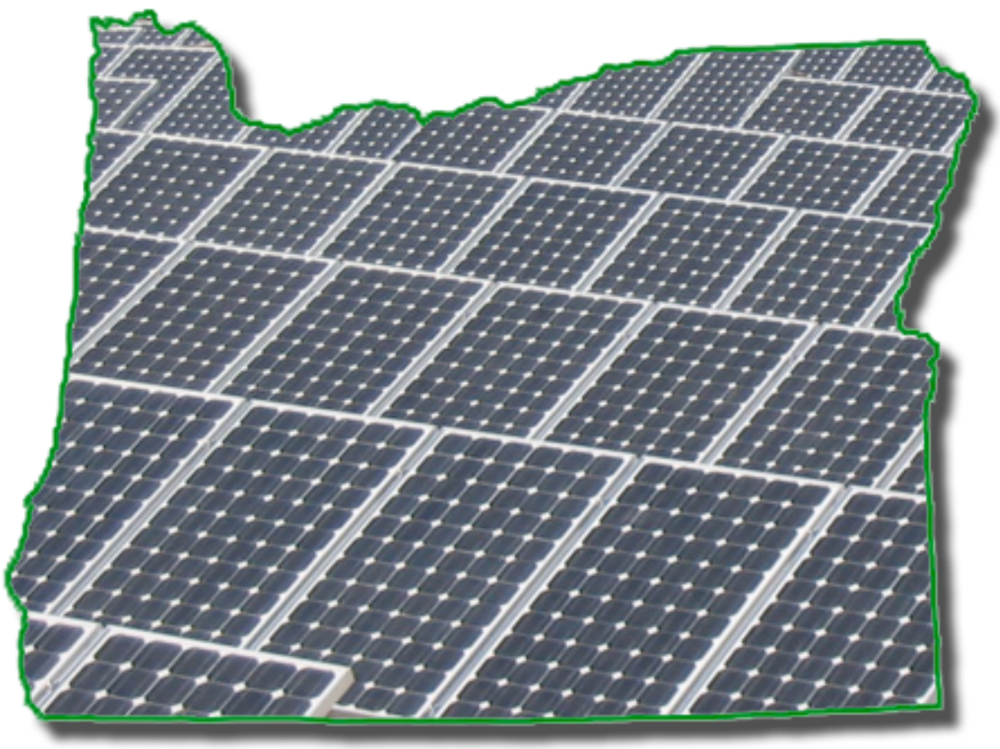
The Right FIT for Oregon

Solar PV in Eugene as a Case Study for Feed-in Tariff Policy Design



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"The Right FIT for Oregon: Solar PV in Eugene as a Case Study for Feed-in Tariff Policy Design," a terminal project prepared by Raymond Neff in partial fulfillment of the requirements for the Master of Community and Regional Planning degree in the Department of Planning, Public Policy and Management. This project has been approved and accepted by:

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Abstract

Climate change and the associated need to reduce greenhouse gas emissions are driving changes across society impacting how we power our cities, homes and businesses. Rapid deployment of renewable energy, including solar photovoltaics (PV), is one way society is addressing this challenge. Research and experience indicates that a well-designed Feed-in Tariff (FIT) is the most effective policy instrument to encourage widespread adoption of this technology and growth throughout the renewable energy industry.

A whole-systems approach, FIT policy addresses the inter-related challenges of climate change, job creation, energy security, and sustainable economic development. A well-designed FIT guarantees a fixed price from the utility for all electricity generated by any renewable energy technology. The rate is designed to pay off the generation equipment with a reasonable rate of return while program costs are spread across all ratepayers equitably. The result is investment security that encourages banks to loan, often with a reduced cost of capital, market stability that encourages industry growth and manufacturing innovation, and family wage jobs in the local community.

In 2006 research showed that solar PV on large commercial and public buildings in Eugene, Oregon could generate 68 MW of electricity annually. On July 22, 2009, Governor Kulongoski signed legislation establishing a pilot program to encourage the adoption of solar PV, using some elements of a FIT. Oregonians for Renewable Energy Payments (OREP) proposed alternative legislation, modeled on successful FIT policy design outlined above. This research uses Eugene as a case study to examine the impact of these two proposals to exploit the solar potential of Eugene and the state of Oregon. Results show that an OREP style FIT could encourage deployment of 331 MW of solar PV in Oregon. At full deployment in 10 years this would displace approximately 153,000 metric tons of CO_2 emissions annually; create close to 11,000 jobs throughout Oregon, and cost residential electricity ratepayers about $42 per year.

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The end of the fossil fuel age is now in sight. As the world lurches from one energy crisis to another, dependence on oil and coal threatens to derail the global economy or disrupt its environmental support systems. If we are to ensure a prosperous world for future generations, only a few decades remain to shift the world economy to reliance on renewable resources.

~ Chris Flavin and Nicholas Lenssen

I. Introduction

This is the opening paragraph of a report titled *Policies for a Solar Economy* produced by the Worldwatch Institute… in 1992. The problem is not new, but the stakes have gotten much higher. Since the late 1800s, our global economy has been dependent on extractive technologies and carbon-based fuels that take hundreds, thousands or millions of years to replenish—predominantly fuel wood, coal and oil (Droege, 2006; Mendonça, 2007). Unleashing this stored energy has lead to unprecedented advances in human health, personal mobility, and industrial growth (Droege, 2006; Sustainable Business Initiative (SBI), 2005). Historically, large, centralized generation plants transform carbon fuels into electricity and deliver it to the majority of end-users in distant urban settings via a high-voltage transmission network or electrical grid. According to Andrews, this model "is rooted in engineering economics, and its basic objective is to satisfy demand cost effectively" (2008, p. 232). Yet we now understand the deleterious impacts of these energy choices that include pollution of our environment, loss of species habitat, war and decreased national security, impacts on human health, and rapid global climate change (Andrews, 2008; Droege, 2006; GCCIG, 2008; Molvar, Public Interest Environmental Law Conference (PIELC), Feb 28, 2009; Salvo, PIELC, Feb 28, 2009).

Renewable energy (RE) technologies harness the natural forces of wind, water, and the sun to generate electricity instead of breaking apart natural elements like wood, coal, petroleum, or uranium to unleash their *stored* energy. Renewable energy fuel is replenished in human time scales, compared to the long historical and geologic time scales necessary to replenish carbon fuel reserves. Hydropower is considered by many to be a good example of a clean renewable energy because the hydrologic systems that feed it are replenished over the course of months, years or decades. Further, hydropower connected to storage reservoirs produce only small amounts of greenhouse gas emissions that exacerbate the negative impacts of climate change (Gleason, email communication, Sept 19, 2009). Yet most hydropower, along with utility-scale wind farms, concentrating solar thermal plants, and geothermal energy have qualities similar to the existing extractive energy model. Large-scale hydropower impacts fish habitat and their ability to reach spawning grounds, including those of endangered or threatened species, and has long-term consequences for other aquatic, terrestrial and cultural resources. Energy comes from distant, centralized facilities requiring extensive capital investment for land acquisition, plant construction, and transmission infrastructure to deliver electricity to urban populations (Wolcott, 1999). Further, projects must meet extensive National Environmental Policy Act (NEPA) regulations and planning horizons that often take several years or longer. In this energy delivery system, the least-cost objective encourages stakeholders to replicate the centralized energy generation model currently in place for carbon fuels.

In the long run, the U.S. will rely on a combination of many forms of renewable energy in order to replace carbon fuels, yet "Inadequate planning, improper siting, insufficient mitigation and the law of unintended consequences have the potential to link clean energy development to unacceptable—but avoidable—environmental impacts" (Darin & Stein, 2008, p. 3). The *American Planning Association Policy Guide on Energy* states that an objective evaluation of renewables is essential as "Controversial questions have already been raised about the social impacts of siting wind turbines, the health impacts of burning biofuels, or the wisdom of promoting a hydrogen fuel cell future when either fossil or renewable energy must be used to produce the hydrogen" (2004, p. 11). Most current efforts to upgrade the western U.S. electrical grid to accommodate renewable energy follow the path of existing and proposed coal plants. This could further degrade sensitive habitat for a wide variety of plant and animal species (Molvar, PIELC, Feb 28, 2009; Salvo, PIELC, Feb 28, 2009). At the 2009 Public Interest Environmental Law Conference, Darin goes on to say that comprehensive transmission planning should: "(1) utilize efficiency/distributed generation first; (2) maximize current grid assets and existing rights-of-way; (3) connect renewable energy sources; and (4) ensure lands/wildlife protection."

Authors suggest that solar photovoltaics (PV) are renewable energy resources that don't have the same degree of extractive qualities that other energy sources do. They can generate power closest to where it's needed first, utilize existing urban infrastructure, and project completion occurs in a matter of days, weeks or months compared to years for most other forms of energy (Robertson & Cliburn, 2006; Anderson, 1996). Solar PV is a resource that is easily scalable and can be deployed as a distributed generation resource (DGR). Instead of being concentrated in a single distant location, a DGR is distributed across large or small areas and networked together to maximize existing infrastructure, much the same way that individual computers are networked together to form the vast reach of the Internet.

A growing body of evidence suggests that a well-designed feed-in tariff (FIT) is the best policy mechanism to rapidly deploy a wide-variety of renewable energy technologies including distributed generation solar PV, encourage community buy-in and support, build the local economy with "green-jobs", and provide stable markets that encourage local investment (Cory, Couture, & Kreycik, 2009; Farrell, 2008; Rickerson, Sawin, & Grace 2007). The design of feed-in tariff laws are still relatively new and can vary considerably, yet Germany and Denmark have had programs in place since the 1990s, while more recently Spain and over 40 other countries are refining the ideas to meet their policy goals.

In a 2009 analysis of state clean energy policies in the U.S., Couture and Cory state that a well-designed FIT includes several key elements to be successful:

- **FIT policy must provide long-term stability.** This communicates "a clear, long-term commitment to RE development" (17) that provides investor confidence as projects progress, and allows manufacturing and related job-creating industries to mature.
- **Payment levels should be based on levelized costs of renewable energy generation.** Levelized costs represent the constant level of annual revenue necessary to cover all capital, fuel, and operating and maintenance costs over the life of the project. Setting the FIT payment right, to cover levelized costs along with a reasonable return over the economic life of the project provides certainty to investors and reduces financial risk. In turn, guaranteed, stable revenue encourages banks to loan and increases investors' ability to finance a higher percentage of debt.
- **The cost of FIT policy should be spread across all ratepayers.** This ensures equitable distribution of the cost of the FIT among all electricity consumers based on the amount of energy they normally use, can encourage energy efficiency to reduce energy use, and ensures stable funding for FIT payments to RE investors even in an economic downturn.
- **Long-term contracts of 15-20 years provide investment security.** Long contracts allow greater opportunity to recover investment costs, lowering the "levelized cost of the project, which can reduce the overall rate impact" (17).
- **Tariffs should decrease incrementally over time at set annual intervals.** For technologies where innovation and economies of scale are expected to reduce project costs, such as solar PV, this avoids creating windfall profits in subsequent years for new generators. "This helps reduce the costs of the

policy over time and creates an incentive for rapid deployment, further cost-reductions, and improved efficiencies in the future" (18).

- **FIT payments should be tailored to specific technology types, project sizes, and resource quality (location).** This promotes deployment of technology diversity as different geographical regions within the state may be more suitable for different technologies; project size can be scaled to specific conditions while reducing profits for larger projects that benefit from economies of scale; and since individual projects can be spread across larger geographical areas and remain profitable, this in turn encourages distributed generation which can take advantage of existing urban infrastructure.
- **Streamlined approval processes reduce transaction costs.** Lower transaction costs improve the economics of smaller projects allowing more individuals and organizations to participate – small businesses, farmers, moderate-income homeowners, non-profits, and government agencies to name a few, "ensuring broader economic benefits for the state,"(18). (Couture, Cory, 2009; Cory, et al. 2009; Farrell, 2008; Mendonça, 2007; Rickerson, et al., 2007)

Further, the increased use of renewable energy in a stable, long-term marketplace encourages technological innovation, manufacturing economies of scale, and cost reductions overall.

MOVING TOWARD A SUSTAINABLE ENERGY MODEL

McDonough, in a 1993 speech at The Cathedral of St. John the Divine in New York City states that there are three critical elements of natural design that should be incorporated in the built environment: 1) we already have all the elements to work with in stone, clay, wood, water, etc.; 2) energy in the form of perpetual solar income cycles through all systems; and 3) biodiversity sustains this complex system of creation and recycling of nutrients from one form to another. Incorporating these ideals brings society closer to the practice of sustainable design and he relates a straightforward example of forward thinking architects when he recounts a story from Gregory Bateson about New College in Oxford, England. When the massive oak beams of a 350-year old building were in need of replacement, the committee in charge of the project was having a difficult time procuring suitable materials. They finally called in the College Foresters to see if they had any suggestions for the potentially cost- and supply-prohibitive project. As it turns out, the original architects over three centuries earlier insisted that a grove of trees be planted for just that purpose. The building over time, and the actions of the architects set in motion a sustainable process.

According to the Oxford American Dictionary, to sustain means to "strengthen or support physically or mentally; cause to continue or be prolonged for an extended period, or without interruption." The Eugene Sustainable Business Initiative Final Report states, "Everyone knows, however, that circumstances change and nothing can be maintained in the same form forever. As a practical matter, therefore, sustainability involves the capacity to adapt successfully to changing conditions" (SBI, 2006, p. 17). This adaptive quality addresses systemic change, rather than single-issue change. Sustainability then is not static, with an ending point or "green" product as a goal to be delivered to the marketplace. Conventional energy delivery follows a linear path from resource extraction and energy generation to the end-user, while dollars follow a relatively similar path in reverse away from the community. A sustainable energy model recirculates energy dollars longer in the local and regional economy through community ownership of generation resources, equipment installation and manufacturing jobs, and capital investment from within the community that uses the energy.

A well-designed FIT does more than simply encourage the use of more renewables within the conventional linear system focused on "least cost" energy delivery. (See Appendix 2 for a detailed look at how Cory and Couture suggest feed-in tariff policy can enhance a wide array of state policy goals including economic, environmental, energy security and renewable energy objectives.) A well-designed FIT lays the foundation for sustainable economic development through the use of clean energy resources, encourages energy conservation and the most efficient use of energy, promotes flexibility by encouraging technology diversity and innovation, and encourages community support for renewables since all energy consumers have the opportunity to participate in energy generation (Farrell, 2008; Mendonça, 2007; Rickerson, et al., 2007). Like the New College architects of three and a half centuries ago, a sustainable model for energy generation assures that the actions taken by communities today, ensure that the resources needed to power the 24th Century are available to that future society as well.

