City of Klamath Falls, Oregon

Geothermal Power Plant Feasibility Study

Prepared for:
The City of Klamath Falls,
The US Department of Energy, and
The Energy Trust of Oregon

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DISCLAIMER

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1. Introduction to the Klamath Falls District Heating System

The City of Klamath Falls (City) operates a geothermal district heating system, providing hot water to businesses in the city's core area and also to melt ice from sidewalks and bridges. The system was initiated in 1981 and improvements to the system enabled reliable deliveries of hot water by 1992. Continued improvements and expansion since 1992 have allowed the system to currently heat over 400,000 square feet of building space, 150,000 square feet of greenhouses and 130,000 square feet of sidewalk snowmelt systems.

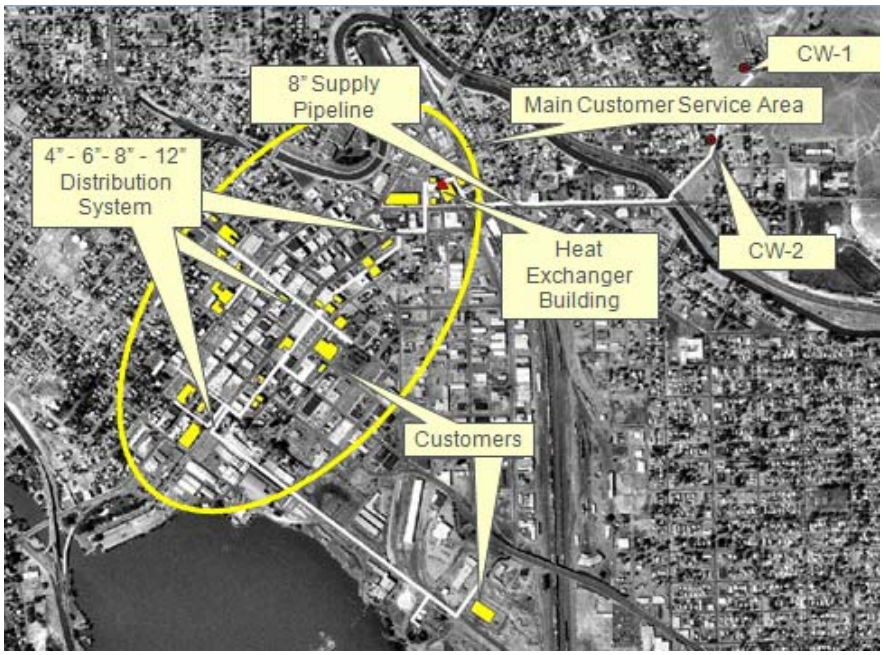

Figure 1. Geothermal Heating System Aerial View

Pumps in the heat exchanger building circulate geothermally heated city water to customers through a closed-loop distribution piping network totaling about 4.5 miles of piping. Heating water is supplied at a seasonally adjusted 170°F to 190°F. Return water at 140°-150°F is reheated by the geothermal supply through plate-and-frame heat exchangers and recirculated to the customers.

Figure 2. District Heating System Photos

This district heating system is supplied by two geothermal wells the City owns and operates, located about 3/4 mile east of the heat exchanger building. These wells are about 370 and 900 feet deep respectively, and can each deliver up to 800 gallons per minute of water at 210 to 220 degrees Fahrenheit. After passing through the heat exchangers, the geothermal water is injected back into the aquifer at typical temperatures of 150°F to 160°F.

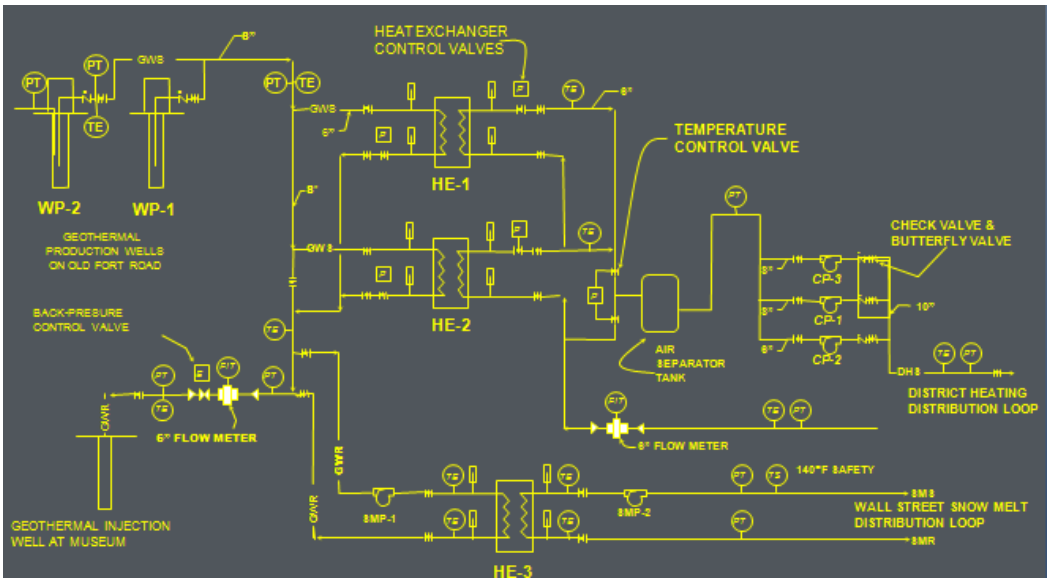

Figure 3. District Heating Schematic

The original design heating capacity of the district heating system was 20 MMBH (million Btu/hr) (5.9 MWt). System thermal capacity has been increased through a series of renovations and improvements to an estimated 40 MMBH. (11.7 MWt) Current connected heating load peaks at about 16 MMBH (4.7MWt). The peak heating load is expected to grow to about 25 MMBH in the next 5-10 years.

The primary operating revenue from the district heating system is derived from sales of thermal energy sales to commercial buildings and greenhouses. These heating loads are by nature seasonal, with a resulting low overall annual load factor for the district heating system. To supplement revenue from operation of the district heating system, the City is contemplating the installation of a small power plant to produce power with a portion of their geothermal water resource.

2. Project Objectives

The City recognized that they have an attractive resource of geothermal energy that could be used for power generation, and chose to investigate this opportunity in more detail. The nearby Oregon Institute of Technology had recently installed a power generation module, and the City believed it might be possible to benefit from use of the same type of equipment.

At the same time, it was recognized that the priority would be the delivery of thermal energy to customers, as opposed to power generation. The value of direct use geothermal heating energy,

which offsets natural gas purchases, is much higher per million BTU than the value of the electricity that could be generated.

The project concept was to design a power plant that would operate using surplus geothermal energy and produce marketable electricity when there is reduced market for direct-use heat. Some of that power would offset electricity used for the district heating pumps; most would be sold to PacifiCorp under a long term Power Purchase Agreement (PPA).

Figure 4 shows an estimated district heating system heat load as a function of outdoor air temperature, based on projected load growth in the next 5 years. The source energy devoted to power production is based on a nominal 280 kW unit, with power generation shut down below 30°F to provide adequate thermal energy for the district heating system.

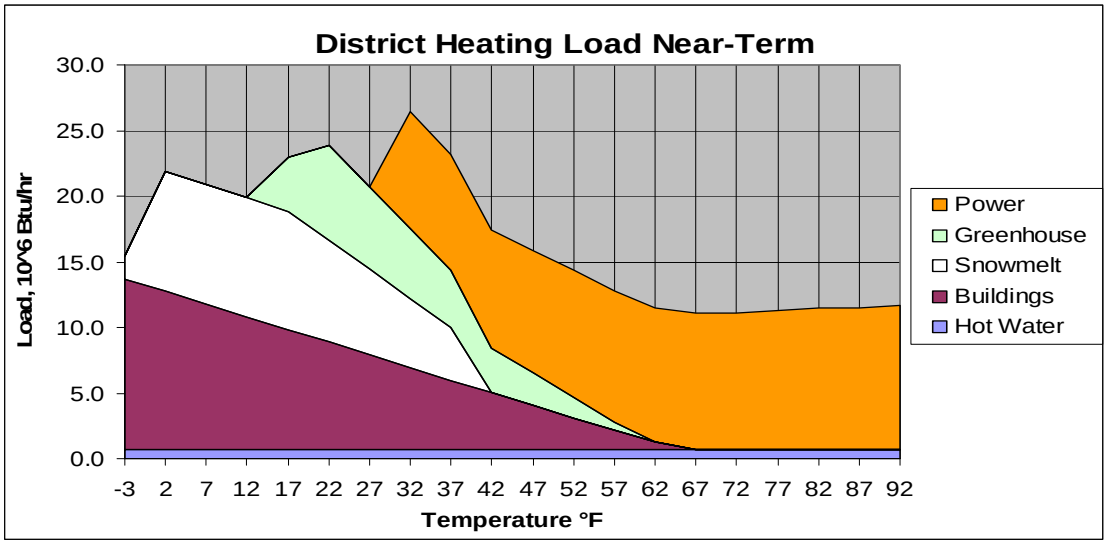

Figure 4. Projected Klamath Falls District Heating Load, ~2015

3. Technology Alternatives

There are three approaches in common usage for converting geothermal energy to electric power. The earliest geothermal power plants used steam from high-temperature steam-dominated resources. The power plants at the geysers geothermal field in California are examples of plants that used hot dry steam to generate power by direct expansion through a steam turbine. High temperature liquid-dominated geothermal resources can produce power using a flash tank to separate steam from liquid, with the steam run through a steam turbine. For the lowest temperature geothermal resources, the hot geothermal water can be used to boil a refrigerant which is then used to power a turbine or screw expander. This technology is known as an Organic Rankine cycle (or "ORC") plant. ORC power plants have been used for over thirty years in various geothermal sites, and the technology has been improved during this period.

The geothermal resource at Klamath Falls is not hot enough or large enough for direct steam turbine power generation. However, the recent development of compact ORC power plant

modules has enabled power production from lower-temperature resources. In general, these new modular power plants can operate wherever there is a temperature difference of at least 100 to 120°F between the geothermal source and the condensing water. This was demonstrated in Chena Hot Springs in Alaska in 2006 with a 250 kW unit, operating on 160°F geothermal water, with 40°F condensing water. At Oregon Institute of Technology, a 280 kW nominal capacity power plant is operating with 194°F geothermal water, using a cooling tower to produce 50° to 70° condensing water.

Modular power plants built using mass production techniques, along with the utilization of standardized chiller equipment components have led to significant cost reductions for some applications. These modules have the potential to reduce the total capital cost of a geothermal power plant, and also reduce the time to complete installation. It is the purpose of this study to determine if such cost reductions would enable a project in Klamath Falls to be economically feasible where purchase power rates are relatively low.

4. System Selection Criteria

The primary objective for the City of Klamath Falls geothermal district heating system is to deliver reliable geothermal heat at a competitive cost. Geothermal power generation can be considered to the extent that it can provide increased revenue and does not detract from reliable district heating system operation. With that in mind, the following design criteria were developed for the power plant selection:

Minimum Requirements:

- Capable of operation on 210°F geothermal resource at 600 to 1400 gallons per minute available flow.
- Generator module size of 250 kW to 700 kW.
- Allow seasonally adjusted 170°F to 190°F district heating system supply temperature.
- Available in the United States.

Preferred:

- 800 gallons per minute or less design flow to allow operation with only one geothermal production pump.
- Ability to utilize 160°F discharge geothermal heat in the power cycle.
- Option for dry or hybrid cooling to save water cost for power plant cooling.
- Oil-free and gearbox-free turbine or expander for reduced maintenance cost.
- Refrigerant selection that allows design pressures less than 200 psig for greater safety.
- Working units in similar service.

5. Equipment Options: Packaged Power Plant Modules

Pratt & Whitney PureCycle 280: The original basis-of-design for the project was the PureCyle 280 unit supplied by Pratt & Whitney division of United Technologies Corporation (UTC). This unit is based on the on their chiller/refrigeration technology, which leverages the manufacturing and cost efficiencies of that high-volume industry. The unit has a gross power

rating of 280 kilowatts and has proven to operate reliably in commercial sites in Alaska, New Mexico and Utah, and at the Oregon Institute of Technology in Klamath Falls.

The Pure Cycle 280 unit meets the minimum design criteria, although meeting the winter maximum district heating supply temperature of 190°F will require shutting off power generation below about 30°F ambient air temperature. The turbine is a fixed-speed, fixed geometry, which does not allow modulation of power production to accommodate varying district heating demands. The turbine-generator includes an oil-lubricated gearbox, with a recommended major rebuild interval of 5 years at an estimated cost of $75,000.

As a modular pre-packaged unit, there is no option for air or hybrid-cooled condensers or use of waste geothermal water for power cycle preheat. The unit uses R245fa as a working fluid, with a typical working pressure of less than 100 psig and an evaporator pressure rating of about 250 psig.

Figure 5. Pratt & Whitney PureCycle 280kW Module

ElectraTherm Green Machine: ElectraTherm of Reno, Nevada builds a 50 kW module called **The Green Machine**. It has been tested at the Southern Methodist University and units operate using a solar heat source in Hawaii and at the Kalamazoo Valley Community College in Michigan. The Green Machine unit does not meet the minimum size requirements for the Klamath Falls project.

General Electric Calnetix CleanCycle: General Electric entered the marketplace by purchasing a company named Calnetix Power Solutions which developed a 125 kW ORC unit. Calnetix has offices in the UK and in Stuart, Florida. The Calnetix module is called the **CleanCycle**, and features a high speed (26,500 RPM) turbine-expander coupled to a high efficiency alternator in one sealed unit, with no gearbox or lubricated bearings. It uses highly efficient magnetic bearings, and thus eliminates lubricating oil that might contaminate the refrigerant working fluid. According to the company website, Calnetix is focused on the heat recovery market, with

resource temperatures of 250°F and higher. The direct-drive turbine-expander is a positive feature, but the unit does not meet the temperature and size requirements for the Klamath Falls project.

Opcon Power Box: A Swedish company called Opcon makes an ORC module called a **Power Box**. With a peak rating of 800 kW and a compact size equivalent to that of a shipping container, the product is very attractive. However, we found that it is not yet available for use in America.

6. Equipment Options: Custom Designed Power Plants

In addition to the commercially produced modules described above, two companies have substantial experience with the fabrication of custom-designed ORC power plants

Ormat Technologies Inc.: Ormat has been the industry leader in ORC equipment for many years. They are well established in the geothermal market, and have typically constructed units larger than that envisioned for the city of Klamath Falls. When contacted by the investigators for the Klamath Falls project, they declined to provide a proposal for a combined heat-power project in this size range.

Turbine Air Systems: TAS fabricates custom ORC systems to meet the specific energy resource available. TAS is located in the Houston, Texas area, and has been responsive to inquiries about their product line. However, the plants they have built are substantially larger than envisioned for the city of Klamath Falls, and they did not provide a specific proposal.

Self-Designed Custom Power Plant. As an alternative to commercially available modular or custom power plants, the investigators considered designing a custom power plant specifically optimized for the requirements of the Klamath Falls geothermal district heating system. The power plant could incorporate all the required and preferred design criteria except having existing working units in similar service. Specific design features included:

- Variable-geometry turbine expander, direct coupled to a high-speed frictionless magnetic bearing, variable-speed generator.
  - The turbine-generator assembly would be hermetically sealed, with no gearbox or oil system, thus reducing oil system maintenance.
  - Variable turbine geometry and variable speed generator operation allow modulated capacity to match power production with district heating system requirements.
- The power plant would be designed with one or two generators, providing 350 kW or 700 kW gross capacity.
- A preheat heat exchanger would be included in the refrigerant circuit, utilizing 160°F discharge geothermal water to provide about 25% to 30% of the heat input to the power cycle.
- The plant could be designed for an air-cooled or hybrid air/water cooled condenser. However, the investigators found that a water cooled unit with a standard cooling tower was more cost effective for this project.

