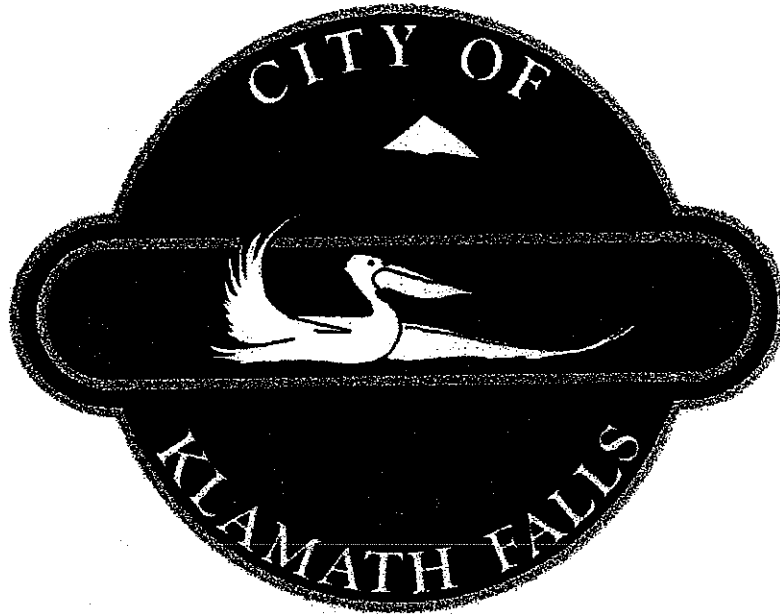


*cc: Mayor & Council*

# CITY OF KLAMATH FALLS, OREGON

## Feasibility Study for a Geothermal Power Plant



June 2009

Prepared by

Brian Brown Engineering  
Betty Riley, South Central Oregon EDD  
Stephen F. Anderson, P.E.

*Billing  
Copy*



## Table of Contents

	Page
1. Introduction and Objectives_____	1
2. Description of the Proposed Geothermal Project_____	2
3. Estimated Capital Cost of the Project_____	3
4. Sources of Financing and Project Incentives._____	4
5. Estimated Power Sales Volume_____	5
6. Revenue Projection_____	6
7. Operating Cost Projection_____	7
8. Financial Projections_____	7
9. Conclusions and Recommendations_____	8
Attachment 1. Financial Projection._____	9
Attachment 2. Application to the Energy Trust of Oregon for Financial Incentive._____	12
Attachment 3. System Integration Technical Considerations._____	13
Attachment 4. PureCycle Proposal_____	14

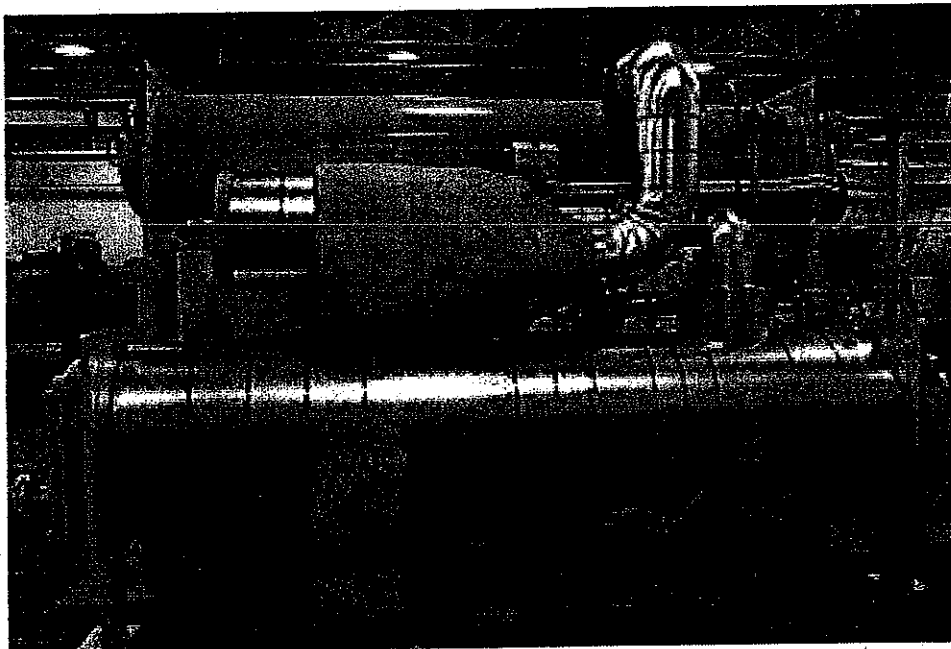
## 1. Introduction and Objectives

---

The City of Klamath Falls operates a geothermal 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 by 1992. Continued improvements and expansion activities since 1992 have allowed the system to currently heat over 350,000 square feet of building space, 150,000 square feet of greenhouses and 130,000 square feet of sidewalk snowmelt systems.

The heat source for this district heating system is two geothermal wells the city owns and operates. These wells are about 370 and 900 feet deep, and can each deliver up to 800 gallons per minute of water that is 210 to 220 degrees Fahrenheit.

The City is contemplating the installation of a small power plant to produce power with a portion of their geothermal water resource. New technology has been developed which may enable the City to convert the thermal energy of their geothermal hot water to electricity. United Technologies Corporation manufactures such a power generation module based on their chiller/refrigeration technology. The unit has a gross power rating of 280 kilowatts, and has proven to operate reliably in a number of commercial sites in Alaska, New Mexico and Utah.



*Figure 1. United Technologies Corporation's PureCycle 280 Module*

It is the purpose of this Feasibility Study to determine if such an installation would be likely to be technically and economically successful at this site. Firm construction costs have not been obtained for the site, but the costs associated with a similar project located in Klamath Falls have been used as a reference.

## 2. Description 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.

The facility will consist of the following key components:

- The United Technologies Corporation PureCycle 280 power 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 480 volt electrical service with PacifiCorp to interconnect the power plant
- A new building to house the plant

Drawings have been prepared to identify the proposed layout and location of major components. Construction cost budget estimates have been prepared to enable completion of this feasibility study. Neither detailed engineering, nor firm construction quotes have been obtained. The preliminary capital cost estimate totals about \$1.62 million.