While North Americans generally assume that the most effective and efficient approach to providing energy is through large centralized production facilities and extensive distribution systems that transport energy long distances, post-carbon cities assume a more decentralized energy production system, where production is more neighborhood-based and relatively small scale.

Timothy Beatley, *Envisioning Solar Cities*

II. Literature Review

According to Beatley, solar cities promote local production of food, raw materials and energy. Further, they strive to be carbon neutral, incorporate solar principles by design into the built environment, utilize renewable energy, and seek to build the local economy. While there is no completely "solar city" by Beatley's definition in today's world, several attempts are in development. Masdar City is being built in Abu Dhabi with the goal of being powered 100% by renewable energy, while creating a global partnership for research and development that includes the Massachusetts Institute of Technology, Cornell University and Caltech, among others (Rosenthal, 2009). Babcock Ranch in southwest Florida is also under development and will be powered by a utility-scale, 75 MW, $300 million solar plant operated by Florida Power & Light, along with distributed generation solar PV on urban infrastructure (Ensha, 2009; Kison & Partners, 2009). It remains to be seen how far these two projects will go in establishing a carbon-neutral city, yet their efforts should prove useful in understanding how to retrofit existing cities as well. Developing policies and practices utilizing these goals as a roadmap, in turn, moves communities in the right direction, efficiently using the most abundant energy source we have – the sun.

CLIMATE CHANGE AND THE NEED TO ACT[1]

The International Panel on Climate Change (IPCC) reached consensus in 2007 that climate change is occurring and asserts that human-induced activities including burning of fossil fuels is a primary cause of these changes. According to the Sustainable Business Initiative Final Report presented to the Eugene City Council, actions that address climate change also provide the ancillary benefit of positive impacts on the local economy, environment, and social equity (SBI, 2006). The Report further states that a failure to act will create even greater risks for municipal governments, organizations and individuals due to increased extreme weather events, changing precipitation patterns, and a general rise in annual temperatures. These in turn, will impact infrastructure and the built environment, population constraints, energy use, and human and non-human health. "Especially in these challenging economic times, actions that save energy, reduce expenditures, improve the environment, and stimulate the local job market are very favorable" (City of Eugene, 2009, p. 2).

According to a 2005 report titled *The Economic Impacts of Climate Change in Oregon: A Preliminary Assessment* by Resource Innovations, a sustainability-focused research organization at the University of Oregon, average surface warming in the Pacific Northwest has risen 1.3 degrees F during the last century and similar to more recent models, projects "a warming of approximately 1 degree F per decade" (2) through the 2050s.

A 2008 study by the Bonneville Power Administration (BPA) on future Northwest power supply states that by 2013, "the flexibility of the hydro system has reached the limits of its ability to meet sustained peak loads, such as a 3-day cold snap or heat wave in a dry year" (p. 5). In July 2009, Eugene, and most of the Willamette Valley, experienced just such a 3-day heat wave with daily highs of at least 101 degrees F. During the same period, Portland General Electric reported a peak-load power usage record of six percent above normal, 3790 MW versus 3300 MW, on one of those days (Portland General Electric, 2009, para. 1). The BPA report further states that, "BPA has enough energy to meet its loads under all water conditions in May. But it is 1,700 MW deficit in December 2013 under poor water conditions" (BPA, 2009, p. 5).

In March 2009 Resource Innovations in collaboration with the U.S. Forest Service and the National Center for Conservation Science & Policy, released *Preparing for Climate Change in the Upper Willamette River Basin of Western Oregon*. The report illustrates the potential impacts of climate change, based on models used by the IPCC and adjusted to local and regional conditions. Based on their findings, "a panel of policy experts then assessed the risks for built, human, and economic systems within the Upper Willamette River Basin" (Doppelt, Hamilton, Deacon Williams, Koopman, Vynne, 2009, p.ii).

While it is beyond the scope of this research to go in-depth into climate science and no models can predict exactly when or how severe climatic conditions will change, these recent findings suggest the following impacts in the Upper Willamette River Basin where Eugene is located:

- Increased annual average temperatures of 2 to 4° F and increased average summer temperatures of 4 to 6° F by around 2040;
- Warmer ocean temperatures provide more moisture in the atmosphere that in turn can lead to more severe storm events and increased flooding;

- Longer and hotter summers, along with increased drought conditions could lead to increased wildfire activity;
- Slightly less precipitation during spring, summer, and fall, and a 60 percent decrease in snowpack in the Pacific Northwest by 2040 (Doppelt, et al., 2009).

Changes of this magnitude would likely impact energy systems throughout the Pacific Northwest because reduced snowpack and summer water levels in reservoirs will likely reduce hydroelectric capacity. Less water may be available for agriculture and forestry including wildfire protection, further complicating the situation by increasing competition for water resources for energy production.

Planning for Long-term Energy Security in a Carbon-constrained World

On the road to energy independence and development of clean energy alternatives, there is no one path that is the "silver bullet" solution. Eileen Claussen, president of the Pew Center on Global Climate Change states that, "Although there is no single technological or policy solution to climate change and energy independence in the U.S., renewable energy is clearly destined to play an important role in the years to come – and now is the time to lay the foundation" (Silverstein, 2008, para.13). Successful replacement of carbon fuels will be managed through the use of a variety of generation sources, distributed generation solar PV being one viable resource used in combination with wind, geothermal and existing hydropower (Doppelt, et al., 2009).

As far back as the Carter Administration, an Office of Technology Administration report titled *Application of Solar Technology to Today's Energy Needs*, suggests "that with the diffusion of onsite solar energy devices, considerable environmental, economic, and social benefits would flow to the country, including reductions in consumption of electricity and conventional pollutants like suspended particulates" (Zahran, Brody, Vedlitz, Lacy, & Schelly, 2008, p. 420). Paul Scott, owner of one of General Motors' early, pilot-program electric vehicles, reaffirms the idea that use of solar technology can actually decrease electricity consumption. In Southern California solar PV powers both his home and his car for about $45 per year. Now, every time he leaves a light on, he realizes that there's energy being wasted that could be used to propel his car a little further down the road. He has become much more energy conscious in the home and on the road (Scott, Keynote: Lane County Energy Round-up: Transportation Future, Oct 16, 2008).

Life-cycle Assessment of Solar PV

A major benefit of solar PV and renewable energy in general, is their environmental advantages over the use of carbon fuel to generate electricity. According to Fthenakis and Kim, accurately representing these advantages is critical to ensuring continued support from both government and the public (2006). Fuel costs for solar PV are essentially zero since there's no need to harvest and transport fuel from the source to the generator. Beyond the cost of fuel, in the context of climate change the greenhouse gas (GHG) emissions generated to produce the electricity and the generation equipment itself are an important concern. As society grapples with the need to decrease GHG emissions while still meeting the energy demands of modern society, nuclear power has gained significant popularity as a carbon-free energy source – even among some environmentalists. Yet there are other issues involved with nuclear power that are not accounted for in the cost of energy generation such as waste disposal, insurance for nuclear power facilities, and the tremendous waste of fresh water during processing and energy generation (Droege, 2006). For that reason, it's important to look at the full life-cycle analysis of a variety of energy production technologies as we plan our energy future in a carbon-constrained world.

While an in-depth discussion of solar PV life-cycle analysis is beyond the scope of this report, research indicates that solar PV "is in a very good position to be included in a portfolio of low-carbon energy technologies for a future sustainable energy supply" (Alsema, deWild-Scholten, Fthenakis, 2006, p.7). Fthenakis and Kim state that "Previous studies showing nuclear technology to have a clear GHG advantage over PV are greatly outdated; the emissions of the two cycles are comparable under today's average U.S. conditions" (2006, p.1).

When assessing the full life-cycle cost of a technology, it's important to consider component manufacturing and design, including equipment recyclability. According to a 1997 study by Lewis and Keoleian at the National Risk Management Research Laboratory in Ohio, electricity production efficiency takes into account the energy produced by a system over it's lifetime compared to the energy inputs to manufacture, install, operate and maintain, and dispose of or reclaim component materials at the end of use. To be considered sustainable, an electricity production efficiency ratio – the amount of energy produced *by* a component being sufficient over the course of its life cycle to *reproduce* itself must be greater than unity, or zero. Accounting for both installation location and module design, the best results in their study were obtained with a frameless PV module in areas of high insolation. Yet even the lowest values were above the U.S. electricity grid efficiency at the time (.32); see Table 1, next page.

Table 1: Electricity Production Efficiency Calculations*

Location and Generation	Module Life (yr)	Electricity Production Efficiencies: Standard Low	Standard high	Frameless low	Frameless high
Detroit, MI	10	0.75	1.33	1.60	2.01
22.3 kWh/yr	25	1.87	3.33	3.99	5.03
Boulder, CO	10	1.24	2.23	2.68	3.39
36.7 kWh/yr	25	3.09	5.57	6.69	8.49
Phoenix, AZ	10	1.56	2.83	3.40	4.33
46.1 kWh/yr	25	3.91	7.07	8.51	10.83

Table Notes:

*Assumes 5% module conversion efficiency, includes module transport energy: Detroit, 19.31 MJ; Boulder, 8.97 MJ; Phoenix, 3.01 MJ.

Standard: module production energy is: material production + manufacture + transport = 162.2 kWh (583.8 MJ) low case; = 293.9 kWh (1058.1 MJ) high case.

Frameless: module production calculated as above = 105.6 kWh (380.0 MJ) low case; = 134.5 kWh.

Source: Lewis, G. & Keoleian, G.; U.S. Environmental Protection Agency & National Risk Management Research Laboratory

Improved PV manufacturing and recycling can provide raw materials for next generation modules. Lewis and Keoleian state that, "increasing the number of module components that can be reused and the number of times they are reused significantly improves energy metrics" (1997, p. 6). At least two panel manufacturers in the U.S. offer end-of-life recycling of PV panel components, and forty-nine companies involved in the global solar supply chain are members of PV Cycle based in the European Union. PV Cycle, founded in 2007, is an industry-wide organization setting up a voluntary take-back and recycling program for Europe. Their goal is to create "truly sustainable energy solutions that take into consideration the environmental impacts of all stages of the product life cycle, from raw material sourcing through end-of-life collection and recycling" (PV Cycle, 2008). In the U.S., the Solar Energy Industries Association (SEIA) established "a committee to address the environmental, health, and safety implications of solar products" and it "is charged with developing the first large-scale recycling initiative in the United States" (Davidson, 2009). Both U.S. companies are members of PV Cycle and state that their modules are fully recyclable and able to be processed into new modules. One offers to recycle any panel from any manufacturer. The other tracks where modules are sold and installed, and pays for all costs associated with the return of panels manufactured by them for complete disassembly and component recycling. The latter sets aside the funds required for end-of-life collection from the sale of each panel, in a restricted account managed by a third-party trust to support the process, even if they were to go out of business (Davidson, 2009; First Solar, 2009; SolarWorld, 2009).

WHY PURSUE ENERGY GENERATION IN AN URBAN SETTING?

Urban centers are the heart of technological innovation, commerce, cultural production, manufacturing and industry, and energy use (Droegge, 2006), and the continuing trend for over 200 years has been a shift from rural to urban living. By focusing energy production closest to where it is used most or first, society avoids costly infrastructure development and energy loss during transmission from distant, centralized resources (Michel, 2007). According to Morris, "Before we build high voltage transmission lines we should harness all available distributed renewable resources and maximize the efficiency of existing transmission and distribution lines" (2009, para. 9).

New, innovative uses for solar energy gained popularity during the 1970s due to the Mideast oil crisis, yet waned once prices stabilized again in the 1980s (Zahran, et al., 2008; Gan, Eskeland, & Kolshus, 2005). As Tabb points out in *Solar Energy Planning,* the use of solar energy is a very ancient practice, rather than simply a contemporary innovation. Ancient civilizations around the world oriented major cities toward the sun and along the cardinal points of the compass to take advantage of passive solar heat. From advanced civilizations in Egypt, Greece and China to the Aztecs, Incas and Anasazi in the Americas, solar energy has been an important part of peoples' built environment (1984).

Today, as society is faced with the impacts of climate change along with rapidly decreasing supplies of carbon fuels, international conflict in oil-rich regions of the world, and excessive pollution and severe land degradation to access coal and other fossil resources – it is clear that to realize energy security, our nation must pursue a variety of alternative energy strategies (Walker, Hunter, Devine-Wright, Evans, & Fay, 2007; Silverstein, 2008; Droege, 2006.) A report on job creation in the German renewable energy industry states:

> A growing number of studies confirm that a significant contribution from renewable energy sources will be essential for solving or alleviating the energy supply problems pertaining to environment and climate protection, reducing import dependencies, avoiding conflicts over fossil resources, etc. Their significance is thus beyond dispute. (Mendonça, 2007, p. 46)

Solar PV uses no moving parts and requires very little maintenance, is easily scalable allowing an incremental increase in capacity, and can be installed almost anywhere there are sufficient solar resources and open space (Droege, 2006; DOE: EERE, 2004).

Urban solar PV as a distributed generation resource is a viable energy choice as communities develop long-range goals to include utility-scale renewable energy in their portfolio mix. Open space for solar installations needn't be confined to vast natural areas like deserts, although these may be very suitable for large solar plants modeled on the centralized energy distribution models that currently exist. Look around any town, city or large urban area, particularly from a bird's eye view, and you will find vast tracts of suitable open space in the form of large commercial and public buildings and parking lots. Very often these areas are free from nearby obstructions that can shade solar panels reducing their efficiency, and are currently under-utilized as an energy generating resource. By taking advantage of existing, urban underutilized open space communities produce electricity closest to where it is used and simultaneously avoid the cost of new infrastructure development to deliver the energy from distant remote locations – moving communities more in the direction of what Beatley defines as a solar city (Neff, 2006). According to Wolcott, as of 1999, new transmission lines and electricity infrastructure can cost $1 million per mile; yet this is what will be needed for many other renewable energy resources like wind, tidal or geothermal energy since the best resources are often not located near existing urban centers or transmission lines like coal or hydropower are. The cost of infrastructure development is, in part, what lead the Sacramento Municipal Utility District (SMUD) to aggressively pursue solar power to meet the demands of explosive urban growth, as early as the 1990s. By 1999, SMUD had developed supply chain agreements with manufacturers for PV panels, inverters and even PV roofing material, all from New Jersey, Washington and a newly constructed PV plant located in Sacramento (1999).

