Appendix 4
Waste Heat-to-Power and Regenerative Technology Evaluation

CLEAResult

Waste Heat to Power and Regenerative Technology Evaluation

August 13, 2014

PREPARED BY CLEAResult
PREPARED FOR PacifiCorp

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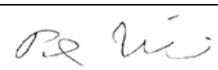
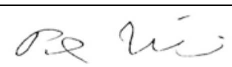
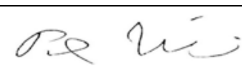
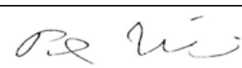
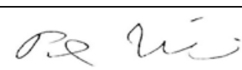
0	2014-06-10	Paul Willis	Managing Director	
1	2014-06-25	Paul Willis	Managing Director	
2	2014-06-30	Paul Willis	Managing Director	
3	2014-08-06	Paul Willis	Managing Director	
4	2014-08-13	Paul Willis	Managing Director	

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1 Executive Summary

1.1 WASTE HEAT TO POWER (WHP) BEST PRACTICE REVIEW

In the Energy Efficiency and Renewable Standards for different jurisdictions, Waste Heat to Power (WHP) is treated as a minor subset of Combined Heat and Power (CHP); in many cases it is not even specifically addressed. In turn, policy is in a state of flux as to whether CHP and WHP should be treated as a supply side (generation) or demand side measure.

WHP projects which only involve customer load displacement (no power exported to the grid) are quite different from most CHP projects in that they do not involve the use of additional fossil fuel. However, because the number of installations of these types of projects has been relatively small, utilities and regulatory bodies have not generally taken this into consideration. The technology change which could prompt a lot more serious consideration of WHP specifically is the Organic Rankine Cycle (ORC) technology. ORC can be used in many applications to generate electricity which can usually be put back into a customer's power distribution system.

The E Source DSM database[1] contains information on 22 different Combined Heat and Power programs in the U.S. The programs which specifically address WHP involve six electric and gas utilities in New Jersey and the California Public Utility Commission's Self Generation Incentive Program (SGIP) which involves Pacific Gas and Electric, Southern California Edison and the Southern California Gas Company. It is important to note that the other CHP programs do not exclude waste heat to power projects they just do not specifically address them. In Canada the Ontario Power Authority and British Columbia Hydro utilities have customer based generation programs that address waste heat to power.

The SGIP program, BC Hydro's program and the Ontario Power program all provide DSM type incentives to encourage the development of WHP.

1.2 REGENERTIVE TECHNOLOGY (RT) BEST PRACTICE REVIEW

In a review of North American regulatory and utility energy efficiency and self-generation policy, no reference could be found where regenerative projects were treated as either a separate energy efficiency program or under a separate self-generation program. Cases were found where regenerative projects were treated as energy efficiency projects under custom type DSM programs.

It is concluded that it is not practical to consider regenerative technology as isolated energy generation because these types of projects are always completely integrated with an end-use load. In promoting it as an energy efficiency measure it should be treated on a site by site basis so its impact on the efficiency of the host end-use system can be properly measured.

[1] *E Source, Boulder Colorado, an organization specializing in maintain and developing energy efficiency information.*

1.3 ESTIMATE OF MAGNITUDE OF OPPORTUNITY

The exhibit below indicates the Planning Horizon magnitude of opportunity in annual MWh of energy savings for the different WHP and RT technologies that were identified. This estimate takes into consideration market factors, which means that even though the economic and other benefits may appear attractive, due to a variety of market factors some potential projects will not get implemented within the Planning Horizon.

Exhibit 1: Magnitude of Opportunity Considering Market Factors (MWh)

Measures	CA	ID	OR	UT	WA	WY	Total
ORC	1,400	1,000	86,200	61,200	6,700	19,700	**176,200**
High Temperature Waste Heat	None Identified	None Identified	6,100	11,600	None Identified	16,000	**33,700**
Micro Hydro	None Identified	None Identified	None Identified	5,600	None Identified	5,200	**10,800**
Steam System Optimization	None Identified	None Identified	8,000	None Identified	8,400	None Identified	**16,400**
Conveyor Regeneration	None Identified	None Identified	None Identified	6,700	None Identified	3,700	**10,400**
Elevator Regeneration	200	300	3,700	9,300	800	1,100	**15,400**
Total	**1,600**	**1,300**	**104,000**	**94,400**	**15,900**	**45,700**	**262,900**

In PacifiCorp's 2013 DSM potential assessment[2], the terms Technical Potential and Achievable Technical Potential were used. For this particular study, it is suggested that a more appropriate term is Magnitude of Opportunity, which is a rough estimate of the potential savings over a 20-year planning horizon, which is useful for determining how much effort should be spent, at this time, in further developing and exploring the potential.

For some of the states as indicated in the above exhibit, there were no facilities that were identified as being suitable for some of the technologies. It should be noted that this is an overview study and no customer sites were visited so that site audits may very well identify opportunities.

[2] "*Assessment of Long-Term System-Wide Potential for Demand-Side and Other Supplemental Resources 2013-2032", The Cadmus Group, March 2013.*

1.4 TOTAL RESOURCE AND UTILITY COSTS

The exhibit below provides information on the economics for the different WHP and RT technologies. It is important to note the application of each of these technologies is very site-specific, so the costs provided should only be considered as indicative of a typical project.

Exhibit 2: Technology Economics

State	Measure Name	Savings per Unit[3] (kWh)	Incremental Cost per Unit	Magnitude of Opportunity With Market Factors (MWh)	Levelized TRC ($ per MWh)	Levelized UCT ($ per MWh)	No. of Projects[4]
California	ORC	8,880,717	$4,000,000	1,421	$64.94	$26.46	1
California	Elevator Regeneration	4,389	$6,000	217	$142.42	$51.76	13
Idaho	ORC	8,650,693	$4,000,000	1,016	$66.67	$22.79	1
Idaho	Elevator Regeneration	4,370	$6,000	347	$143.05	$50.65	20
Oregon	ORC	8,612,792	$4,000,000	86,213	$66.96	$22.18	28
Oregon	High Temperature Waste Heat	8,612,792	$3,000,000	6,067	$53.71	$19.97	2
Oregon	Steam System Optimization	8,612,792	$1,000,000	8,000	$12.10	$7.37	1
Oregon	Elevator Regeneration	4,272	$6,000	3,734	$144.92	$47.39	217
Utah	ORC	8,496,654	$4,000,000	61,164	$67.88	$20.31	16
Utah	High Temperature Waste Heat	8,496,654	$3,000,000	11,583	$54.44	$18.28	2
Utah	Micro Hydro	318,625	$250,000	5,641	$81.75	$25.71	5
Utah	Steam System Optimization	8,496,654	$1,000,000	0	$12.26	$8.73	0
Utah	Elevator Regeneration	4,272	$6,000	9,321	$146.32	$44.95	546
Utah	Conveyors Regeneration	50,014	$70,000	6,662	$145.82	$36.30	7
Washington	ORC	8,710,919	$4,000,000	6,675	$66.21	$23.76	2
Washington	Steam System Optimization	8,710,919	$1,000,000	8,398	$11.96	$10.02	2
Washington	Elevator Regeneration	4,311	$6,000	781	$145.01	$47.23	46
Wyoming	ORC	8,475,541	$4,000,000	19,746	$68.05	$19.97	5
Wyoming	High Temperature Waste Heat	8,475,541	$3,000,000	16,000	$54.58	$17.97	2
Wyoming	Micro Hydro	317,833	$250,000	5,216	$81.95	$25.28	4
Wyoming	Elevator Regeneration	4,281	$6,000	1,062	$146.02	$45.47	63
Wyoming	Conveyors Regeneration	49,889	$70,000	3,698	$146.18	$35.69	4
TOTAL				**262,961**			**987**

[3] *Unit refers to a typical size of project, because the projects are site-specific the actual size of the projects will vary*

[4] *No. of Projects for Elevator Regeneration is calculated with an average of 4 Elevator per project.*

1.5 RECOMMENDATIONS

The key recommendations of this study are as follows:

1. Regenerative technology projects should be treated as DSM projects and processed through PacifiCorp's existing custom DSM programs (i.e. wattsmart Business or Energy FinAnswer)[5]

2. WHP projects within certain size limits, depending on the state, should be treated as DSM projects and also processed by means of PacifiCorp's existing custom DSM programs.

Concerning the first recommendation, PacifiCorp could inform key equipment vendors that utility incentives would be available to customers pending a suitable feasibility study. Guidelines for these types of studies should be developed.

Regarding the second recommendation, the study assumes a 1 MW maximum size limit for WHP projects. The objective of this limit is to provide an incentive for more efficient waste heat utilization from small facilities and is not intended to be an alternate incentive option for equipment that may be eligible as a Qualifying Facility.

[5] *Recommendations made herein assume that resource definitions and recovery mechanisms acceptable to PacifiCorp can be implemented*.

2 Introduction

The study consists of an evaluation of Waste Heat to Power (WHP) and Regenerative Technologies (RT), where generation is use to offset customer requirements. WHP includes situations where surplus heat available on-site can be used to generate electricity that will offset an equivalent electrical load. RT involves regenerative equipment that generates power by recovering braking energy; elevators and conveyors are often applicable end-uses. For both WHP and RT, a best practice review of other utility programs and a savings opportunity assessment was completed.

The work was commissioned by PacifiCorp, who is interested in understanding the best practices in identifying and promoting waste heat to power and regenerative equipment projects. Of particular interest were examples of how such projects are handled from a utility's perspective, and whether incentives for projects fall under demand-side management programs or specialized programs.

2.1 UTILITY BACKGROUND

PacifiCorp is a major utility in the Western United States, consisting of three business units, PacifiCorp Energy, Pacific Power and Rocky Mountain Power. PacifiCorp Energy is responsible for electricity generation and several coal mining operations. Pacific Power delivers electricity to customers in Oregon, Washington and California and Rocky Mountain Power delivers electricity to customers in Utah, Wyoming and Idaho.

2.2 PURPOSE AND OBJECTIVE

The purpose of the study was to: evaluate various WHP and RT technologies, to assess their magnitude of opportunity for savings and to conduct best practice reviews of utility treatment of these technologies. The following categories were considered by CLEAResult throughout the investigation:

- Eligibility of these technologies for incentives under current DSM and generation focused programs.
- Incentive structures considering capacity and energy and type of payment: ongoing or one-time.
- Criteria and policy that can be used to differentiate these technologies from Combined Heat and Power.

2.3 METHODOLOGY

The approach and methodology taken by CLEAResult to complete this study involved: defining the technologies, obtaining detailed facility electricity consumption information, conducting best practice reviews, estimating the magnitude of the saving opportunities, analyzing the costs of the different WHP and RT technologies and developing recommendations for PacifiCorp treatment of the technologies.

2.3.1 DEFINING THE TECHNOLOGIES AND FACILITY CONSUMPTION DATA

Descriptions of each technology were developed; the information provided includes major equipment involved and suppliers, sample mass and energy balances, typical operating parameters, typical applications and sizes.

Following the technology definition, customer utility data for Pacific Power and Rocky Mountain Power was analyzed to identify large customers that, due to their type of business, would be likely candidates for WHP or RT.

The historical utility data was used to assess the magnitude of opportunity and estimate the number of feasible applications in each of the states.

It is also important to note that the magnitude of opportunity was based on existing facilities and did not take into consideration new facilities that may be built over the 20-year planning horizon.

2.3.2 BEST PRACTICE REVIEW

The best practice review was conducted by reviewing CLEAResult and E Source[6] existing databases and through a literature review of published regulatory and utility policies. The review covers regulatory and government policies, utility programs and in some detail programs that specifically deal with the technologies involved.

2.3.3 ESTIMATING MAGNITUDE OF SAVING OPPORTUNITIES

Based on detailed facility consumption data, the MECS[7] database, and CLEAResult's experience estimates were determined of the magnitude of energy savings for each technology in each state. It should be noted that these estimates were not based on detailed analysis of individual site data, however they do provide information that should be useful in assessing whether more detailed work needs to be performed to determine potential or whether enough information is available to make program and policy decisions.

2.3.4 ANALYZING TECHNOLOGY COSTS

In most cases the cost of installing the different WHP and RT technologies is very site dependent but it is useful to have costs of typical installations. The technology costs provided are based on vendor information and CLEAResult experience with actual projects.

2.4 CUSTOMER FOCUS

The study focused on waste heat to power and regenerative technologies. Customer based generation beyond that powered by waste heat or regenerative technologies were excluded from the study.

The selection of customers that the study focused on was based on the following:

- Peak demand – it was estimated in order for customers to have sufficient load to consider customer generation where all the power produced would be used to offset facility load, they would have an existing annual peak demand of at least 1 MW. This criterion would not apply to elevator regenerative systems; the customer focus for this measure was based on the number of office buildings in each state.

The following exhibit summarizes the characteristics of the customers that were selected based on the 1 MW peak demand criteria:

[6] E Source, Boulder Colorado, an organization specializing in maintain and developing energy efficiency information

[7] Independent Statistics & Analysis, U.S. Energy Information Administration. Manufacturing Energy Consumption Survey (MECS): 2010 MECS Survey Data.

Exhibit 3: Summary of the Selected Customers

	CA	ID	OR	UT	WA	WY	Total
Total No. of Meters	9	11	213	394	66	116	809
Total No. of Sites	**9**	**16**	**184**	**277**	**59**	**116**	**661**
No. of Industrial Sites	**3**	**10**	**89**	**158**	**27**	**90**	**377**
Total Demand for Industrial Sites (kW)	14,940	22,002	421,423	1,021,195	117,855	923,809	2,521,224
Total Consumption for Industrial Sites (MWh)	39,679	133,584	1,975,233	5,880,833	740,790	5,271,130	14,041,248
No. of Commercial Sites	**1**	**1**	**90**	**114**	**27**	**21**	**254**
Total Demand for Commercial Sites (kW)	3,042	8,040	262,017	328,208	43,499	52,748	697,554
Total Consumption for Commercial Sites (MWh)	18,104	44,064	970,586	1,357,280	162,529	289,167	2,841,730
Load Factor (Industrial)	**30%**	**69%**	**54%**	**66%**	**72%**	**65%**	**64%**
Load Factor (Commercial)	**68%**	**63%**	**42%**	**47%**	**43%**	**63%**	**47%**

3 Applicable Technologies

3.1 WASTE HEAT TO POWER

Waste heat to power opportunities involve situations where high temperature waste streams are exhausted to the atmosphere. Electric power can be recover from these waste energy sources by using a gas to liquid heat exchanger to convert a fluid into a high pressure/temperature vapor which can be used to drive a turbine/electric generator set.

The conventional fluid has been water and the power cycle has been the steam rankine cycle where water is converted to steam in the heat exchanger which is then used to drive a steam turbine/generator set. For this type of system to be effective the temperature of waste heat source needs to be above 500ºF.

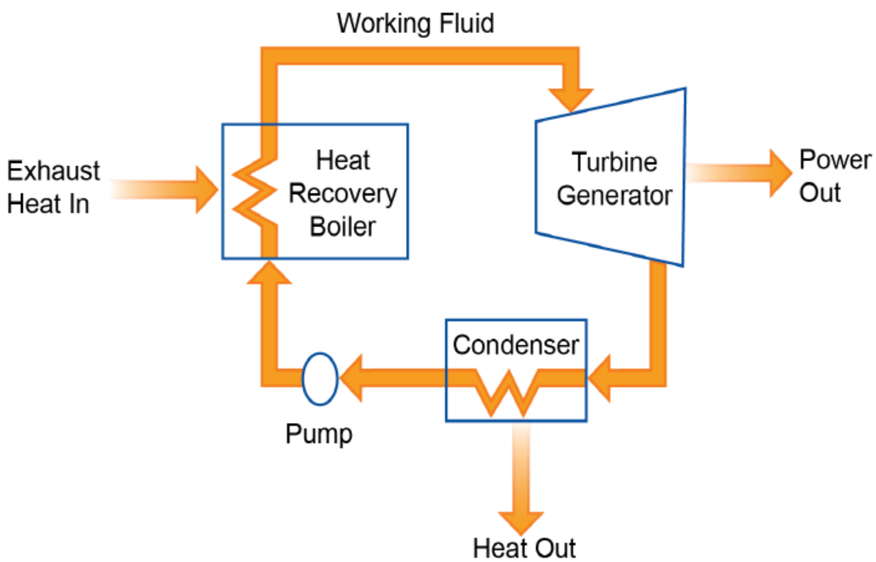
For waste heat streams lower than 650ºF, the organic rankine cycle can be used where different fluids with thermodynamic properties are used which allow a similar cycle to operate as the steam cycle but at much lower temperatures; as low as 150ºF.