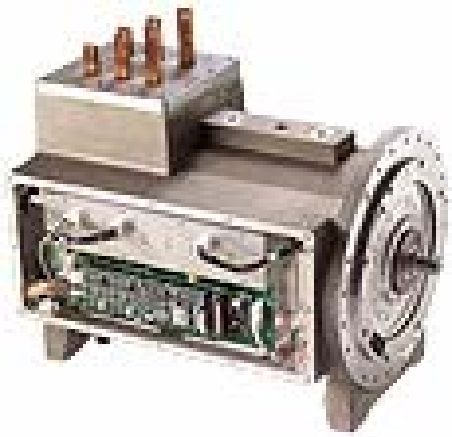

Figure 6. 320kW Magnetic Bearing Generator

The investigators narrowed the field to two approaches in order to investigate specific approaches in more detail. The first approach considered was the 280 kW UTC PureCycle unit, because it seems to have the greatest market acceptance to date. The second alternative considered was to construct a custom designed module using a magnetic bearing generator. The improved efficiency and reduced long term maintenance cost suggested this might be a good potential approach.

The investigators evaluated the following three installation scenarios for City of Klamath Falls installation:

- One (1) UTC / Pratt & Whitney PureCycle 280kW Module
- A module constructed using (1) magnetic bearing 320kW turbine-generator
- A module constructed using (2) magnetic bearing 320kW turbine-generators

The purpose of this Feasibility Study is to determine if any of these power generation module scenarios would likely be technically and economically successful at this site. Construction costs estimates and budgets were assembled based on budget quotes and estimated component costs. Actual costs associated with a similar project located at OIT in Klamath Falls have been used as a reference.

7. Preliminary Design of the Proposed Geothermal Project

The City Public Works Department operates a geothermal pumping station and heat exchanger system in a building located at the corner of North Spring Street and Wall Street near the downtown core area of Klamath Falls. This is the proposed location for the new power plant.

In order to complete cost estimates and financial projections, the investigators prepared conceptual drawings to enable estimates of key component cost and installation cost estimates.

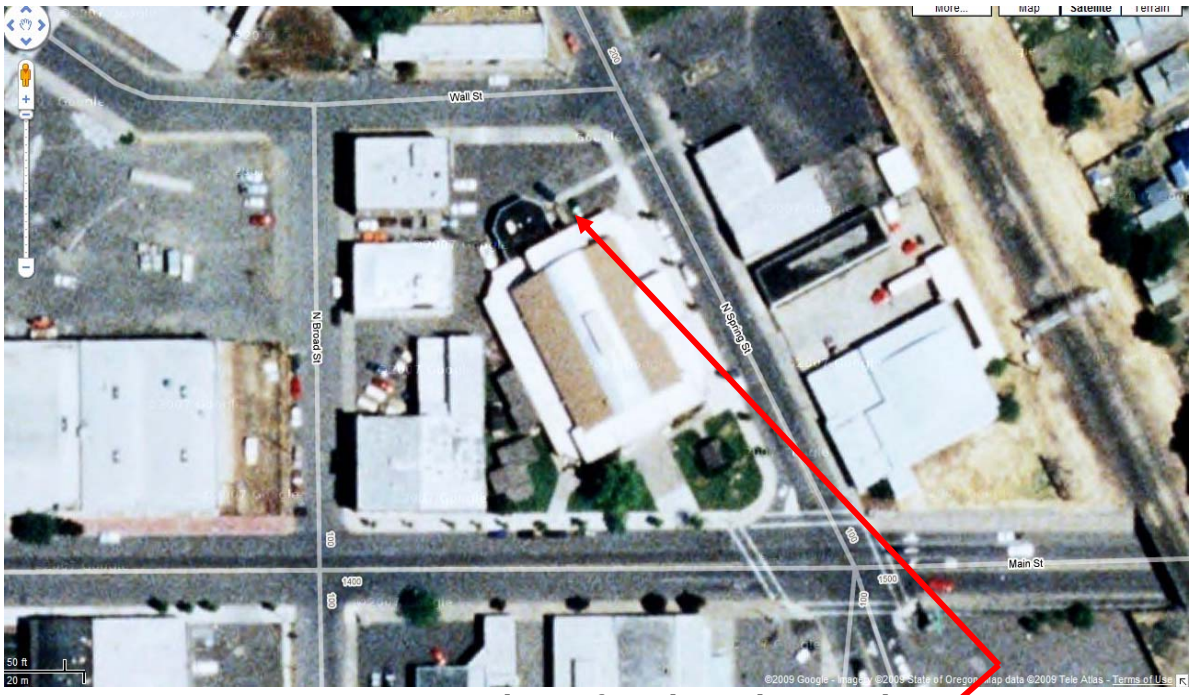

Figure 7. Proposed Site of Geothermal Power Plant.

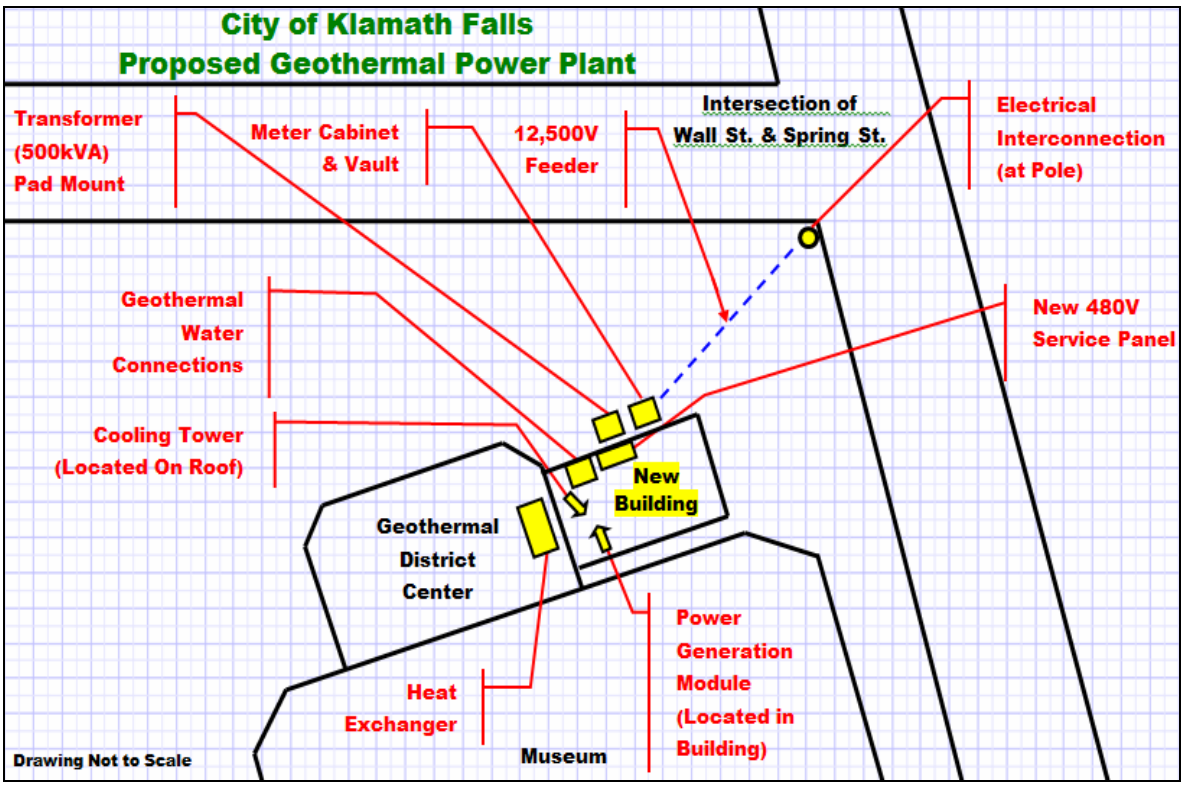

Figure 8. Proposed Site Plan.

Figure 9. Exterior view of the Geothermal District Heat Center

Common to all three power generation module design options, the facility will consist of the following key components:

- A power generation module
- A cooling tower to discharge heat in order to re-condense the refrigerant
- Circulating water pump(s) for the cooling tower
- An electronic control system
- A new PacifiCorp electrical service, with metering system, switchgear, and transformer to interconnect the power plant
- A new building to house the power plant with a structure satisfactory to support the installation of the cooling tower on the roof

Drawings have been prepared to identify the proposed layout and location of major components. Construction budget estimates have been prepared to enable completion of this feasibility study. No detailed engineering or firm construction quotes have been obtained.

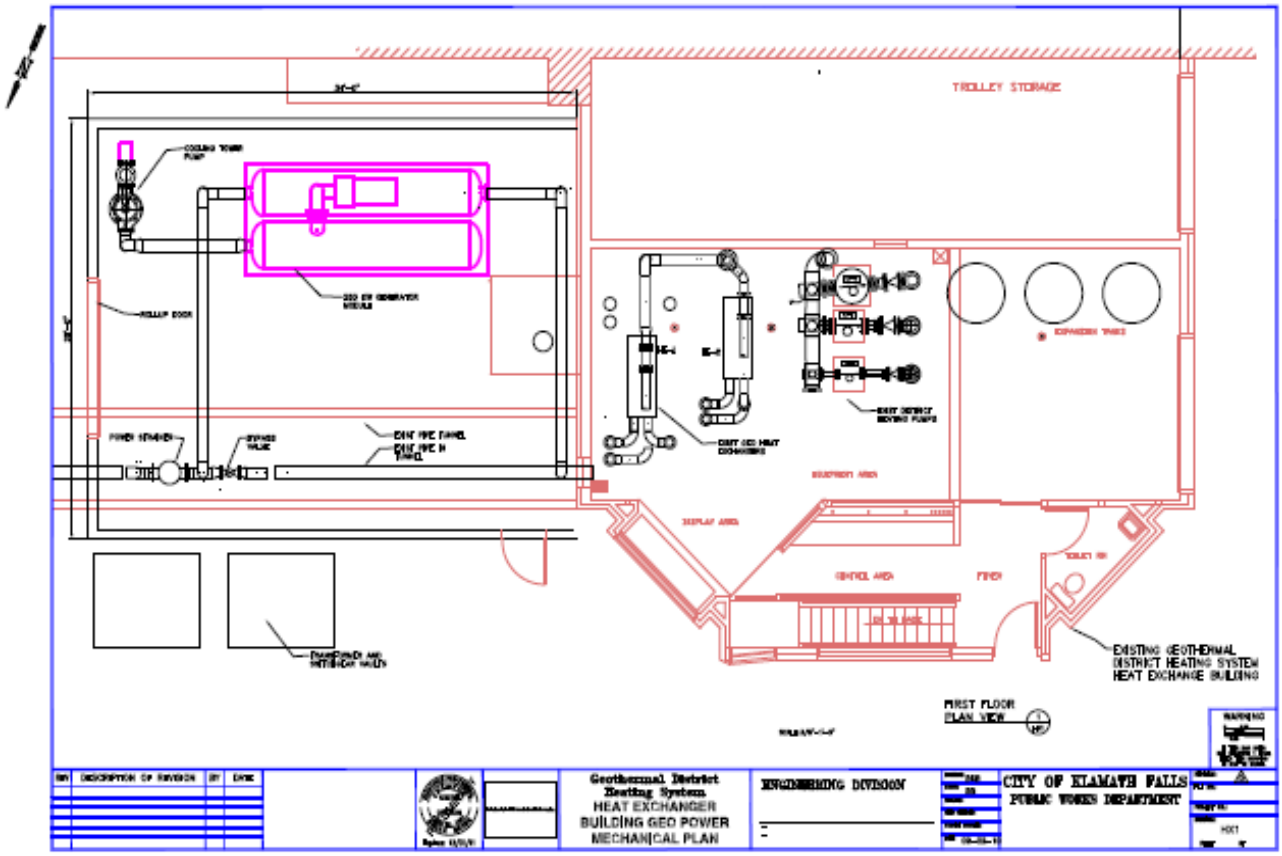

Figure 10. Preliminary site plan for the proposed new geothermal power plant.

8. Projections for the Pratt & Whitney PureCycle 280 kW Module

The Pratt & Whitney PureCycle 280kW module is a well-designed and proven generation module. The costs to complete a system are easy to estimate since there is experience with these units. The preliminary capital cost estimate totals about $1.6 million, as itemized below.

Brian Brown Engineering has estimated the annual net power production to be in the range of 1,655 megawatt-hours per year. The 2012 annual revenue generated is estimated at nearly $83,000. The operating and ownership expenses are estimated to be about $84,000.

8a. Capital Cost Estimate-for the Installation of a PureCycle 280 kW Module

A preliminary estimate of the cost to develop and construct the project with the PureCycle 280kW module has been completed. These costs include the permitting, engineering and contract applications and negotiations necessary to place the system in service. A summary of these costs is presented below.

CAPITAL COST ESTIMATES	
Technical Feasibility Study	40,000
Financial Feasibility Study	36,000
ODOE BETC Application Fee	6,000
PacifiCorp Interconnection Fee	1,000
Travel	8,000
Administrative Costs	5,000
Feasibility Study & Development Costs	**$96,000**
Engineering (civil, electrical & mech.)	100,000
Purchasing & Project Management	60,000
Site civil work; Building	200,000
280 kW module, del.& inst.	360,000
Cooling tower & installation	120,000
Geothermal Heat Exchangers	0
Piping materials & installation	175,000
Control systems; safety monitoring	30,000
Electrical panel, wiring, 480 v svc	180,000
PP&L Interconnection	50,000
Spare Parts	20,000
Contingency	200,000
Interest during construction	0
Insurance during construction	4,000
Design & Construction Costs	**$1,499,078**
TOTAL FUNDS REQUIRED:	**$1,595,078**

These cost estimates are based on the known cost to install a PureCycle unit at a nearby facility. This installation would be comparable in scope. Though detailed design work has not been completed, these estimates are believed to be adequate for decision making purposes. Firm construction quotations would be obtained upon completion of detailed design in the event that a decision to proceed is obtained.

8b. Estimated Power Sales Volume, PureCycle 280 kW Module

Brian Brown Engineering has prepared a projection of the expected net power production for the project. This analysis takes into account the power needed to operate the geothermal pumps when needed for thermal applications and the additional operation when they otherwise would not operate except for power production. In addition, the power required for operating the circulating water pumps and cooling tower needed solely for power production has been reduced from the total.