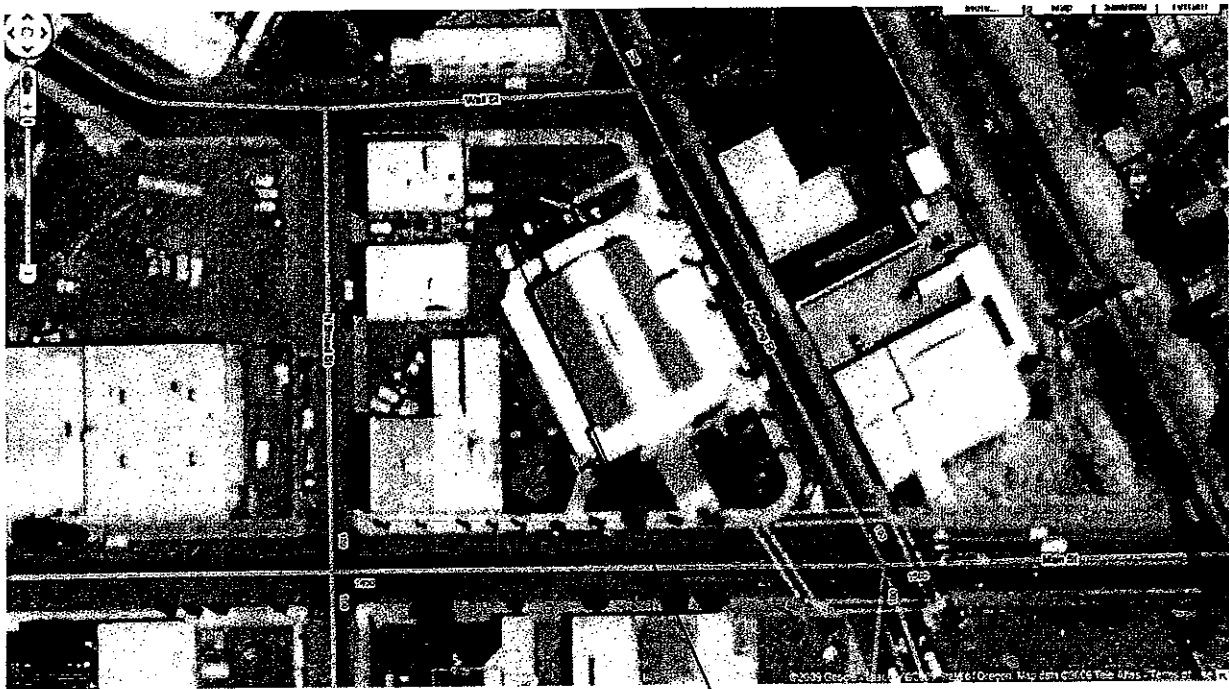


Figure 2. Proposed site of Geothermal Power Plant.

Brian Brown Engineering has estimated the annual net power production to be in the range of 1,479 megawatt-hours per year. If the value of this power is estimated to be \$60 per megawatt-hour, then the annual value of the power is about \$88,740.

### 3. Estimated Capital Cost of the Project

---

A preliminary estimate of the cost to develop and construct the project 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.

<b><u>Development Costs &amp; Financing Charges</u></b>	
Project feasibility study (funded by Oregon DOE)	30,000
Project financing study (funded by City)	8,000
ODOE BETC Fee	8,000
Interest during construction	26,000
Insurance during construction	6,000
<b>Development and financing cost total:</b>	<b>\$78,000</b>
<b><u>Design and Construction</u></b>	
Site civil work; generator building	250,000
UTC PureCycle 280 Module with delivery and installation	388,000
Cooling tower and installation	120,000
Piping materials and installation	175,000
Control system	30,000
Electrical panels and wiring, 480 volt service	160,000
Geothermal Heat Exchangers	50,000
Pacific Power & Light interconnection work	45,000
Engineering & design work (structural, electrical & mechanical)	100,000
Spare Parts	20,000
Project Contingency	200,000
<b>Design &amp; Construction total:</b>	<b>\$1,538,000</b>
<b>Estimated project total cost:</b>	<b>\$1,616,000</b>

These cost estimates are based on work completed at a nearby facility that is comparable in scope. Until design work has been completed, it will be difficult to obtain firm construction quotations.

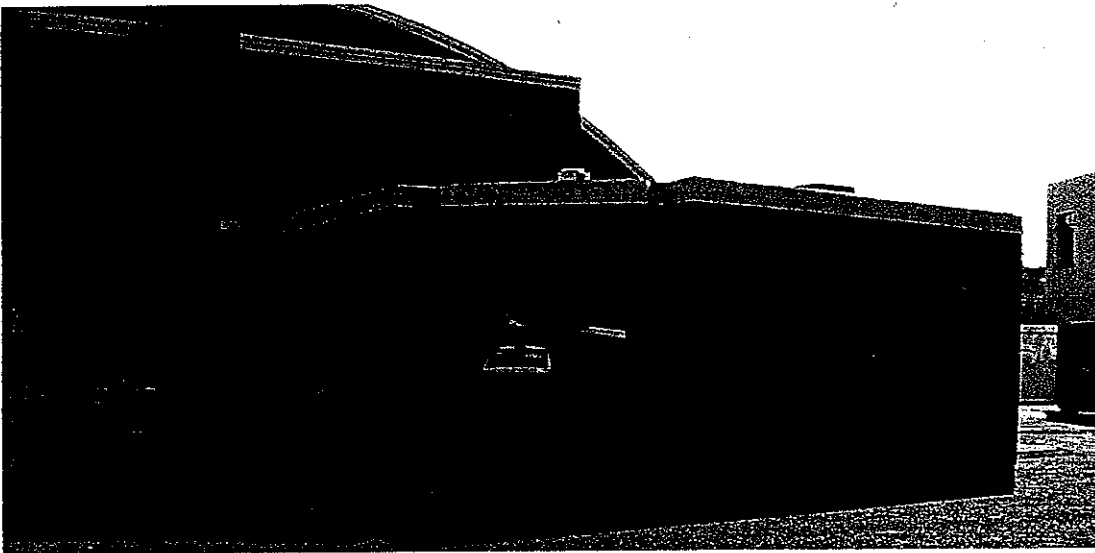


Figure 3. Exterior view of the Heat Exchanger Building

#### 4. Sources of Financing and Project Incentives.

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:

Funds provided by ODOE & City for feasibility studies	38,000
Estimated Oregon Business Energy Tax Credit	541,000
Estimated incentive payment, Energy Trust of Oregon	200,000
Estimated grant from the Blue Sky Program	50,000
Klamath Falls Cash Contribution	22,000
Estimated loan (Oregon SELP or municipal bond funding)	765,000
Estimated project total cost:	<u>\$1,616,000</u>

In this scenario, estimated Oregon Business Energy Tax Credit is at 33.5% of total project cost.