As indicated in the Department of Energy paper[8] on Waste Heat Recovery, there are a number of advanced thermal conversion processes available such as Thermoelectric, Piezoelectric and thermal photovoltaic. In general, however, these processes are not as well proven as the steam rankine or organic rankine cycle technologies. Accordingly, the opportunities identified for this study involve using either the steam or organic rankine cycle technologies.

3.1.1 HIGH TEMPERATURE WASTE HEAT RECOVERY

The exhibit below illustrates a high temperature heat recovery to power arrangement[9].

Exhibit 4: High Temperature Waste Heat to Power



[8] "Waste Heat Recovery: Technology and Opportunities in U.S. Industry" U.S. Department of Energy, Industrial Technologies Program, March 2008

[9] Waste Heat to Power Systems, EPA Combined Heat and Power Partnership

These opportunities occur in high temperature industrial processes such as foundries, heat treating, copper and aluminum refining, and glass manufacturing. The following exhibit provides a rule of thumb type of calculation for estimating the waste heat to power potential for a particular situation where high temperature exhaust is available.

Exhibit 5: High Temperature WHP Calculation

Combustion Unit Input Capacity	50,000 MBH
Before Waste Heat to Power Project	
Waste Heat Temperature	1,400ºF
Excess Air	40%
Efficiency	48.3%
Energy Lost	25,850 MBH
After Waste Heat to Power Project	
Waste Heat Temperature	200ºF
Excess Air	40%
Efficiency	85.0%
Energy Lost	7,500 MBH
Energy Recovered in Heat Recovery	18,350 MBH
Waste Heat to Power Conversion Efficiency	25%
Electrical Output	**1,344.1 kW**

The major barriers to the implementation of these types of projects are:

- Lack of customer in-house expertise to fully analyze design and prepare the business case for the project.
- Other projects that are given higher priority with respect to available funds. Manufacturing facilities often have production improvement opportunities which will provide a rate of return higher than 50%.
- In order to implement the projects, plant will have to be shut-down and typically these types of facilities are shut-down for less than 2 weeks a year.

The U.S. Department of Energy's Industrial Technologies Program published a paper[10] on Waste Heat Recovery technologies where a capital cost range for these types of projects of $1,100 to $1,500 per kW was indicated. However, it is believed that these costs were based on relatively large projects, considering the likely potential for smaller projects a more conservative value of $3,000 per kW was used for this study.

3.1.2 ORGANIC RANKINE CYCLE (ORC)

Other working fluids, with better efficiencies at lower heat source temperatures are used in ORC heat engines. ORCs use an organic working fluid that has a lower boiling point, higher vapor pressure, higher molecular mass,

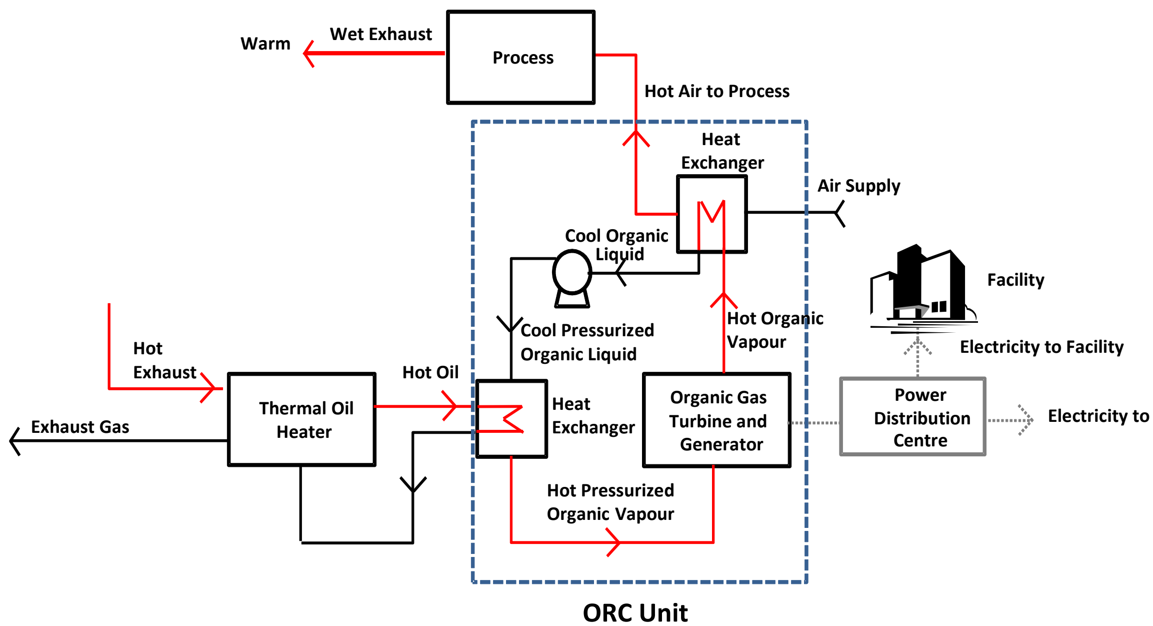
[10] *"Waste Heat Recovery: Technology Opportunities in U.S. Industry" U.S. Department of Energy Industry Technology Program, March 2008*

and higher mass flow compared to water. Together, these features enable higher turbine efficiencies than in the more conventional steam rankine cycle technologies. ORC systems can be utilized for waste heat sources as low as 150ºF, whereas steam systems are limited to heat sources greater than 500ºF.

Typical organic rankine cycle (ORC) units are in the size range of 10 kW to 6 MW. These units can be used as a bottoming or topping cycle, either making use of waste heat for electricity generation, or using a primary heat source to generate electricity and useful heat. Although electrical efficiencies are low, up to 20%, when residual heat is used the overall efficiency can be as high as 90% if the primary process heat use is considered in the efficiency calculation. This type of system is most advantageous where a low grade waste heat source is available.

If the system is installed using a primary heat source then typical components include a combustor, thermal oil heater, ORC unit, and a heat recovery unit. Fuels are based on compatibility with the thermal oil heater, commonly natural gas, biomass, landfill gas, and propane. When a waste heat source is used, the system will require a thermal oil heat recovery unit, and ORC unit. The exhibit below is a schematic for a typical ORC arrangement.

Exhibit 6: Typical ORC Arrangement



The following exhibit provides a rule of thumb type of calculation for estimating the waste heat to power potential for a particular situation.

Exhibit 7: ORC Project WHP Calculation

Combustion Unit Input Capacity	**10,000 MBH**
<u>Before ORC</u>	
Waste Heat Temperature	800ºF
Excess Air	40%
Efficiency	67.4%
Energy Lost	3,260 MBH
<u>After ORC</u>	
Waste Heat Temperature	200ºF
Excess Air	40%
Efficiency	85.0%
Energy Lost	1,500 MBH
Energy Recovered in Heat Recovery	1,760 MBH
Waste Heat to Power Conversion Efficiency	16%
Electrical Output	**82.5 kW**

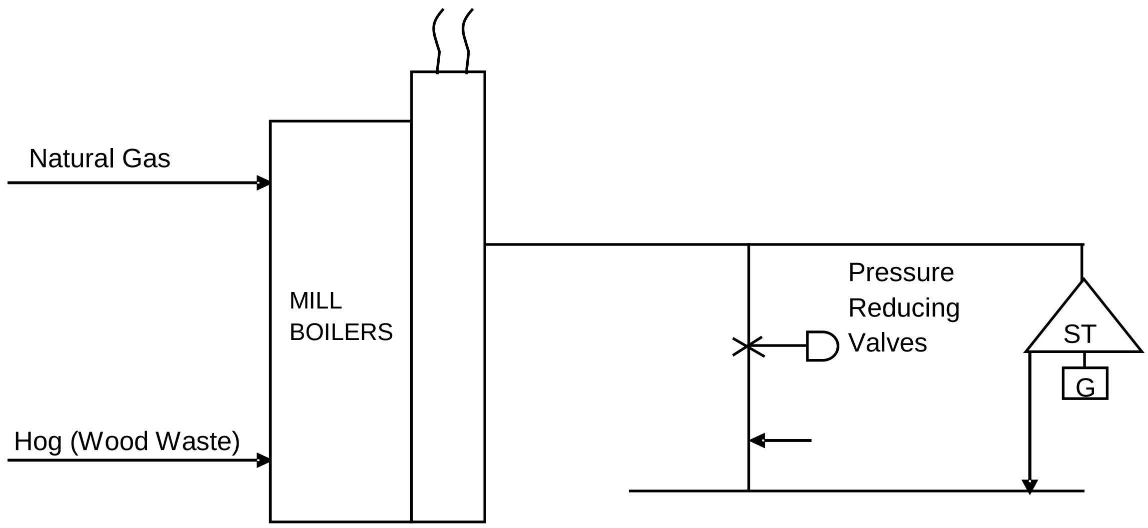
These units are being used extensively in Europe and a number of units have been installed in North America. The market segments where these units have been used are as follows:

- Wood Products
- Pulp and Paper
- Food Processing
- Chemical Manufacturing
- Foundries
- Power Generation → Bottoming cycle
- Cement manufacturing → Kiln heat recovery
- Oil and Gas → Compressor station heat recovery
- Industry with incinerators

3.1.3 STEAM POWER GENERATION OPTIMAZATION

A few of PacifiCorp's customers generate a large amount of steam for their process use and at the same time require large amounts of electricity. These types of facilities will typically have some self- generation equipment already in place involving a backpressure turbine as indicated in the exhibit below.

Exhibit 8: Customer Steam Cogeneration Example



ST - Steam Turbine, G - Electric Generator

Often there are opportunities to optimize these systems by:

- Upgrading the existing steam turbine
- Changing the process steam distribution so that more high pressure steam can be used in the steam turbine.
- Improving the efficiency of steam drives so that more high pressure steam is available for the steam turbine.
- Improve the electric generator efficiency.

The following exhibit provides a rule of thumb type of calculation for estimating the waste heat to power potential for a particular steam power generation optimization opportunity.

Exhibit 9: Steam Optimization Project – WHP Calculation

Before Steam Optimization Project	
Boiler Steam Flow	240,000 lbs/hr
Existing Power Self-Generated	9.0 MW
Existing Cogeneration Plant Efficiency	65%
After Steam Optimization Project	
Boiler Steam Flow	240,000 lbs/hr
Electric Power Generated	11.0 MW
Optimized Plant Efficiency	67%
Incremental Generation	**2.0 MW**

These types of optimization projects are very site specific and will require detailed engineering studies to design, plan and cost; however, customers may have studies already on hand. These projects are usually low cost and range from $100 to $1,000 per kW of incremental generation capacity. For the purpose of this study a value of $1,000 was used. Since for these projects, any additional fuel requirement will be waste fuel and there will be no additional operating and maintenance costs, the incremental fuel, operating and maintenance costs will be less than 0.5 cents per kWh of incremental generation.

Pulp and paper mills, large wood product and food processing facilities are the kinds of facilities where these efficiency opportunities exist. The background for these projects is that they will exist in plants that have been in existence for more than 10 years and over their history the process requirements for the plant change so that the steam generation and distribution system is no longer optimum.

The major barriers to the implementation of these types of projects are:

- Lack of customer in-house expertise to fully analyze design and prepare the business case for the project.
- Other projects that are given higher priority with respect to available funds. Manufacturing facilities often have production improvement opportunities which will provide a rate of return higher than 50%.
- In order to implement the projects, plant will have to be shut-down and typically these types of facilities are shut-down for less than 2 weeks a year.

3.1.4 WASTE HEAT – WASTE FUEL DISCUSSION

Published information on waste heat to power opportunities often includes in the opportunities the use of waste products as a fuel source. For example an Environmental Protection Agency (EPA) paper on Waste Heat to Power[11], identifies landfill gas energy systems and the use of flare gas in the oil and gas exploration sector. These are good opportunities in the broad waste to energy area; however, this report does not include these types of technologies which involve primarily combusting a waste product. Rather the scope for this work is restricted to sources of waste energy that are being discharged from an existing process to the environment resulting in wasted energy.

3.2 REGENERATIVE BRAKING

A way to reduce the energy consumption and improve the energy efficiency of conveyors, hoists and elevators is to install a regenerative brake system. In regenerative braking systems, kinetic energy is converted into electrical energy that can be directly reused or stored. Depending on the type and application of the installation, it is possible to save a substantial amount of energy when using regenerative systems. Common applications of regenerative brakes are hoists, elevators, conveyors and rotating equipment, such as, centrifugal separators. In most applications, the energy can be stored and reused internally. For example, opportunity can be available from the downward movement in a hoist; a regenerative brake system can absorb a portion of the kinetic energy in order to reduce the net energy consumption of the drive.

3.2.1 ELEVATOR

According to a study by Harvey Sachs for the American Council for an Energy-Efficient Economy, titled "Opportunities for Elevator Energy Efficiency Improvements", the estimated energy consumption of elevators in a

[11] *"Waste Heat to Power Systems" EPA Combined Heat and Power Partnerships, Updated May 30, 2012*

typical commercial office building is 5% of electricity use. The elevator opportunity study also indicated that the number of elevators in the United States is around 700,000, with 75% of elevators being Hydraulic. There are roughly 100,000 new elevator installations per year[12].

A case study of an elevator modernization project in a 27 floor office building in Vancouver was funded by BC Hydro. Using an efficient motor and regenerative drive system, the annual energy savings of the project was estimated to be 50,000 kWh[13].

The following exhibit provides a rule of thumb type of calculation for estimating the power regeneration potential for a particular elevator arrangement.

Exhibit 10: Elevator WHP Calculation

Number of Elevator	4
Maximum Motor Power Draw per Elevator	25 kW
Percent of Operating Time	25%
Braking Energy as % of Maximum	20%
Annual Energy Consumption w/o Regeneration	219 MWh
Energy savings with Regeneration	**44 MWh**

After a regenerative system has been installed in a bank of elevators the energy saved can be measured by installing power meters in the input lines of the inverter and the output lines of the regenerative system, measuring actual power consumed and power regenerated.

3.2.2 MATERIAL CONVEYORS

The braking systems in downhill conveyors can be used to generate energy from the motors which can be fed to the drive and into the customer's electrical network, reducing energy consumption from the grid.

The exhibit below provides a rule of thumb type of calculation for estimating the regenerative power potential for a particular overland conveyor arrangement.

Exhibit 11: Conveyor Regenerative Power WHP Calculation

Conveyor Length	15,000 ft
Elevation drop	1,500 ft
Material Transport	100,000 tonnes/day
Potential Head Power	6,957 kW
Friction Loss as % of Head Power	40%
Braking Energy Required	4,174 kW
Efficiency of Regenerative System	95%
Regenerative Power Available	**3,966 kW**

[12] *Sachs, Harvey M. (2005). "Opportunities for Elevator Energy Efficiency Improvements". American Council for an Energy-Efficient Economy (ACEEE). April 2005*

[13] *Building Owners and Managers Association (BOMA). (2011) "BOMA Energy eXpress".*

An example of a downhill conveyor that is using regenerative braking is the overland conveyor at the Los Pelambres Mine in Chile[14]. Three conveyors operate in series over a 12 km distance transporting 5,800 tons of ore per hour from the mine to the concentration facility, including an elevation drop of 1,200 metres. The average grade is 11%, but at times can reach 24% decline. The installed generating capacity on the conveyors is 20 MW which includes eight 2,500 kW drives.

3.2.3 OTHER REGENERATIVE APPLICATIONS

Equipment with frequent start and stop operation provide further opportunity for regeneration. Examples which fit this operation profile are rotating batch process equipment, chipper motors and crushing equipment.

A case study of rotating batch process equipment in a manufacturing facility in Vancouver was funded by BC Hydro. The 9 units spin and discharge batches of material with a 3.5 minute cycle time. Through measurement of power draw and calculation of braking required, it was determined that 50% of the cycle energy required could be recovered through the use of regenerative braking technology. The use of regenerative braking would result in over 400 MWh of annual energy savings. The potential for these types of projects was not estimated because they are very process specific; however in considering these types of opportunities, custom type DSM programs can accommodate projects of this type.