The power generated by the project will first offset the power used in the pumping of geothermal fluid and operation of the heat exchanger building. The additional power generated will be sold to Pacific Power & Light Company under a long term power sales agreement. Shown below is the projected operating plan:

OPERATING PROJECTION	Year 1
Gross Plant Output Average, kW	274
Capacity Factor	82%
Annual Gross Power Generated, MWh	1,961
Less Cooling Tower Pump Load, MWh	-183
Less Cooling Tower Fan Load, MWh	-106
Less Geothermal Pumping Load, MWh	-322
Plus Geothermal Baseline Pumping, MWh	224
Net Annual Power Generated, MWh	**1,575**

8c. Revenue Projection-PureCycle 280 kW Module

For moderate quantities of power generation such as this, the serving utility represents the only viable purchaser. A portion of the power is valued based on the current retail rate at the City's electric service at the heat exchanger building. The remaining portion will be valued based on the avoided costs approved by the Oregon Public Utilities Commission. Currently, the City is paying about 8.0 cents per kilowatt-hour for power at the building. This is what they will save as they generate power to offset those purchases. For the remaining portion of power generated, the project will earn about 5.2 cents per kilowatt-hour during 2012. This rate is calculated based on the melded value of peak and off-peak power purchased by Pacific Power. The project will also produce Renewable Energy Credits (RECs) valued at $5.00 per credit. One credit is equivalent to one gross mega-watt hour generated. As we evaluated this revenue source, it became apparent that an up-front incentive payment from the Energy Trust of Oregon would be more advantageous than selling the RECs to a third party. The revenue projections are shown on the following page:

REVENUE	Year 1
POWER OFFSET:	
Retail Power Purchases Offset, MWh	100
Retail Power Rate, $/MWh	80.00
Subtotal, Value of Power Offset	$8,016
POWER SALES:	
Wholesale Power to Sell, MWh	1,475
Wholesale Power Rate, $/MWh	51.9
Subtotal, Value of Wholesale Power	$76,638
RENEWABLE ENERGY CREDIT SALES:	
Credits to Sell, RECs	1,475
REC Rate, $/REC	0.00
Subtotal, Value of RECs	$0.00
Total Revenue	**$84,654**

The net average retail power rate during this period is 8.0 cents per kilowatt-hour ($80/MWh). The proposed plant will produce approximately 15 times the amount of power used at the heat exchanger building during the past year. The majority of the power generated will be sold at PP&L's avoided cost, indicated by their current Schedule 37. These contractual prices are noted below:

PP&L Avoided Cost Purchase Rates, Schedule 37					
Year	2012	2013	2014	2015	2016
On-Peak (c/kWh)	5.87	6.14	7.96	8.16	8.39
Off-Peak (c/kWh)	4.36	4.50	6.10	6.27	6.46
Weight. Avg. ($/kWh)	**5.20**	**5.41**	**7.13**	**7.32**	**7.53**
Year	2017	2018	2019	2020	2021
On-Peak (c/kWh)	8.60	8.87	8.76	8.85	9.33
Off-Peak (c/kWh)	6.65	6.87	6.74	6.79	7.23
Weight. Avg. (c/kWh)	**7.73**	**7.98**	**7.86**	**7.93**	**8.39**

The revenue to be derived from the proposed project then will be the sum of the value of power not purchased from Pacific Power & Light ($8,000), the value of the remaining amount of power (1,475 MWh), times the weighted average yearly price ($74,944 in 2012).

Since the Energy Trust of Oregon offers to provide a project incentive payment of $100,000 or more, they would claim the value of Green Energy Credits or 'tags'. Thus, the value of the renewable energy credits to be sold is zero.

The total revenue expected if complete and operating during 2012 will be about $84,654.

8d. Operating Cost Projection-PureCycle 280 kW Module

The operating costs for a PureCycle 280 project are expected to be virtually equivalent to the expected revenue during the early years. The following represent the current projections:

OPERATING EXPENSE ASSUMPTIONS		Year 1
FIXED O&M:		
Salaries & OH-Operations		12,000
Salaries & OH-Managment		0
Routine Repairs, Maintenance		6,000
Major Maintenance Reserve		15,000
Remote Monitoring		4,000
PP&L Meter /Testing		3,000
Subtotal, Fixed O&M		$40,000
VARIABLE O&M:		
Supplies/consumables		4,000
Water Supply & Disposal		24,000
Subtotal, Variable O&M		$28,000
Total, Operations & Maintenance		**$68,000**
GENERAL & ADMINISTRATIVE:		
Legal/Audit		2,000
Property Tax	0.0%	0
Insurance	0.5%	7,975
General & Admin. Expense		6,000
Total, General & Administrative		**$15,975**
Total O&M and G&A		**$83,975**

The labor required to inspect and maintain the system is expected to be minimal, requiring only occasional inspections and routine maintenance of the cooling tower.

The unit will require significant major maintenance and refurbishment at five year intervals, budgeted to be about $75,000.

Remote monitoring by local support personnel is expected to cost $4,000 per year. Monitoring by UTC costs $12,000 per year, and is not considered cost effective.

Pacific Power & Light Company requires that the meter and protection equipment be tested on regular intervals. These expenses will be required under their interconnection agreement, but may be reduced as they become routine and the testing intervals are extended.

Water and water disposal services from the city for the cooling tower makeup is estimated to be $24,000 yearly. This is based upon an estimated purchase of 11,400 hundred cubic feet (ccf) at a cost of $1.50 per ccf and a disposal of 2,277 ccf at a cost of $2.92 per ccf.

8e. Sources of Financing and Project Incentives-PureCycle 280 kW Module

A project of this magnitude and cost may be financed in a number of ways and structures. Third party ownership and financing may be considered, which would enable the use of federal tax credits and depreciation benefits, or it may be owned by the city and financed with either municipal bonding authority or the Oregon Department of Energy's Small Energy Loan Funds.

Third party financing is a viable alternative which would enable the City to limit its debt liability and reduce its risk associated with the project. This transaction structure would also increase the overall cost of the project (due to legal and contractual costs), but may reduce the overall cost to the city. It would also reduce the City's control of the asset and the associated maintenance activities. This structure also adds complexity to the overall project evaluation. For these reasons review and consideration of alternative ownership structures has not been considered, but is recommended at a later time.

With the assumption that the project will be owned and operated by the City, the following estimates of capital participation are assumed:

Potential Sources of Funds (All Values in $000's)	
TOTAL FUNDS REQUIRED:	**1,595**
ODOE Feasibility Grant; City Study	36
Energy Trust of Oregon Feasibility Grant	15
USDOE Geothermal Grant	816
Oregon BETC (33.5%)	261
Energy Trust of Oregon Incentive	100
Blue Sky Program Incentive	0
Klamath Falls Cash Contribution	367
TOTAL FUNDS SUPPLIED:	1,595

8f. Financial Projections-PureCycle 280 kW Module

Based on the projections for revenue and expense, it appears that the proposed UTC PureCycle 280 project yields inadequate returns to support repayment of the anticipated investment. With a first year revenue projection of $84,700 and operating costs of $84,000, the operating income would be only $700. In future years, the income improves but would still be inadequate to repay an investment of $367,000 by the City.

As power costs escalate, the cash flow levels would increase. However, the project will not pay an acceptable return on the proposed capital investment of the City, even through the 20th year. The project would offer more favorable returns if: (A) PacifiCorp power purchase rate were to be higher; and/or (B) the project could generate revenue from the sale of Green Energy Credits; and/or (C) the operating and maintenance cost would be lower. The largest operating cost element is for cooling water supply and disposal.

Project Financial Performance (All Values in $000's)					
Year	2012	2016	2021	2026	2031
Revenue	84.7	120.0	134.1	139.3	158.8
Fixed O&M	40.0	45.0	52.2	60.5	70.1
Variable O&M	28.0	31.5	36.5	42.4	49.1
G&A	16.0	18.0	20.8	24.2	28.0
Tot. O&M & G&A	84.0	94.5	109.6	127.0	147.3
Operating Income	0.7	25.5	24.5	12.3	11.5
Internal Rate of Return		**-31.7**	**-8.9-**	**-3.2**	**-1.0**

A detailed financial projection for the PureCycle option may be found in Attachment A.

9. Single 350 kW Magnetic Bearing Turbine/Generator Module

The initial idea behind implementing the magnetic bearing turbine/generator system was that it would increase efficiency and decrease cost. This proposed system represents a potential improvement to the current state of the art through use of a high speed direct-drive generator, eliminating the need for gearing and reducing maintenance costs. The proposed system would also be designed to operate at part load conditions, providing greater power generation potential than the UTC unit which operates only at or near full load. Projected capital costs for the magnetic bearing generator turned out to be higher than anticipated because of the need for a custom built refrigerant turbine and the uncertainty of costs to assemble a custom power module. In particular, it has been difficult to obtain firm quotes for the cost of refrigerant heat exchangers.

The preliminary capital cost estimate totals about $1.9 million.

Brian Brown Engineering has estimated the annual net power production to be in the range of 1,750 megawatt-hours per year. The annual revenue generated is estimated at nearly $105,000.

9a. Capital Cost Estimate-350 kW Magnetic Bearing Turbine/Generator Module

A preliminary estimate of the cost to develop and construct the project with the magnetic bearing turbine/ generator module has been completed. These costs include the permitting, engineering and contract applications and negotiations necessary to place the system in service.

The estimated cost of the generator module was based on estimates of the engineering and design cost of the module, cost of various turbine, generator, heat exchanger and control components and assembly costs. Since this would be a single-unit, custom design, the costs may be higher than that associated with the purchase of a commercially produced module (such as the PureCycle unit). The potential for improved performance and equipment longevity prompted the investigators to pursue this option.

A summary of these capital cost estimates is presented below.

CAPITAL COST ESTIMATES	
Technical Feasibility Study	40,000
Financial Feasibility Study	36,000
ODOE BETC Application Fee	6,000
PacifiCorp Interconnection Fee	1,000
Travel	8,000
Administrative Costs	5,000
Feasibility Study & Development Costs	**$96,000**
Engineering (civil, electrical & mech.)	120,000
Purchasing & Project Management	100,000
Site civil work; Building	200,000
320 kW module (x1), del.& inst.	600,000
Cooling tower & installation	120,000
Geothermal Heat Exchangers	0
Piping materials & installation	175,000
Control systems; safety monitoring	30,000
Electrical panel, wiring, 480 v svc	180,000
PP&L Interconnection	50,000
Spare Parts	20,000
Contingency	200,000
Interest during construction	0
Insurance during construction	4,000
Design & Construction Costs	**$1,799,173**
TOTAL FUNDS REQUIRED:	**$1,895,173**

Without detailed design work, it will be difficult to obtain firm construction quotations.

9b. Estimated Power Sales-350 kW Magnetic Bearing Turbine/Generator Module

Brian Brown Engineering has prepared a projection of the expected net power production for the project. This analysis takes into account the power needed to operate the geothermal pumps when needed for thermal applications, and the additional operation when they otherwise would not operate, except for power production. In addition, the power required for operating the circulating water pumps and cooling tower needed solely for power production has been reduced from the total.

The power generated by the project will first offset the power used in the pumping of geothermal fluid and operation of the heat exchanger building. The additional power generated will be sold to Pacific Power & Light Company under a long term power sales agreement. Shown below is the projected net power production estimate:

OPERATING PROJECTION	Year 1
Net Gross Plant Output Average, kW	317.6
Capacity Factor	89%
Annual Power Generated, MWh	2,642
Less Cooling Tower Pump Load, MWh	-224
Less Cooling Tower Fan Load, MWh	-150
Less Geothermal Pumping Load, MWh	-438
Plus Geothermal Baseline Pumping, MWh	291
Net Annual Power Generated, MWh	**2,121**

9c. Revenue Projection-350 kW Magnetic Bearing Turbine/Generator Module

For moderate quantities of power generation such as this, the serving utility represents the only viable purchaser. A portion of the power generated is valued based on the current retail rate at the City's electric service at the heat exchanger building. The remaining portion will be valued based on the filed utility avoided costs approved by the Oregon Public Utilities Commission.

Currently, the City is paying about 8.0 cents per kilowatt-hour for power at the building. This is what they will save as they generate power to offset those purchases. For the remaining portion of power generated, the project will earn about 5.2 cents per kilowatt-hour during 2012. This rate is calculated based on the melded value of peak and off-peak power purchased by Pacific Power and Light Company. The project will also produce Renewable Energy Credits (RECs) which would be transferred to the Energy Trust of Oregon pursuant to an agreement associated with an incentive payment. The revenue projections are shown below:

REVENUE	Year 1
POWER OFFSET:	
Retail Power Purchases Offset, MWh	100
Retail Power Rate, $/MWh	80.00
Subtotal, Value of Power Offset	$8,016
POWER SALES:	
Wholesale Power to Sell, MWh	2,020
Wholesale Power Rate, $/MWh	52.00
Subtotal, Value of Wholesale Power	$105,022
RENEWABLE ENERGY CREDIT SALES:	
Credits to Sell, RECs	2,020
REC Rate, $/REC	0.00
Subtotal, Value of RECs	$0.00
Total Revenue	**$113,038**

The value of offset power used at the site is estimated at $8,000. The net average power rate during this period is 8.0 cents per kilowatt-hour. The proposed plant will produce

approximately 15 times the amount of power used at the heat exchanger building during the past year. The majority of the power generated will be sold at PP&L's avoided cost, indicated by their current Schedule 37. These contractual prices are noted below:

PP&L Avoided Cost Purchase Rates, Schedule 37					
Year	2012	2013	2014	2015	2016
On-Peak ($/kWh)	5.87	6.14	7.96	8.16	8.39
Off-Peak ($/kWh)	4.36	4.50	6.10	6.27	6.46
Weight. Avg. ($/kWh)	**5.20**	**5.41**	**7.13**	**7.32**	**7.53**
Year	2017	2018	2019	2020	2021
On-Peak ($/kWh)	8.60	8.87	8.76	8.85	9.33
Off-Peak ($/kWh)	6.65	6.87	6.74	6.79	7.23
Weight. Avg. ($/kWh)	**7.73**	**7.98**	**7.86**	**7.93**	**8.39**

The revenue to be derived from the proposed project will be the sum of the value of power not purchased from Pacific Power & Light ($8,000), the value of the remaining amount of power (2,020 MWh) times the weighted average yearly price ($105,022), and the value of the renewable energy credits sold ($0.00).

The total revenue expected if complete and operating during 2012 will be about $113,038.

9d. Operating Cost Projection-350 kW Magnetic Bearing Turbine/Generator Module

The operating costs for the single-magnetic bearing turbine generator project are expected to be modest. The routine operating and maintenance costs appear to be similar to those associated with the operation of the PureCycle unit. It will normally operate un-manned with daily inspections. Routine tests and fluid replenishments should be the only operating necessity. The cost of operating the cooling tower will be similar to that of other modules.

The long-term major maintenance cost should be lower than those of the UTC module, since there will be no gearbox and the high speed system would operate on magnetic bearings. This will eliminate the need for routine and long-term maintenance work on the gearbox.

The following table presents the anticipated operating and maintenance cost projections:

OPERATING EXPENSE PROJECTIONS		Year 1
FIXED O&M:		
Salaries & OH-Operations		12,000
Salaries & OH-Management		0
Routine Repairs & Maint.		6,000
Major Maintenance Reserve		10,000
Remote Monitoring		4,000
PP&L Meter /Testing		3,000
Subtotal, Fixed O&M		$35,000
VARIABLE O&M:		
Supplies/consumables		4,000
Water Supply & Disposal		28,400
Subtotal, Variable O&M		$32,400
Total, Operations & Maintenance		**$67,400**
GENERAL & ADMINISTRATIVE:		
Legal/Audit		2,000
Property Tax	0.0%	0
Insurance	0.5%	9,475
General & Admin. Expense		6,000
Total, General & Administrative		**$17,475**
Total O&M and G&A		**$84,875**

The labor required to inspect and maintain the system is expected to be minimal, requiring only occasional inspections and routine maintenance of the cooling tower.

No precise projections of major maintenance can be made. However, existing refrigeration units using the magnetic bearing motor have experienced extended life and minimal maintenance requirements. A conservative estimate would be that some maintenance on the power train will be required at five year intervals, budgeted to be about $50,000.

Remote monitoring by local support personnel is expected to cost $4,000 per year.

Pacific Power & Light Company requires that the meter and protection equipment be tested on regular intervals. These expenses will be required under their interconnection agreement, but may be reduced as they become routine and the testing intervals are extended.

Water and water disposal services from the city for the cooling tower makeup is estimated to be $28,400 yearly. This is based upon an estimated purchase of 13,672 hundred cubic feet (ccf) at a cost of $1.50 per ccf and a disposal of 2,670 ccf at a cost of $2.92 per ccf.

9e. Sources of Financing and Incentives-350 kW Turbine/Generator Module

A project of this magnitude and cost may be financed in a number of ways and structures. The City has access to low cost bond financing but has limited interest in adding to its debt. The City has considered financing the project with either municipal bonding authority or the Oregon Department of Energy's Small Energy Loan Funds. Neither appears to be attractive to the City at this time.

