

# RENEWABLE ENERGY ASSESSMENT FOR JACKSON & JOSEPHINE COUNTIES, OREGON DECEMBER 2011



Prepared for:

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## TABLE OF CONTENTS

<b>1</b>	<b>GLOSSARY.....</b>	<b>4</b>
<b>2</b>	<b>EXECUTIVE SUMMARY.....</b>	<b>7</b>
<b>3</b>	<b>PROJECT BACKGROUND .....</b>	<b>11</b>
	3.1 Description.....	11
	3.2 Approach .....	11
	3.3 Report Structure .....	13
	3.4 Other Project Deliverables.....	13
<b>4</b>	<b>PROJECT CONTEXT.....</b>	<b>14</b>
	4.1 History of U.S. Energy Consumption.....	14
	4.2 Regional Electricity Generation .....	15
	4.3 Rogue Valley Electricity Renewable Generation and Consumption.....	15
	4.4 General Factors Affecting Renewable Energy Development .....	16
<b>5</b>	<b>EXISTING REWABLE ENERGY PROJECTS .....</b>	<b>26</b>
	5.1 Summary of Existing Projects.....	26
	5.2 Energy Efficiency and Conservation.....	28
	5.3 Hydropower .....	30
	5.4 Biomass (Direct Fired).....	33
	5.5 Landfill Gas-to-Energy.....	34
	5.6 Anaerobic Digestion .....	36
	5.7 Solar Electric .....	36
	5.8 Wind.....	37
	5.9 Geothermal.....	38
<b>6</b>	<b>FEASIBILITY ASSESSMENT OF RENEWABLE TECHNOLOGIES .....</b>	<b>39</b>
	6.1 Summary of Findings.....	39
	6.2 Energy Efficiency and Conservation.....	43
	6.3 Hydropower .....	55
	6.4 Biomass (Direct Fired).....	62
	6.5 Landfill Gas-to-Energy.....	74
	6.6 Anaerobic Digestion .....	78
	6.7 Solar Electric .....	88
	6.8 Wind.....	97
	6.9 Geothermal.....	104
	<b>BIBLIOGRAPHY, BY TECHNOLOGY.....</b>	<b>109</b>
	<b>APPENDIX A: JOBS AND ECONOMIC IMPACTS ANALYSIS.....</b>	<b>116</b>
	Methodology.....	116
	Summary of Results .....	117

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# 1 GLOSSARY<sup>1</sup>

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**Avoided cost:** The cost the utility would pay on the open market for its next new kilowatt hour of electricity.

**Average Megawatt Hour (aMWh):** 8,760 megawatt hours, or 1 megawatt times 8,760 hours in a year.

**Balance of system (BOS):** All components of a photovoltaic system except the panels, including wiring, the inverter, support racks, and switches.

**Baseload:** The minimum amount of power that a utility or distribution company must make available to its customers, or the amount of power required to meet minimum demands based on reasonable expectations of customer requirements. Baseload values typically vary from hour to hour in most commercial and industrial areas.

**British Thermal Unit (Btu):** A British Thermal Unit (BTU) is the amount of heat energy needed to raise the temperature of one pound of water by one degree F. This is the standard measurement used to state the amount of energy that a fuel has as well as the amount of output of any heat-generating device.

**Bone Dry Ton (BDT):** A unit of measurement for the quantity of woody biomass having zero percent moisture content. Wood heated in an oven at a constant temperature of 100°C (212°F) or above until its weight stabilizes is considered bone dry or oven dry.

**Capacity factor:** A value used to express the average percentage of full capacity of an energy generation facility used over a given period of time. For example, a generating facility, which operates at an average of 60% of its normal full capacity over a measured period has a capacity factor of 0.6 for that period.

**Capital cost:** Includes the costs for land, taxes, surveying, construction, inspection, materials, labor, and interest on loans or bonds for new projects. Capital costs generally do not include any costs incurred once the facility is functional, although late-discovered expenses must often be added to capital cost well after construction is complete.

**Carbon intensity:** Describes the life-cycle greenhouse gas emissions (i.e. emissions starting at production of materials through end-of-life disposal of the facility) per unit of electrical output. Carbon intensity is measured in kilograms of carbon dioxide equivalent per kilowatt hour (kg CO<sub>2</sub>e / kWh).

**Combined heat and power (CHP) plant:** A plant designed to produce both heat and electricity from a single heat source. Note: This term is being used in place of the term "cogenerator" that was used by EIA in the past. CHP better describes the facilities because some of the plants included do not produce heat and power in a sequential fashion and, as a result, do not meet the legal definition of cogeneration specified in the Public Utility Regulatory Policies Act (PURPA).

**Energy conservation:** Reduction in the amount of energy consumed in a process or system, or by an organization or society, through economy, elimination of waste, and rational use. One form of energy conservation may be energy efficiency.

**Demand response:** Changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in the price of electricity, incentive payments designed to induce lower electricity use or when system reliability is jeopardized.

**Direct normal insolation/irradiance (DNI):** The amount of solar radiation from the direction of the sun.

**Dispatchable generation:** Sources of electricity that can be dispatched at the request of power grid operators; that is, it can be turned on or off upon demand.

**Distributed generation:** Electricity from generating units that are close to the location of use. An example of this would be rooftop photovoltaic solar panels.

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feedstockfeedstock1 U.S. Energy Information Administration Glossary definitions used for the majority of the terms (<http://www.eia.gov/tools/glossary/index.cfm>)  
Renewable Energy Assessment for Jackson and Josephine Counties (December 2011)

**Electric power grid (i.e. grid):** A system of synchronized power providers and consumers connected by transmission and distribution lines and operated by one or more control centers.

**Energy:** The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Electrical energy is usually measured in kilowatt hours, while heat energy is usually measured in British Thermal Units (Btu).

**Energy efficiency:** Energy efficiency is the process of doing more with less or accomplishing the same units or work and functions as before while using less energy, or producing more work or product with the same amount of energy inputs.

**Energy Returned on Energy Invested (EROEI):** The ratio of the amount of usable energy acquired from a particular energy resource to the amount of energy expended to obtain that energy resource. When the EROEI of a resource is less than or equal to one, that energy source becomes an "energy sink", and can no longer be used as a primary source of energy.

**Firm capacity:** Power or power-producing capacity, intended to be available at all times during the period covered by a guaranteed commitment to deliver, even under adverse conditions.

**Gigawatt:** One billion Watts or one thousand megawatts. A measure of electrical capacity.

**Interconnection:** Two or more electric systems having a common transmission line that permits a flow of energy between them. The physical connection of the electric power transmission facilities allows for the sale or exchange of energy.

**Intermediate load:** The range from baseload to a point between baseload and peak. This point may be the midpoint, a percent of the peak load, or the load over a specified time period.

**Intermittent load:** Any source of energy that is not continuously available.

**Kilowatt (kW):** One thousand watts. A measure of electric capacity.

**Kilowatt hour (kWh):** One thousand Watts of electric capacity operating for one hour. A measure of electric energy consumption.

**Levelized cost:** Measures the cost of generating electricity including initial capital, return on investment, as well as the costs of continuous operation, fuel, and maintenance. The price is normally measured in dollars per megawatt hour.

**Load:** The amount of electric power delivered or required at any specific point or points on a system.

**Marginal costs:** The change in cost associated with a unit change in quantity supplied or produced.

**Megawatt (MW):** One million Watts of electricity. A measure of electric capacity.

**Megawatt Hour (MWh):** One thousand kilowatts of electric capacity operating for one hour. A measure of electric energy consumption.

**Megawatt thermal (MWt):** 1,000 kilowatts of equivalent heat energy or 3.4 million British Thermal Units of heat energy. Usually used as a measurement of geothermal heat output.

**Nameplate Capacity:** Maximum technical output of a power plant. For example 1 MW facility operating at full capacity generates 8,760 MWh in one year.

**Net metering:** An energy-use metering scheme that can measure both energy consumed from a utility and energy fed back to the utility by a customer capable of generating electricity. Net metering regulations were intended to encourage the installation of solar generators, wind turbines, and other renewable energy and green power sources.

**Peak load:** The maximum load during a specified period of time.

**Power:** The rate of producing, transferring or using energy, most commonly associated with electricity. Power is measured in Watts and often expressed in kilowatts (kW) or megawatts (MW). Also known as "real" or "active" power.

**Therm:** A unit of natural gas energy equivalent to 100,000 British Thermal Units (BTUs).

**Transmission:** An interconnected group of lines and associated equipment for the movement or transfer of electric energy between points of supply and points at which it is transformed for delivery to customers or is delivered to other electric systems.

**Transmission system (Electric):** An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers, or is delivered to other electric systems.

**Utility-scale:** A system generating a large amount of electricity that is transmitted from one location to many users through the transmission grid.

**Variable load:** The variation of load on a power station from time to time due to uncertain demands of consumers.

**Watt:** The unit of electrical power equal to one ampere under a pressure of one volt. A watt is equal to 1/746 horsepower.

**Watt-hour:** The electrical energy unit of measure equal to one watt of power supplied to or taken from an electric circuit steadily for one hour.

## 2 EXECUTIVE SUMMARY

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Rogue Valley Council of Governments (RVCOG) in collaboration with Geos Institute, Energy Trust of Oregon, City of Ashland, and Jackson Soil and Water Conservation District (JSWCD) contracted with Good Company to conduct a Renewable Energy Assessment (REA) for Jackson and Josephine counties. The purpose of the REA is to review existing renewable energy projects and assess the potential for new renewable energy generation development that can create jobs, increase local energy security, buffer local economies from energy price volatility, reduce fossil-fuel dependency, and reduce the associated greenhouse gas and local emissions. This assessment considers the following power generation resources:

- |                        |                       |
|------------------------|-----------------------|
| ▪ Energy efficiency    | ▪ Landfill gas        |
| ▪ Solar electric       | ▪ Anaerobic digestion |
| ▪ Wind                 | ▪ Hydroelectric       |
| ▪ Direct-fired biomass | ▪ Geothermal          |

This study provides a foundation of knowledge for planning economic development strategies around renewable energy generation opportunities. The project sponsors (listed above) intend to convene work groups of local experts on the various technologies as well as those that have an interest in renewable energy development in Jackson and Josephine counties.

### Approach and Deliverables

This study combines *existing, publically available research and data* with interviews of state experts, business people, government officials, and other stakeholders in Oregon and specifically, in Jackson and Josephine counties to assess local potential for renewable energy development opportunities.

The following criteria were used to assess each technology. The results are summarized in Figure ES-2.

- |   |  |
|---|--|
| • Energy type                                 | • Risks and challenges                     |
| • Existing resource capacity                  | • Benefits and opportunities               |
| • Resource potential                          | • Levelized cost                           |
| • Employment potential (for select resources) | • Energy return on energy invested (EROEI) |
| • Likely technology for each resource         | • Carbon intensity                         |

In addition to this report, the consultant team will prepare a separate, in-depth study on anaerobic digestion (AD), which will be available in early 2012. The AD study provides an inventory of the available AD feedstocks in southern Oregon and assesses potential utilization scenarios.

### Market Context and Drivers

A number of overarching factors converge to impact the development of renewable energy development. Many of these factors are dynamic, but are critical drivers of renewable energy development.

- **Connection to the electrical grid** can be challenging for large-scale generation projects based on the available infrastructure, line capacity, required upgrades, and the cost of interconnection studies.
- **Financing instruments** exist for energy production and can be as simple as debt financing, but are often more complex and intertwined with incentives. **Incentives** are ever changing, but encourage renewable energy investments.
- **Policies and regulations** are being designed at all levels of government to reduce the carbon intensity of electricity generation and fuel production.
- **Prices of electricity** will rise over time, making renewable generation more economically viable as their manufacture scales up.

## Findings

The high-level findings of the analysis are shown in Figures ES1 and ES2. Figure ES1 shows the annual quantity of electricity consumed in Jackson and Josephine counties (orange bar) set next to the existing (dark green) and potential (light green) of local renewable energy generation and resources. Existing generation capacity (dominated by hydropower) makes up the largest portion of generation, followed by the unrealized potential of the area's energy efficiency resource. In addition to being the area's largest untapped resource, energy efficiency will also produce the greatest number of jobs per unit of investment and distributes economic benefits most equitably across all segments of the public and private sectors as well as across socio-economic status.

A second tier of generation potential is represented by wind, solar, and biomass followed by a third tier represented by hydropower and anaerobic digestion. Two of the technologies assessed in this study, landfill gas and geothermal, were excluded due to lack of available resources for electricity generation.

The generation potentials shown in Figure ES-1 do not represent the maximum generation potential for each of the technologies; rather they represent an average or achievable portion of that maximum (see ES-2 for details). While this assessment highlights feasible projects and resources, it is important to keep in mind that each of these technologies has associated risks and opportunities. The findings of this study serve as a starting point for further studies by the renewable energy working groups being convened by RVCOG.

**Figure ES-1:** Existing electricity use in the study area compared to existing renewable generation and future potential.

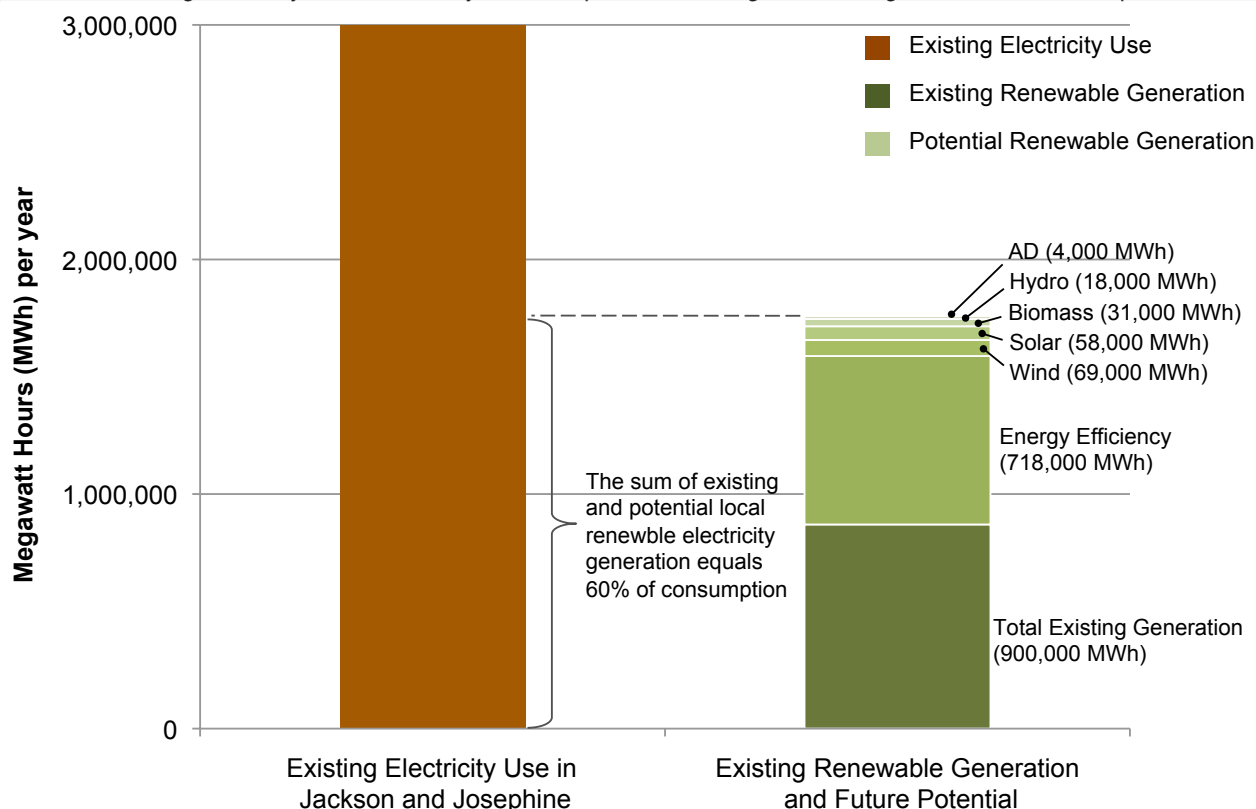


Figure ES-2 summarizes the findings of this study for each of the renewable technologies according to the applied assessment criteria. This figure is meant to provide a relative apples-to-apples comparison across the spectrum of technologies to provide the community with the information required to make an informed decision about which technologies to pursue.

The following points summarize the findings for each technology:

**Energy Efficiency:** The various technologies and practices that make up energy efficiency and conservation represent the greatest potential for the area over the next 20 years combined with the lowest levelized-cost and highest return on investment. There are few barriers to entry; a wide array of projects are possible for all economic sectors and the economic benefits associated with the savings are accessible to anyone who can change a light bulb. The primary risks are high first costs for certain types of projects, poor access to financing vehicles, and a lack of readily available, high-quality and understandable information to compare and contrast the cost/benefit of ownership for similar products.

**Solar:** Solar energy is abundant and small-scale distributed photovoltaic (PV) panels have few barriers to entry. The primary barrier is first cost, but recent trends and future projections show the costs of materials and labor are rapidly decreasing. As costs decrease, this technology will become a viable opportunity to a greater number of residents and businesses. Like energy efficiency, small-scale solar has the potential to distribute economic benefits more broadly than utility-scale projects. While the technical potential is near limitless, larger utility-scale systems pose greater challenges associated with land use, permitting, and electricity grid interconnection. Thermal energy generation is not the focus of this assessment it's important to note that solar water heating also represents a significant opportunity.

**Wind:** While this resource is limited to ridgelines in Jackson and Josephine counties, its potential is large compared to other technologies. The downside is that many of the ridgelines with the highest wind energy are undesirable due to lack of site access, disturbance to local view sheds, and lack of access to the electrical grid. One ridgeline was identified as promising in terms of potential resource, site access, and interconnection, but there may be significant challenges associated with land ownership, as the area is a mix of public and private lands. More study of this site will be required to determine final feasibility.

**Biomass:** Biomass is already a significant source of electricity in the Rogue Valley. Based on the additional available feedstock resource in the area, existing generation capacity could theoretically be expanded, but is constrained by high feedstock acquisition costs, availability, and wholesale price of electricity. While there is unused feedstock technically available in the area, a new biomass plant faces high feedstock acquisition cost, regulatory compliance, permitting, land use, and environmental challenges. A second option for biomass is building level boiler conversions to meet direct thermal loads. This option has fewer risks than would be faced by utility-scale electricity generation.

**Hydroelectric:** Hydroelectricity is by far the largest source of existing, renewable power in the area. While there is abundant kinetic energy available from moving water in the area, the access to this resource is heavily limited by habitat alteration regulations, and water rights. New large hydroelectric dams are unlikely at best. The greatest opportunity for this technology is incremental efficiency projects, such as adding electricity generation to existing flood control dams, water supply lines, or irrigation canals. A few projects are identified in this report, but the combined scale is relatively small.

**Anaerobic Digestion:** While the generation potential associated with this technology is relatively small, it represents an opportunity to make more efficient use of existing organic wastes (i.e., food waste, yard waste and manure) compared to a landfill gas collection system. This technology will be assessed in detail in a separate, but related study. This additional study consists of a feedstock inventory and evaluation of several potential scenarios to determine feasibility of a local anaerobic digester.

**Geothermal:** Geothermal is excluded from consideration due to its lack of available resources in Jackson and Josephine counties. Based on available data, the geothermal resources in Jackson and Josephine counties would not be effective for electricity generation. The research implies that there is no cause to fund further exploration of this technology. However, there is potential for distributed thermal applications (such as ground-source heat pumps or greenhouse use).

**Landfill gas (LFG):** LFG is excluded from consideration due to its lack of an available, cost-effective resource. The only active landfill in Jackson and Josephine counties is Dry Creek Landfill, which already has a gas collection system in place that generates electricity. The gas is also being evaluated for use as a vehicle fuel for Dry Creek Landfill's fleet. The biogas production from the other closed landfills in the area are unlikely to justify the capital cost associated with constructing a new gas collection system given the age of these landfills and the likelihood that most of their useful gas has already been released to the atmosphere.

**Figure ES-2:** Summary of renewable energy technologies, by feasibility criteria.

Category	Energy Efficiency	Solar	Wind	Biomass	Hydroelectric	Anaerobic Digestion	Geothermal	Landfill Gas
Energy Type	Baseload; Peak matched	Intermittent; Peak matched	Intermittent	Baseload or Dispatchable	Baseload or Dispatchable	Baseload	Baseload	Baseload
Existing Resource	8 MW (2002–2008 projects only)	2.1 MW	0 MW	32 MW	121 MW	0.7 MW	0.5 MWe (thermal energy)	3.2 MW
Additional Potential	64 – 100 aMW <sup>2</sup> (560,000 – 876,000 MWh / year)	35 MW <sup>3</sup> (58,000 MWh)	27 MW <sup>4</sup> (68,000 MWh)	5 – 14.5 MW <sup>5</sup> (30,000 – 96,000 MWh / year)	2.4 MW <sup>6</sup> (18,000 MWh / year)	0.5 MW <sup>7</sup> (4,000 MWh / year)	0 MW <sup>8</sup>	0 MW <sup>9</sup>
Risk	First costs; Lack of understandable, comparable information on benefits; Lack of financing vehicles	High first cost; Incentives uncertainty; Land use and utility interconnection (large-scale systems only)	Noise; Aesthetic issues; Land use and ownership; Development of remote areas; Utility interconnection; Raptor mortalities	Air emissions; Ash; Odor; Noise; Ability to source cost-effective feedstocks; Utility interconnection; Loss of soil nutrients; Potential for Habitat disturbance; Carbon-neutrality questioned	Water rights; disruption to water system (turbidity, temperature, habitat); Variable fuel source; Utility interconnection	Ability to cost-effectively source and separate feedstock; Air emissions; Odor; Permits	Lack of resource; Fluid disposal and risk of ground water contamination; Development of pristine areas; Water rights; Zoning; High exploration costs	Low resource potential; Air emissions; Utility interconnection; Permits
Benefit	Displaces need for generation and emissions; Cost savings for utility customers; Various financial incentives; 17 jobs per \$1 million <sup>1</sup>	No air emissions; Carbon neutral during operation; Various incentives; Generates RECs; low cost of operation; 14 jobs per \$1 million	No air emissions; Carbon neutral; Various financial incentives; Generates RECs; 3 jobs per \$1 million	Displaces emissions from open burning; Reduces wildfire risks; Various financial incentives; supports existing industry. Currently generates RECs; 11 jobs per \$1 million	Carbon neutral during operation; Low-impact hydro generates RECs; Various incentives	Generates soil nutrient products; More efficient gas capture compared to landfills; Generates RECs and Carbon Credits; Various incentives	No air emissions; Carbon neutral; Generates RECs; Various incentives	Reduced risk, odor and release of methane (a powerful greenhouse gas); Generates RECs and Carbon Credits
Levelized Cost (\$/MWh)	\$0 - \$106 (average <\$35)	\$90 - \$154	\$44 - \$91	\$65 - \$151	Incremental: \$10 - \$98 Small and Micro: \$57 - \$136	\$36 - \$115	\$42 - \$69	\$50 - \$81
Energy Return	Not available	3 - 6	18 - 34	3 - 27	170 - 280	3 - 20	2 - 13	Not available
Carbon Intensity <sup>2</sup>	Not available	50 – 59 kg CO <sub>2</sub> / MWh	6 – 14 kg CO <sub>2</sub> / MWh	Not available	3 – 23 kg CO <sub>2</sub> / MWh	120 kg CO <sub>2</sub> / MWh	23 – 122 kg CO <sub>2</sub> / MWh	101 kg CO <sub>2</sub> / MWh

RECs = Renewable Energy Certificates

Note 1: Jobs are presented per \$1 million dollars invested in each technology. This analysis was only performed for EE, solar, wind, and biomass. See Appendix A for details.

Note 2: For reference, the Northwest Power Pool (Oregon's regional electricity grid) average carbon intensity is 390 kg CO<sub>2</sub>e / MWh.

<sup>2</sup> These values represent the range of potential over the next 20 years. The point value used in Figure ES-1 represents the mid-point of this range.

<sup>3</sup> This value represents a scenario where 5% of total roof area suitable for solar installations has installations of solar PV panels (assuming current PV panel efficiency).

<sup>4</sup> This value represents the Shale City project described in the wind section of Chapter 6.

<sup>5</sup> This range is based on technically available feedstock estimates. The point value is based on lower end of this estimate and represents electricity generation from currently obtainable feedstock. This feedstock is not currently a cost effective electricity generation resource at \$65 per bone dry ton, but future market conditions may make it viable.

<sup>6</sup> This value represents the potential of electricity generation added to Emigrant Dam and projects found to be feasible in Talent Irrigation district.

<sup>7</sup> This value represents the estimated electricity generation based on the most feasible feedstock sources (food processing, supermarkets, and schools).

<sup>8</sup> No electricity generation resources are available in the study area, but thermal resources are available.

<sup>9</sup> The existing biogas resource is already utilized at Dry Creek Landfill to generate electricity. No other cost-effective resources are available at the closed landfills in the area.

Renewable Energy Assessment for Jackson and Josephine Counties (December 2011)

## 3 PROJECT BACKGROUND

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### 3.1 Description

Rogue Valley Council of Governments in collaboration with Geos Institute, Energy Trust of Oregon, City of Ashland, and Jackson Soil and Water Conservation District contracted with Good Company to conduct a Renewable Energy Assessment (REA) for Jackson and Josephine counties. The purpose of the REA is to review existing renewable energy projects and assess the potential for new renewable energy generation development that can create jobs, increase local energy security, buffer local economies from energy price volatility and reduce fossil fuel dependency, and the associated greenhouse gas and other emissions.

This assessment considers the following power generation technologies:

- Energy efficiency
- Solar electric
- Wind
- Direct-fired biomass
- Landfill gas
- Anaerobic digestion
- Hydroelectric
- Geothermal

This study provides a foundation resource for working groups to plan economic development strategies around renewable energy generation opportunities. The project sponsors plan to convene work groups of local experts on the various technologies as well as those that have an interest in renewable energy development in Jackson and Josephine counties.

### 3.2 Approach

This study combines *existing, publically available research and data* with interviews of state experts on the topic of renewable energy development in Oregon, and more specifically in Jackson and Josephine counties, to assess local potential for resource development opportunities.

This project is broken into four primary tasks:

**Task 1:** Inventory of Existing and Planned Renewable Energy Projects

**Task 2:** Assessment of Future Renewable Energy Technologies Based on Local Conditions

**Task 3:** Further Study of Most Feasible Technologies, Including the Effects on Jobs and the Economy

**Task 4:** In-Depth Feedstock Inventory and Scenario Assessment for Anaerobic Digestion

Task 1 consists of identifying and summarizing the existing renewable energy generation capacity in the study area. The inventory includes all the renewable technologies listed in the project description.

Task 2 considers each of the technologies independently as well as relative to each other and their fit for the communities in the study area. The assessment focuses on electricity generating technologies rather than those that produce thermal energy. Thermal energy production (i.e. solar water heaters, geothermal heat pumps, Combined Heat and Power (CHP), residential / commercial combustion, etc.) is discussed peripherally, but do not get the same focus and detail as electricity generation. The following criteria were used to assess each technology.

**Energy Type:** The renewable energy sources are grouped into three types of generation: baseload, intermittent, and dispatchable.

**Likely Technology:** Renewable electricity generation may have multiple technologies that utilize the same resources. For example, solar electricity may be generated with photovoltaic or solar thermal technologies. Our team chose the most applicable technology for development in Jackson and Josephine counties.

**Risks:** This aspect summarizes the risks associated with each renewable resource. Risks could include negative byproducts such as air or water emissions, impacts to people or habitat, significant regulatory hurdles, costs, and political factors that could affect development.

**Benefits:** This aspect summarizes the benefits associated with each renewable resource. Benefits could include positive byproducts such as displacing carbon emissions, reducing health impacts to people or habitat, reduction in wastes, and financial incentives available to assist in development.

**Levelized Costs:** Measures the cost of generating electricity including initial capital, return on investment, as well as the costs of continuous operation, fuel, and maintenance. The price is normally measured in dollars per megawatt hour.

**Energy Returned on Energy Invested (EROEI):** The ratio of the amount of usable energy acquired from a particular energy resource to the amount of energy expended to obtain that energy resource. When the EROEI of a resource is less than or equal to one, that energy source becomes an "energy sink", and can no longer be used as a primary source of energy.

**Carbon Intensity (CI):** For the purpose of the summary table, carbon intensity describes the life-cycle greenhouse gas emissions (i.e. emissions starting at production of materials through end-of-life disposal of the facility) per unit of electrical output. Carbon intensity is measured in kilograms of carbon dioxide equivalent per kilowatt hour (kg CO<sub>2</sub>e / kWh).

Based on what was learned in Task 1 and Task 2, the technologies were short listed in Task 3 to focus on those most practical for Southern Oregon and to exclude those that could not surmount feasibility thresholds of the aforementioned criteria. The technology categories found to be most practical include the following:

- Energy efficiency
- PV solar
- Biomass
- Hydroelectric
- Anaerobic digestion
- Wind

These technologies received additional study (which varied by technology), but included more detailed estimation of potential, narrowing in on viable sites or vetting findings with local experts. Geothermal energy was excluded for the unlikely availability of the resource, while landfill gas was excluded due to its lack of an available, cost-effective resource.

Task 4 provides an in-depth look at anaerobic digestion. This task began with a feedstock inventory to assess the quantity, quality, and seasonality of regional organic waste feedstock available in the region.

<sup>10</sup> Based on what was learned during the feedstock inventory, feasibility scenarios for building a biogas plant in the region were developed and assessed.

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<sup>10</sup> The study area for anaerobic digestion was expanded to include: Curry, Klamath, Douglas, Siskiyou, Del Norte and Humboldt counties.

### 3.3 Report Structure

The structure of this report from this point forward is as follows:

#### **Section 5: Inventory of Existing Renewable Energy Projects in Jackson and Josephine Counties**

This section summarizes existing renewable energy generation in Jackson and Josephine counties, and describes example projects in each technology category.

#### **Section 6: Feasibility Assessment of Renewable Technologies based on Local Resources**

This section describes the various technology choices within each technology category and the most likely technology based on local resources, estimates the scale of electricity generation, describes the most likely deployment scenarios and/or sites, discusses the barriers and opportunities associated with each technology category and provides information on the carbon intensity, energy returned on energy invested, and levelized cost for each technology.

#### **Bibliography**

Throughout the report you will see abbreviated footnotes (e.g. C-1). These footnotes correspond to the catalog system used in the Bibliography. For each section of the report there is a corresponding table in the Bibliography. The footnotes are used to indicate the table and the reference number of each resource used in this assessment. For example C-1 refers to the 1<sup>st</sup> resource listed in the Context table in the Bibliography.

#### **Appendix A: Jobs and Economic Impacts Analysis**

This section of the report assesses four promising technologies for the Rogue Valley (energy efficiency, solar, wind, and woody biomass) in terms of job creation and local economic impact per \$1 million of investment. This analysis considers these four technologies over their respective life spans in terms of direct impacts from the construction and operation of the project, but also in terms of the economic benefits that results from energy savings or displacement that results from the project.

### 3.4 Other Project Deliverables

This report is the centerpiece deliverable of this project, but is only one of a series of products. This report summarizes the findings of the Renewable Energy Assessment, while the other deliverables focuses on one resource, organic wastes (e.g. food waste, manure, etc.) and one technology group, anaerobic digestion. The deliverables related to anaerobic digestion include the following:

**Biogas Plant Feasibility Study Report:** A detailed report on anaerobic digestion opportunities, which are summarized in Task 5 of this report. This report includes a feedstock inventory and a Scenario Assessment for potential biogas plant locations.

**Biogas Feedstock Inventory Map:** This interactive, updatable Google map presents the findings of the feedstock inventory visually allowing the user to see the geographic relationship between significant sources of feedstock and a potential biogas plant site location.

## 4 PROJECT CONTEXT

### 4.1 History of U.S. Energy Consumption

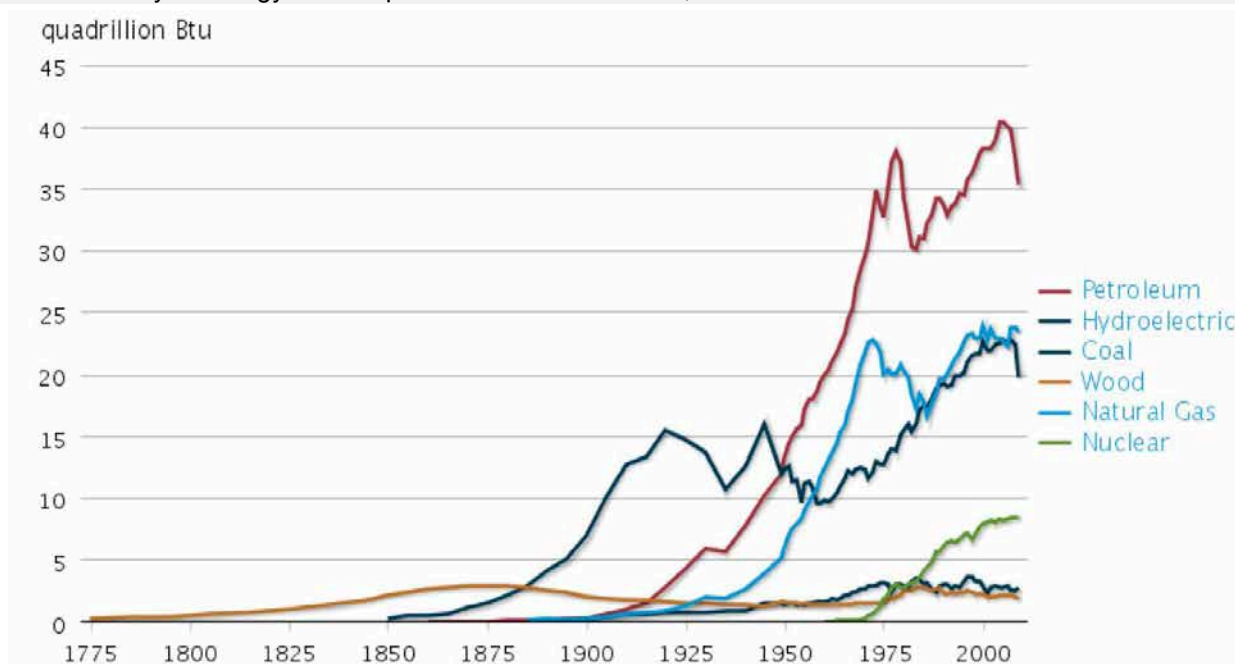
Over the past two centuries, primary source energy in the U.S. has shifted dramatically several times. While our energy use has risen steadily over this time, the composition of the energy economy has changed, driven by opportunities in technology and the economy. Prior to 1800, most all energy used by humankind was from renewable resources.

Figure 1 tells the story of the continual expansion and diversification of several energy sources that together provide electricity, direct heat and transportation. For the half-century after independence, the U.S. economy relied overwhelmingly on wood, followed by animal feed for traction and transportation. In the mid-19<sup>th</sup> century, coal began to climb, passing wood around 1885 as the dominant source and remaining at the top for over fifty years. Petroleum rose quickly as private automobiles became commonplace, taking the top spot around 1950 and holding still today by a large margin. More recent trends have increased the diversity of our energy mix slightly: the rise of natural gas, especially after 1950, and hydropower and nuclear power, for electricity.

The point of considering the history of U.S. energy use is that there is precedent for our economy switching its primary source of energy. We have done it before, and we will do it again.

Today, we are on the verge of another diversification in energy production, one that will likely require substitutes for fossil fuel energy. A number of factors are converging to dictate that alternatives to fossil sources of energy are necessary: energy security, price volatility, climate change, and peak oil. The idea of re-imagining and re-building our energy infrastructure may seem daunting, but it also represents a grand opportunity.

**Figure 1:** History of energy consumption in the United States, 1775 - 2009.



**Source:** Energy Information Administration

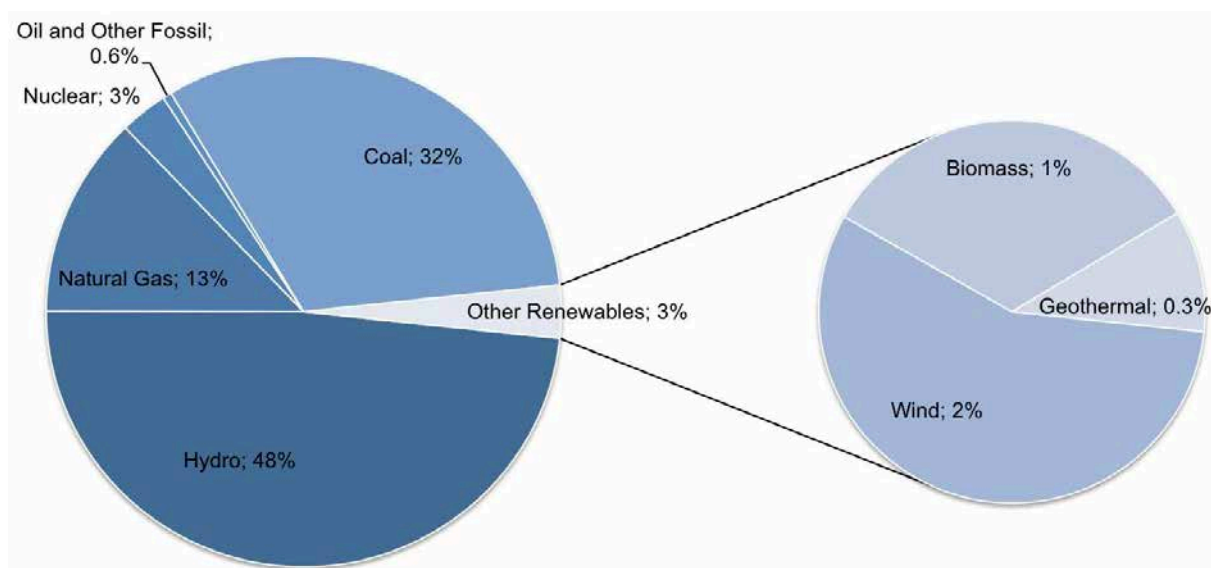
For an interactive version of this graphic visit <http://www.eia.gov/todayinenergy/detail.cfm?id=10>.

## 4.2 Regional Electricity Generation

At any given moment, most utilities either have a surplus or deficit of energy. As a result, electricity is traded across the transmission grid in order to meet these varying demands. In our region, electricity is primarily traded among members of the Northwest Power Pool (NWPP), which includes major generating utilities serving the Northwestern U.S., British Columbia, and Alberta.

Figure 2 below shows the 2007 mix of energy sources for NWPP electricity generation with additional detail for “Other Renewables” (i.e. all renewables except hydro). As you can see, the largest single source of NWPP generation is from hydro (48%) followed by coal (32%), natural gas (13%), nuclear (3%), and renewables other than hydro (3%). As of 2007, wind is the largest non-hydro source of renewable electricity, followed by biomass and geothermal.

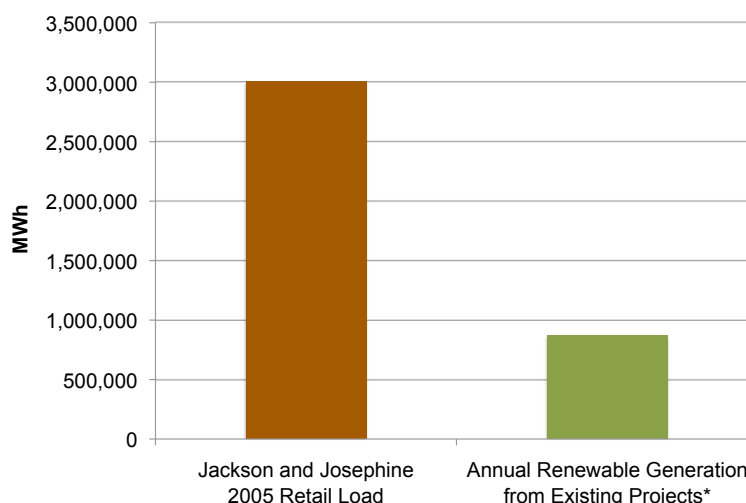
**Figure 2:** 2007 Northwest Power Pool (NWPP) electricity generation fuel mix.



## 4.3 Rogue Valley Electricity Renewable Generation and Consumption

Jackson and Josephine counties generate about 900,000 MWh per year, or about 30% of total consumption of over 3 million megawatt hours (MWh) of electricity (based on 2005 data). While the electricity may be generated in or near the Rogue Valley, that doesn't necessarily mean that it is consumed locally. Once generated the electricity is transmitted via the regional electricity grid. It is also important to note that both the consumption and generation will fluctuate in any given year with a number of factors such as: general economic conditions, seasonality of the resource and the amount of water available to generate hydroelectricity.

**Figure 3:** Retail load compared to existing generation.



## 4.4 General Factors Affecting Renewable Energy Development

A number of factors converge to impact the development of renewable energy development.

- Policy and regulations
- Incentives and Financing
- Price of electricity and other energy sources
- Connection to the electrical grid

These factors are each described in the following sections.

### 4.4.1 Policy and Regulations

#### ***Renewable Portfolio Standards***

Renewable Portfolio Standards (RPS) mandate the development of certain types and amounts of renewable electricity generation.<sup>11</sup> Although an RPS obligates utilities to purchase increasing amounts of renewable resources, it does not require the utilities to sign power purchase agreements at prices that are higher than the utilities' avoided costs. Wind energy generation development in the Northwest has allowed the region's utilities to easily meet their RPS obligations in Oregon and Washington through 2019 without paying significantly higher electric power purchase prices. The combination of decreasing costs for large wind power systems and incentives that offset capital costs has made wind power equivalent to market rate and therefore a common investment.<sup>12</sup>

The Oregon RPS was enacted in 2007 through Senate Bill 838 (ORS 469A).<sup>13</sup> The bill directs Oregon utilities to meet a percentage of their retail electricity needs with qualified renewable resources. For Oregon's two largest utilities (Portland General Electric and PacifiCorp) the standard starts at 5% in 2011, increases to 15% in 2015, 20% in 2020, and 25% in 2025. Smaller electric utilities in the state have standards of 5% or 10% in 2025.

Eligible resources include biomass, geothermal, hydropower, ocean thermal, solar, tidal, wave, wind, municipal solid waste (MSW), and hydrogen (if produced from any of these sources). Biomass and hydropower resource facilities built before 1995 are not eligible to be counted towards Oregon RPS requirements. Some solar projects may receive a Renewable Energy Certificate (REC) with double value to an Oregon investor-owned utility. In addition to contract purchasing of renewable resources with or without the REC cost attached, utilities may meet the requirements of the RPS by purchasing just the RECs unbundled from other renewable resources inside or outside of their service territory. Renewable Energy Certificates can be banked by utilities for meeting obligations in future years for Renewable Portfolio Standards.

Pacific Power has stated that its purchase of bundled renewable electricity generation in the past three years enables it to meet its Renewable Portfolio Standard (RPS) for Oregon through 2019, which reduces its interest in purchasing bundled Renewable Energy Certificates (RECs) through its standard purchase contracts. Although Pacific Power's renewable resource portfolio, on record with the Oregon Public Utility Commission shows that nearly all of its renewable resource requirements under the RPS through 2019 are met by current resources, the displayed portfolio does not include recent additions to Pacific Power's portfolio or those renewable resources still under development (e.g. 1.3 MW at Rough-N-Ready, 9 MW at Douglas County Forest Products and others). All indications are that the 2012 updates to Pacific Power's portfolio will result in its RPS requirements being met through 2026.

The result of Pacific Power being long on RECs means the primary market for the RECs generated by new renewable energy projects is in the secondary, voluntary market rather than in Oregon's RPS

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<sup>11</sup> CI-10

<sup>12</sup> For current information regarding state renewable portfolio standards see [www.dsireusa.org](http://www.dsireusa.org).

<sup>13</sup> CI-11 and CI-12

compliance market. In Oregon, notable purchasers of RECs from renewable projects include Bonneville Environmental Foundation and The Climate Trust (formerly known as the Oregon Climate Trust).

## ***State and Regional Regulation of Greenhouse Gas Emissions***

There is only one regulation in Oregon that places economic requirements on greenhouse gas emissions activities. The Oregon Department of Energy: Energy Facility Siting regulations require new fossil fuel electric generation in the state to be 10% more efficient than the most recent class of combined cycle natural gas power plants included in the facilities heat rate. Developers of those power plants may either directly sequester or offset an equivalent amount of carbon dioxide emissions to comply with that efficiency requirement. Most take a monetary path and pay The Climate Trust to acquire and register the sequestration and/or offsets. There are no other regulations capping or taxing greenhouse gas emissions in Oregon or nationally and most greenhouse gas-emitting activities do not bear a “cost of carbon” either directly or indirectly as a result of policy. However, there is a patchwork of relevant regulations, as well as significant activity in California, and this context warrants a brief review.

### GHG Reporting

Oregon Department of Environmental Quality (ODEQ) currently has an operating greenhouse gas reporting system. Oregon rules require utilities and large industrial facilities to report their annual greenhouse gas emissions to ODEQ using ODEQ-approved protocols.

Facilities required to report greenhouse gas emissions to ODEQ include:

- Facilities emitting 2,500 metric tons or more of carbon dioxide equivalent during a year, including
  - Air quality permit holders (in Oregon's ACDP and Title V programs)
  - Landfills
  - Wastewater treatment facilities
- Gasoline, diesel and aircraft fuel distributors (*protocols not yet approved*)
- Propane wholesalers
- Natural gas suppliers
- Investor-owned utilities and electricity service suppliers
- Consumer-owned utilities

### Low Carbon Fuel Standard

The State of Oregon is in the process of adopting the legislated Low Carbon Fuel Standard (LCFS), which is modeled on a similar standard implemented by the State of California. The goal of Oregon's LCFS is to reduce the average carbon intensity of the mix of transportation fuels used in Oregon by 10% over a 10-year period. Oregon's LCFS does not mandate the use of any specific fuel. Instead, fuel importers and distributors can use a mix of traditional fuels and lower carbon alternative fuels to meet the standards. As the standard tightens over time, fuel suppliers and distributors will need to increase the use of lower carbon fuels. Producers of low carbon fuels can also generate credits that fuel suppliers or distributors could trade to meet their obligations under the program.

When currently promulgated administrative rules are adopted by the Oregon Environmental Quality Commission, Oregon's LCFS will create a market where low-carbon fuels will be sold at a premium to fuel suppliers and distributors to meet the standard's goals. Currently, there is no information available from which to estimate the value of low-carbon fuel credits<sup>14</sup> sold in this marketplace, but it is recommended that project developers monitor Oregon's low carbon standard and evaluate the potential for development of renewable liquid transportation fuel alternatives in the near future.

### AB32

California's Global Warming Solutions Act of 2006 – known as AB 32, its legislative title – will, when fully implemented in 2013, be the second largest carbon cap-and-trade system in the world, behind the European Union's Emissions Trading Scheme (EU ETS). Due to the size of California's population and

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<sup>14</sup> Both Oregon and California program reports were reviewed for estimates of credit pricing. Neither contained this information. Renewable Energy Assessment for Jackson and Josephine Counties (December 2011)

economy, as well as its proximity to Oregon, AB 32 will affect energy markets, resource costs, and technology availability here.

### Western Climate Initiative

One of the potential impacts of AB 32 is its ability to affect regional participation in the Western Climate Initiative. The Western Climate Initiative is a collaboration among several western states and Canadian provinces to develop market-based mechanisms to reduce regional greenhouse gases to 15% below 2005 levels by 2020. One of those mechanisms is a regional cap-and-trade program that allows capped entities in individual jurisdictions to trade emissions allowances with capped entities in other WCI jurisdictions to meet the goals for the emissions cap.

The WCI is an attempt to develop a regional strategy in the absence of regional or a national authority. WCI will be realized by individual states simultaneously passing and implementing enabling legislation. To date, California, New Mexico and three Canadian provinces have passed legislation enabling those jurisdictions to participate in the regional system starting in 2012. However, it is uncertain if New Mexico will continue to pursue implementation—currently the state's Environmental Improvement Board is considering a petition to repeal the state's cap-and-trade program. Oregon has tried and failed to pass the carbon cap-and-trade enabling legislation.

Setting the pace of implementation aside, WCI remains relevant because of the efforts in California in support of AB 32. The current administrative development, in preparation for the implementation of AB32 in 2013, will serve as a model and guidance for other states (like Oregon) that re-commit to WCI and pursue its requirements. The California administrative model will make it easier for other states to participate, which may result in a pathway of support for WCI in the future in absence of a federal regulation or program(s). This possible future has precedent in the past example of California's vehicle tailpipe emissions standards becoming national standard 10 years after implementation in California.

Once implemented, AB 32 (and WCI) would put a market price on a ton of carbon dioxide (and its equivalence for other gases) to be paid directly by industries with large-scale emissions, and indirectly by the public through the supply chain, creating demand for emissions reduction investment and carbon dioxide sequestration.

## ***Federal Mandates and Regulations***

### Reporting

In 2009, Rule 40 CFR part 98 established a federal Greenhouse Gas Reporting Program. This program requires annual GHG reporting from fossil fuel suppliers, industrial gas suppliers, and facilities that inject CO<sub>2</sub> into the ground, both for sequestration and other purposes, at levels above 25,000 MT CO<sub>2</sub>e per year. The program is estimated to cover 85-90% of U.S. GHG emissions from 13,000 facilities. The first deadline for reporting was September 20, 2011 for 2010 activities.

### Cap-and-trade

There have been a few attempts to establish a federal emissions cap-and-trade structure similar to the system in Europe. The Waxman-Markey bill (American Clean Energy and Security Act) of 2009 saw the greatest support. It was approved by the House of Representatives, but failed to pass in the Senate. In 2010, the Kerry-Boxer bill (Clean Energy Jobs and American Power Act), followed by the Kerry-Lieberman bill (American Power Act) were also defeated. Since the failure of these bills, the concept of cap-and-trade has been replaced with other strategies to reduce GHG emissions, such as support for increased efficiency and renewable energy development.