3.3 MICRO HYDRO

In water supply systems often the water is obtained from a reservoir or lake that is at a much higher elevation than the end-use distribution system. In order to protect the distribution system from over pressure, pressure reducing valves (PRVs) are used to lower the pressure. When the pressure is reduced energy is lost, some water supply organizations have replaced these PRVs with micro turbine/generators generating power.

This type of project is obviously not a WHP or RT project but it is similar in that energy is being wasted by an existing process.

An example is outlined in the exhibit below.

Exhibit 12: Micro Hydro Calculation

Flow (Q)	1 ft³/sec
Height (H)	1,000.0 ft
Power	60 kW
Hours of Operation	6,000
Energy	360 MWh

The calculations indicate a situation where 1 ft³/sec (449 gpm) is drawn from a head of 1,000 ft. Considering the practical efficiency levels of the micro hydro system a turbine generator with a capacity of 60 kW could be installed in the system. If the flow existed for 6,000 hours per year, 360 MWh of electricity could be generated.

[14] Rodriquez, Jose, Jorge Pontt, Gerardo Almzamora, Norbert Becker, Ottomar Einenkel, and Alejandro Weinstein. (2002). "Novel 20-MW Downhill Conveyor System Using Three-Level Converters". IEEE Transactions on Industrial Electronics. Vol. 49:5 (1093-1100). October 2002.

4 Magnitude of Opportunity

Estimates were developed to facilitate an understanding of the general magnitude of the energy saving opportunities of the different technologies that were identified. These estimates were based on power consumption in different industrial sub-sectors, general rules of thumb, published literature on the different technologies and on the experience of CLEAResult personnel.

A model was developed for estimating the magnitude of opportunity for each of the energy saving measures. This model is available to PacifiCorp.

4.1 TECHNICAL POTENTIAL VS MAGNITUDE OF OPPORTUNITY

In PacifiCorp's DSM potential assessment[15] the terms Technical Potential and Achievable Technical Potential were used. For this particular study a more appropriate term is Magnitude of Opportunity which was suggested in the work scope for the project.

The reasoning for the change in terminology is that while the theoretical potential for WHP is significant the number of WHP units that have actually been installed has been relatively very small. For example, in an ICF report[16], the technical potential for WHP in the U.S. was given as over 12,000 MW but only 700 MW of projects are in operation and most of the installed projects were not load displacement projects. This large difference is an indication that there are major financial and other barriers to the implementation of these types of projects. A Magnitude of Opportunity estimate is a rough estimate of the potential savings over a 20 year planning horizon and is more heavily weighted towards historical experience than on technical potential. It is useful for determining how much effort should be spent, at this time, in further developing and exploring the potential.

4.2 PROJECT SIZE CONSIDERATIONS

In estimating the magnitude of opportunity, it is useful to consider project size limits. It is suggested that for each state the maximum project size should be consistent with Qualifying Facility size ranges that are in place in each state. With this consideration the opportunity estimates were based on project size limits indicated in the following exhibit.

Exhibit 13: Project Size Considerations

State	Waste Heat Plant Size Limit (aMW)
California	1
Oregon	1
Idaho	1
Utah	1
Washington	1
Wyoming	1

[15] *Assessment of Long-Term, System-Wide Potential for Demand-Side and Other Supplemental Resources, 2013-2032 Volume I, Cadmus, March 2013*

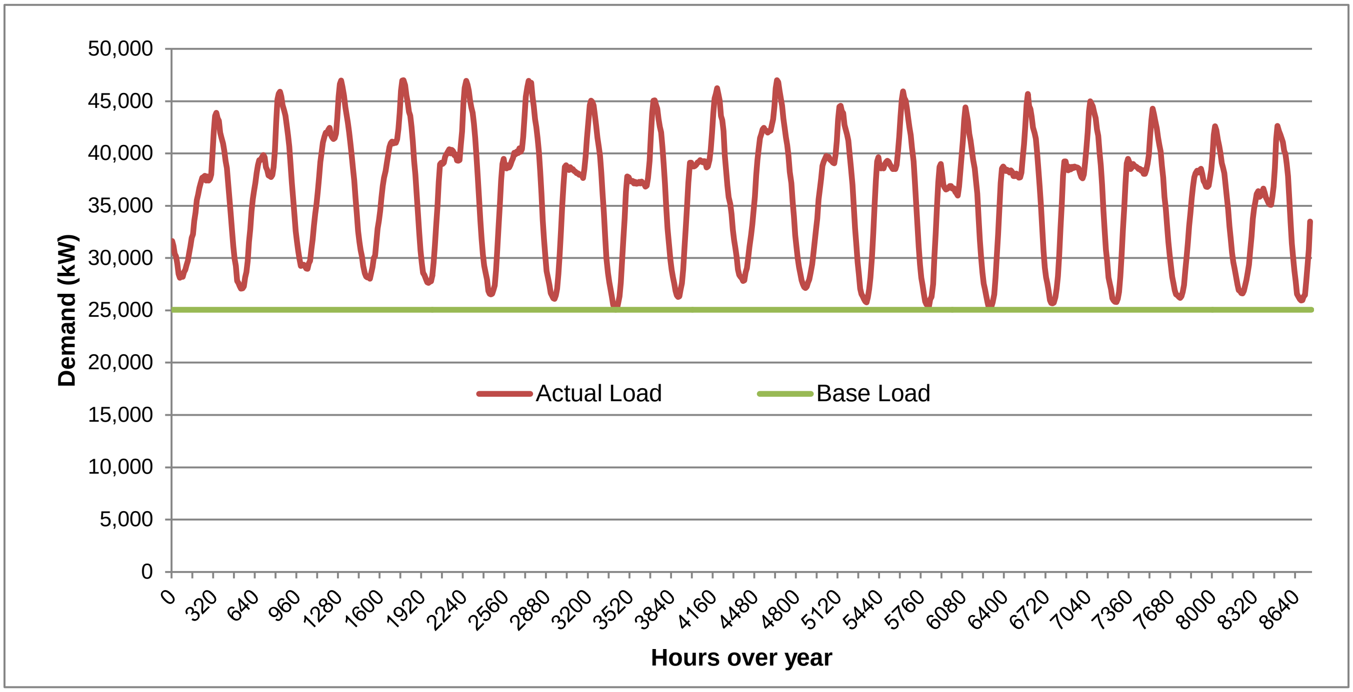
[16] *"CHP and WHP Growth Trends and Opportunity Identification", Bluestein, October, 2013*

4.3 WASTE HEAT

Targeted Facilities with a Peak Demand Larger than 1 MW

The first step in estimating the waste heat to power opportunity was to develop a list of all of the commercial and industrial facilities in PacifiCorp's jurisdictions that had an annual peak demand larger than 1,000 kW (1 MW). The reasoning behind the 1,000 kW level was that the scope of this study was limited to projects that would offset load only, so that it would not be practical to install projects that would generate more power than the base load of the host facility. The base load is the electrical power requirement for the facility that is required on an almost continuous basis or at least 8,000 hours per year. This base load determination is illustrated in the exhibit below.

Exhibit 14: Base Load Determination



In general, a review of the billing data indicated that facilities with a peak demand less than 1,000 kW would have a base demand which would require a size of waste heat to power project that would be too small to be economical.

4.3.1 HIGH TEMPERATURE WASTE HEAT TO POWER

This opportunity for the purposes of this study is defined as situations where exhaust streams at temperatures above 500ºF are being exhausted to the atmosphere creating an opportunity for employing a steam rankine cycle. The types of facilities where these types of conditions can exist are foundries, ore refining, metal treating, cement and glass manufacturing. For an opportunity to exist at such a facility a significant volume of gas needs to be exhausted in order for a waste heat to power project to be economical.

The opportunity was estimated using the following approach:

- Facilities in each state were selected where based on their type of manufacturing it was assumed that large amounts of high temperature gas was being exhausted (7 facilities were selected)
- Volume of waste energy was estimated using Manufacturing Energy Consumption Survey (MECS) data.

- Size of High Temperature waste heat to power facility was estimated based on typical efficiency of such facilities and the waste energy that could be recovered from the waste steam.

The results of the analysis are summarized in the exhibit below.

Exhibit 15: High Temperature Waste Heat to Power Opportunity

State	Estimated Number of Facilities	Estimate of Waste Energy Available for Power Generation (MWh)	Estimate of Magnitude of Waste Heat to Power Opportunity (MWh)
California	None Identified		
Idaho	None Identified		
Oregon	2	24,269	6,067
Utah	3	79,926	19,305
Washington	None Identified		
Wyoming	2	3,827,083	16,000
Total	**7**	**3,931,278**	**41,372**

4.3.2 ORGANIC RANKINE CYCLE (ORC) OPPORTUNTIES

ORC is a relatively new technology although it is well established in Europe and it has significantly increased the opportunities to convert waste heat to power because of its ability to use relatively low grade (lower temperature) waste heat sources. As the DOE paper on Waste Heat Recovery[17] indicates "Although the economics of ORC heat recovery need to be carefully analyzed for any given application, it will be a particularly useful option in industries that have no in house use for additional process heat or no neighboring plants that could make economic use of the heat."

Based on a review of billing data, facilities which would probably have a significant amount of process heat were tagged. The MECS data and the type of facility were used for this task. The magnitude of the opportunity was then determined according to the following criteria:

- Amount of process heat that was available at a particular site based on MECS data.
- An estimate of the waste energy that is available from the process heat exhaust (CLEAResult observation of industrial processes).
- Efficiency of ORC projects in converting waste heat to power (typically 15%).

The results of the analysis are summarized in the exhibit below.

17 "Waste Heat Recovery: Technology Opportunities in U.S. Industry" U.S. Department of Energy Industry Technology Program, March 2008

Exhibit 16: Magnitude of ORC Opportunity

State	Estimated Number of Facilities	Estimate of Waste Energy Available for Power Generation (MWh)	Estimate of Magnitude of Waste Heat to Power Opportunity (MWh)
California	1	12,195	1,421
Idaho	1	32,870	1,016
Oregon	50	1,559,834	153,953
Utah	28	2,873,930	109,222
Washington	3	323,258	11,125
Wyoming	7	1,752,252	32,910
Total	**90**	**6,554,338**	**309,646**

4.3.3 STEAM POWER GENERATION OPTIMIZATION

The facilities where these types of projects would be of interest would be ones with a large existing steam demand and a large power requirement and probably ones that had existing self-generation facilities. Based on the billing data there were only 3 of these type of facilities all pulp and paper companies. The opportunity was based on the following calculations for each of the 3 facilities:

- Estimating the amount of process heat generated from MECS data.
- Assuming a percent of this process heat is being wasted from CLEAResult's experience with similar facilities
- Calculating the amount of waste heat
- Assuming that a percent of this waste heat can be converted to power generation.

The exhibit below summarizes the results.

Exhibit 17: Magnitude of Steam System Optimization Opportunity

State	Estimated Number of Facilities	Estimate of Waste Energy Available for Power Generation (MWh)	Estimate of Magnitude of Waste Heat to Power Opportunity (MWh)
California	None Identified		
Idaho	None Identified		
Oregon	1	755,102	8,000
Utah	None Identified		
Washington	2	477,232	8,398
Wyoming	None Identified		
Total	**3**	**1,232,334**	**16,398**

4.4 REGENERATIVE TECHNOLOGY

The two regenerative technologies that were assessed as to the Magnitude of Opportunity were regeneration on downhill conveyors and regeneration as applied to Elevator.

4.4.1 CONVEYOR REGENERATION

It is important to note that this estimate is not based on detailed site specific data. It was developed by reviewing PacifiCorp's billing data, selecting facilities that would most likely have long conveyor runs and then using google earth to estimate the downhill conveyor runs and their drop in elevation.

Exhibit 18: Magnitude of Conveyors Regeneration Opportunity

State	Estimated Number of Facilities	Estimate of Magnitude of Waste Energy to Power Opportunity (MWh)
California	None Identified	
Idaho	None Identified	
Oregon	None Identified	
Utah	7	6,662
Washington	None Identified	
Wyoming	4	3,698
Total	**11**	**10,360**

4.4.2 ELEVATOR REGENERATION

The energy consumed for commercial office buildings was obtained from the "2013 Assessment of Long-Term, System-wide Potential for Demand-Side and Other Supplemental Resources" and was used as a basis for determining elevator energy savings. As the historical data for Oregon was not included in the DSM review, the commercial sector electricity sales was obtained from the "2013 Integrated Resource Plan" and it was estimated that 15% of the customers are office buildings. This figure was then multiplied by 5%, a factor to determine the electricity consumption of elevator in a typical commercial office building electricity use, according to a study by Harvey Sachs for the American Council for an Energy-Efficient Economy, titled "Opportunities for Elevator Energy Efficiency Improvements". The reduction in energy usage can be up to 40% when compared to a base case scenario, this factor has been assumed as the regeneration efficiency. An additional 50% factor has been added to strictly target high rise traction elevator from the sample.

The results are indicated in the exhibit below.

Exhibit 19: Magnitude of Elevator Regeneration Opportunity

State	Estimated Number of Units	Estimate of Magnitude of Waste Energy to Power Opportunity (MWh)
California	50	434
Idaho	80	695
Oregon	853	7,468
Utah	2,128	18,641
Washington	179	1,561
Wyoming	243	2,123
Total	**3,533**	**30,922**

4.5 MICRO HYDRO

The magnitude of the micro hydro opportunity was estimated by reviewing all of PacifiCorp's billing data and assessing the facilities that may be obtaining their water supply from high elevations. This generally involved water supply facilities, vacation resorts in mountain regions and mining facilities. Based on CLEAResult's experience, the potential for this type of project is not large and only a relatively small percentage of the electricity used by the selected facilities could be offset by this technology. For this initial magnitude estimate a 5% value was used.

The results are provided in the exhibit below.

Exhibit 20: Magnitude of Micro Hydro Regeneration Opportunity

State	Estimated Number of Facilities	Estimate of Magnitude of Waste Energy to Power Opportunity (MWh)
California	None Identified	
Idaho	None Identified	
Oregon	None Identified	
Utah	7	8,059
Washington	None Identified	
Wyoming	5	7,452
Total	**12**	**15,511**

4.6 ESTIMATE OF MAGNITUDE OF OPPORTUNITY FOR ALL WHP AND RT

The exhibit below summarizes the magnitude of opportunity for all of the WHP and RT technologies analyzed. There are opportunities for other RT technologies such as large rotating inertial equipment but the potential for these opportunities is estimated not to be large.

Exhibit 21 indicates the magnitude of opportunity assuming that all of the projects with reasonable economics would be implemented over the planning horizon.

Exhibit 21: Magnitude of Opportunity by Measures (MWh)

Measures	CA	ID	OR	UT	WA	WY	Total
ORC	1,421	1,016	153,953	109,222	11,125	32,910	**309,646**
High Temperature Waste Heat	0	0	6,067	19,305	0	16,000	**41,372**
Micro Hydro	0	0	0	8,059	0	7,452	**15,511**
Steam System Optimization	0	0	8,000	0	8,398	0	**16,398**
Conveyor Regeneration	0	0	0	6,662	0	3,698	**10,360**
Elevator Regeneration	434	695	7,468	18,641	1,561	2,123	**30,922**
Total	**1,855**	**1,710**	**175,487**	**161,889**	**21,084**	**62,182**	**424,207**

4.7 MARKET FACTORS AND RATE OF IMPLEMENTATION

In estimating the number of projects that may actually be implemented if PacifiCorp promoted the installation of such projects, other barriers should be considered besides economic ones. From CLEAResult's experience, these other barriers are:

- Lack of technical resources at customer facilities to properly plan and integrate a project into the industrial process.
- Concern over a risk that a project would reduce the reliability of the industrial process.
- Cost risk, projects of these types have often been more expensive to install than originally estimated.

Considering these factors the rate of implementation was estimated for each technology. In most cases the full potential would not be obtained within the 20 year planning horizon.

The exhibit below indicates the expected implementation rate for the ORC technology. ORC is a relatively new technology and these estimates are very subjective. The thought process is that in Oregon and Utah where there appears to be some potential it would take two or three years to convince one or two customers to install a unit. If these units operated successfully other facilities would gradually follow in deciding to install their own units.