Third party private ownership and financing may be considered, which would enable the use of federal tax credits and depreciation benefits. Such a financial structure could take the form of a lease transaction or a partnership in which the private taxpayer-owner could own the facility for a fixed number of years, after which the facility ownership would be turned over to the City for its long-term operation.

Third party financing is a viable alternative which would enable the City to limit its debt liability and reduce its risk associated with the project. This transaction structure would also increase the overall cost of the project (due to legal and contractual costs) but may reduce the direct capital cost to the city. It would also reduce the City's control of the asset and the associated maintenance activities. This structure also adds complexity to the overall project evaluation.

During the period of time in which this study has been completed, the Oregon Business Energy Tax Credit has been partially phased out. This incentive has for a number of years provided needed financial support for renewable energy projects. Without this option, the project is even more economically questionable.

For these reasons, detailed review and consideration of alternative private ownership structures has not been evaluated. If the incentives for renewable projects become available at a point in the future, the project may be evaluated again at a later time.

With the assumption that the project will be owned and operated by the City, the following estimates of capital sources are assumed:

Potential Sources of Funds (All Values in $000's)	
TOTAL FUNDS REQUIRED:	**1,895**
ODOE Feasibility Grant; City Study	36
Energy Trust of Oregon Feasibility Grant	15
USDOE Geothermal Grant	816
Oregon BETC (33.5% of non-Fed $)	362
Energy Trust of Oregon Incentive	100
Blue Sky Program Incentive	0
Klamath Falls Cash Contribution	567
TOTAL FUNDS SUPPLIED:	**1,895**

9f. Financial Projections-350 kW Magnetic Bearing Turbine/Generator Module

Based on the projections for revenue and expense, it appears that the proposed single magnetic bearing turbine / generator 320 kW project yields inadequate returns to represent an attractive return of the anticipated investment to the City. With a first-year revenue projection of $113,038 and operating costs of $84,875, the operating income of $28,163 would be inadequate to be attractive to the City, based on its investment of the $567,000. As power costs escalate, the cash flow levels would increase, resulting in a positive rate of return after the 10th year.

The project would offer more favorable returns if: (A) if the revenue from power sales were higher; and/or (B) the construction cost could be lower; and/or (C) the operating and maintenance cost (specifically water and water disposal costs) would be lower.

Project Financial Performance (All Values in $000's)					
Year	2012	2016	2021	2026	2031
Revenue	113.0	161.1	179.9	186.4	212.4
Fixed O&M	35.0	39.4	45.7	52.9	61.4
Variable O&M	32.4	36.5	42.3	49.0	56.8
G&A	17.5	19.7	22.8	26.4	30.6
Tot. O&M & G&A	84.9	95.5	110.7	128.4	148.8
Operating Income	28.2	65.6	69.2	58.0	63.6
Internal Rate of Return:		**-20.2%**	**0.5%**	**5.9%**	**7.9%**

A detailed financial projection for the single magnetic bearing turbine/generator module option may be found in Attachment B.

10. 700 kW Magnetic Bearing Turbine/Generator Module

The concept of building a module that would utilize two magnetic bearing turbine / generators arose when it was learned that the standard size 400 kW magnetic motor-generator could only be rated to operate at 350 kW in the mode we are considering. For this reason, and recognizing that there is an adequate geothermal resource available to operate a power plant at 700 kW, this option had the potential of being cost effective.

The idea behind implementing the magnetic bearing turbine / generator is that it would increase efficiency and decrease operating cost. A potential improvement to the current state of the art for this technology by the proposed plan is that the high speed generator would eliminating the need for a gear box, reducing lubricating oil use and long-term maintenance costs. This module would also be designed to operate at part load conditions when only a portion of the geothermal water supply is available. Since the UTC unit only operates when there is a full supply of geothermal heat available, there are periods when the plant would have to be shut down, even though there may be a partial supply of geothermal heat available.

The investigators learned that the turbine-generator would require a custom designed and constructed turbine wheel which added significantly to the total estimated cost of the proposed module. As a result, the proposed 700 kW project became too expensive to be attractive to the City.

The preliminary capital cost estimate totals about $2.64 million.

Brian Brown Engineering estimated the annual net power production to be in the range of 3,700 megawatt-hours per year. The first year annual revenue is estimated at $194,000.

10a. Capital Cost for a 700 kW Magnetic Bearing Turbine/Generator Module

A preliminary estimate of the cost to develop and construct the project with the two magnetic bearing turbine / generators has been completed. These costs include the permitting, engineering and contract applications and negotiations necessary to place the system in service. A summary of these costs is presented below.

CAPITAL COST ESTIMATES	
Technical Feasibility Study	40,000
Financial Feasibility Study	36,000
ODOE BETC Application Fee	6,000
PacifiCorp Interconnection Fee	1,000
Travel	8,000
Administrative Costs	5,000
Feasibility Study & Development Costs	**$96,000**
Engineering (civil, electrical & mech.)	140,000
Purchasing & Project Management	100,000
Site civil work; Building	250,000
320 kW module (x2), del.& inst.	900,000
Cooling tower & installation	240,000
Geothermal Heat Exchangers	0
Piping materials & installation	225,000
Control systems; safety monitoring	50,000
Electrical panel, wiring, 480 v svc	240,000
PP&L Interconnection	75,000
Spare Parts	20,000
Contingency	300,000
Interest during construction	0
Insurance during construction	4,000
Design & Construction Costs	**$2,544,160**
TOTAL FUNDS REQUIRED:	**$2,640,160**

These cost estimates are based on budget quotes obtained for the purchase of key components, engineering and fabrication. Until detailed design work has been completed, it will be difficult to obtain more precise and firm construction quotations.

10b. Estimated Power Production from a 700 kW Turbine/Generator Module

Brian Brown Engineering has prepared a projection of the expected net power production for the proposed twin-turbine project. This analysis takes into account the power needed to operate the geothermal pumps when needed for thermal applications and the additional operation when they otherwise would not operate, except for power production. In addition, the power required for operating the circulating water pumps and cooling tower needed solely for power production has been reduced from the total.

The power generated by the project will first offset the power used in the pumping of geothermal fluid and operation of the heat exchanger building. The additional power generated will be sold to Pacific Power & Light Company under a long term power sales agreement.

OPERATING PROJECTION	Year 1
Net Gross Plant Output Average, kW	604
Operating Hours:	95%
Annual Gross Power Generated, MWh	5,026
Less Cooling Tower Pump Load, MWh	-551
Less Cooling Tower Fan Load, MWh	-293
Less Geothermal Pumping Load, MWh	-730
Plus Geothermal Baseline Pumping, MWh	291
Net Annual Power Generated, MWh	**3,743**

10c. Revenue Projection from a-700 kW Magnetic Bearing Turbine/Generator Module

For moderate quantities of power generation such as this, the serving utility represents the only viable purchaser. A portion of the power is valued based on the current retail rate at the City's electric service at the heat exchanger building. The remaining portion will be valued based on the avoided costs approved by the Oregon Public Utilities Commission. Currently, the City is paying about 8.0 cents per kilowatt-hour for power at the building. This is what they will save as they generate power to offset those purchases. For the remaining portion of power generated, they will be paid about 5.2 cents per kilowatt-hour in the first year. This rate is calculated based on the melded value of peak and off-peak power purchased by Pacific Power. The project will also produce Renewable Energy Credits (RECs) which would be transferred to the Energy Trust of Oregon. The revenue projections are shown below:

REVENUE	Year 1
POWER OFFSET:	
Retail Power Purchases Offset, MWh	100
Retail Power Rate, $/MWh	80.00
Subtotal, Value of Power Offset	$8,016
POWER SALES:	
Wholesale Power to Sell, MWh	3,643
Wholesale Power Rate, $/MWh	52.0
Subtotal, Value of Wholesale Power	$189,451
RENEWABLE ENERGY CREDIT SALES:	
Credits to Sell, RECs	3,643
REC Rate, $/REC	0.00
Subtotal, Value of RECs	$0.00
Total Revenue	**$197,467**

The value of offset power used at the site is estimated at $8,000.

The net average power rate during this period is 8.0 cents per kilowatt-hour. The proposed plant will produce approximately 36 times the amount of power used at the heat exchanger building during the past year. The majority of the power generated will be sold at PP&L's avoided cost, indicated by their current Schedule 37. These contractual prices are noted below:

PP&L Avoided Cost Purchase Rates, Schedule 37					
Year	2012	2013	2014	2015	2016
On-Peak ($/kWh)	5.87	6.14	7.96	8.16	8.39
Off-Peak ($/kWh)	4.36	4.50	6.10	6.27	6.46
Weight. Avg. ($/kWh)	**5.20**	**5.41**	**7.13**	**7.32**	**7.53**
Year	2017	2018	2019	2020	2021
On-Peak ($/kWh)	8.60	8.87	8.76	8.85	9.33
Off-Peak ($/kWh)	6.65	6.87	6.74	6.79	7.23
Weight. Avg. ($/kWh)	**7.73**	**7.98**	**7.86**	**7.93**	**8.39**

The revenue to be derived from the proposed project, then will be the sum of the value of power not purchased from Pacific Power & Light ($8,000), the value of the remaining amount of power (3,643 MWh) times the weighted average yearly price of $5.20 ($189,451), and the value of the renewable energy credits sold ($0.00).

The total revenue expected in the first 12 months of operation will be about $197,467.

10d. Operating Cost Projection-700 kW Magnetic Bearing Turbine/Generator Module

The labor required to inspect and maintain the system is expected to be minimal, requiring only occasional inspections and routine maintenance of the cooling tower.

No precise projections of major maintenance can be made. However, existing refrigeration units using the magnetic bearing motor have experienced long service intervals, and minimal long-term maintenance requirements. A conservative estimate would be that some maintenance on the power train will be required at five year intervals, budgeted to be about $100,000.

Remote monitoring by local support personnel is expected to cost $4,000 per year.

Pacific Power & Light Company requires that the meter and protection equipment be tested on regular intervals. These expenses will be required under their interconnection agreement, but may be reduced as they become routine and the testing intervals are extended.

Water and water disposal services from the city for the cooling tower makeup is estimated to be $57,500 yearly. This is based upon an estimated purchase of 27,658 hundred cubic feet (ccf) at a cost of $1.50 per ccf and a disposal of 5,532 ccf at a cost of $2.92 per ccf.

OPERATING EXPENSE ASSUMPTIONS		Year 1
FIXED O&M:		
Salaries & OH-Opns		12,000
Salaries & OH-Mgmt		0
Routine Repairs & Maint		6,000
Major Maintenance Reserve		20,000
Remote Monitoring		4,000
PP&L Meter /Testing		3,000
Subtotal, Fixed O&M		$45,000
VARIABLE O&M:		
Supplies/consumables		4,000
Water Supply & Disposal		57,500
Subtotal, Variable O&M		$61,500
Total, Operations & Maintenance		**$106,500**
GENERAL & ADMINISTRATIVE:		
Legal/Audit		2,000
Property Tax	0.0%	0
Insurance	0.5%	13,201
General & Admin. Expense		6,000
Total, General & Administrative		**$21,201**
Total O&M and G&A		**$127,701**

10e. Sources of Financing and Project Incentives-700 kW Turbine / Generator Module

A project costing upwards of $2.6 million may be financed in a number of ways and structures. The City has access to low cost bond financing but has limited interest in adding to its debt. The City has considered financing the project with either municipal bonding authority or the Oregon Department of Energy's Small Energy Loan Funds. Neither appears to be attractive to the City at this time.

Third party private ownership and financing may be considered, which would enable the use of federal tax credits and depreciation benefits. Such a financial structure could take the form of a lease transaction or a partnership in which the private taxpayer-owner could own the facility for a fixed number of years, after which the facility ownership would be turned over to the City for its long-term operation.

Third party financing is a viable alternative which would enable the City to limit its debt liability and reduce its risk associated with the project. This transaction structure would also increase the overall cost of the project (due to legal and contractual costs), but may reduce the direct capital cost to the city. It would also reduce the City's control of the asset and the associated maintenance activities. This structure also adds complexity to the overall project evaluation.

During the period of time in which this study has been completed, the Oregon Business Energy Tax Credit has been partially phased out. This incentive has for a number of years provided needed financial support for renewable energy projects. Without this option, the project is even more economically questionable.

For these reasons, detailed review and consideration of alternative private ownership structures has not been evaluated. If the incentives for renewable projects become available at a point in the future, the project may be evaluated again at a later time.

With the assumption that the project would be owned and operated by the City, the following estimates of capital sources are assumed:

Potential Sources of Funds (All Values in $000's)	
TOTAL FUNDS REQUIRED:	**2,640**
ODOE Feasibility Grant; City Study	36
Energy Trust of Oregon Feasibility Grant	15
USDOE Geothermal Grant	816
Oregon BETC (33.5% of non-Fed $)	611
Energy Trust of Oregon Incentive	100
Blue Sky Program Incentive	0
Klamath Falls Cash Contribution	1,062
TOTAL FUNDS SUPPLIED:	**2,640**

10f. Financial Projections-700 kW Magnetic Bearing Turbine/Generator Module

Based on the projections for revenue and expense, it appears that the proposed 700 kW magnetic bearing turbine/generator project yields inadequate returns to support repayment of the anticipated investment, whether financed with debt or cash. With a first-year revenue projection of $197,467 and operating costs of $127,700, the operating income of $69,767 would be inadequate to return much of the $1,062,000 of capital required by the city. As power costs escalate, the cash flow levels would increase. However, the project will still not result in a positive internal rate of return before the 9th year. After 15 years, the projected returns are around 8%.

The project would offer more favorable returns if: (A) If the utility power purchase rate were higher; and/or (B) the construction cost could be lower; and/or (C) the operating and maintenance cost (including water supply and disposal) would be lower.

Project Financial Performance (All Values in $000's)					
Year	2012	2016	2021	2026	2031
Revenue	197.4	283.4	316.1	326.5	371.8
Fixed O&M	45.0	50.6	58.7	68.1	78.9
Variable O&M	61.5	69.2	80.2	93.0	107.8
G&A	21.2	23.9	27.7	32.1	37.2
Tot. O&M & G&A	127.7	143.7	166.6	193.2	223.9
Operating Income	69.7	139.6	149.5	133.4	147.9
Internal Rate of Return:		**-16.9%**	**3.1%**	**8.2%**	**10.1%**

A detailed financial projection may be found in Attachment C.

