and PacifiCorp customer bills. Seventeen percent of the money collected from the charge goes to programs to encourage the development of renewable resources such as solar.

The ETO incentives offset the upfront cost of the solar. The size of the rebate is based on the size of the system (in kW). The incentives have varied over time. Recently, residential customers can receive rebates of up to $1.00 per installed watt, up to a limit of $10,000. Customers who receive an ETO rebate must have a net metering agreement with their utility.

From 2002 through the end of 2013, nearly 6100 systems have received rebates under this program, including:[3]

- 5292 Residential systems
- 786 Commercial systems
- 16 Utility scale projects

Note: These systems are among the 7,000 net metering systems described above. The remaining 960 net metering systems are located in consumer owned utility service areas, and therefore ineligible for the ETO rebate program.

Seven consumer-owned utilities also offer rebates for solar investment. They include the following:

- Ashland Electric offers a rebate of $.75/Watt (residential) or $1.00/Watt (commercial), with a limit of $7500 per system.
- Consumers Coop offers a rebate of $.50/watt, with a limit of $3000 per system.
- Eugene Water and Electric Board (EWEB) offers a rebate of $.60/Watt (residential) or $.50/Watt (commercial). The EWEB program is unique because it is funded entirely by participants in its voluntary "Green Power" program. Thus, the EWEB incentive truly has no impact on non-participating ratepayers.

[3] Data on systems completed by December 2013 provided by ETO.

- Oregon Trail Electric Coop offers a residential rebate of $500 for a 1 kW installation (equivalent to $.50/watt).
- Salem Electric offers a rebate of $600 for the first 3 kW and $300 for each kW above that.
- Columbia River PUD offers up to $1.50/Watt up to a total of $3,500.
- Emerald PUD offers $0.75/Watt up to a limit of $3,500 for residential installations and $10,000 for commercial installations.

Through December 2013, the consumer-owned utility programs have spurred the development of 960 systems with a total capacity of 5.5 MW.

Renewable Portfolio Standard (RPS)

In 2007, the Oregon Legislature adopted the Renewable Portfolio Standard (RPS) to promote the development of renewable resources. Oregon's three largest utilities – PGE, PacifiCorp, and EWEB – must meet the following percentage of their load with renewables:

- 5% by 2011
- 15% by 2015
- 20% by 2020 and
- 25% after 2025.

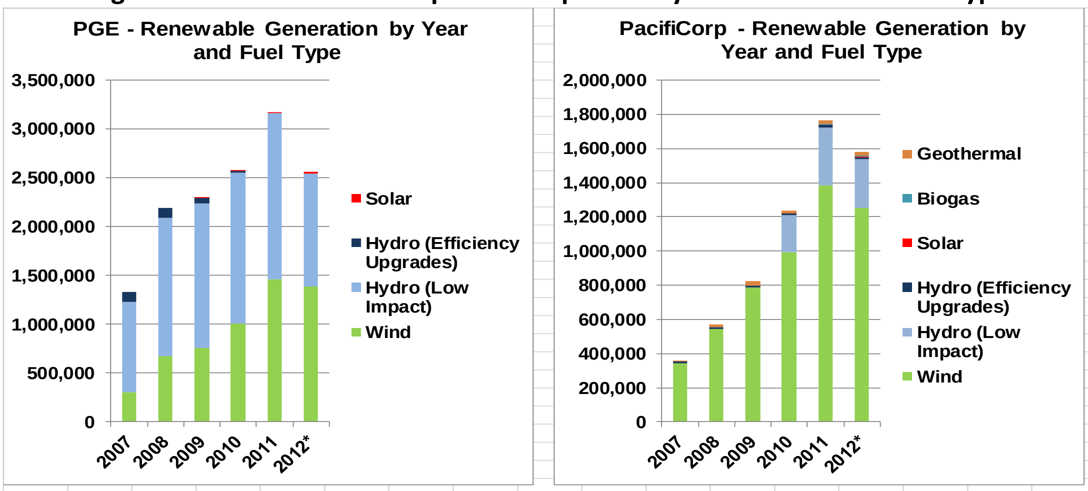
Oregon's other consumer-owned utilities have one target – either 5 or 10 percent in 2025, depending on their size.

Eligible resources include wind, solar, geothermal, biomass, ocean resources, hydrogen derived from certain renewable resources, low-impact hydroelectric facilities, and hydroelectric upgrades built after 1995. Generation must come from a Western U.S. plant.

Utilities can meet the standard by building an eligible generating facility or buying energy from one, buying "unbundled" renewable energy certificates, or making "alternative compliance payments." An investor-owned utility can choose to not comply with the RPS in a particular year if the cost of compliance with the RPS would exceed an amount equal to four percent of the utility's revenue requirement for that year.

To date, PGE and PacifiCorp have met their RPS targets largely through the use of renewable energy certificates and direct investments in wind and hydroelectric upgrades. Utilities have not developed any appreciable amount of solar to meet the standard.

Figure 3 – PGE and PacifiCorp RPS Compliance by Year and Generation Type



Solar Capacity Standard

Under the Solar Capacity Standard adopted in 2009, Oregon's investor owned utilities – Portland General Electric, Idaho Power and PacifiCorp – must acquire at least 20 MW of solar generating capacity with systems exceeding 500 kW or more by 2020. No single system can be larger than 5 MW. The projects also count toward compliance with the RPS. Utilities can build their own project or buy the output from an independent development.

To date, Oregon utilities have built or acquired power from five systems with a total nameplate capacity of 15.4 MW.

Qualifying Facilities under the federal Public Utility Regulatory Policy Act

The United States Congress enacted the Public Utility Regulatory Policy Act (PURPA) in 1978. PURPA created a class of small independent power producers called "qualifying facilities" (QFs) that can sell their generation to local distribution utilities at prices based on utilities' "avoided cost." "Avoided cost" is the cost the utility would pay for the energy and capacity if they were generating it themselves or buying it in wholesale markets.

PURPA is not specific to solar and has been used to develop renewable resources in general.

To date, Oregon has three solar QFs with a total capacity of 124 kilowatts. Also, Idaho Power recently signed QF contracts with developers of six additional solar PV projects in Oregon, each sized at 10 MW.[4]

[4] Idaho Power letter from Michael Youngblood to John Savage, March 24, 2014.

Feed-In Tariff - Volumetric Incentive Rate (VIR) Pilot Program

The 2009 legislature directed the PUC to establish the Volumetric Incentive Rate (VIR) pilot program in the service territories of PGE, Pacific, and Idaho Power. The purpose of the pilot is to demonstrate the use and effectiveness of paying a fixed price, in cents/kWh, for solar electricity produced by retail customers. Participants in this pilot are not eligible for state tax credits or ETO rebates.

The legislature set a cap of 25 MW of solar capacity for the program, and raised the cap to 27.5 MW in 2013. The legislature also established a goal that 75 percent of the capacity be allocated to "residential qualifying systems and small commercial qualifying systems." The legislature defined a "residential qualifying system" as a system with nameplate capacity of 10 kW or less, and a "small commercial" system as a system with a nameplate capacity between 10 kW and 100 kW. Systems larger than 100 kW are eligible for the program, but may not be larger than 500 kW.

Under the VIR Pilot Program, the customer executes a 15-year agreement with their utility and is paid the prevailing incentive rate for each kWh of solar power they generate. The incentive rate is established by the Commission, is intended to recover the system's total installation cost over time, and is set high enough to attract customers and solar developers.[5] The incentive rate is subject to modification by the Commission every six months. However, each customer will receive the rate in effect at the time they execute their contract for the duration of the contract.

The incentive rate was originally set in 2010 at 65 cents/kWh for smaller systems in the Willamette Valley, and 60 cents/kWh in Eastern and Southern Oregon. These rates have steadily declined. The incentive rate is now 39 cents/kWh in the Willamette Valley and 25 cents/kWh in Eastern and Southern Oregon.

For larger commercial and industrial sized systems, the incentive rate is determined by competitive bid. Competitive bidding has produced lower incentive rates for the larger systems. Competitive bids for medium and large systems have declined from 39 cents/kWh in 2010[6] to the current 17.5 cents/kWh in the Willamette Valley and 16 cents in Eastern and Southern counties.

From 2010 through 2013, about 1600 systems have been installed through this program with a capacity of 18 megawatts. Residential systems account for 8 megawatts of capacity and commercial systems account for 10 megawatts.

Oregon state income tax credits and grants

State income tax credits for solar installations have been available to Oregon residents since 1977 and to businesses in Oregon since 1979.

[5] The Commission has also used a competitive bidding process to establish prices for larger commercial and industrial customers.
[6] From 2010 through 2011, only projects larger than 100 kW participated in competitive bidding. Beginning in 2012, projects between 10 kW and 100 kW also received an incentive rate determined by competitive bid.

Today, residents who install solar systems on their property can receive a Residential Energy Tax Credit (RETC) based on the size of their installed system. Homeowners can receive $1.90 per installed watt, up to a limit of 50% of the total installation cost or $6,000 (whichever is less), and may claim no more than $1,500 in one tax year. Approximately 6,000 residents have received a tax credit for installing a solar system. The RETC program is scheduled to sunset on January 1, 2018.[7]

Prior to 2012, businesses that installed solar systems on their property could receive a Business Energy Tax Credit (BETC) based on the cost of their installed system. Through 2006, the credit was 35% of eligible project costs. The Legislature increased the credit to 50% of eligible costs effective January 1, 2007. In both cases, the credit was claimed over a minimum 5-year period. Nearly 1,000 businesses have received a tax credit for installing a solar system. The BETC program will sunset on July 1, 2014.

Organizations that owe little or no state taxes could still receive a benefit through a "pass through" program, which allows a project owner to transfer the tax credit to a taxable partner in return for a lump-sum cash payment upon completion of the project. The BETC program has ended, but the pass through option is still available to homeowners seeking to transfer a RETC to a taxable partner.

The BETC program was replaced in 2011 with an energy incentive program that includes a Renewable Energy Development Grant program. This competitive grant program offers grants up to 35% of project cost or $250,000 (whichever is less) to facilities that generate energy from solar or other renewable energy resources. Funding for the grant program is capped at $3 million per biennium.

These state tax credit and grant programs are administered by the Oregon Department of Energy.

Participants in the feed-in-tariff pilot program described above may not claim a state tax credit or grant for the VIR solar installation.

Note: Tax credit recipients include many investor-owned utility customers who also received rebates from the ETO, numerous consumer-owned utility customers who are ineligible for ETO rebates, and some off-grid residents. All of these tax credit recipients use net metering, with the exception of off-grid residents who are not connected to an electric utility.

Federal Investment Tax Credit

Since 2006, the federal government has offered an investment tax credit for solar installations, equal to 30 percent of expenditures, with no maximum amount. The federal tax credit can be combined with state incentives, greatly reducing the customer's total cost. Anyone with a tax liability is eligible.

The federal tax credit, when combined with other incentives, has also helped in the development of utility scale solar projects. Third party developers use the federal tax credit install systems at tax exempt properties such as churches and schools.

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[7] Chapter 832 Oregon Laws 2005.

This incentive is administered by the U.S. Internal Revenue Service. The credit is scheduled to expire for residential systems and decrease to 10 percent for commercial systems on December 31, 2016.

Other Approaches Outside Oregon

Community Solar

Some states encourage "community solar" in which the output of a single large solar PV installation is shared among several customers. Community solar allows tenants in one apartment building to share the costs and output of a single solar PV installation. Or, several homeowners in a neighborhood can buy shares in a single large installation and share the output.