### Renewable Fuel Standard

A functioning Renewable Fuel Standard (RFS) already exists at the Federal level. The RFS program was created under the Energy Policy Act (EPA) of 2005 and established the first renewable fuel volume mandate in the United States. Under this program biogas (as is generated by landfills or anaerobic

digesters) used as a transportation fuel alternative is considered an advanced biofuel or one that has life-cycle greenhouse gas emissions that are at least 50% less than the baseline conventional fuel.

## 4.4.2 Incentives

### ***Federal Tax Incentives***

#### Production Tax Credit

Since 2004, renewable energy projects have been able to claim a Section 45 Production Tax Credit (PTC) of \$0.015 cents per kilowatt-hour (kWh) against federal income tax liability for the first 10 years of a project's production, with the credit amount escalating with general inflation.<sup>15</sup> The credit can be used in a consolidated return and the unused portion carried forward for up to 20 years.

#### Accelerated Depreciation

Renewable resource projects qualify for the Modified Accelerated Cost Recovery System (MACRS) depreciation tax treatment.<sup>16</sup> Under MACRS, the asset investment cost is depreciated in five years for most energy properties.

### ***State Tax Incentives***

#### Business Energy Tax Credit (BETC)

Since 1984, the BETC credit has provided a tax credit of up to 35% of the cost of energy efficiency projects and renewable resources. Since 2007 the amount of the credit for renewable resources has been 50%. It is scheduled to sunset January 1, 2012.<sup>17</sup>

#### HB 3672 (enacted into law July 2011)

HB 3672 restructures tax credit programs for energy efficiency and renewable resources administered by the Oregon Department of Energy. This bill allows for the sunset of the BETC program, adds new energy conservation and renewable energy tax credits, and amends the residential energy tax credit and biomass producer and collector tax credit.

#### *Renewable Energy Development*

A new tax credit program operated by the Oregon Department of Energy (ODOE) will be funded by an auction of tax credits that will, in turn, fund incentives for the program. The Oregon Administrative Rules (OARs) have not been developed for this incentive as of this writing. The terms of the auction, competitiveness criteria and system performance standards have not been published. The results of the initial auction will be reported by February 15, 2012.

- All awarded applications will be performance-based grants as opposed to capital cost based.
- The total program is limited to \$1.5 million per year and each application may not exceed 35% of project costs or \$250,000, whichever is lower.
- Other government grants or incentives cannot account for more than 75% of the total project costs.

#### *Energy Conservation Projects*

This new tax credit program for efficiency will be more like the previous business tax credits

- Program will have \$28 million per biennium in credit amount
- Covers up to 35% of eligible costs or \$3.5 million maximum eligible cost
- Tax credit taken over 5 years

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<sup>15</sup>CI-7

<sup>16</sup>CI-20

<sup>17</sup>CI-17

- Project must have a simple payback over 3 years
- Pass-through option will be available
- Pre-certifications are eligible for 3 years
- Cogeneration (i.e. combined heat and power) sites will be eligible after January 1, 2013

### ***Utility Incentives***

The Energy Trust of Oregon collects a public purpose charge from the customers of Pacific Power, Portland General Electric, NW Natural Gas, and Cascade Natural Gas. The monies are used within the service territories of the respective utilities to support energy efficiency and, to a lesser extent, renewable energy projects. In 2012 Energy Trust expects to collect \$150 million dollars, of which nearly \$18 million will be available for renewable energy projects. Of that total approximately \$6 million will be available for renewable energy projects delivering energy to Pacific Power's service territory.

In the past, Energy Trust periodically held solicitations for renewable energy projects seeking support, including solicitations specifically for biomass projects. At least three biomass projects received this type of funding. Currently, Energy Trust has an open application process.

Energy Trust provides incentives to pay for a percentage of the "above market costs" of renewable energy projects - buying down the incremental cost that is a deterrent to business and homeowner investment for return on investment decision thresholds. The funding is designed to allow the project to reach a minimum acceptable return to the developers that could not be obtained simply through net metering benefits or power and other energy byproduct revenues. Projects funded through this mechanism in the Jackson and Josephine county region include the Dry Creek landfill, Rough and Ready biomass facility, and numerous solar photovoltaic projects. Pending projects include additional solar photovoltaic installations and the expansion of biogas recovery at the Medford Wastewater Treatment facility. In exchange for this funding, Energy Trust takes a portion of a project's RECs for the life of the project, and retires those tags for RPS use on behalf of the utility customers it serves.

### ***Financing Programs***

#### **State Energy Loan Program (SELP)**

SELP is a fixed rate, low interest, fixed term loan for energy efficiency and renewable energy development projects administered by the Oregon Department of Energy (ODOE).<sup>18</sup> The state periodically sells bonds in order to finance renewable energy development, and will typically consolidate several loan requests into a single bond offering.

To date, individual SELP loans have not exceeded \$20 million, though there is no statutory limit on loan amounts. The length of the loan cannot exceed the expected life of the project and rarely exceed 15 years. Equity requirements are mandatory, and are typically around 20% of total project cost. A late 2011 ODOE bond revealed that an upcoming sale is expected to yield a loan interest rate of 7%. Other local authorities that are able to conduct bond or other incentive-based financing and may provide competitive interest rates and terms include: individual counties, Farm Credit, and Private Lenders using federal New Markets Tax Credits.

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<sup>18</sup>CI-18

## U.S. Department of Agriculture Grants and Loan Guarantees

The U.S. Department of Agriculture has numerous small grant and loan guarantee programs for rural renewable energy projects. The Rural Energy for America Program (REAP) and Value Added Producer grants fund feasibility studies and projects.<sup>19</sup> USDA grants typically can fund up to 40% of the project cost, not to exceed amounts of \$100,000 per project. Federal loan guarantees can also be obtained for up to \$10 million, and in limited cases up to \$25 million. The USDA REAP is funded through 2012 and applies to small rural businesses as well as agricultural producers.

### 4.4.3 Price of Electricity

Electric demand in Oregon is expected to continue to rise predominantly due to continued increases in population. Oregon's Office of Economic Analysis reports roughly 3.8 million Oregon residents in 2009, a number which is predicted to grow to 4.4 million over the next 10 years. In fact, planning efforts are taking place in the form of a Regional Problem Solving project designed to prepare the Bear Creek Valley for the potential doubling of population in the next 50 years.<sup>20</sup>

The Northwest Power and Conservation Council's Sixth Northwest Power Plan (the plan for the entire northwest region) and Pacific Power's Integrated Resource Plan (the largest local utility's plan) both forecast electric load growth in Oregon and across the Pacific Northwest over the next ten years. See Figure 4 for the estimate from the 6<sup>th</sup> Power Plan. Although some local economic factors may cause load growth in Jackson and Josephine County to differ from the regional forecast, population predictions in those counties indicate that load growth may track closely with the Power Council's forecast.

**Figure 4:** Sixth Northwest Power Plan forecast of Oregon's retail load, by economic sector and load type.

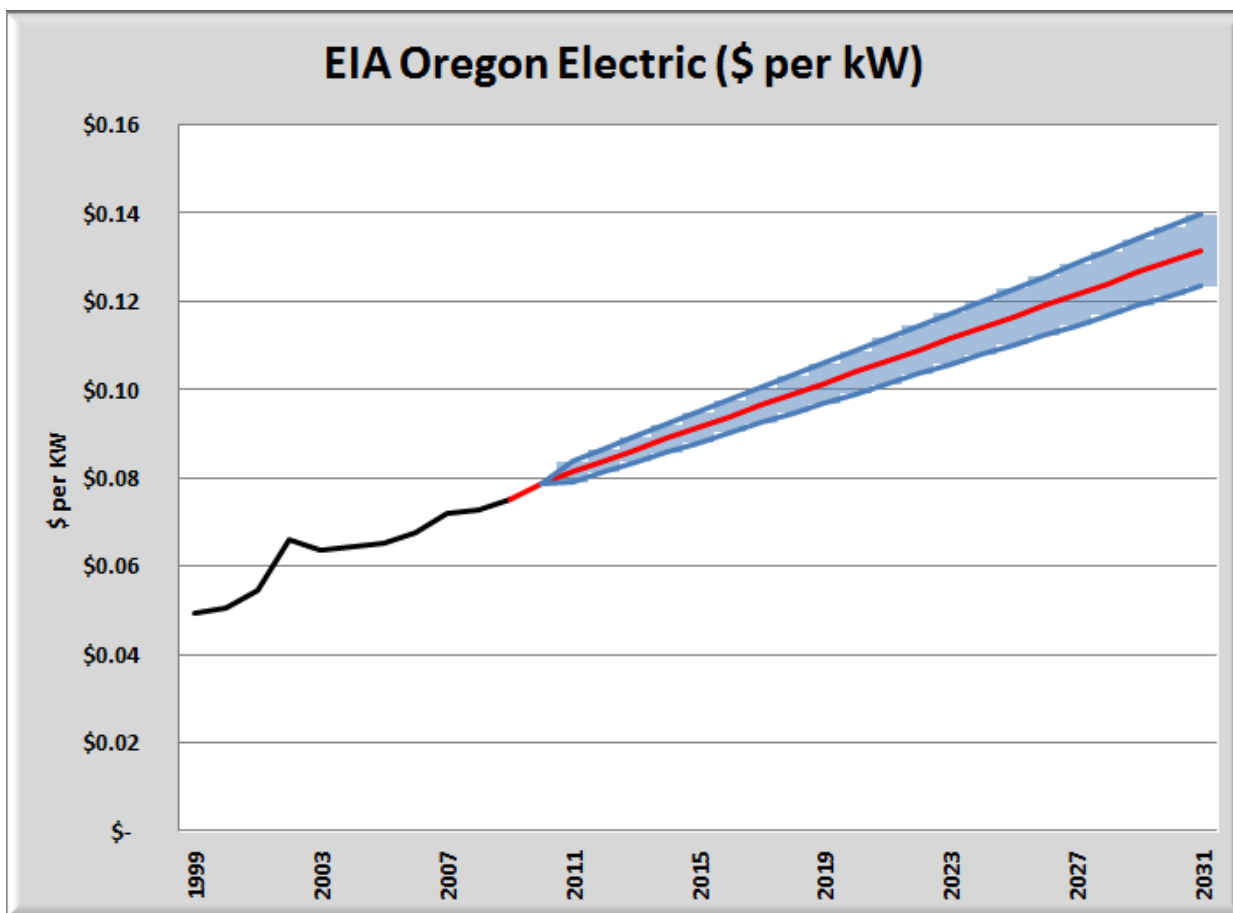
Oregon Retail Sales – Gigawatt-hours (GWh)							
Year	Residential	Commercial	Industrial	Irrigation	Lighting	Other	Total
2011	5,624	5,142	2,298	266	38	0	13,368
2012	5,672	5,399	2,324	282	38	0	13,715
2013	5,573	5,490	2,367	283	38	0	13,750
2014	5,563	5,526	2,368	283	38	0	13,778
2015	5,570	5,557	2,355	283	38	0	13,803
2016	5,612	5,603	2,350	283	38	0	13,886
2017	5,610	5,616	2,325	283	38	0	13,872
2018	5,641	5,647	2,310	283	38	0	13,920
2019	5,675	5,677	2,299	283	38	0	13,971
2020	5,705	5,720	2,297	283	38	0	14,043
Average Annual Growth Rate							
2011-20	0.2%	1.2%	(0.0)%	0.7%	0.0%	-	0.5%

Figure 5 shows a forecast of electric energy rate trends based on a statistical analysis of Energy Information Administration's (EIA) published average retail electricity costs for Oregon. Based on analysis performed by Kendall Energy Consulting, the average Oregon retail electric prices will reach \$0.10 per kWh or \$100 per MWh by 2019 (as compared to a rate of \$0.075 for April 2011). This may prove to be an important threshold, increasing investment in certain energy efficiency or renewable resource technologies.

<sup>19</sup> CI-21

<sup>20</sup> For more information see the City of Medford's website at <http://www.ci.medford.or.us/page.asp?navid=874>.  
Renewable Energy Assessment for Jackson and Josephine Counties (December 2011)

**Figure 5:** Forecast of average Oregon electricity prices, based on EIA price data.



At \$100 per MWh retail price, more energy efficiency and renewable resource opportunities become cost competitive with other projects. For example, a solar photovoltaic system of 2 kilowatts installed on a home in Jackson or Josephine counties will produce roughly 3,500 kWh of energy per year. The cost of the system, at \$6 per watt, is about \$12,000. The ETO provides an incentive of up to \$2 per watt and state and federal tax credits provide up to \$6,000 of incentives reducing the PV system cost to \$2,000. The energy cost savings resulting from the 3,500 kilowatt hours of net metering at current electric retail price of \$0.07 is \$245, resulting in simple payback after tax credits of 8.2 years.

Solar PV system costs are decreasing due to economies of scale as demand increases and technology advances. The Energy Trust of Oregon estimates solar PV cost for polycrystalline systems to be \$4 per watt installed by 2020. Under the aforementioned scenario, a PV system net cost could be some \$1,500 with the phase out of federal tax incentives and the annual savings would be \$350 yielding a 4.3 simple payback or over 20% rate of return. Similar cost and benefit characteristics are emerging in light emitting diodes, heat pump water heaters, and other energy efficient technologies.

### **Utility Avoided Costs**

Utility “avoided costs” are the cost the utility would pay on the open market for its next newly generated kilowatt-hour of electricity. A renewable resource electricity generating project of over 100 kilowatts in capacity may sell its power to an investor-owned electric utility at the same rate the utility pays for other electricity on the market, which is referred to as avoided cost. Avoided cost rates for Pacific Power are determined by the Oregon Public Utility Commission and are awarded to electric generators for on-peak and off-peak hours. Weekday electricity production between 6 AM and 6 PM earns the on-peak rate and the remaining weekday and weekend hours earn the off-peak rate.

Figure 6 shows Pacific Power's avoided cost rates in cents per kilowatt hour for renewable resource facilities generating less than 10,000 kilowatts (10 MW). Notice that the avoided cost crosses over \$0.07 per kWh or \$70 per MWh in 2014. Even though the utilities buy power at higher cost based upon the time of day and regional electric demand, customers currently do not see these time-of-day price fluctuations. Instead customers pay an average rate. Avoided costs are important because they dictate the threshold at which an energy project is economically viable. For example, if the levelized cost of a project is greater than \$0.0587 / kWh or \$59 per MWh, it is likely not viable in 2012, but may become so as the avoided costs rise over time.

**Figure 6:** Pacific Power avoided cost schedule (¢/ kWh).

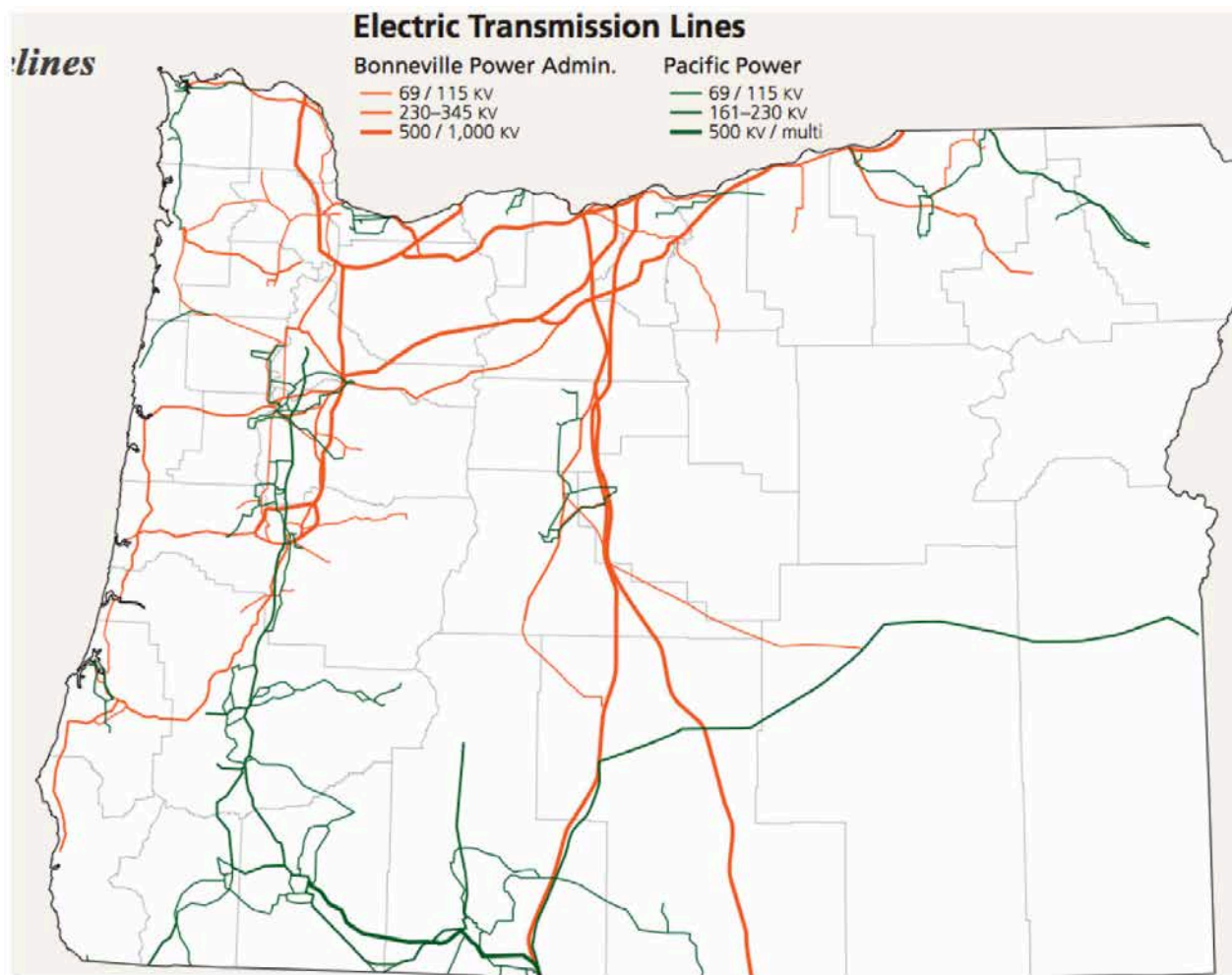
Deliveries During Calendar Year	On-Peak Energy Price	Off-Peak Energy Price
	(a)	(b)
2010	5.12	3.95
2011	5.51	4.21
2012	5.87	4.36
2013	6.14	4.50
2014	7.96	6.10
2015	8.16	6.27
2016	8.39	6.46
2017	8.60	6.65
2018	8.87	6.87
2019	8.76	6.74
2020	8.85	6.79
2021	9.33	7.23
2022	9.84	7.70
2023	9.33	7.15
2024	9.03	6.81
2025	9.47	7.22
2026	9.65	7.36
2027	9.68	7.35
2028	10.04	7.67

#### 4.4.4 Interconnection to the Electricity Grid

Pacific Power and Bonneville Power Administration (BPA) provide electric power transmission of 69, 115, 230, and 500 kilovolt (kV) capacities to Southwestern Oregon. Pacific Power owns and operates all the predominant electric transmission and distribution lines in Jackson and Josephine counties. See Figure 7 for a map of this infrastructure. Based on the existing electricity distribution and transmission system, there is ample capacity to accommodate up to 100 megawatts of new distributed generation in Jackson and Josephine counties in the near to mid term.

Pacific Power is currently upgrading various short distance 69 kV capacity distribution lines to 115 kV serving loads and power producers in the Southern Umpqua, Rogue, and Applegate Valleys in order to carry additional capacity, upgrade old distribution infrastructure, and improve reliability. The implication of these improvements for renewable resource development in Jackson County, and to a lesser degree Josephine County, is that more capacity will be able to be added in the future and that renewable resources may be transmitted to other markets (wheel) with lower line losses.

**Figure 7:** Pacific Power and BPA transmission lines in Oregon.



To date, no Oregon renewable resources in Jackson and Josephine counties wheel resources into higher value markets such as California. A minimum of 10 megawatts of continuous baseload capacity is required for such transactions. As power purchase contracts with Pacific Power expire (e.g. Biomass One 02/2012), local electricity generators may have the opportunity to compete in other markets (Pacific Gas & Electric, Sacramento Municipal Utility District and Southern California Edison) offering higher prices for renewable electricity. Pacific Power is planning a new interconnection of Wyoming, Utah, Idaho, and Eastern Oregon with a 500 kV transmission line, which may provide access to additional markets. The expected time frame of this new line is between 2015 and 2019.

One implication of transmission line upgrades for existing renewable resource projects is that *transformers will require upgrading at a cost to the generator*. New additions to the distribution line will have to meet the interconnection standards for that line at a higher cost than for existing lower capacity lines. Smaller, distributed sources of electricity generation (such as residential solar PV systems) that interconnect with Pacific Power on distribution lines will see no changes in their operations or cost.

#### 4.4.5 Context Summary

While it may appear that the business variables are simply too dynamic and uncertain to engage a renewable energy generation strategy, these “moving pieces” represent the industry preparing to accommodate a large expansion of the low-carbon economy.

In summary, here are some of the key take-aways from this section.

- **Connection to the electrical grid:** In general, existing line capacity will meet near- to mid-term capacity additions. Pacific Power is planning upgrades that will provide access to other markets. For utility scale projects, interconnection studies, and upgrades to the local transmissions lines are required at the generator’s expense.
- **Financing:** Traditional finance models exist for energy production and industrial systems, as well as low-interest debt financing options are available at various levels of government. Complexity is added given the ever-changing incentives and policies and the general move towards decentralization of the grid.
- **Incentives:** Given that all of the benefits of energy production (generally) are shared throughout society, incentives will remain a part of the renewable energy picture – albeit ad hoc and at the whim of politics. Government has been and likely will continue to be a force in the upgrade of energy infrastructure as it has been with highways, rail, water systems and wastewater.
- **Policy and regulations:** Currently there is no overarching cap on carbon emissions in the U.S. However, in nearly every state and in nearly every energy-intense industry, mandatory reporting and rules designed to reduce the carbon intensity of energy production are proliferating. In addition, policy mechanisms are being used to encourage investment in energy efficiency and renewable resource development. These types of policies will likely be expanded and added to over time.
- **Price of electricity:** While the prices are temporarily low due to lower economic activity, consumption is generally rising with an ever-increasing population.

## 5 EXISTING REWABLE ENERGY PROJECTS

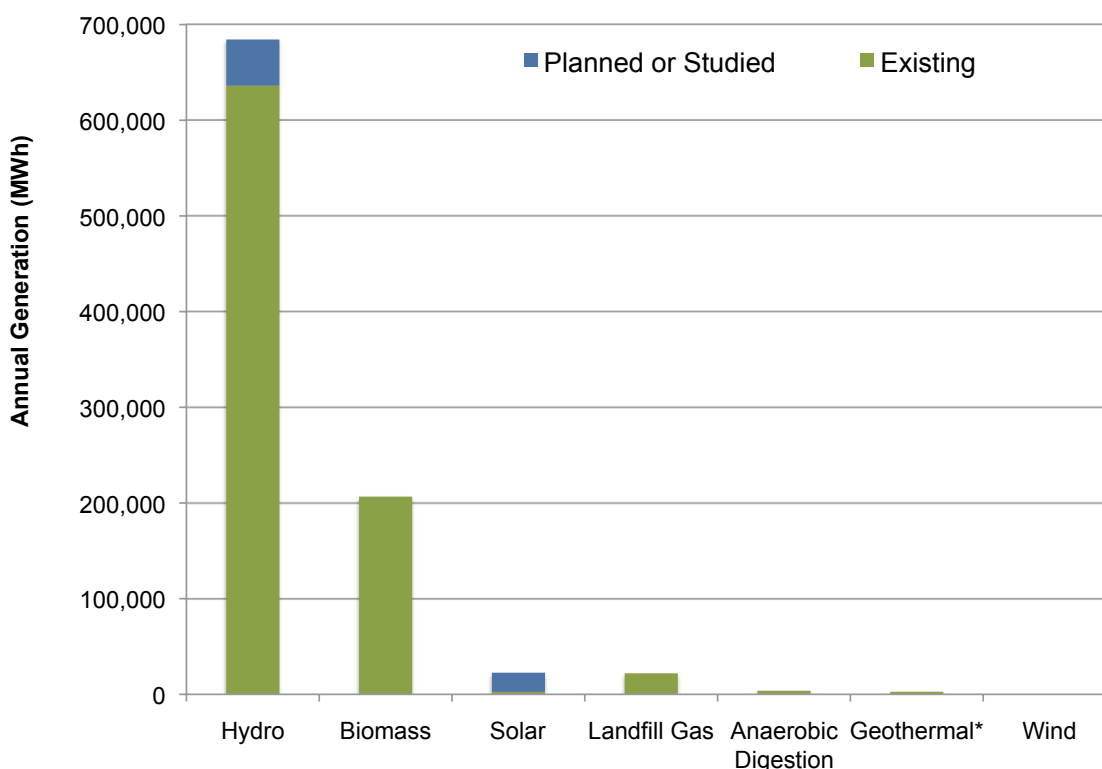
### 5.1 Summary of Existing Projects

The first task in this assessment inventoried the existing renewable energy generation sources in Jackson and Josephine counties. See Figures 8 and 9 for the summary graphic and table. The greatest differentiation amongst generation types is the scale of nameplate capacity and the annual quantity of electricity generation.

Hydroelectric power is the dominant renewable generation source in the region, representing 73% of the total renewable electricity generation per year, or about 630,000 megawatt hours (MWh) of existing generation. The second largest generation source is biomass, which represents 24% of the existing generation or more than 200,000 MWh. This is followed by landfill gas-to-energy, which represents 3% of the total or about 20,000 MWh. Finally smaller contributions (<1%) come from anaerobic digestion, solar PV, geothermal, and wind.

Projects currently in the planning or study phase include hydro and a large (8 MW) solar PV installation. After these additions, the dominant resource is still hydro, making up 79% of the total planned and studied generation or about 50,000 MWh per year. Two planned solar projects make up the remaining 21% or about 13,000 MWh per year.

**Figure 8:** Summary graphic of existing and planned or studied renewable energy projects



\*Geothermal use in the area is thermal only. The bar represents the electricity generation equivalent of the thermal energy.

Figure 9 presents the similar information as Figure 8, but in tabular form and with great detail including location, service year, maximum rated capacity, annual electricity generation (in MWh) and percent of total generation. It is important to note that the generation values reported in Figure 9 are based on either an average of multiple years or a single value (depending on the information publically available), but in either case these values are subject to significant change depending on a number of variables including: electricity market supply and prices, available fuel, downtime for maintenance, etc.

Renewable Energy Assessment for Jackson and Josephine Counties (December 2011)

**Figure 9:** Summary of existing, planned or studied renewable energy projects in Jackson and Josephine counties.

Technology	Project Name	Location	In-Service Year	Nameplate Capacity (MW)	Annual Generation (MWh)	Percent of Total Generation
Hydro	Lost Creek	Near McLeod	1977	49.0	236,809	25.7%
	Prospect 1	Near Prospect	1912	3.8	313,979	34.0%
	Prospect 2	Near Prospect	1928	40.0		
	Prospect 3	Near Prospect	1932	7.2		
	Prospect 4	Near Prospect	1944	1.0		
	Green Springs	Talent	1960	17.3	64,031	6.9%
	Eagle Point	Neat Eagle Point	1957	2.8	16,604	1.8%
	Nichols Gap	Near Nichols Gap	Not available	0.9	3,154	0.3%
	Reeder Reservoir	Ashland	Not available	0.5	1,682	0.2%
	Applegate hydro	Applegate lake.	Planned	10.0	44,300	4.8%
	Grants Pass Municipal Water	Grants Pass	Study	Not available	Not available	
	Medford Water Commission	Medford	Study	Not available	Not available	
Biomass	Talent Irrigation District	Talent	Study	0.6	3,835	0.4%
	Biomass One	White City	1985	30.0	177,002	19.2%
	Boise Building Solutions Manufacturer*	Medford	1956	8.5	19,639	2.1%
	Rough and Ready Lumber	Cave Junction	2008	1.5	10,000	1.1%
	Aggregated boilers for small-scale thermal load	Varies	Varies	Not available	Not available	
Solar	Aggregated net-metered projects in study area	Throughout Region	Varies	2.1	2,730	0.3%
	Medford Reg. Water Reclamation Fac.	Medford	Planned	2.0	2,600	0.3%
	Medford International Airport Solar Park	Medford	Planned	7.9	17,352	1.9%
	Jackson Wellsprings	Ashland	Not available	0.3	1,400	0.2%
Geothermal*	Lithia Resort	Ashland	Not available	0.2	1,300	0.1%
Wind	Aggregated net-metered projects in study area	Varies	Varies	0.03	Not available	
Landfill Gas	Dry Creek Landfill Gas to Energy Project	Eagle Point	2007	3.2	21,972	2.4%
Anaerobic Digestion	Medford Sewage Treatment Plant	Central Point	Not available	0.7	3,775	0.4%
Subtotal Existing (MWh):						
Subtotal Planned (MWh):						
Total (MWh):						
*Nameplate capacity and generation in MW equivalent.						
*Anecdotal information suggests that Boise Building Solutions is not longer generating electricity and cannot do so without equipment upgrades.						

## 5.2 Energy Efficiency and Conservation

Past energy efficiency and conservation efforts have made a significant contribution to reducing electricity demand in the Northwest, Oregon, and the Rogue Valley. Energy Efficiency is not like the other resources considered in this assessment in that energy efficiency saves electricity instead of generating it, but is included in this assessment because of its low cost and enormous potential.

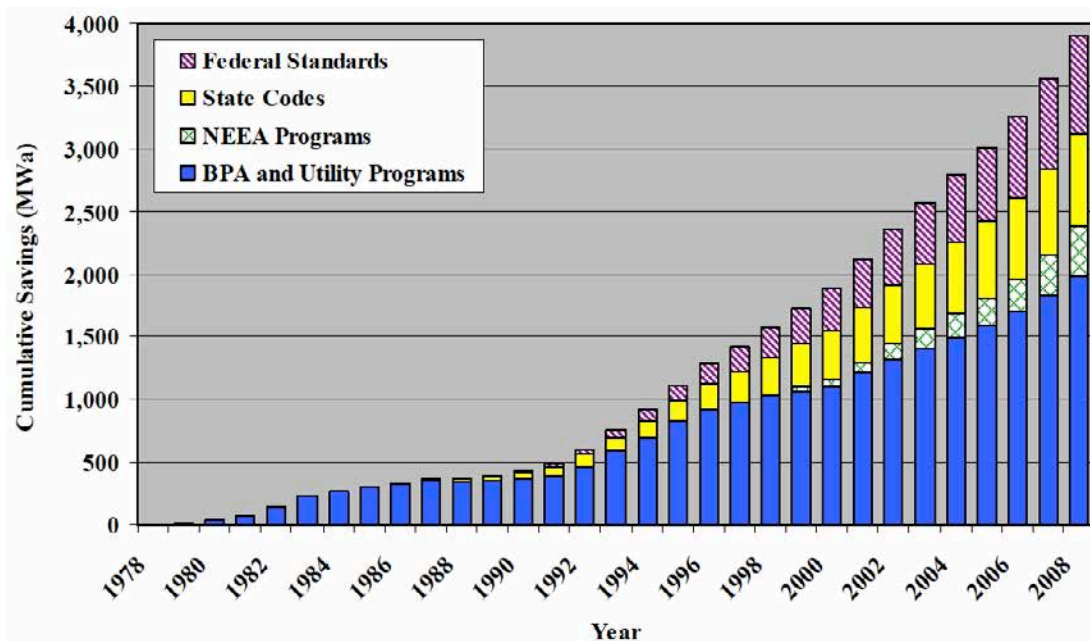
There is no publically available data source that quantifies the aggregate energy savings to date for Jackson and Josephine counties, but there are a number of data sources that estimate the scale of savings in the region that can then be used to extrapolate and estimate savings for the area.

At a regional level, the Northwest Power and Planning Council (NWPPC), summarize the savings through 2008 with the following points:

- Regional energy efficiency savings are equivalent to about 4,000 average megawatts (aMW). Expressed as generated electricity, that is enough to power all of the state of Idaho and Western Montana all year, with enough left over to meet the needs of a city the size of Eugene, or 8-10 new coal or gas-fired generating plants.
- Because consumers didn't have to buy 4,000 aMW of electricity in 2008, they paid \$1.8 billion less for electricity — even after accounting for the cost of energy-efficiency programs
- Since 1980, half of the growth in electricity use in the Northwest has been met with efficiency.
- The types of energy efficiency projects used to deliver those savings include weatherization (insulation, windows), improved efficiency in commercial lighting, improved irrigation efficiency (fewer leaks, more efficient pumps, lower water pressure), industrial motors, and retrofitting residential lighting (particularly the installation of compact fluorescent bulbs).

The annual savings described in the NWPPC summary points are presented on Figure 10, by energy efficiency program. As can be seen, the largest savings between 1980 and 2008 are the result of Bonneville Power Administration (BPS) and utility programs, which significant contributions resulting from Federal Standards and State Energy Codes. Finally a smaller, but rapidly growing, contribution is made by Northwest Energy Efficiency Alliance (NEEA) programs since 2000.

**Figure 10:** Cumulative energy savings from efficiency programs in the Northwest from 1978 - 2008



**Source:** Northwest Power and Conservation Council – 6th Northwest Power Plan

Pacific Power is the primary utility that serves Jackson and Josephine counties, as well as other nearby regions including northern California, other locations in Oregon, and Washington. Figure 11 shows the scale of energy efficiency efforts made in Pacific Power's service territory from 2002 through 2008. According to the Energy Trust of Oregon's 2008 annual report, Pacific Power completed 8,650 energy efficiency projects in 2008 and over 59,000 between 2002 and 2008. In 2008, the average cost for a project was about \$200 for the residential sector, \$4,300 for the commercial sector and \$10,500 for the industrial sector. The average cost of a project is dependent on the type of project and the equipment and labor required. For example, compact florescent light bulbs (CFL) cost less than \$2 per bulb while weatherization projects can cost thousands of dollars. Cumulatively the energy savings from these projects totaled over 15 aMW in 2008 and over 80aMW between 2002 and 2008.<sup>21</sup>

Based on the values in Figure 11 it is estimated that 1.5 aMW were saved in the Rogue Valley service territory in 2008 and 8 aMW between 2002 and 2008.<sup>22</sup>

**Figure 11:** Pacific Power renewable energy and energy efficiency projects and incentives

Incentives per Pacific Power project				
	2007		2008*	
	Pacific Power Projects	\$/Project	Pacific Power Projects	\$/Project
Residential	10,466	\$211	8,270	\$198
CFLs	366,874	\$2	325,196	\$2
Commercial	420	\$4,074	278	\$4,301
Industrial	126	\$25,879	102	\$10,519
Renewable	141	\$6,835	96	\$13,390
<b>Total</b>	<b>378,007</b>	<b>\$18</b>	<b>333,942</b>	<b>\$13</b>

\*Through September 2008

\*\* Does not include CFLs

Pacific Power projects completed*		
Division	2008*	2002–2008**
Energy efficiency	8,650	59,426
Renewable energy	96	540

Incentives provided to Pacific Power customers (in millions)		
Division	2008 Forecast	2002–2008
Energy efficiency	\$10.7	\$54.6
Renewable energy	\$4.9	\$13.0

Energy saved by Pacific Power customers		
Division	2008 Forecast	2002–2008
Energy efficiency	15.1 aMW	81.4 aMW
Renewable energy	32.8 aMW	49.3 aMW

**Source:** Energy Trust and Pacific Power Fact Sheet.

<sup>21</sup> These values do include the energy savings of CFLs.

<sup>22</sup> This estimate is the result of scaling the values presented in Figure 11 with the ratio of annual 2005 electricity consumption in Jackson and Josephine counties over retail sales by Pacific Power and PGE in the ETO service area (3,000,000 MWh / 31,000,000 MWh).

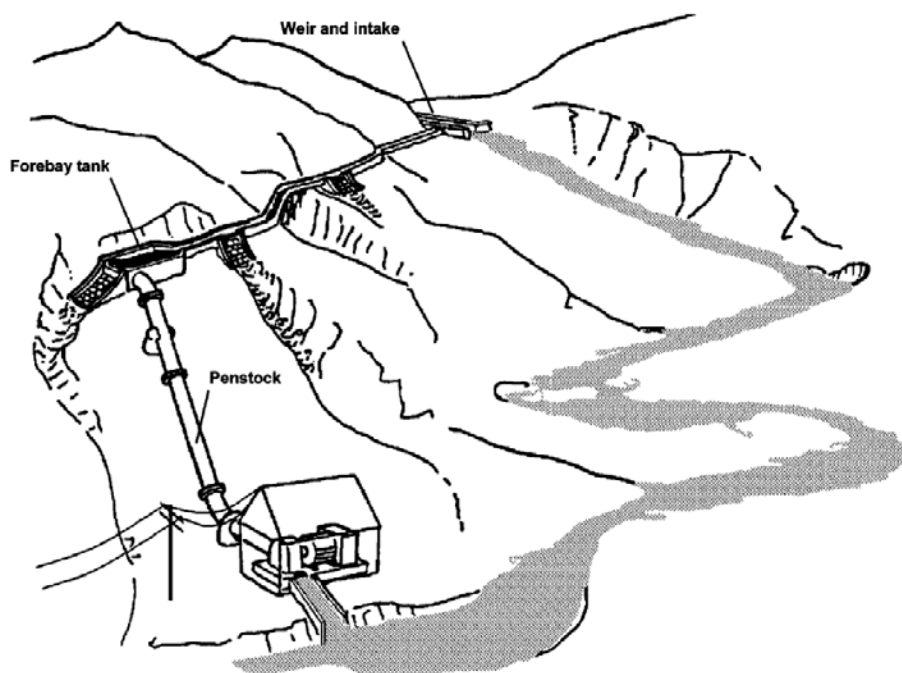
## 5.3 Hydropower

Hydroelectric power is generated from the kinetic energy of water as it moves from a higher elevation to a lower elevation passing through a turbine generator. There are two primary methods used to capture this kinetic energy. Water is either captured behind a dam to create head (water pressure from a change in intake and outlet elevation) or is diverted into a pipe (penstock) using natural contours to create head.<sup>23</sup> The latter is referred to as a 'run-of-river' application.

There is no established convention for the classification of hydroelectric facilities by generation capacity. A common classification system that is used in North America is listed below and will be used for the purpose of categorizing and describing existing and potential hydro projects in this report.<sup>24</sup>

- Large hydroelectric > 100 Megawatts (MW)
- Medium hydroelectric range between 30 MW and 100 MW
- Small hydroelectric range between 1.5 and 30 MW
- Mini-hydroelectric range between 100 kW and 1.5 MW
- Micro-hydroelectric < 100 kW

**Figure 12:** Diagram of 'run-of-river' hydroelectric system



**Source:** Oliver parish, "Small Hydropower: Technology and Current Status", Renewable and Sustainable Energy Reviews

There is a long history of hydroelectric projects in the study area, starting with the California Oregon Power Company developing the Prospect Hydroelectric facilities (now owned by the parent company of Pacific Power, PacifiCorp) in the early 20th century<sup>25</sup> to the Bureau of Reclamation and Army Corp of Engineers projects that took place in the mid-20th century.<sup>26</sup> These medium-scale projects consist

<sup>23</sup> Head is a measure of the pressure of falling water, and is a function of the vertical distance that water drops and the characteristics of the channel, or pipe, through which it flows. Higher head means more available power. The higher the head the less water is needed to produce a given amount of power.

<sup>24</sup> H-12

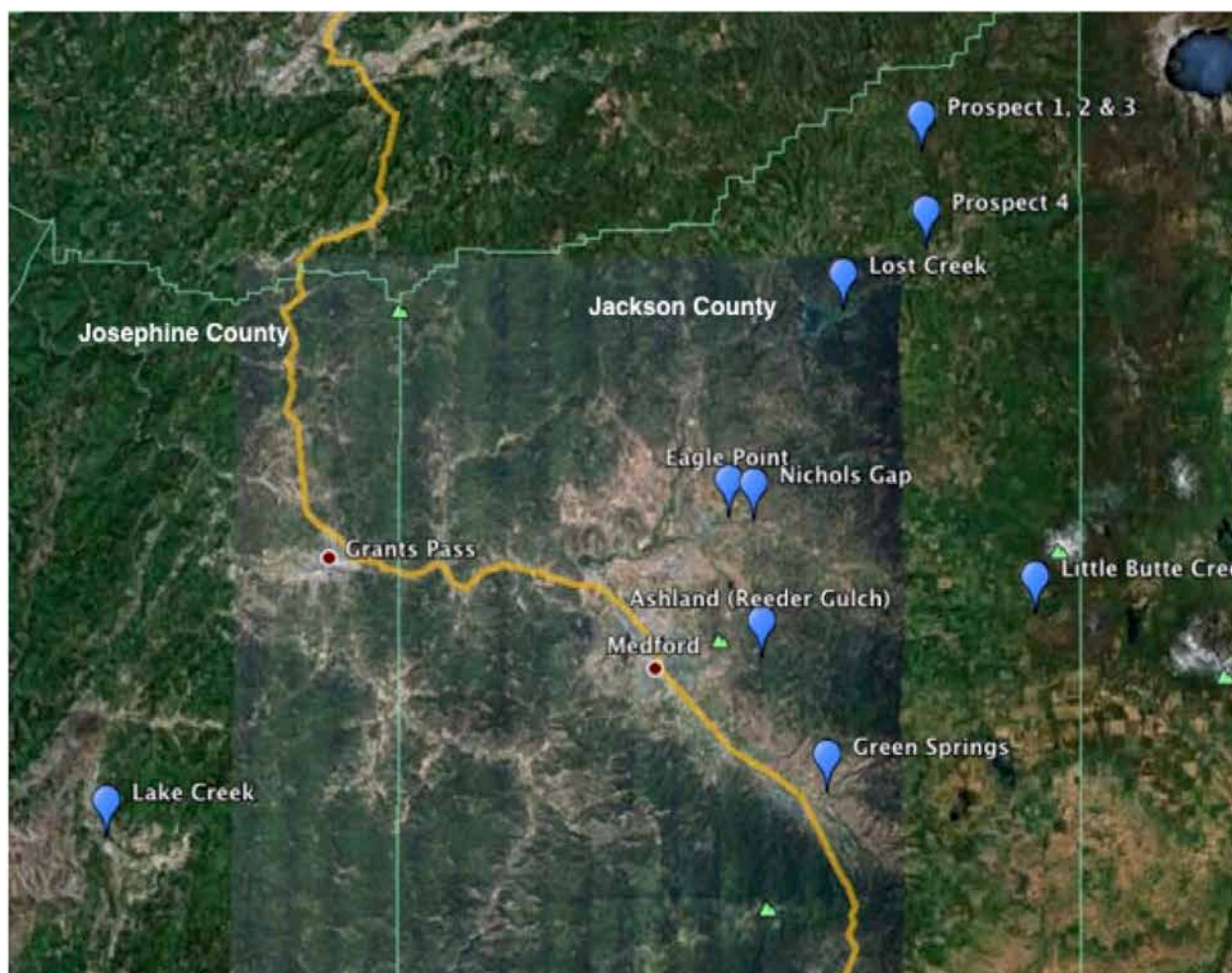
<sup>25</sup> H-6

<sup>26</sup> H-21, H-24

primarily of dams or run-of-river diversions leading to a pipe and turbine generator with interconnection to the electricity transmission or distribution grid. More recently, investigation and development of irrigation districts, municipal water supplies, and additions to existing dams is taking place within the region. The scale of these projects ranges from micro to small.

The medium-scale projects in the region began with the Prospect Hydroelectric facilities located on the upper reaches of the Rogue River. Prospect 1, 2 and 4 consist of three concrete diversion dams located on the Middle Fork of the Rogue River, Red Blanket Creek, and the Rogue River. These dams were constructed starting in 1911 with Prospect No. 1 and were completed in 1944 with Prospect No. 4. Combined, these three dams have a nameplate capacity of approximately 36.8 MW and annual generation of approximately 280,000 MWh (depending on generation factors, such as water year, maintenance, market factors, etc.). Prospect No. 3 is a run-of-river project that has a 172-foot-long, 24-foot-high concrete diversion dam with a rated capacity of 7.2 MW and an average annual generation of about 33,000 MWh. All the Prospect projects are regulated under the Federal Energy Regulatory Commission (FERC) and were recently relicensed in 2008.<sup>27</sup>

**Figure 13:** Map of hydroelectricity facilities in Jackson and Josephine counties



Additional medium-scale hydroelectric projects were developed when the Bureau of Reclamation began work in the region with the Rogue River Basin Project. This project improved and developed much of the irrigation and flood control infrastructure within the Basin. These projects started in the 1950s and

<sup>27</sup> H-25

finished with the last major construction project in 1971. As a result of this effort, several diversions and dam structures were constructed (e.g., Green Springs project near Talent) that have a cumulative rated capacity of 17.3 MW and an annual generation of about 64,000 MWh.<sup>28</sup>

The most recent medium-scale hydroelectric projects in the region were constructed by the Corps of Engineers beginning with William L. Jess Dam at Lost Creek Reservoir and Applegate Dam at Apple Reservoir in 1977. The William L. Jess Dam has a rated capacity of 49 MW and annual generation of 192,000 MWh.<sup>29</sup> Applegate Dam was constructed for flood control and irrigation and initially did not have any hydroelectric generation.<sup>30</sup> In 2004 Symbiotics, a private hydroelectric development company, submitted an application to FERC for the construction of a small scale 10 MW hydroelectric facility with a 15-mile long transmission line at the Applegate dam. The project received its license in 2009 and is currently in the engineering phase with an anticipated construction start date in 2011. Once completed, the project is expected to generate about 44,000 MWh annually.<sup>31</sup>

**Figure 14:** Applegate dam in Jackson County.



One small-scale hydroelectric project was identified in conjunction with an irrigation district. Pacific Power operates a 2.8 MW facility on the conduit system managed by Eagle Point Irrigation District.<sup>32</sup> Several of the other districts have conducted some form of exploratory study, but only the Talent Irrigation District completed a report describing the potential.<sup>33</sup> The Talent Irrigation District identified several micro-scale projects within its conduit system with a total potential generation capacity of 0.62 MW. Further investigation is required by the district to determine if the projects are feasible.<sup>34</sup>

In addition to irrigation districts, several municipal facilities have been identified. The City of Ashland operates a mini-scale hydroelectric facility with a nameplate capacity of 0.48 MW, which supplies 2-3% of Ashland's average system load.<sup>35</sup> The City of Grants Pass currently has a municipal water line serving the Merlin service area that has been identified as having potential, but at this time funding is not available for further study. In Medford, an internal investigation was completed by the Medford Water Commission to determine if in-conduit hydroelectric generation would be feasible on the Butte Falls drinking water supply line. That investigation found technical challenges (age and configuration of the lines) that make this project currently infeasible.

Hydroelectric power has the longest history and is the largest source of renewable electricity generation in Jackson and Josephine counties. Combined, existing projects have a nameplate capacity of 122.4 MW with an additional 10.8 MW of generation in the planning or development stage. The total annual generation for all existing hydroelectric power in the region is 565,000 MWh with an additional 48,000 MWh in the planning and development stages.

It is important to note that the existing hydropower in the Rogue Valley in general does not qualify as an eligible resource under the Oregon Renewable Portfolio Standard (RPS) because the facilities were built prior to 1995. However, a limited amount of hydro from pre-1995 facilities is allowed for compliance

<sup>28</sup> H-20

<sup>29</sup> eGRID data from 2005. In 2004 the annual generation was 281,165 MWh.

<sup>30</sup> H-21

<sup>31</sup> H-22

<sup>32</sup> H-26

<sup>33</sup> H-16

<sup>34</sup> C-50

<sup>35</sup> C-21

purposes (50MW of utility-owned, low-impact power; 40 MW of non-utility owned, low-impact power). In order to be certified as low-impact, a hydropower facility must meet criteria in the following eight areas: river flows, water quality, fish passage, and protection, watershed protection threatened and endangered species protection, cultural resource protection, recreation, and facilities recommended for removal.

The low-impact criteria standards are typically based on the most recent, and most stringent, mitigation measures recommended for the dam by expert state and federal resource agencies, even if those measures aren't a requirement for operating. A hydropower Facility meeting all eight certification criteria will be certified by LIHI, and will be able to use this certification when marketing power to consumers. For more information visit the Low Impact Hydropower Institute's website (<http://www.lowimpacthydro.org/>)

## 5.4 Biomass (Direct Fired)

Direct-fired biomass is commonly used to generate thermal energy as in a residential wood stove. A utility-scale direct-fired biomass system can also produce electricity generation with thermal energy; this type of system is referred to as combined heat and power (CHP). Both Jackson and Josephine County utilize biomass as direct-fired energy in thermal and electricity generation systems. The locations of these facilities are shown on Figure 16.

For the purpose of this feasibility study, biomass is defined as forest residue, crop residue, mill residue, and urban wood residue, which includes construction and demolition waste. These categories are based on the National Renewable Energy Laboratory (NREL) biomass categories.<sup>36</sup> This section of the assessment does not discuss other categories sometimes labeled as biomass including organic solid waste materials (such as food and soiled paper waste), manure, and domestic wastewater. Organic solid waste as an energy feedstock is discussed in the landfill gas-to-energy and anaerobic digestion sections of this report.

The largest biomass facility in the area is Biomass One, which is located in White City, Jackson County and has been operating since 1986. The facility is classified as a small power producer instead of a co-generator because the steam it produces is not utilized in other operations. The installed nameplate capacity of the plant is 30 MW.<sup>37</sup> On an annual basis, the plant uses an estimated 330,000 green tons<sup>38</sup> and 194,000 bone dry tons of woody biomass feedstock from various sources, including 75% from forest residue, and the remainder from urban wood and mill residue. The facility generates about 176,000 MWh per year<sup>39</sup>, which is enough power to meet the needs of about 20,000 homes.