Some may question solar PV as a viable energy source for the cloudy Pacific Northwest, yet Germany (with very similar climatic conditions to Oregon) is a world leader in installed PV capacity. Germany has a stated goal to phase out nuclear energy, replacing it and fossil fuels with solar PV and other renewables that are rapidly and successfully being deployed. A major difference between Germany and the U.S. is in the successful exercising of political will to institute key policy decisions that make solar PV cost-competitive with other heavily subsidized "dirty" energy industries like nuclear or coal (Nelson, Oregon Solar Energy Working Group meeting, Feb 20, 2009; Silverstein, 2008). "While countries such as Germany and Japan have seen an explosion in solar because of government initiatives and long-term, stable tax benefits, the U.S. federal government has been an unfortunate example of unpredictable, on-again off-again policy incentives" (Pernick, Wilder, 2008).

Beyond consumer education on the viability of solar PV, the upfront cost to install the technology is a primary factor inhibiting widespread adoption. Bruce Laird of the Oregon Economic & Community Development Department states that:

> The big issue with renewables, is that you need to pay for all the capital costs up front and then amortize them over a number of years. One of the next breakthroughs needs to be on

financing so that governments can provide low-cost money to build out the scale-up of renewables. (Pernick, 2008, para. 6)

WHY EXPAND USE OF SOLAR PHOTOVOLTAICS?

There are a variety of issues driving the need to switch from extractive energy resources like coal, natural gas, and uranium to clean, renewable energy sources. Urban areas create what's known as the heat-island effect, where the built environment is hotter than the surrounding rural area. As cities become even warmer as a result of climate change, this puts additional stress on electrical demand to accommodate an increase in air conditioning use. According to Botkin and Beveridge, "Information from the Los Angeles Department of Water and Power and Southern California Edison indicates that, for every degree Fahrenheit (F) rise in average annual temperature, an additional 300 MW of electricity is used" (1997, p. 6).

In the Pacific Northwest, Christopher Dymond of the Oregon Department of Energy adds that even a ½-degree increase in average temperature in the Pacific Northwest would reduce snow pack by 34%. He further states that, "Reduced hydropower during the mid to late summer months combined with increased air conditioning loads will drive up the summer cost of power" (2005, para. 1).

To exacerbate the situation even further, a shift to electric vehicles and especially plug-ins that will likely occur as we search for ways to decrease our reliance on foreign oil will also increase total electricity demand (Doppelt, et al., 2009). The Eugene Water & Electric Board's (EWEB) portfolio mix is already a very low-carbon resource due to extensive use of hydropower and increasing use of wind power. Coupled with the City's development of both internal and community-wide greenhouse gas emissions reduction action plans, this is a positive environment for plug-in electric vehicle use because reductions in petroleum-based fuel are not replaced with a high-carbon electricity source such as coal (Kliesch & Langer, 2006). On Earth Day 2009, Lane Community College was awarded a $100,000 grant from EWEB to install a pilot solar PV powered electric vehicle charging station, further seeding this necessary transition.

Given our understanding of a changing climate, the Pacific Northwest, including Eugene, is faced with an increased demand for electricity at precisely the time when reliance on historic generation technologies could get more difficult and therefore costly. On the other hand, distributed generation solar PV reduces that need to replace diminishing low-carbon electric capacity with a high-carbon source. Distributed generation solar PV and expanded use of plug-in electric vehicles form a synergistic and systemic approach to addressing the challenges of climate change. Zahran et al. state that, "Solar heating and photovoltaic power generation can make communities more self-reliant and resilient because they are less dependent on central power grids, can reduce air and water pollution, and can address global climate change" (2008, p. 420).

Summary of Existing Federal, Oregon and Local Policies to Expand Use of Solar PV

Federal Policies: In early October 2008, Congress re-authorized the Production Tax Credits (PTC) and Investment Tax Credits (ITC) for one and eight years respectively (Jesmer & Lacey, 2008). The ITC provides a 30% tax reduction for commercial and residential consumers that install solar PV, and now allows utilities to obtain the same credits. Further, projects eligible for the business energy ITC and placed in service by year-end 2010, can convert the tax credit into a direct grant from the U.S. Treasury. Federal incentives go a long way toward addressing the high, initial, up-front costs to install solar PV (DSIRE, 2009a). Unfortunately these, like state tax credits, are only available to individuals and organizations that have a tax liability, excluding lower-income families, government agencies, non-profits, and businesses with little annual profit, from the program.

State Policies: A second critical component to encourage increased energy production from solar PV occurs at the state level. The State of Oregon offers a Business Energy Tax Credit (BETC) for commercial project owners, applicable towards up to 50% of eligible equipment. Unlike federal regulations, Oregon also has what's called a Pass-through Option (PTO) as part of the BETC. The PTO allows those without a tax liability, like local governments, schools, tribes or non-profit agencies, to contract with a third-party who does, so the latter receives the credit available for a solar installation. The third-party agrees to pay the project owner a lump sum up-front to help reduce initial costs, and in return the BETC reduces their own tax liability by 10% for up to 5 years for projects costing more than $20,000. For those projects costing $20,000 or less, the full value of the credit can be taken in a single year (Oregon Department of Energy, 2008). Residential customers with a tax liability are eligible for a tax credit (RETC) equal to $3 per peak watt up to $6,000 total, up to 50% of the total installed cost (DSIRE, 2008).

Local Policies and Action: The Eugene Water & Electric Board (EWEB), Eugene's community-owned utility, has a long history of investment in energy conservation, energy efficiency and renewable energy. In 2006, EWEB-owned hydroelectric projects generated 185 MW of electricity; they also have a voluntary wind power purchase program with EWEB-owned resources generating 41.4 MW of capacity, and two solar PV programs (EWEB, 2009a).

One EWEB solar program is for Net-Metered Systems where the solar array is installed on the customer side of the utility's meter. Electricity generated by the PV panels is fed directly into the home, office or industrial facility, reducing the facility's need to buy electricity at retail rates. This policy only requires one electric meter that spins backwards when the PV panels generate more electricity than the facility requires at any given point in time. If any excess power is generated above the customer's total demand, EWEB pays the customer for that additional electricity with the excess balance carried over from month to month and a check paid at the end of the year for the year's outstanding balance (EWEB, 2009b). EWEB also provides an incentive for net-metered systems of $2 per AC watt up to $10,000 for residential customers, and $1 per AC watt up to $25,000 for commercial systems. For a 3 kW array on top of a home, that would equal a $6,000 incentive to help defray the up-front cost of the PV system. The customer also retains ownership of all Renewable Energy Credits (RECs) (EWEB, 2009d).

EWEB manages a program for Direct Generation Systems that is a production-based incentive; it is similar to a feed-in tariff, but does not cover the full installation cost of solar PV. The program is for a system size ranging from 10 kW up to 1 MW, so this program targets commercial-scale installations. It started as a pilot program in the early 2000s, implemented fully in 2006 and began to take off in earnest in 2007. A second meter is installed and all the electricity generated by the PV system is fed directly into EWEB's grid portfolio. EWEB purchases the PV electricity at a fixed price each month, based on actual array performance, and maintains ownership of the Renewable Energy Certificates (RECs) that demonstrate compliance with Renewable Portfolio Standards (RPS). EWEB's program currently pays generators 12¢ per kWh (unit of energy production equal to 1000 watts for one hour) up to 45,000 kWh per month and 7.6¢ per kWh over 45,000 kWh per month. The rate paid to customers is based on a variety of factors related to the wholesale cost of electricity, load forecasts, and inflation, but not the cost of generation equipment. The customer then meets all of their electricity demand by buying electricity back from EWEB at the regular retail rate (Wedlin, email from EWEB, Aug 27, 2009; EWEB, 2009c). EWEB customers must choose before connecting their system to the grid which program they want to participate in, Net-Metering or Direct Generation, and are locked in for the life of the project.

EWEB's new distributed generation solar resource increased from 90 kW to 1,127 kW from 2006 to 2007, and annual electric generation from DG solar PV increased from approximately .18 MWh to 1.23 MWh during the same period (EWEB, 2008). These programs have been successful at encouraging significant solar PV expansion in Eugene, relative to pre-2006 trends. Customer response has been enthusiastic and EWEB has not experienced any technical limitations integrating more solar PV into the grid (Wedlin, email, Aug 27, 2009). Yet looking at the German experience and solar PV potential in Eugene of at least 68 MW, there is room for substantially more growth that research suggests can not only increase solar PV capacity but also generate the broader environmental, and socio-economic benefits that are possible with a well-designed FIT program (Mendonça, 2007; Farrell, 2009). EWEB's Direct Generation program is funded through voluntary support from customers who choose to pay a premium on top of their regular electricity charges. Yet according to Gan, Eskeland, and Kolshus, "A voluntary green certificate scheme allows consumers to choose green electricity produced, but may not be very effective in changing the energy structure,"(2007, p. 146). They continue, "Alone, it uses less government power, relies more on consumer motivation, and in most settings will achieve a lower penetration" (2007, p. 153).

The Challenges with Existing U.S. and Oregon Renewable Energy Policy Strategy

Renewable Portfolio Standards mandate specific targets for energy that must be produced from renewable sources and they can be helpful in stimulating demand, but they do little to address one of the major barriers to adoption of solar PV – the high, initial up-front cost. An RPS on its own leaves the question of how to reach those targets solely up to volatile market forces. RPS policies focus on the desired quantity of renewable energy, while in contrast the best FITs are designed to provide a revenue stream sufficient to cover costs along with a reasonable return on investment and are "focused on setting the right *price* to drive RE deployment" (Cory, et al., 2009, p. 8). Together a FIT and RPS may provide an effective set of policy mechanisms, yet Gleason states that an RPS tends to encourage utility-scale generation using the least expensive renewables (email communication, Sept 17, 2009). Mendonça continues that, "Expert opinion from policy researchers suggests that this will undo a lot of the good work of the best feed-in designs" and he believes that more research is necessary for the development of a hybrid approach (2007, p. 125).

Tax incentives can go a long way to decrease the high upfront cost of solar PV, yet they put the burden of paying for those incentives on taxpayers rather than electricity ratepayers. In the case of corporate or large-scale stakeholders with out-of-state or multi-national ownership, this is significant – the non-local system owner receives the tax reduction and direct benefits of the solar investment through overall reduced electricity cost, while Oregon taxpayers shoulder most of the financial burden. Since tax credits are based solely on system cost, they don't encourage optimal system performance; a FIT on the other hand addresses the high cost of a technology and being performance-based, encourages high-quality installations that generate the most substantial output of energy (Gleason, email communication, Sept 17, 2009). Tax credit based incentives also create undue competition for tax revenues between renewable energy supporters and other essential government services, which can be exacerbated even further by an economic downturn. Further, market stability becomes dependent on a fluctuating political climate creating boom and bust cycles in anticipation of continued political support for the incentives whenever they are up for renewal, a pattern that compromises long-term market stability. When supportive incentive legislation is passed, investment increases rapidly; when incentive legislation is set to expire, investment slows. When incentive uncertainty combines with an economic downturn, investment in solar PV can stop almost completely – profits for large businesses or banks decrease along with their tax liability, and therefore the motivation to invest in strategies that reduce that liability (Farrell, 2009; Cory, et al., 2009).

Net metering is regulated by the state in Oregon under ORS 757.300. All utilities operating within the state, except Idaho Power, are required to offer net-metering to their customers. As of September 2009, 42 states and the District of Columbia have adopted some form of net-metering requirement for utilities operating within their jurisdiction (DSIRE, 2009b). Couture states that there are a number of ways net-metering and a feed-in tariff could potentially interact together rather than being mutually exclusive. The first is gross metering as has been implemented in Washington State. With this approach all electricity produced by the system receives a FIT payment, whether it's used on-site or not. The two policies can also co-exist side-by-side and customers have to choose between one or the other program, as is the case at EWEB in Eugene. Customers would have to weigh the retail cost of electricity with the price they could receive from a FIT in making their choice. A third alternative has been implemented in Germany as of the beginning of 2009 and applies to PV systems smaller than 30kW. Customers are allowed to continue net-metering and are paid €0.25/kWh ($.37 US) for electricity used on-site and €0.43/kWh ($.63 US) for energy sent to the grid. The €0.18/kWh ($.26 US) difference represents the price generators pay for the electricity generated by their own system. This difference is slightly less than the average retail cost of electricity in Germany, so it encourages PV users to actually conserve energy overall, in turn reducing demand on the grid. The issue of whether existing net-metered systems can be grandfathered in to a FIT program will have to be decided as FIT policies are developed further. Couture continues, "Given that one of the goals of a FIT policy is to encourage new RE deployment and not to favor incumbents, grandfathering may not be desirable, (2009, p. 24).

Net-Metering versus a FIT. Net-metering is a demand-side or load reduction policy, where the utility's total demand is reduced by the customer's use of energy they generate themselves and use first, before drawing on the utility's grid supply. A feed-in tariff on the other hand is a supply-side policy where all the power generated by the customer's solar panels is fed directly into the grid to increase the utility's total supply of energy. The difference when it comes to value is that net-metering offsets an individual customer's retail cost of electricity that they use, while a FIT requires the utility to purchase all of the customer generated electricity at a fixed price, usually above the retail cost of electricity, to supply energy to the entire community.

The conflicting policies and goals above can create unstable long-term market conditions that rise and fall in dramatic and regular cycles, and they do little to encourage job growth, stable community investment and improve our nation's energy security. The use solely of RPS and tax credit policy mechanisms, each with their own overhead costs, raises the transaction cost to deploy solar PV and increases the risk factor that investors must take into account (Farrell, 2009). By comparison, "The fact that FITs impose very few limits, if any, on who can participate in selling renewable power to the grid has made them a powerful vehicle for leveraging both local and global capital toward RE development" (Cory, et al., 2009, p. 7). Experience in Europe is demonstrating that FITs can create a stable investment environment, provide increased financing opportunities to rapidly deploy proven technology, and drive innovation and improvements throughout the RE sector, "benefiting ratepayers, RE developers, and society at large" (Couture, Cory, 2009, p. v; Cory, et al. 2009; Farrell, 2009).

THE RIGHT FIT – FROM THE 1970S TO TODAY

Investment in solar PV is much more than a way to make money or demonstrate corporate awareness toward environmental values. The issues of climate change and energy security that our society now faces are pervasive, knowing no political boundaries, and have the potential to dramatically change how livable our planet continues to be for humans and non-humans alike. *"Climate change is a problem with unique characteristics*. It is global, long-term (up to several centuries), and involves complex interactions between climatic, environmental, economic, political, institutional, social and technological processes" (Intergovernmental Panel on Climate Change (IPCC) Working Group III, 2001, p. 3). A well-designed FIT addresses many of these complex inter-related issues as a system, rather than in isolation.