Community solar has proved popular in Colorado and Arizona. PGE has proposed a community solar project for its service territory, called "Solar Shares." The project has not been approved yet. Also, the legislature in 2014 enacted Senate Bill 1520, which removed certain financial barriers to the development of community solar in Oregon.

Value of Solar Tariff

In 2012, the municipal utility in Austin, Texas implemented a "Value of Solar" tariff. Under this tariff, the customer receives a price for their solar power based on its value to the utility and its ratepayers. The utility calculates this value taking into account the value of the energy, capacity, transmission and distribution savings, fuel cost hedging, and the value of environmental and societal benefits. The Minnesota PUC recently approved a tariff patterned on the Austin, Texas example. [8] The major features of Minnesota's Value of Solar Tariff are:

- The Value of Solar Tariff is an alternative to net metering.
- The Value of Solar Tariff is based on an estimate of the value of the solar electricity to the utility, its customers, and society, whereas net metering customers receive credit for energy they generate and use based on the utility's retail rate.
- The Value of Solar Tariff allows customers to receive credit for the energy generated so long as the energy does not exceed the customer's usage over the course of a year.

[8] Minnesota Public Utility Commission Docket No. E-999/M-14-65, order issued April 1, 2014.

IV. Solar PV Cost Trends and Projections

Solar System Installation Costs

In 2013, the costs of distributed solar PV systems installed in Oregon averaged:

- $4.73/Watt for residential systems (equivalent to 21 cents per kilowatt-hour), and
- $4.03/Watt for commercial systems (equivalent to 17 cents per kilowatt-hour).[9]

The costs of residential systems varied widely, ranging from about $2.25/Watt to more than $11.00/Watt, and varied based on size of system, location, system efficiency, and system design. Installation costs were relatively consistent among the different regions of the state. For example, residential net metering systems in Central and Southern Oregon averaged $4.62/Watt to install, while similar sized systems in the Willamette Valley averaged $4.89/Watt. However, the energy from those systems cost 18.2 cents per kilowatt-hour in Central and Southern Oregon, versus 24.9 cents per kilowatt-hour in the Willamette Valley.[10] The lower electricity cost in Central and Southern Oregon is due to the better sunlight available in those counties.

The costs of commercial systems ranged from less than $2.50/Watt to more than $10/Watt and varied largely based on size of system, system design, and location. For example, commercial net metering systems installed in 2013 averaged $4.65/Watt in the Willamette Valley and $5.03/Watt in Central and Southern Oregon, while the electricity produced from those systems have an average cost of 23 cents/kilowatt-hour in the Willamette Valley versus 19 cents/kilowatt-hour in Central and Southern Oregon.

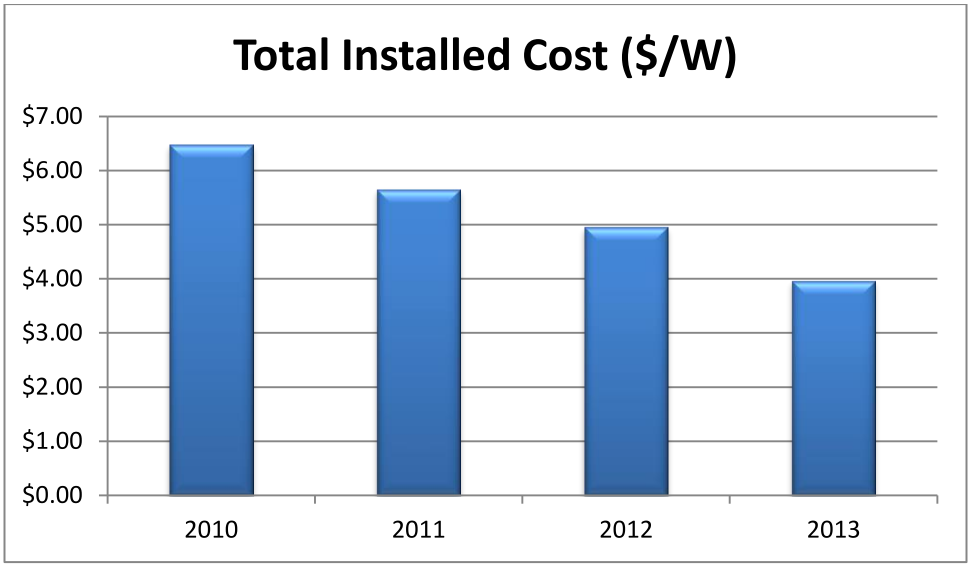
For utility-scale systems – systems exceeding 10 MW in size, utility estimates of the cost of new systems in Oregon range from $2.55/Watt for PGE to $3.30/Watt for Idaho Power.[11] The utilities estimate that the electricity from these installations would cost an average of 14.8 cents/kilowatt-hour.

Trends in Solar PV Costs in Oregon

Over the past four years, solar installation costs have declined, driven by decreases in photovoltaic panel costs. Figure 4 below shows the trend in the cost of solar systems since 2010:

[9] Latest data for net metering installations, provided by ETO.
[10] Based on data provided by ETO.
[11] PGE November 2013 Draft Integrated Resource Plan.

Figure 4: Trend in Total Costs for Systems in the Oregon VIR Program



The figure shows that total installation costs decreased from slightly more than $6.00/Watt in 2010 to about $4.00/Watt in 2013 – a 33 percent decrease.

Solar PV System Cost Components and trends in component costs

The total cost for solar PV can be divided into two components: “hard” costs and “soft” costs.

- *Hard Costs* are the costs of the PV panels themselves, and other electronic components needed to connect the system to the grid. The major “hard” cost is the solar PV panels. Panel manufacturers have brought panel prices down to about one third of what they were in 2010.[12]

  Hard Costs also include electronic components needed to deliver the solar energy to the grid. Solar panels produce Direct Current (DC), while the grid delivers power to customers in Alternating Current (AC). A component called an i*nverter* converts DC to AC. Inverters also include power control features that are needed for safety and grid reliability.

- *Soft Costs* are the various costs incurred by the customer or the solar developer related to installation, labor, and the developers’ cost of doing business. Soft costs include:

  - Supply Chain Costs – the price that a small developer pays to various “middlemen” if they cannot buy components directly from the manufacturer.
  - Installer/Developer Profit – the installation company’s cost of doing business, including a reasonable rate of return.

[12] Photovoltaic system pricing trends: Historical, Recent and Near Term Projections, NREL July 16, 2013.

- Financing – the cost to obtain financing from a bank or other lending institution.
- Incentive Application Costs – the cost to apply for a particular incentive. The contractor generally navigates their customer through the application process. ODOE is collaborating with the ETO to implement a common incentive application process, in an effort to reduce this cost.
- Customer Acquisition – solar developer's cost to market their services, work with customers to design the installation, and help the customer understand the different incentive programs. In states where solar is very popular, developers get much of their business through word of mouth. Because solar penetration is lower in Oregon, developers incur higher costs marketing their services.
- Permitting and Inspection – the cost to obtain applicable city and county building permits and electrical inspections. The Oregon Building Codes Division has worked to streamline the inspection requirements, but there are still costs to acquire the permits and complete the inspections.
- Labor – the cost to actually install the system. This cost varies from project to project, and is higher for small residential projects than for large commercial ones.

The "soft" cost of solar installations in Oregon incentive programs has declined, but not as rapidly as PV panel prices. Figures 5 and 6 compare the trend in PV panel costs with the trend in "soft" costs over the past four years:

Figures 5 & 6: Cost of PV Panels Used in Oregon Incentive Programs & Trend in Solar Installation Soft Costs

Oregon's experience with soft costs is consistent with trends nationwide. The National Renewable Energy Laboratory (NREL) compiles detailed statistics on Solar PV cost trends. NREL reports that nationwide, soft costs account for over 60 percent of total installation cost.[13] We discuss soft costs in more detail in Chapter VII of this report.

Cost of Solar PV compared to other resources

Although the cost of solar has dropped, it remains among the most expensive generating resources.

Figure 7 compares the installed cost of generation for different generating resource. On a pure per megawatt basis, solar systems are cheaper to install than some other forms of generation.

Figure 7: Installation Costs of Utility Generation (from Utility Integrated Resource Plans)[14]

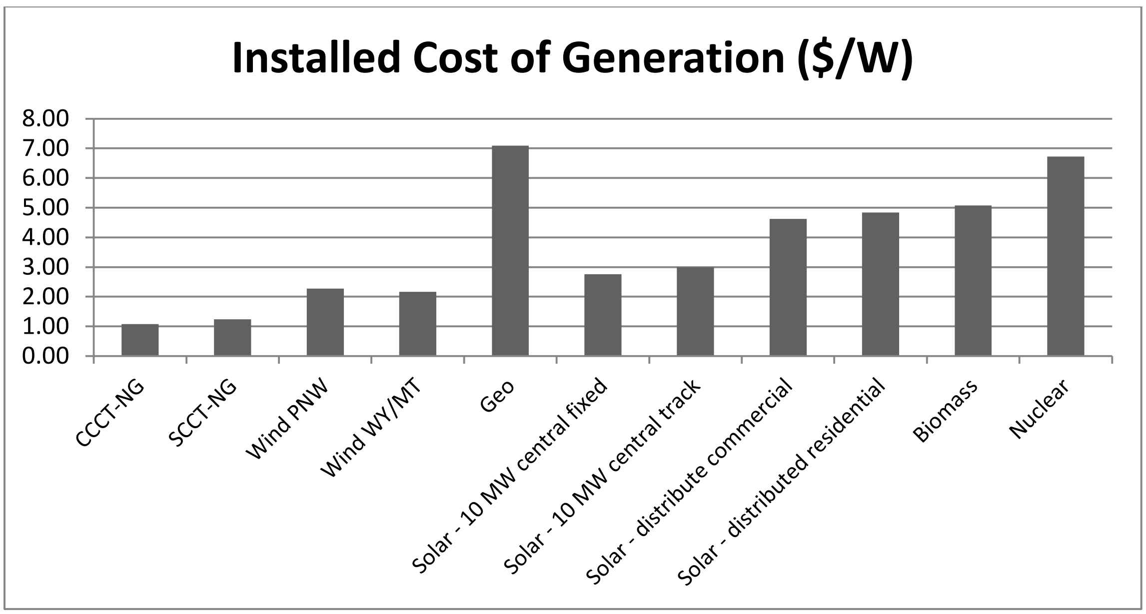
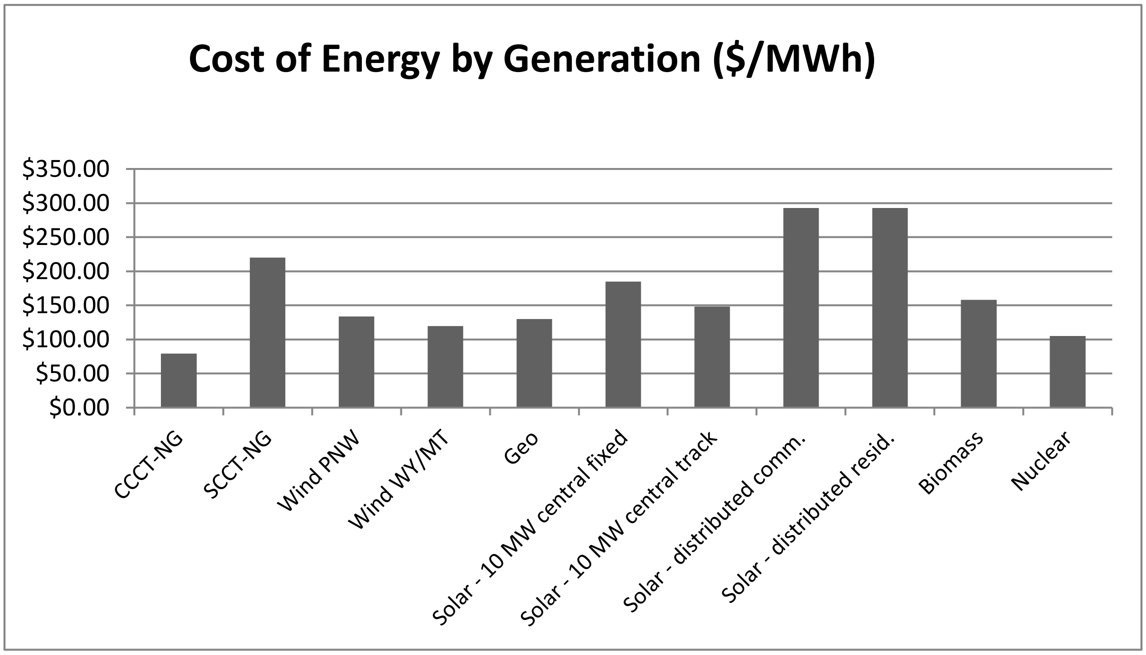


Figure 8 compares the cost of energy from different resources. On an energy basis –assuming no subsidies- solar systems are among the highest cost generating resources.