**Figure 15:** Picture of Rough & Ready Boiler.<sup>1</sup>



The smallest electricity generating biomass facility in the area is Rough and Ready Lumber located in Cave Junction, Josephine County. The wood-fired CHP system, which began operating in 2008, has a boiler rated capacity of 50,000 pounds of steam per hour and a 1.5 MW nameplate capacity. It operates

<sup>36</sup>B-1

<sup>37</sup>B-7

<sup>38</sup> Reported by Biomass One Staff

<sup>39</sup> CI-2

at an average load of 1.28 MW. Rough and Ready has a five-year power purchase agreement with Pacific Power and it is estimated that it sells about 10,000 MWh per year.<sup>40</sup>

The final electricity generating biomass plant in the area is the Boise Building Solutions facility located in Medford, Jackson County. The main function of the plant is manufacturing plywood. The 8.5 MW CHP system produces steam with three wood-fired boilers that are used in the plywood manufacturing process.<sup>41</sup> Currently the boilers are not being used to generate electricity and would require upgrades to do so. The most recent publically available generation data show that in 2005, Boise Building Solutions generated 19,639 MWh and in 2004 generated 31,493 MWh of electricity in addition to the thermal energy.<sup>42</sup>

**Figure 16:** Map of biomass power generation facilities in the study area.



There are also a number of small-scale thermal energy biomass projects in the area including: a project for the Three Rivers School District that will use thermal energy to heat two buildings; Willamina Veneer, a Boise Cascade plant based in White City, that uses thermal energy to dry veneer; and Panel Products based in Rogue River and operated by the Murphy Company<sup>43</sup> that uses biomass for thermal energy to dry plywood.

There is only one known CHP project currently in the planning stage. The Murphy Company and Forest Energy Group are working together to develop a 5 MW capacity CHP project at Panel Products. The project plans are currently on hold, due to the mill's recent sale and reopening. It is unclear whether the project will move forward at a later date.<sup>44</sup>

## 5.5 Landfill Gas-to-Energy

Landfill gas (LFG) results from chemical reactions and microbes reacting as organic material decomposes in a landfill. LFG is approximately forty to sixty percent methane, with the remainder being mostly carbon dioxide. LFG also contains small amounts of nitrogen, oxygen, water vapor, sulfur and other contaminants. Most of these other contaminants are known as "non-methane organic compounds" and usually make up less than one percent.

The rate of LFG production is affected by waste composition and landfill geometry, which in turn influence the bacterial populations within it, including chemical make-up, thermal characteristics, moisture and the escape of gas. The nature of most landfills includes a wide range of physical conditions and biological ecosystems co-existing simultaneously within most sites. LFG generation is highly sensitive to a number of factors, such as moisture, temperature, oxygen and the refuse waste

<sup>40</sup> B-3

<sup>41</sup> B-7

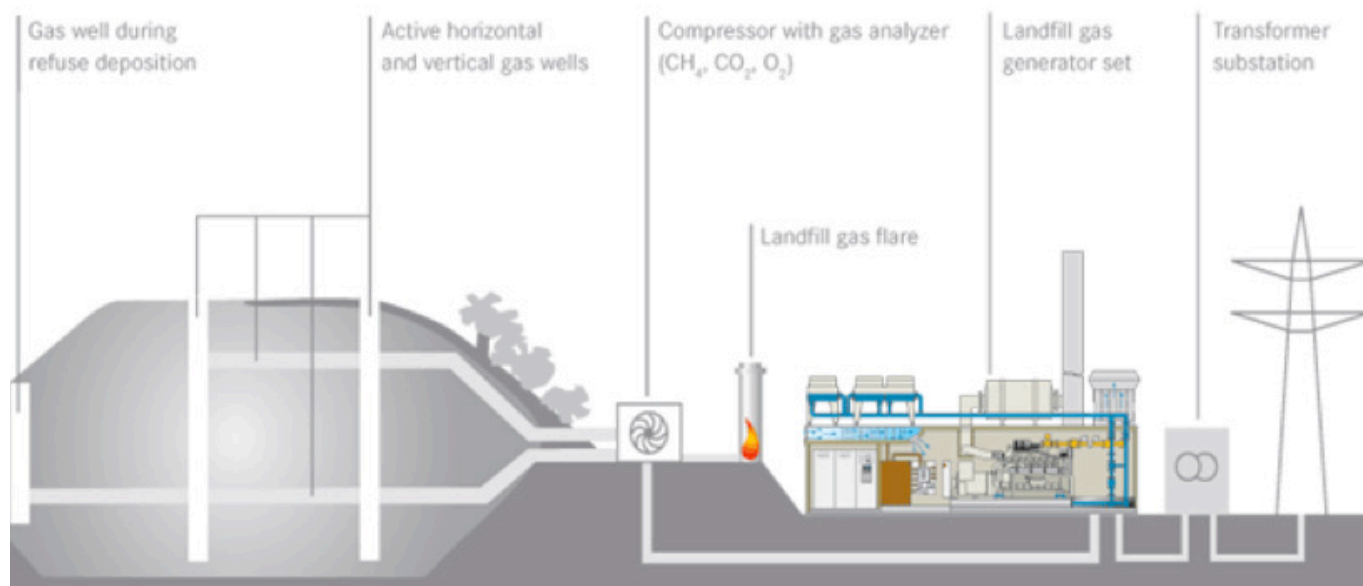
<sup>42</sup> CI-2

<sup>43</sup> B-6

<sup>44</sup> C-55

degradability. For these and other reasons, including the size and depth of the landfill, it is difficult to determine the LFG generation rate through the use of generic computer models.

**Figure 17:** Diagram of landfill gas to energy system



Source: [www.maxwattenergy.com](http://www.maxwattenergy.com)

LFG is typically extracted with wells drilled into the completed (and capped) areas of a landfill. Drilled wells are generally limited to completed fill areas because wellhead facilities, valves, and monitoring ports are incompatible with active filling. To a limited extent, other types of vertical collectors are raised in active fill areas as new lifts (layers) are constructed and eventually interconnected. Because of the time required to attain final fill grade, horizontal collectors (sometimes referred to as trenches) may be installed as an interim measure.

Because landfill gas is approximately 50% methane, which is combustible and has an unpleasant odor, it needs to be managed. General options for managing LFG are: fuel for boilers (for heat), internal combustion engines (for electricity), gas turbines (for electricity), fuel cell (for electricity), converting the methane to methyl alcohol, cleaning the gas enough to pipe it to other industries or into natural gas lines, and flaring.

Only one existing LFG electricity generation facility was identified in Jackson and Josephine counties, Dry Creek Landfill. The generation facility was commissioned in mid-2007 and began commercial operation in September of the same year. The Dry Creek Landfill (DCLF) gas-to-energy project took 17 months to construct at a capital cost of approximately \$6 million. DCLF is networked with 72 LFG wells and produces approximately 1,200 standard cubic feet per minute of LFG. The facility has a nameplate capacity of 3.2 MW and in 2010 the project generated over 21,000 MWh of electricity.<sup>45</sup> DCLF sells the electricity to Pacific Power yielding an average of \$0.064/kWh. The system is currently not configured for heat recovery, in other words the heat by-product of electricity generation is not currently utilized.

DCLF is currently exploring an upgrade to the equipment, which will allow them to “clean” the LFG and convert it to compressed natural gas (CNG), which can be used as transportation fuel. DCLF has recently secured grant funding to conduct a feasibility study for the project.

<sup>45</sup> LFG-1. All facts presented in this section are taken from this source.

## 5.6 Anaerobic Digestion

Like landfill gas, anaerobic digestion (AD) is a series of biological processes in which methanogenic microorganisms break down organic material (food waste, green leafy biomass, fats, oils or greases) in closed reactors in the absence of oxygen, thereby producing biogas. Biogas is primarily composed of methane (i.e., natural gas), which can be combusted to generate electricity or filtered of impurities and compressed for natural gas pipeline injection or use in compression (diesel cycle) or combustion engines (gasoline cycle) to power vehicles.

The Ashland, Grants Pass and Medford wastewater treatment facilities combined treat over 20 million gallons per day (MGD) of wastewater. Currently, only the Medford regional wastewater reclamation facility recovers biogas to add heat to their digesters and generate electricity. The facility has a nameplate capacity of 0.7 MW and approximately 3,775 MWh per year. Biosolids from the facility are used for soil nutrients and also placed in the Dry Creek Landfill where additional energy content is recovered over time. The other systems in Ashland and Grants Pass do not have electricity generation capability.

Typically, serving loads over 1 million gallons a day (MGD) of water treatment are typically considered candidates for biogas recovery in excess of the on-site thermal energy needs. The feasibility, however, depends upon their design. The 1 MGD Ashland facility uses aerobic carousel oxidation and secondary clarifiers, with seasonal reverse osmosis membranes, to treat wastewater to required discharge quality. Despite meeting the capacity threshold, the system is not conducive to recovery of biogas without significant redesign.

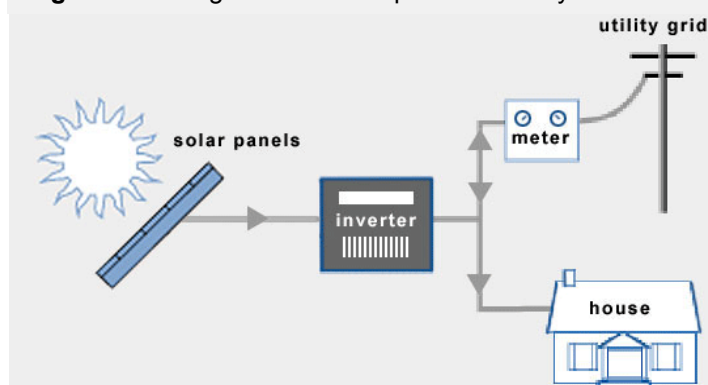
With the exception of Medford Regional, which has remaining capacity, the other facilities are operating at or near maximum treatment capacity. As these facilities age and require renovation or additional capacity becomes necessary, energy recovery may be a cost effective addition to other capital construction plans.

## 5.7 Solar Electric

There are two primary applications for generating electricity from solar radiation. The first, solar thermal, generates electricity by converting the sun's energy into high temperature heat through lenses or mirrors. These systems are referred to as concentrating solar thermal plants (CSP) and have several technologies that typically create steam to drive a turbine for electricity generation.

The second, solar photovoltaic (PV), converts the sun's energy directly into electricity through the use of silicon-based cells. Solar PV can either utilize direct solar exposure to the panel (e.g. common residential or commercial rooftop installations) or concentrating solar PV (CPV) technology. CPV focuses the sun's energy with mirrors or lenses on the panels and typically utilizes a two-axis tracking system to capture as much of the sun's daily energy as possible.

**Figure 18:** Diagram of a solar photovoltaic system



Source: <http://www.caribbeanenergystore.com>

Currently there are no CSP electricity generating facilities within the region. There are however numerous installations of small-scale solar PV (residential and commercial) in the region. The City of Ashland has a long history of providing incentives to promote small-scale solar through its Solar Pioneer I and II programs. These programs have enabled

the installation of several PV arrays on public and civic buildings through a voluntary surcharge on the participating customer's utility bills.<sup>46</sup>

The City of Medford completed a feasibility study that looked at solar PV installations on several city-owned properties and recently installed a small-scale system on a community center funded through an Energy Efficiency Community Block Grant.<sup>47</sup> While all of the individual existing solar PV systems are relatively small in generation capacity compared to other renewable generation in the region, the current aggregate capacity of all the net-metered, distributed systems totals an existing capacity of 2.1 MW with an average annual generation of 2,730 MWh.<sup>48</sup>

One large-scale, project is planned for installation at the Rogue Valley International Airport. The project, if successful, will be installed on a 47-acre parcel of airport-owned land and would have the potential for an installed capacity of 7.9 MW<sup>49</sup> resulting in an estimated 17,352 MWh per year.

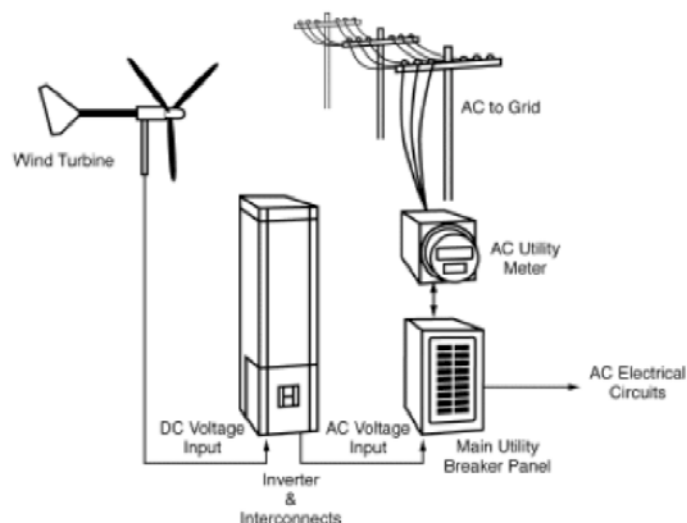
In November 2010, PacifiCorp issued a request for proposals for solar resources serving Oregon's electrical power load. The system size was to be larger than 500 kW and less than 2 MW and be classified as a solar PV system. This request is in response to a recent Oregon Statute, ORS 757.370, pertaining to the solar PV generating capacity standard, which requires Oregon utilities to acquire at least 20 MW of installed capacity.<sup>50</sup> PacifiCorp's share of the total is 8.7 MW. The RFP called for resources to be on line by December 31, 2011. Responses were due January 7, 2011, and bids are currently being evaluated.<sup>51</sup>

## 5.8 Wind

Wind power systems convert the movement of air into power through a rotating turbine and a generator. Utility scale wind turbines range in size from 1 to 3 MW and can be combined to create installations up to 300 MW or larger. Currently in Oregon there are several utility scale wind farms over 100 MW, with the largest being the Biglow Canyon Wind farm in Sherman County with an anticipated generation capacity of 450 MW upon completion.<sup>52</sup> Smaller applications of distributed wind turbines may only generate a few kW of power and are often used to offset localized loads or for off-grid locations.<sup>53</sup>

There are few existing wind energy projects within Josephine and Jackson Counties. Some small-scale distributed, net-metered projects were identified but are primarily used to offset on-site electric load.<sup>54</sup> The current aggregate capacity of all the net-metered, distributed systems within the region is less than 30 kW.<sup>55</sup> Some larger scale systems have been explored in a limited way but no detailed information was available or identified.<sup>56</sup>

**Figure 19:** Diagram of a wind power system



**Source:** Ontario Ministry of Agriculture, Food and Rural Affairs

<sup>46</sup> C-21

<sup>47</sup> S-4

<sup>48</sup> S-3, S-8

<sup>49</sup> C-38

<sup>50</sup> S-2

<sup>51</sup> S-1

<sup>52</sup> W-5

<sup>53</sup> W-3, W-4

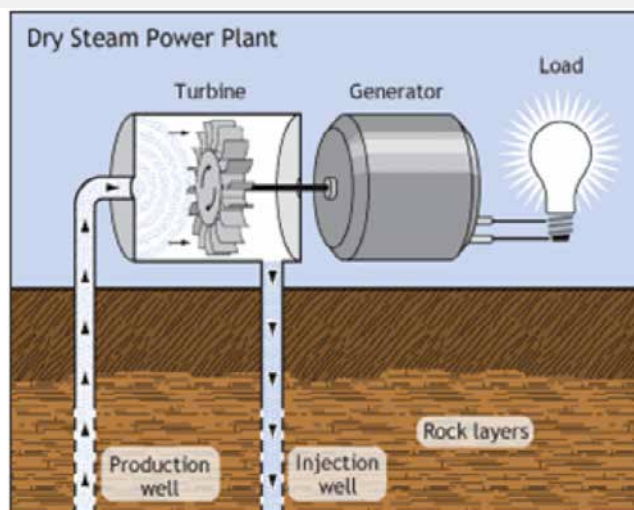
<sup>54</sup> W-3, W-4

## 5.9 Geothermal

There are two primary uses of geothermal resources. Low temperature geothermal is typically utilized in a direct-use application for hot water, greenhouses or space heating. High-temperature geothermal is used to generate steam and drive turbine generators for electricity. No high-temperature resources were identified within the region.

Two existing low-temperature geothermal projects were identified near the City of Ashland. Jackson Wellsprings currently operates a hot springs resort that uses 80,000 gallons of warm water per day for swimming pools and soaking tubs. The warm water is also used for space heating in the resort and to heat a greenhouse. The temperature of the geothermal well is 111°F and has a measured capacity of 0.6 megawatts thermal (MWt). Lithia Springs Resort operates geothermal for heating and spa uses at this resort. The temperature of the geothermal well is 220°F and has a measured capacity of 0.2 MWt.<sup>57</sup>

**Figure 20:** Diagram of a geothermal electricity system.



Source: Pew Center on Global Climate Change

<sup>55</sup> S-8

<sup>56</sup> C-21, C-47

<sup>57</sup> GT-4

## 6 FEASIBILITY ASSESSMENT OF RENEWABLE TECHNOLOGIES

### 6.1 Summary of Findings

The findings of the feasibility assessment are summarized in Figure 21. This summary table describes each of the technologies reviewed according to a number of aspects, which include the following:

**Energy type:** The renewable energy sources are grouped into three types of generation: base, intermittent, and dispatchable.

Baseload generation comes from facilities that are used to meet some or all of a region's continuous electricity demand. These facilities produce electricity at a continuous rate at a low cost relative to other generation resources available in the region. The largest baseload resource in the region is hydro.

Intermittent generation is from facilities that are not able to generate electricity continuously (24 hours per day, 7 days a week) even though they may generate electricity in a predictable way. Intermittent examples include wind and solar.

Dispatchable generation refers to sources of electricity that can be dispatched at the request of power grid operators; that is, it can be turned on or off upon demand.

**Likely technology:** Renewable electricity generation may have multiple technologies that use the same resources. For example, solar electricity may be generated with photovoltaic or solar thermal technologies. This row in the summary table names the most likely technology for development in the Rogue Valley.

**Risks:** This aspect summarizes the risks associated with each renewable resource. Risks could include negative by-products such as air or water emissions, impacts to people or habitat or significant regulatory hurdles to development, among others.

**Benefits:** This aspect summarizes the benefits associated with each renewable resource. Benefits could include positive byproducts such as displacing carbon emissions, reducing health impacts to people or habitat compared to the alternative or financial incentives available to assist in development.

**Levelized costs:** Measures the cost of generating electricity including initial capital, return on investment, as well as the costs of continuous operation, fuel, and maintenance. The price is normally measured in dollars per megawatt hour.

**Energy Returned on Energy Invested (EROEI):** The ratio of the amount of usable energy acquired from a particular energy resource to the amount of energy expended to obtain that energy resource. When the EROEI of a resource is less than or equal to one, that energy source becomes an "energy sink", and can no longer be used as a primary source of energy.

**Carbon intensity (CI):** For the purpose of the summary table, carbon intensity describes the life-cycle greenhouse gas emissions (i.e. emissions starting at production of materials through end-of-life disposal of the facility) per unit of electrical output. Carbon intensity is measured in kilograms of carbon dioxide equivalent per kilowatt hour (kg CO<sub>2</sub>e / kWh).

The remainder of this chapter describes many of these aspects in detail for each technology.

The following points summarize the findings for each technology:

**Energy Efficiency:** The various technologies and practices that make up energy efficiency and conservation represent the greatest potential over the next 20 years combined with the lowest leveled-cost. There are few barriers to entry, a wide array of projects are possible for all economic sectors and the economic benefits associated with the savings are accessible to anyone who can change a light bulb. The primary risks are high first costs for certain types of projects, a lack of access to financing vehicles, and a lack of readily available, high-quality, understandable information to compare and contrast the life-cycle costs of similar products.

**Solar:** Solar energy is abundant and small-scale, and distributed photovoltaic (PV) panels have few barriers to entry. The primary barrier is cost, but recent trends and future projections show the cost of the materials and labor are rapidly decreasing. As costs decrease, this technology will become a viable opportunity to a greater number of residents and businesses. Like EE, small-scale solar has the potential to distribute economic benefits more broadly than utility-scale projects. Larger utility-scale systems pose greater challenges associated with land use, permitting, and electricity grid interconnection. While thermal energy generation is not the focus of this assessment its important to note that solar water heating is identified as the 2<sup>nd</sup> largest energy efficiency opportunity in the region.

**Wind:** While this resource is limited to ridgelines in Jackson and Josephine counties its potential is large compared to other technologies. The downside is that many of the ridgelines with the highest potential are undesirable due to lack of site access, disturbance to local view sheds, lack of access to the electrical grid, etc. One ridgeline was identified as promising in terms of potential resource, site access, and interconnection there may be significant challenges associated with land ownership, as the area is a mix of public and private lands. More study of this site will be required to determine final feasibility.

**Biomass:** Biomass is already a significant source of electricity in the Rogue Valley. Based on the additional available feedstock resource in the area, existing generation capacity could be expanded with new electricity generation plants. While there is available, unused feedstock a new biomass plant faces regulatory, permitting, land use, environmental challenges. This resource could also be used to meet thermal loads with boiler conversions.

**Hydroelectric:** Hydroelectricity is by far the largest source of existing, renewable power in the area. While there is abundant kinetic energy available from moving water in the area, the access to this resource is heavily limited by regulations, environmental concerns, and water rights. New large, hydroelectric dams are unlikely at best. The greatest opportunity for this technology is incremental projects, such as adding electricity generation to an existing flood control, water supply lines or irrigation canals. A few projects are identified in this report, but the scale of these projects is relatively small.

**Anaerobic Digestion:** While the generation potential associated with this technology is relatively small, it represents an opportunity to make more efficient use of an existing organic wastes (e.g. food waste, yard waste and manure) compared to a landfill gas collection system. This technology will be assessed in detail in a separate, but related study. This additional study consists of a feedstock inventory and evaluation of several potential scenarios to determine feasibility of a local anaerobic digester.

**Geothermal:** Excluded from consideration due to lack of available resource. Based on available data, the surface temperatures in Jackson and Josephine counties would not be effective for electricity generation. The research implies that there is no cause to fund further exploration of this technology. However there is potential for distributed thermal applications (such as ground-source heat pumps).

**Landfill gas (LFG):** Excluded from consideration due to lack of an available cost-effective resource. The only active landfill in Jackson and Josephine counties is Dry Creek Landfill, which already has gas collection system in place, which generates electricity and is also evaluating the use of the gas as a vehicle fuel for their owned vehicles. The biogas production from other closed landfills are unlikely to justify the capital cost associated with constructing a new gas collection system.

**Figure 21:** Summary of renewable energy technologies, by feasibility criteria. Note: Risks and benefits are not scaled in this table.

Category	Energy Efficiency	Solar	Wind	Biomass	Hydroelectric	Anaerobic Digestion	Geothermal	Landfill Gas
Likely Technology	Various <sup>58</sup>	Small-scale and utility-scale PV	Utility scale wind farm	Direct-Fire	Incremental and small scale run-of-river	Dry or Wet Fermentation	Low Temperature Direct-Use (i.e. heat pump)	Internal Combustion Engine
Resource Potential (Nameplate Capacity / Annual Generation)	64 – 100 aMW (560,000 – 876,000 MWh)	35 MW <sup>59</sup> (58,000 MWh)	27 MW <sup>60</sup> (68,000 MWh)	5 – 14.5 MW (30,000–96,000MWh)	2.4 MW* (18,000 MWh)	0.5 MW (4,000 MWh)	0 MW <sup>61</sup>	0 MW <sup>62</sup>
Risk	By-Products	None during operation	None during operation	Air emissions; Ash	None during operation	Air emissions; Wastewater	Fluid disposal	Air emissions
	People	Aesthetics issues	Noise; Aesthetics issues	Air & water emissions; Noise; Odor	Flooded historical areas; Water rights	Air emissions; Odor	Risk of ground water contamination	Air emissions
	Habitats	Alteration of large areas for utility-scale ground mounted systems	Development in remote and pristine areas; Vegetation management for transmission corridor; Avian and bat mortality	Habitat disturbance from biomass removal; Water use	Flooding wilderness; disruptions of water flow; Temperature gradients; Turbidity; Upstream blockage	None	Development in remote and pristine areas; Water use; Vegetation management for transmission corridor	None beyond existing landfill operational footprint
	Regulations	Various permits (scale and location dependent)	Various regulatory requirements	Air permits; Water permits; Zoning	Various permits (location dependent); Water rights; Zoning	Air Permits	Water permits; water rights; zoning	Air Permits
	Other	Upfront costs; Lack of information or misinformation; Financing vehicles	Transmission infrastructure; Land ownership; Intermittent generation	Ability to source cost-effective feedstock; Utility interconnection; Carbon neutrality questioned	Fuel source dependent on weather and climate; Transmission infrastructure	Ability to source and separate feedstock	Poor availability and source stability; High exploration costs; High transmission requirements; Financing	None
Benefit	By-Products	Carbon neutral	Carbon neutral; no air pollutants	Renewable	Carbon neutral; no air pollutants	Renewable; Compost products	Carbon neutral; no air pollutants	Renewable; Reduces GHGs
	People	Construction jobs; no air emissions; Community solar	Construction jobs, no air emissions	Ongoing jobs; Displaces emissions from open burning	Construction jobs, no air emissions, recreation	Construction and ongoing jobs	Construction jobs, no air emissions	Construction jobs, reduced risk and odor of methane
	Habitats	None	None	Reduces wildfire risk	None	Reduced water pollution; Soil nutrients	None	None
	Incentives	Various incentives; Feed in tariff; RECs; Peak pricing	Various State and Federal; RECs	CHP Tax Credit; Biomass Producer and Collector Tax Credit; RECs	Various State and Federal; RECs	Various State and Federal; RECs; Carbon Credits	Various State and Federal; RECs	Various State and Federal; RECs; Carbon Credits
	Other	Low leveled cost; large-scale potential	Low leveled cost	Low leveled cost	None	None	Low leveled cost (resource dependent); reliable; small-scale thermal resource	Low leveled cost

<sup>58</sup> Includes a variety of projects types such as lighting retrofits, heating and cooling systems, insulation, windows, doors, etc.

<sup>59</sup> These values represent a scenario where 5% of total J&J roof area is covered with solar PV panels.

<sup>60</sup> Only represents the Shale City project described in the wind section of Chapter 6.

<sup>61</sup> No electricity generation resource potential, only thermal resource available.



Category	Energy Efficiency	Solar	Wind	Biomass	Hydroelectric	Anaerobic Digestion	Geothermal	Landfill Gas
Energy Type	Baseload	Intermittent; Peak matched	Intermittent	Baseload or Dispatchable	Baseload or Dispatchable	Baseload	Baseload	Baseload
Levelized Cost (\$/MWh) <sup>63</sup>	\$0 - \$106 (average <\$35)	\$90 - \$154	\$44 - \$91	\$65 - \$151	Incremental: \$10 - \$98 Small and Micro: \$57 - \$136	\$36 - \$115 <sup>64</sup>	\$42 - \$69	\$50 - \$81
Energy Return	Varies	3 - 6	18 - 34	3 - 27	170 - 280	3 - 20 <sup>65</sup>	2 - 13 <sup>66</sup>	Not available
Carbon Intensity	Not available	50 - 59 kg CO <sub>2</sub> / MWh	6 - 14 kg CO <sub>2</sub> / MWh	Not available	3 - 23 kg CO <sub>2</sub> / MWh	120.1 kg CO <sub>2</sub> / MWh <sup>61</sup>	23 - 122 kg CO <sub>2</sub> / MWh <sup>67</sup>	100.5 kg CO <sub>2</sub> / MWh <sup>68</sup>

Note 1: All levelized cost values presented on Figure 21 come from CI-3, except those noted.

Note 2: All Energy Return values from CI-32, except where noted.

Note 3: For reference, the Northwest Power Pool (Oregon's regional electricity grid) average carbon intensity is 390 kg CO<sub>2</sub>e / MWh.

<sup>62</sup> Existing resource is already utilized at Dry Creek Landfill. No other cost-effective resources are available.

<sup>63</sup> The Northwest Power and Conservation Council's MICROFIN Version 14.2.4 (updated in March 2009) is used to estimate the levelized lifetime costs of electricity production for the above generic power resources. Values shown are real 2006 dollars consistent with Council practices. Additional information regarding levelized costs is found in Appendix A.

<sup>64</sup> CI-31

<sup>65</sup> CI-34

<sup>66</sup> CI-35

<sup>67</sup> CI-36

<sup>68</sup> CI-33.

## 6.2 Energy Efficiency and Conservation

### 6.2.1 Introduction

Energy efficiency (EE) is defined (in this report) as using less energy to perform the same work through changes in technology or behavior. Amory Lovins of Rock Mountain Institute has coined the phrase “negawatts” (instead of megawatts) to describe the “energy” resource of energy efficiency. The implementation of energy efficiency and conservation measures to acquire “negawatts” means avoiding the need for power supply, which replaces the need for electricity generation from new or existing power plants with a clean, abundant resource.

Unlike the other renewable technologies discussed in this report, energy efficiency and conservation are not a source of energy supply. However, it provides similar clean energy benefits and may be regarded as an alternative to generating more supply. Both renewable energy generation and EE are seen as ways to address economic, energy security and environmental challenges associated with meeting the demand for energy. Combined, renewable generation and EE complement each other in an effective future energy strategy.

As you’ll see in the following sections, EE has many competitive advantages over developing renewable supply on many fronts. There is vast EE potential at a levelized cost that is significantly lower than all of the other renewable energy sources while carrying few risks, and no fatal flaws.

There are also many co-benefits associated with EE.

- On the economic front, EE measures are lower cost compared to currently available supply technologies, and in most cases pay for themselves over time.
- The potential is vast in all sectors of the economy: residential, commercial, and industrial.
- After paying for the installation, EE puts income back into the pockets of business owners and residents alike. Perhaps no other source of energy distributes the financial benefits more evenly across the economy than EE.
- On the environmental front, EE measures are clean energy technology because they displace the need for energy at the peak times, when the grid is most likely to have more combustion and fossil fuels powering the summer cooling demands and the winter heating demands.
- And on the social equity front, EE can create local jobs in an ongoing stream of construction and labor positions – a segment that may not raise the ceiling of local income but certainly raises the floor. Finally, it shaves costs for those that live close to the edge while providing comfort and safety to at risk populations.
- There are already existing energy efficiency programs in the area that are run by Energy Trust of Oregon (on behalf of Pacific Power) and City of Ashland’s utility. In addition, Clean Energy Works Oregon is currently rolling out its program in the Rogue Valley.

This section of the assessment will focus on those EE technologies that have been identified as having the most potential for savings combined with the lowest levelized cost. Our team reviewed a large number of publically available studies on energy efficiency potential in our state and region including Energy Trust of Oregon’s studies and Pacific Power’s Integrated Resource Plan (IRP).

### 6.2.2 Technology

Energy efficiency technologies vary across a wide range of applications for both new construction and retrofits of existing residential, commercial and industrial facilities. These technologies include: heat pumps, weatherization (insulation, windows, caulking), new equipment, thermostats, etc. In addition to the

aforementioned technologies, energy audits can be performed on buildings to identify the strategies that offer the greatest energy and cost savings. Audits are a key component of identifying existing conditions, that then allow for the most accurate and practical measures to be implemented. Energy Trust of Oregon staff report that in the course of *“working with dozens of contractors and hundreds of homeowners, that the best chances for deep energy reductions in existing homes, begins with awareness, then conservation efforts, followed by energy efficiency improvements and finally adding renewable energy. The highest rates of success for such deep energy reductions are the result of a guided home energy remodel that begins with an energy audit.”*

Its important to note that before conservation and energy efficiency technologies can be fully realized, consumer education and awareness of energy use are critical. By educating first, all actions that follow, increase savings in all categories of conservation, efficiency and renewable energy.

### **6.2.3 Resource Potential**

The resource potential for energy efficiency and conservation projects is measured differently than the renewable energy generation sources. For generation sources, potential is measured by the quantity of feedstock available, land area, or available energy from natural systems. Energy efficiency however is a measure of the difference between actual energy consumption and the consumption that would occur should consumers adopt more efficient technologies.

A measurement of existing and future EE resource potential is not publically available specifically for Jackson and Josephine counties, but there is considerable information available from a number of completed studies on the scale of the energy efficiency resource at the regional, state and utility level. This report draws on these public resources to scale the resource potential and provide a range for levelized costs in aggregate as well as for specific measures.

#### **Northwest Regional Potential**

At the regional level, the Northwest Power and Conservation Council's 6<sup>th</sup> Power Plan describes the development schedule for resources between 2010 and 2030. Across multiple scenarios considered in the development of the plan, one conclusion was constant: the most cost-effective resource with the least risk for the region is improved efficiency of electricity use.<sup>69</sup>

The plan finds that there is enough available and cost-effective EE potential to meet 85 percent of the region's load growth for the next 20 years. See Figure 22. If developed aggressively, this conservation, combined with the region's past successful development of energy efficiency, could constitute a resource comparable in size to the Northwest federal hydroelectric system.<sup>70</sup>

The plan goes on to provide details about the composition of the 2030 efficiency potential. As can be seen in Figure 23, the top four efficiency resources with the greatest achievable potential<sup>71</sup> in the Northwest region are: residential heating and cooling systems, residential water heating, commercial lighting, and consumer electronics.

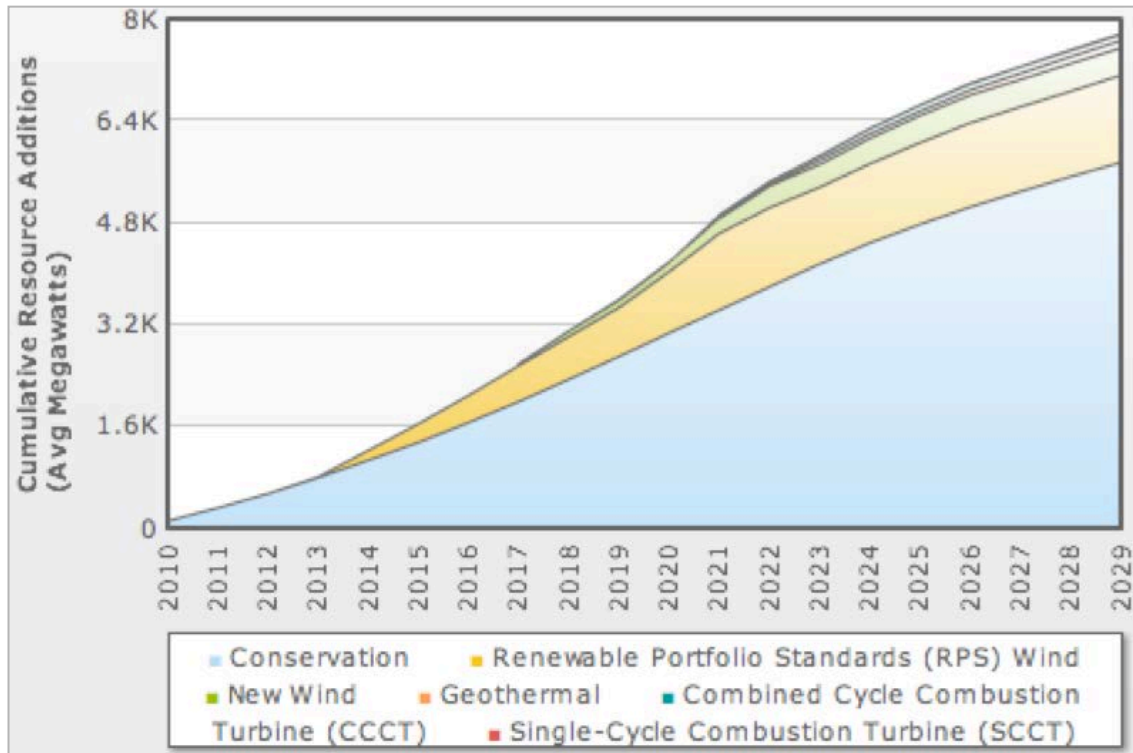
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<sup>69</sup> 6th Power Plan

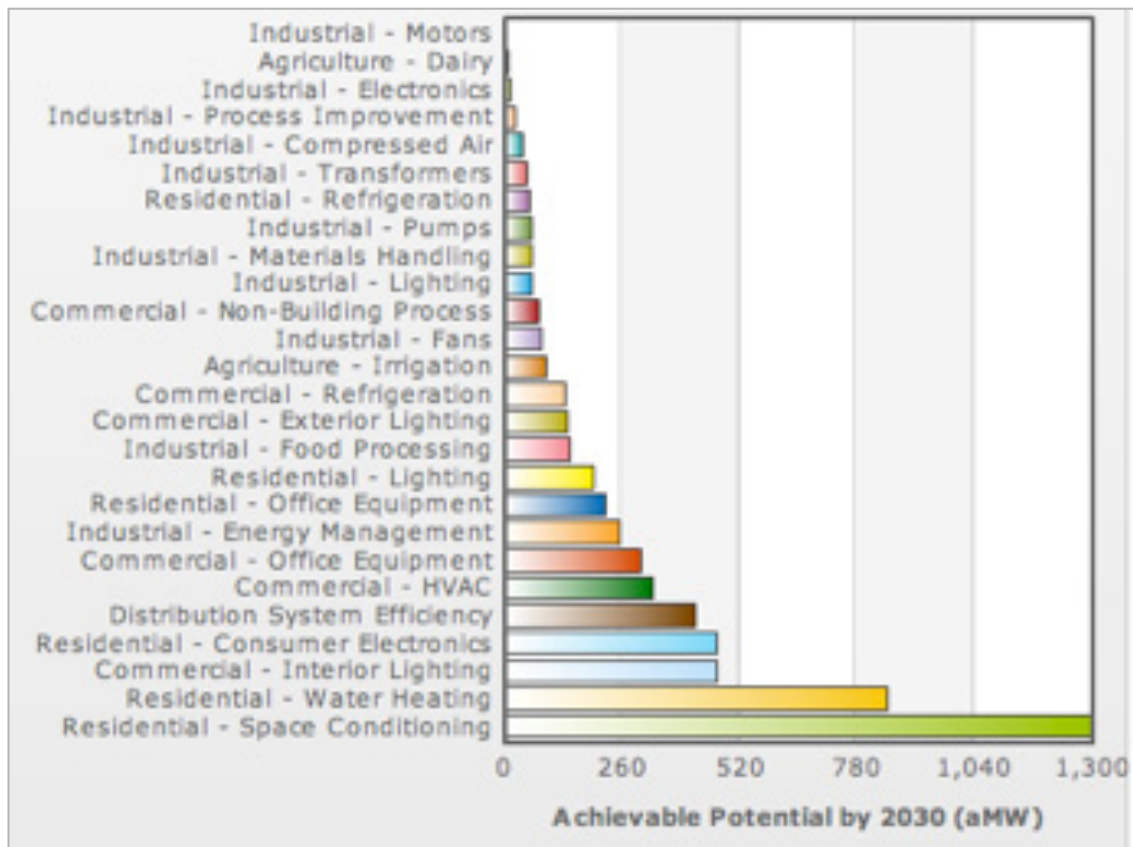
<sup>70</sup> 6th Power Plan

<sup>71</sup> Achievable potential represents a realistic assessment of what could be expected – taking into account the fact that not all consumers can be persuaded to participate and other real world limitations.

**Figure 22:** Energy efficiency development schedule through 2030 according to the Northwest Power Plan.



**Figure 23:** Composition of 6<sup>th</sup> Northwest Power Plan efficiency resources.



Source for Figures 22 & 23: Northwest Power and Conservation Council - 6<sup>th</sup> Power Plan.

## Oregon Potential

At the state level, the Energy Trust of Oregon summarized EE potential for its service territories (which includes Josephine and Jackson counties) in its report titled, *Energy and Conservation Measures Resource Assessment for the Years 2010 – 2030*. The report found that by 2030 there is technical potential<sup>72</sup> of approximately 717 aMW (average megawatts) of EE in its entire service territory. Figure 24 shows the technical EE resource in ETO's service territory and the estimated potential for Jackson and Josephine counties (64 aMW of capacity).

The estimated value to the local economy for accomplishing 64 aMW or 560.6 million kWh of electricity savings over the next 20 years at the current retail electric rate of \$0.07 per kWh would be some \$39 million. That is nearly \$2 million in the first year with the value of the energy saved rising as utility rates increase. At an estimated \$0.10 per kWh in 2020, that would be some \$2.9 million per year. These savings remain in the local community and are distributed to anyone who invests in EE technologies or practices conservation in addition to providing local employment. See Appendix A for an Economic and Jobs Impacts Analysis.

**Figure 24:** Summary of technical potential in Energy Trust of Oregon territory

Economic Sector	ETO Territory Technical Potential aMW	Josephine and Jackson Technical Potential aMW
Residential	181	23
Commercial	358	29
Industrial	178	12
<b>Total:</b>	<b>717</b>	<b>64</b>

## Pacific Power Service Territory

Pacific Power (which is a subsidiary of PacifiCorp) is the largest utility serving Jackson and Josephine counties. Based on its 2011 Integrated Resource Plan (IRP) energy efficiency will be the utility's largest resource over the next 20 years. Figure 25 shows PacifiCorp's preferred resource plan for 2011 through 2030. As can be seen, there are a number of resources included in the plan, but the largest is the row for Demand Side Management (DSM), Class 2, otherwise known as energy efficiency. While this plan is for all of PacifiCorp's territory, which includes a number of Western states, it does show that energy efficiency as a major priority over the next 20 years.

**Figure 25:** PacifiCorp's Preferred Resource Plan 2011 – 2030. EE listed as DSM, Class 2.

Resource	Capacity (MW)																				Total, 20-year
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
CCCT F Class	-	-	-	625	-	597	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,222
CCCT H Class	-	-	-	-	-	-	-	-	475	-	-	-	-	-	-	-	-	-	-	-	475
Coal Plant Turbine Upgrades	12	19	6	-	-	18	-	8	-	-	2	-	-	-	-	-	-	-	-	-	65
Wind, Wyoming	-	-	-	-	-	-	-	300	300	200	200	200	200	200	100	100	100	100	100	-	2,100
CHP - Biomass	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	104
DSM, Class 1	6	70	57	20	97	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	255
DSM, Class 2	108	114	110	118	122	124	126	120	122	125	125	134	133	139	140	146	136	135	141	145	2,563
Oregon Solar Programs	4	4	4	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19
Micro Solar - Water Heating	-	4	4	4	4	4	4	4	4	-	-	-	-	-	-	-	-	-	-	-	30
Front Office Transactions	350	1,240	1,429	1,190	1,149	775	822	967	695	995	700	750	750	750	750	750	750	750	750	750	N/A
Growth Resources	-	-	-	-	-	-	-	-	-	-	11	95	201	250	546	717	863	975	1,150	1,265	N/A

Note: Front office transaction (firm market purchases) and growth resources reflect one-year transaction periods, and are not additive. Growth resources are similar to front office transactions, but are located in load areas as opposed to being purchased at market hubs, and represent generic capacity needed to meet planning reserve margins in the latter half of the IRP planning period.

**Source:** PacifiCorp – 2011 Integrated Resource Plan, Volume I

<sup>72</sup> Technical potential is an estimate of all energy savings that could be accomplished without the influence of any market barriers such as cost and customer awareness.

The IRP goes on to offer more detail about PacifiCorp's energy efficiency plans for Oregon. Over the next 20 years PacifiCorp estimates energy efficiency efforts in Oregon will total 1,028 MW. Scaled for Jackson and Josephine counties, the savings in generation capacity is 155 aMW.

The difference between the ETO and Pacific Power estimates (64 versus 155 aMW) may be attributed to the different assumptions used in each base data source combined with the high-level of uncertainty associated with the method used to scale the potential for study area.<sup>73</sup> That being said, the purpose of this exercise is not to arrive at an exact answer, rather to estimate the scale of the resource relative to the other technologies in this report.

#### 6.2.4 Costs

Levelized costs are presented in the ETO report by economic sector and by specific measure. This section will focus on using levelized cost as a gauge because the range of capital costs across the spectrum of efficiency measures is vast, and for the sake of this assessment is not particularly useful. For the residential sector, the levelized cost range for EE is \$0 - \$83 per MWh with a weighted average of \$35 per MWh. For the commercial sector the range is \$6 - \$86 per MWh with a weighted average of \$30 per MWh. Finally, for the industrial sector the range is \$0 - \$106 with a weighted average of \$0 per MWh.<sup>74</sup>

While the ETO report does present details on specific EE measures, ETO makes clear that it was not the intention of the authors to generate values for use in developing energy strategy.<sup>75</sup> Again, these values represent the potential in ETO's entire territory and are not specific to Jackson and Josephine counties. This means some of these measures will be more applicable to the Rogue Valley region than others.

Only actual equipment and labor costs were included in the levelized-cost calculation used in this analysis. In addition, incremental costs (or savings) related to differences in operations and maintenance were considered in the cost analysis. Costs not considered include program administrative costs, marketing, or other overhead expenses. For each measure, the incremental cost of the equipment examined in the measure over that required by the relevant energy code was used where applicable in new construction, renovation, and replacement markets. The impact of the measure on O&M expenses was calculated and included in the cost-effectiveness analysis. In some cases, there are negative O&M costs – that is, non-energy benefits – that are included in the analysis. In planning terms, the cost represents the full societal cost or total resource cost (TRC). For more details see the ETO's report titled, *Energy Efficiency and Conservation Measure Resource Assessment for the Years 2010 – 2030*.

Figures 26 through 28 describe potential in megawatt hours (x-axis), by EE technology, and levelized cost (y-axis) for each economic sector. The point of presenting these graphics is to show the highest potential and lowest cost technologies, by sector. The potential is measured in terms of technical and achievable potential. Technical (pink bar) describes the potential as if there were no implementation barriers (cost, adoption rates, etc.). Achievable (blue bar) takes into account existing and expected barriers to implementation. The measures are split between new construction, retrofit and replacement. Replacement refers to the annual turnover of equipment in any given year.

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<sup>73</sup> The total capacity for Oregon's DSM, Class 2 programs was scaled by PacifiCorp's total retail electricity sales in Jackson and Josephine counties divided by total retail sales in Oregon.

<sup>74</sup> EE-2

<sup>75</sup> EE-2

## Residential

Energy efficiency measures for the residential sector are split between new construction and renovation. Figure 26, shows the EE potential for the residential sector.

The largest potential savings comes from replacing appliances at a cost of \$21 per MWh. The potential for these savings is large in the near-term but also likely happen without intervention or incentives as existing appliances are replaced over time.

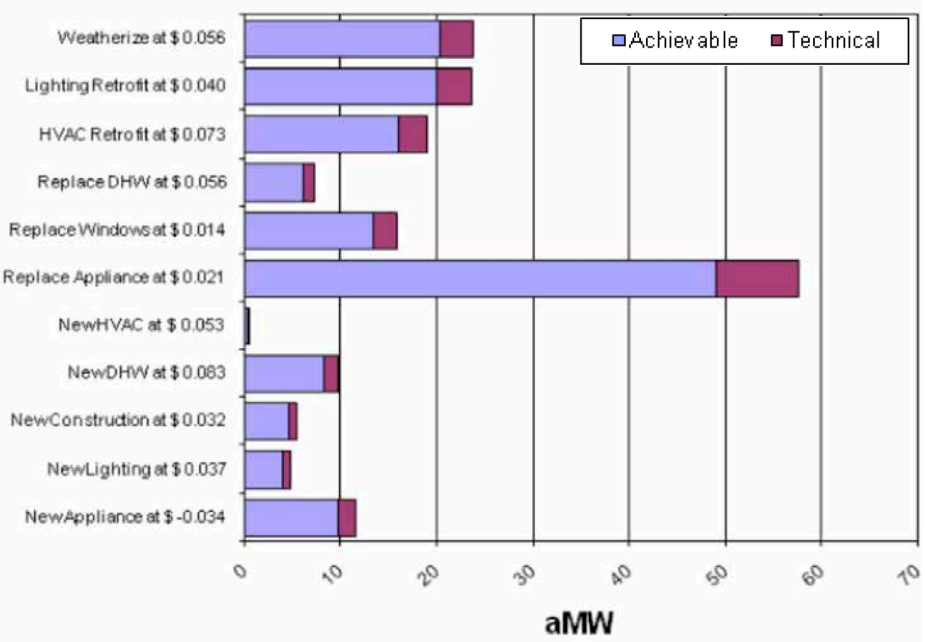
This measure is followed by weatherization (\$56 per MWh) and replacing lighting at (\$40 per MWh). Weatherization consists of building envelope sealing, while lighting refers to switching to more efficient light bulbs (i.e. incandescent bulbs to LED or CFL). The ETO report includes more detailed analysis on the prioritization of resource potential by measure within the residential sector (as well as commercial and industrial). See the ETO report for more details.

## Commercial

Like the residential sector, commercial EE measures are split between new construction and retrofits. The greatest potential for this sector is lighting for new construction at \$36 per MWh, followed by replacing equipment at \$42 per MWh and retrofit lighting at \$23 per MWh.

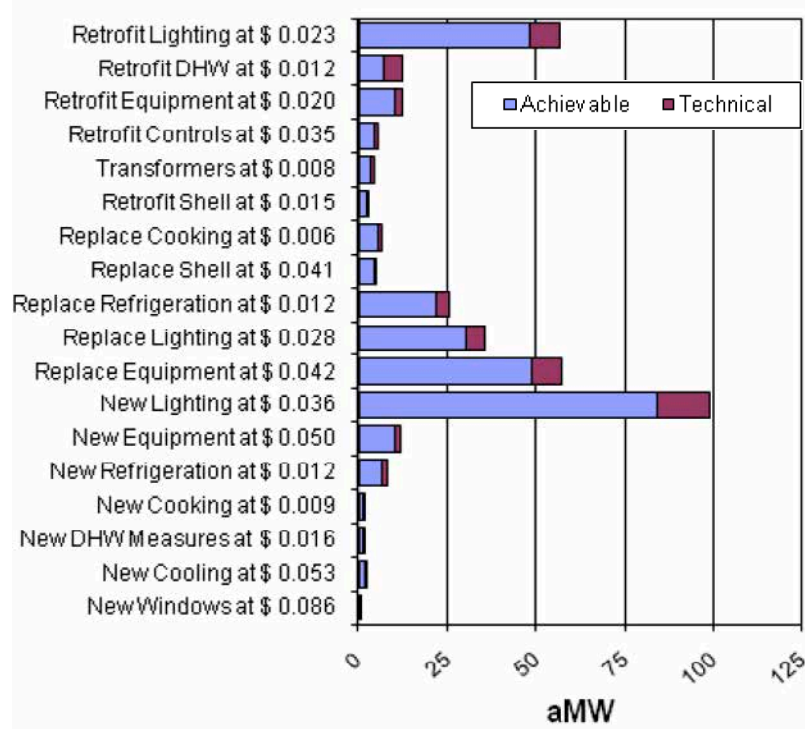
The top 5 measures shown in Figure 27 all have a levelized cost less than \$43 dollars per megawatt of capacity, which is less than the avoided cost of on-peak energy price (\$55.1/MWh) and close to off-peak energy price (\$42.1/MWh). The lowest levelized cost of the group is "Replace Cooking" at \$6 per MW. This measure describes the replacement of conventional commercial cooking equipment with Energy Star rated equipment.