Exhibit 22: Expected Implementation Rate for ORC

ORC	CA	ID	OR	UT	WA	WY	Total
Magnitude of Opportunity (MWh)	**1,421**	**1,016**	**153,953**	**109,222**	**11,125**	**32,910**	**309,646**
No. of Potential Projects	**1**	**1**	**50**	**28**	**3**	**7**	**90**
Year 1, Percent of Potential Implemented							
Year 2, Percent of Potential Implemented							
Year 3, Percent of Potential Implemented			4%	4%			
Year 4, Percent of Potential Implemented			4%	4%			

Year 5, Percent of Potential Implemented			8%	8%	30%	30%	
Year 6, Percent of Potential Implemented			8%	8%	30%	30%	
Year 7, Percent of Potential Implemented			12%	12%	30%	30%	
Year 8, Percent of Potential Implemented			12%	12%	30%	30%	
Year 9, Percent of Potential Implemented			16%	16%	30%	30%	
Year 10, Percent of Potential Implemented	100%	100%	16%	16%	30%	30%	
Year 11, Percent of Potential Implemented	100%	100%	20%	20%	30%	30%	
Year 12, Percent of Potential Implemented	100%	100%	20%	20%	30%	30%	
Year 13, Percent of Potential Implemented	100%	100%	28%	28%	60%	60%	
Year 14, Percent of Potential Implemented	100%	100%	28%	28%	60%	60%	
Year 15, Percent of Potential Implemented	100%	100%	36%	36%	60%	60%	
Year 16, Percent of Potential Implemented	100%	100%	36%	36%	60%	60%	
Year 17, Percent of Potential Implemented	100%	100%	46%	46%	60%	60%	
Year 18, Percent of Potential Implemented	100%	100%	46%	46%	60%	60%	
Year 19, Percent of Potential Implemented	100%	100%	56%	56%	60%	60%	
Year 20, Percent of Potential Implemented	100%	100%	56%	56%	60%	60%	
Planning Horizon, Percent of Potential Implemented	100%	100%	56%	56%	60%	60%	
Magnitude of Opportunity with Market Factors (MWh)	**1,421**	**1,016**	**86,213**	**61,164**	**6,675**	**19,746**	**176,235**
Anticipated Number of Projects	**1**	**1**	**28**	**16**	**2**	**5**	**53**

The exhibit below indicates the expected implementation rate for high temperature waste heat projects. There were seven potential sites identified and it is estimated that over the 20 year planning horizon most of these facilities would be installed.

Exhibit 23: Expected Implementation Rate for High Temperature Waste Heat

High Temperature Waste Heat	CA	ID	OR	UT	WA	WY	Total
Magnitude of Opportunity (MWh)			**6,067**	**19,305**		**16,000**	**41,372**
No. of Potential Projects			**2**	**3**		**2**	**7**
Year 1, Percent of Potential Implemented							
Year 2, Percent of Potential Implemented							
Year 3, Percent of Potential Implemented							
Year 4, Percent of Potential Implemented							
Year 5, Percent of Potential Implemented							
Year 6, Percent of Potential Implemented			50%	30%		50%	
Year 7, Percent of Potential Implemented			50%	30%		50%	
Year 8, Percent of Potential Implemented			50%	30%		50%	

Year 9, Percent of Potential Implemented			50%	30%		50%	
Year 10, Percent of Potential Implemented			50%	30%		50%	
Year 11, Percent of Potential Implemented			50%	30%		50%	
Year 12, Percent of Potential Implemented			50%	30%		50%	
Year 13, Percent of Potential Implemented			50%	30%		50%	
Year 14, Percent of Potential Implemented			50%	30%		50%	
Year 15, Percent of Potential Implemented			100%	60%		100%	
Year 16, Percent of Potential Implemented			100%	60%		100%	
Year 17, Percent of Potential Implemented			100%	60%		100%	
Year 18, Percent of Potential Implemented			100%	60%		100%	
Year 19, Percent of Potential Implemented			100%	60%		100%	
Year 20, Percent of Potential Implemented			100%	60%		100%	
Planning Horizon, Percent of Potential Implemented			**100%**	**60%**		**100%**	
Magnitude of Opportunity with Market Factors (MWh)			**6,067**	**11,583**		**16,000**	**33,650**
Anticipated Number of Projects			**2**	**2**		**2**	**6**

Similarly with micro-hydro it was assumed that over the planning horizon most of the potential projects would be implemented.

Exhibit 24: Expected Implementation Rate for Micro Hydro

Micro Hydro	CA	ID	OR	UT	WA	WY	Total
Magnitude of Opportunity (MWh)				**8,059**		**7,452**	**15,511**
No. of Potential Projects				**7**		**5**	**12**
Year 1, Percent of Potential Implemented							
Year 2, Percent of Potential Implemented							
Year 3, Percent of Potential Implemented							
Year 4, Percent of Potential Implemented				10%		10%	
Year 5, Percent of Potential Implemented				10%		10%	
Year 6, Percent of Potential Implemented				30%		30%	
Year 7, Percent of Potential Implemented				30%		30%	
Year 8, Percent of Potential Implemented				30%		30%	
Year 9, Percent of Potential Implemented				30%		30%	
Year 10, Percent of Potential Implemented				50%		50%	
Year 11, Percent of Potential Implemented				50%		50%	
Year 12, Percent of Potential Implemented				50%		50%	

Year 13, Percent of Potential Implemented				50%		50%	
Year 14, Percent of Potential Implemented				70%		70%	
Year 15, Percent of Potential Implemented				70%		70%	
Year 16, Percent of Potential Implemented				70%		70%	
Year 17, Percent of Potential Implemented				70%		70%	
Year 18, Percent of Potential Implemented				70%		70%	
Year 19, Percent of Potential Implemented				70%		70%	
Year 20, Percent of Potential Implemented				70%		70%	
Planning Horizon, Percent of Potential Implemented				**70%**		**70%**	
Magnitude of Opportunity with Market Factors (MWh)				**5,641**		**5,216**	**10,857**
Anticipated Number of Projects				**5**		**4**	**9**

For steam systems because of the very attractive economics for these projects, it was estimated all three of the potential projects would be installed.

Exhibit 25: Expected Implementation Rate for Steam System Optimization

Steam System Optimization	CA	ID	OR	UT	WA	WY	Total
Magnitude of Opportunity (MWh)			**8,000**		**8,398**		**16,398**
No. of Potential Projects			**1**		**2**		**3**
Year 1, Percent of Potential Implemented							
Year 2, Percent of Potential Implemented							
Year 3, Percent of Potential Implemented							
Year 4, Percent of Potential Implemented			100%		50%		
Year 5, Percent of Potential Implemented			100%		50%		
Year 6, Percent of Potential Implemented			100%		50%		
Year 7, Percent of Potential Implemented			100%		50%		
Year 8, Percent of Potential Implemented			100%		50%		
Year 9, Percent of Potential Implemented			100%		50%		
Year 10, Percent of Potential Implemented			100%		50%		
Year 11, Percent of Potential Implemented			100%		50%		
Year 12, Percent of Potential Implemented			100%		50%		
Year 13, Percent of Potential Implemented			100%		50%		
Year 14, Percent of Potential Implemented			100%		100%		
Year 15, Percent of Potential Implemented			100%		100%		
Year 16, Percent of Potential Implemented			100%		100%		
Year 17, Percent of Potential Implemented			100%		100%		
Year 18, Percent of Potential Implemented			100%		100%		

Year 19, Percent of Potential Implemented			100%		100%		
Year 20, Percent of Potential Implemented			100%		100%		
Planning Horizon, Percent of Potential Implemented			**100%**		**100%**		
Magnitude of Opportunity with Market Factors (MWh)			**8,000**		**8,398**		**16,398**
Anticipated Number of Projects			**1**		**2**		**3**

For conveyors it was assumed that all of the eleven identified projects would be installed over the planning horizon.

Exhibit 26: Expected Implementation Rate for Conveyors Regeneration

Conveyors Regeneration	CA	ID	OR	UT	WA	WY	Total
Magnitude of Opportunity (MWh)				**6,662**		**3,698**	**10,360**
No. of Potential Projects				**7**		**4**	**11**
Year 1, Percent of Potential Implemented							
Year 2, Percent of Potential Implemented				10%		25%	
Year 3, Percent of Potential Implemented				10%		25%	
Year 4, Percent of Potential Implemented				20%		50%	
Year 5, Percent of Potential Implemented				20%		50%	
Year 6, Percent of Potential Implemented				30%		75%	
Year 7, Percent of Potential Implemented				30%		75%	
Year 8, Percent of Potential Implemented				40%		100%	
Year 9, Percent of Potential Implemented				40%		100%	
Year 10, Percent of Potential Implemented				50%		100%	
Year 11, Percent of Potential Implemented				50%		100%	
Year 12, Percent of Potential Implemented				60%		100%	
Year 13, Percent of Potential Implemented				60%		100%	
Year 14, Percent of Potential Implemented				70%		100%	
Year 15, Percent of Potential Implemented				70%		100%	
Year 16, Percent of Potential Implemented				80%		100%	
Year 17, Percent of Potential Implemented				80%		100%	
Year 18, Percent of Potential Implemented				90%		100%	
Year 19, Percent of Potential Implemented				90%		100%	
Year 20, Percent of Potential Implemented				100%		100%	
Planning Horizon, Percent of Potential Implemented				**100%**		**100%**	
Magnitude of Opportunity with Market Factors (MWh)				**6,662**		**3,698**	**10,360**
Anticipated Number of Projects				**7**		**4**	**11**

The economics for elevator retrofits do not appear to be that attractive but if a program to promote the technology was in place it is felt that 50% of the potential would be installed over the planning horizon. Vendors are in place to promote such retrofits.

Exhibit 27: Expected Implementation Rate for Elevator Regeneration

Elevator Regeneration	CA	ID	OR	UT	WA	WY	Total
Magnitude of Opportunity (MWh)	**434**	**695**	**7,468**	**18,641**	**1,561**	**2,123**	**30,922**
No. of Potential Projects	**25**	**40**	**433**	**1,091**	**91**	**125**	**1,805**
Year 1, Percent of Potential Implemented	3%	3%	3%	3%	3%	3%	
Year 2, Percent of Potential Implemented	5%	5%	5%	5%	5%	5%	
Year 3, Percent of Potential Implemented	8%	8%	8%	8%	8%	8%	
Year 4, Percent of Potential Implemented	10%	10%	10%	10%	10%	10%	
Year 5, Percent of Potential Implemented	13%	13%	13%	13%	13%	13%	
Year 6, Percent of Potential Implemented	15%	15%	15%	15%	15%	15%	
Year 7, Percent of Potential Implemented	18%	18%	18%	18%	18%	18%	
Year 8, Percent of Potential Implemented	20%	20%	20%	20%	20%	20%	
Year 9, Percent of Potential Implemented	23%	23%	23%	23%	23%	23%	
Year 10, Percent of Potential Implemented	25%	25%	25%	25%	25%	25%	
Year 11, Percent of Potential Implemented	28%	28%	28%	28%	28%	28%	
Year 12, Percent of Potential Implemented	30%	30%	30%	30%	30%	30%	
Year 13, Percent of Potential Implemented	33%	33%	33%	33%	33%	33%	
Year 14, Percent of Potential Implemented	35%	35%	35%	35%	35%	35%	
Year 15, Percent of Potential Implemented	38%	38%	38%	38%	38%	38%	
Year 16, Percent of Potential Implemented	40%	40%	40%	40%	40%	40%	
Year 17, Percent of Potential Implemented	43%	43%	43%	43%	43%	43%	
Year 18, Percent of Potential Implemented	45%	45%	45%	45%	45%	45%	
Year 19, Percent of Potential Implemented	48%	48%	48%	48%	48%	48%	
Year 20, Percent of Potential Implemented	50%	50%	50%	50%	50%	50%	
Planning Horizon, Percent of Potential Implemented	**50%**	**50%**	**50%**	**50%**	**50%**	**50%**	
Magnitude of Opportunity with Market Factors (MWh)	**217**	**347**	**3,734**	**9,321**	**781**	**1,062**	**15,461**
Anticipated Number of Projects	**13**	**20**	**217**	**546**	**46**	**63**	**905**

4.8 MAGNITUDE OF OPPORTUNITY OVER 20 YEARS

The exhibit below reduces the values in Exhibit 21 according to the implementation rates identified in Exhibits 22 to Exhibit 27 which recognizes that even given favorable economics for a variety of market reasons some projects will not be implemented.

Exhibit 28: Magnitude of Opportunity Considering Market Factors (MWh)

Measures	CA	ID	OR	UT	WA	WY	Total
ORC	1,421	1,016	86,213	61,164	6,675	19,746	**176,235**
High Temperature Waste Heat	0	0	6,067	11,583	0	16,000	**33,650**
Micro Hydro	0	0	0	5,641	0	5,216	**10,857**
Steam System Optimization	0	0	8,000	0	8,398	0	**16,398**
Conveyor Regeneration	0	0	0	6,662	0	3,698	**10,360**
Elevator Regeneration	217	347	3,734	9,321	781	1,062	**15,461**
Total	**1,638**	**1,363**	**104,014**	**94,371**	**15,853**	**45,721**	**262,961**

5 Total Resource and Utility Costs

The Exhibit below indicates the key economic criteria that were used in determining the total resource and utility costs.

Exhibit 29: Key Criteria for Total Resource Cost and Utility Cost Test

State	Discount Rate	Administration Costs as Percent of Total Installed Costs	Industrial Line Losses	Commercial Line Losses
California	6.6%	20%	9.9%	11.1%
Idaho	6.6%	20%	7.5%	10.7%
Oregon	6.6%	20%	7.1%	9.6%
Utah	6.6%	20%	5.8%	8.7%
Washington	6.6%	20%	8.2%	9.5%
Wyoming	6.6%	20%	5.6%	8.9%

5.1 TOTAL RESOURCE COST

The exhibit below provides information on the economics for the different WHP and Regenerative technologies. It is important to note the application of each of these technologies is very site specific so that the costs are provided should only be considered as indicative of typical type of projects.

Exhibit 30: Measure Details (TRC)

State	Measure Name	Savings per Unit (kWh)	Measure Life	Incremental Cost per Unit	Magnitude of Opportunity (MWh)	Levelized TRC ($ per MWh)	Magnitude of Opportunity with Market Factors (MWh)	No. of Projects
California	ORC	8,880,717	20	$4,000,000	1,421	$64.94	1,421	1
California	Elevator Regeneration	4,389	20	$6,000	434	$142.42	217	13
Idaho	ORC	8,650,693	20	$4,000,000	1,016	$66.67	1,016	1
Idaho	Elevator Regeneration	4,370	20	$6,000	695	$143.05	347	20
Oregon	ORC	8,612,792	20	$4,000,000	153,953	$66.96	86,213	28
Oregon	High Temperature Waste Heat	8,612,792	20	$3,000,000	6,067	$53.71	6,067	2
Oregon	Steam System Optimization	8,612,792	20	$1,000,000	8,000	$12.10	8,000	1
Oregon	Elevator Regeneration	4,272	20	$6,000	7,468	$144.92	3,734	217
Utah	ORC	8,496,654	20	$4,000,000	109,222	$67.88	61,164	16
Utah	High Temperature Waste Heat	8,496,654	20	$3,000,000	19,305	$54.44	11,583	2
Utah	Micro Hydro	318,625	20	$250,000	8,059	$81.75	5,641	5
Utah	Steam System Optimization	8,496,654	20	$1,000,000	0	$12.26	0	0
Utah	Elevator Regeneration	4,272	20	$6,000	18,641	$146.32	9,321	546
Utah	Conveyors Regeneration	50,014	20	$70,000	6,662	$145.82	6,662	7

Washington	ORC	8,710,919	20	$4,000,000	11,125	$66.21	6,675	2
Washington	Steam System Optimization	8,710,919	20	$1,000,000	8,398	$11.96	8,398	2
Washington	Elevator Regeneration	4,311	20	$6,000	1,561	$145.01	781	46
Wyoming	ORC	8,475,541	20	$4,000,000	32,910	$68.05	19,746	5
Wyoming	High Temperature Waste Heat	8,475,541	20	$3,000,000	16,000	$54.58	16,000	2
Wyoming	Micro Hydro	317,833	20	$250,000	7,452	$81.95	5,216	4
Wyoming	Elevator Regeneration	4,281	20	$6,000	2,123	$146.02	1,062	63
Wyoming	Conveyors Regeneration	49,889	20	$70,000	3,698	$146.18	3,698	4
TOTAL					**424,207**		**262,961**	**987**

5.2 UTILITY COST TEST

In determining the Utility Costs, the following incentive conditions for each state were used.