Feed-in tariffs were first introduced in the U.S. with establishment of the Public Utility Regulatory Policies Act or PURPA in 1978. This legislation established the "qualifying facility" as a new class of energy producer and required utilities to purchase electricity from them based on "avoided cost" rates – the avoided cost of obtaining electricity through construction of an alternative facility or from another supplier. This is the policy that jump-started so much investment in renewable energy in the U.S., specifically in California, in the 1970s (Mendonça, 2007; Farrell, 2009).

In Germany, by 1989, the federal regulatory framework governing electricity rates allowed utilities to "include cost-covering contracts for electricity using RE technologies, even if these 'full cost rates' exceeded the long-term avoided costs of the utilities concerned" (Mendonça, 2007, p. 29). This single act appears to have put all energy producing technologies on more of an equal footing with each other, instead of being driven by a least-cost approach that favors carbon fuel with its largely externalized costs to society that are not included in the retail electricity price. Farrell states that, "FITs created a vast competitive market for renewable energy production by creating a truly level playing field for development" dramatically expanding ownership opportunities (2009, p. 14).

Germany's introduction of the 1990 Feed-in Law – Stromeinspeisungsgesetz (StrEG) established a feed-in tariff for renewable energy. It was a relatively simple one-page law that primarily targeted small hydro and eventually wind development in southern Germany, and required electric utilities to purchase electricity at 65 to 90 percent of the retail rate. This was eventually expanded to include solar and other renewables but provided no interconnection guarantees to the electrical grid and tended to concentrate investment only in areas that had very good resources; much like solar investment here in the U.S. has been concentrated in places that have significant solar radiation like the Southwest and California. The StrEG was also designed to spread the cost of electricity from renewables across all ratepayers instead of taxpayers. As it was adjusted and increased over time for solar, the StrEG eventually made other subsidies unnecessary (Mendonça, 2007).

In 2000, the StrEG was refined and replaced by the Renewable Energy Sources Act (EEG). This push for increased use of renewables eventually grew to a national movement as the country continued to grapple with the issues of climate change, energy security and the emerging confrontation with nuclear energy as the only alternative to fossil fuels. The stated goal of the EEG was "to at least double the contribution of renewable energy to total energy consumption by 2010" (§1, EEG, 2000 as cited in Mendonça, 2007, p. 31).

Key improvements contained within the EEG differentiated tariffs by renewable energy technology type, size, and location, and changed payment from a percentage of retail cost to a fixed cost over a fixed amount of time. These may seem like simple changes but what they accomplished is the ability to fine-tune tariff payments to local conditions and to promote use of all available renewable energy sources rather than simply the most profitable (Couture & Cory, 2009). "Scientific studies determined the figure that would allow profitable operation with state of the art technology and geographical advantage" (Mendonça, 2007, p. 32). Except for hydro, FITs were guaranteed for 20 years from the operation's start date. Tariffs were designed to pay off system costs, not encourage windfall profits. In the case of solar PV, this opened the market to anyone who had sufficient solar resources and a properly oriented location to install the technology, whether a farmer with under-utilized agricultural land, a homeowner or small business owner, or a major corporate or industrial stakeholder with large under-utilized surface areas like flat roofs or parking lots. Because the tariff contract was designed to pay off the system, banks were more likely to loan a variety of generators the capital to invest in solar PV (Mendonça, 2007), rather than limiting consideration to only those who had the up-front, long-term prospect to be able to pay off the system – energy production was being democratized instead of concentrated in the hands of big business and the wealthy.

Tariffs carry an annual 5 percent degression under the EEG – they were the highest at onset of the law and after review, are reduced each subsequent year. The goal here is to encourage technological innovation and improve generation and manufacturing efficiency that reduces the installation cost. This encourages early adoption by energy generators, which in turn spurs manufacturing output and job creation through economy of scale. As tariffs decrease, technology improvements offset some of that difference – improved efficiency allows new generators to pay off their system with reduced payments because the system can produce more energy. Since payments are based on the amount of energy generated, it ensures "very high-quality installations" and "there is great incentive for operators to run their installations efficiently and with as little interruption of operation as possible" (Mendonça, 2007, p. 34).

In 2004 the EEG was reviewed and amended and the main benefit for solar PV was an increased tariff that made solar even more attractive commercially and resulted in a solar boom that continues to this day. Germany now has over 25% of the installed base of solar PV in the world, yet receives less solar radiation than Eugene and most of Oregon.

While it is beyond the scope of this research to fully examine the interrelated effect of multiple policy issues and mechanisms, it is important to note the whole systems approach that the German legislature has taken to encourage adoption of all forms of renewable energy and notably distributed generation solar PV. Mendonça states that these include:

- Elimination of nuclear power under the 2001 Nuclear Energy Phase-Out Act;
- Commitment to the Kyoto Protocol with a pledge to reduce CO2 emissions 25 percent by 2005 – they reached an 18-20 percent reduction by 2000;

- Eco-tax reform – introduced a tax on electricity consumption and raised the existing tax on mineral oils, i.e. gasoline, diesel fuel, natural gas, etc.;
- Increased support for combined heat and power (CHP) technology and a 2002 requirement of all new buildings to be 30 percent more energy efficient than current standards along with provisions for older buildings including increased insulation requirements;
- Renewable energy targets that increase the share of RE in the electricity supply to 12.5 percent by 2010 and 50 percent by 2050, that work in consort with other programmatic goals such as energy efficiency; and
- The 100,000-roof program – established in 1999 with improved loans for PV and a target of 300 MW installed capacity. When combined with the EEG, by 2003 the two measures had reached 350 MW capacity so the earlier program was terminated and the solar PV market was supported by improved FITs only.

Positive Impacts of the German FIT Legislation, the EEG

In June 2008, the Solar Electric Power Association (SEPA), the Northwest Solar Center and the World Futures Council lead a fact-finding tour to Germany for U.S. utility executives and managers, to learn about their experience with FITs. According to a summary report, a fundamental reason for the EEG is "based on the emergence of the solar and wind industry as an economic development tool for providing high tech goods and services to the future energy sector" and that they get more annual revenue from exports than any other country (SEPA, et al., 2008, p. 2). The renewable energy sector in Germany increased its share of the national electricity mix from 6.3 to 11.9 percent from 2000 to 2006. This is already only 0.6 percent below their 2010 goal (Rickerson, et al., 2007). These efforts are "based principally on demonstrable successes, and the careful planning behind them" (Mendonça, 2007, p. 45).

Miguel Mendonça states that, "German feed-in laws have consistently added to job growth, even during times of rising national unemployment; they have also produced valuable export markets, increased energy security and, most crucially of all, have prevented the emission of vast quantities of GHGs" (2007, p. 43). As the City of Eugene, the State of Oregon and the nation grapple with the impacts of climate change and the need to act, each of these issues looms large in the discussion. Combined with the worst global and national economic climate since the Great Depression, the interconnected challenges of job creation and economic stimulus, energy independence, and the search for clean energy to replace carbon fuels, has never been greater. Taking advantage of this need for transition to a renewable energy economy is a significant opportunity. Mendonça goes on to say that, "Making the shift from fossil and nuclear to renewables sooner rather than later is essential in not only forestalling climate chaos, but also in improving the fortunes of individual nations and their citizens" (2007, p. 43).

The solar sector in Germany has grown significantly and now comprises 26% of the world's installed base of solar PV spread across the country (Martin, 2009). Spain surpassed Germany significantly in 2008 when they offered very generous FIT rates for solar PV, which they now have had to scale back due to oversaturation of the marketplace, illustrating the flexibility of FIT policy to quickly respond to the learning curve and on-the-ground implications of FIT design. This explosive growth has been accomplished not by installation of vast solar farms on large expanses of land, but instead by utilizing available resources that support small, medium, and large installations. Every rooftop owner – industrial, commercial, non-profit organization and homeowner with adequate solar access now has the potential to take part in the growing solar economy and reap a stable, long-term, reasonable return on their investment. Success of the German FIT, particularly after it was updated in 2004, has allowed the federal government to completely eliminate all other subsidies (Mendonça, 2007). In Denmark, that also has a strong FIT law, "over 150,00 families have invested in wind turbines individually or through cooperatives, owning over 80 percent of the country's turbines (with about 60 families per MW)" (Farrell, 2009, p. 10).

Over 40 companies in Germany now produce solar PV components throughout the value chain. The solar power industry employs 20,000 people with financial transactions of €1.7 billion in 2004, the equivalent of $2.4 billion (US) at today's exchange rate. Between 2000 and 2005, monetary turnover increased by 43 percent annually; 2005 was expected to be around €2.7 billion ($3.8 billion US) (Mendonça, 2007). This illustrates the impact that Germany's FIT has had, not only at increasing use of solar PV, but on the industry and the national economy as a whole

Since a well-designed FIT encourages development of all available renewable energy technologies, it's important to also look at the renewable energy industry as a whole. Between 2000 and 2004 electricity generated from solar PV in Germany increased nine-fold, while the volume of wind and biomass generated electricity doubled. Electricity from all renewables in 2006 in Germany increased to a total of 11.8 percent. Transactions from companies in the RE sector rose from €16.4 billion ($23.1 billion US) to €21.6 billion ($30.2 billion US) between 2005 and 2006, and employed 214,000 people. That employment figure is expected to rise to 500,000 by 2020 and the industry currently employs more people than the nuclear energy and coal industries combined (Mendonça, 2007).

The impact on consumer electricity bills has been negligible. In 2004 the average electricity bill for a 3-person household was about €52 per month ($73.25 US); of that about €1.50 ($2.11 US) covers the cost of green electricity from the EEG. On the flip side, cost reduction from decreased environmental damage is equivalent to more than €5.40 per household ($7.60 US) (Mendonça, 2007).

Literature Review Summary

The use of a well-designed FIT to encourage increased adoption of solar PV and all renewables is not limited to Germany. Variations of the German system have been carried out with similar success in Spain, Denmark (the only EU nation that is a net exporter of energy as a result of FIT legislation and growth of the wind industry), Brazil, Greece – over 40 nations worldwide; Ontario, Canada, states like Vermont, and the City of Gainesville, Fl, are also taking bold action to incorporate this successful model into their energy planning.

As urban areas continue to grow, and there is no indication that this trend will reverse, potential sites to increase electric generation capacity create a host of land-use, environmental and social-equity issues (APA, 2004). Solar PV and a well-designed FIT can address many of these inter-related challenges through a coordinated, whole-systems approach. With a FIT, all energy generated from a solar PV array is fed into the grid to balance the community's electricity demand, while creating a 20-yr revenue stream for the owner of individual systems. Best of all, unlike market driven policies that rely on individual or business tax liability to encourage capital-intensive investments, a FIT allows anyone to become an energy producer and encourages local, community-ownership of energy production. According to Farrell, "20-year tariffs stabilize project revenues, lowering the cost of capital for investors" (2008, p. 1). Like energy conservation measures, distributed generation solar PV reduces the need to import energy from distant sources. Unlike energy conservation – solely a demand reduction strategy, solar PV produces energy that can become a revenue stream for those who incorporate the technology into their operations.

Another advantage of solar PV is that it can be installed on top of existing urban infrastructure – commercial, government or residential buildings, parking lots and garages, brownfields, or large open spaces like those at a city's airport. Rather than impacting remote, potentially environmentally-sensitive sites as hydropower, utility-scale wind, or geothermal can, solar PV can be overlaid on top of existing uses saving money in the form of environmental impact assessments, land purchase or lease, and transmission infrastructure to deliver power from distant remote sites to the end-user.

When we consider the unstable or unpredictable nature of climate that society will inevitably face as a result of global climate change—increased summer drought and reduced winter snowpack that will impact historically-significant hydropower capacity for the Pacific Northwest, and potential floods and forest fires that can disrupt transmission infrastructure, energy produced closer to the end-user becomes even more important. While the initial cost of solar technology is still higher than most other forms of energy production on a per kW basis, fully accounting for the externalities of other generating sources – which a well-designed FIT accomplishes through its tiered pricing structure based on technology type – solar PV becomes much more cost-competitive now. This is not to say that solar PV located in urban settings will meet all of a community's energy demand anytime in the near future. Yet reducing the amount of any imported energy will improve energy security and provide grid stability, as well as increase local investment and ownership of energy resources, create family-wage jobs in the emerging green economy and further a host of related sustainability goals over the long run. As solar and other RE technologies mature and innovations allow increased energy output on the same physical footprint, society moves ever closer to being fully powered by renewable energy, through what Beatley describes as a solar city.

III. Methods

The 2009 Oregon Legislature debated two different bills often referred to as feed-in tariff legislation. On July 22 Governor Kulongoski signed HB 3039 into law. While not a true feed-in tariff as described in this research, this pilot program does use elements of FIT policy to encourage new solar PV installations by customers within Investor-Owned Utility (IOU) service districts in the state. Oregonians for Renewable Energy Payments proposed an alternative bill, HB 3038. It was modeled much more closely on the successful experience used in countries like Germany, Denmark, and Spain, and designed to encourage the rapid deployment of all renewable energy technologies by any electric customer throughout the state, regardless of what type of utility company provides their service. See the Discussion section of this report for a more detailed comparison of the two bills and how they've incorporated the elements of successful FIT policy design outlined here and by numerous authors.

This research uses two different scenarios to compare how these two bills' implementation could impact ratepayers and the rapid deployment of renewable energy in Oregon, using Eugene as the baseline. Since HB 3039 is only open to IOU customers and the Eugene Water & Electric Board (EWEB) is a consumer-owned utility, for the purposes of this study, this bill will have no impact on ratepayers in Eugene. As a result, EWEB could refine their existing Direct Generation program to encourage even more rapid deployment of solar PV than it has already accomplished, incorporating more elements of FIT policy design as suggested in this report.

To estimate the impact on electricity ratepayers in Eugene and Oregon, this research:

1. Calculates the appropriate FIT payment rate (for solar PV only):
    a. to meet a target of potential solar capacity; and
    b. provide a 5-7% return on investment for system owner/generators over a 20-year contract.
2. Calculates the impact of this FIT proposal and development of the associated arrays using the scenarios outlined below on the average Residential and Commercial/Industrial customer in:
    a. the EWEB service district; and
    b. throughout the State of Oregon.
3. Estimates some of the broader sustainability benefits to the community including:
    a. Number of new jobs created in the local and state solar industries;
    b. Avoided greenhouse gas (GHG) emissions from installation of such an array.