**Figure 26:** Residential technical potential and levelized cost



Source (Figures 27, 28 and 29): Energy Trust of Oregon - Energy and Conservation Measures Resource Assessment for the Years 2010 – 2030

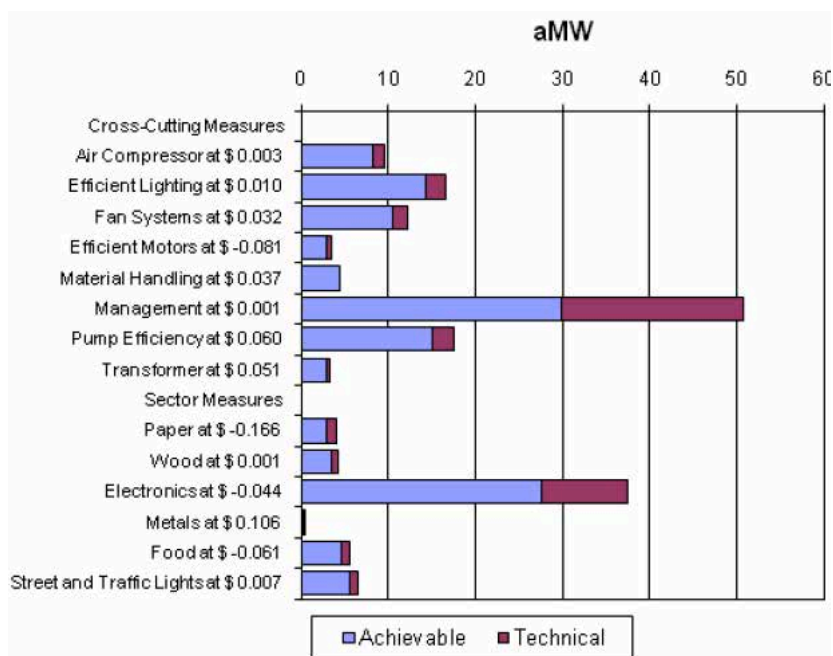
**Figure 27:** Commercial potential and levelized cost



## Industrial

The greatest potential, both achievable and technical, for this sector is energy management at \$1 per MWh. This includes various energy management strategies including having a dedicated energy management staff person. Energy management likely involves a software program integrated with hardware that allows for remote and timed system actions. For example, let's say a building has excellent natural daylight resources. The energy management system could sense how much electric lighting is required at various times of the day to utilize the free daylight while not negatively affecting work conditions. Replacing electronics provides the second greatest potential at a savings of \$0 per MWh, and pump efficiency third at \$60 per MWh.

**Figure 28:** Industrial technical potential and levelized cost



### 6.2.5 Risks and Challenges

While there is significant untapped potential from energy efficiency, there are also a number of challenges that stand in the way of realizing its full potential.

These include, but are not limited to the following:

- High first costs and long payback periods
- Lack of quality information to energy consumers
- Split incentives
- Recognition of externalities

While there are challenges that are applicable to some projects (but certainly not all), in general, there are no fatal flaws associated with energy efficiency. Many technologies are readily available at a cost-effective price, there are no significant regulatory barriers, these measures have been and will be supported in the regional power plan<sup>76</sup> as well as by local utilities<sup>77</sup> through incentives, and there is general consensus about the benefits of energy efficiency.<sup>78</sup>

Many of the existing challenges to the residential and commercial sectors can be mitigated through a combination of financial incentives to upgrade equipment and public education campaigns to inform energy consumers about available incentives, life-cycle costs savings compared to first costs, and the externalities of fossil fuel based electricity generation such as pollution. In addition, information can be used to promote energy auditing services like those offered through Clean Energy Works Oregon to reinforce the benefits of cost-saving behavior changes, such as adjusting the thermostat, using energy-saving settings on computers and televisions, and something as simple as turning off the lights.

Other changes will require regulatory mechanisms to promote increased roll-out of and interest in EE

<sup>76</sup> EE-3

<sup>77</sup> EE-1

<sup>78</sup> EE-13

programs; utilities do not currently have a financial interest in reducing their sales and revenue through energy efficiency programs. Regulations could also be used to increase equipment efficiency standards. Updating building codes could align the interests of homebuilders and homebuyers and provide a model for lease agreements to eliminate a gap that currently exists in the rental market.

Updated building codes and incentives programs through the local utility, the Energy Trust of Oregon, Clean Energy Works and others can also drive investments in efficiency. Further energy efficiency can be realized through public education efforts and the resulting behavior change (adjusting thermostats, turning off the lights or motion sensors, etc.) and utility-driven demand-side management programs.

### ***High First Costs (Investments) and Long Payback Periods***

The first cost of a major energy efficiency project is one of the most significant challenges to energy efficiency technologies. Many of these projects will pay for themselves over time, but competition with other budget priorities and acquiring financing for these projects can be challenging. And while projects do pay for themselves, the payback period can be longer than other competing investments. This long payback period is a direct result of the relatively low current cost of energy. In addition to the capital and O&M costs, staff time required to identify or manage an effort to identify cost-effective projects and industrial equipment upgrades means production downtime adding to the “real” cost of a project.

### ***Lack of Information***

To the trained eye, home improvement stores are an energy saver’s paradise filled with low-E windows, the latest LED lighting, and a lot of caulk. But for others who have neither the time nor inclination to learn the various metrics of efficiency (watts, R-value, etc.) used for different product categories it can mean additional effort to choose the most cost-effective product to meet a particular need.

Energy Star does a good job at establishing a base threshold of efficiency for a number of product classes to assist consumers through the product labyrinth. Since the program began in 1992, Energy Star has saved U.S. consumers over \$250 billion dollars for actions through 2009. However the program could be improved. It currently does not provide an easy to understand comparison of competing products (e.g. the LEED rating system for buildings) for different types of product classes. In addition, the accuracy of Energy Star ratings has been brought into question by Consumer Reports<sup>79</sup> among others, and as a result there is uncertainty about the meaning of the label and the actual savings in energy and dollars. This uncertainty, combined with a lack of easily accessible information at the point of purchase, can result in poor choices based on limited, inaccurate, or inconsistent information.

Recent and current efforts in Southern Oregon seek to address this lack of information. RHT Energy Solutions, an energy-consulting firm based in Medford, conducted a series of energy efficiency workshops early in 2011 beginning with a session on available incentives from the Energy Trust of Oregon.<sup>80</sup> Clean Energy Works Oregon (a public-private alliance with Energy Trust of Oregon) is currently offering free home energy audits to qualifying homes<sup>81</sup> followed by assistance with hiring certified contractors and acquiring financing. RHT Energy Solutions is the ETO’s third-party administrator for energy efficiency and renewable resource incentives for commercial and industrial customers in Southwestern Oregon.

### ***Split Incentives***

The incentives to support EE are not always aligned between various parties. In the case of new home construction, builders have an interest in minimizing the first costs of construction rather than considering the life-cycle costs or comfort of the buyers. Likewise, a rental relationship where a landlord is responsible for maintaining a building but does not pay utility bills, offers no clear incentive to either party to bear the first cost of energy efficiency measures.

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<sup>79</sup> See the Consumer Reports website for more information at <http://www.consumerreports.org/cro/magazine-archive/2010/february/appliances/energy-star-glitches/overview/energy-star-glitches-ov.htm>,

<sup>80</sup> <http://www.oregonlegaljournal.com/main.asp?SectionID=3&SubSectionID=46&ArticleID=302>

<sup>81</sup> See CEW’s website for a list of the criteria <http://www.cleanenergyworksoregon.org/apply-now/>.

## ***Lack of Recognition of Externalities***

The cost of electricity reaches beyond the monthly bill. Collectively, we bear responsibility for the burdens placed on the environment as a result of burning fossil fuels each time we turn on a light or drive our cars. A more general understanding and formal recognition of the relationship between climate change and the other negative health impacts associated with burning fossil fuels could inspire a more rapid shift to more efficient technologies.

### **6.2.6 Benefits and Opportunities**

From a Triple Bottom Line (TBL – economic, social and environmental) perspective, energy efficiency has many benefits.

Economically, the levelized cost of some EE measures is lower than all other generation technologies considered in this analysis. Once the simple payback on the equipment upgrades is reached, energy savings may be felt throughout the local economy as residential, commercial, and industrial owners have more capital available to spend on other things. See Appendix A for a more detailed analysis of the economic and job impacts associated with EE investments. The cost-effectiveness of these measures compared to new generation combined with the vast potential of opportunity creates an economically attractive scenario.

Socially, EE provides local jobs for low-wage workers in the construction field. Temporary construction jobs would be created during development of the other renewable energy technologies discussed in this assessment, but once development is complete these jobs will give way to fewer, higher skilled jobs associated with the operation of the facility. Based on the potential for EE over the next 20 years, it seems reasonable to assume that local businesses could be created, or expanded and sustained to support the resource. Training for a large-scale deployment could be taught at community colleges as it is done in Lane Community College's *Energy Management Program*. In addition reducing total energy consumption provides the community with energy security.

Environmentally, EE displaces the need for electricity generation while performing the same level of work. This could mean displacing fossil fuel power plants (and their associated greenhouse gas emissions and other pollution) during periods of peak load or reducing the need for construction of new generation.

Beyond the general benefits of EE there are also a number of specific opportunities that could be pursued independently or collectively by the appropriate Jackson and Josephine agencies or residents.

### ***Partners***

There are a number of public-to-public agency partnerships as well as public-to-private partnerships that could prove beneficial at developing local EE resources. Many of these relationships already exist and are functioning in the study area. Officials should consider further endorsement or support to help these efforts expand. Local partnerships and information sharing between public and private entities can speed implementation and may be beneficial when applying for financial incentives.

- **Oregon Department of Energy (ODOE):** ODOE has various energy efficiency programs tailored to residences, businesses, industry, public buildings, and schools that provide incentives as well as technical expertise.
- **Energy Trust of Oregon (ETO):** Energy Trust of Oregon is an independent nonprofit organization dedicated to helping utility customers benefit from saving energy and generating renewable energy. ETO services, cash incentives and solutions are available to participating customers of Pacific Power. RHT Energy Solutions is the ETO's third-party incentive administrator for energy efficiency and renewable resources for commercial and industrial customers in Southwestern Oregon.
- **Clean Energy Works Oregon:** In September 2009, Portland began Clean Energy Works Portland as a pilot program to finance energy efficiency retrofits for 500 homes. In April 2010, this program expanded to Clean Energy Works Oregon and is available as of April 2011. This program is funded by the American Recovery and Reinvestment Act of 2009 (ARRA) and has a budget of \$20 million. The goal of

Clean Energy Works Oregon is to finance energy efficiency retrofits for approximately 6,000 homes. Currently, homeowners in Clackamas, Jackson, Josephine, Multnomah, and Washington Counties are eligible to participate in this program.

- **Northwest Energy Efficiency Alliance (NEEA):** NEEA is a nonprofit organization working to maximize energy efficiency to meet future energy needs. NEEA is supported by, and works in collaboration with, the Bonneville Power Administration, Energy Trust of Oregon and more than 100 Northwest utilities on behalf of more than 12 million energy consumers. NEEA works in collaboration with its funders and other strategic market partners to accelerate the innovation and adoption of energy-efficient products, services, and practices.
- **Energy Services Company (ESCO):** An energy savings performance contract (ESPC) is an agreement between an ESCO and a building owner. ESCOs provide services related to the identification, evaluation, recommendation, design and construction of energy conservation measures, including a design-build contract that guarantees energy savings or performance. The owner uses the energy cost savings to reimburse the ESCO and to pay off the loan that financed the energy conservation projects. Agreements with ESCOs are typically for periods of five to seven years.<sup>82</sup> Financing for these projects may be done through the ESCO, private lenders or through the State Energy Loan Program (SELP).
- **Energy Service Providers (ESP):** These organizations provide the expertise and skills to implement various energy efficiency measures. This type of service provider could include an a company like RHT Energy Solutions, who conducts energy audits of heating / cooling systems or lighting system installers.

## ***Buildings Codes***

In 2009, the Oregon Legislature, with the approval of Senate Bill 79, directed the Oregon Building Codes Division (BCD) to increase energy efficiency in buildings that are newly constructed, reconstructed, altered or repaired. These codes are now the base standard and have already had and will continue to have impacts on efficiency.

In addition to increasing efficiency in the statewide mandatory energy code, Senate Bill 79 established a new code called the Reach Code. The Oregon Reach Code is a set of statewide voluntary construction standards for energy efficiency that exceed the requirements of the state's mandatory codes. Rogue Valley builders will have an optional path for high performance construction, and jurisdictions can be assured the innovative construction methods are sound. The Reach Code covers a variety of topics including: mechanical systems, lighting designs, overall building design (both residential and commercial), plumbing practices, and products.<sup>83</sup>

## ***Rating Systems***

Local governments can require energy ratings in new construction, promote voluntary rating programs or offer incentives for the use of ratings. Some building codes also require home energy ratings. A home energy rating involves an analysis of a home's construction plans and onsite inspections to produce a rating or score based on a standard point scale (typically 0 to 100). One of the most common approaches to home energy rating uses the Home Energy Rating System (HERS) Index.

## ***Incentives***

There are various incentives available to help mitigate the first costs and to provide financing for an EE projects. Low cost financing and other creative means will continue to be needed to assist the market, especially in poor economic conditions like those that currently exist.

The following discussion describes the programs available at the Federal, State and Local levels that may be of interest to the residents of Jackson and Josephine counties. For more detail or updates to currently available incentives programs visit <http://www.dsireusa.org/incentives/>.

## **Federal Programs**

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<sup>82</sup> <http://www.oregon.gov/ENERGY/CONS/ESPC/>

<sup>83</sup> <http://www.cbs.state.or.us/external/bcd/programs/reach.html#asst>

- **Residential and Commercial:** The federal government offers residential and corporate tax credits for renewable energy and energy efficiency projects for new home construction as well as retrofits. In 2010 the residential tax credits were 30% of capital cost up to \$1,500 for projects that improved building envelopes, water heating systems and heating and cooling systems. This credit was reduced to 10% of certain types of projects in 2011 and may expire in 2012.

A new bill titled, *The Cut Energy Bills at Home Act*, was introduced as this report is being finalized. The bill would provide a performance based tax credit for residential whole-home energy consumption. The value of the credit begins at \$2,000 for a 20 percent reduction in the energy consumption of a residential home for heating, cooling, water heating, and permanent lighting. The credit increases by \$500 for every additional 5 percentage point increase in energy savings, up to \$5,000. The credit is capped at 30% of the cost of the improvements and expires at the end of 2014. This is an incentive that should be monitored by the EE working group and promoted if passed into law.

- **Industrial:** The Energy Investment Tax Credit (ITC) offers a credit equal to 30% of expenditures with no maximum for solar, small wind turbines, and fuel cells, and 10% for geothermal and combined heat and power (CHP) systems.

### State Programs

- **GreenStreet Lending Program:** Energy Trust of Oregon and Umpqua Bank have partnered to offer this loan to homeowners and small businesses for renewable energy and energy efficiency investments. These loans have no loan fees, no closing costs, and offer preferred rates to homeowners and small businesses interested in certain renewable energy and energy efficiency projects. To qualify for a loan, an individual or business must be a customer of PGE, Pacific Power, NW Natural, or Cascade Natural Gas.
- **Public Purpose Funds for Schools:** The Oregon Legislature passed Senate Bill 1149, which went into effect on March 1, 2002. It provides that PGE and PacifiCorp (parent utility of Pacific Power) must collect a public-purpose charge from consumers within their service areas that is equal to 3% of the total revenues from electricity services. 10% of these public purpose funds must go towards energy efficiency efforts in the public schools within the utility's service area. The administration of the school public purpose funds is being facilitated by the Oregon Department of Energy in cooperation with the Education Service Districts and individual school districts.
- **Tax Credits for Appliances:** Existing credits for Oregon income taxes are available for qualifying appliances in the following categories: dishwashers, refrigerators, clothes washers, heating, ventilation and air conditioning (HVAC), water heaters, wood & pellet stoves, solar energy systems, fuel cells, and wind systems.
- **State Energy Loan Program (SELP):** The purpose of the Program is to promote energy conservation and renewable energy resource development. The program offers low-interest loans to individuals, businesses, schools, cities, counties, special districts, state and federal agencies, public corporations, cooperatives, tribes, and nonprofits. Limited funds are also available for energy evaluations for schools and public buildings.
- **State Home Oil Weatherization Program (SHOW):** The Oregon Department of Energy administers the SHOW Program, which serves Oregon households that heat with oil, propane, kerosene, butane or wood. SHOW-eligible homeowners can conduct their own energy audit and apply for cash rebates for installed weatherization and heating measures. Eligible SHOW homeowners can receive a maximum rebate of \$500 to be used for a variety of efficiency measures.
- **Property-Assessed Clean Energy (PACE):** PACE is a program designed to allow property owners (residential and commercial) to install electric and thermal solar systems and make energy efficiency improvements to their buildings. The cost is paid over 20 years through an annual special tax or assessment on property tax bills.

Oregon has authorized the creation of "local improvement districts" where cities and counties provide financing for the installation of renewable energy systems and energy efficiency improvements to

residential, commercial, industrial or other qualifying real property. HB 2626, enacted in July 2009, authorizes local governments to provide loans for renewable energy and energy efficiency improvements.

*Note: The Federal Housing Financing Agency (FHFA) issued a statement in July 2010 concerning the senior lien status associated with most PACE programs. In response to the FHFA statement, most local PACE programs have been suspended until further clarification is provided.*

### Local Programs

#### Clean Energy Works Oregon (CEWO):

- In February 2011, the Rogue Valley Council of Governments (RVCOG) partnered with Clean Energy Works of Oregon (CEWO) to bring a statewide energy efficiency retrofit program that will help over 100 qualified Jackson and Josephine County homes this year finance and install energy efficiency home improvements, like new insulation or the installation of a high efficiency furnace or water heater.
- Homeowners will have the opportunity to repay their energy efficiency upgrades through low-cost financing, eliminating large upfront out-of-pocket expenses. Homeowners will find a user-friendly application process developed by CEWO, from loan approval to contractor approval.
- There is the potential to retrofit over 60,000 homes in the two counties.
- For more information go to the CEWO website: [www.cewo.org](http://www.cewo.org).

#### Pacific Power (administered through Energy Trust of Oregon):

- For Homes: Pacific Power offers cash incentives through ETO for appliances, heating and cooling systems, windows and insulation, and solar electric systems. These cash incentives are available to single-family residences or property managers. In addition, ETO offers free Home Energy Review for single homes, property owners, and renters. Free weatherization services are available to qualifying low-income homeowners or renters living in single-family homes. Also see the services provided by Clean Energy Works Oregon.
- For Businesses: Cash incentives are available for renovation of existing-building lighting, HVAC systems and installation of solar electric systems as well as for efficient new construction. Technical assistance and incentive programs are also available for improving the energy efficiency of manufacturing, waste water treatment, agriculture, and other industrial processes. For details see ETO's website.<sup>84</sup>

#### City of Ashland Conservation Division:

- Bright Way to Heat Water Loan: Solar water-heating program to residential electric customers who currently use an electric water heater. Under "The Bright Way to Heat Water Program" qualified homeowners may take advantage of the City's zero-interest loan program or a cash rebate. Customers choosing a loan repay as part of their monthly utility bill. Interested customers are provided site evaluations, consumer education, information about available solar systems, and names of qualified contractors.
- Commercial Conservation Loan Program: Zero-interest loans to help commercial customers finance energy efficiency improvements in facilities. The loans can be used for lighting retrofits, water heating equipment, food service equipment and other energy efficient measures. The City of Ashland can provide specific details for proposed projects. Customers should call for a free analysis and details regarding this offering. All equipment and procedural guidelines must be met in order to receive a loan through this program.
- Residential Energy Efficiency Loan Program: Zero-interest loans to help residential customers finance energy efficiency improvements to homes. The maximum loan amount is \$7,500. The loans can be used for a variety of energy saving projects, including solar water heaters, heat pump systems, duct sealing or replacement, replacement windows, and weatherization measures. Contact the City of Ashland for more information on this program.
- Residential Energy Efficiency Rebate Programs: A wide variety of incentives for residential customers to increase the energy efficiency of eligible homes, or build new homes that meet efficient design standards.

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<sup>84</sup> <http://www.pacificpower.net/env/epi.html>

Rebates ranging from \$25 to \$100 are available for energy efficient dishwashers, washing machines, refrigerators, and electric water heaters. State tax credits are also available.

Avista Utilities (Natural Gas only):

- Oregon Residential Weatherization Program: Avista will provide a free in-home inspection to evaluate the cost and benefits associated with weatherization. This free analysis is available to Avista's qualified Oregon residential customers who use natural gas as their main source of heat. After the in-home inspection is complete, customers may request either a cash rebate or a loan from Avista for weatherization.

## 6.3 Hydropower

### 6.3.1 Introduction

Hydropower has the longest development history in Jackson and Josephine counties and is currently the predominant renewable power resource in the region. The Rogue River Basin covers much of Jackson and Josephine counties and the steep terrain and abundance of water in this basin has been the source of most of the hydroelectric resource. For much of the early part of the 20<sup>th</sup> century hydroelectric power was the one of the largest single sources of electricity in the nation, supplying 40% of the electric energy. Currently hydroelectric accounts for only 7% of the electric energy needs in the United States<sup>85</sup> due to a reduction in its growth from environmental concerns associated with dams and the adoption of other fuel sources for energy.

The Rogue River Basin has seen a similar reduction in hydroelectric growth due to the environmental concerns and the designation of much of the Rogue River as 'wild and scenic,' protecting it from development. In addition, there has been restorative work to the areas of the Rogue River with the removal of the Savage Rapids Dam and Gold Ray Dams and the notching of Elk Creek Dam allowing the Rogue River to run unimpeded for 157 miles to the ocean.<sup>86</sup> This type of protection will most likely make the kinds of development that took place in the early 20<sup>th</sup> century unlikely to occur in the future. Although large-scale hydroelectric development may be unlikely to return to the region, there have been extensive studies completed on incremental development to existing structures and small-scale hydro projects that do not pose the same types of environmental concerns. While there are still challenges to these smaller-scale projects, there is potential for new generation.

### 6.3.2 Technology

Hydropower is one of the most efficient means of producing electricity, as the feedstock—water—is transported uphill for free by natural systems (i.e. the hydrologic cycle), providing the potential energy. Hydroelectric generation is regarded as a mature technology and efficiencies have increased to almost 90%. There are two primary types of existing hydroelectric projects: dams that retain and release water in a consistent flow and run-of-river projects that divert a portion of the consistent flow of a river to generate power in real time.

Traditionally, hydroelectricity has been generated through the construction of dams where the stored potential of energy generates power as it moves from a higher elevation to a lower elevation. These projects store large amounts of water behind a dam and can regulate the release of the water through the turbine and can generate electricity year round. These projects can serve as a baseload for energy availability or can ramp up generation quickly to meet peak demand issues (i.e. dispatchable). Due to the large scale of these projects and the associated environmental issues, it is unlikely that any new, large-scale dam and reservoir projects will be developed in Josephine and Jackson counties. However there may be development potential on existing dams that do not already generate electricity.

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<sup>85</sup> Texas Report

<sup>86</sup> <http://www.oregonlive.com/news/oregonian/index.ssf?/base/news/121281811226290.xml&coll=7>

Unlike dams, run-of-river projects do not impound water; instead they divert water and use natural contours of the surrounding land to create head, which powers a turbine to generate electricity. Typical run-of-river projects are affected by seasonal variations in water supply and can have water supply issues due to water rights. These projects do not typically act as a baseload supply of energy; rather they are an intermittent source of generation.

Pumped storage facilities do not capture energy from the natural flow of water, but instead they pump water to a higher elevation and release this water through a turbine to generate electricity when needed. Pumped storage plants do not produce new power; rather, they merely act in an analogous fashion to batteries for storing energy generated by other means. This technology is used to help meet intermittent high demand loads or to help level variable supply loads from other intermittent energy sources such as wind. Pumped storage relies on purchasing power when prices are low to pump the water and generates and sells the power for a premium when demand is high.

### 6.3.3 Resource Potential

There is extensive recent research on the additional resource potential of hydroelectric power generation. Several studies have looked at the incremental addition of electricity generation at existing hydro facilities as well as the potential from small-scale 'run-of-river' facilities.

#### ***Potential at Federal Facilities***

The U.S. Department of Energy (USDOE) in conjunction with the Department of the Interior and the U.S. Department of the Army completed a comprehensive study outlining hydroelectric potential at Federal Facilities as part of the Energy Policy Act of 2005.<sup>87</sup> This study is one of the earliest comprehensive studies of hydroelectric potential nationwide at federal facilities.

The study assessed potential at 871 existing federal facilities, with and without hydroelectric generating capability, assessing their physical capacity for generation or generation expansion and their economic viability based on comparisons with regional electric power rates. The report does not include any assessments of lands not under federal domain or consider new dam construction. The study excluded sites that would be prevented from development due to existing federal land or water use laws that are incompatible with hydroelectric development.

At the time the study was completed, Applegate Dam (constructed and operated by the Army Corps of Engineers), was the only facility in Jackson and Josephine counties that met the screening criteria of the study. The study determined Applegate Dam to be just below the feasibility threshold with a benefit to cost ratio of 0.89<sup>88</sup>, an annual production capacity of 41,600 MWh and a capacity of 9 MW. In 2009 Symbiotics<sup>89</sup> obtained a permit from the Federal Energy Regulatory Commission (FERC) on this facility and is in the engineering stage of development of a hydroelectric power plant.<sup>90</sup> According to its license, Symbiotics predicts additional capacity on this facility beyond the initial estimates in the USDOE study.

In March 2011, the Bureau of Reclamation built on the work of the initial USDOE study utilizing a refined assessment tool.<sup>91</sup> This study reassessed the facilities initially investigated in the 2007 USDOE study and refined the assessment by collecting available flow, head water and tail water elevation data for each site and distance to the nearest transmission or distribution line. Reclamation developed a Hydropower Assessment Tool<sup>92</sup> to estimate potential energy generation and economic net benefits at the identified Reclamation facilities. This study identified Emigrant Dam in Jackson County as a feasible project with a benefit to cost

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<sup>87</sup> H-14

<sup>88</sup> A cost to benefit ratio below 1 is typically considered below the threshold for development whereas a cost to benefit ratio over 1 is prime for development

<sup>89</sup> Symbiotics is a developer of incremental hydro and pumped storage facilities. [www.riverbankpower.com](http://www.riverbankpower.com)

<sup>90</sup> H-1

<sup>91</sup> H-17

<sup>92</sup> <http://gis-ext.inl.gov/vhp/>

ratio of 0.99. In 1991 FERC issued a license on this facility for a 1.8 MW hydroelectric project, which would generate about 15,000 MWh per year.<sup>93</sup> At the time the project was licensed there was a two-year time limit to start construction once the license was issued. The developer was unable to secure a power purchase agreement within the license timeframe and subsequently the project was canceled and has never been developed. It is now common for FERC to issues licenses for a 50-year timeframe.<sup>94</sup>

The Energy Trust of Oregon completed a comprehensive study of irrigation district hydroelectric potential in the State of Oregon.<sup>95</sup> This study evaluated the state's largest irrigation water users to provide base feasibility evaluations, which could result in subsequent development of hydropower projects in Oregon. This study assessed several irrigation districts (ID) in Jackson and Josephine counties and determined that the Eagle Point ID and Talent ID warrant further study. The Talent ID completed a study<sup>96</sup> assessing hydroelectric potential within the district and identified four sites that were economically feasible with a collective nameplate capacity of 0.62 MW and annual generation of 3,300 MWh.

### ***Municipal Opportunities on Existing Facilities***

Several municipal water facilities were identified in Task 1 as being evaluated for the addition of hydropower generation. Most of these projects had either been determined to be infeasible due to technical issues or did not have adequate funding to explore the projects. These types of projects are often small in generation but are typically located near power demand and do not require transmission infrastructure upgrades. Options such as the replacement of pressure-reducing valves on municipal water supplies with turbines for power generation are possible but require additional study to determine the scale of the potential.

### ***Run-of-River***

A hydropower assessment completed in 2006 (*Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants*) by Idaho National Lab (INL) estimates the total resource potential of small hydro (each less than 30 aMW, but greater than 1 aMW<sup>97</sup>) and low-power sites (each less than 1 aMW).

The INL study estimates small hydropower technical potential (i.e. total possible without restriction) using both conventional and unconventional technologies. The approximately 5,400 sites in the U.S. that could potentially be developed as small hydro plants have a total potential of a little over 18,000 aMW. If developed, these projects would result in a greater than 50% increase in total current hydroelectric generation in the United States. Based on this report, Oregon's technical resource potential for projects ranked fourth greatest in the country and equaled 2,072 aMW with potential projects throughout the state.

Within Oregon, the Rogue River Basin has the fourth highest potential behind only the Columbia, the Willamette and the Klamath basins. While this presents a large potential of undeveloped hydroelectric capacity these projects still face large hurdles due to economic challenges of developing small-scale hydropower and environmental constraints such as concerns with water quality and habitat disruption.

## **6.3.4 Costs**

Existing undeveloped hydropower potential, if developed, would provide one of the least expensive sources of power. While the initial capital cost of building the facility can be high, the ongoing operating and maintenance costs are very low. Moreover, since hydropower generation does not require burning fuels, operational costs are not vulnerable to fuel price fluctuations. Hydropower facilities can be very cheap to operate and they can operate for 50 years or more without major replacement.

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<sup>93</sup> H-4

<sup>94</sup> H-28

<sup>95</sup> H-10

<sup>96</sup> H-16

<sup>97</sup> Average megawatt (aMW) is the capacity based on average yearly flows.

Hydroelectric project capital costs vary widely depending on site conditions (e.g. hydrology, accessibility, distance to transmission lines, etc.). In addition to the construction cost variability, hydroelectric facilities are highly resource dependent (i.e. the amount of generation depends on the water year) and the capacity factors typically range from 25 to 85 percent.<sup>98</sup> The type of development for hydroelectric facilities also varies widely. Electricity generation may be added to existing dams or hydro facilities that do not currently generate electricity. Existing generating facilities can be upgraded or expanded, or entirely new hydroelectric facilities can be developed where none currently exist.

A nationwide study was conducted by the Department of Energy that estimated construction costs per kW of capacity. This study determined that in 2003, the nationwide average to develop a hydroelectric project ranged from about \$500 - \$6,000 per kW of installed capacity, with a median about \$2,700/kW for an undeveloped site, and \$700/kW for incremental projects at sites with existing generation.<sup>99</sup> A recent study of the cost of new renewable electricity generation in the western United States estimated the levelized cost of incremental hydropower at existing dams to be between \$10 to \$98 per MWh and the levelized cost of new small and micro hydropower to be between \$57 to \$136 per MWh<sup>100</sup> making hydropower one of the least expensive options for renewable power generation.

The Oregon Department of Energy (ODOE) instituted a Small Scale Energy Loan Program (SELP) in 1980 by initiative of the voters, amending the Oregon Constitution. SELP has been successfully used, based on the state's borrowing authority, since that time. The loan program supported the development of almost all of the irrigation district hydro plants that were constructed in the early 1980s and the loan fund was repaid over the intervening years. Recently, SELP curtailed construction-financing activities and now only provides "take out" funding after construction is complete. Limiting the program to payment after construction makes it generally unusable for most small hydro project proponents as they require large upfront capital financing to get developed.<sup>101</sup>

The Business Energy Tax Credit (BETC) implemented through the Oregon Department of Energy is due to sunset in 2012. Loss of that program is likely to have significant impact on project development. Public entities cannot use a tax credit directly, but the program's pass-through process allows a portion of the future income from renewable energy certificates to be applied against the project development cost.

### 6.3.5 Risks and Challenges

There are extensive challenges and risks in the development of new or incremental hydropower. Although hydroelectric is one of the oldest renewable technologies, much of the early development was completed with disregard for the environment (e.g. habitat destruction, disruption to fish migration, effects on downstream water temperature, loss of sediment deposition, etc.). Increasingly the permitting process for hydropower has become more complex and is requiring longer time frames for execution.

#### **Permitting**

The market for small hydro is segmented by state jurisdictions overseeing permitting. There are different permitting requirements from state to state, and different agencies with which relationships must be built in order to gain entitlements to development. As a result, there are few developers, with the exception of incremental hydro, that operate in multiple regions. In 2007 the Oregon Legislature passed a law (HB 2785) allowing water rights holders with an existing diversion to add a new beneficial use for hydro. This allows projects that meet the requirements of this bill to follow an expedited process relative to the conventional hydro permitting process. The additional beneficial use does not introduce any new water rights; it simply allows the water right holder another non-consumptive use of the water. By piggybacking on the existing water right, the water right holder can bypass some of the complications of the permitting process.

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<sup>98</sup> H-29

<sup>99</sup> H-29

<sup>100</sup> H-31

<sup>101</sup> H-15

## **Land Use**

In addition to the state processes for securing approval for hydro development and clarifying water rights issues where relevant, new hydro projects are also subject to county or city land use ordinances. One irrigation district's biggest barrier to development was navigating the passage of a new zoning amendment at the county level. This irrigation district reported that ODOE is aware of the issue and has determined that none of the counties in Oregon had zoning ordinances in place that would allow, much less encourage, hydro development.<sup>102</sup>

## **Water Rights**

Oregon's water laws are based on the principle of prior appropriation. This means the first person to obtain a water right on a stream is the last to be shut off in times of low stream flows. In water-short times, the water right holder with the oldest date of priority can demand the water specified in their water right regardless of the needs of junior users. If there is a surplus beyond the needs of the senior right holder, the water right holder with the next oldest priority date can take as much as necessary to satisfy needs under his or her right and so on down the line until there is no surplus or until all rights are satisfied. The date of application for a permit to use water usually becomes the priority date of the right to use the water. This can lead junior water rights holders to be at the mercy of water availability and the possibility that generation of electricity can be intermittent based on availability of water. This instability can push incremental and new projects beyond economic feasibility.

## **Environment**

The damming of rivers for small- and large-scale hydroelectric applications has significant environmental impacts. One major issue involves the migration of fish and disruption of spawning habits. For dam projects, one of the traditional solutions to this problem is the construction of fish ladders to aid the fish in bypassing the dam when they swim upstream to spawn. Another potential issue is the flooding of existing valleys that often contain wilderness areas, residential areas, or archeologically significant remains. There are also concerns about the consequences of disrupting the natural flow of water downstream and disrupting the natural course, sedimentation, and soil building.

There are several environmental hurdles and protections a developer must navigate in order to develop hydropower in Oregon. One state permitting requirement that applies to run-of-river projects that can cause complications is the "No Dead Fish Rule" (ORS 543.017(c)). This rule requires developers to demonstrate that there is no net loss of fish due to the proposed project. This requirement is only tied to new water rights and if the project is on an existing facility, the rule does not apply. In addition, there are several federal requirements that can pose extensive upfront work to developing small-scale hydro. Projects must adhere to the requirements of the Endangered Species Act and the Clean Water Act. Hydro development in particular is vulnerable to these regulations and may preclude development, or require extensive studies to show compliance. The Rogue River Basin, for example, has the federal designation of "wild and scenic." This prevents any development within any areas under the designation.

In addition to the above State and Federal designations, there are extensive protected areas as designated by the Northwest Power and Conservation Council (NWPCC).<sup>103</sup> Protected areas are stream reaches where the NWPCC determined that hydroelectric development would cause unacceptable risks of irreversible loss to fish and wildlife. In essence, protected areas are places where fish and wildlife values are judged to outweigh the value of electricity those areas could generate. The protected areas list was completed in 1988; changes to the list were promulgated in 1989, 1990, and 1992. The protected areas designations have continued as a part of the NWPCC's Fish and Wildlife Program dealing with future hydroelectric development.

Under the Northwest Power Act and the Federal Power Act, federal entities—specifically the Bonneville Power Administration, Federal Energy Regulatory Commission, U.S. Army Corps of Engineers, and the Bureau of

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<sup>102</sup> H-10

<sup>103</sup> <http://www.nwcouncil.org/fw/protectedareas/Default.htm>

Reclamation—must consider protected area status and restrictions when making decisions regarding hydroelectric facility permits and access to electricity from those facilities. Inclusion in a protected area does not prohibit hydroelectric development at a site. However, the NWPCC 1) calls on FERC not to license new hydroelectric development in protected areas, and 2) calls on BPA not to acquire the power generated from such a project should one be licensed by FERC, nor to allow access to the Pacific Northwest-Pacific Southwest Intertie (the power grid) in a way that would undermine the protected areas policy.

**Figure 29:** NWPCC protected areas map for Jackson and Josephine counties.

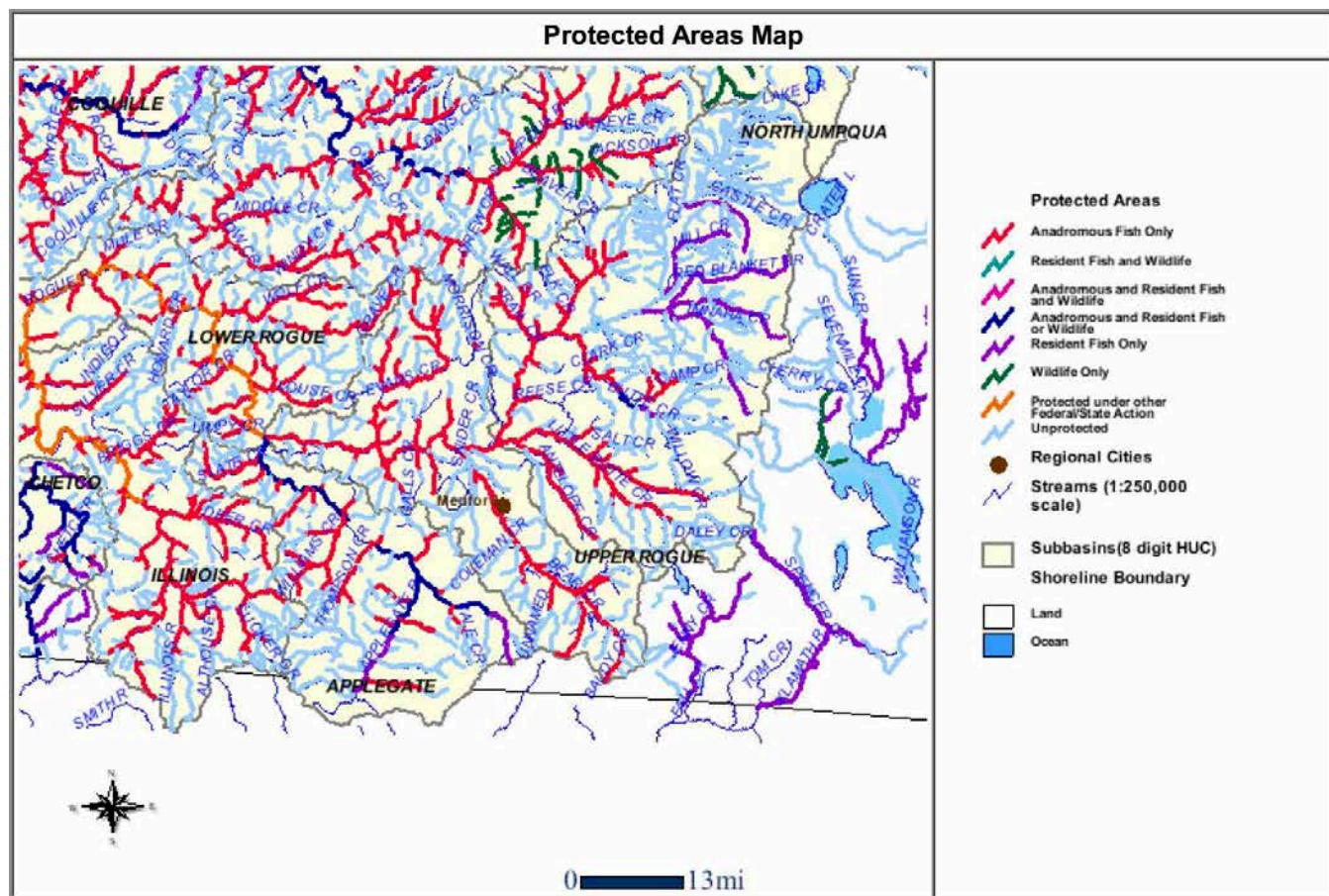


Figure 29 shows the extent of protected streams in Jackson and Josephine counties. The protected areas are extensive throughout the majority of the streams in the Rogue River Basin and limit the possibility of new hydroelectric development to only the upper reaches of most waterways. While these restrictions do limit new development of hydroelectric facilities, incremental improvements to existing facilities are allowed under the rule.

### 6.3.6 Benefits and Opportunities

While the unit cost to develop hydropower is relatively high in comparison with other technologies, it should be considered that hydroelectric facilities offer attractive characteristics that offset the high initial cost, such as long life, no direct fuel costs and low operating costs as well as reliability, dispatchability and peaking power supply potential. Hydropower can be a baseload resource that has the potential to operate 24 hours a day and can be brought on line quickly to help manage peak demand.

One opportunity within the region that shows promise is to conduct a detailed study evaluating the efficiency and hydroelectric potential in all irrigation districts in the region. The project called "Water for Irrigation, Streams and Ecology" (WISE) is aimed at improving efficiency and reliability while improving water quality and implementing conservation measures, and is being led by a group of various water user stakeholders in the

region. This ambitious project has completed the feasibility phase and is currently working to acquire funding for the next phase. The type of extensive capital project being studied provides an excellent opportunity to incorporate hydropower as a component of the work. A project of this type would bring economies of scale that might not otherwise be available to small incremental hydro.

There are also opportunities with municipal facilities for incremental hydropower. Opportunities exist anytime municipal hydro systems are scheduled for upgrades or extensions. Drinking water supply lines, such as the Butte Falls supply line for Medford, will eventually be scheduled for upgrades or replacement. When these types of projects happen the opportunities for coupling the improvement project with hydropower exists and should be studied.

## 6.4 Biomass (Direct Fired)

### 6.4.1 Introduction

The combustion of biomass is one of the oldest forms of energy. First used for heating and cooking purposes, wood was the main source of energy for the world until the mid-1800s.<sup>104</sup> According to the U.S. Department of Energy, “In 2009, biomass production contributed 3.9 quadrillion Btu of energy to the 73.1 quadrillion Btu of energy produced in the United States or about 5.3% of total energy production.”<sup>105</sup>

Biomass power is a baseload power resource. It also has multiple co-benefits including: providing an end use for hazardous forest-fire fuels, reducing wood-waste materials otherwise sent to a landfill, and improving air quality by reducing criteria air pollutants compared to the alternative—open burning of slash material.<sup>106</sup> However, there are also significant concerns including the uncertain cost and availability of feedstock, financing availability, and emerging environmental requirements.

Although the focus of this assessment is electricity generation, it is important to note that the second largest use of biomass energy in the study area is cordwood for residential space heating. According to the U.S. Census Bureau 2010 Census Report, it is estimated that there are up to 70,000 cordwood burning and pellet stoves or fireplaces in the 125,000 living units (56%) in Jackson and Josephine counties. As many as half of those are estimated to use wood as their primary heat source using an average of two cords of firewood per year, or 154,000 tons of biomass for thermal energy per year.

### 6.4.2 Technology

This assessment focuses on direct-combustion technologies, which are used in nearly all of the biomass facilities around the world. Combustion is well understood, proven, and is the most economical technology available. Most biomass power plants use direct-fired systems to produce steam. This steam drives a turbine to generate electricity. The steam from the power plant can have a secondary use as thermal energy in manufacturing processes or to heat buildings. These systems are known as combined heat and power (CHP) systems and greatly increase the overall energy efficiency of the feedstock combustion (from approximately 40% to 80%).<sup>107</sup>

In addition to direct-combustion, there are three other technologies that can be used to convert biomass to energy: physico-chemical, used to produce liquid fuels; bio-chemical, which includes anaerobic digestion; and thermo-chemical, which is the conversion process for direct-combustion. Thermo-chemical conversion also includes pyrolysis and gasification. While pyrolysis and gasification offer future potential, the technologies are still developing and are not yet economically competitive with direct-combustion for electricity generation.<sup>108</sup>

### 6.4.3 Resource Potential

Resource potential for direct-fired biomass is evaluated in two parts: 1) feedstock availability and 2) energy generation potential. The feedstocks evaluated include forest residue (existing slash piles, harvest residue, and potential residue from fire risk management strategies), urban wood residue (yard and C&D waste), crop residue, and mill residue.

#### **Feedstock Availability**

Biomass feedstock is a market commodity and is subject to a variety of market conditions that affect price and availability at any given point in time. These conditions include demand for wood products, the amount of

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<sup>104</sup> B-18

<sup>105</sup> B-19

<sup>106</sup> B-9

<sup>107</sup> B-31

<sup>108</sup> CI-13

feedstock that is economically available, competing sources of demand for woodchips, and the cost of competing sources of energy generation, among others. These variables are dynamic, interrelated, and difficult to predict. The estimates in this report are the best possible based on current information and conditions (as of 12/07/11), but are subject to significant change.

### Forest Residue

Timber harvest residue (i.e. forest residue) represents the majority of underutilized biomass in Jackson and Josephine counties. To estimate the quantity of the forest residue resource, our research team reviewed a number of data sources including Oregon Department of Forestry's (ODF) estimate of slash piles<sup>109</sup>, timber harvest records<sup>110</sup>, interviews with local experts, and the National Renewable Energy Laboratory's (NREL) *BioPower Mapping Application*<sup>111</sup>. Based on these data sources, the range of technically available forest residue is between 26,000 and 84,000 bone dry tons (BDT)<sup>112</sup> per year.

While this feedstock quantity may technically be available, it does not mean that it is cost effective or possible to obtain it. The Bureau of Land Management (BLM) and the U.S. Forest Service (USFS) estimate that less than half of the technically available amount is cost-effectively recovered for transportation to a bioenergy facility. Economically recoverable forest biomass is slash that is delivered to log harvest landings, or piled or windrowed within 100 yards of forest roadways on slopes of less than 25 degrees inclination and within 50 road miles of a biomass power facility.

Oregon Department of Forestry (ODF) conducted a study on the amount of slash that was burned during years 2005 through 2010 on timber harvest and fuel reduction sites.<sup>113</sup> The estimate includes treetops, limbs, branches, shatter, and non-commercial wood. The ODF values represent the best available data to estimate the quantity of available biomass feedstock. Figure 30 shows the estimated slash available by year for Jackson and Josephine counties. ODF reports that the amount of slash burned per year in Jackson and Josephine counties ranged between 130,000 and 175,000 wet tons per year from 2005 to 2010. From the estimate of wet tons it is assumed that 50% of the wet weight is moisture to calculate the weight in dry tons. Of the dry tons it is assumed the 50% of the material is obtainable, which results in a range of between 26,000 and 43,000 BDT per year.

**Figure 30:** Tabular representation of tons of Slash Burned by county for years 2005 – 2010.

Tons of Slash Burned by County 2005 - 2010							
County	2005	2006	2007	2008	2009	2010	Average
Jackson	80,939	89,127	73,656	72,966	70,338	71,370	76,399
Josephine	93,497	77,687	42,356	29,521	66,805	57,918	61,297
Total Wet Tons	174,436	166,814	116,012	102,487	137,143	129,288	137,697
Total Dry Tons*	87,218	83,407	58,407	51,234	68,572	64,644	68,849
Obtainable Dry Tons**	<b>43,609</b>	<b>41,703</b>	<b>29,203</b>	<b>25,617</b>	<b>34,286</b>	<b>32,322</b>	<b>34,424</b>

\*Dry tons are assumed to be 50% of wet weight.

\*\*Of the total dry tons 50% are assumed to be obtainable.

ODF also tracks timber harvests by county. Figure 31 shows the harvest in thousand board feet (MBF) for Jackson and Josephine counties between 2005 and 2010, by landowner. The six-year average for all landowners is almost 88,000 MBF for Jackson County and 28,000 MBF for Josephine County. Forests with

<sup>109</sup> B-25

<sup>110</sup> B-28

<sup>111</sup> B-11

<sup>112</sup> This estimate of potential does not include any forest residues from pre-commercial thinning, fire risk reduction or other forest health stewardship activities.

<sup>113</sup> B-24, B-25

the biomass density indicated in the ODF's *Forest Inventory and Analysis (FIA)* data for Josephine and Jackson counties usually produce between 0.5 and 0.9 tons of biomass residue in excess of forest soil building requirements per 1,000 board feet of timber production.

Assuming that only half the available amount is cost-effectively recovered for transportation to a bioenergy facility and using the averages from timber harvests between 2005 and 2010<sup>114</sup>, there are between 28,900 BDT and 52,000 BDT of residue accessible after timber harvest for biomass power in Jackson and Josephine counties. Figure 31 shows the harvest data from ODF broken down by year, county, and land ownership in addition to the estimated BDT of forest residue available from the harvests. It's important to note that a portion of the biomass materials estimated using this ODF data source is potentially already recovered and utilized at Biomass One or other existing biomass facilities in the study area.