Exhibit 31: Incentive Conditions

State	Incentive in $ per annual savings in MWh	Incentive Limit as % of Cost of Measure
California	$150/MWh	50%
Idaho	$150/MWh	50%
Oregon	$150/MWh	50%
Utah	$150/MWh	70%
Washington	$150/MWh	70%
Wyoming	$150/MWh	70%

The exhibit below indicates the calculated resource cost for each measure per state.

Exhibit 32: Measure Details (UCT)

State	Measure Name	Savings per Unit (kWh)	Measure Life	Incremental Cost per Unit	Magnitude of Opportunity (MWh)	Levelized UCT ($ per MWh)	Magnitude of Opportunity with Market Factors (MWh)	No. of Projects
California	ORC	8,880,717	20	$4,000,000	1,421	$26.46	1,421	1
California	Elevator Regeneration	4,389	20	$6,000	434	$51.76	217	13
Idaho	ORC	8,650,693	20	$4,000,000	1,016	$22.79	1,016	1
Idaho	Elevator Regeneration	4,370	20	$6,000	695	$50.65	347	20
Oregon	ORC	8,612,792	20	$4,000,000	153,953	$22.18	86,213	28
Oregon	High Temperature Waste Heat	8,612,792	20	$3,000,000	6,067	$19.97	6,067	2
Oregon	Steam System Optimization	8,612,792	20	$1,000,000	8,000	$7.37	8,000	1

Oregon	Elevator Regeneration	4,272	20	$6,000	7,468	$47.39	3,734	217
Utah	ORC	8,496,654	20	$4,000,000	109,222	$20.31	61,164	16
Utah	High Temperature Waste Heat	8,496,654	20	$3,000,000	19,305	$18.28	11,583	2
Utah	Micro Hydro	318,625	20	$250,000	8,059	$25.71	5,641	5
Utah	Steam System Optimization	8,496,654	20	$1,000,000	0	$8.73	0	0
Utah	Elevator Regeneration	4,272	20	$6,000	18,641	$44.95	9,321	546
Utah	Conveyors Regeneration	50,014	20	$70,000	6,662	$36.30	6,662	7
Washington	ORC	8,710,919	20	$4,000,000	11,125	$23.76	6,675	2
Washington	Steam System Optimization	8,710,919	20	$1,000,000	8,398	$10.02	8,398	2
Washington	Elevator Regeneration	4,311	20	$6,000	1,561	$47.23	781	46
Wyoming	ORC	8,475,541	20	$4,000,000	32,910	$19.97	19,746	5
Wyoming	High Temperature Waste Heat	8,475,541	20	$3,000,000	16,000	$17.97	16,000	2
Wyoming	Micro Hydro	317,833	20	$250,000	7,452	$25.28	5,216	4
Wyoming	Elevator Regeneration	4,281	20	$6,000	2,123	$45.47	1,062	63
Wyoming	Conveyors Regeneration	49,889	20	$70,000	3,698	$35.69	3,698	4
TOTAL					**424,207**		**262,961**	**987**

6 Waste Heat to Power (WHP) Best Practice Review

6.1 RPS AND EERS SUMMARY

In reviewing utility best practice with respect to WHP it is important to consider the government and regulatory policy background with respect to renewable power and energy efficiency. Utilities of course are affected by these policies and utility best practice should be assessed in terms of how a particular utility implements the policy in its jurisdiction. In this context the following two sub-sections outline Renewable and Energy Efficiency standards across the U.S.

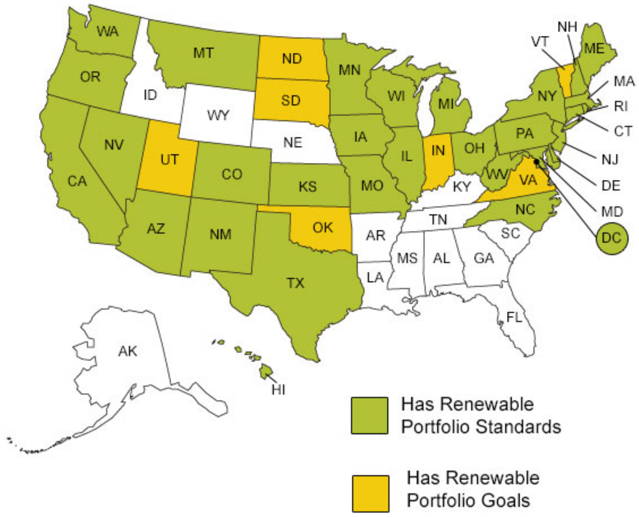
6.1.1 RENEWABLE PORTFOLIO STANDARDS (RPS)

The renewable portfolio standards (RPS) refer to government policies which increase generation of electricity from renewable resources. While there is no national level RPS, state specific level policies have been established. In general these policies outline a minimum share of electricity supply which must be generated by renewable resources such as wind, solar, geothermal, biomass and some types of hydroelectricity. Additionally resources such as landfill gas, municipal solid waste, marine energy, energy efficiency measures and advanced fossil-fueled technologies (including combined heat and power and waste heat to power). As these are state specific programs, they vary widely in their structure, enforcement, size and application. Often policies are created to reflect the state's particular resource base or local preferences.

Where the RPS require that each electric utility meet a specified renewable generation capacity goal, many state policies allow for renewable electricity credits (RECs). This is a trading system put in place for utilities that are exceeding their renewable generation goal, where credits may be sold to other utilities that are falling short of their targets. The impact of RPS with respect to increasing levels of renewable energy generation is not clear. States with RPS policies have seen an increase in renewable energy generation, but some states without RPS policies have also seen this increase as well. This is likely due to the combination of federal incentives, other state programs, and market conditions[18].

[18] *US Energy Information Administration "What are renewable portfolio standards (RPS) and how do they affect renewable electricity generation?" Last updated January 25, 2013; Accessed June 3, 2014. http://www.eia.gov/energy_in_brief/article/renewable_portfolio_standards.cfm*

Exhibit 33: Renewable Portfolios Standards or Goals

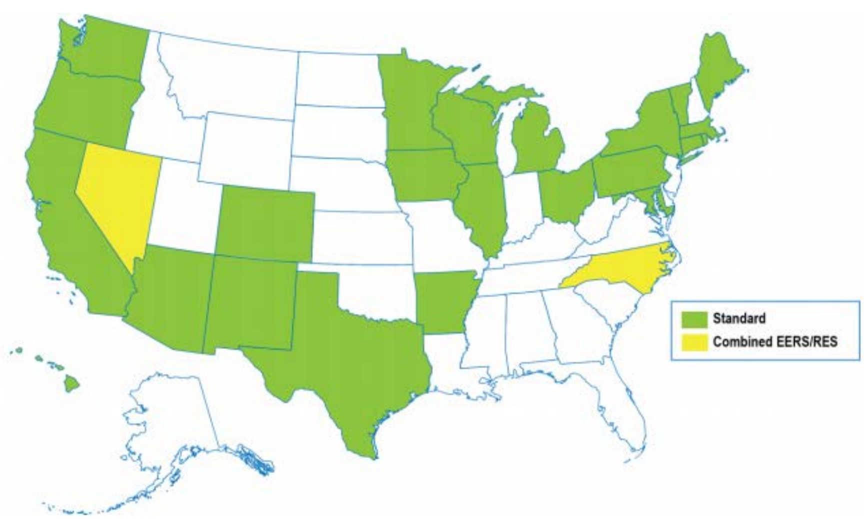


Source: Interstate Renewable Energy Council, Database of State Incentives for Renewables & Efficiency (accessed January 2013).

6.1.2 ENERGY EFFICIENCY RESOURCE STANDARD (EERS)

The energy efficiency resource standards (EERS) are state specific long-term targets for energy savings achieved through energy efficiency programs through utilities and non-utility program administrators. These standards are adopted either through state legislation or regulation where a utility (electric or natural gas) is required to achieve a percentage of reduction in energy sales from energy efficiency measures. Currently no national level EERS is in place. It is believed that the EERS is a critical policy that lays the foundation for sustained investment in energy efficiency[19].

Exhibit 34: EERS Policy approaches by state (as of April 2014)



[19] *American Council for an Energy-Efficient Economy, "Energy Efficiency Resource Standard (EERS)", Accessed June 3, 2014.* http://www.aceee.org/topics/eers

6.2 GENERAL FINDINGS

The following are the principle findings on the treatment of WHP within DSM programs as a result of reviewing regulatory and utility policy across the U.S. and Canada.

1. Policies which promote customer generation usually originate with government or regulatory policies and utilities develop programs as a result of such policies.
2. Often Combined Heat and Power (CHP) and Waste Heat Recovery (WHR) are included under the same policy. The 2012 White House order (Accelerating Interest in Industrial Energy Efficiency) is an example of where CHP and WHR were included under the same policy.
3. Waste heat recovery is generally considered a key component of combined heat and power (CHP). California's Self Generation Incentive Program (SGIP) is an example of this thinking. In the Impact evaluation for this program recovered waste heat is referred to as the amount of waste heat delivered at the back end of a CHP prime mover and is recoverable for possible end use.[20]
4. Due to 2) and 3) to determine how WHP is treated, general CHP and self-generation policies needed to be reviewed to understand how WHP was handled by different utilities. This review was conducted and provided as Appendix 1 (Self-Generation Program Research).
5. Most of the CHP programs reviewed did not specifically address WHP as defined by this study but did not exclude these types of projects.
6. Programs in New Jersey, California, Ontario and British Columbia do specifically address WHP.
7. CHP projects, including WHP, are usually included as part of jurisdiction Energy Efficiency and Renewable Portfolio standards.
8. At this time the actual number of WHP projects that have been given DSM type incentives in any jurisdiction in North America is small.

6.3 POLICY CONCLUSIONS WITH RESPECT TO WHP

In the Energy Efficiency and Renewable standards for different jurisdictions, WHP is treated as a minor subset of CHP; in many cases it is not even specifically addressed. In turn policy is in a state of flux as to whether CHP and WHP should be treated as a supply side (generation) or demand side measure. There is general agreement that CHP should be pursued as an overall efficiency measure. However, because CHP projects generate electricity, they are different from DSM projects which reduce consumption by reducing the consumption at a particular end-use. Accordingly, because of this differentiation CHP is usually not included within a utility's DSM portfolio of programs but will be covered by other specific programs sponsored by a regulatory body, the California Public Utility Commission's SGIP program is a good example.

WHP projects which only involve self-generation (no power exported to the grid) are quite different from CHP projects in that they do not involve the use of additional fossil fuel. However, because the number of these types of projects that have been proposed has been relatively small, utilities and regulatory bodies have not taken this into consideration. The technology change which could prompt a lot more serious consideration of WHP, specifically, is the Organic Rankine Cycle technology. The reason is because this technology enables relatively low temperature

[20] Glossary Item for Recoverable Waste Heat in 2012 AGIP Impact Evaluation and Program Outlook report.

waste heat to be recovered. There is a large amount of waste heat presently available which is not practical to recover as a heat source because an end-use that could use the low-temperature waste heat is not close enough to make recovery viable. However, ORC technology can be used in many of these applications to generate electricity which can usually be put back into a customer's power distribution system. The following quote from DOE's Heat Recovery report[21] supports this analysis "Although the economics of ORC heat recovery needs to be carefully analyzed for any given application, it will be a particularly useful option in industries that have no in house use for additional process heat or no neighboring plants that could make economic use of the heat."

6.4 PROGRAMS THAT SPECIFICALLY ADDRESS WHP

6.4.1 CALIFORNIA – SELF GENERATION INCENTIVE PROGRAM

Under this program Pacific Gas and Electric, Southern California Edison and the Southern California Gas Company do provide DSM type incentives. The incentive level for WHP projects is $1.19 per Watt of capacity but declines for projects greater than 1 MW up to 3 MW per the following table:

Exhibit 35: California - Self Generation Incentive Program Level

Capacity	Base Incentive Level - $1.13 per W
1 – 2 MW	50% of base level
2 MW – 3 MW	25% of base level
Incentives only provided for the first 3 MW of capacity	

It is interesting to note that the incentive levels for SGIP recognize the fact that WHP projects do not involve an increase in fuel use and therefore receive more than double the incentive of conventional CHP type projects.

The key eligibility criteria for these projects are:

- In September 2011, the eligibility of the program was changed to include WHP projects
- Only commercially available and factory new equipment
- Rebuilt or refurbished equipment is not eligible
- There are no minimum size criteria for SGIP eligible technologies.
- There is no maximum system size limit, although the incentive payment is capped at 3 MW.
- Eligible generation equipment must be certified to operate in parallel with the electric system grid (not back-up generation.
- On-site electric load has to be met prior to any export of power to the grid.
- Power exported to the grid cannot exceed 25% of on-site consumption on an annual basis.

[21] *Waste Heat Recovery: Technology and Opportunities in U.S. Industry*

The ICF CHP database[22] notes that there are four waste heat to power projects in California, totaling 19 MW of generation capacity; however these projects were not identified in the SGIP Impact and evaluation report[23]. In fact in this report there is no operational waste heat to power projects identified. In the SGIP budget report[24] 3 Waste Heat to Power projects were identified as applications in the 2012 budget with a total capacity of 687 kW, however it should be noted that WHP projects only became eligible in September 2011.

6.4.2 ONTARIO POWER AUTHORITY – INDUSTRIAL ACCELERATOR PROGRAM

The Industrial Accelerator Program provides incentives for energy efficiency measures to be installed, including generation projects. The energy savings from the generation projects are included as part of Ontario Power Authority's DSM portfolio.

Eligible generation projects with the OPA program are required to involve installation of the measure, provide at least 350 MWh of Annualized Electricity Savings and have a Minimum Expected Life of 10 complete years (micro projects must provide 100 MWh with a minimum expected life of 5 years). Additionally these projects must not exceed 20 MW of nameplate capacity, involve fuels disallowed by the OPA (i.e. coal and diesel), and or have received funding under another OPA contract or funding mechanism. It should be noted that natural gas as a fuel source is allowable.

Project incentives are calculated to be $230/MWh of annualized electricity savings per project up to a maximum of 70% of the total project cost.

Self-generation projects are not allowed to export any power to the grid and the electrical connection between the host facility must be such that power will not flow from the facility to the utility grid under any conditions.

The table below is a sample of the generation projects that are being evaluated or have been awarded incentives by the program. The shaded items in the table are projects that are particularly of interest for this study.

Exhibit 36: Sample of projects being evaluated or awarded incentives by OPA's Industrial Accelerator Program

Industry	Technology	Size (MW)
Steel Manufacturing	By-product gas TG	5.0
Plastics Manufacturing	Gas Fired Turbine-Generator	5.5
Pulp & Paper	**Biomass steam TG**	**8.9**
Food Processing	Gas Fired Turbine-Generator	8.8
Food/Confectionary	Gas Fired Turbine-Generator	5.0
Cement Manufacturing	**Waste Heat ORC**	**5.0**
Water/Wastewater	**Micro-hydro TG**	**0.2**
Ethanol Production	**Steam Turbine replacing Pressure Reducing Value**	**1.0**
Commercial building/labs	Gas-Fired Internal Combustion Engine	0.5
Hospital	Gas-Fired Internal Combustion Engine	0.6
Hospital	Gas-Fired Internal Combustion Engine	1.6

[22] *http://www.eea-inc.com/chpdata*

[23] *"2012 SGIP Impact Evaluation and Program Outlook", Prepared by Itron, February 2014.*

[24] *"Self-Generation Incentive Program Budget Report, Pursuant to D. 11-12-030, OP 2*

Ethanol Production	Gas Fired Turbine-Generator	5.7
Auto Parts Manufacturing	Gas-Fired Internal Combustion Engine	10.0
Multi-Residential	Gas-Fired Internal Combustion Engine	0.02
Polymer Manufacturing	Gas Fired Turbine-Generator	7.9
Auto Manufacturing	Gas Fired Turbine-Generator	9.2
Hospital	Gas-Fired Internal Combustion Engine	1.5

6.4.3 BRITISH COLUMBIA'S INTEGRATED CUSTOM SOLUTIONS PROGRAM

The integrated customer solutions (ICS) load displacement program at BC Hydro was developed for customers who want to generate electricity for self-supply or sale to BC Hydro. If electricity sales to BC Hydro are part of the proposed project the ICS program may refer the project to BC Hydro's energy procurement (EP) program, if available and applicable, or determine a project solution jointly between ICS and EP.