11. System Comparisons

The following charts summarize the capital costs, power sales, revenue, operating costs, sources of financing, and financial projections associated with the three power plant options at the Klamath Falls site:

11a. Capital Cost Estimates

CAPITAL COST ESTIMATES	PureCycle 280 kW	Magnetic Bearing T/G 320 kW	Magnetic Bearing T/G 640 kW
Technical Feasibility Study	40,000	40,000	40,000
Financial Feasibility Study	36,000	36,000	36,000
ODOE BETC Application Fee	6,000	6,000	6,000
PacifiCorp Interconnection Fee	1,000	1,000	1,000
Travel	8,000	8,000	8,000
Administrative Costs	5,000	5,000	5,000
Feasibility Study & Development Costs	**96,000**	**96,000**	**96,000**
Engineering (civil, electrical & mech.)	100,000	120,000	140,000
Purchasing & Project Management	60,000	100,000	100,000
Site civil work; Building	200,000	200,000	250,000
280 kW module, del.& inst.	360,000	600,000	900,000
Cooling tower & installation	120,000	120,000	240,000
Geothermal Heat Exchangers	0	0	0
Piping materials & installation	175,000	175,000	225,000
Control systems; safety monitoring	30,000	30,000	50,000
Electrical panel, wiring, 480 v svc	180,000	180,000	240,000
PP&L Interconnection	50,000	50,000	75,000
Spare Parts	20,000	20,000	20,000
Contingency	200,000	200,000	300,000
Interest during construction	0	0	0
Insurance during construction	4,000	4,000	4,000
Design & Construction Costs	**1,499,078**	**1,799,173**	**2,544,160**
TOTAL FUNDS REQUIRED:	**1,595,078**	**1,895,173**	**2,640,160**

11b. Estimated Power Sales Volumes

OPERATING PLAN (Year 1)	PureCycle 280kw	Magnetic Bearing T/G 350 kW	2 X Magnetic Bearing T/G 700 kW
Gross Plant Output Average, kW	273	317	604
Operating hours:	82%	95%	95%
Annual Gross Power Generated, MWh	1,961	2,641	5,026
Less Cooling Tower Pump Load, MWh	-183	-224	-551
Less Cooling Tower Fan Load, MWh	-106	-150	-293
Less Geothermal Pumping Load, MWh	-322	-438	-730
Plus Baseline Pumping, MWh	224	291	291
Net Annual Power Generated, MWh	**1,574**	**2,120**	**3,743**

11c. Revenue Projections

REVENUE (Year 1)	PureCycle 280kw	Magnetic Bearing T/G 350 kW	2 X Magnetic Bearing T/G 700 kW
POWER OFFSET:			
Retail Power Purchases Offset, MWh	100	100	100
Retail Power Rate, $/MWh	80.00	80.00	80.00
Subtotal, Value of Power Offset	8,016.00	8,016.00	8,016.00
POWER SALES:			
Wholesale Power to Sell, MWh	1,474	2,020	3,643
Wholesale Power Rate, $/MWh	52.0	52.0	52.0
Subtotal, Value of Wholesale Power	$76,638	$105,022	$189.451
RENEWABLE ENERGY CREDIT SALES:			
Credits to Sell, RECs	1,474	2,020	3,643
REC Rate, $/REC	0.00	0.00	0.00
Subtotal, Value of RECs	$0.00	$0.00	$0.00
Total Revenue	**$84,654**	**$113,038**	**$197,467**

11d. Operating Cost Projections

OPERATING EXPENSE ASSUMPTIONS (Year 1)		PureCycle 280kw	Magnetic Bearing T/G 350 kW	Magnetic Bearing T/G 700 kW
FIXED O&M:				
Salaries & OH-Operations		12,000	12,000	12,000
Salaries & OH-Mgmt		0	0	0
Routine Repairs & Maint		6,000	6,000	6,000
Major Maintenance Reserve		15,000	10,000	20,000
Remote Monitoring		4,000	4,000	4,000
PP&L Meter /Testing		3,000	3,000	3,000
Subtotal, Fixed O&M		40,000	35,000	45,000
VARIABLE O&M:				
Supplies/Consumables		4,000	4,000	4,000
Water Supply & Disposal		24,000	28,400	57,500
Subtotal, Variable O&M		28,000	32,400	61,500
Total, Operations & Maintenance		**68,000**	**73,400**	**106,500**
GENERAL & ADMINISTRATIVE:				
Legal/Audit		2,000	2,000	2,000
Property Tax	0.0%	0	0	0
Insurance	0.5%	7,975	9,475	13,201
General & Admin. Expense		6,000	6,000	6,000
Total, General & Administrative		**15,975**	**17,475**	**21,201**
Total O&M and G&A		**83,975**	**84,875**	**127,700**

11e. Sources of Financing and Project Incentives

Potential Sources of Funds (All Values in $000's)	PureCycle 280kw	Magnetic Bearing T/G 350kW	Magnetic Bearing T/G 700 kW
TOTAL FUNDS REQUIRED:	**1,595**	**1,895**	**2,640**
	0	0	0
ODOE Feasibility Grant; City Study	36	36	36
Energy Trust of Oregon Feasibility Grant	15	15	15
USDOE Geothermal Grant	816	816	816
Oregon BETC (33.5%)	261	362	611
Energy Trust of Oregon Incentive	100	100	100
Blue Sky Program Incentive	0	0	0
Klamath Falls Cash Contribution	367	567	1,062
TOTAL FUNDS SUPPLIED:	**1,595**	**1,895**	**2,640**

11f. Financial Projections

	Project Financial Performance (All Values in $000's Except IRR)						
	Capital Cost	Year	2012	2016	2021	2026	2031
PureCycle 280kw	$1,595,000	Operating Income	0.7	25.5	24.5	12.3	11.5
		IRR,%:		**-31.7**	**-8.9**	**-3.2**	**-1.0**
Magnetic Bearing T/G 350kW	$1,895,000	Operating Income	28.2	65.6	69.2	58.0	63.6
		IRR, %:		**-20.2**	**0.5**	**5.9**	**7.9**
Magnetic Bearing T/G 700 kW	$2,640,000	Operating Income	69.8	139.6	149.5	133.4	147.9
		IRR, %:		**-16.9**	**3.1**	**8.2**	**10.1**

12. Conclusions and Recommendations

The city of Klamath Falls operates a geothermal district heating system which would appear to be an attractive opportunity to install a power generation system. Since the two wells have operated reliably and consistently over many years, no new sources or resource exploration would be necessary.

It appears that it will cost more to construct, operate, maintain and amortize a proposed geothermal facility than the long-term value of the power it would produce. The success of a future project will be determined by whether utility power production costs will remain low and whether costs of construction, operations, or financing may be reduced.

There are areas that it would be possible to reduce construction cost. More detailed design could enable the city to obtain more precise quotes for components and construction, resulting in reduction in contingency projections. The current level of the contingency for uncertainty of costs is between $200,000 and $300,000.

Another key issue with this project appears to be operation cost. While it is expected that only minimal routine monitoring and operating expenses will occur, the cost of water supply and waste water disposal represents nearly one quarter of the value of the power. If the cost of water alone could be reduced, the project could become viable. In addition, the projected cost of insurance may be lower than estimated under a city-wide policy.

No provisions have been made for utilization of federal tax incentives. If a transaction with a third-party owner/taxpayer were to be negotiated, perhaps the net cost of ownership could be reduced.

It is recommended that these options be investigated to determine if the costs and benefits could be brought together. The project has good potential, but like many alternative energy projects today, they only work economically if the federal tax incentives come into play.

Financial Projection for Pratt & Whitney PureCycle 280 kW Plant at the City of Klamath Falls

7/5/2011 15:22

SCHEDULE & MILESTONES ASSUMPTION

Decision to Proceed	Jan-11
Complete Engineering and Permitting	Mar-11
Order Equipment & Initiate Construction	Mar-11
Complete Construction and Startup	Dec-11

CAPITAL COST ESTIMATES

	SUBTOTAL, $000	
Technical Feasibility Study	40	
Financial Feasibility Study	36	
ODOE BETC Application Fee	6	
PacifiCorp Interconnection Fee	1	
Travel	8	
Administrative Costs	5	
Feasibility Study & Development Costs		$96
Engineering (civil, electrical & mech.)	100	
Purchasing & Project Management	60	
Site civil work; Cooling tower structure	200	
280 kW module, del.& inst.	360	
Cooling tower & installation	120	
Geothermal Heat Exchangers	0	
Piping materials & installation	175	
Control systems; safety monitoring	30	
Electrical panel, wiring, 480 v svc	180	
PP&L Interconnection	50	
Spare Parts:	20	
Project contingency:	200	
Interest during construction	0	
Insurance during construction	4	
		$1,499
TOTAL FUNDS REQUIRED:		$1,595

SOURCES OF FUNDS

ODOE feasibility grant; city study			36
Energy Trust of Oregon, Feasibility Study			15
USDOE Geothermal Grant:			816
Oregon BETC	33.5%	779	261
Energy Trust of Oregon, Incentive			100
Blue Sky program			0
Klamath Falls Cash Contribution			367
TOTAL FUNDS SUPPLIED:			$1,595

OPERATING PLAN

	Year 1	Year 2
Operating Hours:	82.0%	82.0%
Gross Plant Output,Avg., kW:	273.0	273.0
Annual Energy Generated, MWh:	1,961	1,961
Less Cooling Tower Pump Ld, MWh:	-183	-183
Less Cooling Tower Fan Ld, MWh:	-106	-106
Less Geothermal Pumping Ld, MWh:	-322	-322
Plus Baseline Pumping:MWh:	224	224
Annual power prod., MWh:	1,574	1,574

REVENUE

Retail Pwr Purchase offset, mWh:	100.2	100.2
Retail power rate, $/mWh:	$80.00	$82.40
Value of power offset:	$8,016	$8,256
Wholesale power to sell, mWh:	1,473.8	1,473.8
Wholesale power rate:	$52.00	$54.10
Value of wholesale power:	$76,638	$79,733
Total Revenue:	$84,654	$87,990

OPERATING AND OWNERSHIP EXPENSES

FIXED OPERATIONS & MAINTENANCE			
Salaries & OH-Opns @:		12,000	12,360
Routine Repairs & Maint		6,000	6,180
Major Maintence Reserve		15,000	15,450
Remote Monitoring		4,000	4,120
PP&L Meter /Testing		3,000	3,090
Total Fixed O&M:		**$40,000**	**$41,200**
VARIABLE OPERATIONS & MAINTENANCE			
Supplies/consumables		4,000	4,120
Water Supply & Disposal		24,000	24,720
		$28,000	**$28,840**
GENERAL AND AMINISTRATIVE EXPENSES			
Legal/Audit		2,000	2,060
Property Tax	0.0%	0	0
Insurance	0.5%	7,975	8,214
Management & Supervisory Expense		6,000	6,180
Total, General & Administrative:		**$15,975**	**$16,454**
TOTAL O&M and G&A:		**$83,975**	**$86,494**
Operating Income:		**$679**	**$1,496**

INFLATION ASSUMPTIONS

PP&L Retail	PP&L Whsl	General Inflaton
3.00%	3.00%	3.00%

RESULTS i n s x ac

Project Financial Performance

	yr 5	yr 10	yr 15	yr 20	yr 25
Revenue	120.0	134.1	139.3	158.8	184
Fixed O&M	45.0	52.2	60.5	70.1	81
Variable O&M	31.5	36.5	42.4	49.1	57
Admin. Exp.	18.0	20.8	24.2	28.0	32
Tot. Expenses	94.5	109.6	127.0	147.3	171
Oper Income	25.5	24.5	12.3	11.5	13

Cash flow Sensitivity

	5 yr IRR	10 yr IRR	15 yr IRR	20 yr IRR	25 yr IRR
Contingency	-31.7%	-8.9%	-3.2%	-1.0%	0.6%
$5	-23.2%	-2.0%	2.9%	4.5%	5.6%
$50	-25.6%	-4.0%	1.2%	3.0%	4.2%
$100	-27.9%	-5.8%	-0.5%	1.5%	2.9%
$150	-29.9%	-7.5%	-1.9%	0.2%	1.7%
$250	#NUM!	-10.3%	-4.3%	-2.0%	-0.3%
Major Maint	-31.7%	-8.9%	-3.2%	-1.0%	0.6%
$5,000	-24.0%	-2.6%	3.0%	5.2%	6.4%
$10,000	-27.7%	-5.5%	0.2%	2.5%	3.9%
$12,000	-29.2%	-6.8%	-1.1%	1.2%	2.7%
$20,000	#NUM!	-13.0%	-7.7%	-6.5%	-5.1%
Water	-31.7%	-8.9%	-3.2%	-1.0%	0.6%
$5,000	-18.2%	2.1%	7.2%	9.1%	10.1%
$10,000	-21.3%	-0.4%	5.0%	7.0%	8.2%
$20,000	-28.4%	-6.2%	-0.4%	1.9%	3.3%
Oper Hrs	-31.7%	-8.9%	-3.2%	-1.0%	0.6%
85.0%	-29.0%	-6.2%	-0.4%	1.8%	3.3%
88.0%	-26.6%	-3.9%	1.8%	4.0%	5.4%
91.0%	-24.3%	-1.8%	3.8%	5.9%	7.1%
94.0%	-22.3%	0.1%	5.5%	7.5%	8.6%
Ret Pwr Rate	-31.7%	-8.9%	-3.2%	-1.0%	0.6%
$80	-31.7%	-8.9%	-3.2%	-1.0%	0.6%
$85	-31.3%	-8.6%	-2.8%	-0.6%	1.0%
$90	-30.9%	-8.2%	-2.4%	-0.2%	1.4%
ETO Incent.	-31.7%	-8.9%	-3.2%	-1.0%	0.6%
50	#NUM!	-10.6%	-4.6%	-2.2%	-0.4%
150	-29.3%	-7.0%	-1.5%	0.5%	2.0%
300	-17.5%	2.7%	6.9%	8.1%	8.8%

Financial Projection for Pratt & Whitney PureCycle 280 kW Plant at the City of Klamath Falls