**Figure 31:** Timber harvest and average by county for years 2005 – 2010 and range of residue.<sup>115</sup>

Jackson County Timber Harvest (MBF) <sup>116</sup>								Average Forest Residue Available per Year (BDT)	
Landowner	2005	2006	2007	2008	2009	2010	Average	Low	High
Forest Industry	67,702	81,374	54,818	69,027	46,140	68,491	64,592	32,296	58,133
Other Private	6,734	6,666	5,674	2,218	331	2,598	4,037	2,018	3,633
State	-	1	-	-	-	12	2	1	2
BLM	12,463	7,102	645	4,728	25,869	5,509	9,386	4,693	8,447
USFS	7,983	3,210	12,574	15,473	5,280	11,216	9,289	4,645	8,360
Other Public	2,669	237	3	326	-	-	539	270	485
Totals	97,551	98,590	73,714	91,772	77,620	87,826	87,846	43,923	79,061
Josephine County Timber Harvest (MBF)								Average Forest Residue Available per Year (BDT)	
Landowner	2005	2006	2007	2008	2009	2010	Average	Low	High
Forest Industry	16,244	17,043	13,686	12,104	15,019	11,047	14,191	7,095	12,771
Other Private	12,373	6,142	3,767	2,710	1,497	1,643	4,689	2,344	4,220
State	1	297	710	181	696	-	314	157	283
BLM	1,367	1,464	-	202	177	789	667	333	600
USFS	23,889	4,055	-	-	73	2,887	5,151	2,575	4,636
Other Public	2,367	1,384	4,239	5,405	1,837	1,322	2,759	1,380	2,483
Totals	56,241	30,385	22,402	20,602	19,299	17,688	27,770	13,885	24,993
Total Forest Residue (Jackson + Josephine)								57,808	104,054
Cost-Effective Collection Total (50% of J&J Total)								28,904	52,027

The National Renewable Energy Laboratory's *BioEnergy Atlas* data estimates there are 122,024 BDT of forest residue available per year in Jackson county and 46,468 BDT per year in Josephine County, for a total of 168,492 BDT in the study area. Of this total, 50% is assumed to be obtainable or 84,246 BDT.

Based on these sources, the range of available biomass quantities is between 26,000 and 84,000 BDT per year. The most realistic point value for obtainable biomass is 34,000 BDT per year, which comes from the slash pile estimates. However, it's important to note that these data sources are based on visual estimates, not measurements of quantity, made by ODF staff.

<sup>114</sup> B-28

<sup>115</sup> B-24

<sup>116</sup> B-28

In addition to reviewing data on the subject, our research team interviewed the Forest Energy Group (FEG), the largest biomass supplier in the study area, multiple times over a period of several months. The changes in the information they provided are illustrative of the dynamic biomass marketplace. When first contacted in mid-summer 2011, FEG staff estimated there were 70,000 BDT of forest residual feedstock in the study area, which is almost identical to the estimate of total dry tons based on the ODF slash data.

Since that time their estimate of available feedstock has been reduced by 50% to 35,000 BDT. The difference is the result of a shift in the demand from pulp wood markets, or in other words the price that industry is willing to pay has risen to a point where it became cost effective to collect the additional biomass. Specifically, pulp wood exports to China have increased the value of treetops for pulpwood. The treetops have typically been left in the slash piles created from logging operations, but are currently going to Roseburg Forest Products. Roseburg Forest Products is purchasing the treetops and processing them into pulpwood. The pulpwood is transported to North Bend for export to China.

According to FEG, the remaining 35,000 BDT is obtainable, but at a price point that is too high to support electricity generation based on current market conditions. As electricity prices rise, collection of this feedstock will become economically viable, but currently the delivered price for this material is \$65 per bone dry ton. The most feasible of this feedstock is located on the industrial forests located from the Butte Falls area to Diamond Lake.

FEG also reported that poor lumber markets have reduced the commercial harvests on industrial land, thus reducing the amount of available biomass.

#### Fire Risk Management Strategies - Forest Residue Potential

The estimate for available forest residue does not take into consideration any further fire risk management strategies that could be employed on BLM land, which would significantly increase the availability of local biomass feedstock. An estimate reported in 1999 to former Jackson County Commissioner, Sue Kupillas, stated that the 2.6 million acres of Federal lands within the Rogue Basin contain an estimated six billion board feet (BBF) of materials in trees under 12 inches diameter. The details of the study called out 2.4 BBF that are 1,000 feet from existing roads and located on slopes with less than a 40 percent incline.<sup>117</sup>

Using the assumption that per 1,000 board feet between 0.5 and 0.9 tons of biomass residue exists, there is an estimated 1.2 to 2.2 billion BDT of biomass available from fire risk management strategies on all BLM forest lands in Jackson and Josephine counties. This estimate does not account for forest growth since the BLM report was completed. If these estimates are accurate and fire risk management strategies were employed on 1% of the federal acreage per year (26,000 acres) it could yield an additional 13,000 to 23,000 BDT per year.

However, there is too much uncertainty regarding the rate of federal forest stewardship activity, federal funding for that activity and lands with current environmental impact allowance, to include this potential feedstock in the total forest residue estimate.

#### Urban Wood Waste and Construction & Demolition Wastes

Available quantities of urban wood waste (including construction and demolition materials) are relatively small, considering Biomass One is already drawing on this source of feedstock for its current operations.

Two sources were used to estimate the annual range of urban wood waste of between 12,000 and 42,000 BDT per year. In the *Biomass Feasibility Study for the Applegate Watershed*, recoverable yard debris and wood waste in Jackson and Josephine counties is estimated to be 12,620 BDT per year.<sup>118</sup> According to NREL's

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<sup>117</sup> B-29

<sup>118</sup> B-4

biomass study, the feedstock availability is estimated to be 42,462 BDT per year total for Jackson and Josephine counties.<sup>119</sup>

It is assumed that Biomass One already recovers a large percentage of this estimated quantity, stating on its website that it recovers wood waste from six county landfills in Southern Oregon and Northern California and provides drop box services for construction debris, trimmings and other waste from the public.<sup>120</sup>

### Crop Residue

According to the *Biomass Feasibility Study for the Applegate Watershed*, peach pits and orchard removal make up the majority of the crop residue of 4,670 BDT per year based on 2006 data.

### Mill Residue

There is general consensus that the majority of mill residue currently produced in Josephine and Jackson counties is already being utilized at existing mills in their onsite boilers.<sup>121</sup>

## ***Energy Generation Potential***

### Electricity Generation Potential

In total, there is the technical potential for new biomass power facilities with a total nameplate capacity of between 5 MW and 14.5 MW per year plus thermal energy if the system is combined heat and power (CHP). This range of capacity can be expected to generate between 30,000 and 96,000 MWh per year. Forest residue represents between 4.2 to 13.7 MW,<sup>122</sup> with an additional 0.8 MW<sup>123</sup> (or 5,335 MWh per year) available from crop residue. Urban wood waste and mill residue are assumed to be already utilized in existing facilities and as such not included in this estimate. In addition, forest residue from fire management is also excluded from this estimated based on the previously stated uncertainty associated with this source.

### Existing Boiler Conversion Potential

While this report focuses on electricity generation, there is also potential in the area for boiler conversions to biomass. The State of Oregon Boiler Master List of licensed pressure vessels identifies boilers using all fuels across the state. Listed biomass boilers in Jackson and Josephine counties only include those at industrial sites.<sup>124</sup> Figure 32 identifies institutional and commercial boilers using natural gas, oil, propane and electricity, but not the recent addition of biomass thermal boilers at schools in Jackson and Josephine counties. The conventional fuel boilers on the list vary in capacity from 300,000 BTU per hour up to 4 million BTU per hour. Boilers using propane and oil typically have a seven- to ten-year simple return on investment for converting to biomass fuels.

There are thirteen boilers in the study area that have potential for cost-effective conversion to woody biomass, ideally wood pellets. Natural gas fueled boilers do not lend themselves well to conversion due to the lower existing fuel cost (\$6.0 per million BTUs) compared to oil and propane boilers (\$22 per million BTU's). Premium wood pellets at \$200 per ton cost \$16 per million BTU's (\$200 divided by 12 million BTU's per ton). Figure 32 identifies biomass conversion candidate boilers in Jackson and Josephine counties. The estimated annual pellet demand from boilers of this capacity and typical loading rates is between 1,800 and 2,400 tons of woody biomass pellets per year. That would offset between 216,000 to 280,000 gallons of heating oil and propane per year.

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<sup>119</sup> B-1

<sup>120</sup> B-2

<sup>121</sup> B-10

<sup>122</sup> B-11: Calculations used variables from Biopower Map

<sup>123</sup> B-11

<sup>124</sup> B-30

**Figure 32:** Existing boilers in Jackson and Josephine counties with biomass conversion potential

fuel_desc	site_name	site_addr1	site_city	site_contact_name	site_phone	MANUF_YR
PROPANE	PROSPECT HIGH	160 MILL CREEK DR	PROSPECT	GERG SINCLAIR	541 5603653	1980
OIL	ROCK N READY MIX	6960 BLACKWELL RD	CENTRAL POINT	WES NORTON/JOHN WR	541 6642292	2000
OIL	ST. ARNOLD APTS	1005 W MAIN ST	MEDFORD	NICK	541 6460636	1950
OIL	PINEHURST ELEM	15337 HWY 66	ASHLAND	JIM TITUS	503 4821910	2005
OIL	JOSEPHINE CO OFFICE	102 S REDWOOD HWY	CAVE JUNCTION	TOM		1998
OIL	HIDDEN VALLEY HIGH	651 MURPHY CREEK RD	GRANTS PASS	LLOYD	541 4766304	2008
OIL	LINCOLN SAVAGE MIDDLE	8551 NEW HOPE RD	GRANTS PASS	LLOYD	541 4766304	2004
OIL	FT VANNOY ELEM	5250 UPPER RIVER RD	GRANTS PASS	LLOYD	541 4766304	2008
OIL	LORNA BYRNE MIDDLE	101 S JUNCTION AVE	CAVE JUNCTION	JAMIE	541 5922163	2002
OIL	LORNA BYRNE MIDDLE	101 S JUNCTION AVE	CAVE JUNCTION	JAMIE	541 5922163	2002
PROPANE	TAYLOR SAUSAGE	525 WATKINS ST	CAVE JUNCTION	TERRY TAYLOR	541 5924185	1986
OIL	OREGON CAVES NATION	19000 CAVES HWY	CAVE JUNCTION	JOHN CAVIN	541 5922100	2003
OIL	JEROME PRAIRIE ELEM	2555 WALNUT AVE	GRANTS PASS	LLOYD RUSSELL	541 4766304	2007

## 6.4.4 Cost

The levelized cost for biomass ranges between \$65 to \$151 per MWh.<sup>125</sup> Biomass has a comparable levelized cost to other technologies, however it has two large sources of uncertainty other technologies do not—the cost and availability of feedstocks and the regulatory future of combustion emissions.

### Construction and Operational Costs

From the Applegate Watershed study, the project size investigated was between 4.8 MW to 6.5 MW capacity. The capital cost was between \$12.2 million and \$13.2 million, or between \$2 and \$2.5 million per MW. The O&M cost range was \$3.7 to \$4.1 million per year which included fuel cost estimates, or between \$0.8 and \$1.6 million dollars per year.<sup>126</sup> For a 15 MW or greater project, the total project cost is estimated to be \$4,000 to \$5,000 per kW.<sup>127</sup>

### Feedstock Costs

According to the *Biomass Feasibility Investigation for the Applegate Watershed*, estimates for feedstock range from \$24 per BDT for crop residue (listed as agriculture byproducts in Figure 33 below) to \$60 per BDT for forest residue from timber harvests. The cost of feedstocks can significantly affect the feasibility of a project. Another biofuels study that TSS Consultants conducted for Southern Oregon University forecasted the price of forest residue at \$45 per BDT.<sup>128</sup> Biomass One reports that feedstock prices are typically in the range of \$35 – 40 per BDT, but as this report was being prepared is paying \$42 per BDT.

**Figure 33:** Delivered feedstock price range.<sup>129</sup>

Fuel Type	Low Estimate	High Estimate
Timber Harvest Residuals	\$35	\$60
Fuels Treatment - Public	\$50	\$54
Fuels Treatment - Private	\$50	\$54
Urban Wood	\$30	\$40
Forest Products Residuals – hog fuel (market value plus transport)	\$35	\$45
Agricultural Byproducts – Peach Pits	\$24	\$29
Agricultural Byproducts – Orchard Removals	\$35	\$40

<sup>125</sup> CI-14, CI-3

<sup>126</sup> B-4

<sup>127</sup> CI-14

<sup>128</sup> B-42

<sup>129</sup> B-4

## ***Incentives***

Due to the uncertain cost of feedstock and the low cost of electricity currently in Jackson and Josephine counties, incentives will play an important role in the near-term feasibility of biomass projects. Incentives that are unique to biomass are discussed below; for a general discussion of renewable energy incentives refer to the *Context* section 5.4.2.

### **Combined Heat & Power Tax Credit (CHP)**

In Section 48 of the Federal tax code is a combined heat and power (CHP) investment tax credit (ITC) of up to 10% for projects that use steam for both electricity generation and process heat.<sup>130</sup> Most forest products-based projects would qualify for this incentive. In order to qualify, at least 20% of the net heat must be used each for power generation and process heat.

The CHP credit also has an efficiency and size test. The full 10% ITC can only be claimed if the project has an overall thermal efficiency of 60% (power plus steam) –a difficult standard for a biomass project. A prorated amount is awarded for lower efficiencies. Also, the full credit is available only up to 15 MW of capacity, with reductions for larger projects and a full phase out at 50 MW. Any project must be in service by 2016 to qualify.

With the recent extension of the production tax credit PTC/ITC election, also in Section 48, there is now language that does not allow a party to take both the PTC/ITC and the CHP credits, but must choose between them.

### **Biomass Producer and Collector Tax Credit (BPC)**

The State of Oregon provides tax credits to subsidize the production, collection and transportation of biomass that is used for energy production.<sup>131</sup> This incentive provides up to \$10 per BDT for collection of various biomass. The tax credit recently changed from \$10 per green ton to \$10 per bone dry ton. The Oregon Department of Energy is evaluating other changes to the program including what types of woody biomass qualifies for the tax credit.

In general, financial incentives for biomass energy production are being reduced. The federal investment tax credit buyback authorized under ARRA expires at the end of 2012. That could provide a 30% offset to the cost of construction of up to \$30 million. This incentive sunset reduces financier appetite for biomass investment. Furthermore, Oregon Business Energy Tax Credits are being reduced and there is higher uncertainty of their availability due to program competitiveness requirements that show no preference for baseload characteristics of biomass or other external benefits such as forest health and fire risk reduction.

## **6.4.5 Risks**

### ***Environmental Concerns***

#### **Air Quality**

Air pollutants associated with biomass power include: particulate matter (PM), volatile organic compounds (VOC), carbon monoxide (CO), nitrogen oxide (NOx) and sulphur oxide (SOx). Emission controls can significantly reduce emissions from a biomass system. While the emissions from power generation facilities are considered point source, they generally reduce the absolute emissions compared with the open-air slash-burning alternative.<sup>132</sup> Pending U.S. EPA requirements for the application of Maximum Achievable Control Technology (MACT) may require new woody biomass plants to include urea injection systems on exhaust flues that could prohibitively increase biomass cogeneration costs for systems applying for new air quality permits.

#### **Land Use**

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<sup>130</sup> CI-7

<sup>131</sup> B-33

<sup>132</sup> B-37

Choosing where to site a biomass project can be difficult. Locating the facility far enough away from population corridors to avoid potential issues with noise and emissions will be important. Finding land already designated as brownfield may mitigate some potential community issues. In addition, sites with electric turbine generators over 1 MW should be within 2 miles of a 69 kilovolt power distribution line to avoid prohibitive power line extension costs that can be upwards of \$1 million per mile.

### Water

Water is necessary for a biomass system using a steam-generated turbine. Most water can be recycled or evaporated. If water were discharged it would require treatment.

### Sourcing Feedstock

Environmental concerns associated with feedstock include ensuring sustainable harvesting and collection practices in order to avoid harming habitat and wildlife and the loss of topsoil to the greatest extent possible. When evaluating forest residue feedstocks it is essential to refer to the *Principles for Sustainable Biomass*<sup>133</sup> to avoid inadvertent habitat impacts and the likely controversy that is a substantial threat to operations. These principles were developed by a collaborative of environmental groups and highlight important considerations when developing biomass projects. Several of the principles refer to the impact of sourcing feedstock from forests. This is specifically pertinent to the discussion of feedstock availability for Jackson and Josephine counties.

Prominent among wildlife-related concerns is the Northern spotted owl, listed as an endangered species for 21 years. As part of the recovery plan for the spotted owl, logging practices significantly changed in Oregon. Soil nutrient loss and soil compaction from displacing biomass must also be considered. Soil becomes more exposed after thinning, increasing the likelihood of erosion, loss of nutrients and decreasing its ability to absorb water. The nutrients that would remain if the slash were not collected for energy generation would be those post open burning. This burning will create air and carbon emissions that exceed the emissions of the energy facility substantially in absolute emissions terms.<sup>134</sup>

Another common concern is the use of whole logs for energy purposes alone. While this practice seems unlikely given the basic economics of lumber production and harvest, this concern does apply to forest thinning and reduction of beetle kill devastated stands.

To avoid much of this risk, use of industrial by-products, slash, and waste materials are the best choices for biomass feedstock.

### Community

There are multiple environmental issues that may become barriers to gaining community support including odor, sound, emissions, and air quality concerns. Opinions about biomass use as an energy source and the political tension between logging and environmental concerns are a genuine factor in evaluating a potential project.

## ***Physical and Economic Constraints***

The report released by Energy Trust of Oregon, *Phase II Biopower Market Assessment Sizing and Characterizing the Market for Oregon Biopower Projects*, states, "The primary obstacle is uncertainty regarding fuel-supply: the lack of a dependable contractual mechanism to assure that forest waste resources will be available throughout the life of a project with enough certainty to justify a major investment in a power generation project."<sup>135</sup> Given that the historic method for sourcing biomass has occurred on a commodity or daily handshake basis, many investors are reluctant given that the facilities must run for many years in the

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<sup>133</sup> B-21

<sup>134</sup> B-9

<sup>135</sup> B-10

future before returning the investment to their owners. For this reason, private investment is likely to come from existing groups with experience in the wood products or forestry industries.

At the other end of the spectrum, the off-take side, there are two pieces of uncertainty: the current price of other sources of electricity and the ability to negotiate a power purchase agreement with only one party. According to *Oregon Biomass Market Assessment*, “The highest rated deterrent to project development by respondents was that the retail electric energy prices in Oregon limit the competitiveness of biomass fueled self generation.”<sup>136</sup> While the capital costs for developing a cellulosic fuels plant are significantly higher per unit of energy production, the ability to sell the energy product to a wider array of parties and at higher cost per million BTU's ensures more flexibility, ability to negotiate price, and a relative economy of scale. However, cellulosic ethanol production from high lignin woody biomass (soft and hardwood conifers) is difficult and not commercially competitive at current gasoline and diesel prices in North America.

Sourcing feedstock has multiple barriers including seasonality, ability to transport feedstock economically, storage, moisture content of the feedstock and availability of affordable sources.<sup>137</sup>

Other constraints discussed in the general context section include the price of electricity in the region, utility interconnection and operating surcharges, lack of financial recognition of environmental benefits and lack of federal policies creating a price for carbon dioxide in an effort to reduce greenhouse gas emissions and the effects of climate change.

### ***Permitting and Regulations***

Coordination between the multiple permitting activities, including securing both a wastewater permit and air emissions (Title V Operating) permit, is required by Oregon Department of Energy.<sup>138</sup>

#### Land Use

Electrical generating facilities are only allowed in industrially zoned property in Jackson and Josephine counties. Individual land use permit requirements will need to be met in order to site a facility. Depending on where the facility is sited, zoning change and a Conditional Use permit may have to be obtained.<sup>139</sup>

#### Water

A wastewater discharge permit from Oregon Department of Environmental Quality (ODEQ) will be necessary. Also, a stormwater discharge permit will be needed if feedstock is stored onsite and uncovered. A plan will be required for stormwater pollution prevention for the storage yard and facility.<sup>140</sup>

#### Air Quality

##### *National Ambient Air Quality Standards (NAAQS)*

The Medford-Ashland urbanized area attained non-attainment status first in 1985 for O<sub>3</sub> (Ozone) emissions and was in violation again in 2001 for excessive carbon monoxide (CO) emissions. Currently, the Medford-Ashland area is a maintenance area.<sup>141</sup>

ODEQ air quality standards may affect the feasibility of biomass projects. Non-attainment areas are required to implement strategies to improve air quality and meet National Ambient Air Quality Standards (NAAQS), meaning for new biomass facilities specialized equipment may need to be implemented to reduce emissions. Additions to capital cost will lower the returns and make projects less attractive. Compliance with maintenance plans and reduction targets is a disincentive for businesses to locate biomass facilities in non-attainment

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<sup>136</sup> B-9

<sup>137</sup> B-4

<sup>138</sup> B-4

<sup>139</sup> B-4

<sup>140</sup> B-4

<sup>141</sup> CI-26

zones. Regional air quality non-compliance costs are not typically associated, valued or in a feasibility analysis, due to the amount of speculation and difficulties identifying exact dollar amounts.

There are options to mitigate air quality through lower cost pollution reduction programs such as weatherization and woodstove upgrades or replacements. A good example of this is the Warm Homes - Clean Air program run by Lane Regional Air Protection Agency, through a grant from ODEQ.<sup>142</sup>

#### *Title V*

An Air Contaminant Discharge Permit from the ODEQ would also have to be obtained, and if the facility were listed as a major source of air emissions, the facility would have to go through the Title V permitting process.

Title V of the 1990 Federal Clean Air Act requires each state to develop a comprehensive operating permit program for major industrial sources of air pollution. The Title V Operating Permit program places responsibility on businesses for monitoring, reporting and certifying compliance. For facilities that have the potential to emit 100 tons per year of any criteria pollutant or for hazardous air pollutants emitters (which either have the potential to emit 10 tons of any single hazardous air pollutant or a combination of 25 tons of hazardous air pollutants) a Title V Operating Permit is required.<sup>143</sup>

The EPA also recently forwarded new rules under their Clean Air Act authority for public review. The rules, as proposed, will require new woody biomass generation and biomass thermal facilities to meet particulate matter (2.5 micron) and nitrogen oxide emissions requirements that call for the use of Maximum Achievable Control Technology (MACT). Those controls would include urea injection systems or other tertiary treatment of exhaust emissions in addition to electrostatic precipitators.

#### *EPA Boiler Rule*

The EPA also set forth the industrial/commercial/institutional boiler and process heaters rules under the Clean Air Act.<sup>144</sup> The new rule affects local boilers by changing the reporting requirements and standards of maintenance. Major facilities will be required to file new forms that prove that annual maintenance was performed and completed. This type of annual maintenance is in line with requirements in warranty contracts and industrial standard practices. This will affect businesses that do not keep boilers continually maintained and will have a greater effect on older boilers. Later in a boiler's life businesses try to minimize inputs to the capital assets and maximize profits. This rule has the possibility of raising the life-cycle cost of a boiler at the end of its useful life.

The effect on area boilers, boilers that emit less than 10 tons per year of any single air toxin, or less than 25 tons per year of any combination of hazardous air pollutants, will require more financial investment from owners. Maintenance must be conducted every two years. Moving from a particulate emissions code to a standard practice will affect small boilers more. Many of the smaller area boilers do not follow the same strict maintenance protocols as the major boilers. Many of these companies have tighter budgets and run the boilers to specifications as long as possible without routine maintenance.

The new EPA rules will not have substantial effects on large-scale biomass projects. If increases in late stage maintenance are required, the effects will be minimal on net present value and internal rate of return due to the discount effect on future cash flows.

The EPA released a reconsideration notice the same day it released the Boiler rule, however that does not necessarily postpone compliance. All rules can be found at the EPA's industrial/commercial/institutional boiler and process heaters web page.<sup>145</sup>

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<sup>142</sup> B-36

<sup>143</sup> B-34

<sup>144</sup> CI-27

<sup>145</sup> CI-28

## EPA GHG Reporting Requirements

The EPA is deferring its greenhouse gas permitting requirements for carbon dioxide emissions from biomass-fired and other biogenic sources for three years. During this deferral period, EPA will conduct a detailed examination of the science associated with biogenic carbon dioxide emissions from stationary sources. This study will consider technical issues that the EPA must resolve in order to account for biogenic carbon dioxide emissions in ways that are scientifically sound and also manageable in practice.

## Carbon Neutrality Questioned

Until recently, biomass power was described as carbon neutral—in other words, emitting a net amount of zero greenhouse gas emissions. Recently, that logic has come under fire. An article in *Science* summarizes the issues: “It does not count CO<sub>2</sub> emitted from tailpipes and smokestacks when bioenergy is being used, but it also does not count changes in emissions from land use when biomass for energy is harvested or grown. This accounting erroneously treats all bioenergy as carbon neutral regardless of the source of the biomass, which may cause large differences in net emissions.”<sup>146</sup>

Biogenic GHG emissions are those carbon dioxide emissions associated with the combustion of non-fossilized, biologically based materials, such as biomass (e.g. wood waste), and biofuels (e.g. biodiesel). Carbon dioxide emissions from the combustion of these biologically derived fuels are generally considered climate neutral because they are a part of a naturally occurring biological carbon cycle. However, the actual carbon benefits of biologically based fuels, in terms of mitigating climate change, depend largely on the source of feedstock materials, the combustion technology and the fossil fuel it displaces. The discussion is leading policy makers to question what forms of biomass power should qualify as renewable energy, which could affect the incentives that specific sources of biomass feedstock and biomass power projects are eligible for in the future.

In general, environmental requirements are becoming more expensive and rigorous for biomass energy development. The additional cost of those controls, the potential for Jackson and Josephine counties to be out of attainment for any one criteria air pollutant and the waning availability of incentives to offset cost, combined with higher fuel, point to increased development and operational project costs.

## **6.4.6 Benefits and Opportunities**

### ***Environmental***

Biomass projects that make use of feedstock from forest fire fuel management projects help restore balance to forests<sup>147</sup> that are prone to catastrophic fires. The *Rogue Basin Collaborative Forest Restoration Project* states, “Restoration treatments provide a clear opportunity to balance the need for reintroduction of fire while minimizing uncharacteristic effects and reducing risk to communities.”<sup>148</sup>

Forest fire management practices also reduce the threat of declining biodiversity of the forest, which is currently shifting from a landscape dominated by large-diameter trees to a dense infill of small-diameter trees.<sup>149</sup> Figure 34 shows a map of the fire hazard for the study area.

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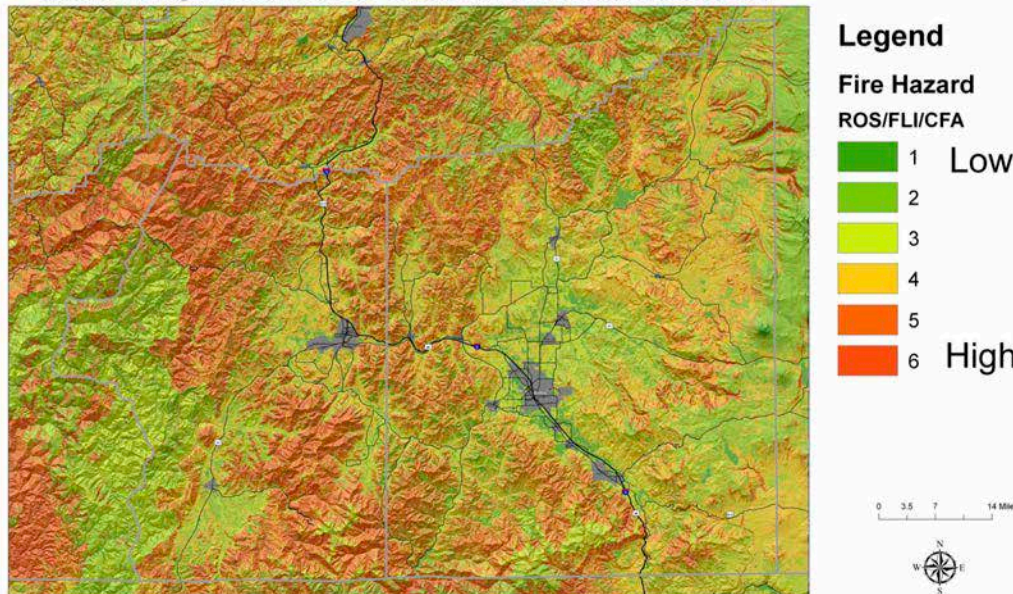
<sup>146</sup> B-23

<sup>147</sup> CI-12

<sup>148</sup> B-14

<sup>149</sup> B-14

**Figure 34:** Small Diameter Collaborative map of the fire hazard in Jackson and Josephine counties<sup>150</sup>



Oregon's Forest Practices Act documents the treatment (disposal) of slash as a necessary tool for the protection of reproduction and residual forest stands from fire, insects and disease to prepare the site for future productivity and to minimize the risk of material entering streams.

Compared to open burning of slash piles or forest fires, biomass power reduces emissions released into the atmosphere.<sup>151</sup> Open burning of slash creates visible smoke and particulates, and significant quantities of nitrogen oxide (NO<sub>x</sub>), carbon monoxide (CO), and hydrocarbon emissions that contribute to the formation of ozone. The processing of slash at a biomass cogeneration plant significantly reduces the smoke and particulate emissions associated with open burning and significantly reduces other emissions released to the atmosphere.<sup>152</sup>

Figure 35 shows the comparison of emissions associated with open burning compared to a biomass facility from the technical paper titled, *Emission Reductions from Woody Biomass Waste for Energy as an Alternative to Open Burning*.<sup>153</sup> The technical paper shows that the biomass project emits significantly less emissions than open burning.

**Figure 35:** Table of emissions comparison of open pile burning vs. biomass energy.

Operation	Air Emissions (t)						
	NO <sub>x</sub>	PM	NMOC	CO	CO <sub>2</sub>	CH <sub>4</sub>	CO <sub>2</sub> e <sup>a</sup>
Baseline, open pile burning							
Open pile burning	17.37	37.65	28.96	362	10,618	17.37	10,983
Displaced power from grid	0.47	0.28	0.06	1	2,733		2,733
Total	17.84	37.93	29.02	363	13,352	17.37	13,717
Biomass project							
Boiler	6.58	0.98	0.22	9	11,178	0.55	11,189
Process and transport							
Grinding	0.43	0.52	0.02	1	73	0.04	74
Loading	0.31	0.01	0.01	0	19	0.03	19
Chip van transport	0.91	0.02	0.03	2	118	0.05	119
Total	8.23	1.53	0.28	12	11,388	0.70	11,402
Emissions reductions	9.62	36.39	28.74	350	1,965	16.7	2,315
Percent reduction	54%	96%	99%	97%	15%	96%	17%

<sup>150</sup> B-22

<sup>151</sup> B-9

## Social

A survey commissioned by the Southern Oregon Small Diameter Collaborative found that a majority (66%) of the residents polled approve of thinning small trees primarily to reduce the risk of forest fire.<sup>154</sup> Air quality could potentially be improved for communities if biomass power replaced open burning of forest residue.

## Economic

Biomass is one of the few firm power resources available in the Pacific Northwest. Not only can local biomass energy generation eliminate regional transmission constraints, but it can also help hedge against the volatility in hydroelectric generation and fossil fuel prices.<sup>155</sup> It is also a local source of power that can be counted upon in times of global or national disruptions to the economy in general.

Biomass energy can also add efficiency to existing systems and companies - like most waste elimination efforts, biomass energy adds dollars to the bottom line of the companies that are already part of the lumber value chain. Finally, biomass energy can also be sold out of the area to meet California power needs at a premium price above what a local agreement will pay.

## 6.5 Landfill Gas-to-Energy

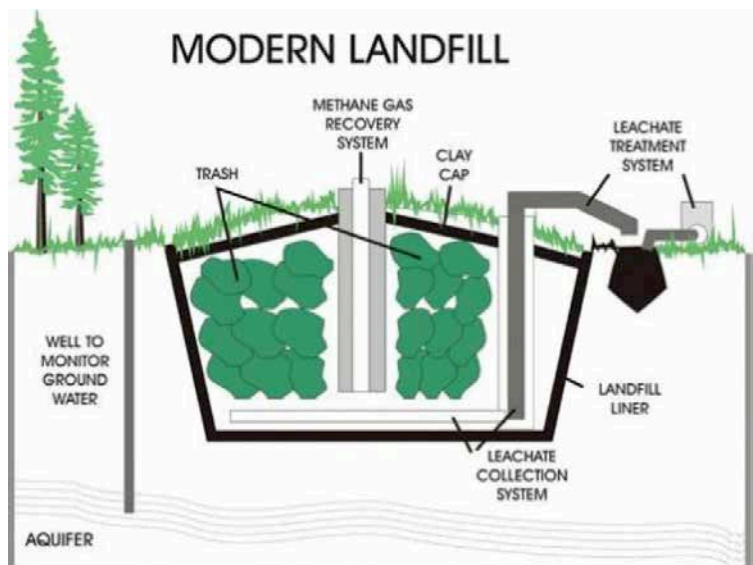
### 6.5.1 Introduction

Jackson and Josephine counties have met landfill needs over the years with five landfills: Dry Creek, Kerby, Prospect, Ashland, and South Stage. The Kerby Landfill and Prospect Landfill were closed in 1994. Both are currently being used as transfer stations. The Ashland Landfill closed in 1998 and the South Stage Landfill closed in 1999. The Merlin site closed in 2001. Currently, the only operating landfill in the region is Dry Creek Landfill in Eagle Point.

When organic materials are landfilled they produce methane (i.e., natural gas). This biomethane may be captured and used as an energy source to be burned directly for heat, used to generate electricity or power vehicles. Dry Creek Landfill, has been operating a 3.2 MW landfill gas (LFG) electric generating facility that is currently operating at capacity with excess LFG production that is underutilized. The landfill is exploring the feasibility of using the excess LFG to power its vehicle fleet as compressed natural gas (CNG).

The remaining landfills (which have all closed since 2001) are unlikely to justify the capital cost associated with constructing a new gas collection system, based on age and ever-decreasing biogas volumes.

**Figure 36:** Diagram of landfill gas-to-energy system



Source: Copper Wiki

<sup>152</sup> B-37

<sup>153</sup> B-41

<sup>154</sup> B-14

<sup>155</sup> B-37

## 6.5.2 Landfill Gas

When a landfill is capped, landfill gas (LFG) is emitted as organic portions of the municipal solid wastes (MSW) decompose without oxygen (anaerobically). A variety of factors impact the generation of LFG and the expected period over which it may be produced. This period can range from fifty to one hundred years, with usable landfill gas production periods ranging from ten to fifteen years.

Historically, landfill operators flared or vented landfill gas in a controlled process. Recent industry trends have seen a movement towards more sophisticated gas collection systems where the gas is scrubbed or upgraded for use in power generation, or in some cases, converted to transportation fuel such as compressed natural gas (CNG).

The composition of the landfill gas varies depending on the input and characteristics of the waste, age of a landfill and weather conditions among other factors. In general, landfill gas contains about 50% methane ( $\text{CH}_4$ ), 45% carbon dioxide ( $\text{CO}_2$ ), and traces of gases such as nitrogen ( $\text{N}_2$ ), oxygen ( $\text{O}_2$ ), hydrogen sulfite ( $\text{H}_2\text{S}$ ), and water vapor.

**Figure 37:** Diagram of landfill layers



Methane is the valuable component of landfill gas because it combusts, providing a means for energy generation. The amount of methane that is produced varies significantly based on the composition of the waste. Most of the methane produced in MSW landfills is derived from food waste (20-30%), composite paper (15-22%), and corrugated cardboard (15-20%) based on historical averages at MSW landfills in the United States. In recent years, with aggressive recovery programs being put into place, the paper and corrugated cardboard figures are generally decreasing, and the percentage of food waste is increasing to 30% or more.

The landfill gas production rate will typically peak between five and fifteen years depending on the conditions and composition, at which point it begins to decline. Since gas is being generated simultaneously from multiple cells, production can be leveled to produce a consistent volume of gas to feed power generation and other associated site projects. As landfills near the end of their useful life, operators must consider the return-on-investment associated with landfill gas collections systems, upgrades and retrofits to existing systems, and other related projects.

Landfill gas is “pulled” from landfills through extraction wells placed depending on the size of the landfill. Roughly one well per acre is typical, with extraction taking place through horizontal trenches instead of vertical wells. Generally, a blower is needed to pull the gas from the collection wells to the collection header and further downstream. If gas extraction volumes and rates do not warrant direct use or electricity generation, the gas can be flared off to reduce the risk, odor, and global warming potential of the methane in the LFG.

Landfill gas must be treated to remove impurities, condensate and other particulates. The treatment system depends on the end use. Minimal treatment is needed for the direct use of gas in boilers, furnaces or kilns. Using the gas in an electricity generation capacity typically requires more in-depth treatment. Treatment systems are divided into primary and secondary treatment processing. Primary processing systems remove moisture and particulates, where gas cooling and compression are common. Secondary treatment systems employ multiple cleanup processes, both physical and chemical, depending on the specifications of the end use.

### 6.5.3 Technology

The use of landfill gas can generally be divided into two categories: electricity generation and direct use, with direct use usually being limited to close geographic proximity of the landfill in order to be economically viable.

#### ***Electricity Generation***

If the landfill gas extraction rate is high enough, a gas turbine or internal combustion engine can be used to produce electricity to sell commercially or use on site. Typically, active medium to large landfills produce enough landfill gas to support the investment in an infrastructure to facilitate conversion of the biogas into electricity, which is considered renewable power, or perform an upgrading process to create pipeline quality gas as described above.

##### Internal Combustion Engine

More than seventy percent of all landfill gas to electricity projects use internal combustion (IC) engines due to the relatively low cost, high efficiency and favorable size match with gas production. Efficiency rates typically run from 25-35%. IC engines have relatively high maintenance costs and air emissions when compared to gas turbines, with a range of 800 kW to 3 MW depending on the gas flow.

##### Gas Turbines

Gas turbines usually meet an efficiency of 20-28% at full load with landfill gas, although efficiencies may drop when the turbine is operating at partial load. Gas turbines have relatively low maintenance costs and nitrogen oxide emissions when compared to IC engines. Gas turbines usually require high gas compression, which may use more electricity to compress, thereby reducing the efficiency. Gas turbines are also more resistant to corrosive damage than IC engines.

##### Micro-turbine

Micro-turbines can produce electricity with lower amounts of landfill gas than gas turbines or IC engines, and operate between 20 and 200 cubic feet per minute (cfm), emitting less nitrogen oxides than IC engines. They can also function with less methane content (as little as 35%).

#### ***Boilers, Dryers and Process Heaters***

Pipelines transmit gas to boilers, dryers or kilns, where it may be used much in the same way as natural gas. Landfill gas is usually less expensive than natural gas because it holds approximately half the heating value of natural gas. Boilers, dryers, and kilns are used often because they can maximize the utilization of the gas, as limited treatment is needed and the gas can be mixed with other fuels to be further optimized. The primary disadvantages of boilers, dryers, and kilns are that they typically must be retrofitted in order to accept the LFG and they require the installation of pipelines, which can be expensive, to transport the gas.

#### ***Pipeline Quality Gas, CNG and LNG***

Landfill gas can be converted to high-Btu gas by reducing the carbon dioxide, nitrogen and oxygen content. High-Btu gas can be piped into existing natural gas pipelines or upgraded to a form for conversion to CNG or liquid natural gas (LNG). Either form of transportation fuel can be used to power vehicles and operating equipment, or sold commercially through onsite or offsite fueling stations. LNG is a refrigerated fuel and has significantly more energy input into its conversion from gas and storage than CNG does.

### 6.5.4 Resource Potential

While Jackson and Josephine counties have multiple closed landfills, which are still producing gas, only one—Dry Creek Landfill—is still in operation and generating enough gas to make a landfill gas-to-energy project economically feasible. DCLF has for several years been running a state-of-the-art landfill gas recovery system with electricity conversion under an arrangement with Pacific Power.

Data available from Oregon Department of Environmental Quality (ODEQ), who contributed to the Landfill Methane Outreach Program (LMOP) landfill study, indicate marginal economically recoverable biogas resources at the Ashland, Kerby, Prospect, and Merlin landfills. Reasons range from the age of the landfill, time that has passed since closure, uncertainty of the characterization of the waste, uncertainty about the total tonnage of refuse and site-specific conditions including proximity to utility infrastructure or landfill design.

These closed landfills will continue to see a decline in the volume of gas produced over time. As such, the long-term value of the biogas volumes is unlikely to justify the capital cost associated with constructing a new gas collection system. The remaining gas that is being produced at each site could potentially be combined with another project to create some short-term value.

In addition to generating electricity, DCLF is currently studying the feasibility of making changes that would allow it to upgrade the gas for conversion to transportation-grade CNG for use in its collection and operating fleet. Based on the current permitted airspace availability, life expectancy and projected future MSW volumes, it is highly likely that the economics will prove to be compelling enough to make such an investment. In general, the CNG would be replacing diesel fuel that has a cost of nearly \$28 per million Btu (138,800 Btu per gallon at \$3.80 per gallon) compared to the energy sold from the electric generator at the landfill at \$14 per million Btu (3.4 million Btu per MWh at \$47 per MWh).

On the West Coast, where electricity prices per kWh are relatively low in comparison to other geographic areas in North America, many landfills, composting operations and other types of solid waste facilities are giving careful consideration to CNG production from biogas. Given the projected long-term value of CNG as a substitute for diesel fuel, the transition of the landfill gas from electricity to transportation fuel uses is a key strategic decision and may yield returns that are up to 3 times greater than producing electricity.

### **6.5.5 Benefits and Opportunities**

Landfill gas emitted from decomposing garbage is a reliable and renewable fuel option that remains largely untapped at many landfills across the U.S. despite its many potential benefits. Generating energy from landfill gas creates a number of environmental benefits according to the United States Environmental Protection Agency (EPA) including: 1) the destruction of methane as a potent heat-trapping gas; 2) projects can generate renewable energy and offset the use of non-renewable resources such as coal, natural gas and oil; 3) landfill gas projects can provide cost-effective options for reducing methane emissions while generating energy and producing monetary carbon benefits; 4) projects help reduce local air pollution; and 5) projects have the ability to create jobs, revenues and landfill operating cost savings.

MSW landfills are the third-largest human-generated source of methane emissions in the United States, releasing an estimated 27.5 million metric tons of carbon equivalent to the atmosphere in 2009 alone. Given that all landfills generate methane, it makes a great deal of sense to use the gas for the beneficial purpose of energy generation rather than emitting it to the atmosphere. Methane is a potent greenhouse gas that is a key contributor to global climate change (more than twenty-one times the heat trapping effect of CO<sub>2</sub>). Methane also has a short (ten years or fewer) atmospheric life. Since methane is both potent and short-lived, reducing emissions from MSW landfills is one of the best ways to achieve a near-term beneficial impact in mitigating global climate change.

It is estimated that most landfill gas-to-energy projects will capture 40-80% of the methane emitted from the landfill, depending on system design and effectiveness, although modern landfill gas collection systems are far more efficient than some of the original systems still in place. The captured methane is destroyed (converted to water and the much less potent greenhouse gas, CO<sub>2</sub>) when the gas is flared or combusted to produce electricity.

Producing energy from landfill gas avoids the need to use non-renewable resources such as coal, oil or natural gas to produce the same amount of energy. This can avoid end user and power plant emissions of CO<sub>2</sub> and criteria pollutants such as sulfur dioxide, particulate matter, nitrogen oxides (NO<sub>x</sub>), and trace hazardous air pollutants. Overall, landfill gas electricity generation projects can significantly improve the environment,

because of the large methane reductions, hazardous air pollutant reductions, and avoidance of the use of limited non-renewable resources such as coal and oil that generate more pollutants than landfill gas.

Landfill gas energy projects generate revenue from the sale of the gas and can also create jobs associated with the design, construction, and operation of energy recovery systems. Much of this cost is spent locally for drilling, piping, construction, and operational personnel, helping communities to realize economic benefits from increased employment and local sales.

## **6.6 Anaerobic Digestion**

### **6.6.1 Introduction**

Similar to the biological processes that produce landfill gas anaerobic digestion (AD) is a series of biological processes in which microorganisms break down organic material (such as food waste) in the absence of oxygen, thereby producing biogas. Biogas is primarily composed of methane (i.e., natural gas), which can be combusted to generate electricity, meet a thermal load, or power vehicles. In addition to energy, anaerobic digestion at a dry or wet fermentation biogas plant also produces other valuable products including digestate (used as fertilizer or further processed into compost) and environmental commodities: Renewable Energy Certificates (RECs), carbon credits, Renewable Identification Numbers (RINs), and potentially Low Carbon Fuel Credits if proposed legislation moves forward.

While the process and biogas product of AD are similar to landfills there are two primary benefits. First is the efficiency of biogas capture. On average 25% of landfill gas is lost as fugitive emissions either before the LFG collection system has been installed or afterwards through holes and leaks in the landfill cap. The second benefit is the ability to utilize the organic feedstock material after it has generated the biogas as a soil nutrient.

### **6.6.2 Technologies**

As was previously described, AD is the breakdown of organic wastes in an oxygen-free environment, which generates methane in the form of biogas. This methane requires some level of filtering, after which it is a valuable energy commodity. This, in general, is the same biologic process that is taking place in Dry Creek Landfill. After organics are landfilled a cap and gas collection system are put in place to generate electricity from the biogas.

The primary difference between a dedicated anaerobic digester biogas plant and a landfill biogas collection system is the efficiency of biogas capture. According to research by the EPA, the average efficiency of a landfill is roughly 75% whereas an AD biogas plant's efficiency is closer to 99%. In terms of efficiency, it is important to note that the efficiency of biogas collection at a landfill increases over time, with lower collection efficiency in early years and higher collection efficiency later. The EPA reports that a landfill with aggressive biogas collection is 25% efficient in the first year and 95% efficient after eight years.<sup>156</sup> Efficiency is especially important when considering biogas generated by food waste, which tends to partially decompose before a landfill cap and biogas collection system can be installed and put into operation.

Anaerobic digester technologies can be categorized into two general types: wet and dry. Within each of these categories there are a number of different technologies and designs. AD systems have been developed to operate at different temperatures, moisture levels, speed of throughput, and with utilization of various feedstocks as well as being optimized for various outputs such as increased biogas collection or quality of compost.

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<sup>156</sup> EPA (2010). Documentation for the WASTE Reduction Model (WARM) – Landfilling Chapter. Downloaded online at <http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html>.

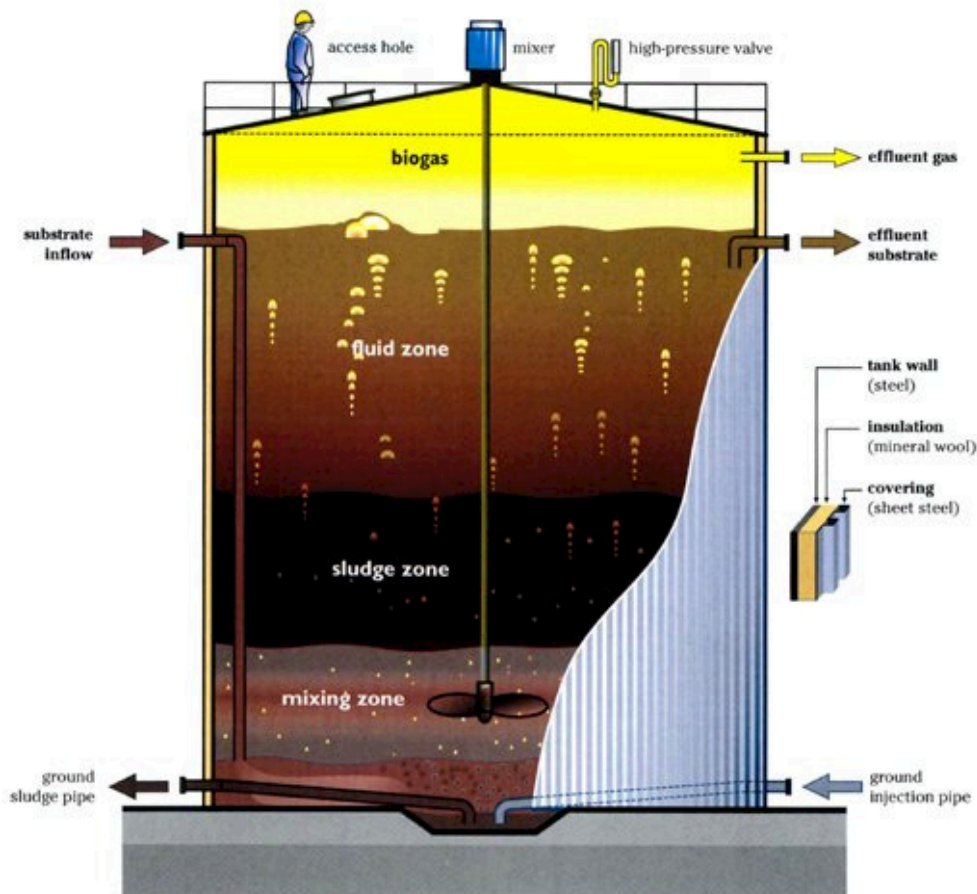
The primary differentiation between wet and dry AD is the percentage of total solids<sup>157</sup> in the digester feedstock. Wet fermentation anaerobic digesters operate with a feedstock composition of less than 15% solids and 85% liquids, while dry fermentation anaerobic digesters use a feedstock composition of 15-40% solids and 60-85% liquids.

Dry and wet AD systems are shown in Figures 38 and 39. Figure 40 compares and contrasts the two systems, but is not meant to imply one system is superior. The type of system desired will ultimately depend on the types and quantities of feedstocks available.

### ***Wet System (liquid or low solids)***

Wet systems are common in the U.S. at municipal wastewater treatment plants and livestock operations such as dairies. Wet digestion systems are designed to process organics with a total solids content of less than 15%. For materials with higher solids content water is added or the material is co-digested with another feedstock with lower total solids.

**Figure 38:** Wet AD fermentation system.



Source: [www.daviddarling.info](http://www.daviddarling.info)

Pre-treatment of the feedstocks with a series of different types of equipment is necessary to process the material into a slurry of proper consistency and free of contaminants. Compared to dry systems, wet systems require larger digester vessels, more facility infrastructure (pumps, pipes and pre-processing equipment) and more process energy (parasitic load) to heat the digesters.