There is also the potential for additional grant funds from the American Recovery and Reinvestment Act of 2009 under the Geothermal Technologies Program. This funding has been announced through the U.S. Department of Energy with a application deadline of July 22, 2009. Under goal of DOE under this funding is to promote the development and commercial application of energy production from Low-Temperature Geothermal Fluids at temperatures between 150 and 300 degrees Fahrenheit. The three-year grant would fund up to fifty percent of a project and require data be reported to DOE including direct and indirect equipment costs and installation costs as well as direct and indirect jobs created by the project.

Funds provided by ODOE & City for feasibility studies	38,000
DOE Geothermal Technologies Program Grant	789,000
Estimated Oregon Business Energy Tax Credit	264,315
Estimated incentive payment, Energy Trust of Oregon	200,000
Estimated grant from the Blue Sky Program	100,000
Klamath Falls Cash Contribution	24,685
Estimated loan (Oregon SELP or municipal bond funding)	200,000
Estimated project total cost:	<u>\$1,616,000</u>

With the grant funds from US DOE, plus the Energy Trust incentive and Blue Sky grant that has been submitted, the project could generate enough revenue to offset debt financing.

## 5. Estimated Power Sales Volume

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.

Monthly power production is a function of the outside air temperature and humidity. When it is warm and humid outside the power plant will produce less power because the temperature differential between the geothermal heat source and cooling water is lower. This lower temperature difference results in lower pressure in the refrigerant cycle, which in turn results in lower power to turn the turbine and lower power production. During the winter months, the higher temperature difference results in greater power production, but there are occasions that all of the heat energy in the geothermal fluid must be used for district heating loads. The following is a summary of the monthly net power generation totals in megawatt-hours (and average kilowatt production):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
MWh	81.2	101.0	116.5	125.7	147.0	143.4	144.5	145.9	143.0	142.5	111.6	77.0	1,479
kWAv	109	140	161	175	198	192	201	196	199	192	155	103	169

The total annual power production is estimated to be about 1,479 megawatt-hours (1,479,000 kWh).

## 6. Revenue Projection

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 7.5 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 7.0 cents per kilowatt-hour. The actual rate will be calculated based on the melded value of peak and off-peak power purchased by Pacific Power.

The value of offset power used at the site is estimated as follows (actual cost of power, through March, 2009):

	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Total</u>
Kwh	12,000	12,160	10,000	11,040	10,080	6,240	1,920	1,280	2,000	6,800	8,400	18,240	100,160
\$	\$890	\$902	\$775	\$1,071	\$698	\$601	\$214	\$180	\$218	\$569	\$653	\$1,196	\$7,967

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:

Year:	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
On-peak, c/kWh	7.21	7.16	7.68	7.72	7.95	8.25	8.4	8.55	8.69	8.86	9.03
Off-peak c/kWh	5.59	5.42	5.86	5.86	6.06	6.32	6.44	6.55	6.66	6.78	6.91
On-peak hours	4800	4800	4800	4800	4800	4800	4800	4800	4800	4800	4800
Off-peak hours	3960	3960	3960	3960	3960	3960	3960	3960	3960	3960	3960
Wtd. Avg. c/kWh	6.96	6.89	7.42	7.44	7.68	7.98	8.13	8.27	8.41	8.57	8.73

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 (\$7,967), and the value of the remaining amount of power (1,379 mW hour) times the weighted average yearly price. During the first year, this will be about \$95,978

The total revenue expected in the first 12 months of operation will be about \$103,945.

## 7. Operating Cost Projection

---

The operating costs for a UTC PureCycle 280 project are expected to be modest. The following projections represent the current projections:

<u>Cost Component</u>	<u>Cost</u>
Incremental labor cost:	\$12,000
Routine repairs and maintenance	3,000
Major maintenance reserve	15,000
UTC Remote monitoring	12,000
PP&L meter and protection equipment testing	3,000
Supplies & consumables	4,000
Makeup Water Supply & Disposal	30,000
Professional services	1,000
General & Administrative	1,000
Total	\$81,000

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 work at five year intervals, budgeted to be about \$75,000.

After the first year of operations, it is questionable as to whether the UTC remote monitoring is of significant value. Termination of the UTC monitoring agreement may be considered after the warranty expires.

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.

## 8. Financial Projections

---

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 debt. With first year revenue projection of \$103,945 and operating costs of \$81,000 the operating cash flow would be only \$22,945. Depending on the way the project is financed, income may not be sufficient to cover debt service. If \$765,000 is borrowed for a period of 15 years at 5.5%, the annual debt service would be \$75,000, yielding a loss of \$52,000. As power costs escalate, the negative cash flow levels would decline. The project would offer more favorable returns if (A) the interest rate were to be lower; and/or (B) the construction cost could be lower; and/or (C) the operating and maintenance cost or water supply costs would be lower.

A detailed financial projection may be found in Attachment A.

## 9. Conclusions and Recommendations

This is an attractive opportunity to install a power generation system which would not require new fuel sources nor require any resource exploration. Since it appears that it will cost more to operate, maintain and amortize than the value of the power, its success will be determined by whether the construction costs or the operating costs may be reduced from the current projections.

There are areas that it would be possible to reduce construction cost. If the building could be more modest and the cooling tower located on the ground, perhaps the construction cost could be reduced. The current level of the contingency for unknown costs is high at \$200,000. This could be reduced if definitive construction quotes could be obtained.

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.