Eugene's Solar Capacity: In 2006 this researcher estimated that the community of Eugene could generate 68 MW of electricity annually from solar PV on large commercial and public buildings. The potential capacity was arrived at using GIS software and aerial photographs to first determine how much roof space was available within the city limits. Approximately 1500 buildings were sampled and 500 were randomly selected, based on input that about 25–50 percent of the buildings in Eugene would be suitable for solar PV. Of those buildings sampled, the available square footage was further reduced by an additional 35 percent to account for space needed for existing HVAC (heating, ventilation, and air-conditioning) equipment and necessary PV infrastructure (Vignola, email communication, 10/10/2005). Solar panel output was based on real-world measurements from PV test arrays monitored by Dr. Frank Vignola of the University of Oregon's Solar Radiation Monitoring Lab. It's important to note that estimated output from individual installations and therefore the aggregate total, were derived from sample arrays monitored under actual conditions in Eugene, not simply PV panel ratings from the manufacturer. This should provide a more accurate reflection of what large-scale deployment of solar PV may achieve on a per kilowatt-hour basis, in this geographic context. Given that technology innovation continues to occur, 68 MW may even be a conservative estimate compared to today.

For comparison purposes, the EWEB scenario addresses the impact of this type of policy change on ratepayers using two capacity thresholds of 68 MW and 30 MW, as the latter would have less impact on ratepayers.

Oregon's Solar Capacity: The second scenario uses Eugene's potential PV capacity of 68 MW, and extrapolates the State's PV capacity through comparison of Eugene with several randomly selected Oregon cities – Albany, Beaverton, Bend, Gresham, Medford, and Salem. Eugene's PV capacity was based primarily on the square footage of available roof-space on large commercial, industrial or public buildings within the urban growth boundary. Like Eugene, most of these cities are located in the Willamette Valley (see the assumption regarding solar irradiance below for information about Bend and Medford, which are outside the Willamette Valley.) A visual inspection of each of the cities using Google Earth illustrates that each has a relatively comparable built environment based on the ratio of actual city size compared to Eugene. Given these factors, it's assumed that they would also have comparable available under-utilized urban infrastructure. These seven cities, including Eugene, represent 19.3 percent of the area of all cities in Oregon. Combined with the fact that solar PV can be deployed on more than just large buildings and can also include residential structures, open areas like parking lots, or even under-utilized agricultural land surrounding an urban growth boundary, this should provide a conservative estimate of the state's actual PV capacity.

Table 2: Estimating Oregon's Solar PV Capacity

Community	Area/City (Sq Miles)	Ratio to Eugene	Solar Capacity (kW)	Solar Capacity (MW)	Solar Capacity Output (kWh) (2, 3)	Cost to Install (4)
Totals:	195.5		331,161.7	331.2	374,017,931	$2,318,131,983
Eugene Baseline	40.6	1	68,773.2	68.8	77,673,289	$481,412,575
Albany (1)	16.1	39.7%	27,272.1	27.3	30,801,477	$190,904,987
Salem	46.4	114.3%	78,598.0	78.6	88,769,473	$550,185,800
Beaverton	16.3	40.1%	27,610.9	27.6	31,184,104	$193,276,477
Bend	32.2	79.3%	54,544.3	54.5	61,602,953	$381,809,974
Medford	21.7	53.4%	36,758.1	36.8	41,515,034	$257,306,721
Gresham	22.2	54.7%	37,605.1	37.6	42,471,601	$263,235,448

Table Notes
1) Source of Area for Oregon cities: Wikipedia.com
2, 3) Solar Output per MW installed: 1,129,411.8 kWh; based on Eugene baseline; Source: Neff, 2006
4) Install Cost of Solar PV: $7,000/kW

A detailed analysis of these cities' PV capacity, like that completed for Eugene in 2006, is very feasible yet beyond the time and resources available for this research project. There are several more assumptions that inform these methods and they are acknowledged below to provide a cogent argument for the conclusions. With proper supporting background, there can be value in using broad assumptions at this stage in the development of this decision support model. These variables provide opportunity for policymakers to fine-tune the model, which is one of the strengths of successful FIT policy design, to meet local or regional policy goals within a place-sensitive environmental, social, and economic context.

ASSUMPTIONS AND BACKGROUND:

- **Solar irradiance influences PV output:** The six other cities were chosen because most are located in the Willamette Valley with similar solar irradiance as Eugene, and therefore it is assumed similar PV output.
    - Bend and Medford are not in the Willamette Valley yet it is assumed that they would most likely produce more or less kWh of electricity respectively, from similar-sized solar PV arrays and together they would be comparable to Eugene.

- **Under-utilized urban infrastructure capacity:** The communities also are assumed to have a similar built-environment profile as Eugene, with comparably sized downtowns, most buildings assumed to be under 5-7 stories tall which reduces potential for shading on nearby rooftops, and have a comparable area in square miles relative to Eugene.
- **Solar installations on large commercial buildings versus smaller residential solar installations:** The original dataset consisted solely of larger buildings with flat roofs in Eugene (> 1,000 sq. ft.), and did not include any residential buildings, whereas both legislative bills would be open to all classes of electric customer. Further, HB 3038 would limit the size of any RE installation to 1 MW maximum, while the original data included five arrays larger than 1 MW. The average installed array from the original Eugene dataset is 135 kW and the median installed array is 76.1 kW. The total output of the array averages 1.129 MWh for each MW installed capacity. It is assumed that even though there would be a different ratio between larger and smaller installations in a more detailed study, this aggregate data provides a similar PV capacity for the sample community.
- **Population, density and demographics:** Eugene has the second largest population in the state while the others are among the top eleven, according to the Population Research Center at Portland State University (Proehl, 2009). As population centers, it is assumed that they have relatively similar income, political, and educational demographics.[2]
    - Beaverton and Gresham are two outliers that exist in the Portland Metro area and have a population density 1.3 times greater than Eugene. As a result, they may not have as many large commercial and public buildings as Eugene, yet the generally higher average income levels may encourage more residential installations than some of the other communities and should balance this out.
- **PV Installation Cost, $7 per watt ($7000 per kW):** According to a Feb 2009 report on solar PV cost trends the 2007 price for PV in Oregon was $8 per watt ($8,000/kW), yet the authors also conclude that prices have been going steadily down at a rate of 3.5 percent per year. The same report states that the national average in 2007 was $7.60 per watt; with a 3.5% annual drop, that would equal $7.08 per watt in 2009. Oregon also had the third lowest installed cost of the states surveyed in the report and the researchers indicate that, "markets with large PV deployment programs often tend to have lower average installed costs for residential PV" (Wiser, Barbose, Peterman 2009, p. 2). They further state that, "recent developments portend a potentially dramatic

shift over the next few years in the customer-economics of PV" (2). This trend is confirmed by recent media reports on both the local and national level, and as such provides support for this variable (Ofseyer, 2009; Bradsher, 2009).

- **Tax Credits:** The percentage of installations that take advantage of Federal ITC credits is based on experience in Germany where 60% of installations were either commercial or large, ground-mounted arrays, and 40% were residential (Solar Energy Power Association (SEPA), Northwest Solar Center, & World Future's Council, 2008). This research assumes a similar ratio and that commercial and larger installations would also be eligible for the ITC, while in general, smaller installations may not have sufficient tax liability to take advantage of the ITC. If the number of installations able to take advantage of the ITC were larger, this would reduce the end-cost to ratepayers and vice versa. No other potential funding, such as Energy Trust of Oregon grants, are included in calculating the installed cost of PV for this distributed generation array.
- **Number of years to deploy, 10:** Personal communication with several of EWEB's staff and a former staff member who now works at the Gainesville Regional Utility, indicates that while this may be an ambitious goal, it is technically feasible, with sufficient resources allocated to carry it out.
- **Public Finance Interest Rate:** Based on communication with a City of Eugene staff member in the Finance department, this is assumed to be 5.5%; 5% is used for the Oregon FIT calculations.
- **These calculations do not use a digressive FIT rate, due to technical constraints.**

Table 3 on the following page illustrates how these calculations were implemented to determine the FIT rate and the estimated impact on ratepayers for a 68 MW distributed generation array in Eugene, based on the HB 3038 proposal.

Table 3: Calculating FIT Rate and Impact on EWEB Ratepayers, 68 MW Solar PV

Total Distributed Generation Array Attributes	Total System Capacity (MW)	Total Power Production (kWh)	Total System Cost	Number of years to Deploy	Power Production/Yr (kWh)	System Capacity MW/Yr	System Cost per Yr
	68.8	77,673,289	$481,412,575	10	7,767,329	6.9	$48,141,258

Array - Tax Credits Avail	60%	
Finance Rate Funded Through Bonds	5.5%	
Systm Capacity Deploy/Yr	6.9	MW
Construction Cost	$7.00	per watt
Power Production per Year	4,660,397	kWh

EWEB 2007 Facts & Figures (2)	Number of Customers	Power Consumption	Percentage of Total Consum	Mnthly Cost per Customer	Annual Cost per Customer	Total Monthly Cost, Full Deployment	Total Annual Cost, Full Deployment
Residential	77,533	1,026,244,981	37.8%	$0.71	$8.57	$7.14	$85.68
Comm/Indust	8,987	1,688,099,543	62.2%	$10.13	$121.59	$101.32	$1,215.86
Total	86,520	2,714,344,524	100.0%				

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2029	Total
Initial Cost (Percent of Annual System Cost/Yr)													$28,884,755
OR BETC (OREP, N/A)													$0
Federal ITC	-$8,665,426												-$8,665,426
Power Generation (FIT)*	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$35,139,396
Finance Interest	$1,588,661	$1,102,806	$1,066,827	$1,028,869	$988,824	$946,576	$902,004	$854,981	$805,371	$753,034	$697,817	$42,102	$13,970,685
Net Cash Flow	-$8,833,735	-$654,164	-$690,143	-$728,101	-$768,146	-$810,394	-$854,966	-$901,989	-$951,598	-$1,003,936	-$1,059,153	-$1,714,868	-$29,834,137
Amount Owed	$20,051,020	$19,396,856	$18,706,713	$17,978,613	$17,210,467	$16,400,073	$15,545,107	$14,643,118	$13,691,520	$12,687,583	$11,628,431	-$949,383	
*FIT rate	$0.377	/ kwh										**ROI**	6.57%
REC Value	$50	/MWh											

Array - No TaxCreds Avail	40%	
Finance Rate Funded Through Bonds	5.5%	
Systm Capacity Deploy/Yr	6.9	MW
Construction Cost	$7.00	per watt
Power Production	3,106,932	kWh

EWEB 2007 Facts & Figures (2)	Approx # Cust.s	Power Consumption	Percentage of Total Consum	Mnthly Cost per Customer	Annual Cost per Customer	Total Cost/Mth per Yrs to Deploy	Total Annual Cost, Full Deployment
Residential	77,533	1,026,244,981	37.8%	$0.66	$7.95	$6.63	$79.54
Comm/Indust	8987	1,688,099,543	62.2%	$9.41	$112.88	$94.07	$1,128.78
Total	86,520	2,714,344,524	100.0%				

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2029	Total
Initial Cost (Percent of Annual System Cost/Yr)													$19,256,503
Oregon BETC N/A													$0
Federal ITC													$0
Power Generation Cost*	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$32,622,782
Finance Interest	$1,059,108	$1,027,646	$994,454	$959,436	$922,492	$883,517	$842,398	$799,017	$753,250	$704,966	$654,027	$49,102	$12,677,008
Net Cash Flow	-$572,031	-$603,493	-$636,685	-$671,703	-$708,647	-$747,622	-$788,741	-$832,122	-$877,889	-$926,173	-$977,112	-$1,582,037	-$19,945,773
Amount Owed	$18,684,472	$18,080,978	$17,444,293	$16,772,590	$16,063,944	$15,316,321	$14,527,580	$13,695,458	$12,817,569	$11,891,396	$10,914,284	-$689,270	
*FIT rate	$0.525	/ kwh										**ROI**	7.16%
REC Value	$50	/kwh											

CALCULATING THE APPROPRIATE FIT RATE

The FIT rate is calculated once the target solar capacity and total cost are determined, and variables such as sample size of customers and associated energy demand are included in the model. The rate is adjusted up or down until the Amount Owed is less than zero, and then further adjusted until the desired Return on Investment (ROI) is reached. If the impact on customers is higher than desired, adjust the target capacity, other variables as able, or reduce the desired ROI until the impact on ratepayers reaches a desired level. For a more detailed look at the calculations and what data was needed to complete the process, see Appendix 3.

So we have a choice to make. We can remain one of the world's leading importers of foreign oil, or we can make the investments that would allow us to become the world's leading exporter of renewable energy. We can let climate change continue to go unchecked, or we can help stop it. We can let the jobs of tomorrow be created abroad, or we can create those jobs right here in America and lay the foundation for lasting prosperity.

~ President Barack Obama, March 19, 2009

IV. Discussion and Findings

A well-designed renewable energy Feed-in Tariff does much more than simply encourage the uptake of new, clean energy resources; research indicates that a FIT accomplishes that better than any other policy mechanism. More importantly, a FIT creates synergy between the parallel and interrelated issues of economic development and job creation, environmental protection, climate change adaptation, and energy security (Couture & Cory, 2009). The challenges that society faces as a result of climate change and the current economic crisis require a systemic approach to problem solving and a FIT combined with other policies such as Renewable Portfolio Standards (RPS) can do just that. At the state level, aggressive RPS targets provide the goal, while a FIT can provide a cost-effective and equitable policy mechanism to reach those targets (Rickerson, et al., 2007; Couture & Cory, 2009).

The most successful FIT policies share several key elements:

- Policy provides long-term stability for investors, the industry and utilities, using fixed payment rates and long-term contracts of at least 15-20 years; longer terms appear most effective.
- Payment levels are set to cover all project costs over time with a reasonable return on investment; 5-7% returns are adequate and create a safe investment.
- Tariffs decrease over time at set annual intervals to encourage industry innovation and account for technology cost reductions as industries mature.
- Tariffs are tiered to account for variations between the cost of different renewable energy technologies, project sizes that benefit from economies of scale, and resource quality inherent at different geographical locations.
- The full cost of the program is spread across all ratepayers equitably.
- Approval processes are streamlined and simplified to reduce transaction costs and improve the economics of small-scale projects.

- Policy guarantees access to the electrical grid.
- Policy impact is monitored over time and flexible enough to allow adjustments as needed after required, regular program reviews. (Couture & Cory, 2009; Cory, et al., 2009; Farrell, 2008; Mendonça, 2007; Rickerson, et al., 2007)

These guidelines encourage deployment of a diverse energy portfolio, from a range of large and small investors throughout the community, building public support for the program. Banks are encouraged to loan, often with a reduced cost of capital, as guaranteed contracts provide ample investment security. Payment rates tiered to different technology types, project sizes, or locations encourage technology diversity and efficient operation without generating windfall profits. A well-designed FIT allows anyone in the community with adequate natural and capital resources to participate and democratizes the generation of energy that everyone relies on.