<sup>157</sup> total solids or dry weight = total weight – water weight

### Dry System (high solids)

Dry digestion systems are designed to process organics with a total solids content of between 15 and 40%. The difference in feedstock solids content results in different handling and pre-treatment of the waste input than for wet systems. Conveyor belts, front-end loaders and powerful pumps designed for high solids content materials transport the high solids-content materials. This equipment is more expensive than the centrifugal pumps used in wet systems. However, this additional cost is offset by the smaller vessels required for digesters vessels and reduced storage requirements due to the lower water content of the feedstock.

The only pre-treatment that is necessary before feeding the wastes into the dry digester is the removal of the coarse impurities, which can be accomplished either via screens or shredders. Materials such as stones, glass and plastics that pass the screens or shredder need not be removed from the waste stream for digestion. Undesirable materials can be sorted at the end of digestion to create a higher-value compost material.

While dry systems may still require additions of water (or co-digestion with low solid content material) to achieve a total solids content of around 30%, dry systems require less water as part of the process than wet systems. This in turn leads to lower energy requirements for in-plant needs because less energy is needed for heating process water and for de-watering AD digestate than for wet systems.

**Figure 39:** Dry fermentation system



Source: [www.biofermenergy.com/us/](http://www.biofermenergy.com/us/)

**Figure 40:** Characteristics of wet and dry anaerobic digester systems

Category	Dry Fermentation	Wet Fermentation
Feedstock Solids Content	15 - 40%	< 15%
Feedstock Pre-processing	Minimal pre-processing required	Requires pre-processing to prepare a slurry
Feedstock Transport	Trailer truck and conveyer	Tanker truck and pipes
Energy Input	Less energy required	More energy required for pump, process and heat needs
Water Input	Little to no additional water required	Added to high solids feedstock to achieve the proper solids content
Wastewater Output	Very little; some drainage may be required if using wet feedstocks	Ongoing
Compost Products	Windrows or in vessel	De-watered and blended with other materials in windrows

## ***Products of Anaerobic Digestion***

An aerobic digester biogas plant can produce a number of valuable products including: renewable energy (from biogas), heat, fibrous material (i.e. compost, which is a soil nutrient if uncontaminated) and environmental commodities (e.g., carbon credits and RECs). Each of these products has value in an existing marketplace.

Another, less desirable product is process liquor, a waste product that is present primarily in wet AD systems and needs to be disposed of. The disposal method varies depending on content.

### Energy (Biogas)

Biogas is produced during the anaerobic digestion of organics. It is composed largely of methane (50-70%) and carbon dioxide (30-50%).<sup>158</sup> At 65% methane, biogas has a heat content of approximately 650 Btu per cubic foot, compared to approximately 1,000 Btu per cubic foot in pipeline-quality natural gas.<sup>159</sup>

The methane component of biogas may be used to either generate electricity or to fuel a dedicated fleet of vehicles. The biogas will likely need to be filtered to remove water and hydrogen sulfide for use in either of these applications. If the biogas is to be injected into a natural gas pipeline, the carbon dioxide will also need to be removed to increase the concentration of methane to ~97%.

As an example of the energy content in biogas, consider a 50,000 wet short tons per year dry fermentation biogas plant. Assuming that the feedstock is composed of 25% food waste, 60% yard debris and 15% food-soiled paper, the annual biogas generation would be 132 million cubic feet or over 8,000 megawatt hours of electricity. For sense of scale, that is enough electricity to power over 700 homes.<sup>160</sup>

A portion of the energy generated by a biogas plant will likely be used to meet some of the plant's operational energy needs (i.e., parasitic load) while the rest may be sold. The previous example excludes the parasitic load from the annual generation. The energy load of a facility is directly related to the moisture content in the feedstock. High-moisture systems require more heat energy than low-moisture systems for pumping, mixing, pre-processing equipment and heating.

### Heat Co-Product of Electricity Generation

If the biogas is used to generate electricity in a combined heat and power (CHP) facility, the heat co-product of electricity generation is also a valuable product. Electricity generation from biogas is at best 40% efficient, but if the waste heat is captured and utilized, the system efficiency is increased to 80%.

The waste heat can be used in a variety of ways including but not limited to: pre-treatment of feedstock, maintaining temperatures in the digester, building space heating and cooling, and heating a greenhouse. The ultimate use for the heat is dependent on the needs of the facility and neighboring facilities. If a heat load and potential user are not co-located at the project site, using the biogas as vehicle fuel should be explored to maximize revenue.

### Soil Nutrients

Digestate is the residual fibrous material left after biogas has been extracted. Digestate contains valuable soil nutrients including nitrogen, phosphorus and potassium. This material can be directly land applied or fed into an existing composting operation to generate a higher value compost product that takes less time to mature into a final product. Another potential use for digestate is as a landfill cover material. The selection of the end product use largely depends on digestate quality and available markets.

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<sup>158</sup> The composition will vary depending on the composition of the organics digested to produce the biogas.

<sup>159</sup> The Climate Registry. General Reporting Handbook.

<sup>160</sup> Assuming the average household uses 11 MWh per year.

Digestate quality varies and is dependent on feedstock quality. The phrase garbage in, garbage out is uniquely appropriate. For example, if the feedstock is heavily contaminated with plastic, the digestate may need post-processing to prepare it for market. If the feedstock is contaminated with heavy metals, it would severely limit the digestate's use. If the desired end use is as a soil nutrient, then the feedstock needs to be identified and selected with that end product in mind.

### Environmental Commodities

In addition to generating electricity and salable compost, AD also has the potential to generate carbon credits and Renewable Energy Certificates (RECs) or Renewable Identification Numbers (RINs) or Low Carbon Fuel Credits. The costs of generating these credits and the associated revenue will be assessed more thoroughly in Task 2 of the Biogas Plant Feasibility Study. The following sections provide a general description of each type of environmental commodity. Price estimates for each of these commodities will be included in Task 2.

#### *Carbon Credits (i.e., Carbon Offsets)*

Carbon emissions reductions from an AD facility would be generated by efficiently capturing the methane component of the biogas generated in the system, thereby displacing the fugitive methane emissions that would have occurred had the same quantity and composition of waste been disposed of by other anaerobic means (landfills or lagoons in the case of manure) with lower efficiency or no biogas collection system.

The Climate Action Reserve's Organic Waste Digestion Project Protocol (among others) may be used to determine project eligibility and quantify avoided methane emissions from a biogas plant. The avoided emissions would be the difference between AD emissions and the baseline (typically landfill disposal).

Currently the only market for these credits in the U.S. is the voluntary market.

#### *Renewable Energy Certificates (RECs)*

In addition to the carbon credits described in the previous section, a biogas plant would also be eligible to generate and sell RECs if the produced biogas is used to generate electricity. When a renewable energy facility operates, it creates electricity that is delivered into a vast network of transmission wires, known as the grid. The grid is segmented into regional power networks called pools. To help facilitate the sale of renewable electricity nationally, a system was established that separates renewable electricity generation into two parts: the electricity or electrical energy produced by a renewable generator, and the renewable "attributes" of that generation. These renewable attributes are referred to as Renewable Energy Certificates or RECs. RECs can be sold with the electricity (bundled) or sold separately (unbundled). One REC is issued for each megawatt hour (MWh) of renewable electricity generated.

RECs are used to comply with Oregon's Renewable Portfolio Standard (RPS). Utilities regulated under Oregon's RPS are required to own a certain number of RECs in order to comply with the standard. California also has an RPS and Oregon-generated credits may be sold into the California market. The other primary market for RECs is the national voluntary market where individuals or organizations will pay a premium through their utility or purchase unbundled RECs directly in order to meet self-imposed sustainability goals.

#### *Renewable Fuel Credits*

Renewable fuel credits or Renewable Identification Numbers (RINs) are the means for compliance with the Federal Renewable Fuel Standard (RFS). The RFS program was created under the Energy Policy Act (EPA) of 2005 which established the first renewable fuel volume mandate in the United States. Under this program, biogas is considered an advanced biofuel or one that has life-cycle greenhouse gas emissions that are at least 50% less than the baseline conventional fuel.

In addition to the Federal program, California and Oregon are both developing state-level Low-Carbon Fuel Standards (LCFS). If implemented, Oregon's LCFS will create a market where low-carbon fuels will be sold at a premium to fuel suppliers and distributors to meet the standard's requirements.

## 6.6.3 Resource Potential

Resource potential for anaerobic digestion in Jackson and Josephine counties is split into two categories: waste water treatment facilities and all other wet and dry anaerobic digestion biogas plants.

### ***Municipal Wastewater Treatment***

A report commissioned by Energy Trust of Oregon and prepared by CH2MHILL titled *Sizing and Characterizing the Market for Oregon Biopower Projects* identifies the Municipal Sewage Treatment Plants (STP) in Jackson and Josephine counties with an anaerobic digester, if the digester is capable of generating electricity, and if it does the annual amount of generation.

Figure 41 shows the existing STP facilities in Oregon. There are two facilities in the study area: Medford STP in Jackson County and Grants Pass STP in Josephine County. Both have anaerobic digesters, but only the Medford facility generates electricity. The nameplate capacity for the Medford and Grants Pass facilities are 398-575 kW and 105-151 kW respectively. This translates to approximately 3,800-5,000 MWh per year for Medford and 995-1,300 MWh per year for Grants Pass.

The report does not comment on the feasibility of adding electricity generation at the Grants Pass facility.

**Figure 41:** Existing Oregon sewage treatment facilities with anaerobic digesters

Plant Name	City	County	Service Area	Avg Flow (ODOE), mgd	Gas (ODOE), Mcf/year	Energy MMBtu/yr	Power potential @ 9,000 Btu/kWh heat rate, kW	Power potential @ 12,000 Btu/kWh heat rate, kW	Has Anaerobic Digester	Has Electricity Generation
Columbia Boulevard STP	Portland	Multnomah	PGE	65	379.3	227,580	2,887	1,998	Yes	Yes
Rock Creek STP	Hillsboro	Washington	PGE	33.7	153	91,800	1,164	806	Yes	Yes
MWMC—Eugene/Springfield STP	Eugene	Lane	neither	39.2	119.4	71,640	909	629	Yes	Yes
Salem Willow Lake STP	Keizer	Marion	PGE	40.5	118.6	71,160	903	625	Yes	Yes
Durham STP	Tigard	Washington	PGE	22.3	117	70,200	890	616	Yes	Yes
Gresham STP	Portland	Multnomah	neither	13.2	77	46,200	586	406	Yes	Yes
Medford STP	Central Point	Jackson	Pacific Power	18.8	75.5	45,300	575	398	Yes	Yes
Kellogg Creek STP	Milwaukie	Clackamas	PGE	7.9	36	21,600	274	190	Yes	Yes
Tri-City WPCP	Oregon City	Clackamas	PGE	8.2	23.1	13,860	176	122	Yes	Yes
Corvallis STP	Corvallis	Benton	neither	10.8	21	12,600	160	111	Yes	
Grants Pass STP	Grants Pass	Josephine	Pacific Power	5.7	19.9	11,940	151	105	Yes	
Albany STP	Albany	Linn	Pacific Power	0.2	18.9	11,340	144	100	Yes	
Bend Wastewater Control Plant	Bend	Deschutes	neither	4.5	18	10,800	137	95	Yes	
Oak Lodge STP	Milwaukie	Clackamas	PGE	3.7	17.9	10,740	136	94	Yes	
R.U.S.A. Roseburg STP	Roseburg	Douglas	Pacific Power	4.6	14	8,400	107	74	Yes	
Pendleton STP	Pendleton	Umatilla	Pacific Power	2.5	13.7	8,220	104	72	Yes	
Wastewater Treatment And Reclamation Facility (@ Spring Street)	Klamath Falls	Klamath	Pacific Power	3.7	10.7	6,420	81	56	Yes	
Brookings WWTP	Brookings	Curry	neither	1.6	6.5	3,900	49	34	Yes	
Coos Bay STP No. 2—Empire	Coos Bay	Coos	Pacific Power	1.1	6.3	3,780	48	33	Yes	
The Dalles STP	The Dalles	Wasco	neither	2.1	4.8	2,880	37	25	Yes	
Woodburn POTW	Woodburn	Marion	PGE	2.8	4.7	2,820	36	25	Yes	
Cottage Grove STP	Cottage Grove	Lane	Pacific Power	2	3.7	2,220	28	19	Yes	
Hermiston STP	Hermiston	Umatilla	Pacific Power	1.4	3.1	1,800	24	16	Yes	
Hood River STP	Hood River	Hood River	Pacific Power	1.1	2.3	1,380	18	12	Yes	
Tillamook STP	Tillamook	Tillamook	neither	1.7	2.2	1,320	17	12	Yes	
Coos Bay STP No. 1	Coos Bay	Coos	Pacific Power	1.8	1.8	1,080	14	9	Yes	
Tryon Creek WWTP	Lake Oswego	Clackamas	PGE	8.4	0.5	300	4	3	Yes	
Water Pollution Control Facility	Troutdale	Multnomah	neither	1.4	0.4	240	3	2	Yes	
<b>Totals</b>				<b>317.9</b>	<b>1269.3</b>	<b>761,580</b>	<b>9,660</b>	<b>6,688</b>	<b>28</b>	<b>9</b>

Source: CH2MHill, *Sizing and Characterizing the Market for Oregon Biopower Projects*

## Other Wet and Dry Anaerobic Digestion

Other anaerobic digester systems would use one of two categories of feedstock for operation

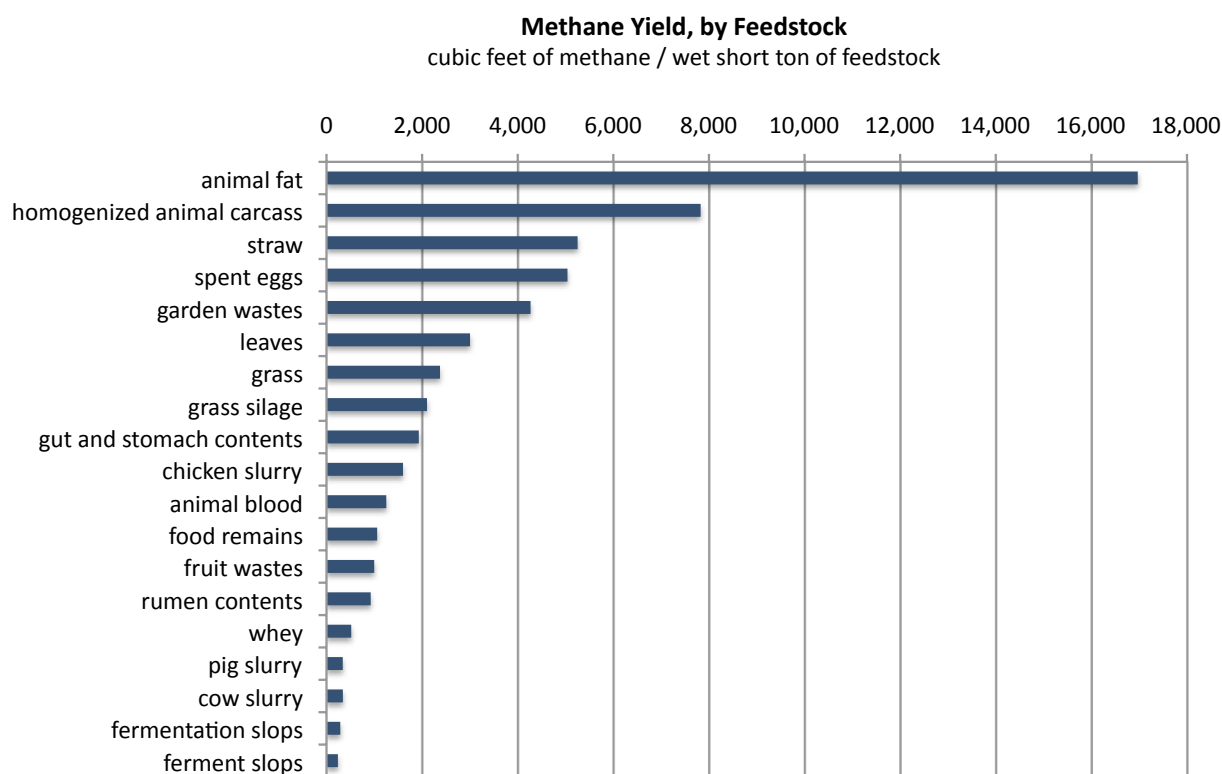
- Organic solid waste (e.g., food waste, soiled paper, etc.)
- livestock manure

### Feedstock Biogas Production

Different organic materials produce different quantities and compositions of biogas, as can be seen in Figure 42. The quantity of biogas that any given material will generate is variable and will require laboratory testing early in the development of a biogas plant. When considering Figure 42, it important to bear in mind that none of these feedstocks will be digested individually. The materials will be co-digested.

Co-digestion is the process of mixing different organic materials for the purpose of increasing the biogas yield and optimizing decomposition of the waste. The mixing of wastes has a synergistic effect, where combining different feedstocks results in more methane than a single feedstock could produce on its own. Mixing wastes balances moisture content and nutrient availability for a balanced biological system and maximum methane production.

**Figure 42:** Methane yield per wet short ton of common biogas feedstocks.



**Source:** This graphic was created based on Steppen, et al. *Feedstocks for Anaerobic Digestion*.

### Feedstock Potential

As was previously mentioned, a related, but separate study is being conducted on anaerobic digestion. As part of that study an AD feedstock inventory was conducted. The priority for this feedstock inventory was to identify all potential sources in the study area, specifically those materials with high biogas yield per ton of material that are available in large quantities and located near feasible biogas plant sites.

The results of the inventory are shown at a high level in Figure 43. This figure summarizes the categories of organic wastes currently being landfilled and presents quantities and methane potential for each, by county. The first row of the figure, Total Food and Yard Waste in the Region, represents an estimate of the total technical potential feedstock in Jackson and Josephine counties.

The next sets of lines summarize pre and post-consumer food waste, which are subsets of the Total Food and Waste row. The exemptions are food processors and wineries, which typically dispose of their organics wastes through onsite composting operations.

A notable category in the pre-consumer waste is food processing in Jackson County, where an estimated 9,500 short tons per year are generated. This feedstock source represents the single largest food waste opportunity in the area. Secondly, supermarkets also generate a large quantity, about 3,000 short tons in Jackson and Josephine counties. The k – 12 schools food waste is also notable because all of the schools in the counties are centrally controlled by a single facilities management organization, Southern Oregon ESD.

The bottom set of rows shows agricultural products including manure, mortalities (i.e. animal carcasses) and straw. The quantities on Figure 434 represent what is technically available in the area, not what is feasible or achievable. For example, many of the farm owners contacted during the study report that they are nearing retirement and unsure what will become of the farms after they retire. A second potential concern is competing use for manure as the farms currently use it as a natural fertilizer. In order to utilize the manure in an off-site biogas plant, it may be necessary to return the AD digestate to the farms to be land applied. Animal mortalities (i.e. animal carcasses) have a high biogas yield, but would require special plant design and handling to remove hides, heads, and spines and grind the carcasses for use in the digester. The final agricultural feedstock explored is wheat straw. This material has an excellent biogas yield, but is sold as a commodity and may not be economical viable as a primary feedstock, but could be used as a secondary, filler feedstock.

For additional details on the feedstock inventory please see the Biogas Plant Feasibility Study – Task 1 report.

**Figure 43:** Methane yield per wet short ton of common biogas feedstocks.

Categories	Jackson		Josephine	
	Tons Disposed	Methane Production	Tons Disposed	Methane Production
	wet short tons / year	thousand ft <sup>3</sup> / year	wet short tons / year	thousand ft <sup>3</sup> / year
<b>Total Food and Yard Waste in Region</b>	51,934	49,877	8,339	8,815
<b>Pre-Consumer Food Waste</b>				
Food Processing	9,518	7,544		
Supermarkets	2,387	2,523	846	894
Wineries	73	62	36	30
<b>Pre-Consumer Sub-Total</b>	<b>11,978</b>	<b>10,128</b>	<b>882</b>	<b>925</b>
<b>Post-Consumer Food Waste</b>				
Restaurants	8,489	8,974	2,687	2,840
Schools (k - 12)	467	494	179	189
Higher Education	228	241	8	9
Retirement Communities	193	204	112	119
Jails	52	55	48	51
<b>Post-Consumer Subtotal</b>	<b>9,428</b>	<b>9,968</b>	<b>3,033</b>	<b>3,207</b>
<b>Food Waste Subtotal (Pre+Post)</b>	<b>21,406</b>	<b>20,097</b>	<b>3,916</b>	<b>4,132</b>
<b>Agriculture Waste</b>				
Manure	21,489	19,102	71,942	42,447
Mortalities	11	85	24	184
Wheat Straw	396	2,078		
<b>Agriculture Sub-Total</b>	<b>21,896</b>	<b>21,265</b>	<b>71,965</b>	<b>42,630</b>
<b>TOTAL (Food + Ag):</b>	<b>43,303</b>	<b>41,361</b>	<b>75,881</b>	<b>46,762</b>
Note: Not available	=			

## Electricity Generation Potential

Based on the estimated combined quantities of organic wastes for Jackson and Josephine counties, the associated methane production or technical potential (i.e., maximum) is the equivalent of about 13,700 MWh per year.<sup>161</sup> If more realistic near-term assumptions are made about what feedstock sources are feasibly collectable in an emerging program, the achievable potential is estimated at 3,656 MWh per year, which equates to a facility with a 0.5 MW nameplate capacity. The achievable potential value only includes food waste from food processors, supermarkets, and schools (k-12 and higher education).

**Figure 44:** Estimated technical and achievable electricity generation potential for the study area.

Potential Classification	Jackson County MWh / year	Josephine County MWh / year	Totals MWh / year
Technical Potential: (Food Waste + Yard Waste + Ag Waste)	8,214	5,516	13,730
Feasible Potential: (Select Food Waste* + Yard Waste)	3,148	508	3,656

\* Includes food processing, supermarket, k-12 school and higher education food waste only

### 6.6.4 Costs

According the Intergovernmental Panel on Climate Change (IPCC) Special Report on Renewable Energy the range of capital costs for \$170 and \$1,000 per kW. The operation and maintenance costs on an annual basis are between \$37 and \$140 per kW. The levelized cost at a 7% discount rate is between \$36 - \$115 per MWh. The range is dependent on a number of factors including scale of the system.

### 6.6.5 Benefits and Opportunities

AD facilities have many benefits. First and foremost they generate valuable commodities with feedstocks that are currently hauled away and buried as waste. The commodities include biogas which may be used to generate electricity or may be filtered, compressed and sold as a renewable natural gas, heat which may be used to meet onsite or nearby thermal loads, fibrous material which can be used as a soil nutrient or pre-cursor to compost, and environmental commodities such as carbon credits, RECs, and RINs.

Biogas is a source of local, low-carbon energy generated with local waste products that displaces grid electricity or natural gas that have relatively higher embodied carbon intensity. Also, the generation of local energy increases local energy security and reduces the risks associated with volatility in future energy market prices. AD technologies, wet or dry, also are feedstock-flexible, allowing them to operate on various feedstock types and compositions to adjust to changing feedstock availability overtime. A dedicated AD facility's efficient capture of biogas reduces greenhouse gas emissions compared to landfill disposal, even with an aggressive biogas collection system.

Keeping organic materials out of the landfill also allows them to be utilized as soil nutrients, increasing soil health, productivity and its ability to sequester carbon, while at the same time displacing the need for synthetic fertilizers and the associated production emissions. In addition to energy and emissions benefits, biogas plants also reduce the quantity of waste going into the landfill, thereby extending the landfill's useful life.

Specific opportunities and scenarios will be assessed in Task 2 of the Biogas Plant Feasibility Assessment. Please see that report for detail and findings.

<sup>161</sup> This estimate assumes a biogas heat value of 600 Btu/cubic foot, an electricity conversion efficiency of 40%, and that 3,412 Btu = 1 kWh.

### **6.6.6 Risks and Challenges**

Development of a biogas plant requires significant capital investment. In the current economy it may be difficult to secure the necessary capital required for construction from conventional debt sources.

#### ***Feedstock sourcing***

The plant will need a consistent quantity and composition of feedstock. In most communities, the quantity, quality and composition of the waste stream will vary with changing seasons. For example, food processing or wine making operations may have a significant spike in waste materials that coincide with harvest season. To ensure a predictable schedule of inputs, the operator will need to secure feedstock contracts early in the development of any biogas plant development. The current economy is also reducing the quantity of available feedstocks. During stakeholder interviews for this project, it was reported that since the 2008 recession began, municipal solid waste (MSW) quantities are down 20%.

#### ***Permitting***

A biogas plant would require the same land use review and permitting that any energy generation facility would require. This permitting is more established for wet AD facilities, while there is little precedent for dry AD systems.

#### ***By-products***

AD systems can generate undesirable air and water byproducts. For example, wastewater from the process may contain a high concentration of metals, nitrogen and organic materials. The metals are due to inbound feedstock contamination, not an inherent contamination problem associated generally with these feedstocks. When the biogas is combusted during the use phase of the biogas plant, air contaminants will be emitted. These emissions could be emitted at a stationary source (as is the case with electricity generation) or from mobile sources (if the biogas is used to power vehicles). These emissions are already emitted at Dry Creek Landfill (during electricity generation and flaring) and therefore any change in total air pollutants will likely be small compared to the business-as-usual alternative.

## 6.7 Solar Electric

### 6.7.1 Introduction

Solar power is a renewable energy source familiar to most everyone. It is relatively accessible due to its scalability and its distributed nature. Jackson and Josephine counties have a relatively long history in the implementation of solar power with the Pioneer programs in Ashland and the net-metered projects facilitated by incentive programs throughout the region. There are over 400 individual solar projects that have been installed since 2000 in Jackson and Josephine counties.

### 6.7.2 Technology

There are several technologies used in capturing the energy of solar radiation or “insolation” and converting it to electricity. The two primary technologies discussed in this section are solar photovoltaic (PV) and solar thermal.

#### ***Photovoltaic (PV)***

Solar PV converts solar radiation directly into electricity. There are two main types of solar PV technologies: single crystal or polycrystalline silicon cells and thin film technology.

Single crystal or polycrystalline silicon cells are the most widely used today. Single crystal cells are manufactured by growing single crystal ingots, which are sliced into thin cell-size material. The cost of the crystalline material is significant. The production of polycrystalline cells can cut material costs, but with some reduction in cell efficiency.

Thin film solar cells are made from layers of semiconductor materials only a few micrometers thick. These materials make applications more flexible, which allows it to be integrated into roofing tiles or windows. Thin film cells significantly reduce cost per unit area, but also result in lower efficiency cells and a lower productivity per unit of area.

Solar PV has the ability to be installed in utility-scale applications with plant capacities of 3 MW or larger and capacity factors of 23%.<sup>162</sup> Utility applications are dependent on large areas of land and can face issues of interconnection with the transmission grid, as they may be located in remote areas. Solar PV more typically is utilized in a small-scale, distributed application on new or existing buildings with residential capacities of typically less than 100 kW and commercial capacities of 100 kW or more. These applications are typically net-metered and do not face the transmission issues that utility-scale projects face.

Concentrating photovoltaic (CPV) plants provide power by focusing solar radiation onto a PV module, which converts the radiation directly to electricity. Mirrors or lenses are used to concentrate the solar energy for a CPV system. Most CPV systems use two-axis tracking to achieve point focus images on PV cells. CPV systems have potential for cost reduction compared with conventional, non-concentrating PV systems in two primary ways.

First, a major portion of the conventional PV system cost is for the semiconductor material, which makes up the PV modules. By concentrating sunlight onto a small cell, the amount of semiconductor material can be reduced, albeit at additional cost for mirrors or lenses and for tracking equipment. Recent decreases in solar module prices due to semiconductor-grade silicon have made CPV more cost effective.

Second, use of smaller cells allows for more advanced and efficient cell technology, making the overall system efficiency higher than for a conventional flat plate system. CVP technology appears to be more applicable to

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<sup>162</sup> AZ report B&V

utility size installations due its scale, land requirements and need for tracking mounts in order for the system to be cost effective.

## **Solar Thermal**

Unlike PV, which converts sunlight directly into electricity, Concentrating Solar Power (CSP) systems make use of the direct normal insolation (DNI) component of solar radiation to generate heat using mirrors or lenses. The heat is then transferred to a working fluid to run a turbine or engines for electricity generation. Because this technology utilizes DNI there is a need for these systems to track the sun in order to achieve high enough working fluid temperature to generate electricity. CSP systems require a significant amount of area and ideal solar conditions and are typically utility scale.

There are several different technologies that are either commercially viable or in initial stages of development. Parabolic Trough, Parabolic Dish-Engine and Power Tower technology are the most common systems.

Parabolic trough solar thermal systems have been the primary solar thermal technology installed to date. Parabolic trough systems concentrate solar radiation using single axis tracking, parabolic curved, trough-shaped reflectors onto a receiver pipe located at the focal line of the parabolic surface. A high temperature heat transfer fluid picks up the thermal energy and is then used to make steam in a steam generator.

A solar parabolic dish-engine system is made up of a solar concentrator in the form of a parabolic dish and a power conversion unit that heats a working fluid to power a Stirling Engine.<sup>163</sup> The dish redirects solar radiation to a receiver mounted on a boom at the dish's focal point. The system uses a two-axis tracker so that it points at the sun continuously. This technology is unitized in 10 to 25 kW modular systems and can be implemented in a distributed arrangement independent of the transmission grid.

**Figure 47:** Parabolic tower



**Figure 45:** Parabolic trough system



**Figure 46:** Parabolic dish engine



A parabolic tower uses thousands of sun-tracking mirrors called heliostats to redirect solar radiation to a receiver at the top of a tower where a molten nitrate salt heated in the receiver is used to generate steam. This steam is then used in a conventional turbine generator to produce electricity.

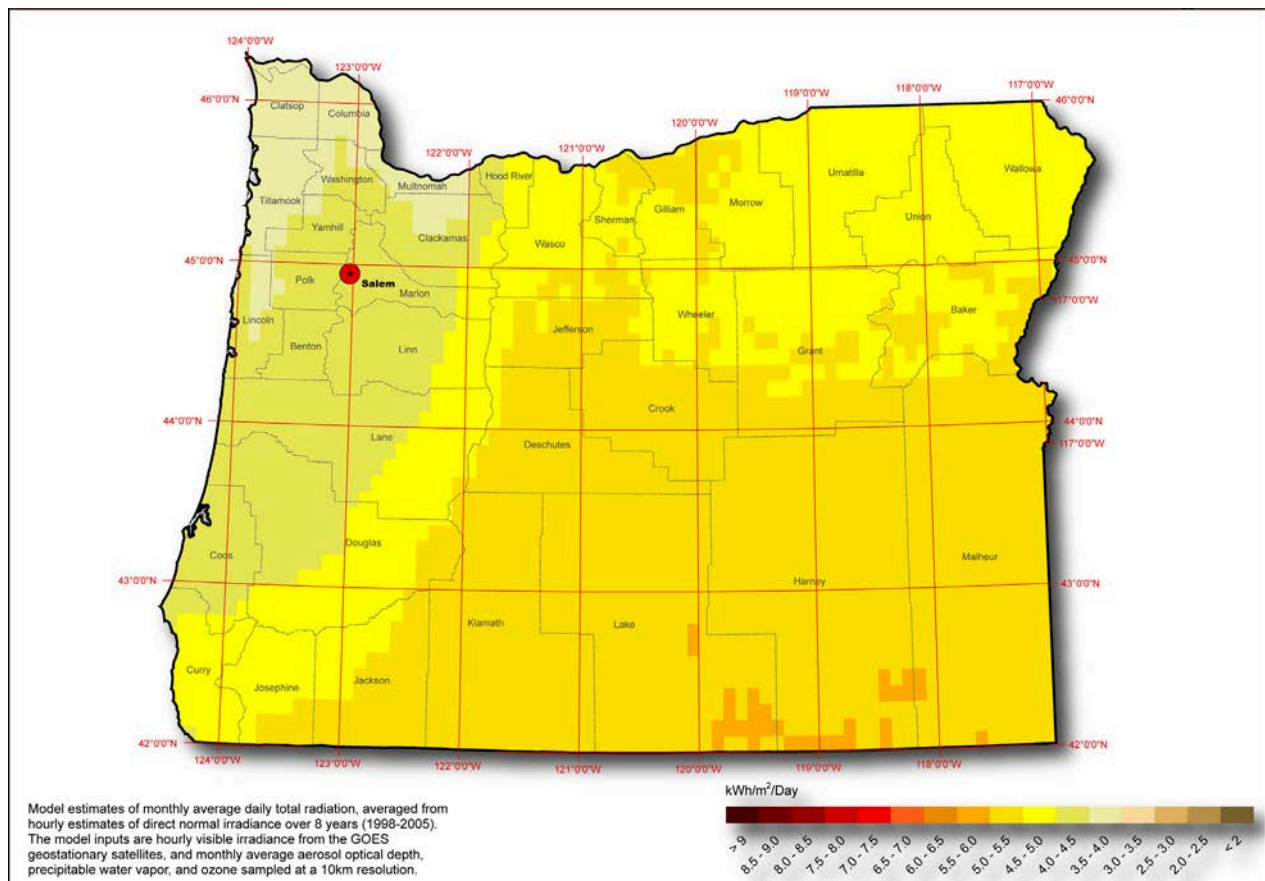
<sup>163</sup> [http://en.wikipedia.org/wiki/Stirling\\_engine](http://en.wikipedia.org/wiki/Stirling_engine)

### 6.7.3 Resource Potential

Solar energy resources are massive and widespread, and they can be harnessed anywhere that receives sunlight. The amount of solar radiation reaching the earth's surface is about 10,000 times greater than the amount required for all current human energy needs.<sup>164</sup> While the theoretical potential of solar energy may be near limitless, there are a number of technical factors that limit this potential. Issues such as geographic location, time of day, and current weather conditions, all affect the amount of energy that can be harnessed for electricity production.

Although solar energy is vastly abundant, it is also variable and intermittent. Solar power is only able to generate electricity during daylight hours and currently, as there is not a cost-effective means of storage, there are limits to its application. Although it is intermittent, its generation is well matched to peak electricity demand. In other words, typical peak electric demand occurs during periods when solar power generation is at its peak allowing it to help level peak loads.

**Figure 48:** Average annual solar ration at latitude tilt



**Source:** National Renewable Energy Laboratory

Jackson and Josephine counties receive between 4.5 and 5.5 kWh/meter<sup>2</sup> of solar energy per day according data collected by NREL (see Figure 49). This makes solar PV well-matched for implementation as a renewable energy resource in these counties. Although several programs exist in Ashland, Medford, and Grants Pass to help develop solar PV and have resulted in over 400 PV installations on buildings.<sup>165</sup>

In addition to building mounted PV installations, Jackson and Josephine counties have extensive land resources that could be utilized for ground mounted PV applications. The City of Medford conducted a study to

<sup>164</sup> C-31

<sup>165</sup> S-8

determine solar PV potential on city owned properties.<sup>166</sup> The results of this study identified several building mounted applications as well as underutilized land and parking areas that were well suited for solar applications. The identified ground-based applications were either in areas where parking lots could benefit from shading provided by PV or pieces of land that were unlikely to be used for other applications due to their location, such as land adjacent to the sewer treatment plant.

Another project that was identified in the research for existing alternative energy projects in development by RHT Energy Solutions utilizes land adjacent to the airport that, due to aviation restrictions, has limited potential for other types of development. The generation potential at this single project could increase the current total installed PV resource in Jackson and Josephine counties by 400%. The urbanized land area in Jackson and Josephine counties offer extensive opportunities for PV installations that do not face issues of interconnection to transmission grid and offer direct load reduction at the location of the demand. In addition, there is extensive rural land that could support utility scale solar PV or solar thermal plants if located adequately close to the transmission grid. The resource potential in Jackson and Josephine counties is vast and is not limited by the amount of solar radiation it receives or sites to locate solar energy resources.

RVCOG is partnering with the City of Portland Bureau of Planning and Sustainability's (BPS) Solar Now! program, Solar Oregon, Energy Trust of Oregon (ETO), Southern Oregon Clean Energy Alliance (SOCEA), and RHT Energy Solutions to develop and implement "Rogue Solar" which is a photovoltaic (PV) solar panel installation pilot program. Implementation of this project will increase the demand for solar energy in the Rogue Valley (Jackson & Josephine Counties). This pilot project focuses on residential and commercial solar installations.

Rogue Solar, will be a volunteer-driven, community-based solar panel leasing and bulk buying pilot project operated by the Rogue Valley Council of Governments (RVCOG) in partnership with local solar contractors and support from the Southern Oregon Green Jobs Council (SOGJC). The SOGJC in this project will facilitate homeowner and business participation in the local workshops that will cover how much solar to purchase, what to budget, and how to get started. The SOGJC will also generate support and legitimacy for the program within the community, in which is likely to attract participants.

Rogue Solar intends to install solar on 100 to 150 homes and 25 businesses, for over 800 kilowatts of new solar electric capacity by mid-2012. In addition, the program hopes to increase the energy efficiency of more than 100 area homes by connecting residents to the Rogue Valley - Clean Energy Works Oregon weatherization program. Interested homeowners can choose to invest in solar, participate in weatherization upgrades, or both.

Figure 51 presents the estimated rooftop solar PV potential in Jackson and Josephine counties split by residential and non-residential roof types. The primary difference between these two roof types is pitch (i.e., non-residential roofs are typically flat). This estimate is performed using the methodology<sup>167</sup> outlined in Chapter 2 of the report titled *Potential for Renewable Energy in the San Diego Region*<sup>168</sup> by the San Diego Regional Renewable Energy Study Group. Roof area data is publically available from Jackson and Josephine counties in the form of Geographic Information System (GIS) layers, specifically the Building Poly layer from Jackson County<sup>169</sup> and the Building layer from Josephine County.<sup>170</sup> The Josephine county layer does not include buildings in Grants Pass. To estimate the roof area in Grants Pass, Josephine County data was used to estimate based on the average roof space per person in Josephine County.

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<sup>166</sup> S-4

<sup>167</sup> For residential structures it is assumed that 50% of buildings are suitable and of those buildings, 50% of roofs are suitable. For non-residential structures it is assumed that 100% of buildings are suitable, but only 50% of roofs are suitable. For both roof types it is assumed that alternating current (AC) electricity represents 77% of direct current (DC) electricity, pitch is adjusted at 99% and 100 square feet of roof area is required for 1 kW of installed capacity. More details can be found in the San Diego report. The National Renewable Energy Laboratory's tool PV Watts is used to estimate electricity generation based on DC nameplate capacity.

<sup>168</sup> Download the report at

<sup>169</sup> Data at <http://www.smartmap.org/portal/gis-data.aspx>

<sup>170</sup> Data at <http://68.185.2.151/website/data/shapefiles/>

**Figure 50:** Estimated solar PV electricity potential for Jackson and Josephine counties

County	Roof Type	Total Roof Area	Total Capacity (AC)	Total Electricity Generation	Electricity Generation (1% of potential)	Electricity Generation (5% of potential)	Electricity Generation (10% of potential)
		square feet	MW	MWh	MWh	MWh	MWh
Jackson	Residential	181,671,267	346	569,727	5,697	28,486	56,973
	Non-residential	95,118,421	363	596,589	5,966	29,829	59,659
Josephine	Residential	58,907,194	209	184,735	1,847	9,237	18,473
	Non-residential	30,842,298	234	193,445	1,934	9,672	19,345
Totals:		276,789,688	709	1,166,317	11,663	58,316	116,632

Note: Total roof area in Figure 51 represents total suitable roof area in Jackson and Josephine counties.

As is seen in Figure 51, if all suitable roof space were covered with PV solar panels, based on today's panel electricity conversion efficiency, it would generate approximately 1.2 million MWh per year. This represents about 40% of the quantity of electricity consumed in Jackson and Josephine counties in 2005 (~3 million MWh). The table also includes percentages of the total (1%, 5%, 10%) to show generation if these rates of penetration are achieved. One percent of the total generation equals 2.5 kW systems on about 3,700 homes, 5% equals about 18,600 homes and at 10% equals about 37,000 homes. If the nameplate capacity is increased to 25 kW the number of commercial (non-residential) systems required for 1% equals about 370 installations, 5% equals about 1,800 installations and 10% equals about 3,700 installations.

There is also large potential for the use of small-scale solar thermal for water heating use. Solar thermal can be used as residential or commercial potable or process water heating as well as for heating pools. This is one of the most economical sources of solar energy production and can be easily implemented on existing rooftops and infrastructure. In addition, it requires no additional transmission infrastructure and can be used to reduce demand load during peak times, potentially deferring the need to improve distribution infrastructure. The focus of this assessment is electricity generation, not thermal energy generation, so the potential of this resource is not assessed. That said the 6<sup>th</sup> Northwest Power Plan lists residential water heating as the second largest energy efficiency opportunity in our region.

Domestic solar thermal water heaters come in a variety of configurations, technology types (flat plate, evacuated tube, drain down, drain back, etc.) that are all proven technologies. Solar domestic water heaters using copper plates were installed in many homes in Jacksonville in the early to mid 1800's. Some are rumored to still be operational. According to the Oregon Department of Energy Solar Domestic Water Heating Systems Yield Charts, the average two panel solar water heater can supply as much as half the hot water used by a family of four in Jackson and Josephine counties.

Two panel or 30 evacuated tube systems cost between \$7,000 and \$9,000 to install and can produce the equivalent of 2,000 to 2,500 kilowatt hours of equivalent thermal energy per year. The first year annual energy cost savings for solar water heating can range between \$60 for natural gas water heated homes to as much as \$180 per year for electric water heated homes. The State of Oregon, ETO and federal government all have incentives to buy down the cost of solar domestic water heating to less than half of the system's installed cost.

#### 6.7.4 Costs

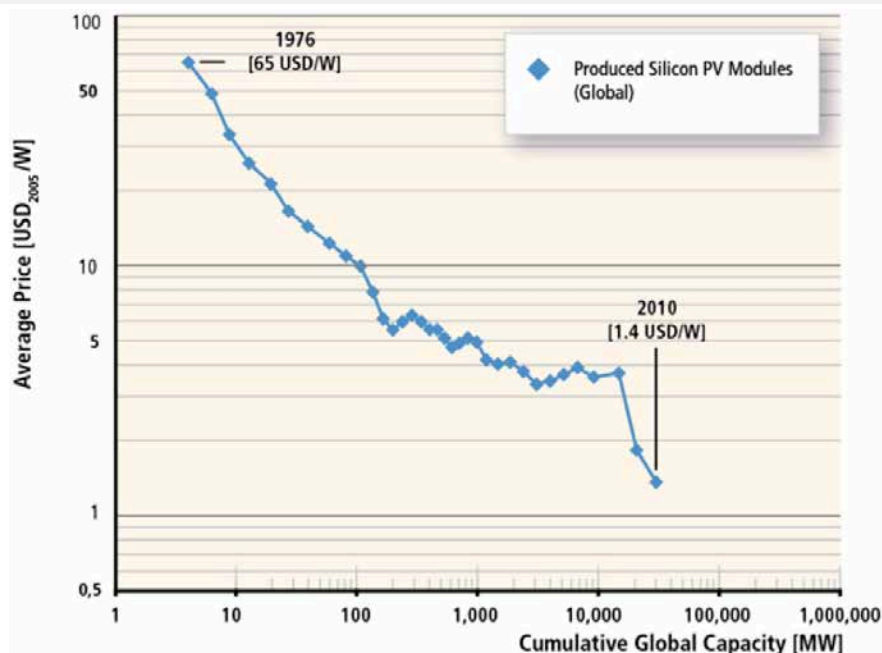
While the potential for solar power is extensive, the cost to manufacture and install the solar modules limits its widespread use. The levelized cost to install crystalline solar PV ranges between \$128 and \$154 per MWh, thin film solar PV ranges between \$96 and \$124 per MWh, and solar thermal installations can range between \$90 and \$145 per MWh.<sup>171</sup> The capital costs of solar generation are among the highest of all renewables with crystalline solar PV between \$4,500 and \$5,000 per kW, thin film PV between \$3,250 and \$4,000 per kW and

<sup>171</sup> CI-3

solar thermal between \$4,500 and \$6,300 per kW.<sup>172</sup> These capital costs are based on nameplate capacity and do not take into account capacity factors and dispatch characteristics, which limit solar generation.

Although solar currently is the most expensive renewable technology, over the last 30 years solar technologies have seen very substantial decreases in cost. These decreases are dependent on production volume, research and development, and access to capital. In the mid 1970's solar manufacturing costs were at \$65 per Watt while the current cost of manufacture today is closer to \$1.40 per Watt. This resulting cost curve is often equated to Moore's Law, in which every doubling of manufacturing capacity results in costs falling 20%<sup>173</sup> (see Figure 51).

**Figure 51:** Solar PV manufacture costs trends



Source: IPCC SEERN

While solar manufacturing costs have seen these types of reductions, the installation or Balance of System (BOS) cost (which includes financing, structural racking, electrical wiring, transformers and other miscellaneous installation costs) is more complicated to project due to variables in permitting, financing and labor. The BOS costs are currently a substantial factor in the implementation of solar power and can make up about 50% of the cost of a system.<sup>174</sup> A recent study by the Rocky Mountain Institute has looked closely at BOS costs and projects that with advances in installation techniques and financing changes, the BOS costs could drop by 50% in the next 5 years.<sup>175</sup>

## 6.7.5 Risks and Challenges

### **Variable Production Profile**

Solar energy typically has a production profile affected by both intermittency issues (it is variable due to weather factors and the fact that daylight hours are limited) and uneven geographic distribution of solar resources. These aspects inherently limit the production of energy from solar power, and must be taken into account when determining whether specific sites are appropriate for solar installations.

<sup>172</sup> CI-3

<sup>173</sup> CI-31

<sup>174</sup> S-9

<sup>175</sup> S-9

## **Cost**

Solar power remains expensive relative to electricity produced using traditional fossil fuel generation sources as well as certain renewable energy sources like wind. Currently solar energy is the most subsidy-dependent renewable energy source. Based on a study by Lazard<sup>176</sup> on levelized cost of energy, the levelized cost of solar power would increase between 55-65% without federal tax incentives whereas other renewable technologies such as geothermal, wind and biomass would only increase by 20-30% without federal tax incentives, making solar highly dependent on subsidies to be cost effective.

## **Land Requirements**

Solar projects have faced concerns regarding land requirements for centralized CSP and PV plants, and perceptions regarding visual impacts and aesthetics. Selecting areas with low population densities and low environmental sensitivity can minimize Land use impacts.

## **Transmission**

Solar power, specifically utility-scale PV and CSP, is also limited by a lack of transmission infrastructure that is necessary to utilize solar resources in remote areas, such as deserts, and transport the electricity generated to end users. However, solar technologies offer a number of opportunities for on-site or distributed generation applications in which energy is produced at the point of consumption, including rooftop PV arrays and building-integrated photovoltaic (BIPV) systems. Such systems can make solar power more cost-competitive by avoiding costs associated with transmission and distribution.

## **Industry Capacity and Supply Chain Issues**

In recent years there has also been a lack of input materials (notably processed silicon) for the manufacturing of PV, though these shortages are expected to ease in the near future. Lack of materials may also place constraints on the manufacturing of some advanced next-generation PV.

## **Materials Issues**

The most significant environmental, health, and safety hazards are associated with the use of hazardous chemicals in the manufacturing phase of the solar cell. Improper disposal of solar panels at the end of their useful life also presents an environmental, health, and safety concern. The extraction of raw material inputs, especially the mining of crystalline silica, can also pose an environmental, health, and safety risk.

The environmental, health, and safety concerns for the life-cycle phase are minimal and limited to rare and infrequent events. With effective regulation, enforcement and vigilance by manufacturers and operators, any danger to workers, the public and the environment can be minimized. Further, the benefits of PV tend to far outweigh risks, especially when compared to conventional fossil fuel technologies. According to researchers at the Brookhaven National Laboratory, regardless of the specific technology, PV generates significantly fewer harmful air emissions (at least 89%) per kilowatt hour than conventional fossil fuel-fired technologies.<sup>177</sup>

## **6.7.6 Benefits and Opportunities**

### **Production Matches Peak Demand**

There are numerous benefits to utilizing the sun to generate electricity. Solar radiation is a free and plentiful fuel and although it is intermittent it is well matched to peak energy use. Energy provided by PV panels can be especially valuable because the energy production often occurs at times of peak loads on the grid, as in cases where there is a large summer daytime load associated with air conditioning (see Figure 52).