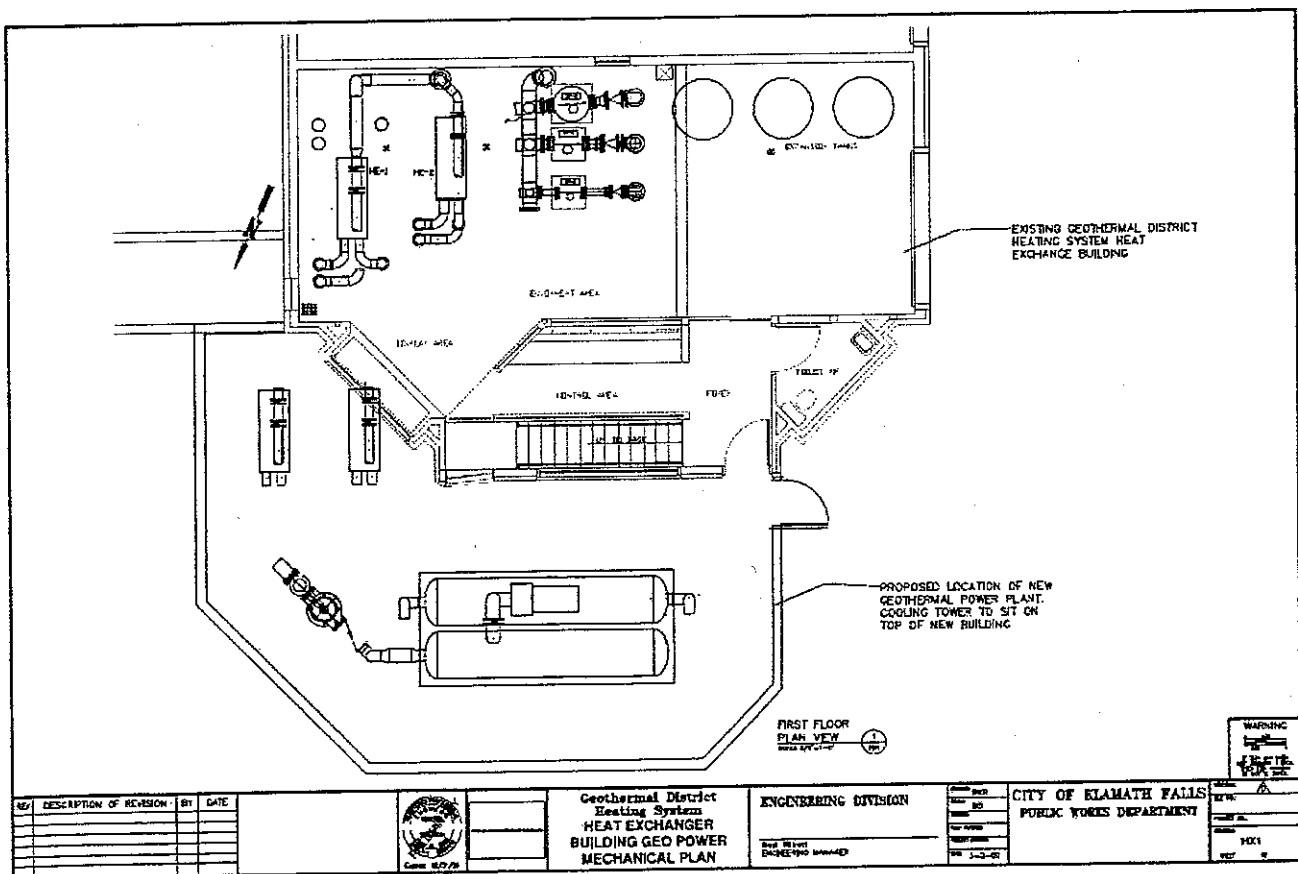


Figure 4. Preliminary site plan for the proposed new geothermal power plant.

*Attachment 1 Financial Projections*

---

# Klamath Falls Geothermal Power Project, UTC PureCycle 280

## SCHEDULE & MILESTONES ASSUMPTION

Decision to Proceed	Jul-09
Complete Engineering and Permitting	Sep-09
Order Equipment & Initiate Construction	Oct-09
Complete Construction and Startup	Feb-10

## CAPITAL COST ESTIMATES

	SUBTOTAL \$000
Technical Feasibility Study	30
Financial Feasibility Study	8
ODOE BETC Application Fee	8
Interest during construction	26
Insurance during construction	6
Site civil work; generator building	250
UTC PureCycle 280 module, del. & inst.	368
Cooling tower & installation	120
Geothermal Heat Exchangers	50
Piping materials & installation	175
Control system	30
Electrical panel, wiring, 480 v svc	160
PP&L Interconnection	45
Engineering (civl, electrical & mech.)	100
Spare Parts:	20
Project contingency:	200
	1,538
<b>TOTAL FUNDS REQUIRED:</b>	<b>1,616</b>

## SOURCES OF FUNDS

ODOE feasibility grant; city study	38
Oregon BETC	33.5%
Energy Trust of Oregon	200
Blue Sky program	50
Klamath Falls Cash Contribution	22
Sr Debt (yrs, rate):	15 5.5%
Total Capital Supplied:	1,616
Senior Debt Payment:	\$/Mo 6 \$/Yr \$75



## OPERATING PLAN

	Year 1	Year 2	Year 3
Plant Rating (kW):	179.6	179.6	179.6
Capacity Factor:	94.0%	94.0%	94.0%
Annual power prod., mWh:	1,479	1,479	1,479

## REVENUE

	Yr 1	Yr 2	Yr 3
Retail Power Purchases offset, mWh:	100.2	100.2	100.2
Retail power rate, \$/mWh:	\$80.00	\$84.80	\$84.80
Value of power offset:	\$8,016	\$8,497	\$8,497
Wholesale power to sell, mWh:	1,378.7	1,378.7	1,378.7
Wholesale power rate:	\$69.60	\$68.90	\$68.90
Value of wholesale power:	\$95,957	\$94,992	\$94,992
Total Revenue:	\$103,973	\$103,489	\$103,489

## OPERATING EXPENSE ASSUMPTIONS

<b>FIXED O&amp;M:</b>	
Salaries & OH-Optns @:	12,000
Salaries & OH-Mgmt	0
Routine Repairs & Maint	3,000
Major Maintenance Reserve	15,000
UTC Monitoring	12,000
PP&L Meter Testing	3,000
	\$45,000
<b>VARIABLE O&amp;M:</b>	
Supplies/consumables	4,000
Water Supply & Disposal	30,000
	\$34,000
Total, Operations & Maint:	\$79,000
<b>General &amp; Admin:</b>	
Legal/Audit	1,000
Property Tax	0
Insurance	0
General & Admin. Expense	1,000
Total, Gen. & Admin.:	\$2,000
<b>TOTAL O&amp;M and G&amp;A:</b>	<b>\$81,000</b>
Operating Income:	\$22,973
PP&L	PP&L
Retail	Whol
Escalation Assum	6.00%
Assum	4.00%
	3.00%