Within the program, eligible projects are required to have a minimum nameplate capacity of 50 kW. Projects are typically expected to have a minimum 10 year life and must not export power to the BC Hydro grid. Natural gas fired projects are not eligible.

Meeting the eligibility requirements does not necessarily result in receiving a financial incentive. Factors which influence incentive funding include BC Hydro's need for load displacement and new electricity supply, the cost-effectiveness of the customer's project relative to other resources, and available budgets for programs or offers. The detailed process for the project is provided in appendix 3. The energy savings from projects are included within BC Hydro's DSM program.

This program was launched in May 2013. One 2 MW ORC project was implemented prior to this date on a pilot project basis and one 2 MW ORC project was approved after the program launch, this project still has not been built. It is interesting to note that in late 2013, BC Hydro indicated that they were going to delay the awarding of incentives for future projects due to the utility being in a large surplus condition. However, they will still provide incentives to study future projects so they are in a pipeline so to speak. The implemented ORC project and the one approved are in the wood products sub-sector and there is a strong indication that there will be applications for more projects in this sub-sector if BC Hydro lifts the present moratorium on incentives.

7 Regenerative Technology Best Practice Review

In a review of North American regulatory and utility energy efficiency and self-generation policy, no reference could be found where RT projects were treated as either a separate energy efficiency program or under a separate self-generation program. Cases were found where RT was treated as an energy efficiency project under custom type DSM programs. An example of an elevator project that was provided a DSM type incentive is described below.

"Golden Properties Ltd. is a privately-owned real estate and investment company that is taking the extra step to make their office buildings more energy efficient and sustainable. They recently signed off on an elevator modernization project in their 27 floor office tower located at 1177 West Hastings Street, Vancouver. Through BC Hydro's Custom Power Smart Partners Program, they were able to obtain an incentive of 40% of the incremental cost increase to upgrade from an industry-standard motor drive to an ultra-efficient motor drive with energy regeneration capabilities by showing that the efficiency upgrade would result in annual additional annual energy savings of 50,000 kWh. This was BC Hydro's first incentive awarded for an elevator upgrade, and shows the opportunity for property owners and managers to work with Hydro to find innovative ways to reduce electricity consumption."[25]

Information on a specific program to promote Energy Efficient Elevator and Escalators[26] in Europe was found, called E4. The objective of this program is to promote the energy performance of elevator and escalators. It is supported by the countries of Germany, Italy, Portugal and Poland, as well as the European Lift Association (ELA). This program includes the promotion of RT but also high efficient motors and drives, better control software, optimization of counterweights, direct drives versus rope traction Elevator, cabin lighting, and other measures.

7.1 OBSERVATIONS

Regenerative technologies that are the focus of this study are ones that improve the efficiency of a particular end-use such as elevators, conveyors or large inertia rotating process equipment. It is not practical in these cases to separate out the regenerative process from the end-use process itself. In discussing the technology with elevator manufacturers, they indicated that their most up to date elevator systems do employ regenerative technology but they emphasized that it is important to consider the complete energy package of the elevator system. The same type of thinking is evident in the European program to promote efficient elevators and escalators.

In our research on belt conveyors, regenerative technology was identified as an energy efficiency opportunity in some cases but a number of other energy efficiency items were mentioned involving items such as system layout, belt material, and lubrication. In order to obtain optimum conveyor efficiency the whole system needs to be considered.

7.2 CONCLUSIONS

It is not practical to consider regenerative technology as an isolated energy generation technology because it is completely integrated with an end-use load. In promoting it as an energy efficiency measure it should be treated on a site by site basis so its impact on the efficiency of an end-use system can be properly measured.

[25] [25] *Building Owners and Managers Association (BOMA). (2011) "BOMA Energy eXpress".*

[26] *Energy efficient elevators and escalators, Patrao, Fong, Rivet, Almelda,2009*

8 Recommendations

8.1 KEY OBSERVATIONS AND FINDINGS

- There were no examples of utilities that had programs specifically designed for regenerative technologies either in terms of generation or DSM.
- Most utilities considered WHP projects as a subset of CHP projects.
- There were only a few utilities that specifically addressed WHP projects in terms of incentive calculations and guidelines for evaluation.
- In general, the numbers of WHP projects are small relative to their potential, indicating that the barriers to implementation are significant.
- Regenerative technology projects are generally small in size and very strongly integrated with an end-use. The regenerative technology is usually only part of an overall efficiency improvement of the system involved (i.e. efficient elevators involve regenerative technology but a number of other measures as well).
- High temperature waste heat and steam optimization projects can be relatively large in size and are only applicable to large customers.
- ORC projects involve a new technology to North America but one that has been used extensively in Europe and has the potential of significantly increasing the opportunity to use low temperature waste heat.

8.2 RECOMMENDATIONS

1. Regenerative technology projects should be treated as DSM projects and evaluated by means of PacifiCorp's existing custom DSM programs.
2. WHP projects within certain size limits, depending on the state, should be treated as DSM programs and evaluated by means of PacifiCorp's existing custom programs.

8.2.1 RECOMMENDATION 1 – REGENERATIVE TECHNOLOGIES

Regenerative technology projects should be treated under PacifiCorp's custom type DSM programs such as the FinAnswer program. Under this type of program Pacific Power or Rocky Mountain power sponsor an initial study to analyze an opportunity and if a potential project is economical and will save energy an incentive agreement is completed. For Regenerative projects, one of the key considerations is measurement and verification because power consumed by an end-use has to be measured over a specific time period while over the same time period the power regenerated and injected into the customer's distribution system has to be measured.

The approach recommended is to inform key vendors such as elevator and material transport equipment suppliers that under certain conditions, utility incentives would be available to customers for the implementation of regenerative packages. Product suppliers such as Otis, ThyssenKrupp, Hitachi and ABB have regenerative packages that can be retrofitted to elevators and conveyors that they are already marketing as an energy efficiency measure. Indicate to these vendors that in each case a feasibility study would need to be completed prior to an incentive being awarded. PacifiCorp should develop the guidelines for conducting feasibility studies for regenerative systems in elevators and conveyors.

After some feasibility studies have been completed, it may make sense for a semi-prescriptive incentive to be put in place such as is the case with FinAnswer Express. For example with elevator regenerative packages it may be appropriate to determine the very specific site information and the spot measurements that would be required to pre-qualify and post verify the savings on a particular project.

8.2.2 RECOMMENDATION 2 – WHP PROJECTS

WHP projects within certain size capacity limits should also be treated under a DSM custom type program. It is doubtful for these types of projects that a semi-prescriptive type process could be developed because each project will be very site specific and feasibility studies will be required. PacifiCorp should develop the guidelines for these feasibility type studies.

There are ORC vendors such as Turboden, Ormat and ABB that would be interested in incentives being available for the installation of their type of equipment. It would be useful to also inform any customer's with large process heating loads that WHP projects would be eligible for incentives under a custom program.

These types of projects would most likely require interconnection agreements with Pacific Power or Rock Mountain Power because they would involve generators that are operating in parallel with the utility grid and they would need to be interconnected according to specific utility specifications.

With respect to appropriate size limits, it is useful for the treatment of WHP projects to be consistent with Qualifying Facility policy in each state. Based on this consideration, the suggested size limits are the ones listed in Exhibit 13 in Section 4.2.

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10 Definition of Terms

Terms	**Definition**
aMW	Average Megawatt
Annual Load Factor	The ratio of the average load to peak load during a year.
Annual Peak Demand	The maximum load during a year
Base Load	A base load is the electrical power requirement for the facility that is required on an almost continuous basis or at least 8,000 hours per year.
Cogeneration	The production of electrical energy and another form of useful energy (such as heat or steam) through the sequential use of energy.
Conveyors Regeneration	Conveyor Regeneration or Regenerative Conveyors are conveyors for which the heads are at a substantially lower altitude than the tails (downhill conveying), generating power.
Elevator Regeneration	Elevator Regeneration or Regenerative Elevators are elevators that capture mechanical energy from braking and convert that energy into electrical power.
High Temperature Waste Heat	An energy recovery heat exchanger that recovers heat from hot streams with potential high energy content, such as hot flue gases from a diesel generator or steam from cooling towers
MECS	Manufacturing Energy Consumption Survey, a survey conducted by U.S. Department of Energy, Energy Information Administration, on how different types of manufacturers use their energy.
Micro Hydro	Micro hydro is a type of hydroelectric power that typically produces up to 100 kW of electricity using the natural flow of water.
NAICS Code	The North American Industry Classification System or NAICS is used by business and government to classify business establishments according to type of economic activity (process of production) in Canada, Mexico, and the United States of America.
ORC	The Organic Rankine cycle (ORC) is named for its use of an organic, high molecular mass fluid with a liquid-vapor phase change, or boiling point, occurring at a lower temperature than the water-steam phase change. The fluid allows Rankine cycle heat recovery from lower temperature sources such as biomass combustion, industrial waste heat, geothermal heat, solar ponds etc. The low-temperature heat is converted into useful work that can itself be converted into electricity.
Planning Horizon	Refers to a specific period of time. For this study the time assumed was 20 years and was assumed to occur from 2014 to 2033.

SIC Code	The Standard Industrial Classification (SIC) is a system for classifying industries by a four-digit code. Established in the United States in 1937, it is used by government agencies to classify industry areas.
Steam System Optimization	Steam System Optimization is to optimize the plant's steam system to cut steam and condensate loss, lower CO2 emissions through reduction of generated steam, optimize all steam-using applications, and ultimately enhance the energy balance of the plant.
Waste Heat Recovery	The use of heat that is produced in a thermodynamic cycle, as in a furnace, combustion engine, etc, in another process, such as heating feedwater or air
Waste Heat to Power	Waste heat to power (WHP) is the process of capturing heat discarded by an existing industrial process and using that heat to generate power

Appendix 1 – Self-Generation Program Research

Introduction

This research provides:

1. An overview on US context and trends for integration of Combined Heat and Power (CHP) and customer self-generation in general into DSM programs in the US
2. Answers to three key questions for the ten US states with the most advanced customer generation policies (MA, CT, OR, WA, CA, OH, NY, NJ, AZ, WI, MD). The key questions answered are:
    a. Is CHP treated as load generation or as efficiency?
    b. Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?
    c. What criteria must CHP meet in order to be incentivized as energy efficiency?
3. To observe how the policy transfers to utility program implementation, we further provide examples of specific utility programs in each of these states
4. Links to additional resources on customer generation policies and industry trends are provided.

US Context and Trends

The US electric industry is at an early stage of recognizing that the business models of the past will not work in the future as annual demand growth rates approach zero. An April 2014 report from ACEEE that details possible CHP policies for states finds that "[g]iven the concurrent generation of power and useful thermal energy, the overall combined electric and thermal efficiency of customer generation units can reach or exceed 80%, whereas the current electric generation fleet is only about 35% efficient...CHP currently represents about 8% of installed U.S. electric generating capacity. The growth trends in both CHP and WHP are described a report by Joel Bluestein[27].

Where states list these technologies within their EERS or renewables portfolio, they are frequently considered lower tier technologies (see Connecticut, Washington, Maryland). To treat these systems on par with other energy efficiency technologies, states must develop a specific methodology for counting energy savings attributed to programs running this type of technology (see Massachusetts). From a policy perspective, one could argue that if such systems are allowed to become a fully eligible resource, energy savings targets could be increased to reflect this potential.

The benefits of cogeneration and waste heat recovery systems are being recognized more and more by federal and state policy makers. A 2012 White House Executive Order (Accelerating Interest in Industrial Energy Efficiency), establishes a national goal of deploying 40 GW of new CHP and waste heat recovery (WHR) by the end of 2020, a 50 percent increase from 2010. This report shows that it is easy to find evidence of increasing state interest as well, with a good amount of states that are not included with this research offering incentives or financing programs for CHP as eligible "custom" measures. With pressure to lower emissions from the EPA's Clean Air Act, this type of technology could serve as a promising alternative. CHP technologies also hold the promise of increased microgrid resiliency, as shown during 2012's Hurricane Sandy. A report published by the DOE, HUD, and EPA states that, during Sandy, CHP "enabled a number of critical infrastructure and other facilities to continue their operations when

[27] "CHP and WHP Growth Trends and Opportunity Identification" Joel Bluestein, ICF International, October 8, 2013

the electric grid went down." In fact, the authors asserted that CHP's "value as an alternative source of power and thermal energy (heating and cooling) during emergencies" has been demonstrated repeatedly.

The future for CHP technologies looks bright, and utilities have reason for investigating how to include them in their business model. Low and stable gas prices in North America will likely have a positive impact on future CHP market development, and as the energy industry evolves, CHP and self-generating programs are becoming more and more widespread. While self-generation can be a hard sell to utilities, these commercially available, efficient, cost effective technologies have demonstrated economic and environmental benefits including increased reliability and emissions reductions.

Findings from Top Ten States Analysis

Massachusetts

- Is CHP treated as load generation or as efficiency?

Both. In MA, the 2008 Green Communities Act requires that electric and gas utilities procure all cost-effective energy efficiency before more expense supply resources, requiring a three year planning cycle. The law states that "Energy efficiency activities eligible for funding under this section shall include combined heat and power and geothermal heating and cooling projects…The programs shall be administered by the gas distribution companies. In authorizing such programs, the department shall ensure that they are delivered in a cost-effective manner capturing all available efficiency opportunities, minimizing administrative costs to the fullest extent practicable and utilizing competitive procurement processes to the fullest extent practicable." The Act also stipulates the establishment of an alternative energy portfolio standard – CHP is included as an alternative energy generating source.

Massachusetts has a variety of policies to encourage CHP deployment, including incentive and financing programs, inclusion of CHP as an eligible resource within the state's EERS, and an interconnection standard. The Act also established the state's Alternative Portfolio Standard (APS), which is the first known national portfolio standard to identify CHP as a "key technology of interest. The APS sets targets for sales of "alternative" energy to retail customers by electricity suppliers. For the purposes of the APS, CHP is specifically included as an "alternative generation unit." Mass Save also runs a three tiered CHP Program and systems are offered as custom measures for several utilities there.

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Yes, natural gas is considered an alternative energy supply when used in gasification or CHP systems.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

CHP is also a part of one of the commonwealth's renewable/alternative energy and energy efficiency goals: "[M]eet at least 25 per cent of the commonwealth's electric load, including both capacity and energy, by the year 2020 with demand side resources including: energy efficiency, load management, demand response and generation that is located behind a customer's meter including a combined heat and power system with an annual efficiency of 60 per cent or greater with the goal of 80 per cent annual efficiency for combined heat and power systems by 2020…"

- Utility Level

There is not currently an IRP requirement in place in Massachusetts, but the Green Communities Act requires electric and natural gas utilities to file EE plans every three years. In November 2012, the following utilities file a Joint Statewide Electric and Gas Energy Efficiency Plan: N Star, National Grid, Columbia Gas of Massachusetts, Western Massachusetts Electric, Cape Light Compact, Berkshire Gas, Unitil, New England Gas Company, and Blackstone Gas Company. The CHP programs are detailed within.

Connecticut

- Is CHP treated as load generation or as efficiency?

Both. The state's renewable portfolio standard, established in 1998 and revised thereafter, requires that electricity providers and wholesale suppliers obtain 27% of their retail load from renewable energy and energy efficiency by 2020. Energy efficiency measures and combined heat and power systems installed after January 1, 2006 are considered "Class III sources". Additionally, HB 6360 passed on June 5, 2013. Among other things, this bill makes CHP more competitive within the portfolio standard by eliminating utilities' conservation savings from the tier of resource applicable to CHP. The 2007 Electricity and Energy Efficiency Act further defines Class III renewable energy sources, including CHP systems. This 2007 act also stipulates that utilities, the Connecticut Energy Advisory Board, and the Department of Public Utility Control should consider CHP systems and facilities when creating procurement plans, conservation plans, etc. In this document, CHP systems fall under EE generation sources, as is evidenced by the establishment of a municipal renewable energy and efficient energy generation grant program – CHP operations with greater than 65% efficiency are folded into the EE generation sources category of grants rather than the renewable energy sources category.