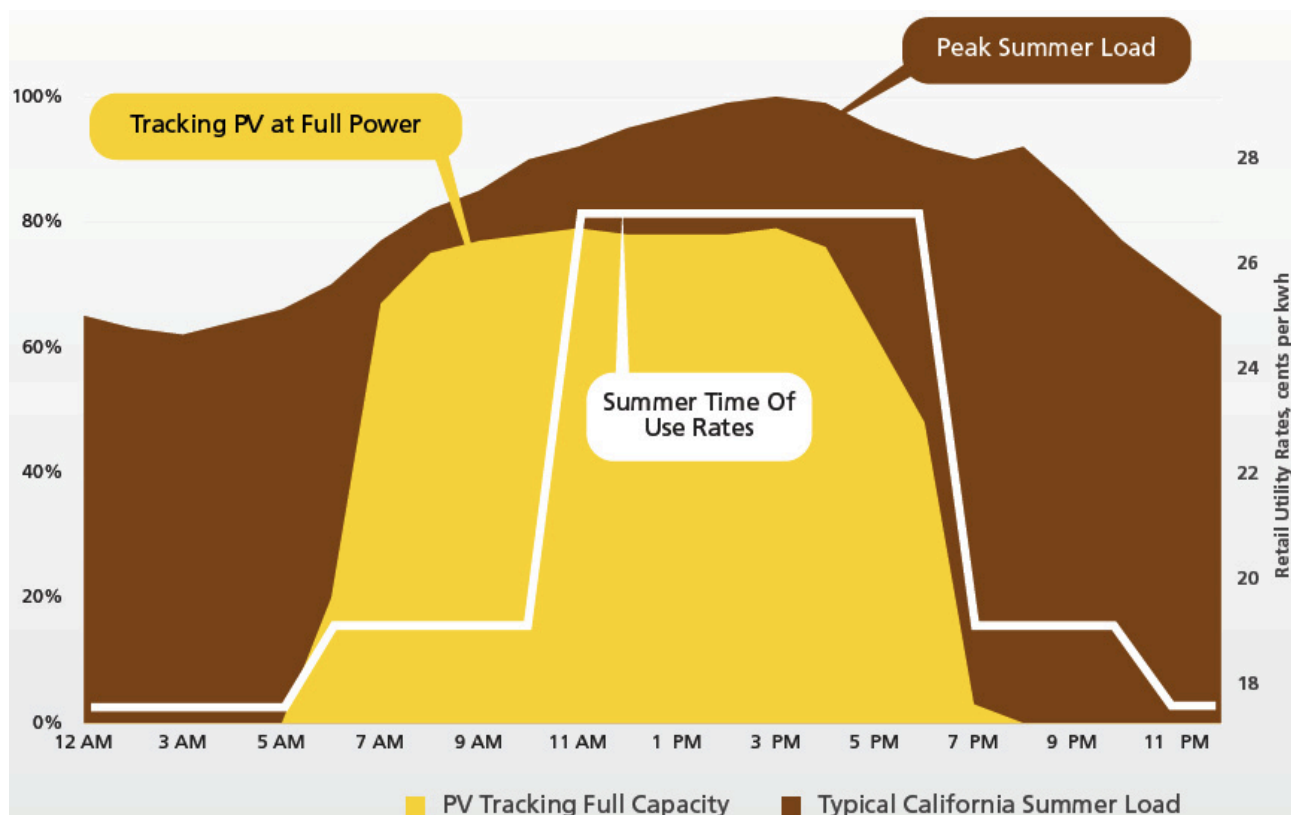
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<sup>176</sup> CI-3

<sup>177</sup> S-12

This is when the cost of electricity is at its highest and when the utilities rely on gas peaker plants to generate electricity. This tends to be some of the dirtiest (in terms of criteria air pollutants and greenhouse gas emissions) and least efficient electricity to generate. The peaker plants are often plants that no longer meet current air permit requirements and cannot run year round, but still hold an air permit. The facility stays below the annual threshold for total pollutants, but produces for short periods of time and at peak price and then shuts down.

**Figure 52:** Peak solar generation matched with peak electricity demand



### ***Distributed***

Solar PV also has the benefit of being a distributed source of power generation. This places the generation of electricity at the source of the demand and does not rely on transmission or distribution grid upgrades. If solar PV installations are targeted where grids are near capacity during peak demand cycles they offer the opportunity to offset the need for upgrades to the grid, providing the potential for large cost savings.

### ***Quick Implementation***

Solar PV is also quick to market. It can be produced and installed at a pace far faster than most energy technologies and can be quickly deployed on existing infrastructure (warehouses, commercial buildings, residences) providing immediate economic value.

### ***Low Life-Cycle Greenhouse Gas Emissions***

The lifecycle GHG emissions from the development of PV panels are relatively low and range between 30 and 80 g CO<sub>2</sub>/kWh with energy payback ranging from 2-5 years depending on technology and location.<sup>178</sup>

### ***Feed in Tariff (FIT)***

Pacific Power currently offers a Feed in Tariff (FIT) program, an incentive program in which the electric utility pays the owner of a solar electric system a fixed premium rate for every solar kilowatt hour generated over a

<sup>178</sup> CI-31

15 year term. Those payments allow the owner to recoup the investment over time. The program started in 2010 and will end no later than 2015, and allows for 25 MW of capacity statewide. There is a dedicated capacity reserve for each category of small, medium, and large systems. Capacity will be made available every six months for small and medium systems and annually for large capacity systems. While this is a promising program, it currently is insufficient to meeting demand of developers for solar installations. In both the July and October offerings in the Pacific Power service area were completely allocated within four minutes.<sup>179</sup>

### ***Community Solar***

Due to the high cost and small-scale implementation of solar PV, several community solar programs have been developed to help lower the costs and increase the scale of projects. Community solar happens wherever multiple community members share in the costs and benefits of a single solar installation.

Many different models have emerged and the city of Ashland has been a leader in the region with the Pioneer programs. Another variation of community solar is the Solarize program started in Portland. The program was developed to help residents overcome the financial and logistical hurdles of installing solar power by organizing bulk purchases of materials and labor. Due to the scale of these types of projects, expertise and purchase power can be leveraged to substantially reduce the cost and complication of small-scale distributed solar power.

Within its initial six months Solarize Portland had signed up more than 300 homes and installed solar on 120 homes in one neighborhood. The 120 installations added 350 kilowatts of new PV capacity to Portland, and will produce an estimated 359,000 kWh of electricity per year. The project also helped provide 18 professional wage jobs for site assessors, engineers, project managers, journeyman electricians, and roofers.<sup>180</sup>

### ***Peak Pricing***

Due to the matching of solar power production and peak electricity, larger scale utility solar power installation have the opportunity to negotiate much better pricing on power purchase agreements with the local utility. This ability to charge a higher rate for the sale of peak power makes the high cost of solar development more economically viable. In addition, there are significant benefits with the replacement of high GHG producing gas peaker plants with non-GHG producing solar plants.

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<sup>179</sup> S-4

<sup>180</sup> S-14

## 6.8 Wind

### 6.8.1 Introduction

Wind is one of the oldest sources of energy harnessed by humankind. Wind has been historically used to pump water for irrigation, grind grain and propel sailing ships. Recently there has been resurgence in the use of wind at a large scale for the production of electricity. Currently, wind power in Oregon consists of 1,477 operating utility-scale turbines with a nameplate capacity of 2,200 MW. There is an additional 4.1 GW in development or under construction.<sup>181</sup> Currently in Jackson and Josephine counties, there are fewer than 30 kW of capacity installed as small-scale distributed locations.

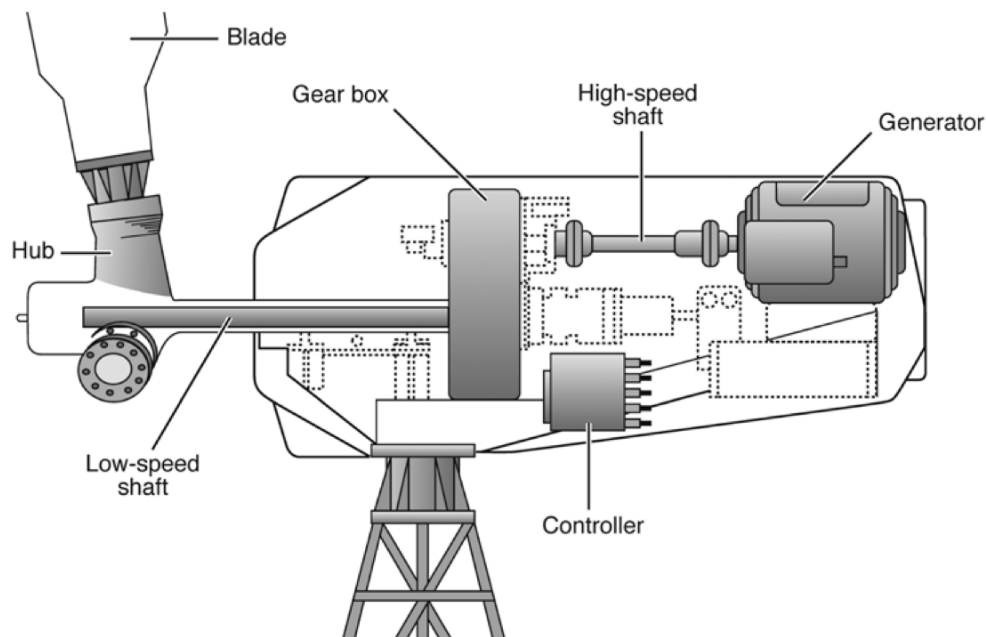
### 6.8.2 Technology

Wind energy relies, indirectly, on the energy of the sun. A small proportion of the solar radiation received by the earth is converted into kinetic energy in the form of wind. The earth's rotation, geographic features and temperature gradients affect the location and nature of the resulting winds. The use of wind energy requires that the kinetic energy of moving air be converted to useful energy.

There are two types of wind turbines used to convert wind energy; drag devices where blades move parallel to the wind; and lift devices where blades, like propellers move perpendicular to the wind.

Lift devices are classified according to the orientation of the rotor axis: vertical axis wind turbines (VAWT) and horizontal axis wind turbines (HAWT). The most common deployment of commercial wind turbines is HAWT turbines. They typically have a gearbox to increase revolutions per minute (RPMs) attached to a variable speed generator (see figure 53). VAWT turbines are often deployed where wind speeds are more variable and turbines are relatively small in capacity.

**Figure 53:** Horizontal axis wind turbine (HWAT) components



Source: <http://www.infinitepower.org/newfact/96-817-No17.pdf>

Typical commercial turbines range in size from 1 to 3 MW. Economies of scale have led to commercial units as large as 6 MW with a rotor span of 126 meters. Units of 10 MW in size are in the development stages. In

<sup>181</sup> W-7

addition to large-scale commercial use of wind, small-scale utilization (less than 100 kW) has been utilized for a long time. Windmills have historically been used in rural areas for pumping water for livestock and residential use. Small wind power systems used to generate electricity are also commonly used as a distributed generating source to offset localized loads.

### 6.8.3 Resource Potential

Wind is an intermittent resource as power is only generated when the wind is blowing. Capacity factors are highly dependent on the speed and frequency of the wind in a specific area and can range from 20 to 40 percent<sup>182</sup> depending on the wind regime and turbine characteristics. The capacity factor is directly tied to the economic performance of the turbine and sites with strong resources are required for cost-effective installations. Due to wind power being so dependent on siting the turbines near the highest quality wind resource, it is often not situated near population centers where the demand load occurs or near transmission lines. Often additional transmission infrastructure is required to match the wind resource to the current transmission grid and energy load (population) centers. This infrastructure requirement can add significant cost to wind development.

Due to the intermittent dispatch of wind energy, it cannot be relied upon as baseload capacity or for peak power demands. Because wind energy is generated with a very low marginal operating cost, it is typically used to meet demand when it is available, thereby displacing the use of other generators that have higher marginal costs. To provide a dependable resource wind can be coupled with energy storage systems, such as pumped storage, to provide power when required. While this coupling with storage increases dependability it also can add considerable expense to a system.

Turbine power output is proportional to the cube of wind speed, which makes small differences in wind speed very significant. Wind strength is rated on a scale from Class 1 to Class 7 – see US DOE classification listed below.

US DOE Classes of Wind Power. Height Above Ground: 50 m (164 ft)*		
Wind Power Class	Wind Power Density (W/m <sup>2</sup> )	Speed** (m/s)
1	0 to 200	0 to 5.60
2	200 to 300	5.60 to 6.40
3	300 to 400	6.40 to 7.00
4	400 to 500	7.00 to 7.50
5	500 to 600	7.50 to 8.00
6	600 to 800	8.00 to 8.80
7	800 to 2000	≥ 8.80

Notes:

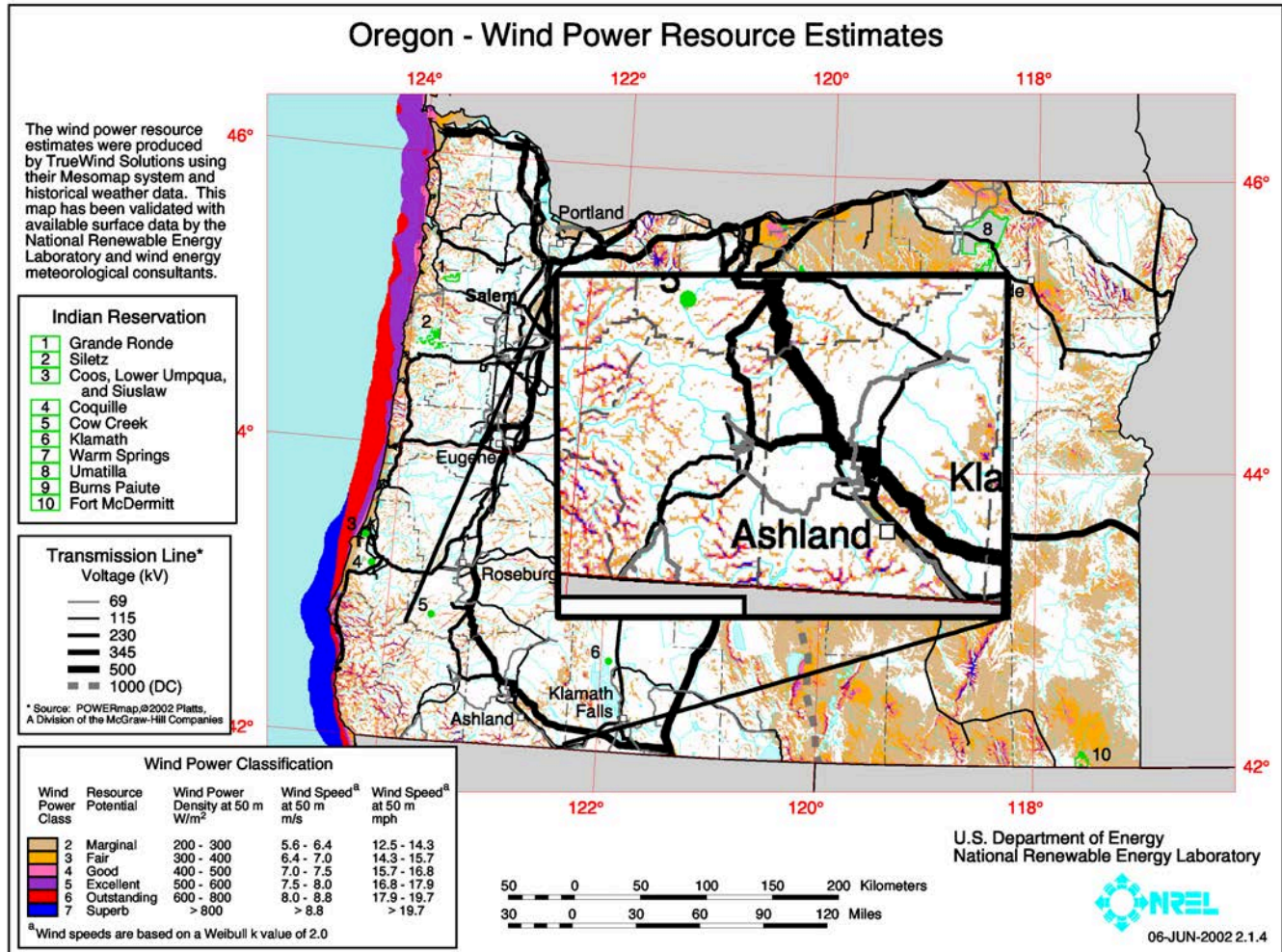
\* Vertical extrapolation of wind speed based on the 1/7 power law, defined in Appendix A of the *Wind Energy Resource Atlas of the US, 1991*.

\*\* Mean wind speed is based on Rayleigh speed distribution of equivalent mean wind power density. Wind speed is for standard sea level conditions. To maintain the same power density, wind speed must increase 3% per 1,000 m (5% per 5,000 ft) elevation.

Currently, there is very little utilization of wind in the study area. The only sources identified in Task 1 were small distributed applications that were used to offset local loads. While currently there is very little wind resource developed, Jackson and Josephine counties do have several areas with good wind potential. Based on data gathered by NREL (see Figure 54) there are many areas that have Class 3 and above wind resource with concentrations of Class 4 and above along the ridgelines in southern Jackson and Josephine counties. Typically wind classifications of 3 are at the edge of being commercially viable while wind classifications of 4 and above can be very productive.

<sup>182</sup> CI-13

**Figure 54:** Wind potential map showing power class and transmission line locations.

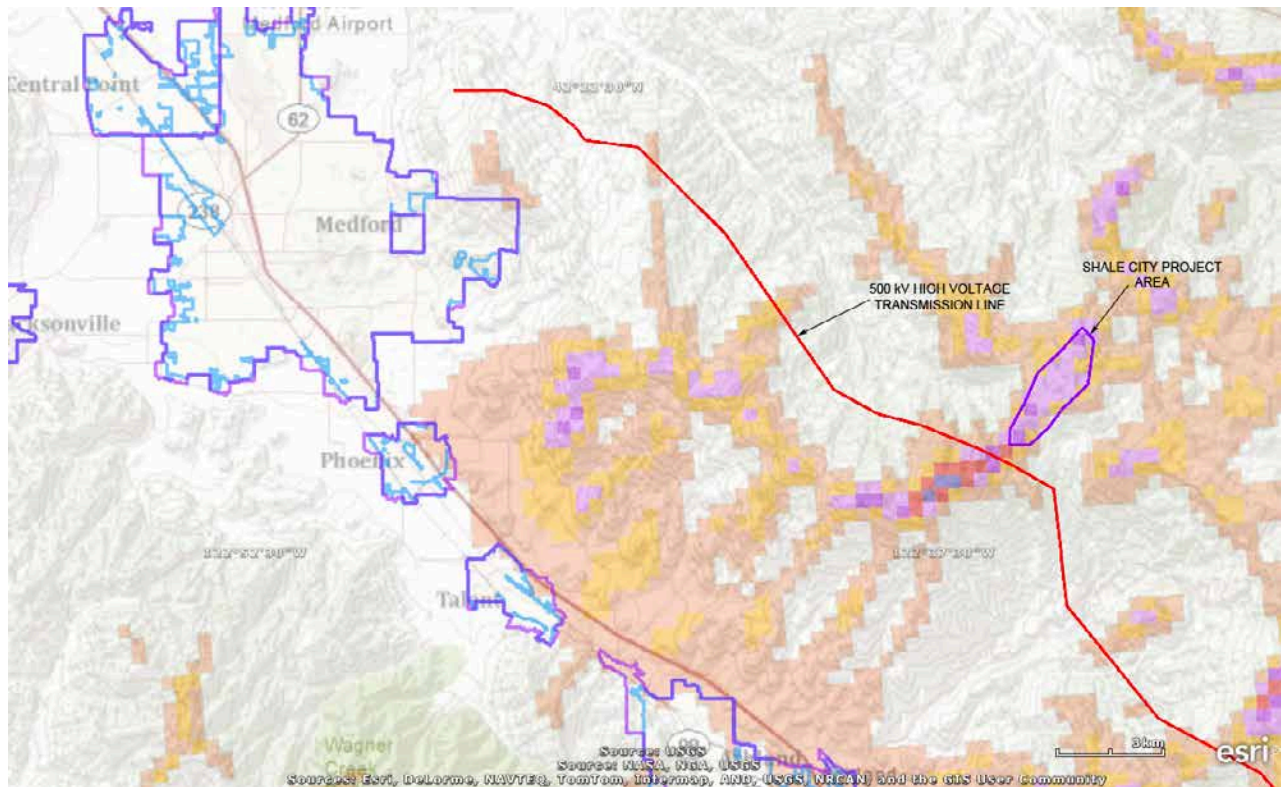


**Source:** National Renewable Energy Laboratory

Information was gathered on Jackson and Josephine counties wind resources, topographic characteristics, transmission infrastructure, transportation access, and environmental limitations in order to determine specific areas conducive to the development of utility-scale wind projects.

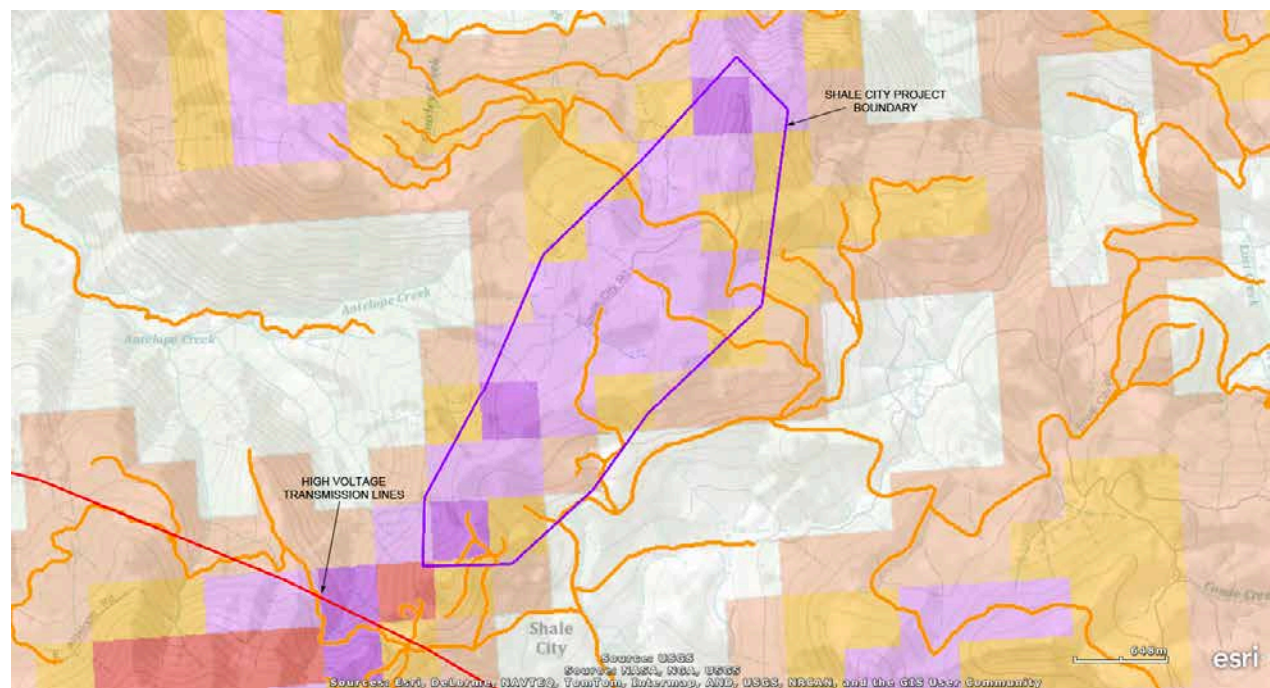
An initial list of potential sites was created based on the presence of significant land area with a Class 4 or greater wind power classification. Each of these sites were then reviewed based upon its proximity to adequate transmission line (high voltage, greater than 69 kV), being located outside of federal, state or locally designated environmentally sensitive areas, and based upon access to roads that would allow constructability and transport of the equipment to the site. In addition, sites with steep slopes or with potential view corridor conflicts (i.e., areas within view of the Pacific Crest Scenic Trail) were eliminated as too challenging to construct and too difficult to garner public approval.

**Figure 55:** Image 1 of the most promising wind development site identified, Shale City Project Area



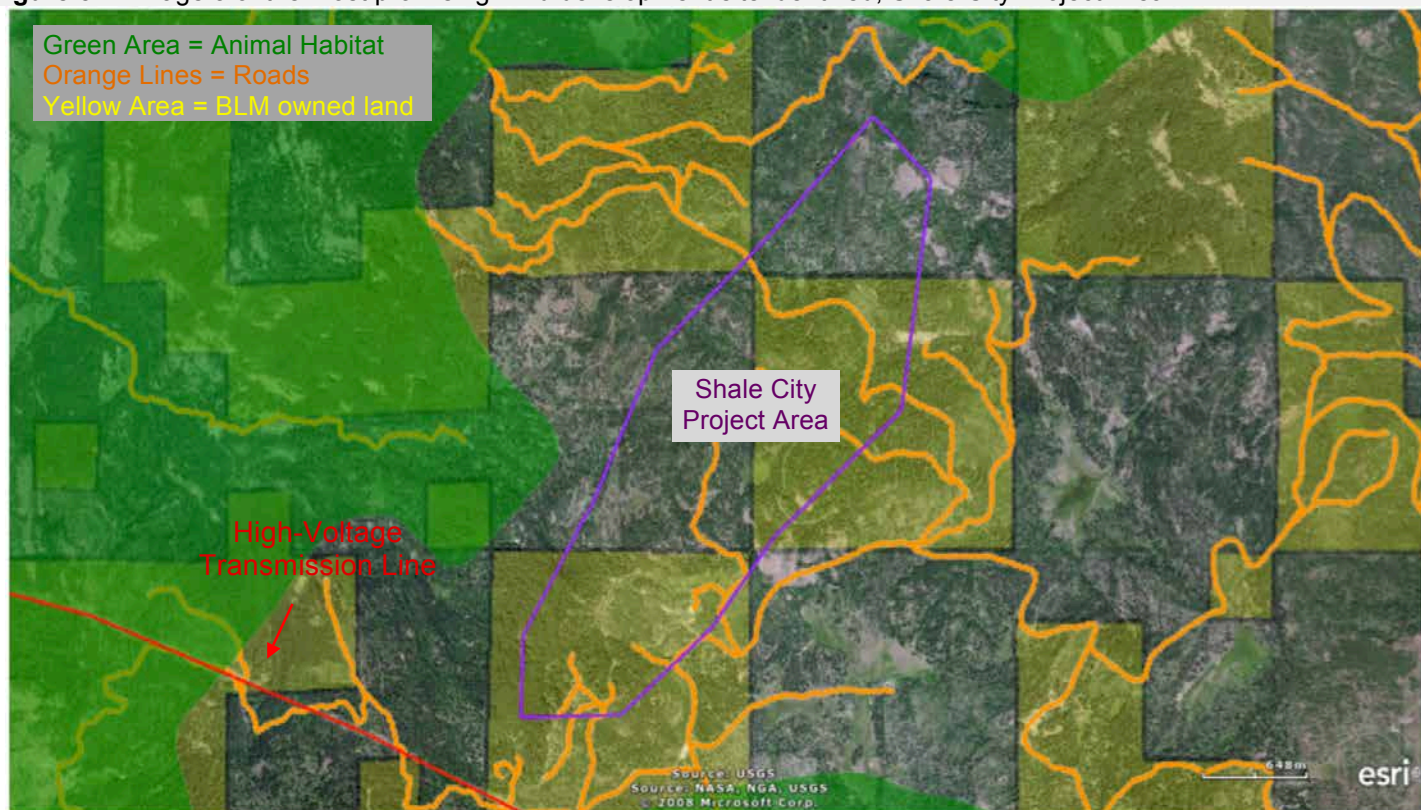
Several sites with adequate wind power resource were identified in the southeastern and western portions of Josephine County and in the southern portions of Jackson County (see Figure 54). Most of these areas were either too steep, inaccessible by road or happened to fall within the view corridor of the Pacific Crest Scenic Trail. Due to these challenges the sites were eliminated from further analysis. One promising site was identified just west of Medford in Jackson County and is referred to as the Shale City Project Area (see Figure 55 and 56).

**Figure 56:** Image 2 of the most promising wind development site identified, Shale City Project Area



The Shale City Project Area consists of 930 acres and is located 11 miles east of Medford and 7 miles west of Howard Prairie Lake in an area noted on the map as Shale City. The site is one of the few ridge tops in the region that has relatively gentle slopes and maintains good exposure to class 4 and 5 winds. There is access on existing roads running out of Ashland along Walker Creek direct to the project site allowing for delivery of equipment and facilitating construction (shown in orange in Figures 56 and 57). A major 500 kV transmission line runs directly adjacent to the site, making the possibility of interconnection to the grid likely. The site also falls outside of the designated winter range habitat of black-tailed deer and Roosevelt elk herds (shown green in Figure 57) as designated by the Jackson County land use code and the Oregon Department of Fish and Wildlife.

**Figure 57:** Image 3 of the most promising wind development site identified, Shale City Project Area



The site consists of land under both private and federal ownership. In Figure 57 the yellow areas are BLM ownership while the uncolored areas are private ownership. This is typical for much of the wind resource within Jackson and Josephine counties as the ridge tops with wind resource are relatively isolated and do not tend to coincide with ownership boundaries. This may present challenges to assembling large enough areas to make development feasible. For the purpose of this analysis the entire area was modeled to determine potential generation capacity.

Potential power generation was modeled using RET Screen4,<sup>183</sup> a renewable energy analysis tool developed by the Government of Canada to perform high level tests to screen potential development sites worldwide. The Vestas V90-1.8 GridStreamer with a 90 meter rotor was selected for analysis due to its suitability with the project's wind classification, its proven performance in the marketplace and its ability to be grid connected to a wide variety of grid specifications. Turbine spacing was determined using the guidelines in a technical report published by the National Renewable Energy Laboratory in 2009. A hypothetical layout using parallel string alignment over the 930 acres was used to determine a total of fifteen 1.8 MW turbines over the project site with an average capacity factor of 29%. Based on these parameters and the RET Screen4 analysis tool, this site could support a 27 MW project with a projected 68,591 MWh of annual generation.

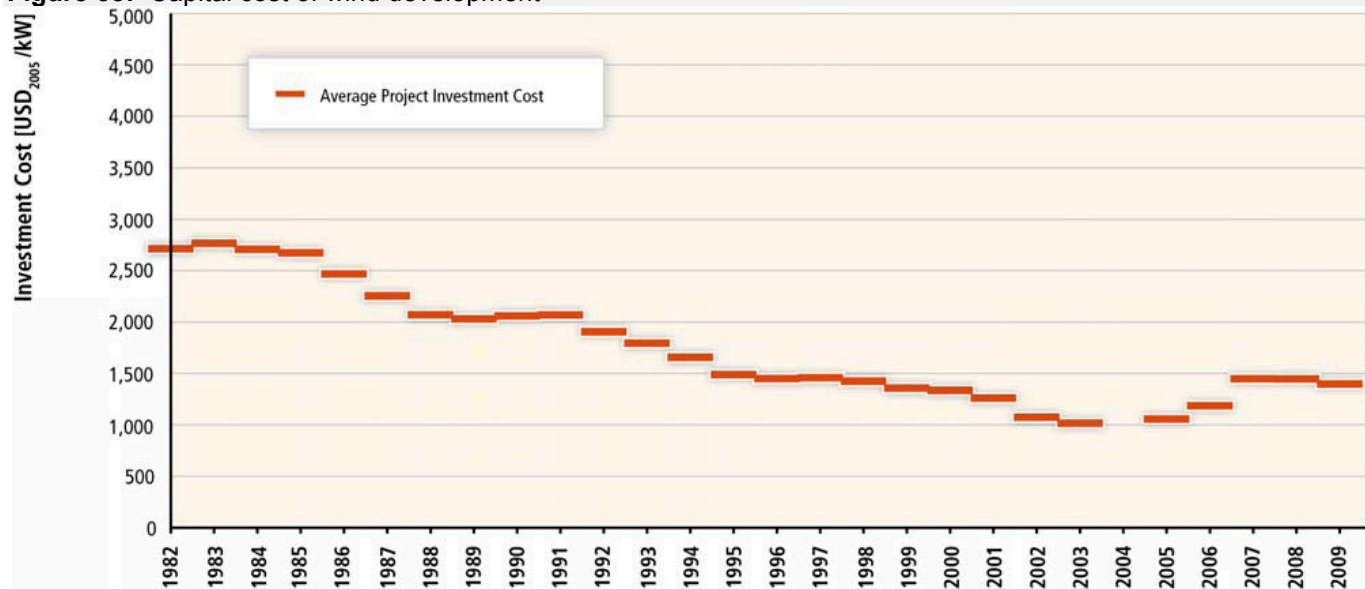
<sup>183</sup> <http://www.retscreen.net/ang/home.php>

## 6.8.4 Costs

The costs for wind energy development can vary considerably due to projects that require upgrades to the grid or long transmission lines for tie in. In addition, issues such as terrain and access to transportation can vary greatly and have large cost impacts. The development of sites with better wind resources can significantly improve the capacity factors of turbines, which directly ties to the levelized cost of wind. The current levelized cost of wind ranges from \$57-\$113 per MWh<sup>184</sup> making it one of the least expensive renewable energy sources and comparable or less expensive than most conventional energy sources. Wind is also one of the most competitive energy sources based on the capital cost to develop ranging from \$1,900 to \$2,500 per kW.<sup>185</sup>

Wind is capital intensive with the initial investment of the development ranging from 75 to 80% of the total expenditure of the project. This initial cost includes the cost of the turbines, transmission and grid connection, the cost of the roads, foundations, engineering, permitting, and licensing costs. The remaining 20% of the cost is made of the O&M costs consisting of land leases, insurance, taxes, and the maintenance of the turbines.<sup>186</sup>

**Figure 58:** Capital cost of wind development



Source: IPCC SRREN report

The historic trend in the cost of the development of commercial wind energy has dropped (see Figure 58). Issues such as turbine design improvements, siting improvements and increasing turbine scales have led to these cost reductions. Between 2004 and 2009, costs to develop wind energy rose primarily due to turbine cost increases. This was due to increases in raw material costs and increased demand enabling turbine manufacturers to increase their profits.<sup>187</sup>

## 6.8.5 Risks

### Transmission

Wind power is highly dependent on being geographically located near wind resources. This can lead to high development costs due to transmission interconnection issues and energy dispatch that is variable. Improvements to transmission infrastructure and development of energy storage systems may help mitigate these risks but these solutions have been slow to develop and pose cost issues.

<sup>184</sup> CI-3

<sup>185</sup> CI-3

<sup>186</sup> CI-31

<sup>187</sup> CI-31

## ***Land Area***

There are several environmental issues that accompany the development of wind. Commercial wind development typically encompass a large area, thereby using space that might otherwise be used for other purposes or might displace or disrupt wildlife. The land footprint specifically disturbed by onshore wind turbines and their supporting roads and infrastructure, however, typically ranges from 2 to 5% of the total area encompassed by a wind power plant,<sup>188</sup> allowing agriculture, ranching, and certain other activities to continue within the area. There is also the opportunity for large-scale wind development to be coupled with ground mounted utility scale solar power helping to level the production profile of two intermittent energy sources.

## ***Avian and Bat Fatalities***

Bird and bat fatalities from collisions with wind turbines are among the most publicized environmental concerns associated with wind power plants. Populations of many species of birds and bats are in decline, leading to concerns about the effects of wind energy on vulnerable species. Though most of the bird fatalities reported in the literature are of songbirds, which are the most abundant bird group in terrestrial ecosystems, raptor fatalities are considered to be of greater concern, as their populations tend to be relatively small<sup>189</sup> and they regulate populations of other creatures as top level predators.

The magnitude and population-level consequences of bird and bat collision fatalities can also be viewed in the context of other fatalities caused by human activities. The number of bird fatalities at existing wind power plants appears to be orders of magnitude lower than other anthropogenic causes of bird deaths (e.g., vehicles, buildings and windows, transmission lines, communications towers, house cats, pollution, and other contaminants). Moreover, it has been suggested that onshore wind power plants are not currently causing meaningful declines in bird population levels, and that other energy supply options also impact birds and bats through collisions, habitat modifications, and contributions to global climate change.<sup>190</sup>

## ***Visual, Aesthetic and Sound***

Visual impacts, and specifically how wind turbines and related infrastructures fit into the surrounding landscape, are often among the top concerns of communities considering wind power. A variety of nuisance effects are also sometimes raised with respect to wind energy development, the most prominent of which is noise. Noise from wind turbines can be a problem, especially for neighbors living within close range. Often a lengthy community involvement process is required to ensure these concerns will not derail the development of wind projects close to urban areas. This is unlikely to pose a conflict in Jackson and Josephine counties as most of the wind resources occur on the ridges and away from urban areas.

Most of the wind resource in Jackson and Josephine counties are located along ridge tops and in potentially pristine habitat. This makes the turbines highly visible and presents the risk of disrupting scenic view corridors.

## ***Regulatory Framework***

There are various levels of regulation involved in the development of wind power. Large, utility-scale wind projects face approvals at the federal, state and local level, while small, distributed wind projects may only face local approvals. Projects of up to 105 MW can choose to pursue permitting through local planning departments or apply for a site certificate from the state Energy Facility Siting council (EFSC). Projects of 105 MW or larger must be permitted through EFSC. In order to receive a permit the project must meet a number of siting requirements including organizational expertise, financial assurance, land use, soil protection, and public health and safety, among others. In addition, there are several federal permits that must be obtained through the Oregon Department of Environmental Quality (DEQ). These permits are above and beyond what is required by EFSC. These permits can take a long time to obtain and can add significant cost to a project. There is guidebook that outlines wind power siting requirements, which is published by the American Wind Energy Association.<sup>191</sup>

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<sup>188</sup> CI-31

<sup>189</sup> CI-31

<sup>190</sup> CI-31

<sup>191</sup> W-6

## 6.8.6 Benefits

### Cost

Wind is one of the least expensive forms of renewable energy to develop and since the fuel is free, it has one of the lowest levelized costs.<sup>192</sup> It is also a mature technology that has a proven track record in development, presenting little risk once it is permitted and located near a reliable wind resource.

### GHG emissions

The energy used and GHG emissions produced in the direct manufacture, transport, installation, operation and decommissioning of wind turbines are small compared to the energy generated and emissions avoided over the lifetime of wind power plants: the GHG emissions intensity of wind energy is estimated to range from 8 to 20 g CO<sub>2</sub>/kWh in most instances, whereas energy payback periods are between 3 and 9 months.<sup>193</sup>

## 6.9 Geothermal

### 6.9.1 Introduction

The State of Oregon has abundant geothermal resources. There is an estimated geothermal potential of 4,600 MWt in Oregon, but only a little over 1% of that potential is being utilized. Oregon's geothermal potential is third only to that of Nevada and California. Almost the entire state east of the Cascade Range has ample low- to mid-temperature geothermal resources for direct heat applications. This is especially true of the south and southeastern portions of the state. As a result, Oregon has about 2,200 thermal wells and springs that furnish churches, schools, homes, communities, businesses and facilities with 500 to 600 billion Btu of energy per year.<sup>194</sup> Task 1 identified very limited resource being utilized in Jackson and Josephine counties and it appears the region sits just outside of the most productive geothermal resources in Oregon.

### 6.9.2 Technology

Geothermal energy taps into the natural heat of the earth to produce electricity. More specifically, conventional geothermal energy draws on the earth's hydrothermal resources (underground heated water and steam). Lower temperature geothermal resources can be directly utilized as a heat resource.

Below is a list of geothermal temperature ranges and their typical application.<sup>195</sup>

- Surface Temperature (40°F to 80°F)
  - Geothermal HVAC systems for homes and buildings
- Low Temperature (70°F to 165°F)
  - Direct Use: agriculture and greenhouses, aquaculture (fish farming), mineral water spas and bath facilities, district water heating, soil warming, fruit and vegetable drying, concrete curing, and food processing
- Moderate Temperature (165°F to 300°F)
  - Binary fluid generators for electrical production; Direct Use: absorption chillers, fabric dyeing, pulp and paper processing, lumber and cement drying, and sugar evaporation
- High Temperature (>300°F)
  - Electricity production, hydrogen production, ethanol, and biofuels production; Direct Use: minerals recovery

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<sup>192</sup> CI-3

<sup>193</sup> CI-31

<sup>194</sup> GT-4

<sup>195</sup> GT-14

## Direct Use of Heat

Developing the direct use of geothermal energy typically involves a production facility, a well and pump to bring the warm water to the surface, a mechanical system (piping, heat exchanger, controls, etc.) to deliver the heat to the processing space, and a disposal system in the form of an injection well or storage pond that receives the cooled geothermal fluid.

District geothermal systems distribute hydrothermal water from one or more geothermal wells through a series of pipes to several houses and buildings, or to blocks of buildings. The geothermal production well and distribution piping replace the fossil fuel-burning heat source of the traditional heating system.

Direct use of geothermal resources has been well received within the agribusiness industry, with the two primary uses being greenhouses and aquaculture (fish farming).

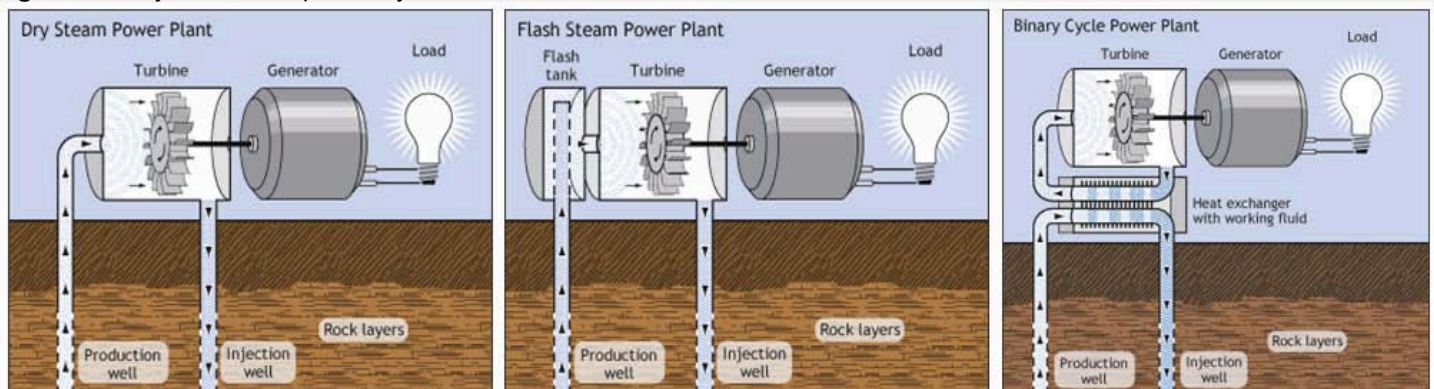
## Electricity Production

Electric power generation development using geothermal energy has been very active worldwide, with systems in the U.S. developed since the 1960s. Most of the focus and knowledge are on geological locations that are tectonically active, such as volcanoes, geyser fields and hot springs in the western United States. These are areas where heat from within the earth has reached sufficiently shallow depths to make the economics of heat recovery feasible for large-scale power production.

Electricity is generated through either a flash steam plant, direct steam plant or a binary cycle plant. All of these technologies utilize geothermal resources classified as medium or high temperature. The most common type of geothermal reservoir is a flash steam plant using a two-phase mixture of liquid and vapor. The conventional approach is to use only the vapor in a steam driven turbine with the liquid available for use in a variety of direct heat applications. Direct steam plants utilize high temperature, dry, saturated or superheated steam from wells transmitted by pipeline to a powerhouse where it is used directly in impulse turbines. Dry steam reservoirs are rare and there are no documented wells of this type in Oregon.

Binary cycle plants operate in areas with moderate temperature geothermal wells. Rather than using hydrothermal resources to drive a turbine, binary cycle uses the earth's heated water to vaporize a working fluid, which can be any fluid with a lower boiling point than water. The vaporized working fluid drives a turbine that powers a generator, while the extracted geothermal water is promptly re-injected into the reservoir without ever leaving its closed loop system. The latter two technologies are being considered at several prospective well sites in Oregon (outside of Jackson and Josephine counties) that are in the early stages of development. These sites are typically located along the Cascade Crest or in Southeastern Oregon. Currently, there are no existing or planned electricity generating plants located in Jackson or Josephine counties.<sup>196</sup>

**Figure 59:** Hydrothermal power systems



Source: U.S. Department of Energy. Geothermal Technology Program

## Enhanced Geothermal Systems (EGS)

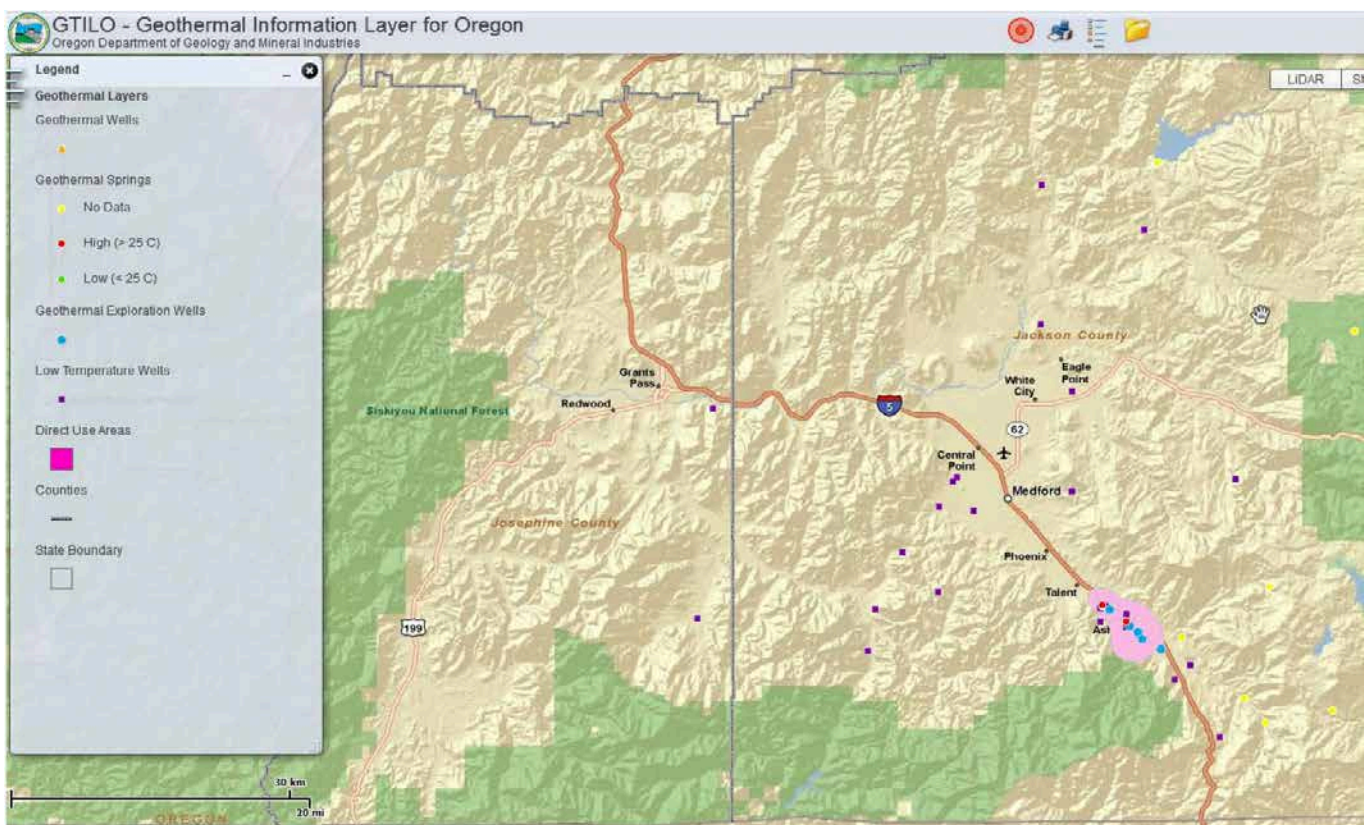
Enhanced Geothermal Systems (EGS) utilize hot dry rock and inject water deep in the earth with an injection well resulting in hot water that is removed with a production well. This technology is theoretically limitless and can be utilized almost anywhere. Currently EGS is limited by the economic limits of drill depth and only has experimental projects underway.<sup>197</sup>

### 6.9.3 Resource Potential

There is an extensive well head data base for the State of Oregon that is compiled by the Oregon Department of Mineral Industries called the *Geothermal Information Layer for Oregon (GTILO)*.<sup>198</sup> The goal of GTILO is to establish a database of the state's geothermal resources as an effective means to communicate Oregon's geothermal potential and promote future investment. The database was compiled from several sources that inventoried warm or hot springs (above 68°F) in Oregon.

In the GTILO Database, Jackson Hot Springs, located in Ashland, is the only geothermal source listed for thermal direct use. An additional hot spring near Ashland was identified in a study conducted by the Oregon Institute of Technology.<sup>199</sup> All other geothermal resources contained within these well logs were categorized as surface temperature and would not be effective for the lowest threshold of direct use, much less electricity generation. A map showing all geothermal resources is shown in Figure 60.

**Figure 60:** Geothermal layer for Oregon



**Source:** Geothermal Information Layer for Oregon by DOGAMI

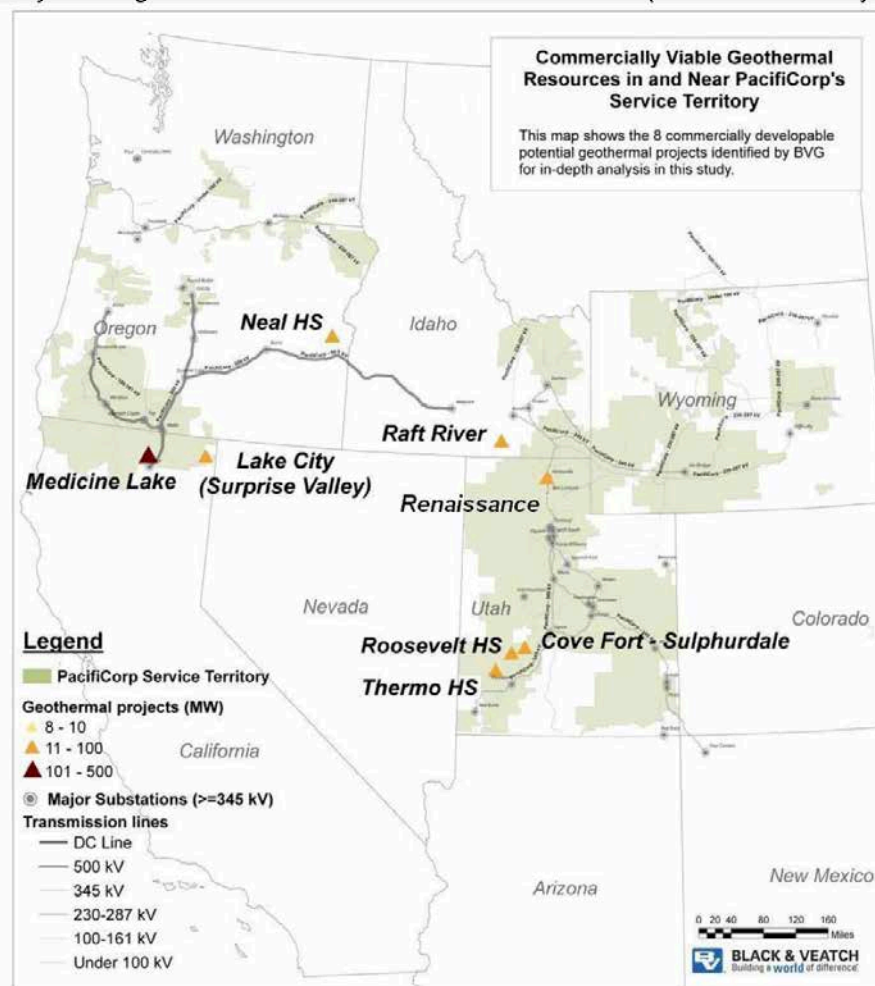
<sup>197</sup> GT-12

<sup>198</sup> GT-7, GT-8

<sup>199</sup> GT-4

A second regional study by Pacific Power was completed as part of their Integrated Resources Plan.<sup>200</sup> This report assesses the commercial viability of geothermal resources within its service area. Classification as a commercially viable resource was under the assumption that only projects in the confirmation and development stages would have a level of resource risk sufficiently low to be considered. Out of the more than 80 geothermal resource areas initially identified, only eight geothermal resource areas met the commercial viability criterion and none of these resources were located in Jackson or Josephine counties.