OREGON'S CURRENT FIT

Oregon's HB 3039 differs from the recommendations above in several very important ways and appears to have potentially competing policy goals. The bill uses elements of feed-in tariff policy, yet is designed to encourage the adoption of a single technology – solar PV, rather than a diverse mix of technologies. The FIT portion of the bill is a pilot program ending on March 31, 2015 or when the program cap of 25 MW is met, and no qualifying system can be greater than 500 kW. Though it requires 15-year contracts with a fixed rate paid to generators, the payment rate is related to the avoided cost of energy, distribution and transmission, plus the value of renewable energy certificates. This is referred to as the resource value. The most successful policy design decouples the payment rate from the avoided cost of electricity and instead relates the payment rate to the cost of the generation technology, leveling the playing field better between all generation types including carbon fuels. Under HB 3039, FIT rates are required to have no greater than a 0.25% impact on ratepayers, again tied to the cost of electricity rather than the cost of the technology generating the energy.

In support of HB 3039's policy design, participants in the pilot program would have to choose between receiving either residential or business energy tax credits (RETC, BETC) or receiving a FIT payment. Finally, the Public Utility Commission (PUC) is required to submit a report to the legislature every two years beginning Jan 1, 2011. This report will evaluate the effectiveness of incentive rates on the adoption of solar PV and encouraging installation cost reductions, as well as the cost of the program itself (Oregon Legislative Assembly, 2009).

While the solar FIT portion of the bill specifically states that a goal is to encourage “smaller-scale qualifying systems” as defined by the PUC (Section 2:7), the legislation contains a “solar generating capacity standard” (Section 3) that is unrelated to a FIT. The standard requires all electric companies[3] in the state to obtain an aggregate of 20 MW of electricity from solar PV systems greater than 500 kW by Jan 1, 2020, and provides a 2-for-1 value to Renewable Energy Certificates (REC) for systems that become operational before Jan 1, 2016. This provision actually reduces the real capacity value of Oregon’s RPS goals and creates an artificial trade-off between the values of a Renewable Portfolio Standard versus the deployment of solar PV (Sickenger, 2009). Since required systems are greater than 500 kW, they don’t qualify for FIT payments as above, so financing will follow standard market practices and be dependent on prevailing economic conditions. Any prudently incurred costs above the resource value associated with this standard are recoverable through customers eligible for the FIT portion of the program above (Section 3:10). This section of the legislation will encourage large, utility-scale installations to meet the required standard, yet it will be paid for by all ratepayers in the investor-owned utilities (IOUs) while predominantly benefiting those with the available capital to invest. The bill, most likely, will not provide the broad benefits that a FIT is capable of, especially for many small-scale investors distributed throughout a community.

This legislation can provide some economic and environmental benefits to Oregon. The FIT portion of HB 3039 should have minimal impact on ratepayers since the bill requires a 0.25% or less impact, could create as many as 825 jobs in the solar industry by full deployment, and reduce the state’s CO2 emissions by approximately 11,500 metric tons. The latter is the equivalent of 0.1% of the state’s 2007 CO2 emissions from electricity generation that equaled 9.52 million metric tons (MMT), according to the EPA’s statewide reporting measurements (EPA, 2009a). HB 3039 may be a small step in the right direction for solar PV, yet it does not take advantage of Oregon’s full energy producing potential and encourage the widespread adoption of all renewable energy technologies, including solar PV, that are so necessary at this time. Further, the economic benefits received from solar investment will continue to be concentrated in the hands of those who have sufficient capital to invest, rather than spreading economic opportunity throughout the community.

Locally, as a customer-owned utility, EWEB is not an “electric company” as defined by Oregon statutes, and therefore would not be regulated by this legislation. EWEB customers would also not be eligible to receive FIT payments for solar PV they install under HB 3039. Since HB 3039 is open only to customers within the investor-owned utility service districts in Oregon, no further analysis of its rate impact on EWEB customers is necessary.

THE RIGHT FIT FOR OREGON

Oregonians for Renewable Energy Payments developed a FIT proposal that was also debated in the 2009 Oregon legislature, yet it was not passed out of committee. HB 3038 was modeled more on the successful German legislation and includes the elements of a well-designed FIT outlined in this research. According to an OREP statement comparing the two bills:

> HB 3038 is designed to encourage Oregonians throughout the state to participate in the generation of renewable energy from any of the technologies that qualify for Oregon's RPS that are market ready for small-scale production. It is aimed at small-scale (residential, schools, churches, small farms, etc.) production and designed to encourage growth of the renewable energy manufacturing and installation industry in Oregon.

HB 3038 had no program cap or termination date, was open to all electricity customers in Oregon, and prices paid to generators were to be fully ratepayer funded. The FIT rates per kWh paid to participants were to be based on the project installation cost tiered to different generation technologies, with a 5-7% return on investment built in to 20-30 year contracts. The prices would further be tiered to account for the availability of federal tax credits and include "a differential rate for nontaxable entities that cannot benefit from federal tax incentives" (OREP, 2009, Section 3:2:C). Participants would have to choose between receiving either the BETC or RETC, and receiving FIT payments in OREP's version as well, serving to reduce the impact of renewable energy deployment on state tax revenues. HB 3038 would have also required utilities to purchase any electricity generated by a qualifying system, thereby ensuring connection to the grid for all renewable energy generators.

While OREP's proposal was available for all renewable energy technologies, this research focuses solely on the solar PV component. It has been established that Eugene's solar PV potential is approximately 68 MW annually. This is close to the equivalent amount of energy generated by three of the four hydroelectric dams owned by EWEB. The Smith Creek, Leaburg-Walterville and Stone Creek Hydroelectric Projects generate 71 MW of electricity annually, based on 2006 nameplate capacity (EWEB, 2009a). Comparing the area of six other Oregon cities with relatively similar built environments to Eugene provided an estimate of the state's solar potential of 331 MW annually. This is enough electricity to power close to 33,300 homes each year, according to 2007 data from the U.S. Energy Information Administration (EIA, 2009). It's also slightly larger than all of EWEB-owned generation resources including hydroelectric, wind, and steam co-generation that total 313.6 MW (EWEB, 2009a).

Two different scenarios were used to evaluate the OREP proposal on ratepayers – the first addresses the impact on EWEB's customer base if the City of Eugene were to develop a similar proposal on its own. The City of Berkeley, CA unveiled a renewable energy incentive program called BerkeleyFIRST in 2008 that could serve as a model. The CityFIRST[4] (City Financing Initiative for Renewable and Solar Technology) program is now being replicated in other jurisdictions in California and in Boulder, Colorado. The program is financed with taxable municipal bonds, and provides fixed, low interest loans for 20 years that are repaid through an attachment to the system owner's property tax bill. The program requires no up-front cost from the system owner and if the property is later sold, the loan stays with the property, just as the PV system does. According to Pauker, who researched the legal issues of implementing a similar model in other states, Oregon statute allows a "variety of permissible 'special districts' that can be established to finance particular purposes" and would require "an amendment to Section 198 of the Oregon Revised Statues to include residential solar or energy efficiency improvements as a permissible purpose" (2008, p. 21).

According to Svendsen, a City of Eugene staff member in the Finance department, the City or EWEB could probably already use bonds to fund such a program, with loans for PV installation attached to the property tax bill. He indicates that the State Energy Loan Program (SELP) could be an example (Email communication, Aug 31, 2009). SELP provided its first loan in 1981 and offers low-interest loans for both conservation and renewable energy projects that can include "individuals, businesses, schools, cities, counties, special districts, state and federal agencies, public corporations, cooperatives, tribes, and non-profits" (Oregon Energy Loan Program, 2009, para. 3). According to Pauker, general obligation bonds fund SELP, with the most common form of security being a lien on the property. Past loans have ranged from $20,000 to $20 million (2008). While it is beyond the scope of this research to provide all the legal ramifications of developing a FIT in Oregon or Eugene, it appears there is precedent to allow it to be fully developed.

How's it All FIT Together?

Eugene or EWEB FIT: The first scenario illustrates the impact of Eugene developing a FIT on its own or EWEB refining its existing Direct Generation program. This scenario would deploy a target of 68 MW of solar PV over ten years or the equivalent of 2.9% of EWEB's 2007 total demand for residential and commercial/industrial customers. This would require a FIT rate of 37.7¢ per kWh for installations eligible for the Federal ITC and 52.5¢ per kWh for installations not eligible for the ITC. The return on investment (ROI) for generators would be 6.57% and 7.16% respectively. The impact on EWEB ratepayers would be about $1.40 per month (about $17/year) for residential customers, and approximately $20 per month ($235/year) for commercial and industrial customers, each year. After ten years, the impact would be about $14 per month ($165/year) for residential customers, and approximately $195 per month ($2,345/year) for commercial and industrial customers (See Table 4; Appendix 3 for a more detailed look at the calculations.)

Table 4: Impact of Eugene FIT on EWEB Ratepayers, 68 MW Solar PV

	Number of Customers	Power Consumption	Percentage of Total Consum	Mnthly Cost per Customer	Annual Cost per Customer	Total Monthly Cost, Full Deployment	Total Annual Cost, Full Deployment
Tax Credits Available; 60% of Total; Installed Cost: $28,884,7555							
FIT Rate	$0.377	**ROI**	**6.57%**				
Residential	77,533	1,026,244,981	37.8%	$0.71	$8.57	$7.14	$85.68
Comm/Indust	8,987	1,688,099,543	62.2%	$10.13	$121.59	$101.32	$1,215.86
Total	86,520	2,714,344,524	100.0%				
No Tax Credits Available; 40% of Total; Installed Cost: $19,256,503							
FIT Rate	$0.525	**ROI**	**7.16%**				
Residential	77,533	1,026,244,981	37.8%	$0.66	$7.95	$6.63	$79.54
Comm/Indust	8,987	1,688,099,543	62.2%	$9.41	$112.88	$94.07	$1,128.78
Total	86,520	2,714,344,524	100.0%				
Combined Impact							
Residential	77,533	1,026,244,981	37.8%	$1.38	$16.52	**$13.77**	**$165.22**
Comm/Indust	8,987	1,688,099,543	62.2%	$19.54	$234.46	**$195.39**	**$2,344.64**
Total	86,520	2,714,344,524	100.0%				

Table Notes:

(1) Source Customer Data: EWEB 2007 Facts & Figures (2008)

(2) According to the SEPA 2008 Fact-Finding Mission to Germany, "In Germany, the PV market is 10% large ground mounted field systems, 40% residential, and 50% commercial." This provides the basis for the percentage of systems eligible for a Federal ITC and those that are not eligible.

(3) Solar PV Installation Cost = $7/W; Wiser, R., Barbose, G., Peterman, C. (2009).

By comparison, in the late 1990s, the Sacramento Municipal Utility District (SMUD) attached a $4 per month surcharge to their residential customers' utility bill to fund the PV Pioneer program. While not a FIT, SMUD customers enthusiastically received the program as an alternative to other costly transmission infrastructure development. SMUD installs solar PV on rooftops of customers that volunteer through a lease arrangement and the utility receives all the power generated for the local grid (Wolcott, 1999).

Another advantage of a FIT is the flexibility to fine-tune the program to match policy goals, which is an important component of their success and cost-efficiency (Cory, et al., 2009). If the original capacity goal of 68 MW of installed solar PV impacts customers more than desired, policymakers can adjust the target. A 30 MW array over ten years would use the same FIT rate as above and produce the same return on investment for generators. To meet this reduced target would cost residential customers about 60¢ per month (about $7/year) each year for ten years, and about $6 per month ($72/year) at full deployment. The cost to commercial and industrial users would be approximately $9 per month ($100/year) each year, and $85 per month ($1000/year) at full deployment. This is still an aggressive goal, yet able to be accomplished with less impact on ratepayers.

Table 5: Impact of Eugene FIT on EWEB Ratepayers, 30 MW Solar PV

	Number of Customers	Power Consumption	Percentage of Total Consum	Cost/Mth per Customer	Annual Cost per Customer	Total Cost/Mth per Yrs to Deploy	Total Annual Cost per Cust., fully Deployed
Tax Credits Available; 60% of Total; Installed Cost: $12,600,000							
FIT Rate	$0.377	**ROI**	**6.57%**				
Residential	77,533	1,026,244,981	37.8%	$0.31	$3.74	$3.11	$37.37
Comm/Indust	8,987	1,688,099,543	62.2%	$4.42	$53.04	$44.20	$530.38
Total	86,520	2,714,344,524	100.0%				
No Tax Credits Available; 40% of Total; Installed Cost: $8,400,000							
FIT Rate	$0.525	**ROI**	**7.16%**				
Residential	77,533	1,026,244,981	37.8%	$0.29	$3.47	$2.89	$34.70
Comm/Indust	8,987	1,688,099,543	62.2%	$4.10	$49.24	$41.03	$492.39
Total	86,520	2,714,344,524	100.0%				
Combined Impact on Ratepayers							
Residential	77,533	1,026,244,981	37.8%	$0.60	$7.21	**$6.01**	**$72.07**
Comm/Indust	8,987	1,688,099,543	62.2%	$8.52	$102.28	**$85.23**	**$1,022.77**
Total	86,520	2,714,344,524	100.0%				

Source of Customer Data: EWEB 2007 Facts & Figures

Statewide FIT: The second scenario uses the estimated state solar PV potential to explore the impact of an OREP style proposal on all ratepayers across the state, regardless of what type of utility serves them. The difference from above is significant, even though this scenario would finance 331 MW of solar PV or the equivalent of 0.8% of total residential and commercial/industrial customer demand for 2007. While 331 MW displaces a relatively small percentage of total 2007 electricity demand in this scenario, as will be illustrated below, the cost is less than the potential impact on residential energy costs that could result from climate change. Spreading the cost of the FIT program among a much larger pool of customers reduces the impact on any individual household or organization considerably.

The FIT rate necessary to meet this target would be 36.1¢ per kWh for generators eligible for the Federal ITC, and 50.4¢ per kWh for generators not eligible for the ITC. The return on investment for generators would be 6.15% and 7.11% respectively. In this scenario, the impact on residential customers throughout Oregon would be about 35¢ per month ($4/year) each year. The impact on commercial and industrial customers would be approximately $3 per month ($37/year), each year to deploy. At full deployment in ten years, this would be about $3.50 per month and $42 annually for residential customers, and approximately $31 per month and $375 annually for commercial and industrial customers across the state.