7/5/2011 17:20

Year Number:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Year:		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Retail power offset (MWh)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Retail power price/MWh		80.0	82.4	84.9	87.4	90.0	92.7	95.5	98.4	101.3	104.4	107.5	110.7	114.1	117.5	121.0	124.6	128.4	132.2	136.2	140.3
Retail power value offset (1,000's)		8.02	8.26	8.50	8.76	9.02	9.29	9.57	9.86	10.15	10.46	10.77	11.10	11.43	11.77	12.12	12.49	12.86	13.25	13.65	14.06
Wholesale power sales, (MWh)		1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474	1,474
Wholesale power value/MWh		52.0	54.1	71.3	73.2	75.3	77.3	79.8	78.6	79.3	83.9	88.9	83.6	80.4	84.7	86.3	86.4	89.8	92.5	95.3	98.2
Wholesale power value (1,000's):		76.6	79.7	105.1	107.9	111.0	113.9	117.6	115.8	116.9	123.7	131.0	123.2	118.5	124.8	127.2	127.3	132.3	136.3	140.5	144.7
REVENUE ($ 000's except otherwise noted)																					
Retail power offset		8.0	8.3	8.5	8.8	9.0	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.8	12.1	12.5	12.9	13.2	13.6	14.1
Wholesale power sales:		76.6	79.7	105.1	107.9	111.0	113.9	117.6	115.8	116.9	123.7	131.0	123.2	118.5	124.8	127.2	127.3	132.3	136.3	140.5	144.7
Total Revenue:		**84.7**	**88.0**	**113.6**	**116.6**	**120.0**	**123.2**	**127.2**	**125.7**	**127.0**	**134.1**	**141.8**	**134.3**	**129.9**	**136.6**	**139.3**	**139.8**	**145.2**	**149.6**	**154.1**	**158.8**
OPERATING AND OWNERSHIP EXPENSES																					
FIXED OPERATIONS & MAINTENANCE																					
Salaries & OH-Opns @:		12.0	12.4	12.7	13.1	13.5	13.9	14.3	14.8	15.2	15.7	16.1	16.6	17.1	17.6	18.2	18.7	19.3	19.8	20.4	21.0
Routine Repairs & Maint		6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.1	8.3	8.6	8.8	9.1	9.3	9.6	9.9	10.2	10.5
Major Maintence Reserve		15.0	15.5	15.9	16.4	16.9	17.4	17.9	18.4	19.0	19.6	20.2	20.8	21.4	22.0	22.7	23.4	24.1	24.8	25.5	26.3
Remote Monitoring		4.0	4.1	4.2	4.4	4.5	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.7	5.9	6.1	6.2	6.4	6.6	6.8	7.0
PP&L Meter /Testing		3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.2	4.3	4.4	4.5	4.7	4.8	5.0	5.1	5.3
Total, Fixed O&M:		**40.0**	**41.2**	**42.4**	**43.7**	**45.0**	**46.4**	**47.8**	**49.2**	**50.7**	**52.2**	**53.8**	**55.4**	**57.0**	**58.7**	**60.5**	**62.3**	**64.2**	**66.1**	**68.1**	**70.1**
VARIABLE OPERATIONS & MAINTENANCE																					
Supplies/consumables		4.0	4.1	4.2	4.4	4.5	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.7	5.9	6.1	6.2	6.4	6.6	6.8	7.0
Water Supply & Disposal		24.0	24.7	25.5	26.2	27.0	27.8	28.7	29.5	30.4	31.3	32.3	33.2	34.2	35.2	36.3	37.4	38.5	39.7	40.9	42.1
Subtotal Variable O&M:		**28.0**	**28.8**	**29.7**	**30.6**	**31.5**	**32.5**	**33.4**	**34.4**	**35.5**	**36.5**	**37.6**	**38.8**	**39.9**	**41.1**	**42.4**	**43.6**	**44.9**	**46.3**	**47.7**	**49.1**
GENERAL &ADMINISTRATIVE EXPENSES																					
Legal/Audit		2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.5	2.5	2.6	2.7	2.8	2.9	2.9	3.0	3.1	3.2	3.3	3.4	3.5
Property Tax		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance		8.0	8.2	8.5	8.7	9.0	9.2	9.5	9.8	10.1	10.4	10.7	11.0	11.4	11.7	12.1	12.4	12.8	13.2	13.6	14.0
Management & Supervisory Expense		6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.1	8.3	8.6	8.8	9.1	9.3	9.6	9.9	10.2	10.5
Total, General & Administrative:		**16.0**	**16.5**	**16.9**	**17.5**	**18.0**	**18.5**	**19.1**	**19.6**	**20.2**	**20.8**	**21.5**	**22.1**	**22.8**	**23.5**	**24.2**	**24.9**	**25.6**	**26.4**	**27.2**	**28.0**
TOTAL O&M and G&A:		**84.0**	**86.5**	**89.1**	**91.8**	**94.5**	**97.4**	**100.3**	**103.3**	**106.4**	**109.6**	**112.9**	**116.2**	**119.7**	**123.3**	**127.0**	**130.8**	**134.8**	**138.8**	**143.0**	**147.3**
Operating Cash Flow:	**-367.0**	**0.7**	**1.5**	**24.5**	**24.9**	**25.5**	**25.9**	**26.9**	**22.4**	**20.7**	**24.5**	**28.9**	**18.1**	**10.2**	**13.3**	**12.3**	**9.0**	**10.5**	**10.8**	**11.1**	**11.5**
Net Present Value @:	8.0%	**-339.3**	**-338.1**	**-320.1**	**-303.1**	**-287.1**	**-272.0**	**-257.4**	**-246.2**	**-236.7**	**-226.1**	**-214.6**	**-208.0**	**-204.5**	**-200.3**	**-196.8**	**-194.3**	**-191.7**	**-189.2**	**-186.8**	**-184.5**
Net Present Value @:	6.0%	**-345.7**	**-344.4**	**-325.0**	**-306.4**	**-288.4**	**-271.2**	**-254.3**	**-241.1**	**-229.5**	**-216.6**	**-202.2**	**-193.8**	**-189.3**	**-183.7**	**-178.9**	**-175.5**	**-171.9**	**-168.3**	**-164.8**	**-161.4**
	IRR	**#NUM!**	**#NUM!**	**#NUM!**	**#NUM!**	**-31.7%**	**-23.9%**	**-18.1%**	**-14.4%**	**-11.6%**	**-8.9%**	**-6.5%**	**-5.2%**	**-4.6%**	**-3.8%**	**-3.2%**	**-2.7%**	**-2.2%**	**-1.8%**	**-1.4%**	**-1.0%**

EVERGREEN ENERGY

Attachment B: Financial Projections for a 350 kW Turbine/Generator Module

Financial Projection for Custom Magnetic Bearing T/G 350 kW Plant at the City of Klamath Falls

7/5/2011 17:37

SCHEDULE & MILESTONES ASSUMPTION

Decision to Proceed	Jan-11
Complete Engineering and Permitting	Mar-11
Order Equipment & Initiate Construction	Mar-11
Complete Construction and Startup	Dec-11

CAPITAL COST ESTIMATES	SUBTOTAL, $000	
Technical Feasibility Study	40	
Financial Feasibility Study	36	
ODOE BETC Application Fee	6	
PacifiCorp Interconnection Fee	1	
Travel	8	
Administrative Costs	5	
Feasibility Study & Development Costs		$96
Engineering (civil, electrical & mech.)	120	
Purchasing & Project Management	100	
Site civil work; Cooling tower structure	200	
320 kW module, design & install	600	
Cooling tower & installation	120	
Geothermal Heat Exchangers	0	
Piping materials & installation	175	
Control systems; safety monitoring	30	
Electrical panel, wiring, 480 v svc	180	
PP&L Interconnection	50	
Spare Parts:	20	
Project contingency:	200	
Interest during construction	0	
Insurance during construction	4	
		$1,799
TOTAL FUNDS REQUIRED:		$1,895

SOURCES OF FUNDS			
ODOE feasibility grant; city study			36
Energy Trust of Oregon, Feasibility Study			15
USDOE Geothermal Grant:			816
Oregon BETC	33.5%	1,079	361
Energy Trust of Oregon, Incentive			100
Blue Sky program			0
Klamath Falls Cash Contribution			567
TOTAL FUNDS SUPPLIED:			$1,895

OPERATING PLAN	Year 1	Year 2
Operating Hours:	95%	95%
Gross Plant Output,Avg., kW:	317.0	317.0
Annual Energy Generated, MWh:	2,641	2,641
Less Cooling Tower Pump Ld, MWh:	-224	-224
Less Cooling Tower Fan Ld, MWh:	-150	-150
Less Geothermal Pumping Ld, MWh:	-438	-438
Plus Baseline Pumping:MWh:	291	291
Annual power prod., MWh:	2,120	2,120

REVENUE	Year 1	Year 2
Retail Pwr Purchase offset, mWh:	100.2	100.2
Retail power rate, $/mWh:	$80.00	$82.40
Value of power offset:	$8,016	$8,256
Wholesale power to sell, mWh:	2,020	2,020
Wholesale power rate:	$52.00	$54.10
Value of wholesale power:	$105,022	$109,263
Total Revenue:	$113,038	$117,520

OPERATING AND OWNERSHIP EXPENSES			
FIXED OPERATIONS & MAINTENANCE			
Salaries & OH-Opns @:		12,000	12,360
Routine Repairs & Maint		6,000	6,180
Major Maintence Reserve		10,000	10,300
Remote Monitoring		4,000	4,120
PP&L Meter /Testing		3,000	3,090
Total Fixed O&M:		$35,000	$36,050
VARIABLE OPERATIONS & MAINTENANCE			
Supplies/consumables		4,000	4,120
Water Supply & Disposal		28,400	29,252
		$32,400	$33,372
GENERAL AND AMINISTRATIVE EXPENSES			
Legal/Audit		2,000	2,060
Property Tax	0.0%	0	0
Insurance	0.5%	9,475	9,759
Management & Supervisory Expense		6,000	6,180
Total, General & Administrative:		$17,475	$17,999
TOTAL O&M and G&A:		$84,875	$87,421
Operating Income:		$28,163	$30,098

INFLATION ASSUMPTIONS

PP&L Retail	PP&L Whsl	General Inflaton
3.00%	3.00%	3.00%

RESULTS	i	n	s	x	ac
Project Financial Performance					
	yr 5	yr 10	yr 15	yr 20	yr 25
Revenue	161.1	179.9	186.4	212.4	218.7
Fixed O&M	39.4	45.7	52.9	61.4	63.2
Variable O&M	36.5	42.3	49.0	56.8	58.5
Admin. Exp.	19.7	22.8	26.4	30.6	31.6
Tot. Expense	95.5	110.7	128.4	148.8	153.3
Oper Income	65.6	69.2	58.0	63.6	65.4
Cash flow					
Sensitivity	5 yr IRR	10 yr IRR	15 yr IRR	20 yr IRR	25 yr IRR
Contingency	-20.2%	0.5%	5.9%	7.9%	9.0%
$5	-14.0%	5.4%	10.1%	11.7%	12.5%
$50	-15.7%	4.1%	8.9%	10.7%	11.6%
$100	-17.3%	2.8%	7.8%	9.7%	10.7%
$150	-18.8%	1.6%	6.8%	8.8%	9.8%
$250	-21.5%	-0.6%	5.0%	7.2%	8.3%
Major Maint	-20.2%	0.5%	5.9%	7.9%	9.0%
$5,000	-18.2%	2.1%	7.3%	9.3%	10.3%
$10,000	-20.2%	0.5%	5.9%	7.9%	9.0%
$12,000	-21.1%	-0.2%	5.3%	7.4%	8.5%
$20,000	-24.6%	-3.0%	2.7%	5.0%	6.3%
Water	-20.2%	0.5%	5.9%	7.9%	9.0%
$5,000	-11.4%	7.4%	12.0%	13.6%	14.3%
$10,000	-13.2%	6.0%	10.8%	12.5%	13.3%
$20,000	-16.9%	3.1%	8.2%	10.1%	11.1%
Oper Hrs	-20.2%	0.5%	5.9%	7.9%	9.0%
85.0%	-28.5%	-6.1%	0.0%	2.6%	4.2%
88.0%	-25.8%	-4.0%	2.0%	4.4%	5.8%
91.0%	-23.3%	-2.0%	3.7%	6.0%	7.2%
94.0%	-21.0%	-0.2%	5.3%	7.4%	8.6%
Ret Pwr Rate	-20.2%	0.5%	5.9%	7.9%	9.0%
$80	-20.2%	0.5%	5.9%	7.9%	9.0%
$85	-20.0%	0.6%	6.0%	8.1%	9.2%
$90	-19.8%	0.8%	6.1%	8.2%	9.3%
ETO Incent.	-20.2%	0.5%	5.9%	7.9%	9.0%
50	-22.0%	-0.9%	4.7%	6.9%	8.1%
150	-18.3%	2.0%	7.2%	9.1%	10.1%
300	-10.3%	8.4%	12.6%	14.0%	14.7%

Financial Projection for Custom Magnetic Bearing T/G 350 kW Plant at the City of Klamath Falls

Year Number:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Year:		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Retail power offset (MWh)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Retail power price/MWh		80.0	82.4	84.9	87.4	90.0	92.7	95.5	98.4	101.3	104.4	107.5	110.7	114.1	117.5	121.0	124.6	128.4	132.2	136.2	140.3
Retail power value offset (1,000's)		8.02	8.26	8.50	8.76	9.02	9.29	9.57	9.86	10.15	10.46	10.77	11.10	11.43	11.77	12.12	12.49	12.86	13.25	13.65	14.06
Wholesale power sales, (MWh)		2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020	2,020
Wholesale power value, $/MWh		52.0	54.1	71.3	73.2	75.3	77.3	79.8	78.6	79.3	83.9	88.9	83.6	80.4	84.7	86.3	86.4	89.8	92.5	95.3	98.2
Wholesale power value (1,000's):		105.0	109.3	144.0	147.8	152.1	156.1	161.2	158.7	160.2	169.4	179.5	168.8	162.4	171.1	174.3	174.5	181.4	186.8	192.5	198.3
REVENUE ($ 000's except otherwise noted)																					
Retail power offset		8.0	8.3	8.5	8.8	9.0	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.8	12.1	12.5	12.9	13.2	13.6	14.1
Wholesale power sales:		105.0	109.3	144.0	147.8	152.1	156.1	161.2	158.7	160.2	169.4	179.5	168.8	162.4	171.1	174.3	174.5	181.4	186.8	192.5	198.3
Total Revenue:		**113.0**	**117.5**	**152.5**	**156.6**	**161.1**	**165.4**	**170.7**	**168.6**	**170.3**	**179.9**	**190.3**	**179.9**	**173.8**	**182.8**	**186.4**	**187.0**	**194.2**	**200.1**	**206.1**	**212.4**
OPERATING AND OWNERSHIP EXPENSES																					
FIXED OPERATIONS & MAINTENANCE																					
Salaries & OH-Opns @:		12.0	12.4	12.7	13.1	13.5	13.9	14.3	14.8	15.2	15.7	16.1	16.6	17.1	17.6	18.2	18.7	19.3	19.8	20.4	21.0
Routine Repairs & Maint		6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.1	8.3	8.6	8.8	9.1	9.3	9.6	9.9	10.2	10.5
Major Maintence Reserve		10.0	10.3	10.6	10.9	11.3	11.6	11.9	12.3	12.7	13.0	13.4	13.8	14.3	14.7	15.1	15.6	16.0	16.5	17.0	17.5
Remote Monitoring		4.0	4.1	4.2	4.4	4.5	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.7	5.9	6.1	6.2	6.4	6.6	6.8	7.0
PP&L Meter /Testing		3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.2	4.3	4.4	4.5	4.7	4.8	5.0	5.1	5.3
Total, Fixed O&M:		**35.0**	**36.1**	**37.1**	**38.2**	**39.4**	**40.6**	**41.8**	**43.0**	**44.3**	**45.7**	**47.0**	**48.4**	**49.9**	**51.4**	**52.9**	**54.5**	**56.2**	**57.8**	**59.6**	**61.4**
VARIABLE OPERATIONS & MAINTENANCE																					
Supplies/consumables		4.0	4.1	4.2	4.4	4.5	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.7	5.9	6.1	6.2	6.4	6.6	6.8	7.0
Water Supply & Disposal		28.4	29.3	30.1	31.0	32.0	32.9	33.9	34.9	36.0	37.1	38.2	39.3	40.5	41.7	43.0	44.2	45.6	46.9	48.3	49.8
Subtotal Variable O&M:		**32.4**	**33.4**	**34.4**	**35.4**	**36.5**	**37.6**	**38.7**	**39.8**	**41.0**	**42.3**	**43.5**	**44.8**	**46.2**	**47.6**	**49.0**	**50.5**	**52.0**	**53.6**	**55.2**	**56.8**
GENERAL &ADMINISTRATIVE EXPENSES																					
Legal/Audit		2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.5	2.5	2.6	2.7	2.8	2.9	2.9	3.0	3.1	3.2	3.3	3.4	3.5
Property Tax		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance		9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.7	12.0	12.4	12.7	13.1	13.5	13.9	14.3	14.8	15.2	15.7	16.1	16.6
Management & Supervisory Expense		6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.1	8.3	8.6	8.8	9.1	9.3	9.6	9.9	10.2	10.5
Total, General & Administrative:		**17.5**	**18.0**	**18.5**	**19.1**	**19.7**	**20.3**	**20.9**	**21.5**	**22.1**	**22.8**	**23.5**	**24.2**	**24.9**	**25.7**	**26.4**	**27.2**	**28.0**	**28.9**	**29.8**	**30.6**
TOTAL O&M and G&A:		**84.9**	**87.4**	**90.0**	**92.7**	**95.5**	**98.4**	**101.3**	**104.4**	**107.5**	**110.7**	**114.1**	**117.5**	**121.0**	**124.6**	**128.4**	**132.2**	**136.2**	**140.3**	**144.5**	**148.8**
Operating Cash Flow:	**-566.5**	**28.2**	**30.1**	**62.5**	**63.9**	**65.6**	**67.0**	**69.4**	**64.2**	**62.8**	**69.2**	**76.3**	**62.5**	**52.8**	**58.2**	**58.0**	**54.8**	**58.0**	**59.8**	**61.6**	**63.6**
Net Present Value @:	8.0%	**-500.4**	**-476.5**	**-430.6**	**-387.2**	**-345.8**	**-306.7**	**-269.2**	**-237.1**	**-208.0**	**-178.4**	**-148.1**	**-125.1**	**-107.1**	**-88.8**	**-71.9**	**-57.1**	**-42.5**	**-28.7**	**-15.5**	**-2.8**
Net Present Value @:	6.0%	**-509.4**	**-484.1**	**-434.7**	**-386.9**	**-340.7**	**-296.1**	**-252.6**	**-214.6**	**-179.5**	**-143.1**	**-105.2**	**-75.9**	**-52.6**	**-28.3**	**-5.4**	**14.9**	**35.2**	**55.0**	**74.2**	**92.9**
	IRR				**-30.7%**	**-20.2%**	**-13.1%**	**-7.9%**	**-4.4%**	**-1.8%**	**0.5%**	**2.3%**	**3.6%**	**4.4%**	**5.2%**	**5.9%**	**6.4%**	**6.8%**	**7.3%**	**7.6%**	**7.9%**