[13] "Benchmarking Non-Hardware Balance of System Costs for U.S. Photovoltaic Systems, Using a Bottom-Up Approach and Installer Survey- Second Edition" NREL, October 2013.
[14] Data shown in figures 4 and 5 are provided in Table form in Appendix 2.

Figure 8: Comparison of Levelized Cost of Energy from Utility Generation Sources

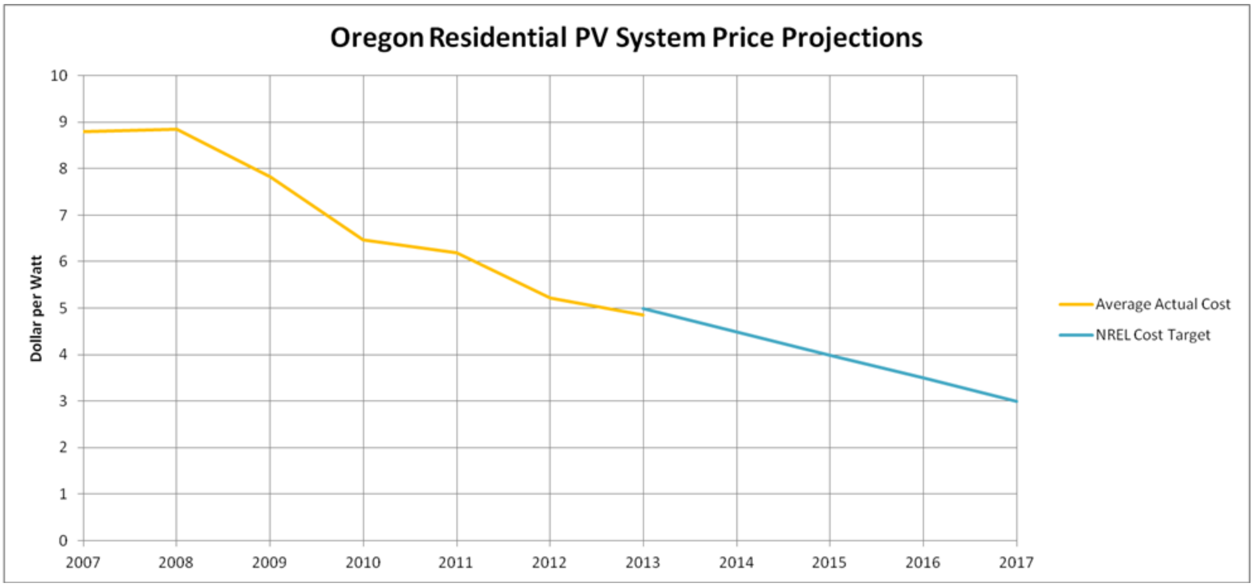


Projections for Solar PV Costs

Most of the recent decrease in solar PV system costs was due to the decrease in panel prices. The National Renewable Energy Lab (NREL) projects that PV panel prices will continue to decrease, but not as rapidly as they have over the last 6 years. NREL projects that total “hard” costs will decrease from their current level of slightly more than $2/Watt to about $1/Watt by 2020. Further cost decreases will come from reductions in soft costs.

Oregon and Washington have jointly received a federal grant through the USDOE “Sunshot” initiative, with the goal of reducing soft costs to less than $1/Watt, and total residential PV system costs to $1.50/Watt, by 2020. These are ambitious targets. However, Figure 9 below shows the trend in total residential solar installation costs from 2013 to 2017 based on NREL projections.

Figure 9: Projected Solar PV System Installation Cost in Oregon



Source: 2007-2013: Actual Prices supplied by Oregon Department of Energy
2013-2017: "Non-Hardware ("Soft") Cost-Reduction Roadmap for Residential and Small Commercial Solar Photovoltaics, 2013-2020," NREL August, 2013

This figure shows that the cost of residential solar installations could be reduced to about $3.00/Watt by 2017, a reduction of approximately 67 percent from 2007 to 2017.

V. Resource Value of Solar

The resource value of solar refers to the benefits that ratepayers and taxpayers receive from distributed solar generation.

The resource value of solar can be divided into hard and soft benefits, based on the direct benefits to utility ratepayers and the difficulty of quantifying the value of a given benefit.

“Hard” benefits include:

- The value of the energy that the utility would otherwise generate or purchase,
- Avoided need for new generating capacity[15] due to the capacity provided by solar, and
- Savings in transmission line losses.

“Soft” benefits include:

- Value of distributed energy in preventing or recovering from blackouts,
- Improved power quality,
- Avoided need for new transmission and distribution investments,
- Hedge against future gas price volatility, and
- Societal Benefits including carbon and pollution reduction and Economic development.

Solar Benefit Estimates

A number of studies have been conducted recently to estimate the value of solar. Most of these studies are summarized in a 2013 Rocky Mountain Institute (RMI) report.[16] Most of the examples below are taken from this RMI report. Table 5.1 below summarizes the results:

[15] In this report, “capacity” means the amount of generating resources needed to meet peak load.
[16] “A Review of Solar PV Benefit & Cost Studies” RMI, September 2013.

Table 5.1: Summary of Nationwide Avoided Cost Study Results (per kWh)

	BENEFITS/COSTS per KWH						
	Energy	Transmission Losses	Avoided Generation	Avoided Transmission & Distribution	Grid Support	Fuel Hedge	Soft
AZ	2.7		0.72	0.14			
AZ	7.91 to 11.1		0 to 1.85	0 to 0.82			
AZ	6.4 to 7.5		6.7 to 7.6	2.4 to 2.5	1.5		0.1
Austin	6		1.7	1			2
Austin	7.8	0.7	1.5	0.11			2.2
CA	6	0.2	4.5	2	0.5		2
CA	6	1	4	2	0.5		2
MN	6.7		2.4	1.1			3.1
NREL	3.2 to 2.7		1.1 to 10	0.1 to 10	0 to 1.5	0 to 0.9	0.4 to 6.2
NJ	6.1		1.6 to 2.2	1 to 8		2.5 to 4.7	2.3 to 5.5
TX	10.6		1.6 to 1.9	0.5		2.6	
CO	3.6 to 7.6	0.5 to 0.8	1.15	0.1		0.7	0.5
RMI	2.5 to 12	0 to 4.5	0 to 13	0 to 11	<1 to 1.8	0 to 4.5	0.5 to 5.5
OREGON	3.7	0.5	2.0	0	0.5	0	NA

The results vary considerably. Estimates range from 4 cents per kilowatt-hour to 25 cents per kilowatt-hour. Here are some specific examples:

- In Arizona, a 2009 study yielded a result of 12 cents/kWh. A 2013 study by the same consultant resulted in value of 4 cents/kWh. A different consultant performed a study of the same utility and calculated a value of 21 cents/kWh.
- In 2012, Austin Energy calculated the value of solar at 12.8 cents/kWh. In January 2014, the same utility, using the same consultant, lowered the rate to 10.5 cents/kWh.
- A paper by the Interstate Renewable Energy Council (IREC) described how the utility serving San Antonio, Texas, 80 miles from Austin, calculated the value of distributed solar at roughly half of its retail rate. IREC noted that a competing study, sponsored by Solar San Antonio, showed a value of over 17 cents/kWh, nearly twice the utility's retail rate.[17]

[17] See "A Regulator's Guidebook: Calculating the Benefits and Costs of Distributed Solar Generation: Interstate Renewable Energy Council, October 2013.

- The California PUC took a different approach, comparing the costs and benefits of net metering. In 2012, a study by consultant E3 calculated distributed solar benefits at 13 cents/kWh. A competing study by consultant Crossborder calculated benefits at over 20 cents/kWh.

The wide range is driven by assumptions, methodologies, and decisions about which costs and benefits to quantify. No two studies are identical. For example, some studies reported levelized cost and benefit over 20 years; others used a 25 or 30 year life. The Arizona values are not levelized at all, but are a "snapshot" of value in the year 2025, discounted back to 2012. Different studies used different approaches to estimating avoided costs of energy, capacity, and transmission and distribution costs. Some states placed a dollar value on environmental and societal benefits; others did not. No two studies placed values on the same set of benefits.

Range in "Hard" Benefits

To estimate the benefit from avoided energy and capacity and avoided transmission losses, most states used similar methodologies. Even so, there was a wide range of estimates for the "hard" benefits:[18]

- *Energy*: Some states used the energy cost from a gas turbine; others used a "market price." Estimates ranged from 3 cents/kwh to as high as 11 cents/kWh.
- *Transmission losses*: Most estimates ranged from 0 to 1 cent/kWh, but a few were higher. Some utilities, such as Austin, Texas, do not report a value for avoided transmission losses but include them in the calculation of energy benefit.
- *Avoided Investments in Generating Capacity*: Most estimates for this benefit were in the range of 1 to 2.5 cents/kWh, but one California study had an estimate of 10 cents/kWh.

Table 5.2 below shows the range of "hard" benefit estimates among studies outside Oregon:

Table 5.2 – Estimates of Hard Benefits in Studies Outside Oregon[19]

Benefit (in cents/kWh)	Low	"Typical"	High
Avoided Energy Cost	2.7	6 - 8	12
Avoided Transmission Losses	0	0.5	4.5
Avoided Investment in Generating Capacity	<1	1-2.5	13

Range in "Soft" Benefits

Benefits such as grid services, fuel price hedge, and societal, environmental, or economic benefits are more difficult to quantify and more uncertain. For example, estimating benefits from carbon emission reduction depends on the underlying assumption about whether or not Congress will enact a carbon tax.

[18] This comparison excludes values in the RMI study that were dated before 2007.
[19] Values on this table are from "A Review of Solar PV Benefit & Cost Studies" RMI, September 2013.