Table 6: Impact of HB3038 (OREP Proposal) on Ratepayers Statewide, 331 MW

	Number of Customers	Power Consumption (MWh)	Percentage of Total Consum	Cost/Mth per Customer	Annual Cost per Customer	Total Monthly Cost, Full Deployment	Total Annual Cost Full Deployment
Tax Credits Available; 60% of Total; Installed Cost: $139,087,919							
FIT Rate	**$0.361**	**ROI**	**6.15%**				
Residential	1,599,788	19,372,337	42.5%	$0.18	$2.15	$1.79	$21.53
Comm/Indust	240,334	26,198,533	57.5%	$1.61	$19.38	$16.15	$193.79
Total	1,840,122	45,570,870	100.0%				
No Tax Credits Available; 40% of Total; Installed Cost: $92,725,279							
FIT Rate	**$0.504**	**ROI**	**7.11%**				
Residential	1,599,788	19,372,337	42.5%	$0.17	$2.00	$1.67	$20.04
Comm/Indust	240,334	26,198,533	57.5%	$1.50	$18.04	$15.03	$180.37
Total	1,840,122	45,570,870	100.0%				
Combined Impact							
Residential	1,599,788	19,372,337	42.5%	$0.35	$4.16	**$3.46**	**$41.56**
Comm/Indust	240,334	26,198,533	57.5%	$3.12	$37.42	**$31.18**	**$374.15**
Total	1,840,122	45,570,870	100.0%				

Source of Customer Data: 2007 Oregon Utility Statistics, p. 39, Oregon Public Utility Commission

THE COST OF CHANGE

In February 2009, Ernie Niemi, a Senior Economist and Policy Analyst with ECONorthwest and a Climate Leadership Initiative Fellow, along with a team of academic and private economists, produced *An Overview of Potential Economic Costs to Oregon of a Business-As-Usual Approach to Climate Change*. Recognizing the very complex nature of climate modeling and the difficulty of localizing the impacts that might occur as well as the full economic impacts of those potential changes, their work provides "an estimate of costs that might materialize if climate change is not reined in, not a forecast of how things will actually unfold" (p. iii). The report estimates that a business-as-usual approach to climate change could cost Oregon families $1930 per year by 2020, with $830 of that related to energy expenditures (Niemi, Buckley, Neculae, Reich, 2009). According to Niemi, $761 of the energy related costs are from inefficient use of energy alone, which are not included for comparison purposes within this study. If Oregonians become more efficient in their use of energy as they incorporate more renewables to meet demand, the change in this value would also offer significant cost-saving opportunities, yet this is beyond the scope of this current research project. The year 2020 represents the same timeframe as modeled above to deploy 331 MW of solar PV in Oregon under HB 3038, the OREP style FIT proposal.

Niemi and his colleagues address three primary components regarding energy-related costs in detail that could result from climate change in Oregon — reduced hydropower generation, increased energy consumption for residential indoor air cooling and increased energy loss during transmission. Based on a recent regional assessment of climate change impacts, a reduction in streamflow could result in a 664 MW reduction in annual average productivity of the Pacific Northwest hydropower system by 2020. The report estimates Oregon's share of this diminished energy generation capacity to be 175 MW by 2020, 550 MW by 2040, and 1,300 MW by 2080, assuming a current share of production continues. Using $48.25 per MWh as the estimated bulk electricity price, this translates to a loss in productive value of hydropower generation in Oregon of $74 million by 2020, $233 million by 2040, and $552 million by 2080 (Niemi, et al., 2009).

Regional assessment of climate change impacts also suggests that July-August temperatures will increase 2.9°C (5.2°F) by 2040 and data suggests that this will increase average residential electricity demand by 200 MW in the region due to increased demands for air conditioning. (See Appendix 4 for a more detailed look at the impacts that a range of temperature increases resulting from climate change could incur.) Based on the assumption that Oregon's 2000 electricity demand will continue into the future, this will place an additional demand of about 23 MW by 2020, 54 MW by 2040, and 140 MW by 2080. This translates to an increased energy cost due to air conditioning of $16 million, $37 million and $92 million respectively (Niemi, et al., 2009).

One of the advantages of distributed generation solar PV is that it reduces the impact of energy-loss from transmission since energy is generated closer to where it is used. A certain amount of energy is already lost as it is converted to waste heat during transmission from generation resources located away from population centers. Higher temperatures during a heat-wave further increase the amount of this energy loss. According to the *American Planning Association Policy Guide on Energy*, the August 2003 blackout across much of the Eastern U.S. was not the result of a lack of power supply but instead "the inability of the stressed transmission system to deliver on the demand" (APA, 2004, P.15). Niemi, et al. state, "If the additional transmission-line losses during a heat-wave day equal one-third of the electricity being transmitted,[5] the annual losses would total 410,000 MW-hours by 2020, 820,000 MW-hours by 2040, and 2.4 million MW-hours by 2080" (2009, P.18). Assuming a wholesale summertime electricity price of $71 per MWh (2008 dollars), this translates to a loss of $29 million by 2020, $58 million by 2040, and $171 million by 2080 for Oregon residential electricity users.

The following table summarizes the energy-related costs that could be incurred from a business-as-usual approach to climate change.

Table 7: Energy-related Cost of Business-As-Usual Approach to Climate Change in Oregon

	2020		2040	2080
	$Million	MW	$Million	$Million
Reduced Hydropower Generation	$74	175	$233	$552
Increased Indoor Air Conditioning	$16	23	$37	$92
Energy Loss During Transmission	$29	47	$58	$171
Totals:	$119	245	$328	$815

Source: Niemi, et al. (2009).

Applying the 2007 average number of retail electricity customers in the state to the figures above illustrates the potential cost of energy loss as a result of climate change on household ratepayers in Oregon. Table 8 below compares the cost of a business-as-usual approach to climate change, to the proactive approach of the cost of the solar component of a well-designed FIT on ratepayers in Oregon. The latter could result in a savings of approximately $33 per househhold while deploying a net gain of 86 MW of energy generation.

Table 8: Comparison of Cost of Business-As-Usual vs. the Right FIT

Cost	Residential Cust., 2020	Total MW
Due to Climate Change	$74.38	245
HB 3038, OREP FIT	$41.56	331
Difference	**$32.82**	**86**

Notes: Oregon Public Utility Commission. (2008, p. 39). 2007; 1,599,788 Residential Customers

The report from the SEPA fact-finding tour to Germany states, "According to Badenova, the municipal utility in Freiburg, in 2007 the feed-in tariff cost 52 USD for the average three-person household, representing 4.7% of electricity costs" (2008, p. 3). The cost of a business-as-usual approach to climate change would represent approximately 7.5% of residential electricity costs for Oregonians. By comparison, the cost to Oregon residential customers of an OREP style FIT for 331 MW of solar PV would represent approximately 4.2% of their electricity costs based on 2007 data.

OTHER BENEFITS OF THE RIGHT FIT

Grover conducted research in 2007 to estimate the energy, economic and environmental benefits of the U.S. Department of Energy's Solar America Initiative (SAI). Several assumptions and conclusions from that research provide valuable background for the conclusions below. Grover states that one of the primary benefits of the SAI is displacement of a portion of the natural gas currently used to meet peak load demands, since PV output "is highly correlated with peak demand on the electricity system" (2007, p. 2). Grover assumes at relatively low PV penetration levels, that PV would offset natural gas loads on a one-to-one ratio and determines that 1 MW of solar would be the equivalent of 0.6 MW of natural gas peak generation. For purposes of this research then it is assumed that 331 MW of solar PV installed in Oregon would offset the need to construct and deliver 198.7 MW of electricity generated by natural gas.

Grover further states that the *gross* impact of solar PV installation refers to the direct impacts only related to the increased use of solar. This does not account for the loss of activity associated with use of natural gas, as in construction of new natural gas plants. In response, a counterfactual scenario was also used that assumes that if no PV were installed all of that demand would be met with natural gas generation. The difference between the two would be the *net* impacts associated with new PV installation. It is beyond the scope of this research to do as detailed an analysis of the impacts of installing 331 MW of solar in Oregon, so this researcher acknowledges that the benefits below refer to the gross benefits of new PV installation in Oregon and the actual benefits would be somewhat less than currently stated. Further research using the IMPLAN input-output model could determine the net benefits of HB 3039 or HB 3038 on Oregon's economy and family wage job creation.

Jobs. Direct jobs in the solar industry include on-site labor for installation, auditors to conduct on-site energy analysis to determine optimal energy saving and generation opportunities, manufacturing, and to a lesser degree, maintenance. Oregon is already home to five companies that manufacture various components for the solar industry including silicon wafers, solar panels, and inverters. On September 26, 2009 Uni-Chem, a South Korean company announced that it plans to purchase the former Hynix Semiconductor facility in West Eugene and will be converting it to manufacture solar cells, adding one more entry to the state's solar industry. According to Uni-Chem's Yoon Ho Kim, "Timing is critical because industry analysts predict that the United States will be the "next big market" for solar in coming years" (McDonald, 2009). McDonald continues, "By 2010 or 2011, Uni-Chem plans to produce enough solar cells annually in Eugene to generate 1 gigawatt of energy and anticipates employing 1,000 workers in Eugene, he said." These are local and regional jobs, of which the installation jobs can't be outsourced, strengthening the local economy of every community that participates in energy generation.

Fried states that according to a 2007 University of California study of renewables, "Solar photovoltaics (PV) creates more jobs per megawatt of capacity than any other energy technology - 20 manufacturing and

13 installation/maintenance jobs per installed megawatt" (2007, para. 4). Roger Ebbage is Director of the Northwest Energy Efficiency Institute (NEEI) at Lane Community College (LCC) that trains energy efficiency auditors, and solar PV and solar hot water installers. In an interview with KLCC radio, "he claims 100 percent of his students find work in the Northwest" (Burns, J., KLCC: The Northwest Passage: Special Issues: Green Jobs, Dec 9, 2008). This is good news for future graduates, local solar installers, and the state's economy as a whole, given that under a FIT, solar PV installations would be occurring at a substantially higher rate than has ever been experienced before in Eugene or Oregon. According to Martin, 2008 U.S. PV installations totaled 500 MW; 331 MW of solar in Oregon would therefore be the equivalent of approximately 2/3 of the 2008 U.S. total.

This research suggests that a well-designed FIT could mirror the success experienced in Germany for job creation. According to the NEEI/LCC website, there is a waiting list for new enrollment until 2010, which provides some indication of the popularity of this nationally recognized program already. Table 9 shows that, excluding jobs lost in parallel industries that generate electricity for Oregonians, installing 68 MW of solar in Eugene has the potential to create close to 2300 jobs, while installing 331 MW of solar across the state has the potential to create close to 11,000 family wage jobs in Oregon.

Table 9: Job Creation Resulting from the Right FIT

	MW Installed	Installation	Manufacturing	Total
Jobs per MW (1)		13	20	
Eugene, 68 MW (2)				
Per Year	6.9	89	138	227
Full Deployment	68.8	894	1,376	2,270
Oregon, 331 MW				
Per Year	33.1	431	662	1,093
Full Deployment	331.2	4,305	6,623	10,928

Table Notes:

(1) Source: Fried, 2007.

(2) In September 2009, Uni-Chem announced their intent to purchase the former Hynix Semiconductor facility to manufacture solar cells in Eugene.

Greenhouse gas emissions reduction. The State of Oregon's energy mix is already a low-carbon fuel source due to historically abundant hydropower resources, especially compared to the rest of the U.S. Yet, since the early 1990s, CO2 emissions from electricity have generally grown steadily, from 1.79 million metric tons (MMT) in 1990 to 9.52 MMT in 2007 (EPA, 2009a). As streamflows are impacted by reduced snowpack, traditional hydropower resources could be replaced by much dirtier sources of energy such as coal or natural gas. Whether replacing a high-carbon source of electricity generation or alleviating reduced capacity of historic generation resources, solar PV is a clean alternative that does provide opportunities for overall greenhouse gas emission reductions.

The U.S. Environmental Protection Agency (EPA) estimates that .41 metric tons of CO2 are emitted for every MWh of electricity within the Western Electricity Coordinating Council (WECC) Northwest region (EPA, 2009b). At full deployment in ten years, 68 MW of solar PV in Eugene would displace approximately 31,700 tons of CO2. At full deployment, 331 MW of solar across Oregon would displace approximately 153,000 metric tons of CO2, or the equivalent of 1.6% of the state's 2007 CO2 emissions from electricity generation.

CONCLUSION

Recent climate change debate includes a claim by some that addressing the impacts of climate change are simply too costly to the American economy to pursue aggressively. This work, along with the efforts of others dedicated to addressing the issue, negates that argument and illustrates that taking a proactive approach now to climate change, at least as it relates to energy use, could actually be cheaper than continuing with business-as-usual. This is the case, even though the current up-front cost to install solar PV remains higher than almost any other market-ready energy generation technology on a per kilowatt-hour basis. More research is needed to determine the additional impact of including all renewable energy technologies that are open to all potential energy generators, in the next generation of FIT policy in Oregon, as the most successful policies do. Given that other RE technologies cost less than solar PV, it seems reasonable to assume that the additional impact on ratepayers may still be less than the cost of a business-as-usual approach to climate change, while working to meet society's urban and rural energy generation potential.

The methods used here are replicable anywhere in the United States using a few relatively easy-to-learn tools. With a very basic knowledge of GIS software (Geographical Information Systems), access to aerial photographs, and the ability to "connect the dots," drawing polygons on top of rooftops and parking lots determines the available under-utilized urban infrastructure in a community and the size of a distributed generation array that could be deployed. PVWatt is a web-based, photovoltaic performance calculator developed by the National Renewable Energy Laboratory, and an individual can then estimate the PV output for this or any grid-connected system in the world. The spreadsheets developed for this project, combined with other localized data can then be used to estimate the right FIT for that community or state using solar PV. As research is conducted for other RE technologies, this too can be incorporated into the overall package to determine the impacts of a complete renewable energy feed-in tariff, fine-tuned to local conditions. This research, along with the work of many others addressing the complex interrelated issues of climate change, could provide a package of tools that can be used for a systemic approach to the interconnected environmental, social and economic challenges presented by climate change.