## RESULTS

Project Financial Performance					
	Yr 1	Yr 5	Yr 10	Yr 15	20 Yr NPV
Revenue	104.0	116.0	131.7	142.9	
Fixed O&M	45.0	50.6	58.7	68.1	
Variable O&M	34.0	38.3	44.4	51.4	
Admin. Exp.	2.0	2.3	2.6	3.0	
Tot. Expenses	81.0	91.2	105.7	122.5	
Oper Income	20.1	24.8	26.0	20.4	
Debt Svc:	75.0	75.0	75.0	75.0	
Cash flow	-52.0	-50.2	-49.0	-54.6	
<b>Sensitivity Analysis-After Tax Cash Flow IRR</b>					
Contingency	-52.0	-50.2	-49.0	-54.6	-470.1
\$0	-52.0	-50.2	-49.0	-54.6	-470.1
\$40	-52.0	-50.2	-49.0	-54.6	-470.1
\$80	-52.0	-50.2	-49.0	-54.6	-470.1
\$120	-52.0	-50.2	-49.0	-54.6	-470.1
\$150	-52.0	-50.2	-49.0	-54.6	-470.1
Major Maint	-52.0	-50.2	-49.0	-54.6	-470.1
\$2,000	-39.0	-35.6	-32.0	-35.0	-291.5
\$5,000	-42.0	-39.0	-36.0	-39.5	-332.7
\$10,000	-47.0	-44.6	-42.5	-47.1	-401.4
\$12,000	-49.0	-46.8	-45.1	-50.1	-428.9
Water	-52.0	-50.2	-49.0	-54.6	-470.1
\$1,000	-23.0	-17.6	-11.2	-10.8	-71.7
\$15,000	-37.0	-33.3	-29.4	-32.0	-264.0
\$20,000	-42.0	-39.0	-36.0	-39.5	-332.7
Cap. Fact	-52.0	-50.2	-49.0	-54.6	-470.1
90.0%	-56.4	-55.0	-54.4	-60.3	-526.5
97.0%	-48.7	-46.6	-45.0	-50.4	-427.8
98.0%	-47.6	-45.4	-43.6	-48.9	-413.7
Int. Rate	-52.0	-50.2	-49.0	-54.6	-470.1
4.0%	-52.0	-50.2	-49.0	-54.6	-470.1
5.0%	-52.0	-50.2	-49.0	-54.6	-470.1
6.0%	-52.0	-50.2	-49.0	-54.6	-470.1
ETO Incent	-52.0	-50.2	-49.0	-54.6	-470.1
300	-52.0	-50.2	-49.0	-54.6	-470.1
400	-52.0	-50.2	-49.0	-54.6	-470.1
500	-52.0	-50.2	-49.0	-54.6	-470.1

Use 20 year debt-service?

625009 16:49

		\$765,000 Debt Assumption																											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25			
Year Number:	Year:	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034			
0	Year Number:	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034			
	Year:	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			
	Retail power offset (mWh)	80.0	84.8	89.9	95.3	101.0	107.1	113.5	120.3	127.5	135.2	143.3	151.9	161.0	170.6	180.9	191.7	203.2	215.4	228.3	242.0	256.6	272.0	288.3	305.6	323.9			
	Retail power price/mWh	8.02	8.50	9.01	9.55	10.12	10.73	11.37	12.05	12.78	13.54	14.36	15.22	16.13	17.10	18.12	19.21	20.36	21.59	22.86	24.25	25.71	27.25	28.89	30.62	32.46			
	Retail power value offset (1,000's)	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379			
	Wholesale power generation, (mWh)	88.6	88.9	74.2	74.4	76.8	79.8	81.3	82.7	84.1	85.7	87.3	87.0	86.9	87.0	90.5	84.1	97.9	101.8	105.9	110.1	114.5	119.1	123.8	128.8	134.0			
	Wholesale power value/mWh	96.0	95.0	102.3	102.6	105.8	110.1	112.1	114.1	116.0	118.2	120.4	119.9	119.8	120.0	124.8	129.8	134.9	140.3	146.0	151.8	157.9	164.2	170.7	177.6	184.7			
	Wholesale power value (1,000's)	8.0	8.5	9.0	9.5	10.1	10.7	11.4	12.1	12.8	13.5	14.4	15.2	16.1	17.1	18.1	19.2	20.4	21.6	22.9	24.3	25.7	27.3	28.9	30.6	32.5			
	REVENUE	104.0	103.5	111.3	112.1	116.0	120.8	123.5	126.1	128.7	131.7	134.8	135.1	135.9	137.1	142.9	149.0	153.3	161.9	168.8	176.0	183.6	191.4	199.6	208.2	217.1			
	Wholesale power sales:																												
	Total Revenue:																												
	OPERATING EXPENSE ASSUMPTIONS:																												
	FIXED O&M:																												
	Sales & 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	21.7	22.3	23.0	23.7	24.4			
	Sales & OH-Mgmt:	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	0.0	0.0	0.0	0.0	0.0			
	Salaries & OH-Mgmt:	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	5.4	5.6	5.7	5.9	6.1			
	Routine Repairs & Maint:	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	27.1	27.9	28.7	29.6	30.5			
	Major Maintenance Reserve:	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	21.7	22.3	23.0	23.7	24.4			
	UTC Monitoring:	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	5.4	5.6	5.7	5.9	6.1			
	PP&L Meter Testing:	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	81.3	83.7	86.2	88.8	91.5			
	Subtotal Fixed O&M:																												
	VARIABLE O&M:																												
	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	7.2	7.4	7.7	7.9	8.1			
	Water Supply & Disposal:	30.0	30.9	31.8	32.8	33.8	34.8	35.8	36.9	38.0	39.1	40.3	41.5	42.8	44.1	45.4	46.7	48.1	49.6	51.1	52.6	54.2	55.8	57.5	59.2	61.0			
	Subtotal Variable O&M:	34.0	35.0	36.1	37.2	38.3	39.4	40.6	41.8	43.1	44.4	45.7	47.1	48.5	49.9	51.4	53.0	54.6	56.2	57.9	59.6	61.4	63.3	65.1	67.1	69.1			
	GENERAL & ADMINISTRATIVE EXPENSES:																												
	Legal/Audit:	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2.0	2.0			
	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	0.0	0.0	0.0	0.0	0.0			
	Insurance:	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	0.0	0.0	0.0	0.0	0.0			
	General & Admin. Expense:	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2.0	2.0			
	Total, Gen. & Admin.:	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.1	4.1			
	TOTAL O&M and G&A:	81.0	83.4	85.9	88.5	91.2	93.9	96.7	99.6	102.6	105.7	108.9	112.1	115.5	119.0	122.5	126.2	130.0	133.9	137.9	142.0	146.3	150.7	155.2	159.9	164.7			
	Operating Income:	23.0	20.7	25.4	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3			
	Debt Payment:	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0			
	Pretax Cash Flow:	-52.0	-54.9	-49.6	-51.4	-50.2	-46.1	-48.2	-48.5	-48.9	-49.0	-49.1	-52.0	-54.6	-56.9	-54.6	-52.2	-53.3	-28.0	-30.9	-34.0	-37.3	-40.7	-44.4	-48.3	-52.5			
	NPV @10%:	-67.0	-113.1	-152.4	-190.8	-226.2	-258.2	-288.5	-317.2	-344.5	-370.3	-394.7	-419.1	-443.2	-467.0	-488.5	-507.9	-499.0	-489.7	-480.1	-470.1	-459.7	-449.1	-438.1	-426.8	-415.3			