Estimates of soft benefits range widely, depending on assumptions and approaches. Some states did not include soft benefits at all, and no state made estimates of all of the potential benefits. The following examples show the range in estimates for "soft" benefits from state to state:[20]

- *Hedge against fuel price volatility*: Many states acknowledge that this benefit exists, but few tried to quantify it. Most estimated the value between 0 and 1 cent/kWh, but one study in Texas calculated a benefit of 3 cents/kWh, and a study in New Jersey calculated nearly 4 cents/kWh.
- *Avoided Need for investments in Transmission and Distribution*: Estimates for this benefit ranged from 0 to 11 cents/kWh, but most estimates "clustered" from 1 to 2.5 cents.
- *Grid Support Services*: Some states considered the services that solar energy might provide to help with grid stability and reliability, also called "ancillary services, "as a benefit. Six studies assigned a dollar value to this benefit. In four studies, the value was close to zero, but one study in Arizona estimated 1.5 cents/kWh.
- *Environmental Benefits*: Again, there is widespread agreement that solar energy has some environmental benefits, but no agreement on how to calculate them. The uncertainty around possible carbon legislation in Congress makes estimating a value difficult. We found 11 studies that had a dollar estimate for environmental benefit. Most of the estimates were "clustered" around 2 cents/kWh, with some estimates as high as 4 cents/kWh.
- *Societal and Economic Benefits*: There is no agreement on the value of societal and economic benefits, or even whether they exist. Nationwide, we found only one study that included a dollar figure for economic benefits. That study, done by New Jersey, showed a value of 4.5 cents/kWh.

Table 5.3 below shows the wide range in soft benefit estimates among these studies.

Table 5.3 – Estimates of Soft Benefits in Studies outside Oregon

Benefit (in cents/kWh)	Low	"Typical"	High
Hedge against fuel price volatility	0	1	4.7
Avoided Transmission and Distribution Investment	0	1-2.5	11
Grid Support	0	0-0.5	1.8
Environmental Benefits	<1	2	4
Societal and Economic Benefits	0	?	4.5

[20] Examples are from "A Review of Solar PV Benefit & Cost Studies" RMI, September 2013.

DRAFT REPORT TO THE LEGISLATIVE ASSEMBLY

Oregon Commission Docket UM 1559

Under the Feed-in tariff Pilot Program, Oregon's utilities must report the solar resource value every two years. The reporting requirement uses the definition of resource value in statute ORS 757.360(5), which is:

a) The avoided cost of energy, including the avoided fuel price volatility, minus the cost of firming and shaping the electricity generated from the facility; and
b) Avoided distribution and transmission cost.

The resource value will be used to determine payments to VIR participants at the end of the 15-year pilot program.

Because of stakeholder concerns over the values reported early in the VIR Pilot Program, the Commission opened an investigation into the appropriate method of calculating resource value. At the conclusion of that investigation, the Commission determined that it was not necessary now to choose a specific approach to calculate solar resource value. The Commission concluded that all that was needed to comply with ORS 757.365(9) was a finding on whether or not the resource value was greater than the VIR incentive rate. The Commission concluded that the resource value was not greater than the incentive rates. That finding was not disputed.[21]

The Commission directed utilities to estimate the benefits of avoided energy, avoided investments in capacity, and avoided transmission line losses. The Commission chose to not require calculations of avoided transmission and distribution investments, firming and shaping costs, fuel price hedging, or carbon costs. The Commission based this decision on the current low penetration of solar PV in Oregon. Order 12-396 stated that although these are "…legitimate components of resource value of SPV, we are not ready at this time to require the utilities to report estimates for these components."[22]

Integration, or firming and shaping, is among the components listed in the definition of solar resource value at ORS 757.360. The Commission required that utilities not include an estimate of the costs of integrating solar because of the low level of development.

Utilities were required to estimate the value of avoided energy benefits using three methods:

i. The "Standard" method used to set the Avoided Cost Price under PURPA,
ii. A "Renewable" method, also used to set the Avoided Cost under PURPA, and
iii. An "IRP" method, which uses computer models to compare the utility's total cost to serve its loads with and without the solar generation. The Commission also directed utilities to calculate

[21] Order No. 12-396; *In the Matter of the Public Utility Commission of Oregon Investigation into the Appropriate Calculation of Resource Value for Solar Photovoltaic Systems,* Docket No. UM 1559.
[22] Order 12-396 at p. 4.

the capacity contribution of solar using the "Effective Load Carrying Capacity" or "ELCC" method, a computer based method recommended by ODOE and Commission staff.[23]

The table below shows the resource values reported by utilities.

Table 5.4: Solar Resource Value $/MWh Reported by Oregon IOUs[24]

Solar Value $/MWh Reported by Utilities under OAR 860-084-0370			
Calculation Method	**PGE**	**Idaho**	**PAC**
Standard	67.03	64.56	62.89
Renewable	66.65	N/A (*)	59.41
IRP	55.19	49.89	55.07

**Idaho Power did not report a value using the "Renewable Avoided Cost" method because the Commission has not required Idaho Power to create a Renewable avoided cost price for Qualifying PURPA facilities.*

[23] In our review of solar value studies outside Oregon, we found several that also used the ELCC method for this purpose.

[24] Values for all utilities were adjusted to 2014 dollars using the Oregon Consumer Price Index reported by the Oregon Department of Economic Analysis.

VI. Evaluation of Solar Programs

In this chapter we compare the solar incentive programs that we described in Chapter 3, and evaluate them for cost effectiveness and impact on non-participating ratepayers. We discuss the potential for long term solar growth. Finally, we discuss barriers within the programs for promoting solar generation.

We chose five criteria to evaluate the various solar incentive programs:

- Total Cost of Energy – the cost per kilowatt-hour of energy produced under each program over a 20 year period.
- Cost of Incentive Program to Ratepayers –the total cost per kilowatt-hour of incentives paid out under each program. This shows how much a solar project s is subsidized under each program, and whether that subsidy comes from utility ratepayers or state taxpayers.
- Impact on cost of solar –reduction to installation costs of solar generation.
- Greenhouse Gas Reduction – how much natural gas fired power is displaced by solar.
- Jobs –the number of jobs attributable to the different programs.

In the tables below, we compare the different programs under each of the above criteria. The Renewable Portfolio Standard (RPS) does not appear in these tables because no solar facilities in operation were installed specifically as a result of this statute. However, if the cost of solar generation becomes less than the cost of other renewable sources, the RPS will likely result in large utility-scale solar projects, most likely in Eastern and Southern counties.

Note: We consider ETO rebates and state tax credits as separate programs for comparison purposes. However, as explained in Chapter 3, most net metering projects received both ETO rebates and state tax credits, so these two incentive programs include many of the same projects.

Total Cost of Solar Energy

Table 6.1 below, shows the total cost of solar energy over a 20 year period, without taking into account incentives or subsidies.

Table 6.1: Total Cost of Solar Energy[25]

Program	Levelized Energy Cost (Cents/kWh)
Net metering –ETO rebate	42
Net metering – Residential Tax Credit	42
Net metering –Business Tax Credit	33
Qualifying Facilities (QFs) under PURPA	
Solar Capacity Standard	
Feed-in- Tariff Pilot	36

Projects built through ETO rebates and state tax credits had a higher total cost over 20 years than projects built under other programs. The difference in total cost reflected differences in project size.

- The cost of projects under the Solar Capacity Standard was not available because these projects were not built by the utility. Instead, their output is purchased under contract for an average price of 9.6 cents/kWh. This price does not indicate the actual development cost.
- Oregon currently has three QF projects under PURPA, with a total capacity of 124 kilowatts. The total cost of these projects is not known because their output is purchased under contract for the avoided cost price. The average contract price paid by the utility for the energy from these QF projects is 6.5 cents/kWh.
- Projects funded through the feed-in tariff were, on average, larger than those funded through ETO rebates. This was especially true for projects larger than 10 kW, which averaged 65 kW in size for PacifiCorp and 140 kW for PGE, versus 38 kW for ETO projects.

[25] These costs are based only on projects completed in 2013. Because of the rapid decrease in solar costs, we believe costs from more recent projects are a better indicator of the true cost of solar.

- Feed-in-tariff projects in 2013 included two large PGE projects (one 400 kW and one 500 kW), with very low installation cost. Without these two large projects, the total energy cost for feed-in tariff projects was about 40 cents, comparable to the total cost of ETO-funded projects.
- Projects funded with the Business Energy Tax Credit were lower in cost because that program is specifically designed for large commercial projects.

Cost to Ratepayers and Taxpayers

Table 6.2, below, shows the cost of the incentives to ratepayers and taxpayers.

Table 6.2: Cost of Incentive Programs[26]

Program	Cost of Incentives (Cents/kWh)
Net metering –ETO rebate	6.4
Net metering – Residential Tax Credit	9
Net metering –Business Tax Credit	16
QFs under PURPA	
Solar Capacity Standard	
Feed-in-Tariff Pilot	31

- Incentive costs for QFs under PURPA are not shown because under federal law, the price utilities pay for QF power is the avoided cost price – the price the utility pay would for power from the least-cost alternative source of supply. For PGE's three QF projects, the average contract price was 6.5 cents/kWh. However, these projects did receive incentives through tax credits and ETO rebates, which helped make these projects financially viable.
- Incentive costs for the Solar Capacity Standard are also not shown, because the Solar Capacity Standard is not an incentive but rather a legislative mandate. The utilities *must* acquire these projects, with or without incentives. However, the contract price that PGE pays for the power from these facilities averages 9.6 cents/kWh - about 3 cents/kWh higher than cost PGE would incur in acquiring the power from the least-cost alternative. The projects acquired by the utility

[26] These costs are based on projects completed in 2013. Incentives in earlier years were higher, but we believe current incentives are a better indicator of the true impact of the program on ratepayers.

to comply with this mandate received state tax credits and ETO rebates. These rebates and tax credits caused these projects to be built sooner.

- In addition to the ETO rebates and state tax credits, net metering participants also save on their electric bill. These savings are not shown on this table, but they do result in a cost shift to non-participating ratepayers. An accurate value for this impact is difficult to quantify, but we discuss this issue in greater detail in Chapter VII of this report.

In summary, the feed-in-tariff pilot had higher impact on non-participating ratepayers than other programs, while the Solar Capacity Standard and QF projects had the least.

Reduction in Installation Costs

Table 6.3 shows the decline in solar cost under each program between 2010 and 2013:

Table 6.3: Reduction in Installation Cost

Program	Cost in 2010 ($/Watt)	Cost in 2013 ($/Watt)
Net metering –ETO rebate	$6.84	$4.60
Net metering – Residential Tax Credit	$6.41	$4.63
Net metering –Business Tax Credit	$4.91	$4.21[27]
QFs under PURPA		
Solar Capacity Standard		
Feed-in-Tariff Pilot	$6.48	$3.95

Installation costs declined consistently under all of the programs. BETC projects were lower in cost than other projects because that program was specifically designed for large commercial projects, which have economies of scale. Projects funded through ETO rebates decreased in cost by about the same amount as feed-in tariff projects. The Solar Capacity Standard projects were acquired by the utility through power purchase agreements, making it difficult to know the developer's actual installation cost.

We do not show a reduction in installation costs for QFs under PURPA because the utility purchases the energy from these projects for a contract price, making it difficult to know the developers' actual installation costs.

[27] This value is for 2012 as no solar project received BETC in 2013.

Feed-in-tariff projects in 2013 included two large PGE projects (one 400 kW and one 500 kW), with very low installation cost. Without these two large projects, feed-in-tariff project installation costs were comparable to the cost of projects under the ETO and tax credit programs.