Craig Morris, a guest speaker on the SEPA tour to Germany for utility executives and decision-makers and author of *Energy Switch: Proven Solutions for a Renewable Future,* states that, “Germans have a very different mindset from Americans. They ask ‘where will we get our energy?’ We ask ‘can renewable ever meet our energy needs?’ ” (SEPA, 2008, p. 5). Now there’s another question to add to the mix – “What is our renewable energy *potential* and how little will it cost to attain that goal, if we all share the burden?” This research begins to address these questions in the context of Oregon’s energy supply in a carbon-constrained world. The answer appears to be yes, renewable energy and solar PV can make a significant, cost-effective contribution to meeting the state’s energy needs.

Establishing the right renewable energy feed-in tariff policy design and taking advantage of the policy mechanism’s design flexibility, provides citizens, businesses, farmers, government agencies and all members of the Oregon community the opportunity to demonstrate a commitment to mitigate the impacts of climate change while improving the economy for Oregonians, now and into the future.

Acknowledgements

Isaac Newton is credited with having said, “If I have seen further it is by standing on the shoulders of giants.” This research project is no exception. I would like to thank my committee members, Robert Young, PhD, Assistant Professor of Planning, Public Policy, and Management, and Bob Doppelt, Associate Professor of Planning, Public Policy and Management and Director of the Climate Leadership Initiative at the University of Oregon’s Institute for a Sustainable Environment for their invaluable feedback and editorial comments throughout this project. Their expertise, attention to detail, and encouragement have challenged me to think more critically and improve this research every step of the way. I’d also like to thank the many colleagues and/or friends who have reviewed this work and provided editorial review, critical feedback, or suggestions. They include: Thomas Osdoba, Felicity Fahy, Jennifer Gleason, Christopher Dymond, James Krumsick (provided the original financial calculations during my 2006 solar research, that provided a solid foundation for modifications that allowed me to estimate the impact of a FIT on ratepayers), John Crider, Glen Svendsen, Colleen Wedin, and John Baumann.

I’d also like to thank the many researchers and authors that continue to shed light on the use of Feed-in Tariff policies across the world and in the United States, and the climate scientists and economists whose recent research has provided a depth of analysis unattainable by this researcher even one short year ago. This project would not have been possible without each of their extraordinary and valuable contributions. And finally to my family who have supported and encouraged my quest for new understanding, with humor and patience. Thank you all for helping guide this project to where it is today and joining me on the journey.

Appendices

Appendix 1: Further Research Considerations

1) Conduct a detailed analysis of Oregon's solar PV potential for the sample cities included in this research.

2) Explore the potential for small-scale wind generation in urban settings in Oregon. The Arts and Technology Academy Elementary School in Eugene has installed a small-scale wind turbine. If data is not currently being collected, this feature could be added to gather information similar to the solar PV test arrays monitored in Eugene by the University of Oregon's Solar Radiation Monitoring Lab that informed this researcher's 2006 study. Real world data collection over time provides valuable information within the local environmental context. As small-scale wind installations increase throughout the state, a statewide database could be established to monitor the state's urban wind generation potential, further strengthening next generation FIT calculations in Oregon.

3) Lane Community College's Northwest Energy Efficiency Institute and the Columbia Gorge Community College Renewable Energy Technician Training program train the next generation of solar and wind technicians, respectively. Determine what is needed to expand these programs to meet the workforce demands of a growing wind and solar industry in Oregon.

4) Further research is necessary to determine the impacts of policy interactions between a Feed-in Tariff and such policies as Renewable Portfolio Standards or Net-metering.

Appendix 2: State Policy Goals Enhanced Through Feed-In Tariff Policy

State Policy Drivers	Specific State Policy Objectives	FIT Policy Impacts	Notes
Economic Objectives	Job creation	High	• Due to the guaranteed terms and low barriers to entry offered by FIT policies, they have been highly successful at driving economic development and job creation • Fixed prices for renewable energy sources can also help stabilize electricity rates
	Economic development	High	
	Economic transformation	High	
	Stabilize electricity prices	Moderate	
	Lower long-term electricity prices[12]	Low/Moderate	
	Grow the state economy	High	
	Revitalize rural areas	High	
	Attract new investment	High	
	Develop community ownership[13]	High	
	Develop future export opportunities	High	
Environmental Objectives	Clean air benefits (Mercury, particulates, etc.)	Moderate	• The rapid RE development seen in jurisdictions with FIT policies has helped reduce the environmental impacts of electricity generation, while providing valuable air quality and other environmental benefits. • Differentiating FIT payments by resource type can also target various biomass waste streams.
	Greenhouse gas emissions reduction	Moderate	
	Preserve environmentally sensitive areas	Low	
	Minimize human impacts of energy development	Moderate	
	Manage waste streams (biogas, landfill gas, biomass, agricultural wastes, forestry wastes, etc.)	High	
	Reduce exposure to carbon legislation	Moderate	
Energy Security Objectives	Secure abundant future energy supply	High	• Well-designed FIT policies can improve overall energy security by helping diversify energy supply and helping domestic energy resources be more widely harnessed.
	Reduce long-term price volatility	High	
	Reduce dependence on natural gas[14]	Low/Moderate	
	Promote a more resilient electricity system[15]	Moderate	
Renewable Energy Objectives	Rapid RE deployment	High	• By creating favorable conditions for RE market growth, FIT policies can help jurisdictions meet RE targets. • FIT policies have also helped countries move toward a green energy economy.
	Technological innovation	High	
	Drive RE cost reductions	High	
	Meet RPS targets	High	
	Reduce fossil fuel consumption	Moderate	
	Provide base-load generation	Low/Moderate	
	Stimulate green energy economy	Low/Moderate	
	Reduce barriers to RE development	Moderate/High	

[12] Cost reduction is more likely to be ensured if lower cost RE resources like wind and biogas are included.
[13] Community ownership will depend on how high the payment levels are set, and whether or not communities are able to participate.
[14] Dependence on natural gas will be reduced primarily in areas where natural gas is the marginal supply.
[15] Greater grid resilience will be fostered if more distributed resources are encouraged, and particularly if they are sited in highly congested areas.

Source: Couture, T., Cory, K. (2009).

Appendix 3: Calculations to Determine FIT Rate and the Impact on Ratepayers

Total Distributed Generation Array Attributes	Total System Capacity (MW)	Total Power Production (kWh)	Total System Cost	Number of years to Deploy	Power Production/Yr (kWh)	System Capacity MW/Yr	System Cost per Yr
	68.8	77,673,289	$481,412,575	10	7,767,329	6.9	$48,141,258

Array - Tax Credits Avail 60%

Finance Rate Funded Through Bonds	5.5%	
Systm Capacity Deploy/Yr	6.9	MW
Construction Cost	$7.00	per watt
Power Production per Year	4,660,397	kWh

EWEB 2007 Facts & Figures (2)	Number of Customers	Power Consumption	Percentage of Total Consum	Mnthly Cost per Customer	Annual Cost per Customer	Total Monthly Cost, Full Deployment	Total Annual Cost, Full Deployment
Residential	77,533	1,026,244,981	37.8%	$0.71	$8.57	$7.14	$85.68
Comm/Indust	8,987	1,688,099,543	62.2%	$10.13	$121.59	$101.32	$1,215.86
Total	86,520	2,714,344,524	100.0%				

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2029	Total
Initial Cost (Percent of Annual System Cost/Yr)													$28,884,755
OR BETC (OREP, N/A)													$0
Federal ITC	-$8,665,426												-$8,665,426
Power Generation (FIT)*	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$1,756,970	-$35,139,396
Finance Interest	$1,588,661	$1,102,806	$1,066,827	$1,028,869	$988,824	$946,576	$902,004	$854,981	$805,371	$753,034	$697,817	$42,102	$13,970,685
Net Cash Flow	-$8,833,735	-$654,164	-$690,143	-$728,101	-$768,146	-$810,394	-$854,966	-$901,989	-$951,598	-$1,003,936	-$1,059,153	-$1,714,868	-$29,834,137
Amount Owed	$20,051,020	$19,396,856	$18,706,713	$17,978,613	$17,210,467	$16,400,073	$15,545,107	$14,643,118	$13,691,520	$12,687,583	$11,628,431	-$949,383	
*FIT rate	$0.377 / kwh											ROI	6.57%
REC Value	$50 /MWh												

Array - No TaxCreds Avail 40%

Finance Rate Funded Through Bonds	5.5%	
Systm Capacity Deploy/Yr	6.9	MW
Construction Cost	$7.00	per watt
Power Production	3,106,932	kWh

EWEB 2007 Facts & Figures (2)	Approx # Cust.s	Power Consumption	Percentage of Total Consum	Mnthly Cost per Customer	Annual Cost per Customer	Total Cost/Mth per Yrs to Deploy	Total Annual Cost, Full Deployment
Residential	77,533	1,026,244,981	37.8%	$0.66	$7.95	$6.63	$79.54
Comm/Indust	8987	1,688,099,543	62.2%	$9.41	$112.88	$94.07	$1,128.78
Total	86,520	2,714,344,524	100.0%				

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2029	Total
Initial Cost (Percent of Annual System Cost/Yr)													$19,256,503
Oregon BETC N/A													$0
Federal ITC													$0
Power Generation Cost*	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$1,631,139	-$32,622,782
Finance Interest	$1,059,108	$1,027,646	$994,454	$959,436	$922,492	$883,517	$842,398	$799,017	$753,250	$704,966	$654,027	$49,102	$12,677,008
Net Cash Flow	-$572,031	-$603,493	-$636,685	-$671,703	-$708,647	-$747,622	-$788,741	-$832,122	-$877,889	-$926,173	-$977,112	-$1,582,037	-$19,945,773
Amount Owed	$18,684,472	$18,080,978	$17,444,293	$16,772,590	$16,063,944	$15,316,321	$14,527,580	$13,695,458	$12,817,569	$11,891,396	$10,914,284	-$689,270	
*FIT rate	$0.525 / kwh											ROI	7.16%
REC Value	$50 /kwh												

HOW THE FIT RATE IS CALCULATED

1. Total System Capacity (Table Heading from top left): Aggregate value from 2006 study
2. Total Power Production: Aggregate value from 2006 study
3. Total System Cost: Based on installation cost of $7,000 per kW, before Federal ITC reduction if applicable
4. Power Production/Year: Total Power ÷ Number of Yrs to Deploy
5. Array Percentage for each section: Based on German experience of 60% large ground-mounted and commercial installations, and 40% residential solar installations (SEPA, et al., 2008)
6. Finance Rate Funded Through Bonds: Email communication with staff from the City of Eugene Finance department
7. Power Production per Year: Power Production/Yr * Percent for that section (see 5 above)
8. Power Generation (FIT)*: Power Production * FIT Rate
9. Finance Interest: Amount Owed * Finance Rate (Note: the first year, the amount owed is equal to the Total Initial Cost)
10. FIT Rate: Variable, user defined; the rate is adjusted until the amount owed in 2029 is less than $0 and the ROI is between 5-7%
11. ROI: (Amount Owed 2029 + Total Net Cash Flow – Total Initial Cost) ÷ Total Initial Cost

Impact on Ratepayers Calculated

12. Percentage of Total Consumption: Power Consumption per Customer Class ÷ Total Power Consumption
13. Annual Cost Per Customer: (Power Generation (FIT) * % of Total Consumption) ÷ Number of Customers

The original financial calculations for this project are courtesy of James Krumsick, Eugene, OR; they have been modified for a distributed generation array and extended to calculate the FIT rate impact on ratepayers.

Appendix 4: Potential impacts of Incremental Increases in Average Global Temperature

1°C (1.8°F)	Increased potential for prolonged drought, converting some parts of the American West to sandy deserts, on a scale much larger than the 1930s Dustbowl.
2°C (3.6°F)	Small mountain glaciers will disappear and mountain snowpack diminish, as will stream flows dependent on snow melt. Large areas of the oceans will become too acidic for organisms with calcium carbonate shells, and for many species of plankton, the basis of the marine food chain. Onset of irreversible melting of the Greenland ice sheet would raise sea levels by about seven meters. Heat waves similar to the most extreme in recent history likely would occur every year in many places. About one-third of all species around the globe may be driven to extinction. Increased risk of hunger for many communities, especially in Africa and Asia.
3°C (5.4°F)	An increase of this magnitude could be a tipping point that causes climate change to become uncontrollable. The middle areas of North America likely would become deserts. Extreme weather, such as hurricanes, may become more intense, doubling damage costs in the U.S. Millions, perhaps billions may face famine from extreme drought, flooding, and insect infestations. Perhaps 50 percent of species face extinction.
4°C (7.2°F)	The West Antarctic ice sheet may collapse and raise sea levels another five meters. Crop yields likely would continue to fall in many regions. Significant shortages of water may affect more than a billion people, as some areas may see runoff increase by one-third. Perhaps 50 percent of species face extinction. Conditions typical of the Sahara Desert probably will materialize across southern Europe.
5°C (9.0°F)	Entire regions of the Earth might see major declines in crop production and ecosystems unable to maintain their current form. Forest fires, droughts, flooding, and heat waves will increase in intensity. Increasing probability of abrupt, large-scale shifts in the climate system, e.g., tropical conditions, may materialize in Arctic regions. Rising sea level threatens major coastal cities.
6°C (10.8°F)	The Earth would experience climate conditions associated with a period, about 250 million years ago, that saw perhaps 95 percent of all species go extinct.

Source: ECONorthwest, adapted from Intergovernmental Panel on Climate Change (2007; and Stern, N. 2006. (Niemi, 2009, p. 3).

Endnotes

[1] Some of this section on climate change and the need to act first appeared in an early Draft of the City of Eugene Greenhouse Gas Emissions Reduction Action Plan, March 12, 2009. This researcher co-authored the draft with a team of City mangers, as an intern for the City of Eugene Sustainability Office.

[2] Interested in early predictions like those from the Carter Administration compared to the reality of today's concentration of household solar PV applications across the U.S., Zahran and his colleagues used geographical information systems (GIS) and statistical software to analyze home use of solar energy at the county level across the contiguous U.S. "By analyzing what predicts conditional expectations of solar energy use, we hope to make it possible to design incentives and plans suited to specific communities" (Zahran, et al., 2008).

[3] As defined by ORS 757.600, "(11) "Electric company" means an entity engaged in the business of distributing electricity to retail electricity consumers in this state, but does not include a consumer-owned utility" i.e. Investor-Owned Utilities only. Retrieved from http://www.leg.state.or.us/ors/757.html.

[4] More information and case studies can be found at Renewable Funding, LLC: http://www.renewfund.com/

[5] Niemi, et al., "Ackerman, F. and E.A. Stanton. 2008. The Cost of Climate Change: What We'll Pay If Global Warming Continues Unchecked. Natural Resources Defense Council. May. Retrieved January 20, 2009, from http://www.nrdc.org/globalwarming/cost/cost.pdf.

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