Attachment 2. Application to the Energy Trust of Oregon for Financial Incentive.

Form 901  
**Open Solicitation Project Application**  
 Renewable Resources, Open Solicitation Program



To be completed by Applicant

Attach pages, as needed, to answer each question. On this form, refer to the attachment. On each attachment, please identify the section and question numbers for each answer provided.

**Section 1—Applicant Information**

A. Project Name City of Klamath Falls Geothermal Power Plant		B. Submission Date (m/d/yy)	
C. Provide a brief project description. The proposed project includes a UTC PureCycle 280 geothermal power plant module, heat exchangers and cooling towers system to generate about 180 kW net using existing geothermal water resources.			
Enter information for the company or organization that may enter into an agreement with the Energy Trust if this application were to be selected for further review and negotiations.			
D. Company or Organization City of Klamath Falls			
E. Applicant Contact Jeffrey Ball, City Manager			
F. Applicant Address 500 Klamath Avenue	City Klamath Falls	State OR	Zip 97601-
G. Telephone 541-883-5316 <input type="checkbox"/> cell <input checked="" type="checkbox"/> office <input type="checkbox"/> home	H. Fax 541-883-5399		
I. Email ball@ci.klamath-falls.or.us	J. Website		
K. Business Classification <input type="checkbox"/> Corporation <input type="checkbox"/> Individual/Sole Proprietor		<input type="checkbox"/> Partnership <input checked="" type="checkbox"/> Other (specify below) Government	
L. Please indicate the site's self-direction status as of the date this application is submitted: <input type="checkbox"/> Not currently eligible to self-direct. <input type="checkbox"/> Eligible to self-direct but not currently using self-direct credits against the renewables portion of the public purpose charge. <input type="checkbox"/> Eligible to self-direct and currently using self-direct credits against the renewables portion of the public purpose charge. Frequently Asked Questions about self-direction: <a href="http://www.energytrust.org/library/policies/faq_self_direct.html">http://www.energytrust.org/library/policies/faq_self_direct.html</a>			
M. If you are attaching any documents to provide project detail, please list them here. Attach additional sheets if you want to provide longer answers than this form accommodates. Energy Trust may request additional documentation, such as more detailed technical specifications and/or financial <i>pro formas</i> , at the time of application submittal and/or at any point during its application review process. Preliminary Feasibility Study, -May 2009			

**Resource Type**

Eligible resource type:  
 Eligible hydroelectric<sup>1</sup>     Solar thermal electric     Geothermal     Wind     Other Type:

<sup>1</sup> Hydroelectric facilities located outside protected areas as defined by Federal law in effect on July 23, 1999.

Please keep a copy of this document for your records.



Form 901  
**Open Solicitation Project Application**  
 Renewable Resources, Open Solicitation Program



**To be completed by Applicant**

Attach pages, as needed, to answer each question. On this form, refer to the attachment. On each attachment, please identify the section and question numbers for each answer provided.

**Section 3—Utility Information**

A. Please select your electric utility	<input type="checkbox"/> Portland General Electric (PGE)	<input checked="" type="checkbox"/> Pacific Power
B. I have contacted the utility to discuss interconnection options.	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
Utility Representative Name	Utility Representative Telephone	
Fill out item C only if you intend to sell power to a utility.		
C. Have you secured a power purchase agreement from your utility?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
If no, have you contacted your utility for information about a power purchase agreement?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
Utility Representative Name	Utility Representative Telephone	

**Section 4—Project Cost**

A. Estimated installed cost of project, including all up-front charges.	\$ 1,646,000.00
B. Estimated annual operating and maintenance costs. (Please include all costs: do not net out tax credits or other offsets.)	\$ 52,000.00
C. Applicable tax credits	\$ 0.00

**Section 5—Financial Information and Applicant Team**

A. In a few sentences, describe the development organization's experience financing, developing and managing projects of the scale and complexity anticipated. Indicate whether sufficient owner equity is available to support project financing. <b>The City of Klamath Falls is an experienced and capable constructor and operator of large civil works and complex systems. This facility will be within its capabilities to operate and maintain using its existing personnel.</b>	
B. Has the applicant organization, its predecessors, if any, or any principal of the firm been insolvent or declared bankrupt within the past 5 years? If yes, explain.	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
C. I have a financial pro-forma for this project.	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
D. If your project requires financing, have you contacted the Oregon Department of Energy's (ODOE) State Energy Loan Program?	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
E. I have contacted ODOE concerning the Oregon Business/Residential Energy Tax Credit.	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
F. The project qualifies for Federal incentives. If yes, please indicate program or programs. If a taxpayer were to be an owner, it would qualify. As a city-owned facility, it is uncertain that any Federal incentives may be applicable.	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
G. To whom have you submitted this proposal, other than Energy Trust?	Blue Sky
H. List staff that will be involved in the proposed project and explain the role of each.	

Please keep a copy of this document for your records.