As discussed in Chapter 4 above, the decline in project costs was driven mainly by lower PV panel prices. That price depends on market conditions worldwide, not Oregon incentives.

In summary, no single incentive program appears to be more effective than others at lowering installation costs.

Greenhouse Gas Reduction

Table 6.4 is a measure of each program's impact on Oregon's greenhouse gas emissions:

Table 6.4: Greenhouse Gas (CO_2) Reduction[28]

Program	Tons CO_2 Displaced/Year
Net metering –ETO rebate	13,240
Net metering – Residential Tax Credit	6,705
Net metering –Business Tax Credit	12,608
QFs under PURPA	Minimal
Solar Capacity Standard	6,160
Feed-in-Tariff Pilot	7,905

Greenhouse gas reduction benefit is directly related to the amount of solar power produced. A kWh of solar energy from one program reduces emissions the same amount a kWh of solar from another program.

- These numbers represent CO_2 savings from solar projects built in 2010 through 2013.
- The large greenhouse impact of ETO and BETC programs reflects the large number of projects funded by these incentives, and the number of large commercial scale projects included among them.
- The Solar Capacity Standard had created less CO_2 reduction because only 15 MW of solar capacity has been acquired under this standard.
- QFs under PURPA have minimal greenhouse gas reduction because there are currently only three small solar QFs operating in Oregon.
- The feed-in tariff's impact on greenhouse emissions reflects the statutory cap on the size of the program.
- CO_2 reductions from ETO and tax credit programs are *not* cumulative because most projects received both incentives and are listed under both programs.

[28] Assumes that all solar generation replaces energy from a natural gas combined cycle combustion turbine.

Jobs Created

The Oregon Solar Energy Industries Association (OSEIA) reports that 1,239 individuals make their living in Oregon's solar industry, with installation and manufacturing being the top two sectors.[29] Table 6.5, below, compares the likely job impact of the different solar programs

Table 6.5 Jobs

Program	Jobs
Net metering –ETO rebate Net metering – State Tax Credits Feed-In-tariff Pilot	These programs support a small, ongoing stream of smaller installation jobs, primarily in population centers.
QFs under PURPA Solar Capacity Standard	This program promotes large projects that create jobs during construction, but end when the project is complete. The jobs are located in rural areas where there is good sunlight.

The complete calculations showing these results are in Appendix 1. A detailed discussion of these calculations is in Appendix 2.

Based on these results,

- The total cost of solar energy was higher for net metering than for the feed-in tariff program, and lowest for large scale projects installed under the Solar Capacity Standard.
- Commercial size projects (shown under the Business Tax Credit) were less costly than residential programs.
- The cost of incentives in the feed-in tariff pilot was the highest of any program. The payments covered nearly all of the system installation costs over time. Participants in that program were fully subsidized by other ratepayers.

[29] Email from Paul Israel, OSEIA to Adam Bless Re: Employment Data for Solar Incentive Programs, May 3, 2014

- ETO rebates and state tax credits covered less than half of the total cost of the energy produced by solar PV projects. Participants in those programs paid a higher share of the cost of energy from their projects.
- All programs show a decrease in installation cost from 2010 to 2013. No single program was more effective at reducing costs than any other. Most of the decrease is caused by the worldwide decrease in PV panel costs, which benefits all programs equally.
- Greenhouse gas reduction is greater for programs that promote large projects in locations with the best sunlight. These projects also had the lowest total energy cost.
- There is a trade-off between job creation and solar cost. Much of the "soft" cost of solar is labor. Therefore, much of the future cost reduction will come from reducing the amount of labor. This will reduce the cost of solar, but it will do so by creating fewer jobs. Small residential rooftop projects in cities create more jobs, but are more costly. Large-scale projects have significant economies of scale, but create fewer jobs.

Potential for Growth in Solar Generation

The potential for solar growth in Oregon depends on two factors:

- "Technical" potential – the amount of available area, on rooftops or on the ground, with the proper sunlight for solar development, and
- "Economic" potential – the amount of funds available to invest in solar, taking into account the cost of subsidies.

Technical Potential

Oregon has more than adequate area available for solar development. In 2012, NREL published an analysis of the technical potential for solar development in each state.[30] NREL took into account the amount of sunlight, the proper building characteristics for rooftop solar, and the proper siting characteristics for urban and rural large scale projects. NREL concluded that Oregon has the potential for:

- Rooftop area for 8,000 MW of solar capacity, equal to 8.4 million MW-hours of solar energy per year,
- Available urban land for 13,000 MW of solar capacity, equal to 25.8 million MW-hours per year, and,

[30] "U.S. Renewable Energy Technical Potential," NREL, July 2012.

- Available rural land for 1.9 million MW of solar capacity, equal to 3,700 million MW-hours per year.

For comparison purposes, Oregon's peak load is about 8,200 MW, and total electric retail sales in Oregon were 46.5 million MW-hours in 2012. In summary, physical potential is not a barrier to solar growth under any of Oregon's programs to promote solar development.

Economic Potential

The economic potential for solar growth in Oregon depends on the cost of solar, the impact on electric rates, and the funds available for incentives. Economic factors limiting solar potential for each program include:

Net Metering: Currently there is no cap on the total amount of net metering capacity in Oregon, although the Commission has the statutory authority to set one. As discussed below, net metering may shift some of the utility's fixed costs from program participants to other ratepayers. This cost shift limits the economic potential for solar from net metering.

ETO Rebate: The ETO rebates are funded by Oregon's Public Purpose Charge (PPC) imposed on customers of PGE and PacifiCorp, and is equal to 3 percent of utility retail sales. Seventeen percent of the PPC funds provided to the ETO are for developing renewable resources. And, solar is only one of several renewable technologies eligible for these rebates. The total growth in distributed solar through this incentive is therefore limited by the funds available.

State Tax Credits: The residential tax credit is scheduled to expire in 2017, and the business tax credit has expired already. Most net metering solar projects to date were installed with a combination of ETO rebates and state tax credits. It is unlikely that these projects would be built without these incentives.

Feed-in Tariff: The feed-in-tariff pilot is scheduled to end after 2016. The statute authorizes the Commission to limit the capacity allocated to any class of customers under the program if the rate impact of the program exceeds an amount equal 0.25% of the utility's revenue requirement for the class. Reports from the utilities indicate that this limit has been reached under the current program.[31]

Renewable Portfolio Standard: Utilities have met the RPS primarily through wind and hydroelectric power. PGE and PacifiCorp have enough renewable generation in place now to meet their RPS obligation through 2019. However, after that, the RPS has potential to create large utility scale solar projects if the cost of solar continues to decline at current rates.

QFs under PURPA: There are currently three solar QFs operating in Oregon, with a total capacity of 124 kilowatts. Idaho Power recently signed contracts with six additional QF projects which, if built, will total an additional 60 MW. If the cost of large scale solar continues to decrease at current rates, then QF

[31] *See* "Solar Photovoltaic Volumetric Incentive Program" report to the legislative assembly, Jan. 1, 2013, Figure 10.

development in Oregon has the potential to create large projects in Eastern and Southern Oregon, but little if any potential to create distributed solar projects in residential zones.

Cost of Solar: Chapter 4 of this report describes the downward trend in the cost of solar electricity, and compares the cost of solar with the cost of other energy sources. If the cost of solar decreases further, growth can be sustained with fewer incentives. Large scale solar will need to decrease in cost by about 25 to 30 percent to be cost competitive with other forms of renewable generation, such as wind. Residential solar will need to decrease in cost substantially to continue growth without incentives.

Federal Investment Tax Credit: The federal investment tax credit pays 30 percent of installation costs. Right now, this credit is available for residential, commercial, and utility-scale systems. In 2017, the credit is scheduled to expire for residential systems and decrease to ten percent for commercial and industrial systems. Even with good progress in reducing solar installation costs, the expiration of this incentive will limit solar growth, particularly for residential systems.

In summary, without further incentives, the economic factors will limit solar growth over the next few years. The potential for solar growth is:

- Greater for programs that emphasize projects with lower overall costs, such as larger projects in areas with more sunlight,
- Greater for programs with less cost shifting from participants to non-participants, and
- Greater for programs that can adjust incentives to changing solar costs.

Costs and Benefits to Program Participants and Non-Participants

Program Participants – who they are

As part of the feed-in-tariff pilot program, PGE and PacifiCorp asked participants to fill out detailed surveys. Participation was voluntary, and not all participants gave information about their income. Of those who did:

- For PGE, 96 percent of survey respondents reported annual household income greater than $40,000 and 55 percent reported incomes greater than $80,000.
- For PacifiCorp, 89 percent of survey respondents reported annual household income greater than $40,000 and 55 percent reported incomes greater than $80,000.

On February 25, 2014, PGE gave a presentation to the House Committee on Energy and the Environment, with information about the participants in its solar programs. PGE noted that its residential customers who install solar PV systems are:

- More likely to be highly educated
- More likely to have a dual income
- Likely to be high consumers of information
- Likely to value green products and buy renewable power
- More likely to own single family homes with value over $300,000[32]

Benefits to Participants

Below is a comparison of the benefits that participants receive from different Oregon solar incentive programs.

Feed-in-tariff participants

Feed-in-tariff participants receive direct payments. Their total benefit is the incentive rate multiplied by the total number of solar kWh produced over the 15-year term of the program. Their average benefit is about 12 cents per kWh. [33]

Net metering participants

Net metering customers benefit from ETO rebates, state tax credits, and savings on their electric bill.

- The ETO rebates (residential) were about 6 cents per kWh on average.
- The tax credits were about 9 cents per kWh on average. Many net metering participants received both ETO rebates and state tax credits, for a total benefit of 16 cents per kWh.
- Commercial net metering customers received the Business tax credit, worth on average about 16 cents/kWh. ETO rebates in this sector averaged about 7 cents, for a total of 23 cents/kwh.
- Net metering customers also receive bill savings at the utility's retail rate for each kWh they generate. For example, PacifiCorp residential customers decrease their net electricity use by about 40 percent, resulting in about $33/month bill savings for a typical residential customer. [34]

The bill savings to net metering customers has a levelized value of about 11 cents/kWh over a 20 year period.[35] Thus, residential net metering customers can combine ETO rebates, state tax credits, and bill savings for a total benefit of about 25 cents/kWh, or about 58 percent of their investment in solar energy. When combined with the federal tax credit of 30 percent, the incentives for residential net metering customers can cover nearly 90 percent of their original installation cost over time.

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[32] "Snapshot of Solar PGE Development in Oregon," PGE presentation to House Committee on Energy and Environment, Feb 25, 2014.
[33] VIR participants also receive bill savings, but those savings are already included in the VIR payment.
[34] Email from Joelle Stewart/PacifiCorp, to Adam Bless/OPUC, March 28, 2014.
[35] We estimated the value of bill savings over time using an assumption of 2 percent annual rate increase and a 5 percent discount rate for typical residential customers.

Combined, these benefits are enough to cover most of the participants' costs of system installation. In other words, most of the program participants' costs are paid for through incentives over time.

For a summary of benefits to participants, refer to Appendix 2, Table A.2.3.