In 2013, the state passed Public Act 13-298, An Act Concerning Implementation of Connecticut’s Comprehensive Energy Strategy. Like the 2007 Electricity and EE Act, this Act stipulates that this plan should include a detailed description of how CHP will be implemented. This act also categorizes CHP as an EE generation source rather than a renewable energy source, and states that “[t]he Commissioner of Energy and Environmental Protection shall establish a pilot program to promote large combined heat and power systems by mitigating the economic disincentives for such systems created by the existing demand charge tariffs of the electric distribution companies.”

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Yes.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

Technologies eligible to meet the standard are grouped into tiers or classes, with each class assigned a specified percentage of load it must meet. As part of Connecticut’s 1998 Renewable Portfolio Standard, CHP is classified as a qualifying renewable-energy resource provided it has a minimum operating efficiency of at least 50%. Connecticut established a tiered structure for its RPS. CHP is part of “Class III” resources, which are supposed to comprise 4% of the state’s total output by 2010. The Class III measures mentioned above were required to meet 1% of retail load in 2007, 2% in 2008, 3% in 2009 and 4% in 2010 and thereafter.

- Utility Level

Similar to MA, Connecticut does not have an IRP requirement in place. The Energy Efficiency Board (EEB) advises and assists the electric and natural gas utilities in the development of energy efficiency programs included in their Conservation and Load Management Plan, which is subject to review and approval by the Public Utilities Regulatory Authority (PURA) and the Department of Energy and Environmental Protection (DEEP). All programs included in the plans are required to pass a benefit-cost test. The DEEP and PURA oversee the fully integrated electric distribution utility and natural gas utility programs. The EEB, appointed by the PURA, administers the Connecticut Energy Efficiency Fund (CEEF) through Energize Connecticut. The utilities administer the energy efficiency programs. The utilities and contractors hired by the utilities implement the programs. Energize Connecticut, on behalf of The Connecticut Light & Power Co., United Illuminating Co., Yankee Gas, Connecticut Natural Gas Corp., and Southern Connecticut Gas Co., publishes an Electric & Natural Gas Conservation & Load Management plan every three years. Annual updates to this are released in February of each year. This report contains detailed historical, lifetime, and annual data for each utility listed above, with CHP technologies falling under the “Energy Conscious Blueprint” C&I Lost Opportunity program. The total CL&P budget for the 2014 Blueprint program is $9,913,103, with $229,000 spent on marketing, $7,097,000 spent on incentives, and a 2014 savings goal of 4,489 kW/22,982 kWh.

As a result of Public Act 13-298, Energize Connecticut offers a CHP Pilot Program. The program seeks proposals for grants, loans, loan enhancements or power purchase incentives to help finance the cost of combined heat and power equipment for energy-generating projects. Projects must be in the development phase and cannot already be under construction. The Connecticut Department of Energy and Environment (DEEP) offers monetary grants and other financial incentives to help businesses develop and install CHP systems to reduce operating expenses. Resources are available to support projects from scratch and those that are further along in development.

Oregon

- Is CHP treated as load generation or as efficiency?

Load generation. Oregon's Ten-Year Energy Action Plan (released 12/2012) has three primary goals, one of which, "Enhance clean energy infrastructure development by removing finance and regulatory Barriers," covers CHP's contribution: "Distributed generation and CHP has (sic) huge potential to help the state meet its energy goals...The benefits of distributed generation are many, including increased efficiency, typically reduced environmental impact, reduced grid cost, increased reliability and quality, and business certainty." Additionally, the Energy Trust of Oregon’s 2009 Strategic Plan lays out regulations for renewable energy generation, but does not specifically name CHP as a source to be used. Applicable only to systems powered by renewable fuels such as biomass and biogas, Oregon’s renewable portfolio standard requires that 25% of the electricity sold to retail customers is derived from renewable resources by 2025. RPS compliance must be demonstrated through the purchase of renewable energy credits through the Western Renewable Energy Generation Information System.

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Yes. Oregon has three categories of interconnection standards that apply to CHP, one for net-metered systems, one for non-net-metered small facilities, and one for non-net-metered large facilities. Both fossil-fueled and renewably-fueled CHP systems are eligible for standardized interconnection.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

As the RPS does not include specific CHP technologies, there are no prerequisites for CHP to meet in order to qualify as EE.

- Utility Level

Oregon utilities file biannual IRPs, with updates being published in March of the off years. PacifiCorp published an update to their 2013 IRP in March 2014. This update contains planned capacity data for CHP projects and progress on action items re: CHP from past IRPs, including an Executive Summary of an extensive CHP marketing analysis performed by the utility mandated by the original 2013 IRP. The IRP delineates only 1 MW of savings from CHP for every year from 2014-2023. In PG&E’s most recent IRP update, CHP systems are categorized as a distributed generation supply-side option.

The Oregon Department of Energy provides grants for feasibility studies for renewable energy, heat, and fuel projects under the Community Renewable Energy Feasibility Fund (CREFF). The ODOE’s Energy Incentives Program provides grants for a variety of types of energy efficiency projects. Grants are distributed through a competitive application process. About $8 million is available specifically for CHP projects.

Ohio

- Is CHP treated as load generation or as efficiency?

Efficiency. CHP is included as an eligible resource in the state's energy efficiency resource standard. In May 2008, Ohio enacted SB 221, establishing an Alternative Energy Resource Standard. The AERS requires a particular percentage of utilities’ electricity supply to come from “alternative energy resources,” a steadily increasing portion of which must be from designated renewable resources. As part of this restructuring effort, Ohio utilities are also required to meet cumulative energy savings and peak demand reduction goals. CHP systems installed after January 1, 1998 are eligible as “alternative energy resources” for the purposes of this AERS. In OH Revised Code 4928.66, it is stipulated that an EE program “may include a combined heat and power system placed into service or retrofitted on or after the effective date of the amendment of this section… or a waste energy recovery system placed into service or retrofitted on or after the same date…For a waste energy recovery or combined heat and power system, the savings shall be as estimated by the public utilities commission.” This position is echoed again in 2012’s SB 315.

In the staff-proposed draft rules for Case no. 13-651-EL-ORD, issued Jan. 29, 2014, CHP systems are defined as “"the coproduction of electricity and useful thermal energy from the same fuel source designed to achieve thermal-efficiency levels of at least sixty per cent, with at least twenty per cent of the system's total useful energy in the form of thermal energy.” Furthermore, the definition for energy efficiency and further comments on EE programs specifically name CHP systems as a qualifying energy source: “Such programs, at a minimum, shall achieve established statutory energy benchmarks for energy efficiency and peak demand reduction, and may include a combined heat and power system placed into service or retrofitted on or after September 10, 2012, or a waste energy recovery system placed into service or retrofitted on or after the same date…”

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Any conventional CHP (fossil fuel fired permitted) can qualify as energy efficiency if it meets the requirements.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

Under the EERS, a CHP system must achieve 60% thermal efficiency with 20% of energy generated as useful thermal energy. Under the state’s RPS, fossil fuel fired CHP does not qualify.

- Utility Level

Participating Ohio utilities are required to file an Alternative Energy Portfolio Status Report on April 15 of each year. AEP-Ohio, Dayton Power & Light, Duke Energy Ohio, and FirstEnergy all file electric security plans, updated every three years. However, since CHP technologies are not emphasized in AERS stipulations, there does not seem to be any data available on CHP systems in Ohio from the regulated utilities.

Currently, The PUCO is engaged in a pilot project with the U.S. Department of Energy to remove educational and regulatory barriers to CHP development in Ohio and across the nation.

California

- Is CHP treated as load generation or as efficiency?

Generation. There is currently no portfolio standard in place under which CHP is eligible, but California has CHP-friendly standby rates, streamlined interconnection standards for systems up to 10 MW, and emissions regulations that acknowledge the benefits of CHP systems by including a mechanism to credit useful thermal output. Its Self-Generation Incentive Program (SGIP, see below) provides rebates for electric utility customers who install clean distributed generation. In 2012, 12 new CHP installations were completed.

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Yes.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

PUC 216.6(a) requires recovered useful heat from CHP systems to exceed 5% of combined recovered heat plus the electrical energy output of the system. PUC 216.6(b) requires the sum of electricity generated and half of the recovered heat by CHP systems to exceed 42.5% of energy entering the system as fuel.

The state run Self-Generation Incentive Program provides incentives to customers who produce electricity from a variety of sources, including CHP. The program is administrated by San Diego Gas & Electric, Pacific Gas & Electric, Southern California Edison, and Southern California Gas. Today, the SGIP is recognized as one of the largest funded and longest running DG incentive programs in the country. Since the program's inception, CHP has been included as an eligible technology. There is no minimum or maximum eligible system size, although the incentive payment is capped at 3 MW. Further, the first MW in capacity will receive 100% of the calculated incentive, the second MW will receive 50% of the calculated incentive, and the third MW will receive 25% of the calculated amount. SGIP - with 544 completed projects for a total capacity of 252 megawatts - is one of the longest-running and most successful distributed generation incentive programs in the country.

- Utility Level

The utilities participating in SGIP put forward an annual Impact Evaluation and Program Outlook. The 2012 report was published in February 2014. Utilities also publish quarterly reports on SGIP and annual budget recommendations in addition to their impact evaluation reports.

Washington

- Is CHP treated as load generation or as efficiency?

Generation. The state has an interconnection standard for distributed generation, including CHP systems <20 MW in capacity, and an output-based emissions standard. Washington offers incentives for CHP projects, and CHP is included as an eligible resource in the state's EERS, although at a lower tier. Established by the voters of Washington State in 2006, the state's Renewable Energy Standard includes a conservation target defined as "all available conservation that is cost-effective, reliable and feasible". Highly efficient CHP systems (see below for definition) count towards a utility's conservation target. The RES categorizes CHP systems under distributed generation as an "eligible renewable resource". Under the RES, distributed generation, defined as a "generation facility or any integrated cluster of such facilities" with a capacity of five MW or less, may be counted as double the facility's electrical output if the utility owns the facility, has contracted for the distributed generation and the associated RECs, or has contracted to purchase only the associated RECs. Eligible renewables from a facility that began operation after December 31, 2005 where the developer used an approved apprenticeship program during facility construction may count 1.2 times its base value.

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Yes. Both fossil-fueled and renewably-fueled CHP systems are eligible for standardized interconnection.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

Highly efficient CHP systems – systems with a "useful thermal energy output of no less than 33% of the total energy output" – are eligible to count towards a utility's conservation target.

- Utility Level

Washington requires utilities to file biannual IRPs. Puget Sound Energy published their 2013 IRP in May 2013. It contains a handful of references to their CHP programs in the distributed generation appendix.

New York

- Is CHP treated as load generation or as efficiency?

New York offers incentives for CHP projects, and includes CHP as an eligible resource within its energy efficiency resource standard. Twelve new CHP installations were completed in 2012. In June 2008, the New York PSC issued an Order Establishing EEPS and Approving Programs (filed 08/22/2008).

The New York PSC adopted a renewable portfolio standard in September 2004, and a customer-sited tier was reauthorized and expanded in April 2010 as part of the larger expansion of the RPS to 30% by 2015. Eligible resources for this customer-sited tier include fuel cells, photovoltaics, solar hot water, wind turbines, digester gas-fueled CHP systems of 50 kW or larger, and methane digesters. CST systems are generally limited to the size of the load at the customer's meter. The EEPS program now allows CHP program savings towards its EEPS goals and is currently proposing to use some of the EEPS funds for CHP programming.

Through NYSERDA's Distributed Generation and Combined Heat & Power program, the state has provided significant financial incentive and technical assistance to encourage CHP deployment. Over the last seven years, these programs have invested over $94 million, about 75% of which has resulted in permanent equipment in the field with a capacity of about 192 MW.

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Yes. Under the RPS, renewably-fueled CHP is eligible under the Main Tier; Digester gas-fueled CHP and fuel cell CHP using any type of fuel are eligible under the Customer Sited Tier. Both fossil-fueled and renewably-fueled CHP systems are eligible for standardized interconnection.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

For the RPS, CHP systems must be greater than 50 kW. Standardized interconnection applies to systems <2 MW.

NYSERDA runs a CHP Performance Program for their commercial & industrial customers. In this program, incentives are available for CHP Systems with an aggregate nameplate greater than 1.3 MW that provide summer on-peak demand reduction.

The C&I FlexTech Program offers its customers the choice of a CHP feasibility study, among others, and the CHP Acceleration Program provides incentives for the installation of pre-qualified and conditionally qualified CHP systems by approved CHP system vendors in the size range 50kW – 1.3MW. To be eligible for incentive payments, the installation site must pay the System Benefits Charge (SBC) surcharge on their electric bill, or be located within New York City or Westchester County and the CHP system will be fueled by natural gas that is subject to the SBC surcharge on the gas bill. NYSERDA will accept applications only from approved CHP system vendors and all incentive payments will be made to the CHP system vendors.

- Utility Level

NY does not currently have filing requirements for utility long-term plans, but NYSERDA does publish savings data consistently. CHP Performance Program and CHP Acceleration Program EM&V data are kept in NYSERDA's DG Integrated Data System. FlexTech Program data can be found in the annual and quarterly reports the state government authority is required to publish. It is due for an interim report in Q4 2014.

New Jersey

- Is CHP treated as load generation or as efficiency?

Generation. New Jersey's renewable portfolio standard requires utilities to procure 22.5% of its electricity sold in New Jersey from renewables by 2021. For the purposes of this standard, biomass systems and renewable-powered fuel cells may qualify towards those goals. In the most recent amendment to the RPS, CHP facilities, or "co-generation facilities", are considered "base load electric power generation facilities".

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Yes. Additionally, for several important policies, including a natural gas sales and use tax and a pending portfolio standard change, NJ legislators have defined "contiguous property" in a manner that includes a CHP system and an end-user separated by an easement, a right-of-way, or another building. It also allows an end-user who may not physically be located next door to be deemed "contiguous" if the end-user takes thermal power from the CHP system. This definition is significant because it recognizes that the thermal host for a CHP system may sometimes not be in the same building as the end-user, and that the CHP system might have excess electricity that it would like to sell. Importantly, the legislation also requires that the sale of electricity to a contiguous property can employ existing utility distribution infrastructure to "wheel" the power, and that the utility must treat it as a typical wheeling customer. This definition also could apply to district energy systems that might wish to incorporate CHP systems.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

NJCE runs a Combined Heat & Power and Fuel Cell Program that provides incentives to customers with CHP and FC systems with recovery and productive use of waste heat that are located on-site. There is a Small Scale CHP and Fuel Cell Incentive Program and a Large Scale CHP and Fuel Cell Incentive Program. Neither specifies eligible fuels. For the small scale program, CHP or Fuel Cell systems with waste heat utilization must achieve annual system efficiency of at least 60%; electric only generation must achieve 45% electrical efficiency. For the large scale program, projects must be greater than 1.0 MW and CHP systems must achieve annual system efficiency of at least 65%. Fuel cells without heat recovery must achieve annual system efficiency of at least 45%. See the links above for more detailed eligibility requirements.

NJCE also runs a Renewable Energy Biopower Program. Eligible fuel for this program includes landfill gas, biomass, biogas, and other. Minimum efficiency required is 65%. However, it is no longer accepting applications for 2014 and detailed information outlining the incentives and eligibility requirements is not currently available on the website.

NJCE offers incentives for CHP systems through its C&I Pay for Performance – Existing Buildings Program. The program is funded by the state Societal Benefits Charge, hence it is only available to retail electric and/or gas service customers of the following New Jersey utilities that collect the SBC: Atlantic City Electric, Jersey Central Power & Light, Rockland Electric Company, New Jersey Natural Gas, Elizabethtown Gas, PSE&G, and South Jersey Gas. CHP projects involve a separate application package and are governed by program rules and requirements in addition to those described above.

- Utility Level

NJ does not have any rules requiring IRP publication, but progress towards goals and financial information for both of these programs is included in NJCE's progress reports outlining data on all DSM programs. The Monthly Report on Progress Towards Goals show savings and financial information: for FY 2014 (7-1-2013 to 12-31-2013) the C&I CHP-Fuel Cell Programs cost a total $1,103,782.34 with $0.00 being spent on marketing and sales, training, administration/program development, and evaluation/related research. $1,078,364.00 was spent on direct incentives for the program.

Arizona

- Is CHP treated as load generation or as efficiency?