Attachment C: Financial Projections for a 700 kW Turbine/Generator Module

Financial Projection for Custom Magnetic Bearing T/G 700 kW Plant for the City of Klamath Falls

7/5/2011 17:44

SCHEDULE & MILESTONES ASSUMPTION

Decision to Proceed	Jan-11
Complete Engineering and Permitting	Mar-11
Order Equipment & Initiate Construction	Mar-11
Complete Construction and Startup	Dec-11

CAPITAL COST ESTIMATES		SUBTOTAL, $000
Technical Feasibility Study	40	
Financial Feasibility Study	36	
ODOE BETC Application Fee	6	
PacifiCorp Interconnection Fee	1	
Travel	8	
Administrative Costs	5	
Feasibility Study & Development Costs		$96
Engineering (civil, electrical & mech.)	140	
Purchasing & Project Management	100	
Site civil work; Cooling tower structure	250	
320 kW X 2 module, design & install	900	
Cooling tower & installation	240	
Geothermal Heat Exchangers	0	
Piping materials & installation	225	
Control systems; safety monitoring	50	
Electrical panel, wiring, 480 v svc	240	
PP&L Interconnection	75	
Spare Parts:	20	
Project contingency:	300	
Interest during construction	0	
Insurance during construction	4	
		$2,544
TOTAL FUNDS REQUIRED:		$2,640

SOURCES OF FUNDS			
ODOE feasibility grant; city study			36
Energy Trust of Oregon, Feasibility Study			15
USDOE Geothermal Grant:			816
Oregon BETC	33.5%	1,824	611
Energy Trust of Oregon, Incentive			100
Blue Sky program			0
Klamath Falls Cash Contribution			1,062
TOTAL FUNDS SUPPLIED:			$2,640

OPERATING PLAN		Year 1	Year 2
Operating Hours:		95%	95%
Gross Plant Output,Avg., kW:		604.0	604.0
Annual Energy Generated, MWh:		5,026	5,026
Less Cooling Tower Pump Ld, MWh:		-551	-551
Less Cooling Tower Fan Ld, MWh:		-293	-293
Less Geothermal Pumping Ld, MWh:		-730	-730
Plus Baseline Pumping:MWh:		291	291
Annual power prod., MWh:		3,743	3,743
REVENUE			
Retail Pwr Purchase offset, mWh:		100.2	100.2
Retail power rate, $/mWh:		$80.00	$82.40
Value of power offset:		$8,016	$8,256
Wholesale power to sell, mWh:		3,643	3,643
Wholesale power rate:		$52.00	$54.10
Value of wholesale power:		$189,451	$197,102
Total Revenue:		$197,467	$205,358
OPERATING AND OWNERSHIP EXPENSES			
FIXED OPERATIONS & MAINTENANCE			
Salaries & OH-Opns @:		12,000	12,360
Routine Repairs & Maint		6,000	6,180
Major Maintence Reserve		20,000	20,600
Remote Monitoring		4,000	4,120
PP&L Meter /Testing		3,000	3,090
Total Fixed O&M:		$45,000	$46,350
VARIABLE OPERATIONS & MAINTENANCE			
Supplies/consumables		4,000	4,120
Water Supply & Disposal		57,500	59,225
		$61,500	$63,345
GENERAL AND AMINISTRATIVE EXPENSES			
Legal/Audit		2,000	2,060
Property Tax	0.0%	0	0
Insurance	0.5%	13,200	13,596
Management & Supervisory Expense		6,000	6,180
Total, General & Administrative:		$21,200	$21,836
TOTAL O&M and G&A:		$127,700	$131,531
Operating Income:		$69,767	$73,827

INFLATION ASSUMPTIONS

PP&L Retail	PP&L Whsl	General Inflaton
3.00%	3.00%	3.00%

RESULTS	i	n	s	x	ac
Project Financial Performance					
	yr 5	yr 10	yr 15	yr 20	yr 25
Revenue	283.4	316.1	326.5	371.8	430.9
Fixed O&M	50.6	58.7	68.1	78.9	91.5
Variable O&M	69.2	80.2	93.0	107.8	125.0
Admin. Exp.	23.9	27.7	32.1	37.2	43.1
Tot. Expense	143.7	166.6	193.2	223.9	259.6
Oper Income	139.6	149.5	133.4	147.9	171.3
Cash flow					
Sensitivity	5 yr IRR	10 yr IRR	15 yr IRR	20 yr IRR	25 yr IRR
Contingency	-16.9%	3.1%	8.2%	10.1%	11.1%
$5	-11.8%	7.1%	11.7%	13.2%	14.0%
$50	-12.7%	6.4%	11.1%	12.7%	13.5%
$100	-13.6%	5.7%	10.4%	12.1%	12.9%
$150	-14.5%	5.0%	9.8%	11.6%	12.4%
$250	-16.2%	3.7%	8.7%	10.6%	11.5%
Major Maint	-16.9%	3.1%	8.2%	10.1%	11.1%
$5,000	-13.9%	5.4%	10.3%	12.0%	12.9%
$10,000	-14.9%	4.7%	9.6%	11.4%	12.3%
$12,000	-15.3%	4.4%	9.3%	11.1%	12.0%
$20,000	-16.9%	3.1%	8.2%	10.1%	11.1%
Water	-16.9%	3.1%	8.2%	10.1%	11.1%
$5,000	-7.1%	10.8%	15.0%	16.3%	16.9%
$10,000	-8.0%	10.1%	14.4%	15.8%	16.4%
$20,000	-9.7%	8.7%	13.1%	14.7%	15.4%
Oper Hrs	-16.9%	3.1%	8.2%	10.1%	11.1%
85.0%	-24.5%	-2.9%	3.0%	5.4%	6.8%
88.0%	-22.1%	-1.0%	4.7%	6.9%	8.1%
91.0%	-19.8%	0.8%	6.2%	8.3%	9.4%
94.0%	-17.6%	2.5%	7.7%	9.7%	10.7%
Ret Pwr Rate	-16.9%	3.1%	8.2%	10.1%	11.1%
$80	-16.9%	3.1%	8.2%	10.1%	11.1%
$85	-16.8%	3.2%	8.3%	10.2%	11.1%
$90	-16.7%	3.2%	8.3%	10.2%	11.2%
ETO Incent.	-16.9%	3.1%	8.2%	10.1%	11.1%
50	-18.0%	2.3%	7.5%	9.5%	10.5%
150	-15.8%	3.9%	8.9%	10.8%	11.7%
300	-12.0%	7.0%	11.5%	13.1%	13.8%

EVERGREEN ENERGY

Financial Projection for Custom Magnetic Bearing T/G 700 kW Plant for the City of Klamath Fa

7/5/2011 17:43

Year Number:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Year:		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Retail power offset (MWh)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Retail power price/MWh		80.0	82.4	84.9	87.4	90.0	92.7	95.5	98.4	101.3	104.4	107.5	110.7	114.1	117.5	121.0	124.6	128.4	132.2	136.2	140.3
Retail power value offset (1,000's)		8.02	8.26	8.50	8.76	9.02	9.29	9.57	9.86	10.15	10.46	10.77	11.10	11.43	11.77	12.12	12.49	12.86	13.25	13.65	14.06
Wholesale power sales, (MWh)		3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643	3,643
Wholesale power value/MWh		52.0	54.1	71.3	73.2	75.3	77.3	79.8	78.6	79.3	83.9	88.9	83.6	80.4	84.7	86.3	86.4	89.8	92.5	95.3	98.2
Wholesale power value (1,000's):		189.5	197.1	259.8	266.7	274.3	281.6	290.7	286.4	288.9	305.7	323.9	304.6	292.9	308.6	314.4	314.8	327.2	337.0	347.2	357.8
REVENUE ($ 000's except otherwise noted)																					
Retail power offset		8.0	8.3	8.5	8.8	9.0	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.8	12.1	12.5	12.9	13.2	13.6	14.1
Wholesale power sales:		189.5	197.1	259.8	266.7	274.3	281.6	290.7	286.4	288.9	305.7	323.9	304.6	292.9	308.6	314.4	314.8	327.2	337.0	347.2	357.8
Total Revenue:		**197.5**	**205.4**	**268.3**	**275.4**	**283.4**	**290.9**	**300.3**	**296.2**	**299.1**	**316.1**	**334.7**	**315.7**	**304.3**	**320.4**	**326.5**	**327.3**	**340.0**	**350.3**	**360.9**	**371.8**
OPERATING AND OWNERSHIP EXPENSES																					
FIXED OPERATIONS & MAINTENANCE																					
Salaries & OH-Opns @:		12.0	12.4	12.7	13.1	13.5	13.9	14.3	14.8	15.2	15.7	16.1	16.6	17.1	17.6	18.2	18.7	19.3	19.8	20.4	21.0
Routine Repairs & Maint		6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.1	8.3	8.6	8.8	9.1	9.3	9.6	9.9	10.2	10.5
Major Maintence Reserve		20.0	20.6	21.2	21.9	22.5	23.2	23.9	24.6	25.3	26.1	26.9	27.7	28.5	29.4	30.3	31.2	32.1	33.1	34.0	35.1
Remote Monitoring		4.0	4.1	4.2	4.4	4.5	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.7	5.9	6.1	6.2	6.4	6.6	6.8	7.0
PP&L Meter /Testing		3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.2	4.3	4.4	4.5	4.7	4.8	5.0	5.1	5.3
Total, Fixed O&M:		**45.0**	**46.4**	**47.7**	**49.2**	**50.6**	**52.2**	**53.7**	**55.3**	**57.0**	**58.7**	**60.5**	**62.3**	**64.2**	**66.1**	**68.1**	**70.1**	**72.2**	**74.4**	**76.6**	**78.9**
VARIABLE OPERATIONS & MAINTENANCE																					
Supplies/consumables		4.0	4.1	4.2	4.4	4.5	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.7	5.9	6.1	6.2	6.4	6.6	6.8	7.0
Water Supply & Disposal		57.5	59.2	61.0	62.8	64.7	66.7	68.7	70.7	72.8	75.0	77.3	79.6	82.0	84.4	87.0	89.6	92.3	95.0	97.9	100.8
Subtotal Variable O&M:		**61.5**	**63.3**	**65.2**	**67.2**	**69.2**	**71.3**	**73.4**	**75.6**	**77.9**	**80.2**	**82.7**	**85.1**	**87.7**	**90.3**	**93.0**	**95.8**	**98.7**	**101.7**	**104.7**	**107.8**
GENERAL &ADMINISTRATIVE EXPENSES																					
Legal/Audit		2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.5	2.5	2.6	2.7	2.8	2.9	2.9	3.0	3.1	3.2	3.3	3.4	3.5
Property Tax		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance		13.2	13.6	14.0	14.4	14.9	15.3	15.8	16.2	16.7	17.2	17.7	18.3	18.8	19.4	20.0	20.6	21.2	21.8	22.5	23.1
Management & Supervisory Expense		6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.1	8.3	8.6	8.8	9.1	9.3	9.6	9.9	10.2	10.5
Total, General & Administrative:		**21.2**	**21.8**	**22.5**	**23.2**	**23.9**	**24.6**	**25.3**	**26.1**	**26.9**	**27.7**	**28.5**	**29.3**	**30.2**	**31.1**	**32.1**	**33.0**	**34.0**	**35.0**	**36.1**	**37.2**
TOTAL O&M and G&A:		**127.7**	**131.5**	**135.5**	**139.5**	**143.7**	**148.0**	**152.5**	**157.1**	**161.8**	**166.6**	**171.6**	**176.8**	**182.1**	**187.5**	**193.2**	**199.0**	**204.9**	**211.1**	**217.4**	**223.9**
Operating Cash Flow:	-1,062.0	**69.8**	**73.8**	**132.8**	**135.9**	**139.6**	**142.9**	**147.8**	**139.2**	**137.3**	**149.5**	**163.0**	**138.9**	**122.3**	**132.8**	**133.4**	**128.3**	**135.1**	**139.2**	**143.5**	**147.9**
Net Present Value @:	8.0%	**-923.5**	**-864.9**	**-767.3**	**-674.8**	**-586.8**	**-503.4**	**-423.5**	**-353.9**	**-290.3**	**-226.2**	**-161.5**	**-110.4**	**-68.8**	**-26.9**	**12.1**	**46.7**	**80.5**	**112.8**	**143.6**	**173.0**
Net Present Value @:	6.0%	**-939.8**	**-877.8**	**-772.6**	**-671.0**	**-572.6**	**-477.6**	**-384.8**	**-302.4**	**-225.8**	**-147.0**	**-66.0**	**-0.9**	**53.2**	**108.6**	**161.1**	**208.8**	**256.1**	**302.1**	**346.9**	**390.4**
	IRR					**-16.9%**	**-10.0%**	**-5.0%**	**-1.6%**	**1.0%**	**3.1%**	**4.8%**	**6.0%**	**6.8%**	**7.6%**	**8.2%**	**8.7%**	**9.1%**	**9.5%**	**9.8%**	**10.1%**