Impact of Feed-in Tariff on Non-Participants

To date, the rate impact of solar incentive programs has been small because the programs are limited in size. Oregon's solar generation capacity, including customer owned projects and large utility-scale projects, is about 1 percent of Oregon's total generating capacity. The Feed-in-tariff pilot is capped by statute at 27.5 megawatts, and at the end of 2012 PGE and PacifiCorp reported that the rate impact of the VIR Pilot Program was about 0.25 percent.[36]

Impact of ETO rebates and Net Metering on Non-Participants

The total rate impact of the ETO rebate program is limited by statute and generally will not exceed 0.5 percent.[37] In addition to the direct cost of rebates, there is also an indirect rate impact from net metering. Net metering customers benefit from savings on their electric bill, but in doing so they also avoid paying a portion of the utility's fixed costs. These fixed costs are shifted to other ratepayers. This impact is small now, because the amount of net metered solar capacity is a small fraction of total generation capacity. As solar installation costs decline, the impact of net metering on non-participating ratepayers could become more significant. We discuss the issue of fixed cost recovery in more detail in Chapter VII of this report.

Overall, for projects built in 2013 through the combination of ETO rebates and state tax credits, we estimate that the costs to ratepayers exceeded the benefits by about 6 cents per kWh. For projects built in 2013 under the feed-in-tariff pilot, we estimate that the cost to ratepayers exceeded the benefit by about 24 cents/kWh. It is important to note that the actual impact on ratepayers bill was less than 0.5 percent, because the number of solar participants was small, and the program costs were spread out over the entire population of ratepayers.

For a summary of costs to non-participants, refer to Appendix 2, Table A.2.4.

Impact on Taxpayers

Finally, the Oregon taxpayer bears the cost of providing the tax credit incentives - the lost revenue not collected through taxes because of the credit. The benefits to taxpayers are "soft" benefits such as greenhouse gas reduction, reduced pollution, and economic development. A more detailed discussion of soft benefits is in Chapter V of this report. For a summary of costs to taxpayers, refer to Appendix 2, Table A.2.5.

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[36] OPUC "Solar Photovoltaic Pilot Program-report to the Legislative Assembly" January 2013.
[37] The public purpose charge created by ORS 757.612(3) is set at three percent, of which 17 percent is allocated to development of renewables, resulting in a maximum rate impact of 0.5 percent for solar development.

Barriers to Development

The legislature directed the Commission to "…identify barriers within the programs to providing incentives for the development of solar photovoltaic energy systems."

The obvious barrier to solar development is the initial installation cost. Chapter IV, above, describes the trend in these costs.

To identify barriers that are specific to Oregon's incentive programs, we used two sources of information: (1) barriers identified in surveys of program participants, and (2) barriers named by solar development community stakeholders in public comments during this investigation.[38]

The participants and stakeholders listed a variety of barriers, but three specific barriers were mentioned most often:

1. Financing was a barrier mentioned most often by stakeholders and survey participants alike. Financing was also a frequent reason cited by VIR program participants requesting additional time to complete their projects. However, the third party lease model has helped overcome this barrier for many customers, because the third party has better access to financing.
2. Confusing Array of Incentive Programs: Solar installation contractors described the difficulty of explaining the different available incentives to potential clients. VIR survey respondents said it was difficult to figure out which program was the best "fit" for them.
3. Duplicative Incentive Application Requirements: Having different application requirements for each incentive adds extra work for solar contractors, and may be confusing to potential solar PV customers. ODOE is collaborating with the ETO to create a more uniform incentive application requirement.

Despite these concerns, participation in the various programs has been strong as costs have decreased. All of the available capacity in the VIR Pilot Program was reserved in every enrollment window except one, and applications for ETO rebates and residential state tax credits continued to increase even after the VIR Pilot Program started.

[38] The Commenters were the City of Portland, Idaho Power, Renewables Northwest Project, Sierra Club, Alliance for Solar Choice, Oregon Department of Energy, Oregonians for Responsible Energy Progress, PacifiCorp, Portland General Electric, Citizen's Utility Board, Oregon Solar Energy Industry Association, and Energy Trust of Oregon.

VII. Other Solar Policy Issues

Three related issues have surfaced with the growth in solar development in Oregon and elsewhere. These are:

i. Recovery of utility fixed costs,

ii. Integrating distributed solar reliably into the local grid (Smart Inverters), and

iii. Reducing the "soft costs" of solar.

Recovery of Utility Fixed Costs

A key issue for solar projects that use net metering is the potential for cost shifting of utility fixed costs. A portion of each residential customer's electric bill pays for fixed utility costs of transmission and distribution. Net metering customers enjoy a reduced electric bill, but in doing so they avoid paying some of these fixed costs. The utility must recover them from other ratepayers. This has been a small concern in Oregon, because distributed solar generation is only a small fraction of Oregon's total generation. However, it has become a significant concern in high-solar states such as Arizona and California.[39]

In its comments during this investigation, PGE stated that a 6.4 cents/kwh charge would have to be deducted from the bill credit given to net metering participants to recover distribution costs from net metering participants.[40] In January 2014, PacifiCorp testified before the Utah PUC, proposing a Net Metering charge of $4.25 per month.[41] PacifiCorp states that an equivalent calculation for Oregon would produce a $6.90 charge.[42]

This issue has been raised in other states as well. Arizona Public Service (APS) proposed a charge on net metering participants in order to recover fixed costs. In a July 2013 filing with the Arizona Corporation Commission, APS proposed that existing net metering customers pay a higher service charge based on the amount of electricity they use. This charge would range from $45 to $80 per month.[43]In November, 2013, the Arizona Commission approved the addition of a 70 cent/kW fee on net metering customers,

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[39] This is more of a concern for residential net metering customers than for commercial customers. Commercial rates in Oregon include a demand-charge that reflects the highest amount of power used during any hour of the billing period. These demand charges are designed to cover utility fixed costs, and do not change much, if at all, when solar generation is installed.
[40] Initial Comments of PGE in Docket No. UM 1673, December 19, 2013.
[41] Direct Testimony of Joelle Stewart, "Cost of Service" Rocky Mountain Power Docket No. 13-035-184.
[42] Email Joelle Stewart/PacifiCorp, to Adam Bless/OPUC, March 28, 2014.
[43] See "Distributed Generation – an Overview of Recent Policy and Market Developments, American Public Power Association, November 2013.

equivalent to about $5/month for an average installation.[44] This fee was less than APS proposed, but was a compromise decision taking into account the Arizona Commission's general support for solar development and its concern over cost-shifting.

The most extensive work on recovery of fixed costs is happening in California. Assembly Bill AB 327 directs the California Public Utilities Commission to perform a comprehensive study of fixed cost recovery and implement a remedy. Results will not be available in time to inform this report. However, we will monitor the results of AB 327 to determine if they apply here in Oregon.

Integrating Distributed Solar Generation Reliably into the Local Grid – Smart Inverters

All Solar PV generation, whether from small distributed installations or large grid scale projects, produces Direct Current (DC), and requires an inverter to convert power to Alternating Current (AC). The main national standards that govern inverters in the U.S. are IEEE[45] 1547 "Standard for Interconnection Distributed Resources with Electric Power Systems" and UL[46] 1741 "Standard for Safety for Inverters, converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources." The Commission's current rules at OAR Chapter 860 Divisions 39 (for Net Metering) and 84 (for the Solar Pilot Program) endorse the 2001 edition of IEEE 1547.

Distributed solar PV generation presents challenges that were not foreseen in current editions of these codes. These issues have surfaced notably at San Diego Gas and Electric, which has a higher penetration of distributed solar than Oregon.[47] The Western Electric Industrial Leaders (WEIL) issued a White Paper in August 2013 signed by the senior officers of 16 western utilities, including PGE and Pacific Power. The technical issues listed in the White Paper were:

- Rapid localized fluctuations in PV power from cloud cover and fog burn-off
- Voltage swings on distribution lines
- Safety settings on older inverters causing solar SPV to trip off-line in response to short voltage drops on the local distribution grid. This is not a problem in neighborhoods with only a small number of solar PV installations. However, if several solar PV installations on one distribution feeder trip off line simultaneously, this can exacerbate the low voltage condition.

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[44] "APS Distributed Solar PV Study and AZ Update," David Weinglass, APS, December 4, 2013
[45] The IEEE is the Institute of Electrical and Electronics Engineers, the nation organization that produces consensus codes for safety and reliability of electrical devices in use by most utilities in the US.
[46] UL is Underwriters Laboratory, which tests and certifies electrical devices for safety.
[47] *See* "Integration of PV on the Distribution System," presentation by SDG&E at the EUCI Distributed Solar Conference December 5, 2013.

The WEIL committee recommended that standards be updated to permit inverters to have smart functions, such as:

- Communications capabilities, to permit remote changing of setpoints by the utility
- Dynamic Voltage Control
- Expanded frequency trip points
- Low Voltage Ride through (to permit solar PV to stay online during short local grid voltage drops, providing voltage support that could help stabilize the local grid).
- Randomization of timing for trip and reconnection (so that all solar PV installations on a distribution feeder with a high penetration of SPV do not trip offline simultaneously).

Inverters with these features are available in the United States, but the features are disabled to comply with the current edition of IEEE 1547 and UL 1741. Modern inverters have the features built in, with firmware that enables the utility to enable or disable the features by changing program settings. Utility owned inverters are not required to comply with UL 1741 requirements, but Commission rules require compliance with this code for installations under its pilot program.

The IEEE has established a code committee to update IEEE 1547. The updated code, named IEEE 1547a, has been drafted and could be adopted by the code committee as soon as early 2014.[48] UL would then need to implement testing procedures to certify inverters' compliance with the new code.

The Commission will update its rules to endorse the new IEEE and UL codes. A state agency cannot endorse new editions of industry codes in advance, and state agency rules that endorse industry standards must specify the edition of the code to avoid unlawful delegation of authority. For this reason, ODOE recommends, and we concur, that the Commission begin with workshops to gather developer and utilities' technical input, followed by rulemaking that would make new smart inverter requirements applicable in January 2016.

Using smart inverters will not greatly increase the cost of SPV installations. The WEIL whitepaper notes that the cost to build these smart functions into currently available inverters adds about 10 cents per installed watt to the cost of an installation. For a 3 kW residential system, the WEIL white paper estimates a total cost impact of about $150, a small fraction of total cost.

[48] PacifiCorp Distributed Energy Resource Standards Update**,** January 17, 2014.

Reducing Soft Costs of Solar Installation

The US Department of Energy (USDOE) launched a program in 2011 called the “Sunshot” Initiative, aimed at reducing solar costs in general and in particular reducing “soft costs.” The mission of this initiative is to make solar energy cost competitive with other energy sources by the end of this decade.[49]

Soft costs include components such as permitting and inspection, and other costs like financing, contracting, customer acquisition, and labor. Permitting and inspection are the components of soft costs that are most directly under state and local government control. There is some potential for reducing permitting and inspection costs, but the soft cost analysis performed by the USDOE suggests that this potential is limited because permitting and inspection costs are not a large fraction of soft costs overall. Oregon state and local agencies have already done much to reduce permitting and inspection costs. The Commission in 2007 adopted rules standardizing the interconnection process and requirements, based on nationally accepted engineering codes. To streamline the inspection process, the Oregon Building Codes Division issued the Oregon Solar Installation Specialty Code, standardizing solar installation electrical requirements throughout the state. In 2011 HB 3516 made residential solar installation an outright permitted use. The legislature has also exempted residential solar installations from local property taxes.

Other soft costs, such as supply chain costs, developer profits, transaction costs, installation labor and customer acquisition costs, are part of the installers’ business models.