Form 901  
Open Solicitation Project Application  
Renewable Resources, Open Solicitation Program



To be completed by Applicant

Attach pages, as needed, to answer each question. On this form, refer to the attachment. On each attachment, please identify the section and question numbers for each answer provided.

Existing city maintenance personnel

### Section 6—Terms and Conditions

#### No Commitment

This application does not constitute an offer to enter into a contract with Energy Trust, nor does it commit Energy Trust to enter into a contract or similar undertaking with the Applicant or any organization associated with the Applicant. Energy Trust reserves the right to suspend or modify the application process or to issue a new application that would supersede and replace this one.

Any commencement of negotiations in connection with this application does not signify a commitment by Energy Trust to execute a contract or to continue discussions with respect to the Applicant's organization. Any party involved in these negotiations can terminate contact at any time and for any reason. Energy Trust is under no obligation to pursue this application, or to disclose to the Applicant any information concerning its disposition of, or action on, the Application. Any recommendations or conclusions from this application process concerning the Applicant shall not constitute a right (property or otherwise). No binding obligation shall be created unless Energy Trust or its representative and the concerned parties execute a binding agreement. Any awards made by the Energy Trust as a result of this application will be subject to the terms of a definitive written agreement between the parties.

#### Treatment of Information

Applications will be reviewed by Energy Trust staff and/or consultants. If Energy Trust uses an outside party to help review the application, it will require that party to sign a confidentiality agreement. Subject to litigation or other legal disclosure requirements, Energy Trust will not otherwise disclose information submitted in this application, without the consent of Applicant. Applicant acknowledges that it understands that, in order to be considered for any Energy Trust funding, Energy Trust's Open Solicitation policy (available on our website at <http://www.energytrust.org/library/policies.html>) requires that Energy Trust staff present details of certain potential projects to its Renewable Advisory Council and/or Board of Directors for review and discussion.

#### Waiver of Claims

Applicant waives any right it may have to bring any claim, whether in damages or equity, against Energy Trust, Energy Trust's Board of Directors, Energy Trust's Renewable Advisory Council, Energy Trust's agents, employees, or contractors with respect to any matter arising out of any process associated with this application.

Please keep a copy of this document for your records.

Form 901 v03 081105

Page 4 of 5

Return completed form to:  
Open Solicitation Program • Energy Trust of Oregon, Inc.  
851 SW Sixth Avenue, Suite 1200, Portland, Oregon 97204-1349  
1-866-366-7878 • Fax 503-546-6862 • [energytrust.org](http://energytrust.org)



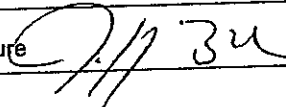
To be completed by Applicant

Attach pages, as needed, to answer each question. On this form, refer to the attachment. On each attachment, please identify the section and question numbers for each answer provided.

**Section 7—Applicant Certification and Signature**

I hereby certify that:

1. Applicant is duly authorized to submit this proposal and the undersigned is authorized by the Applicant to submit this application to Energy Trust on Applicant's behalf;
2. The information provided by Applicant in this application, and any other related documents delivered to Energy Trust, is true, accurate and complete to the best of Applicant's knowledge;
3. Applicant has read, understands and agrees to all of the terms and conditions as set forth in this application;
4. Applicant understands and accepts that the approval or rejection of this application is within the sole discretion of Energy Trust;
5. Applicant understands and accepts that all costs associated with completing this application are the sole responsibility of Applicant and that the application and all materials submitted with it shall become the property of Energy Trust and shall not be returned to the Applicant;
6. Applicant authorizes Energy Trust to contact references and to investigate the business financial credit history of the Applicant, its affiliates, and all associated partners, principals and management and authorizes the release of all said information to Energy Trust;
7. Applicant has included in this application all information necessary to ensure that the statements herein do not in whole or in part mislead Energy Trust as to any material fact; and
8. Applicant will report immediately in writing to Energy Trust any changes to the information contained herein at any time while this application is under consideration.

Authorized Representative	Jeff Ball <i>(printed)</i>	Title City Manager	Signature 	Date 5/15/09
---------------------------	-------------------------------	--------------------	--	--------------

Please keep a copy of this document for your records.

### **Attachment 3. System Integration Technical Considerations**

The City of Klamath Falls geothermal district heating system provides energy for heating buildings, greenhouses, potable and process water, and sidewalks in the city's core area. The majority of the heating load is seasonal, leaving the district heating system operation with significant unused capacity most of the year. Adding power generation to the system gives the potential to balance the load profile by increasing utilization of the system in warmer weather when the heat is not otherwise needed.

Direct use of geothermal energy to offset natural gas is more valuable than using the available geothermal energy to produce electricity. However, since electricity is needed year-round geothermal power production can make economic sense if it can be accomplished without reducing direct-use heat sales. The major questions are:

- Does the district heating system have the thermal capacity to support planned growth plus power generation over the 20-year planning life?
- What impact might the power generation have on operation of the district heating system?

#### **DISTRICT HEATING SYSTEM CAPACITY**

**Production Wells:** The Klamath Falls Geothermal District Heating System is served by two geothermal production wells, CW-1 and CW-2. Pumps at both wells have been upgraded to 75 hp motors with adjustable frequency drive speed control. The pumping capacity is about 800 gpm in either well with existing piping. With planned upgrades to the geothermal pipeline, the anticipated total production capacity will be about 1600 gpm for both pumps operating together. Operation at that capacity would require an upgrade to the Oregon water right for the wells.

**Geothermal Transmission Pipeline:** Geothermal flow from the production wells is conveyed to the heat exchanger building through an 8-inch pre-insulated steel pipeline, about 4400 feet long. About one-third of the pipeline is direct-buried; the rest is enclosed in a concrete pipe tunnel. Plans have been developed to replace the entire production pipeline with pre-insulated ductile iron, and increase the size below Well CW-2 to 12-inch. Replacement of the buried portion of the pipeline is planned for this year, with the balance to be completed as funding allows.

**Injection Well:** The injection well is approximately 1180 ft. deep, with casing to about 180 ft. and an inner liner extending to about 400 ft. Operating logs from January 2008 show at 768 gpm geothermal flow at an injection pressure of 13.4 psi. Assuming injection pressure is linear with flow, the well would accept the maximum production flow of 1600 gpm at about 28 psi injection pressure. The well was designed for up to 50 psi injection pressure.