EVERGREEN ENERGY

Attachment D: Thermodynamic Projections for a PureCycle 280 kW Module

Klamath Falls Geothermal Power; PureCycle 280 Generator Module

WEATHER			POWER PLANT OPERATION										NET POWER PRODUCTION								EXISTING GEO		
Temp Bin °F °F	Bin Hours	MCWB °F	UTC flow gpm	GEO Flow gpm	UTC Disch T °F	GEO to HX °F	Cooling T °F	Turbine Eff %	Cooling Flow gpm	Generator kW	Gross Power kWh	Refrig Flow lb/s	Cond Pump kW	Cond Pump kWh	Tower kW	Tower kWh	Geo Pump kW	Geo Pump kWh	Net kW	Net Power kWh	GEO Flow gpm	Pump Power kW	Pump Power kWh
																						1.5 W/gal	
97	1	63	575	575	170.0	170.0	70.0	79%	1775	244.2	234	33.7	28.0	27	19.1	18	30.9	30	166.2	159	120	10.8	10
92	39	61	575	575	170.0	170.0	68.6	79%	1770	248.3	9,261	33.5	27.8	1,037	19.1	711	30.9	1,153	170.6	6,360	120	10.8	403
87	124	59	575	575	170.1	170.1	67.2	79%	1764	252.4	29,922	33.3	27.6	3,275	19.0	2,253	30.9	3,665	174.8	20,730	120	10.8	1,281
82	234	58	575	575	170.1	170.1	66.5	79%	1761	254.4	57,156	33.2	27.5	6,184	19.0	4,262	30.9	6,945	177.0	39,765	120	10.8	2,427
77	312	56	575	575	170.2	170.2	65.1	79%	1755	258.3	77,309	33.0	27.3	8,176	18.9	5,659	30.9	9,250	181.2	54,223	120	10.8	3,232
72	372	54	575	575	170.2	170.2	63.7	79%	1749	262.2	93,516	32.7	27.1	9,670	18.8	6,722	30.9	11,024	185.3	66,100	130	11.7	4,173
67	466	52	575	575	170.3	170.3	62.3	79%	1743	266.0	119,048	32.5	26.9	12,040	18.8	8,405	30.9	13,831	189.4	84,771	180	16.2	7,249
62	549	50	575	575	170.4	170.4	60.9	79%	1737	269.8	142,149	32.3	26.7	14,064	18.7	9,862	30.9	16,284	193.5	101,938	230	20.7	10,906
57	655	48	575	575	170.5	170.5	59.4	79%	1731	273.5	172,089	32.1	26.5	16,661	18.7	11,736	30.9	19,447	197.5	124,245	280	25.2	15,855
52	780	45	575	600	170.6	172.2	57.3	79%	1721	279.0	208,864	31.8	26.2	19,582	18.6	13,890	33.3	24,961	200.9	150,431	330	29.7	22,236
47	823	41	575	720	170.8	178.7	55.0	79%	1706	284.3	224,573	31.3	25.7	20,262	17.2	13,547	46.8	36,972	194.7	153,792	380	34.2	27,011
42	927	37	575	840	171.4	183.5	55.0	79%	1683	281.4	250,507	30.9	24.9	22,159	12.1	10,777	58.7	52,289	185.7	165,282	430	38.7	34,451
37	1040	33	575	900	171.9	185.6	55.0	79%	1659	278.4	277,942	30.4	24.1	24,101	9.3	9,315	60.6	60,525	184.3	184,001	480	43.2	43,125
32	1127	30	575	900	172.3	185.9	55.0	79%	1641	276.2	298,926	30.1	23.6	25,535	8.0	8,629	60.6	65,627	184.0	199,136	530	47.7	51,630
27	672	25	0	580	172.9	210.0	55.0	79%	0	0.0	-	-	0.0	-	0.0	-	52.2	-	-52.2	-	580	52.2	-
22	351	21	0	630	173.5	210.0	55.0	79%	0	0.0	-	-	0.0	-	0.0	-	56.7	-	-56.7	-	630	56.7	-
17	149	16	0	680	174.1	210.0	55.0	79%	0	0.0	-	-	0.0	-	0.0	-	61.2	-	-61.2	-	680	61.2	-
12	82	12	0	730	174.7	210.0	55.0	79%	0	0.0	-	-	0.0	-	0.0	-	65.7	-	-65.7	-	730	65.7	-
7	39	7	0	780	175.4	210.0	55.0	79%	0	0.0	-	-	0.0	-	0.0	-	70.2	-	-70.2	-	780	70.2	-
2	17	3	0	830	175.9	210.0	55.0	79%	0	0.0	-	-	0.0	-	0.0	-	74.7	-	-74.7	-	830	74.7	-
-3	6	-2	0	880	176.6	210.0	55.0	79%	0	0.0	-	-	0.0	-	0.0	-	79.2	-	-79.2	-	880	79.2	-
-8	2	-7	0	930	177.3	210.0	55.0	79%	0	0.0	-	-	0.0	-	0.0	-	83.7	-	-83.7	-	930	83.7	-
-13	0	-11	0	980	177.8	210.0	55.0	79%	0	0.0	-		0.0	-	0.0	-	88.2	-	-88.2	-	980	88.2	-
	8766 Total annual hours									Gross kWh	1,961,494		kWh	182,772		105,785		322,003		1,350,934		Geo kWh	223,989
	7150 Operating hours				82%					Avg kW	274.3		Avg kW	25.6		14.8		45.0		188.9		Avg kW	31.3

Analysis is an engineering estimate based on an Excel spreadsheet, linked to NIST RefProp 8 for thermodynamic analysis. Power generation is suspended below 30°F to conserve heat for district heating. Assumed 96% availability when conditions allow generator operation.

Net power with exist GEO pump kW 1,574,924

Sewer	Water		
2,277	11,386	ccf	
2.9155	1.496	$/ccf	
$ 6,639	$ 17,033	$	23,673

Attachment E: Thermodynamic Projections for a 350 kW Module

Klamath Falls Geothermal Power; 350 kW Magnetic Bearing Generator

WEATHER			POWER PLANT OPERATION										NET POWER PRODUCTION								EXISTING GEO		
Temp Bin °F °F	Bin Hours	MCWB °F	UTC flow gpm	GEO Flow gpm	UTC Disch T °F	GEO to HX °F	Cooling T °F	Turbine Eff %	Cooling Flow gpm	Generator kW	Gross Power kWh	Refrig Flow lb/s	Cond Pump kW	Cond Pump kWh	Tower kW	Tower kWh	Geo Pump kW	Geo Pump kWh	Net kW	Net Power kWh	GEO Flow gpm	Pump Power kW	Pump Power kWh
																						1.5 W/gal	
97	1	63	700	700	185.2	185.2	70.0	79%	1854	279.0	264	35.1	30.9	29	20.0	19	44.3	42	183.8	174	120	10.8	10
92	39	61	700	700	185.2	185.2	68.6	79%	1846	283.0	10,443	34.8	30.6	1,128	19.9	734	44.3	1,637	188.2	6,945	120	10.8	399
87	124	59	700	700	185.3	185.3	67.2	79%	1837	286.9	33,662	34.6	30.3	3,549	19.8	2,322	44.3	5,203	192.5	22,588	120	10.8	1,267
82	234	58	700	700	185.4	185.4	66.5	79%	1833	288.8	64,224	34.4	30.1	6,692	19.7	4,391	44.3	9,861	194.6	43,280	120	10.8	2,402
77	312	56	700	700	185.4	185.4	65.1	79%	1825	292.6	86,663	34.1	29.8	8,820	19.7	5,821	44.3	13,134	198.8	58,886	120	10.8	3,199
72	372	54	700	700	185.5	185.5	63.7	79%	1816	296.3	104,585	33.9	29.5	10,399	19.6	6,905	44.3	15,652	202.9	71,628	130	11.7	4,129
67	466	52	700	700	185.6	185.6	62.3	79%	1807	300.0	132,829	33.6	29.1	12,907	19.5	8,623	44.3	19,639	207.0	91,661	180	16.2	7,174
62	549	50	700	700	185.7	185.7	60.9	79%	1798	303.5	158,237	33.3	28.8	15,028	19.4	10,103	44.3	23,122	211.0	109,985	230	20.7	10,792
57	655	48	700	700	185.8	185.8	59.4	79%	1789	307.0	191,124	33.1	28.5	17,743	19.3	12,005	44.3	27,612	214.8	133,763	280	25.2	15,690
52	780	45	700	700	185.9	185.9	57.3	79%	1775	312.0	231,168	32.7	28.0	20,749	19.1	14,178	44.3	32,857	220.5	163,384	330	29.7	22,004
47	823	41	700	720	186.1	186.7	54.5	79%	1756	318.4	248,886	32.1	27.3	21,368	18.9	14,800	46.8	36,587	225.4	176,131	380	34.2	26,730
42	927	37	700	840	186.3	190.2	51.7	79%	1736	324.5	285,879	31.6	26.7	23,491	18.7	16,501	58.7	51,745	220.4	194,143	430	38.7	34,092
37	1040	33	700	900	186.5	191.7	48.9	79%	1716	330.2	326,230	31.0	26.0	25,668	18.5	18,295	60.6	59,894	225.1	222,373	480	43.2	42,675
32	1127	30	700	900	186.6	191.8	46.8	79%	1700	334.3	358,068	30.6	25.5	27,278	18.4	19,664	60.6	64,943	229.8	246,183	530	47.7	51,093
27	672	25	700	900	187.0	192.1	45.0	79%	1668	334.4	213,569	29.9	24.4	15,603	15.0	9,592	60.6	38,725	234.3	149,650	580	52.2	33,340
22	351	21	700	900	187.4	192.4	45.0	79%	1638	329.2	109,655	29.4	23.5	7,819	11.6	3,867	60.6	20,194	233.5	77,774	630	56.7	18,885
17	149	16	700	900	187.9	192.8	45.0	79%	1600	322.7	45,802	28.7	22.3	3,168	9.0	1,277	60.6	8,606	230.8	32,752	680	61.2	8,686
12	82	12	700	900	188.3	193.2	45.0	79%	1569	317.4	24,629	28.1	21.4	1,662	7.6	590	65.7	5,098	222.7	17,279	730	65.7	5,098
7	39	7	700	900	188.9	193.6	45.0	79%	1531	310.8	11,468	27.4	20.3	750	6.4	235	70.2	2,591	213.8	7,891	780	70.2	2,591
2	17	3	700	900	189.3	193.9	45.0	79%	1500	305.4	4,912	26.9	19.5	313	5.6	91	74.7	1,202	205.5	3,306	830	74.7	1,202
-3	6	-2	0	880	189.8	210.0	45.0	79%	0	0.0	-	-	0.0	-	0.0	-	79.2	-	-79.2	-	880	79.2	-
-8	2	-7	0	930	190.3	210.0	45.0	79%	0	0.0	-	-	0.0	-	0.0	-	83.7	-	-83.7	-	930	83.7	-
-13	0	-11	0	980	190.8	210.0	45.0	79%	0	0.0	-		0.0	-	0.0	-	88.2	-	-88.2	-	980	88.2	-
	8766 Total annual hours									Gross kWh	2,642,297		kWh	224,166		150,012		438,343		1,829,777		Geo kWh	291,457
	8320 Operating hours				95%					Avg kW	317.6		Avg kW	26.9		18.0		52.7		219.9		Avg kW	35.0

Analysis is an engineering estimate based on an Excel spreadsheet linked to NIST RefProp 8 for thermodynamic analysis. Power generation is based on 350 kW gross generator capacity, with heat recovery from return geothermal water supplying 28% of the power generation heat rate. Assumed 95% availability.

Net power with exist GEO pump kW 2,121,234

Sewer		Water		
	2,734		13,672	ccf
	2.9155		1.496	$/ccf
$	7,972	$	20,453	$ 28,425

Attachment F: Thermodynamic Projections for a 700 kW Module

Klamath Falls Geothermal Power; (2) - 350 kW Magnetic Bearing Generators

WEATHER			POWER PLANT OPERATION										NET POWER PRODUCTION								EXISTING GEO		
Temp Bin °F °F	Bin Hours	MCWB °F	UTC flow gpm	GEO Flow gpm	UTC Disch T °F	GEO to HX °F	Cooling T °F	Turbine Eff %	Cooling Flow gpm	Generator kW	Gross Power kWh	Refrig Flow lb/s	Cond Pump kW	Cond Pump kWh	Tower kW	Tower kWh	Geo Pump kW	Geo Pump kWh	Net kW	Net Power kWh	GEO Flow gpm	Pump Power kW	Pump Power kWh
																						1.5 W/gal	
97	1	63	1,200	1,200	182.9	182.9	70.0	79%	3574	519.4	491	67.8	74.3	70	38.5	36	75.5	71	331.1	313	120	10.8	10
92	39	61	1,200	1,200	183.0	183.0	68.6	79%	3562	527.8	19,477	67.4	73.7	2,719	38.4	1,416	75.5	2,788	340.2	12,554	120	10.8	399
87	124	59	1,200	1,200	183.0	183.0	67.2	79%	3550	536.1	62,896	66.9	73.1	8,574	38.2	4,485	75.5	8,864	349.2	40,972	120	10.8	1,267
82	234	58	1,200	1,200	183.1	183.1	66.5	79%	3543	540.1	120,105	66.7	72.8	16,179	38.2	8,486	75.5	16,799	353.7	78,641	120	10.8	2,402
77	312	56	1,200	1,200	183.1	183.1	65.1	79%	3530	548.2	162,358	66.2	72.1	21,362	38.0	11,263	75.5	22,375	362.5	107,358	120	10.8	3,199
72	372	54	1,200	1,200	183.2	183.2	63.7	79%	3517	556.1	196,283	65.8	71.5	25,230	37.9	13,374	75.5	26,664	371.2	131,014	130	11.7	4,129
67	466	52	1,200	1,200	183.2	183.2	62.3	79%	3504	563.9	249,732	65.3	70.8	31,368	37.8	16,719	75.5	33,455	379.8	168,189	180	16.2	7,174
62	549	50	1,200	1,200	183.3	183.3	60.9	79%	3491	571.6	298,024	64.9	70.2	36,588	37.6	19,611	75.5	39,389	388.3	202,437	230	20.7	10,792
57	655	48	1,200	1,200	183.3	183.3	59.4	79%	3477	579.2	360,595	64.4	69.5	43,278	37.5	23,329	75.5	47,038	396.6	246,949	280	25.2	15,690
52	780	45	1,200	1,214	183.4	183.8	57.3	79%	3455	590.2	437,291	63.7	68.5	50,748	37.3	27,598	76.6	56,718	407.9	302,227	330	29.7	22,004
47	823	41	1,200	1,276	183.6	185.2	54.5	79%	3426	604.5	472,454	62.8	67.1	52,456	36.9	28,878	81.3	63,556	419.1	327,563	380	34.2	26,730
42	927	37	1,200	1,345	183.7	186.6	51.7	79%	3396	618.2	544,575	61.9	65.7	57,884	36.6	32,275	87.4	77,011	428.4	377,406	430	38.7	34,092
37	1040	33	1,200	1,422	183.9	188.0	48.9	79%	3365	631.3	623,624	61.0	64.3	63,492	36.3	35,875	95.4	94,202	435.3	430,055	480	43.2	42,675
32	1127	30	1,200	1,486	184.0	189.0	46.8	79%	3341	640.7	686,302	60.3	63.2	67,674	36.1	38,634	103.0	110,275	438.5	469,719	530	47.7	51,093
27	672	25	1,200	1,500	184.3	189.5	45.0	79%	3288	643.5	410,985	59.1	60.9	38,877	29.6	18,909	104.7	66,885	448.3	286,314	580	52.2	33,340
22	351	21	1,200	1,500	184.7	189.8	45.0	79%	3238	635.4	211,634	58.2	58.7	19,544	23.0	7,645	104.7	34,879	449.1	149,566	630	56.7	18,885
17	149	16	1,200	1,500	185.2	190.2	45.0	79%	3174	625.2	88,735	57.0	56.0	7,950	17.9	2,534	104.7	14,863	446.6	63,389	680	61.2	8,686
12	82	12	1,200	1,500	185.6	190.5	45.0	79%	3123	616.9	47,867	56.1	53.9	4,185	15.1	1,175	104.7	8,125	443.1	34,382	730	65.7	5,098
7	39	7	1,200	1,500	186.0	190.8	45.0	79%	3072	608.6	22,457	55.1	51.9	1,915	12.8	472	104.7	3,864	439.1	16,205	780	70.2	2,591
2	17	3	1,200	1,500	186.0	190.8	45.0	79%	3072	608.6	9,789	55.1	51.9	835	11.5	186	104.7	1,684	440.4	7,084	830	74.7	1,202
-3	6	-2	0	880	186.0	210.0	45.0	79%	0	0.0	-	-	0.0	-	0.0	-	79.2	-	-79.2	-	880	79.2	-
-8	2	-7	0	930	186.0	210.0	45.0	79%	0	0.0	-	-	0.0	-	0.0	-	83.7	-	-83.7	-	930	83.7	-
-13	0	-11	0	980	186.0	210.0	45.0	79%	0	0.0	-		0.0	-	0.0	-	88.2	-	-88.2	-	980	88.2	-
	8766 Total annual hours									Gross kWh	5,025,674		kWh	550,929		292,901		729,507		3,452,338	Geo kWh		291,457
	8320 Operating hours				95%					Avg kW	604.0		Avg kW	66.2		35.2		87.7		414.9	Avg kW		35.0

Analysis is an engineering estimate based on an Excel spreadsheet linked to NIST RefProp 8 for thermodynamic analysis. Power generation is based on (2) 350 kW generators capacity, with heat recovery from return geothermal water supplying 30% of the power generation heat rate. Assumed

Net power with exist GEO pump kW 3,743,796

Sewer Water