ODOE is the lead agency in Oregon investigating soft costs under the Sunshot initiative. The program is just getting underway, and results will not be available in time to inform this report. However, the installation cost data collected by ODOE and the ETO show that installation costs vary widely, even for installations with similar size and location. Therefore, we can reduce solar costs simply by reaching the cost levels already being achieved by some of the more efficient contractors. That goal is the basis for the 5-year cost projection shown in Chapter IV of this report.

[49] See US Department of Energy: SunShot Initiative. Available at http://www1.eere.energy.gov/solar/sunshot/mission_vision_goals.html

DRAFT REPORT TO THE LEGISLATIVE ASSEMBLY

Appendices

Appendix 1: Incentive Evaluation Matrix

Appendix 2: Description of the Incentive Evaluation Matrix

Appendix 1

Oregon Solar Projects - Incentive Evaluation Matrix

			Average	Total	Total	Install Cost/W		Levelized Costs	
	No. Systems	Installed kw	kwh/year	System Install Cost$	Incentive $	$/W	KW/Project	Energy	Incentives
Net Metering									
ETO (Residential)	**4,217**	**16,789**	**17,479,641**	**$ 97,906,648**	**$ 21,452,152**	**5.83**	**4.0**		
2010	1066	3,140	3,251,531	$20,577,565	$5,463,480	6.55	2.9		
2011	1199	4,552	4,735,180	$30,114,877	$7,446,650	6.62	3.8		
2012	1114	4,630	4,804,332	$26,052,859	$5,508,179	5.63	4.2		
2013	838	4,468	4,688,599	$21,161,347	$3,033,844	4.74	5.3	$0.43	$0.06
ETO (Non-Residential)	**428**	**14,945**	**15,621,712**	**$ 87,457,861**	**$ 15,149,531**	**5.85**	**34.9**		
2010	129	4,186	4,324,544	$29,568,246	$5,010,322	7.06	32.5		
2011	129	3,720	3,953,911	$21,586,773	$3,492,070	5.80	28.8		
2012	127	4,538	4,691,538	$25,410,426	$4,576,463	5.60	35.7		
2013	42	2,501	2,651,720	$10,892,415	$2,070,676	4.35	59.6	$0.39	$0.07
ETO (Utility)	**12**	**15,264**	**17,745,388**	**$ 73,730,625**	**$ 12,911,293**	**4.83**	**1272.0**		
2010	7	2,406	2,406,096	14,083,369	2,333,913	5.85	343.7		
2011	2	2,840	2,840,000	17,407,842	3,278,880	6.13	1420.0		
2012	3	10,018	12,499,292	42,239,414	7,298,500	4.22	3339.4	$0.32	$0.05
RETC	**4,232**	**16,102**	**16,764,080**	**$ 91,332,937**	**$ 24,562,494**	**5.67**	**3.8**		
2010	1172	3,474	3,647,246	22,264,999	6,777,192	6.41	3.0		
2011	1468	5,774	6,062,873	35,285,825	8,473,479	6.11	3.9		
2012	1030	4,084	4,288,591	20,893,151	6,003,493	5.12	4.0		
2013	562	2,770	2,913,961	12,820,145	3,308,330	4.63	4.9	$0.42	$0.09
BETC	**244**	**26,299**	**31,522,282**	**$ 114,654,682**	**$ 57,327,367**	**4.36**	**107.8**		
2010	126	7,567	9,070,082	37,117,207	18,558,620	4.91	60.1		
2011	81	5,940	7,119,637	23,733,629	11,866,822	4.00	73.3		
2012	37	12,792	15,332,563	53,803,846	26,901,925	4.21	345.7	$0.33	$0.16
VIR	**1,002**	**17,506**	**19,762,595**	**$ 88,319,601.37**	**$ 7,754,063.58**	**5.05**	**17.5**		
PAC	**335**	**6,094**	**8,152,653**	**$ 31,542,042**	**$ 3,109,112**	**5.18**	**18.2**		
2010	50	316	392,609	2,073,121	234,365	6.55	6.3		
2011	140	2,096	3,232,546	12,183,252	1,394,062	5.81	15.0		
2012	145	2,183	2,827,567	10,704,814	853,166	4.90	15.1		
2013	145	1,498	1,699,931	6,580,855	627,519	4.39	10.3	$0.37	$0.34
PGE	**620**	**10,989**	**10,989,220**	**$ 54,435,351**	**$ 4,418,134**	**4.95**	**17.7**		
2010	86	545	544,920	3,509,025	343,205	6.44	6.3		
2011	244	3,955	3,954,810	22,021,300	1,840,450	5.57	16.2		
2012	290	3,750	3,750,200	18,694,616	1,363,631	4.98	12.9		
2013	213	2,739	2,739,290	10,210,410	870,848	3.73	12.9	$0.35	$0.29
IPCO	**47**	**423**	**620,722**	**2,342,209**	**226,817**	**5.54**	**9.0**		
2010	9	88	128,963	551,450	70,930	6.25	9.8		
2011	30	273	401,075	1,530,472	127,141	5.61	9.1		
2012	8	62	90,684	260,287	28,747	4.22	7.7	$0.27	$0.29

Description of the Incentive Cost Matrix

Appendix 2 provides a summary of the costs related to each of Oregon's major incentive programs: ETO rebates, state tax credits, and feed in tariff, broken out by year. Since the feed in tariff pilot begin in 2010, we only tabulated figures for the years 2010 through 2013. Since the price of solar equipment dropped dramatically in the last five years, including early cost data will disproportionately skew the total cost amounts and provide an inaccurate view of current costs.

For each program, we tabulated the installed capacity (kilowatts), annual energy generation (kilowatt-hours), total system cost and total incentives paid. From these data we estimate a levelized cost of energy (LCOE) and incentives (LCOI) over a 20-year period. We compared the various incentive programs based on projects completed in 2013, to reflect current solar costs rather than the higher costs of earlier years.

Assumptions

In calculating the LCOE, we spread the installation cost of solar projects over all energy generated by the systems over a 20 year period. We assumed solar energy production for each system to be constant for each year. We calculated the levelized cost of energy in cents/kWh, using a 7.1 percent discount rate.[1]

We estimated the LCOI over the same 20 year period. For the feed in tariff program, we assumed that incentive payments in years 16 through 20 of the program will be 15 cents/kWh. For tax credit programs, we assumed the customer takes the tax credit over the first four years. Dividing the LCOI by LCOE gives the percentage of the project that is paid by ratepayers or taxpayers.

For net metering customers (those receiving ETO rebates and state tax credits), we also estimated the electric bill savings. For this analysis, we assumed a 2 percent annual escalation rate. We calculated a levelized value of bill savings assuming a seven percent discount rate.

In Order 12-396, docket No. UM 1559, the Commission directed utilities to report a solar value based on Avoided Costs under the federal Public Utility Regulatory Policy Act (PURPA). This value is the cost the utility would incur generating or purchasing energy and capacity using the least-cost source of supply. In the tables below, we used the values filed by the utilities in compliance with Order 12-396 to estimate the avoided energy, avoided transmission loss and avoided capacity benefit of solar generation.

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[1] To ensure consistency between the estimates of annual solar generation for the different programs, we used county-specific energy production factors (in kWh/installed KW) provided by the Energy Trust.

Cost of ETO rebate program to Ratepayers

In 2013, the levelized cost of energy (LCOE) for systems receiving ETO rebates was about 43 cents/kWh for residential systems, and 39 cents/kWh for commercial systems. ETO rebates covered about 6 cents of this cost for residential systems, and about 7 cents for commercial systems. Thus, on average the ETO rebates covered about 13% of overall residential project costs, and about 18% of commercial system costs. Because ETO rebates are funded by the public purpose charge, ratepayers fund this 13 to 18 %. Project costs were also covered partly by state tax credits under the RETC or BETC programs, and by federal tax credits worth 30% of project cost. The remainder of project cost was paid by the project participants.

We next compared the LCOE for projects receiving ETO rebates in 2013 with the avoided cost of energy reported by the utilities in their response to the Commission's Order 12-396 in Docket No. UM 1559. For example, Portland General Electric (PGE) reported an avoided cost of 6.7 cents/kWh (levelized value over 15 years), compared with 43 cents/kWh for ETO-funded solar projects. This means that although solar energy has dropped in cost drastically over the last several years, the energy from residential projects funded through ETO still costs more than five times the cost of the energy the utilities would otherwise produce or purchase.

Cost of State Tax Credits (RETC and BETC) to Taxpayers

The two tax credit programs demonstrate trends that are similar to each other, and similar to the ETO program. For investments receiving RETC, the LCOE for projects built in 2013 was around 42 cents per kwh, comparable to the LCOE for projects receiving ETO rebates in that same year. This was expected, since most projects that qualify for ETO rebates also qualify for tax credits.

The RETC incentive covered about 22% of the project costs. The BETC covered 47% of the project costs. Oregon taxpayers bore the cost of these programs.

Projects funded through the BETC program in 2013 had an LCOE of 33 cents, substantially lower than residential projects. This also is expected, and demonstrates the economies of scale with larger systems.

Cost of Feed in Tariff Pilot (VIR) to Ratepayers

The LCOE for the VIR in 2013 was about 36 cents/kWh, lower than the LCOE under ETO (excluding utility projects) or residential state tax credit programs for the same year. However, the LCOE under the VIR program remains far higher than the avoided cost of energy for the utilities. Our calculations show the LCOI for VIR programs was about 31 cents/kWh, effectively covering 87 percent of the LCOE over the course of the program; in other words, the incentive nearly completely paid for the system over time.

Table A.2.1 below compares the percentage of solar project costs paid for by ratepayers or taxpayers for Oregon's major incentive programs.

Table A2.1: Percent of Solar Projects Financed by Non-Participants

INCENTIVE PROGRAM	WHO PAYS	UPFRONT INCENTIVE PORTION
ETO Rebate	Ratepayers	15%
Residential Tax Credits	State Taxpayers	22%
Business Tax Credits	State Taxpayers	47%
Volumetric Incentive Rate	Ratepayers	87%