**Figure 61:** Commercially viable geothermal resources in and near PacifiCorp's service territory



Source: Pacific Power IRP

Based on these two studies, it appears unlikely there is an abundant enough resource identified to significantly increase geothermal power in Jackson or Josephine counties in the near future. This also implies that there would not be cause to fund further exploration.

## 6.9.4 Costs

The capital costs for geothermal development are highly variable depending the depth and temperature of the resource and the technology used to generate the electricity. There are also large cost variations based on the capacity of the generation plant. While the capital cost to develop a geothermal plant can be very high, the operations cost to generate the electricity, including maintenance, can be very low as there is no cost to purchase fuel.

<sup>200</sup> EE-1

The levelized cost of energy for geothermal ranges from \$58 to \$93 per MWh with capital costs ranging from \$3,425 to \$4,575 per kW to develop, making geothermal one of the least expensive renewable energy sources and comparable to or better than many conventional generation technologies.<sup>201</sup>

## **6.9.5 Risks and Barriers**

### ***Financing***

Geothermal development costs are heavily loaded upfront with exploration, reservoir characterization and drilling (all high risk and cost) and because of this, locating investment can be difficult. Historically, financiers of geothermal projects have considered some percentage of production at the wellhead (typically about 25%) as a threshold for proceeding with a construction loan.<sup>202</sup> Without confidence in well production or resource availability, funding for development of projects is unlikely to occur.

### ***Regulatory Issues***

An extensive report has been generated by the Oregon Institute of Technology outlining the regulatory framework in Oregon for Geothermal development.<sup>203</sup> There are a variety of issues that need to be addressed when considering development of new geothermal power. All groundwater and surface water in Oregon is considered owned by the public and use of the water with some exceptions for small uses, requires a water right from the State.

Fluid disposal (injection or surface) is governed by a set of procedures and guidelines delegated to the State through the U.S. Environmental Protection Agency. Direct-use injection wells come under the jurisdiction of the DEQ in Oregon and surface disposal of low-temperature geothermal water is generally covered under either an NPDES (National Pollution Discharge Elimination System) or WPCF (Water Pollution Control Facility) permit. The regulatory environment for geothermal can lead to permitting delays and can increase the amount of time it takes to bring new geothermal facilities on-line, increasing project costs and developer risk.

### ***Environmental***

Reinjection of geothermal water, if not handled properly, poses the risk of ground water contamination. Extensive water use without reinjection can cause land sinks and may deplete ground water resource.

## **6.9.6 Benefits and Opportunities**

### ***Cost***

Geothermal is a free fuel technology. When resource is available, it can be very cost effective. If a good resource is located, the levelized cost is one of the lowest of any renewable or traditional energy sources.

### ***Reliability***

Geothermal is a baseload resource that can provide firm power operating 24 hours a day. If not providing a baseload it can be used to manage peak demand as it can quickly ramp up production.

### ***Small-Scale Thermal***

Earth coupled heat pump opportunities exist in Jackson and Josephine counties and can provide the next-to-the-lowest cost of operation and carbon space conditioning system right after from biomass thermal. In areas of the counties where there is no natural gas service and there are significant heating and cooling loads, earth coupled heat pumps provide low connected electric load solutions.

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<sup>201</sup> CI-3

<sup>202</sup> GT-15

<sup>203</sup> GT-6

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# Hydropower

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H-5	Year by Year cost and generation information on Greensprings Power Plant	Bureau of Reclamation (2007)	
H-6	Prospect History	Historical Resarch Associates (2011)	
H-7	FERC list of licensed, exempt and pending licenses	FERC	<a href="http://www.ferc.gov/industries/hydropower/gen-info/licensing/small-low-impact/get-started/projects-nearby.asp">http://www.ferc.gov/industries/hydropower/gen-info/licensing/small-low-impact/get-started/projects-nearby.asp</a>
H-8	OWRD Dam Inventory	ODWR	<a href="http://apps.wrd.state.or.us/apps/misc/dam_inventory/default.aspx">http://apps.wrd.state.or.us/apps/misc/dam_inventory/default.aspx</a>
H-9	Merlin Waterline flow data - Grants Pass		email
H-10	Oregon wide irrigation district study for hydro power	Energy Trust of Oregon, Black Rock Consulting (2009)	
H-11	Water Rights explained	Oregon Water Resources Department (2009)	<a href="http://www.wrd.state.or.us">http://www.wrd.state.or.us</a>
H-12	Micro-Hydro power overview	Natural Resources Canada (2004). <i>Micro-hydropower systems, A Buyer's guide</i>	
H-13	Hydro power overview	Dan New (2004). <i>Intro to Hydro Power</i>	Energy Trust of Oregon
H-14	Potential at Federal Facility	U.S. Department of the Interior, U.S. Department of the Army, U.S. Department of Energy (2005) <i>Potential Hydroelectric Development at Existing Federal Facilities</i>	
H-15	Oregon market assessment for small hydro	Energy Trust of Oregon, Summit Blue (2009). <i>Small Hydropower Technology and Market Assessment</i>	Energy Trust of Oregon
H-16	Talent Irrigation District Study		
H-17	Bureau of Reclamation Existing facility report	United States Department of the Interior, Bureau of Reclamation, Power Resources Office	
H-18	US small Hydro Feasibility	United States Department of Energy	
H-19	FERC hydro license data base		FERC: Projects Near You
H-20	Bureau of Reclamation Rogue River Basin Project site		Project details - Rogue River Basin Project - Bureau of Reclamation
H-21	Corps of Engineer website		Lost Creek
H-22	Riverbank Power - Applegate Dam website		Riverbank Power-applegate
H-23	RRV Irrigation District improvement study	HDR (2009)	
H-24	Bureau of Reclamation RRV Prject history	Linenberger, Bureau of Reclamation (1999)	
H-25	Prospect License renewal - FERC	FERC	
H-26	Pacific Power Website - Rogue River Project	<a href="http://www.pacificcorp.com/es/hydro/hl/rr.html#">http://www.pacificcorp.com/es/hydro/hl/rr.html#</a>	
H-27	NOT USED	NOT USED	
H-28	FERC Licensing guide	FERC	
H-29	Estimation of Economic Parameters of US Hydropower Resources	INEEL(2003)	
H-30	Renewables and Climate Change	IPCC	
H-31	California RETI	Black & Veatch (2008)	

## Biomass (Direct Fired)

Index number	Title	Author	Link or Source
B-1	A Geographic Perspective on the Current Biomass Resource Availability in the United States	A. Milbrandt (2005)	<a href="http://www.nrel.gov/docs/fy06osti/39181.pdf">http://www.nrel.gov/docs/fy06osti/39181.pdf</a>
B-2	Biomass One website		<a href="http://www.biomassone.com">http://www.biomassone.com</a>
B-3	Rough and Ready project profile	DOE	<a href="http://www.chpcenter.nw.org/NwChpDocs/Rough%20and%20Ready%20-%20case%20study%20-%20pp011811.pdf">http://www.chpcenter.nw.org/NwChpDocs/Rough%20and%20Ready%20-%20case%20study%20-%20pp011811.pdf</a>
B-4	Biomass Feasibility Study For the Applegate Watershed	TSS Consultants (2007)	<a href="http://www.applegatepartnership.org/Files/Applegate%20Biomass%20Feasibility%20Report.pdf">http://www.applegatepartnership.org/Files/Applegate%20Biomass%20Feasibility%20Report.pdf</a>
B-5	How Many? A Dictionary of Units of Measurement: Bone-dry ton discription	Russ Rowlett and the University of North Carolina at Chapel Hill	<a href="http://www.unc.edu/~rowlett/units/dict8.html">http://www.unc.edu/~rowlett/units/dict8.html</a>
B-6	Murphy Co. buys Panel Products	Greg Stiles, Mail Tribune (Dec. 10, 2009)	<a href="http://www.mailtribune.com/apps/pbcs.dll/article?AID=/20091210/NEWS/912100318">http://www.mailtribune.com/apps/pbcs.dll/article?AID=/20091210/NEWS/912100318</a>
B-7	Annual Electric Generator Report - 2009	US Energy Information Administration (2009)	<a href="http://www.eia.gov/cneaf/electricity/page/eia860.html">http://www.eia.gov/cneaf/electricity/page/eia860.html</a>
B-8	Combined Heat and Power Partnership	US EPA	<a href="http://www.epa.gov/chp/basic/index.html">http://www.epa.gov/chp/basic/index.html</a>
B-9	Oregon Energy Trust Biomass Assessment	Itron (2004)	<a href="http://www.oregon.gov/ENERGY/RENEW/docs/CREFF/ItronBiomass.pdf?qa=t">http://www.oregon.gov/ENERGY/RENEW/docs/CREFF/ItronBiomass.pdf?qa=t</a>
B-10	Phase II Biopower Market Assessment Sizing and Characterizing the Market for Oregon Biopower Projects	CH2MHILL (2005)	<a href="http://www.oregon.gov/ENERGY/RENEW/docs/CREFF/CH2MHill_Bioenergy_Market_Assessment.pdf?qa=t">http://www.oregon.gov/ENERGY/RENEW/docs/CREFF/CH2MHill_Bioenergy_Market_Assessment.pdf?qa=t</a>
B-11	EPA BioPower Mapping Application	NREL	<a href="http://rpm.nrel.gov/biopower/biopower/launch">http://rpm.nrel.gov/biopower/biopower/launch</a>
B-12	Wood2Energy: A State of the Science and Technology Report	University of Tennessee Office of BioEnergy Programs (2010)	<a href="http://www.usendowment.org/images/Wood2Energy_Publicat ion_Final_S.pdf">http://www.usendowment.org/images/Wood2Energy_Publicat ion_Final_S.pdf</a>
B-13	Bioenergy Technologies –A Review of Current Commercial Technologies	Larry Swan and Tad Mason (2006)	<a href="http://www.sustainablenorthwest.org/resources/biomass/Larry%20Swan%20-%20TSS.pdf">http://www.sustainablenorthwest.org/resources/biomass/Larry%20Swan%20-%20TSS.pdf</a>
B-14	Rogue Basin Collaborative Forest Restoration Project CFLRP Proposal	The Rogue River-Siskiyou National Forest and the Rogue Basin Collaborative	<a href="http://www.fs.fed.us/r6/rogue-siskiyou/projects/rog-basin-coll-forest-landscape-restoration/01-rogue-basin-cflrp-proposal.pdf">http://www.fs.fed.us/r6/rogue-siskiyou/projects/rog-basin-coll-forest-landscape-restoration/01-rogue-basin-cflrp-proposal.pdf</a>
B-15	Regulatory and Siting Considerations for Biomass Power Plants	TSS Consultants, Frederick Tornatore (2009)	<a href="http://www.tssconsultants.com/inc/download.php?filename=presentationsFile25_Regulatory%20and%20Siting%20Considerations%20for%20Biomass%20Power%20Plants%2020100113.ppt.pdf">http://www.tssconsultants.com/inc/download.php?filename=presentationsFile25_Regulatory%20and%20Siting%20Considerations%20for%20Biomass%20Power%20Plants%2020100113.ppt.pdf</a>
B-16	Biomass Energy Use Incentives Market-Based Mechanisms	TSS Consultants, Christopher Calvin (2009)	<a href="http://www.tssconsultants.com/inc/download.php?filename=presentationsFile23_CClavin%20CBC%20Market%20Mechs%2020090512.pdf">http://www.tssconsultants.com/inc/download.php?filename=presentationsFile23_CClavin%20CBC%20Market%20Mechs%2020090512.pdf</a>
B-17	Lessons Learned From Biopower Development Efforts in North America	TSS (2008)	<a href="http://www.tssconsultants.com/inc/download.php?filename=presentationsFile24_SAF%202008%20Conv%20BiopowerDev%2020081104.pdf">http://www.tssconsultants.com/inc/download.php?filename=presentationsFile24_SAF%202008%20Conv%20BiopowerDev%2020081104.pdf</a>
B-18	Energy Kids: Biomass	U.S. EIA	<a href="http://www.eia.gov/kids/energy.cfm?page=biomass_home-basics">http://www.eia.gov/kids/energy.cfm?page=biomass_home-basics</a>
B-19	Biomass Energy Data Book: Edition 3	U.S. Department of Energy (2010)	<a href="http://cta.ornl.gov/bedb/pdf/BEDB3_Full_Doc.pdf">http://cta.ornl.gov/bedb/pdf/BEDB3_Full_Doc.pdf</a>
B-20	USDA Forest Service. Fuel Value Calculator	US Department of Agriculture (2004)	<a href="http://www.fpl.fs.fed.us/docmnts/techline/fuel-value-calculator.pdf">http://www.fpl.fs.fed.us/docmnts/techline/fuel-value-calculator.pdf</a>
B-21	Principles for Sustainable Biomass	Environmental Working Group * Environmental Defense Fund * Friends of the Earth * Geos Institute * Greenpeace USA * National Wildlife Federation * Natural Resources Defense Council * Southern Alliance for Clean Energy * Southern Environmental Law Center * The Wilderness Society * World Wildlife Fund	<a href="http://www.nobiomassburning.org/BAP/Public_Health_files/Principles%20for%20Sustainable%20Biomass%20FINAL_4April11.pdf">http://www.nobiomassburning.org/BAP/Public_Health_files/Principles%20for%20Sustainable%20Biomass%20FINAL_4April11.pdf</a>
B-22	Southern Oregon Small Diameter Collaborative Landscape Assessment of Fire Risk Map	Southern Oregon Small Diameter Collaborative/ U.S. Department of the Interior BLM	<a href="http://www.blm.gov/or/districts/medford/forestry/pilot/pilot-maps.php">http://www.blm.gov/or/districts/medford/forestry/pilot/pilot-maps.php</a>
B-23	Fixing a Critical Climate Accounting Error	Timothy Searchinger et al, Science (2009)	<a href="http://www.sciencemag.org/content/326/5952/527.summary">http://www.sciencemag.org/content/326/5952/527.summary</a>
B-24	Tons of slash burned between 2005-2010 in Oregon by county Map	Oregon Department of Forestry (2010)	
B-25	Tons of slash burned between 2005-2010 in Oregon by county - numbers per year by county	Oregon Department of Forestry (2010)	
B-26	Forest Inventory Analysis (FIA) data - Jackson County	U.S. Department of Forestry (2009)	
B-27	Forest Inventory Analysis (FIA) data - Josephine County	U.S. Department of Forestry (2009)	
B-28	Annual Oregon Timber Harvest Reports	Oregon Department of Forestry	<a href="http://www.oregon.gov/ODF/STATE_FORESTS/FRP/Charts.shtml">http://www.oregon.gov/ODF/STATE_FORESTS/FRP/Charts.shtml</a>
B-29	Letter to Commissioner Sue Kupillas	Blair Moody (1999)	
B-30	List of boilers and fuel feedstock in Oregon	McKinstry	
B-31	Biopower	NREL (2010)	<a href="http://www.nrel.gov/learning/re_biopower.html">http://www.nrel.gov/learning/re_biopower.html</a>
B-32	Direct-Fired Biomass	U.S. DOE Energy Efficiency and Renewable Energy	<a href="http://www1.eere.energy.gov/ba/pba/pdfs/direct_fire_bio.pdf">http://www1.eere.energy.gov/ba/pba/pdfs/direct_fire_bio.pdf</a>
B-33	Biomass Producer or Collector Tax Credits	Oregon Department of Energy	<a href="http://www.oregon.gov/ENERGY/RENEW/Biomass/TaxCdt.shtml">http://www.oregon.gov/ENERGY/RENEW/Biomass/TaxCdt.shtml</a>
B-34	Air Quality Title V Operating Permit Program	Oregon Department of Environmental Quality	<a href="http://www.deq.state.or.us/eq/permit/tv/about.htm">http://www.deq.state.or.us/eq/permit/tv/about.htm</a>
B-35	Woody Biomass Feedstock Yard Business Development Guide	The Federal Woody Biomass Utilization Working Group	<a href="http://www.forestsandrangelands.gov/Woody_Biomass/documents/feedstock_yard_guide.pdf">http://www.forestsandrangelands.gov/Woody_Biomass/documents/feedstock_yard_guide.pdf</a>
B-36	Projects And Programs: Warm Homes - Clean Air	LRAPA	<a href="http://www.lrapa.org/projects_and_programs/warm_homes_clean_air/index.php">http://www.lrapa.org/projects_and_programs/warm_homes_clean_air/index.php</a>
B-37	Seneca Sustainable Energy Biomass Cogeneration Plant: Sustainability Assessment of Proposed Power Resource	Good Company (2009)	<a href="http://www.eweb.org/public/documents/seneca/goodCo.pdf">http://www.eweb.org/public/documents/seneca/goodCo.pdf</a>
B-38	The Value of the Benefits of U.S. Biomass Power. Produced for the National Renewable Energy Laboratory	Gregory Morris (1999)	<a href="http://www.nrel.gov/docs/fy00osti/27541.pdf">www.nrel.gov/docs/fy00osti/27541.pdf</a>
B-39	Bioenergy and Greenhouse Gases	Pacific Institute, Gregory Morris (2008)	<a href="http://www.pacinst.org/reports/Bioenergy_and_Greenhouse_Gases/Bioenergy_and_Greenhouse_Gases.pdf">http://www.pacinst.org/reports/Bioenergy_and_Greenhouse_Gases/Bioenergy_and_Greenhouse_Gases.pdf</a>
B-40	EPA to Defer GHG Permitting Requirements for Industries that Use Biomass	EPA (2011)	<a href="http://www.epa.gov/aging/press/epanews/2011/2011_0112_1.htm">http://www.epa.gov/aging/press/epanews/2011/2011_0112_1.htm</a>

## Landfill Gas-to-Energy

Index number	Title	Author	Link or Source
LFG-1	Interview with Lee Fortier at Dry Creek Landfill.	Interview conducted by Jon Angin of Columbia Business Resources	Info summarized in Task deliverable.
LFG-2	Landfill Methane Outreach Program (LMOP)	US EPA	<a href="http://epa.gov/lmop/">epa.gov/lmop/</a>

## Anaerobic Digestion

Index number	Title	Author	Link or Source
AD-1	Manure Quantities and Characteristics	American Society of Agriculture and Biological Engineers	<a href="http://www.extension.org/pages/15375/manure-production-and-characteristics">http://www.extension.org/pages/15375/manure-production-and-characteristics</a>
AD-2	Dry Fermentation vs. Wet Fermentation	Biofirm Energy Systems	<a href="http://www.biofermentenergy.com/us/wp-content/uploads/2010/02/BIOFerm-Dry-Fermentation.pdf">http://www.biofermentenergy.com/us/wp-content/uploads/2010/02/BIOFerm-Dry-Fermentation.pdf</a>
AD-3	Key Elements of Biogas Energy Anaerobic Digesters	Biogas Energy Inc.	<a href="http://www.biogas-energy.com/site/BiogasEnergy.pdf">http://www.biogas-energy.com/site/BiogasEnergy.pdf</a>
AD-4	Dairy Manure Production and Nutrient Content	Chastain John P., and Camberato James J.	<a href="http://www.clemson.edu/extension/livestock/...files/dairy/dch3a_04.pdf">http://www.clemson.edu/extension/livestock/...files/dairy/dch3a_04.pdf</a>
AD-5	Renewable Energy from Crops and Agrowastes	CropGen	<a href="http://www.cropgen.org/">http://www.cropgen.org/</a>
AD-6	Anaerobic Digestion of Food Waste	East Bay Municipal Utility District	<a href="http://www.epa.gov/region9/organics/ad/">http://www.epa.gov/region9/organics/ad/</a>
AD-7	Financial Viability of Biogas Plants	E.C. Oregon	<a href="http://www.aorr.org/.../Foor_Financial_Viability_Biogas_Plants_061710.pdf">http://www.aorr.org/.../Foor_Financial_Viability_Biogas_Plants_061710.pdf</a>
AD-8	Noble Dairy Manure Anaerobic Digester Feasibility Study Report	E.C. Oregon	<a href="http://www.oregon.gov/ENERGY/RENEW/docs/.../NobleFeasibilityStudy.pdf">www.oregon.gov/ENERGY/RENEW/docs/.../NobleFeasibilityStudy.pdf</a>
AD-9	Volbeda Dairy Manure Anaerobic Digester Feasibility Study Report.	E.C. Oregon	<a href="http://www.oregon.gov/ENERGY/RENEW/.../VolbedaFeasibilityStudy.pdf">http://www.oregon.gov/ENERGY/RENEW/.../VolbedaFeasibilityStudy.pdf</a>
AD-10	Oregon Dairy Digester Feasibility Study Report	E.C. Oregon	<a href="http://energytrust.org/.../reports/100125_DairyBiogasSummaryReport.pdf">energytrust.org/.../reports/100125_DairyBiogasSummaryReport.pdf</a>
AD-11	Sizing and Characterizing the Market for Oregon Biopower Projects	Energy Trust of Oregon	<a href="http://www.oregon.gov/.../CH2MHill_Bioenergy_Market_Assessment.pdf">http://www.oregon.gov/.../CH2MHill_Bioenergy_Market_Assessment.pdf</a>
AD-12	Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM) – Landfilling chapter	Environmental Protection Agency	<a href="http://www.epa.gov/climatechange/wywd/waste/SWMGHGReport.html">http://www.epa.gov/climatechange/wywd/waste/SWMGHGReport.html</a>
AD-13	Biogas from Energy Crop Digestion.	International Energy Agency	<a href="http://www.iea-biogas.net/download/energycrop_def_Low_Res.pdf">http://www.iea-biogas.net/download/energycrop_def_Low_Res.pdf</a>
AD-14	2006 LMOP Project Expo – Roseburg Landfill	Landfill Methane Outreach Program	<a href="http://www.epa.gov/lmop/documents/pdfs/RoseburgLMOP_handout.pdf">http://www.epa.gov/lmop/documents/pdfs/RoseburgLMOP_handout.pdf</a>
AD-15	Lane County Food Waste to Energy Feasibility Study	Lane County Oregon	<a href="http://www.oregon.gov/ENERGY/.../docs/.../LaneCountyFood_to_Waste.pdf">http://www.oregon.gov/ENERGY/.../docs/.../LaneCountyFood_to_Waste.pdf</a>
AD-16	Carcass Disposal: A Comprehensive Review	National Agricultural Biosecurity Center Consortium	<a href="http://fss.k-state.edu/.../CarcassDisposal/.../CH1-Burial.pdf">fss.k-state.edu/.../CarcassDisposal/.../CH1-Burial.pdf</a>
AD-17	Sustainable Energy Planning: Using Waste to Energy Feasibility Study as a Guide	Nelson, Ethan	
AD-18	Oregon Labor Market Information System	Oregon Department of Employment	<a href="http://www.qualityinfo.org/olmis/OlmiZine">http://www.qualityinfo.org/olmis/OlmiZine</a>
AD-19	Recycling Characterization and Composition Study: 2009/2010	Oregon Department of Environmental Quality	<a href="http://www.deq.state.or.us/lq/sw/disposal/wastecompoststudy2009.htm">http://www.deq.state.or.us/lq/sw/disposal/wastecompoststudy2009.htm</a>
AD-20	2002 Waste Characterization and Composition	Oregon Department of Environmental Quality	<a href="http://www.deq.state.or.us/lq/sw/disposal/wastecompositionstudy.htm">http://www.deq.state.or.us/lq/sw/disposal/wastecompositionstudy.htm</a>
AD-21	Commercial Food Waste Composting Study	Oregon Department of Environmental Quality	<a href="http://www.deq.state.or.us/lq/sw/compost/foodwastestudy.htm">http://www.deq.state.or.us/lq/sw/compost/foodwastestudy.htm</a>
AD-22	APPROXIMATE MANURE PRODUCTION AND VALUE TABLE	Pennsylvania - Future Farmers of America Association	<a href="http://www.paffa.state.pa.us/paffa2/files/specialrecords/manuretable.pdf">http://www.paffa.state.pa.us/paffa2/files/specialrecords/manuretable.pdf</a>
AD-23	Feasibility of Generating Green Power through Anaerobic Digestion of Garden Refuse from the Sacramento Area	RIS International Ltd.	<a href="http://www.nerc.org/documents/sacramento_feasibility_study.pdf">http://www.nerc.org/documents/sacramento_feasibility_study.pdf</a>
AD-24	Oregon Schools Database	SchoolTree.org	<a href="http://oregon.schooltree.org/elementary/Jackson-County-Schools.html">http://oregon.schooltree.org/elementary/Jackson-County-Schools.html</a>
AD-25	Education Data Partnership	State of California Department of Education	<a href="http://www.ed-data.k12.ca.us/Pages/Home.aspx">http://www.ed-data.k12.ca.us/Pages/Home.aspx</a>
AD-26	Search for a Licensed Care Facility Database	State of California	
AD-27	Network of Care	State of Oregon	<a href="http://networkofcare.org/facilitylocator/search.cfm">http://networkofcare.org/facilitylocator/search.cfm</a>
AD-28	Feedstocks for Anaerobic Digestion	Steffen, R., et al.	<a href="http://www.adnett.org/dl_feedstocks.pdf">http://www.adnett.org/dl_feedstocks.pdf</a>
AD-29	Southern Oregon Wineries Map	Southern Oregon Wineries Association	<a href="http://www.sorwa.org/map.php">http://www.sorwa.org/map.php</a>
AD-30	The Andersons Centre	A Detailed Economic Assessment of Anaerobic Digestion Technology and its Suitability to UK Farming and Waste Systems	<a href="http://www.nnfcc.co.uk/tools/economic-assessment-of-anaerobic-digestion-technology-and-its-suitability-to-uk-farming-and-waste-systems-report-2nd-edition-nnfcc-10-010">http://www.nnfcc.co.uk/tools/economic-assessment-of-anaerobic-digestion-technology-and-its-suitability-to-uk-farming-and-waste-systems-report-2nd-edition-nnfcc-10-010</a>

## Solar

Index number	Description	Author	Link or Source
S-1	Pacific Power RFP	Pacific Power	
S-2	Legislative Rule for implementation of Feed-in-tariff	Oregon Legislature	
S-3	Ashland Solar Installations	Ashland Municipal Utility, Hanks	
S-4	City of Medford Solar Study	RHT Energy Solutions (2010)	
S-5	Solar Thermal Market Assessment	ETO, Dethman & Associates (2004)	<a href="http://energytrust.org/library/reports/040521_Solar_Thermal.pdf">energytrust.org/library/reports/040521_Solar_Thermal.pdf</a>
S-6	Feed In Tariff Information	ETO (2010)	<a href="http://energytrust.org/residential/incentives/solar-electric/SolarElectric/">http://energytrust.org/residential/incentives/solar-electric/SolarElectric/</a>
S-7	Legislative Rule for FIT Pilot Program	Oregon Legislature	<a href="http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=OR134F&amp;re=1&amp;ee=1">http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=OR134F&amp;re=1&amp;ee=1</a>
S-8	Net metering information from Pacific Power	Pacific Power	<a href="http://www.pacificpower.net/env/nmcg/nm.html">http://www.pacificpower.net/env/nmcg/nm.html</a>
S-9	Solar cost reduction study	Rockey Mountain Institute (2010)	<a href="http://www.rmi.org/Content/Files/BOSReport.pdf">www.rmi.org/Content/Files/BOSReport.pdf</a>
S-10	Installed cost of solar PV	Lawrence Berkeley National Lab (2010)	<a href="http://eetd.lbl.gov/ea/emp/reports/lbnl-5047e.pdf">http://eetd.lbl.gov/ea/emp/reports/lbnl-5047e.pdf</a>
S-11	Renewables and Climate change	IPCC	<a href="http://srren.ipcc-wg3.de/report/IPCC_SRREN_Full_Report.pdf">http://srren.ipcc-wg3.de/report/IPCC_SRREN_Full_Report.pdf</a>
S-12	Health and Safety concerns	Good Company for ODOT	<a href="http://www.oregon.gov/ODOT/HWY/OIPP/inn_solarhighway.shtml">http://www.oregon.gov/ODOT/HWY/OIPP/inn_solarhighway.shtml</a>
S-13	Solarize Guidebook	NREL and City of Portland with NWSEED	<a href="http://www.nrel.gov/docs/fy11osti/50440.pdf">www.nrel.gov/docs/fy11osti/50440.pdf</a>

## Wind

Index number	Title	Author	Link or Source
W-1	A Comparative Analysis of Community Wind Power Development Options in Oregon	ETO, Bolinger, Wisner, Wind, Juhl, Grace	
W-2	Community Wind: An Oregon Guidebook	ETO, Bolinger, Wisner, Wind, Juhl, Grace	
W-3	"Farm gets Wind Power", Ashland Daily Tidings, August 2009	Pugh	<a href="http://www.dailytidings.com/apps/pbcs.dll/article?AID=/20090814/NEWS01/908140313">http://www.dailytidings.com/apps/pbcs.dll/article?AID=/20090814/NEWS01/908140313</a>
W-4	"Wind Powering 3 neighbors", Bend Bulletin, December 2010	Aldous	<a href="http://www.bendbulletin.com/article/20101224/NEWS0107/12240397/">http://www.bendbulletin.com/article/20101224/NEWS0107/12240397/</a>
W-5	Wind Power in Oregon	Wikipedia	<a href="http://en.wikipedia.org/wiki/Wind_power_in_Oregon">http://en.wikipedia.org/wiki/Wind_power_in_Oregon</a>
W-6	Wind Energy Siting Handbook	American Wind Energy Association (2008)	
W-7	ODOE wind projects list.	ODOE	<a href="http://www.oregon.gov/ENERGY/SITING/docs/Wind_Projects110124.pdf">http://www.oregon.gov/ENERGY/SITING/docs/Wind_Projects110124.pdf</a>

## Geothermal

Index number	Title	Author	Link or Source
GT-1	Final Report Low-Temperature Resource Assessment	Lienau P.J., Ross H. (1996). <i>Oregon Insitiute of Technlogy - Geo Heat Center</i>	
GT-2	Oregon Geothermal Resources (map)	Laney P., Brizzee J. (2003). <i>Idaho National engienering and Environmental laboratory</i>	
GT-3	US Geothermal Resource map	Roberts, B.J. (2009). <i>National Renewable Energy laboratory</i>	
GT-4	Geotehrmal in Oregon - Where it is being used	Boyd, T. (2007). <i>Oregon Institute of Technology - Geo Heat Center</i>	
GT-5	Status of US Geothermal Energy and Permitting in the Western States and Tribal Lands	Environmental Management and Planning Solutions Inc. (2008)	
GT-6	Regulatory Issues for Direct-Use Geothermal Resource Development in Oregon	Rafferty K. <i>Oregon Institute of Technology - Geo Heat Center</i>	
GT-7	GTILO Data set	ODOGAMI	<a href="http://www.oregongeology.com/su/b/gtilo/download_data.htm">http://www.oregongeology.com/su/b/gtilo/download_data.htm</a>
GT-8	Geothermal Information Layer for Oregon	ODOGAMI	<a href="http://www.oregongeology.org/gtilo/index.html">http://www.oregongeology.org/gtilo/index.html</a>
GT-9	Programmatic Environmental Imapct Statement for Geothermal Leasing in the Western United States	BLM, US Forest Service (2008)	
GT-10	Programmatic Environmental Imapct Statement for Geothermal Leasing in the Western United States - Presentation	BLM, US Forest Service (2008)	
GT-11	Small Geothermal Power Plants: Design, Performance and Economics	Univerrsite of massachusetts Dartmouth, DiPippo (1999)	
GT-12	The Future of Geothermal Energy	MIT (2006)	
GT-13	SRREN	IPCC	
GT-14	Geothermal Data - Jackson and Josephine	Geothermal Education Office	<a href="http://geothermal.marin.org/">http://geothermal.marin.org/</a>
GT-15	Power Generation, Geothermal Resource Study	Black & Veatch (2010)	

## APPENDIX A: JOBS AND ECONOMIC IMPACTS ANALYSIS

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This section of the report assesses four of the most promising technologies for the Rogue Valley (energy efficiency, solar, woody biomass and wind) in terms of job creation and local economic impact. This analysis considers these four technologies over their respective life spans in terms of direct impacts from the construction and operation of the project, but also in terms of the economic benefits that results from energy savings or displacement that results from the project.

The following sections provide details about each of these technologies, but the following points provide a high-level summary of findings.

- Most of the technologies (excluding wind) have similar direct and indirect impacts in the short term.
- Energy efficiency provides the greatest net economic impact, per unit of investment.
- In the case of energy efficiency, a significant percentage of the net economic benefit is the result of the lifetime energy savings of the project.

For this particular task, Good Company partnered with the University of Oregon's Ecosystem Workforce Program<sup>204</sup> (EWP) to utilize their expertise and tools to estimate the economic impact and job-creation potential associated with renewable energy development.

While this analysis provides a glimpse of important impacts associated with energy, it should not be seen as the last word on the matter. We are moving from a time of inexpensive energy and a stable energy economy to period of higher cost and rapid change. As a result, the findings here will not easily translate to future contexts. Still, we believe the methodology will provide an important foundation for similar regional energy planning efforts in the future.

### Methodology

This economic assessment was conducted using the IMPLAN System<sup>205</sup> either directly or indirectly. Two of the technologies (biomass and energy efficiency) were directly assessed with latest version of IMPLAN using its default multipliers combined with publically available data on facility construction, operations and maintenance costs. The other two technologies, solar and wind, were assessed using the National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impacts (JEDI) models, which are built using IMPLAN data combined with NREL data on solar and wind technologies.

Both IMPLAN and JEDI are Input-Output models, which project the impact that activity in one economic sector will have on others. The economic impacts of these models are measured and reported in terms of jobs, wages and economic output, normalized to some initial investment or expenditure. These impacts are described for three distinct categories: direct, indirect and induced, per \$1 million of investment.

**Direct Effects:** These include the jobs and wages supported by the development, construction and operation of renewable energy projects.

**Indirect Effects:** These effects are associated with the demand created in the supply chain for materials, equipment and peripheral services necessary in supporting renewable energy development.

**Induced Effects:** These effects are produced when people employed in the direct and indirect sectors spend their incomes on goods and services. When this money is spent it supports other businesses that provide goods (food, housing) and services (medical care).

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<sup>204</sup> EWP's current research links forest and watershed restoration activities to economic industries and provides a preliminary assessment of the potential economic and employment impacts for these activities. EWP has found that investments in ecological restoration play a large role in public and private natural resource management with projects ranging from stream habitat enhancements and fish passage to irrigation canal improvements, riparian reforestation, road decommissioning, hazardous fuels reduction, forest thinning, and wildlife habitat enhancement.

<sup>205</sup> For more details visit the IMPLAN website at [www.implan.com](http://www.implan.com).

The direct effects for most of the technologies will likely be felt locally, but the extent of direct local economic impact often depends on whether the Rogue Valley has existing businesses and expertise to perform the services and functions required.

Indirect effects could happen locally or not depending on the local resources and manufacturing. Currently there are no solar panel manufacturers in Southern Oregon, so the dollars for that capital expense will leave the local area, but do not have to leave the state if panel are purchased from an Oregon manufacturer like Solar World. However, there are many products that may not be manufactured locally, but can be purchased locally which sends the marginal profit into the local economy.

Induced effects are felt locally as the developers and construction employees spend their wages on goods and services, but also elsewhere as distant suppliers spend their wages at their local stores. In addition to construction and operation, the impacts energy and cost savings (from energy efficiency) or dollars retained locally through local electricity generation are also assessed.

This analysis considers these three categories by various outputs including:

**Jobs:** Annual full and part-time positions, depending on the industry.

**Labor income:** All forms of employment income.

**Total economic value added:** The difference between an industry's total output and the cost of its intermediate inputs. Value added consists of compensation of employees, taxes on production and imports less subsidies, and gross operating surplus.

**Economic output:** Output represents the value of industry production.

## Summary of Results

The results of this analysis are presented in Figure A-1 for four of the most feasible renewable technologies: energy efficiency, solar, biomass and wind. These are not the only technologies identified as feasible in the study, but were selected for this portion of the assessment based on the scale of electricity generation potential.

Energy efficiency produces the most jobs per \$1 million invested, approximately 17.9. The majority of these jobs are induced or represent the service jobs supported by the money saved through energy efficiency measures and subsequently spent on other goods and services. In addition, EE also produces a number of direct jobs associated with the installation of the EE technologies. For solar the majority of the 13.8 jobs are in the supply chain (i.e. indirect) supporting the manufacture of the solar panels and racking systems. Biomass produces a total of 11.4 jobs per \$1 million dollars invested, with the majority being direct in the construction and operation of the facility and collection of the feedstock. Wind per \$1 million invested produces the fewest jobs by far at 3.3. Consistent with the number of jobs created, solar, biomass, and energy efficiency create similar labor income values and total economic output, with wind having lower performance according to both metrics.

**Figure A-1:** Comparison of IMPLAN results for feasible renewable technologies per \$1 million invested.

Assessment Category	Solar	Biomass	Energy Efficiency	Wind
Total Jobs	13.8	11.4	17.9	3.2
<i>Direct Jobs (construct &amp; operate)</i>	3.6	5.2	6.5	1.0
<i>Indirect Jobs (supply chain)</i>	6.8	2.2	1.3	1.6
<i>Induced Jobs</i>	3.4	4.0	10.5	0.6
Labor Income	\$750,000	\$690,000	\$680,000	\$170,000
Economic Output	\$1,800,000	\$2,540,000	\$1,910,000	\$770,000

## Solar PV

Solar PV, for the purpose of this analysis, consists of the labor and materials required to install and maintain solar photovoltaic (PV) arrays. The systems considered here range in size from residential systems (<5 kW) to small-scale commercial systems (10 – 50 kW) to utility-scale systems (100 kW – 2MW).

This technology was assessed using NREL's JEDI PV Model. The model considers the solar resources specific to Oregon. The capacity of the systems was set in the model such that the total cost was approximately equal to \$1,000,000 for each of the different types of installation (residential – new construction, small commercial, utility, etc.). JEDI's default values are used as is with the exception of the module cost, which was updated to reflect current market prices (\$2 per watt).

The results of these model runs are summarized on Figure A-2. As can be seen the number of jobs, earnings, and total economic output are all relatively similar regardless of the scale of the system. The most significant difference is the capacity per \$1 million of investment. As can be seen, the cost per kW decreases with an increase in the scale of the project.

**Figure A-2:** Comparison of various types of solar PV installations.

Assessment Categories	Residential	Commercial – Small	Commercial – Large	Utility
Typical Capacity	<5 kW	10 – 50 kW	100kW – 2MW	100kW – 2MW
Single system capacity	2.5 kW <sub>DC</sub>	15 kW <sub>DC</sub>	100 kW <sub>DC</sub>	1,000 kW <sub>DC</sub>
Number of Systems per \$1 million of investment	55	10	1.6	0.2
Capacity per \$1 million	137.5 kW <sub>DC</sub>	150 kW <sub>DC</sub>	160 kW <sub>DC</sub>	200 kW <sub>DC</sub>
Single System Cost	\$14,588 (\$7,294/1 kW <sub>DC</sub> )	\$97,000 (\$6,514/1 kW <sub>DC</sub> )	\$648,000 (\$6,480/1 kW <sub>DC</sub> )	\$1,000,000 (\$5,601/1 kW <sub>DC</sub> )
Total Jobs	13.6	12.3	13.4	13.5
Total Earnings	\$701,000	\$670,000	\$726,000	\$738,000
Total Economic Output	\$1,726,000	\$1,623,000	\$1,753,000	\$1,788,000

## Biomass

Biomass consists of the labor and materials required to construct and operate a direct-fire woody biomass electricity generation facility. Biomass was assessed using IMPLAN combined with existing data collected by Ecosystem Workforce Partnership (EWP) and a report by the University of Massachusetts titled *Energy from Forest Biomass: Potential Economic Impacts in Massachusetts*. The biomass analysis is slightly different from the other technologies examined in that it is the only technology that requires a fuel (i.e. woody biomass). Therefore biomass has much higher operating expenses, which requires a different approach than the other technologies to assess its impacts per \$1 million dollars.

To assess biomass, the construction costs were combined with the operational costs (fuel + operations & maintenance) for 25 years. The construction cost is assumed to be roughly \$2.2 million (2006 dollars) / MW, the fuel cost is assumed to be \$30.94 per bone dry ton (BDT) and roughly 10,000 BDT are required per MW of capacity. The analysis was performed for a hypothetical 15 MW facility for three future fuel price scenarios (no change (NC) relative to 2006 dollars, 3% decrease per year and 2% increase per year).

The results of these model runs are summarized on Figure A-3. The jobs are concentrated, regardless of future prices, in direct jobs associated with operations (fuel supply and facility operations and maintenance). Per \$1 million of investment, construction jobs represent only 0.5 of the direct jobs shown on Figure A-3, while supply chain and facility operations jobs represent 4.7. In other words, the majority of the jobs associated with biomass are long-term, collecting the biomass fuel and operating and maintaining the facility.

**Figure A-3:** Comparison of three different scenarios for future costs associated with fuel and O&M.

Impact Type	Employment			Labor Income		
	3% annual decrease	No change	2% annual increase	3% annual decrease	No change	2% annual increase
Direct Effect	5.2	5.2	5.1	\$367,578	\$371,731	\$373,929
Indirect Effect	2.3	2.2	2.3	\$108,364	\$122,337	\$168,426
Induced Effect	3.1	3.1	3.0	\$100,632	\$163,925	\$131,661
<b>Total Effect</b>	<b>10.6</b>	<b>10.5</b>	<b>10.5</b>	<b>\$576,574</b>	<b>\$657,992</b>	<b>\$674,016</b>
Impact Type	Value Added			Output		
	3% annual decrease	No change	2% annual increase	3% annual decrease	No change	2% annual increase
Direct Effect	\$430,136	\$434,841	\$437,309	\$708,387	\$696,828	\$690,276
Indirect Effect	\$214,173	\$204,721	\$220,808	\$373,353	\$387,851	\$383,265
Induced Effect	\$182,137	\$331,440	\$130,883	\$324,250	\$560,935	\$329,958
<b>Total Effect</b>	<b>\$826,445</b>	<b>\$971,002</b>	<b>\$789,001</b>	<b>\$1,405,990</b>	<b>\$1,645,615</b>	<b>\$1,403,499</b>

## Energy Efficiency

Assessing energy efficiency (EE) is not as straightforward as some of the other technologies because EE represents many very different types of technologies and materials, which have dramatically different costs and associated labor requirements. For the purpose of this analysis is assumed that average labor costs represent 55% of the total and materials represent 45%.<sup>206</sup> In addition, material costs assume equal distribution over a number of different types of EE measures including windows, other forms of weatherization, and heating and cooling systems.

Energy efficiency was assessed using IMPLAN combined with data from two ECONorthwest studies, *Economic Impact Analysis of Property Assessed Clean Energy Programs (PACE)* and *Economic Impact Analysis of Energy Trust of Oregon Program Activities*. These studies assess very similar economic activity with very similar results to this analysis, albeit to answer slightly different research questions. The findings of each are directly relevant to the question in this analysis: What are the impacts on jobs and the economy in Jackson and Josephine counties as a result of a \$1 million investment in energy efficiency?

These total impacts, scaled to \$1 million in investment, result in the following:

- 10 new jobs
- Wages increase by roughly \$400,000
- Output in southern Oregon's economy increases by roughly \$1 million
- An additional \$40,000 in state and local taxes

These results are based on average published values for the split between spending on labor and materials, 55% and 45% respectively. It was assumed that spending on materials was equal between a number of categories such as windows, heating and cooling systems, caulk, etc. In addition to using the "average" values the analysis also considered the impacts if the labor costs were high and low relative to the average.

Figure A-4 shows the results of that analysis. The analysis was performed for three scenarios that consider the percentage of total project expenditures on materials. In the "low" scenario 30% are spent on materials, "mid" is 45%, and "high" is 70%. The results show that as the percentage of material costs in the project budget increases it reduces the number of jobs, wages, and economic output created.

<sup>206</sup> ECONorthwest, *PACE analysis*.

**Figure A-4:** Comparison of three different scenarios for labor and material costs.

Impact Type	Employment			Labor Income		
	Low (70%:30%)	Mid (55%:45%)	High (30%:70%)	Low (70%:30%)	Mid (55%:45%)	High (30%:70%)
Direct Effect	7.9	6.5	4.2	\$354,082	\$292,943	\$191,046
Indirect Effect	1.4	1.3	1.0	\$55,501	\$50,045	\$40,953
Induced Effect	2.6	2.2	1.5	\$86,070	\$71,930	\$48,364
<b>Total Effect</b>	<b>12.0</b>	<b>10.0</b>	<b>6.7</b>	<b>\$495,653</b>	<b>\$414,919</b>	<b>\$280,362</b>
Impact Type	Economic Value Added			Economic Output		
	Low (70%:30%)	Mid (55%:45%)	High (30%:70%)	Low (70%:30%)	Mid (55%:45%)	High (30%:70%)
Direct Effect	\$474,360	\$392,089	\$254,972	\$785,714	\$678,571	\$500,000
Indirect Effect	\$84,533	\$76,216	\$62,355	\$171,133	\$157,454	\$134,656
Induced Effect	\$158,372	\$132,290	\$88,819	\$280,238	\$234,107	\$157,222
<b>Total Effect</b>	<b>\$717,265</b>	<b>\$600,595</b>	<b>\$406,146</b>	<b>\$1,237,086</b>	<b>\$1,070,133</b>	<b>\$791,879</b>

## Wind

The analysis for wind energy consists of the labor and materials required installing and maintaining wind turbine installations. Wind was assessed using NREL's JEDI Wind Model. The model allows the user to estimate economic development impacts from wind power generation projects. JEDI Wind uses wind power industry averages to run impacts analysis. This analysis uses JEDI default values with no changes. The model was set for Oregon and the capacity of the systems was set such that the total cost was approximately equal to \$1,000,000 for each of the different types of installation (residential – new construction, small commercial, utility, etc.).

The findings can be summarized in the following points:

- System cost = \$1,000,000 (\$2,000 / 1 kW)
- 500 kW installed system for \$1,000,000
- Total Jobs: 3.1
  - *Direct Jobs (construction and operation): 1*
  - *Indirect Jobs (supply chain): 1.6*
  - *Induced Jobs: 0.6*
- Labor income: \$170,000
- Economic Output: \$770,000

## Secondary Impacts from Energy Savings and Local Electricity Generation

In addition to the “direct” impacts from the construction and operation of a project there is also a second set of induced impacts associated with additional disposable income circulating in the community as a result of the energy savings or energy production per \$1 million of investment.

For example, a household upgrades 20, 40-watt incandescent bulbs to 20, 2-watt LED bulbs as an energy efficient upgrade. Once the cost of the bulbs is paid back, the household realizes cost savings for the life of the bulbs from reduced electricity consumption. A portion of these cost savings is disposable income, which gets spent for goods and services thereby generating economic activity and jobs. A similar circumstance is true for small-scale solar. The electricity generated by the solar panels will reduce the amount of electricity a household needs to purchase from a utility, thereby generating savings and disposable income.

To analyze the induced impacts from these savings for EE and solar the annual electricity generation (per \$1 million of investment) was multiplied by the difference between the price of wholesale electricity (price of producing the electricity, or the cost of purchasing the PV or EE equipment) and the price of retail electricity (the amount a household needs pays the utility for electricity) to estimate the value of the savings (about \$0.045 per kWh). The savings were then analyzed with IMPLAN to determine the impacts.

For utility-scale biomass and wind projects, the savings is the result of money being spent by the utility in the local community for electricity generation rather than sending that same money to another generator in a different community. For utility-scale projects, the effect on the community is the difference between the amount it takes to produce the electricity and the wholesale price (i.e. profit). The profit is assumed to be 10% of the wholesale cost of electricity (\$0.035 / kWh). Where the profit is ultimately spent depends on where the owner is located, but for the purposes of this analysis it is assumed that the owner is part of the community and spends locally.

The induced impacts from the savings by renewable technology are presented in Figure A-5. As can be seen the greatest impacts are from EE investments, generating almost 8 jobs per \$1 million invested and over \$260,000 of labor income. This is because a \$1 million investment in EE saves about 5.6 million kWh<sup>207</sup> at a cost savings of \$0.045/kWh for a total value of \$1.3 million (discounted at 5% per year) over the life of the project (assumed to be 7 years).

The jobs created by these savings are all in the induced category. The values on Figure A-5 are included in the Summary of Results section, Figure A-1.

**A-5:** Comparison of induced impacts, by technology, from energy savings or local generation.

Assessment Category	Solar	Biomass	Energy Efficiency	Wind
Annual energy savings or generation (kWh)	188,162	6,441,176	5,600,000	1,250,000
Estimated life time value of energy (\$0.045/kWh)	\$49,000	\$129,000	\$1,271,000	\$25,000
Induced Jobs	0.3	0.9	7.9	0.2
Labor Income	\$10,000	\$28,000	\$261,000	\$5,000
Total Economic Value Added	\$18,000	\$51,000	\$471,000	\$10,000
Economic Output	\$32,000	\$896,000	\$839,000	\$18,000

<sup>207</sup> Energy Trust of Oregon