Both. In November 2006, the Arizona Corporation Commission adopted final rules to expand the state's RES to 15% by 2025, with 30% of the renewable energy to be derived from distributed energy technologies. The standard allows for "Renewable Combined Heat and Power Systems," distributed generation systems, fueled by an eligible renewable energy resource, and produce both electricity and useful renewable process heat. Both the electricity and renewable process heat may be used to meet the standard's Distributed Renewable Energy Requirement. Additionally, Arizona's EERS specifically calls out CHP, stating that "an affected utility may count the energy savings from combined heat and power (CHP) installations that do not qualify under the Renewable Energy Standard toward meeting the energy efficiency standard."

As indicated in the 2009 EERS document, utilities can count energy supply from combined heat and power systems that do not qualify under the state's Renewable Energy Standards towards the standard. If this occurs, the CHP system is considered a "DSM measure". The codes enacting the EERS, AAC R-14-2-2401 and -2501 (electricity and natural gas, respectively) addresses CHP systems as so: A CHP system must "generate electricity and useful thermal energy in a single, integrated system such that the useful power output of the facility plus one-half the useful thermal energy output during any 12-month period must be no less than 42.5% of the total energy input of fuel to the facility;"

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Yes. For the RES, renewably-fueled CHP, including biomass or biogas systems, is specifically identified as an eligible resource. The EERS allows that all CHP not used to comply with the renewable energy standard may qualify as "custom or other technology," but must seek approval from the Arizona Corporation Commission.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

For the RES, eligible CHP systems must have started operation on or after January 1, 1997. There are no further requirements on project size or minimum efficiency required for either the EERS or RES.

- Utility Level

Arizona requires IRP updates every two years with a planning horizon of 15 years. APS filed its 2014 IRP in April 2014, but there is no mention of CHP technology. Their 2013 DSM Report also does not include any mention of CHP technology.

Wisconsin

- Is CHP treated as load generation or as efficiency?

Generation, for the most part. The PSC has adopted interconnection standards for distributed generation including CHP systems <15 MW in capacity. The rules categorize DG including CHP systems by capacity and provide for several levels of interconnection review, as follows: Category 1: applies to systems <20 kW; Category 2: applies to systems >20 kW and <200 kW; Category 3: applies to systems >200 kW and <1 MW; Category 4: applies to systems >1 MW and <15 MW. Additionally, Wisconsin established an EERS in 2006. This standard requires that energy efficiency goals be met, and looks to the Wisconsin Focus on Energy Program to achieve these goals. CHP is not specifically identified as an eligible resource, but Focus on Energy programs support the deployment of CHP in certain sectors of the economy. The Wisconsin statue that outlines the regulation of public utilities states that one of the commission's duties involves "Small-Scale Generation Incentives", including "technologies such as combined heat and power systems, fuel cells, microturbines, or photovoltaic systems that may be situated in, on, or next to buildings or other electric load centers."

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Yes. Both fossil-fueled and renewably-fueled CHP systems are eligible for standardized interconnection. And while CHP is not specifically identified as an eligible resource under the EERS, deployment of CHP that is fueled by renewable fuels or waste heat is supported by grants from the Focus on Energy Program. From this, the 2011-2014 net annual electric energy savings goal equals 1,816,320,000 kWh and the net annual natural gas savings goal is 73,040,000 therms.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

Standardized interconnection applies to systems <15 MW.

- Utility Level

Wisconsin requires biannual evaluations on the impact of the RPS on their renewable portfolio. Focus On Energy publishes a separate Evaluation Report, updated annually. Unfortunately, there are no CHP projects outlined in the current version of the report.

Maryland

- Is CHP treated as load generation or as efficiency?

Generation. Maryland has an interconnection standard, and includes CHP within its EERS. In 2011, the Maryland legislature passed legislation (S.B. 690) expanding the portfolio standard's Tier I definition to include waste-to-energy systems. Affected utilities are required to meet 6.4% of their retail sales with Tier I resources in 2012. The percentage expands up to 18% in 2022.

- Is natural gas an eligible fuel for use with CHP as an energy efficiency or alternative energy source?

Both fossil-fueled and renewably-fueled CHP systems are eligible for standardized interconnection.

- What criteria must CHP meet in order to be incentivized as energy efficiency?

Standardized interconnection applies to systems <10 MW. The programs offered by Baltimore Gas & Electric, Pepco, and Delmarva (detailed below) all require projects to operate at a minimum of 65% efficiency (Higher Heating Value) on an annual basis. For the BG&E program, eligible CHP projects may be driven by either a reciprocating engine or a gas turbine. All qualifying systems must not export electricity to the grid. Projects must be pre-approved by December 31, 2014. All projects must be commissioned and operational by December 31, 2016.

- Utility Level

Several large utilities in Maryland offer their customers CHP programs.

BG&E's Smart Energy Savers CHP Program provides incentives up to $2 million to industrial and commercial customers who install an onsite CHP system. It is open to all BGE customers, regardless of supplier. Pepco and Delmarva offer CHP incentives through their Existing Building Program for C&I Customers.

EmPOWER Maryland, run by the Maryland Energy Administration (MEA) and other public and private stakeholders, implement programs aimed toward achieving 5% of the overall 2015 electricity savings. See the EmPOWER Maryland Standard Report for 2013 for details about the state's relatively new CHP programs. This evaluation states that BG&E expects around 68,500 MWh in annualized energy savings from their CHP proposals for 2014.

Additional Resources

The Opportunity for CHP in the United States. ICF International, 2013.

Combined Heat and Power: A Resource Guide for State Energy Officials. National Association of State Energy Officials, 2013.

Guide to the Successful Implementation of State Combined Heat and Power Policies. SEE Action, 2013.

Industry, Nonprofits, and Government Team Up to Harness More CHP in the Midwest. ACEEE, 2014.

CHP and WHP Growth Trends and Opportunity Identification. ICF International, 2013.

Appendix 2 – Waste Heat to Power Programs

The E Source[28] DSM database contains information on 22 different Combined Heat and Power programs in the U.S. and a number of them specifically address waste heat to power (WHP). The programs specifically addressing WHP involve six electric and gas utilities in New Jersey and the California Public Utility Commission's Self Generation Incentive Program which involves Pacific Gas and Electric, Southern California Edison and the Southern California Gas Company. It is important to note that the other CHP programs do not exclude waste heat to power projects they just do not specifically address them. In Canada the Ontario Power Authority and British Columbia Hydro have customer based generation programs that address waste heat to power.

The three programs that are the most appropriate to the scope of this study are California's Self Generation Incentive Program, British Columbia Hydro's Integrated Customer Solutions program and the Ontario Power Authority's Industrial Accelerator Program. The following are more detailed descriptions of the aspects of these programs.

California Public Utility Commission: Self-Generation Incentive Program (SGIP)

From the 2012 SGIP Impact Evaluation and Program Outlook: California's SGIP is distinct in a number of ways. Established in 2001, the SGIP is one of the longest-lived DG incentive programs in the country. The SGIP has been operating for over twelve years; only New York's CHP program has been longer lived. The SGIP is also unique in the transparency of program results. Detailed impact reports, process evaluations, economic analyses, and special topical reports have been produced since the creation of the program and are freely available on public websites. Another distinctive and important feature of the SGIP is how it has evolved to meet the changing needs of California's ratepayers and citizens. As the SGIP has evolved, there have been accompanying changes in the technologies and key market players in the program.

The following section discuss some of the key changes in state government policies, the SGIP guidelines, and the energy market conditions or players that have influenced the SGIP portfolio and may affect the future mix of technologies and impacts. Prior to 2007, the SGIP provided incentives to both fossil-fueled and biogas-fueled gas turbines, internal combustion engines, fuel cells and microturbines; as well as to solar photovoltaic (PV) and wind turbine systems. With the emergence of the California Solar Initiative (CSI), PV system eligibility was eliminated in 2007. PV incentives were provided instead under the CSI. Beginning in 2008, the list of eligible technologies was expanded to include advanced energy storage systems coupled with renewable energy systems, waste heat to power systems and pressure reduction turbines. Almost half of SGIP capacity recovers waste heat to serve a heating end use exclusively. These systems typically displace heat that would otherwise have been generated by on-site boilers fueled by natural gas. 12% of SGIP capacity use recovered heat in an absorption or adsorption chiller to serve a cooling load. In the absence of the program, the cooling load would have been served by an electric chiller. The exhibits below taken from SGIPs Impact and Evaluation Outlook report[29] provide summaries of the projects and the end uses that they served. Overall, 601 projects representing approximately 282 MW of rebated capacity generated 970 GWh of electricity and recovered 18.4 million therms of useful heat during 2012. Fuel cells generated over one-third of the total electrical energy impacts of the program but collectively recovered the least amount of useful heat. Internal combustion engines and gas turbines recovered the most heat and achieved the highest overall system efficiencies (65 and 59 percent respectively).

[28] E Source, Boulder Colorado, an organization specializing in maintain and developing energy efficiency information.

[29] 2012 Impact Evaluation and Program Outlook, prepared by Itron, February 2014.

Summary of Energy Impacts by Program Administrator

Program Administrator	Project Count	Rebated Capacity (MW)	Electricity Generation (GWh)	Fuel Consumption (Million Therms LHV)	Useful Heat Recovered (Million Therms)
California Center for Sustainable Energy	61	33.4	150	10.0	3.0
Pacific Gas & Electric	281	109.3	397	28.6	5.9
Southern California Edison	116	51.1	129	6.7	1.3
Southern California Gas Company	143	88.5	294	27.4	8.1
Total	**601**	**282.3**	**970**	**72.6**	**18.4**

The distribution of end uses served by capturing useful waste heat is summarized below:

Distribution of Waste Heat End Uses

Waste Heat End Use	Project Count	Rebated Capacity (MW)	Percent of Total Capacity
Heating	368	129.3	46%
Cooling	39	33.5	12%
Heating and Cooling	87	68.8	24%
Not Required	105	50.3	18%
Unknown	2	0.4	0%
Total	**601**	**282.3**	**100%**

About one-fifth of the SGIP's capacity is not required to recover waste heat because it is either fueled by renewable biogas or is otherwise exempt from heat recovery requirements. The remaining 496 projects recover waste heat to serve an end use.

The following table shows SGIP projects in the queue and the distribution by technology type as of April 12, 2013, noting that there is one waste heat to power project in the queue. The ICF CHP database[30] notes that there are four waste heat to power projects in California, totaling 19 MW of generation capacity; however these projects were not identified in the SGIP Impact and evaluation report[31]. In fact in this report there no operational waste to power projects identified. In the SGIP budget report[32] 3 Waste Heat to Power projects were identified as applications in the 2012 budget with a total capacity of 687 kW.

[30] *http://www.eea-inc.com/chpdata*

[31] *"2012 SGIP Impact Evaluation and Program Outlook", Prepared by Itron, February 2014.*

[32] *"Self-Generation Incentive Program Budget Report, Pursuant to D. 11-12-030, OP 2*

Reserved Project Status (April 12, 2013)

Technology	Project Count	Rebated Capacity (MW)	Percent of Total Capacity
Advanced Energy Storage	641	27.49	19%
Fuel Cells CHP	10	2.92	2%
Fuel Cells Electric	81	45.31	32%
Gas Turbines	3	18.04	13%
IC Engines	20	21.75	15%
Microturbines	14	6.91	5%
Pressure Reduction Turbines	6	1.90	1%
Waste Heat to Power	1	0.05	0%
Wind	10	18.90	13%
Total	**601**	**282.3**	**100%**

Ontario Power Authority's Industrial Accelerator Program

The industrial accelerator program provides incentives for energy efficiency measures to be installed, including generation projects. This report will focus on the generation project eligibility criteria and incentive structure.

Eligible generation projects with the OPA program are required to involve installation of the measure, provide at least 350 MWh of Annualized Electricity Savings and have a Minimum Expected Life of 10 complete years (micro projects must provide 100 MWh with a minimum expected life of 5 years). Additionally these projects must not exceed 20 MW of nameplate capacity, involve fuels disallowed by the OPA (i.e. coal and diesel), and or have received funding under another OPA contract or funding mechanism. It should be noted that natural gas as a fuel source is allowable. All feasibility and detailed engineering studies must be completed prior to incentive funding application, and any agreements with vendors and contractors or other project initiation cannot have taken place.

Project costs which are eligible to be included in incentive funding determination are capital expenses, equipment and products, data collection services, meter purchases, labour costs, professional services, travel, printing, permits and licences and technical studies. Project incentives are calculated to be $230/MWh of annualized electricity savings per project up to a maximum of 70% of the total project cost.

Self-generation projects are not allowed to export any power to the grid and the electrical connection between the host facility must be such that power will not flow from the facility to the utility grid under any conditions.

The table below is a sample of the projects that are being evaluated or have been awarded incentives by the program. The shaded items in the table are projects that are particularly of interest for this study.

Sample of projects being evaluated or awarded incentives by OPA's Industrial Accelerator Program

Industry	Technology	Size (MW)
Steel Manufacturing	By-product gas TG	5.0
Plastics Manufacturing	Gas Fired Turbine-Generator	5.5
Pulp & Paper	**Biomass steam TG**	**8.9**
Food Processing	Gas Fired Turbine-Generator	8.8
Food/Confectionary	Gas Fired Turbine-Generator	5.0
Cement Manufacturing	**Waste Heat ORC**	**5.0**
Water/Wastewater	**Micro-hydro TG**	**0.2**
Ethanol Production	**Steam Turbine replacing Pressure Reducing Value**	**1.0**
Commercial building/labs	Gas-Fired Internal Combustion Engine	0.5
Hospital	Gas-Fired Internal Combustion Engine	0.6
Hospital	Gas-Fired Internal Combustion Engine	1.6
Ethanol Production	Gas Fired Turbine-Generator	5.7
Auto Parts Manufacturing	Gas-Fired Internal Combustion Engine	10.0
Multi-Residential	Gas-Fired Internal Combustion Engine	0.02
Polymer Manufacturing	Gas Fired Turbine-Generator	7.9
Auto Manufacturing	Gas Fired Turbine-Generator	9.2
Hospital	Gas-Fired Internal Combustion Engine	1.5

British Columbia's Integrated Customer Solutions Program

The integrated customer solutions (ICS) load displace program at BC Hydro was developed for customers who want to generate electricity for self-supply or sale to BC Hydro. If electricity sales to BC Hydro are part of the proposed project BC Hydro ICS may refer the project to energy procurement (EP) program, if available and applicable, or determine a project solution jointly between ICS and EP.

Within the ICS load displacement program, eligible projects are required to have a minimum nameplate capacity of 50 kW. Projects are typically expected to have a minimum 10 year life and must not export power to the BC Hydro grid. Meeting the eligibility requirements does not necessarily result in receiving a financial incentive. Factors which influence incentive funding include BC Hydro's need for load displacement and new electricity supply, the cost-effectiveness of the customer's project relative to other resources, and available budgets for programs or offers. The following illustrates the ICS process[33]:

[33] *BC Hydro "Integrated Customer Solutions: Process and Proposal Submission Guide", May 2013.*

Integrated Customer Solutions Gated Process

Energy Procurement Solution

Energy Procurement Solution

ICS Gates	Gate 0 - Pre-Screen		Gate 1 - Proposal		Gate 2 - Review	Gate 3 - Contract Terms Discussion	Gate 4 - Agreement
ICS Steps	Project Initiation	Pre-Screen	Feasibility Study	Project Proposal	Proposal Review	Contract Terms Discussion	Agreement
Requirements	ICS Process Initiation Form Non-disclosure Agreement (NDA) Load Displacement Pre-screening Assessment (LDPA) Interconnections Study Application		**Completed ICS Proposal Including:** Load Displacement Feasibility Study (LDFS) or equivalent Fuel Plan Interconnection Study First Nations Consultation Plan		Review and Discussion		First Nations Consultation Assessment Signed Agreement
Estimated Timeline	1-2 Months		8-14 Months		1-2 Months	1-3 Months	1-3 Months
Overall Timeline	12-24 Months						

ICS PROCESS

Funding opportunities exists at each of the steps in the ICS process. For the load displacement pre-screening assessment, BC Hydro will pay 50% of the study costs up to a maximum of $5,000. The load displacement feasibility study is again 50% funded with a funding cap at $50,000 at this stage. Funding at each stage is contingent on the project not resulting in being referred to EP. Project implementation funding is available and determined based on the lesser of the following criteria:

1. 75% of the project cost
2. The amount needed to reduce the payback period to one year
3. The total lifespan electricity savings multiplied by the eligible incentive rate

The incentive rate is determined by BC Hydro at the time of application.