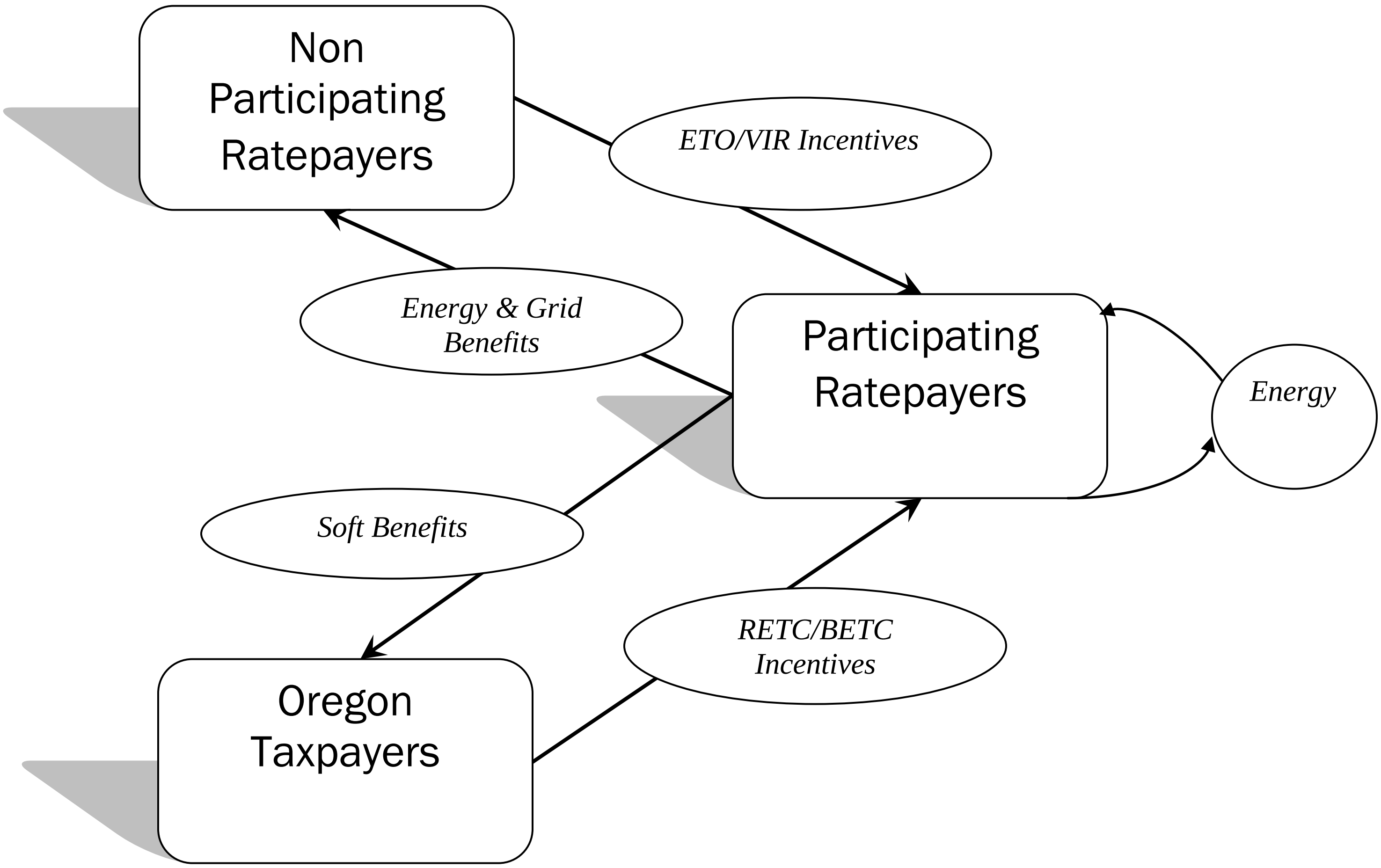
Cost Shifting Associated with Bill Savings for Net Metering

We also considered the bill savings accrued by net metering customers. Utility rates are designed to recover utility costs on a "per kwh" basis, based on an assumed level of retail sales. Solar participants enjoy bill savings, often referred to as a utility's "lost revenue." However, the utility must still recover its fixed costs, which it does by increasing rates. Since the participant is producing much of their own energy, they are insulated against these rate increases. The utility's non-participating ratepayers see the increase in rates. This is referred to as "cost shifting."

The Figure below is a flow chart that illustrates the flow of costs and benefits of solar incentive programs among participants, ratepayers, and taxpayers.

Flow of Benefits Diagram

The following chart shows the flow of costs and benefits among participants and non-participants in Oregon solar programs.



Benefits of Incentive Programs

As discussed in Chapter 5, solar benefits fall into two broad categories – benefits associated with electric grid characteristics such as avoided energy cost and availability, and benefits associated with non-grid attributes of solar energy, such as its low environmental impact and the broad participation in energy generation allowed. Some of these benefits are easily monetized; others are far more difficult.

All of the benefits discussed are independent of incentive program. That is, all of the benefits are benefits of solar in general, and apply to all of the solar incentive programs equally and without differentiation.

Benefits and costs are dependent on which stakeholder perspective one takes. For example, for each kilowatt-hour of solar energy, the utility sees a cost equal the retail price. Part of this lost revenue is offset by the fact the utility did not have to produce that unit of energy – the "avoided cost." The participant's benefit is the full retail price, while the utility's (and ratepayers') cost is the retail rate minus the avoided cost. Thus, each stakeholder will have a different perspective of costs and benefits. Table A.2.2 below summarizes these avoided costs as calculated in numerous detailed studies in other states:

Table A2.2: Summary of Nationwide Avoided Cost Study Results (cents per kWh)

	BENEFITS/COSTS per KWH						
	Energy	Transmission Losses	Avoided Generation	Avoided Transmission & Distribution	Grid Support	Fuel Hedge	Soft
AZ	2.7		0.72	0.14			
AZ	7.91 to 11.1		0 to 1.85	0 to 0.82			
AZ	6.4 to 7.5		6.7 to 7.6	2.4 to 2.5	1.5		0.1
Austin	6		1.7	1			2
Austin	7.8	0.7	1.5	0.11			2.2
CA	6	0.2	4.5	2	0.5		2
CA	6	1	4	2	0.5		2
MN	6.7		2.4	1.1			3.1
NREL	3.2 to 2.7		1.1 to 10	0.1 to 10	0 to 1.5	0 to 0.9	0.4 to 6.2
NJ	6.1		1.6 to 2.2	1 to 8		2.5 to 4.7	2.3 to 5.5
TX	10.6		1.6 to 1.9	0.5		2.6	
CO	3.6 to 7.6	0.5 to 0.8	1.15	0.1		0.7	0.5
RMI	2.5 to 12	0 to 4.5	0 to 13	0 to 11	<1 to 1.8	0 to 4.5	0.5 to 5.5
OREGON	3.7	0.5	2.0	0	0.5	0	NA

Note: For Oregon avoided energy value we used avoided cost of energy from utility compliance filings with Order 12-396, using PGE's filing for this example. Avoided transmission losses are estimated at about 9%. We estimated the value of avoided capacity investment using the difference between on peak and off peak avoided energy for PacifiCorp schedule 37. Since the utilities provided no value for "grid support," we used a typical value from the studies done in other states, without comment on whether or not that is a correct value for Oregon.

Cost-Benefit Analysis

Oregon utilities are required to report the avoided cost of energy, including avoided cost of transmission and avoided investments in generating capacity, on an annual basis.[2] This provides a concrete value for the hard benefits discussed in Chapter 5.

Distributed solar energy may also provide grid support or "ancillary" services, such as voltage support and regulation. It is very difficult to estimate an exact value for this benefit if there is one at all. Rather than calculate this value, we reviewed the results of nearly twenty extensive studies performed in other states. Most of these studies report the value of grid support from distributed solar to be about 0.5 cents/kWh, with a few outliers at the high and low end. Table A.2.2 shows the "typical" result from the studies outside Oregon as a reasonable estimate. We note that these studies were performed in states with higher solar penetration, and may not be correct for Oregon.

Each state, and in fact each utility within a state, has a different avoided cost of transmission based on their specific transmission plant. Oregon has a relatively strong position for transmission resources, with both PacifiCorp and Bonneville Power Association providing transmission services. Also, utilities must still maintain enough transmission capacity to meet winter peak load, when solar the solar contribution is reduced. At this point, it is unlikely that even a vast amount of solar, especially distributed solar, will have an appreciable impact on transmission planning in the near horizon. For that reason, we assume a zero benefit value for avoided transmission capacity investment costs.

In summary, rather than calculate exact values for "soft" benefits, we present "typical" values from the many studies performed outside Oregon.

Cost and Benefit from Participant Perspectives

The participant bears the original cost of the solar project. This cost is represented by the LCOE under the various programs.

These costs are offset by the benefits incurred by the participant – the bill savings enjoyed by the participant combined with incentive payments. Assuming 2 percent annual retail rate escalation and using a 7 percent discount rate for residential customers, we estimate the levelized value of bill savings at 11 cents/kwh over 20 years.

As we discussed, solar projects often combine incentives. ETO rebate participants typically receive either the RETC or BETC (but not both). Those who participate in the VIR program are not eligible for the RETC or BETC. For the analysis below, we assume that the ETO rebate is combined with one of the tax benefits to fully utilize the stream of benefit values. Table A.2.3 compares the net benefit to residential net metering participants, commercial net metering participants, and feed in tariff participants:

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[2] *See* Commission Final Order in Phase 1 of Docket No. UM 1610.

Table A.2.3: Estimates of Participant Benefits for projects built in 2013 (¢/kwh)

	Participant Cost	Participant Benefit			Value to Participant
	LCOE	Bill Savings	ETO Rebate	Tax Credits	Benefits - LCOE
Net metering residential (ETO + RETC)	43	11	6	9	-17
Net metering commercial (ETO + BETC)	39	11	7	16	-5
VIR – average of residential and commercial	36	0	31	0	-5

Non Participant (Utility Ratepayers)
The nonparticipants bear the cost of incentives and also bear the cost of fixed-cost recovery discussed above. For each kilowatt-hour the solar project produces, there is a fixed cost that is not paid for by the participant. This revenue is not “lost” to the utility; it is in fact shifted to the non-participants. The exact value of this unrecovered fixed cost is difficult to calculate, but for this comparison we estimated it at approximately 6 cents or half of the levelized retail rate over the 20 year analysis period.

The nonparticipants benefit from the general grid benefits as well as avoiding future rate increases due to increased generation, transmission and distribution resources. As in Table A.2.2 above, we based the benefit to ratepayers on PGE’s compliance filing with Commission Order 12-396 in docket UM 1559. The costs and benefits are summarized in Table A.2.4 below:

Table A.2.4: Estimates of Ratepayer Costs for projects built in 2013 (¢/kwh)

	Fixed Cost	Incentive Cost	Benefits	
	Shifted Fixed Cost	LCOI	Sum of Benefits	Benefits - Costs
ETO + RETC	6	6	6.7	-5.3
ETO +BETC	6	7	6.7	-6.3
VIR	0	31	6.7	-24.3

Note: Sum of “benefits” for Oregon is the avoided cost of energy, capacity and transmission losses shown in Table A.2.2, not counting “soft benefits” such as environmental or societal benefits.

Finally, the Oregon taxpayer bears the cost of providing the tax credit incentives. More precisely, this value represents the lost revenue not collected through taxes because of the credit. The benefits gained by the taxpayers are very difficult to quantify, representing avoided costs related to environmental pollution cleanup, quality of life, economic development and other factors. A more detailed discussion of soft benefits is in Chapter V of this report.

Table A.2.5: Estimates of Taxpayer Costs for projects built in 2013 (¢/kwh)

	COSTS	Benefits	
Oregon Taxpayers	Tax Credits		
ETO + RETC	9	(soft)	-9 + soft benefits
ETO +BETC	16	(soft)	-16 + soft benefits

In summary, program participants recover much of their initial investment through incentives, particularly under the feed in tariff. If we consider "benefits" to ratepayers as the avoided cost of energy, capacity investment and transmission losses, then non-participating ratepayers see a negative benefit for all programs. Whether or not that negative benefit is offset by environmental or societal factors is subjective.

Program Comparison

If we compare the cost/benefit value of the two primary incentive approaches – net metering coupled with ETO rebates and tax credits (ETO/TC) vs. the VIR – we see a difference in value. The VIR represents a high level of incentive and cost shift when compared to the ETO/TC programs.

In general, the solar project completed under either of these incentive programs will be identical in terms of equipment, interconnection and ability to generate power. However, the benefit to participants, and corresponding impact on ratepayers, is greater for the feed in tariff pilot than for other programs.

In this analysis we have not quantified environmental or societal benefits. These arguably do benefit all stakeholders but are difficult to quantify. We discuss how other states have treated environmental and societal benefits in Chapter 5.