#### **Production System Heating Capacity:**

Condition	WELL CW-1		WELL CW-2		Total Flow gpm	Injection Temp °F	Heat Million Btu/hr
	Flow gpm	Temp °F	Flow gpm	Temp °F			
CW-1 Only	800	220	0	210	800	150	28
CW-2 Only	0	220	800	210	800	150	24
Both Well Pumps	800	220	800	210	1600	150	52

**District Heating Pumps:** Currently only one of the three pumps can be operated at a time because of limitations in the building electrical service; normally either CP-2 or CP-3 is operated. Upgrades to the electrical system are planned to allow parallel operation of two pumps, increasing pumping capacity.

TAG	FLOW GPM	HEAD FT	MOTOR			CONTROL
			RPM	HP	VOLTS/Φ	
CP-1	1000	100	1750	50	240/3	Starter
CP-2	1200	130	1750	60	480/3	VFD
CP-3	1200	130	1750	60	480/3	VFD

**Distribution System Piping:** The district heating distribution pipeline consists of parallel supply and return pipes. The main line is 10-inch steel from the heat exchanger building to 8<sup>th</sup> Street, 8-inch ductile iron from 8<sup>th</sup> to about 5<sup>th</sup> Street, 6-inch ductile iron to 4<sup>th</sup> Street, and 8-inch ductile iron to IFA Nursery. The steel portion of the pipeline is scheduled to be replaced with 12-inch ductile iron this summer. The 6-inch section between 5<sup>th</sup> and 4<sup>th</sup> Streets is scheduled to be replaced with 8-inch. The replacements will increase pipeline flow capacity.

**Distribution System Heating Capacity:** The heat delivery capacity of the distribution system is affected by both flow capacity and temperature differential ( $\Delta T$ ). Improvements in the pipelines and the pump station electrical system will increase the flow capacity. Temperature differential can be improved by better flow control at customer connections and cascading the heating water flow from higher temperature uses such as building heating to lower temperature uses such as snow melting.

Condition	CP-2 Flow gpm	CP-3 Flow gpm	Total Flow gpm	Temperature		Heat Million Btu/hr
				Supply °F	Return °F	
One Pump, Exist pipes	1000	0	1000	180	140	20.0
One Pump, New Pipes, Improve delta-T	1200	0	1200	190	130	36.0
Both Pumps	800	800	1600	190	130	48.0

**Heat Exchangers:** The link between the geothermal production system and the district heating distribution system is two plate-and-frame heat exchangers. At the maximum flows and temperature differentials shown for the production and distribution systems, the heat exchangers are sized to supply the required  $48 \times 10^6$  Btu/hr heat transfer.

## DISTRICT HEATING SYSTEM LOAD

The existing district heating system load is currently comprised of:

- Building heat
- Commercial greenhouses
- Sidewalk snowmelt systems
- Potable and process water heating

The proposal to add power generation to the mix provides the opportunity to increase the overall load factor and revenue for the system. The question is if power generation can be added while minimizing impact on the core district heating operation.

**Building Heat:** Buildings currently on the system total about 350,000 sq. ft. floor area. The current system design building heating load is estimated to be about  $7 \times 10^6$  Btu/hr at the 99% heating design outside air temperature of 10°F. Building heat is billed based on metered energy usage. The general commercial rate is currently \$9.526/ $10^6$  Btu. Geothermal energy used for building heat offsets natural gas that currently costs about \$12.93 per million ( $10^6$ ) Btu at 100% efficiency or \$16.16/ $10^6$  Btu at 80% combustion efficiency.

**Greenhouses:** The greenhouses at IFA Nursery are generally operated starting in February through the cool weather in the spring. Since they do not operate during the coldest weather in December and January, the greenhouse heating system was sized based on an outside design temperature of 20°F. There are three greenhouses currently on the system totaling about 160,000 sq. ft., with an estimated design load of  $7.5 \times 10^6$  Btu/hr. The billing rate is currently \$7.50/ $10^6$  Btu.

**Sidewalk Snowmelt:** There are about 105,000 sq. ft. of heated sidewalks currently supplied by the district heating system. Another 150,000 sq. ft. is planned for the Timbermill Shores development, including about 30,000 sq. ft. that is connected but not fully operational. The Main Street and Timbermill Shores snowmelt systems will be operated by the City, with operation coordinated with the overall geothermal control system. That snowmelt load can be partially or fully shed based on heating needs in the system.

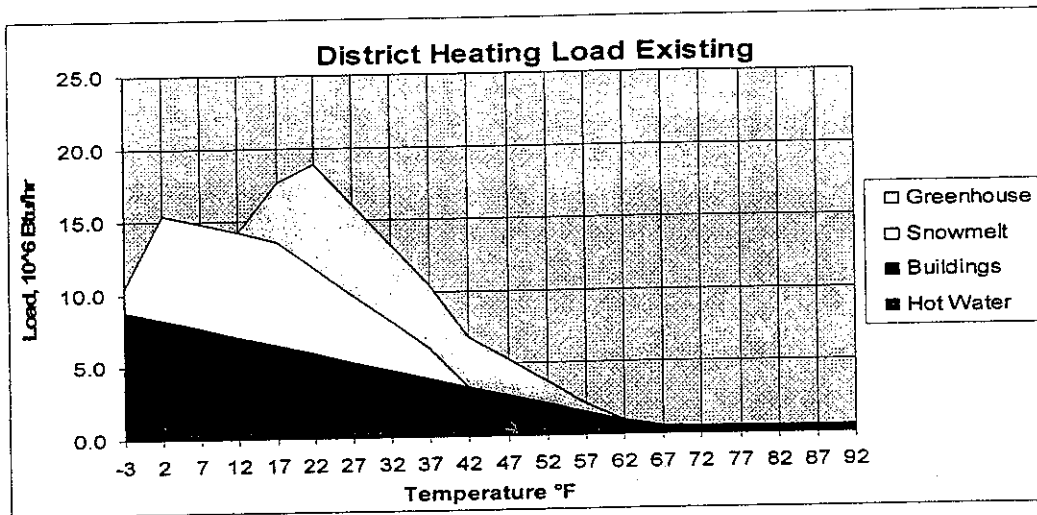
Snowmelt is primarily operated as a service rather than as a significant revenue source. Most snowmelt systems are un-metered, and billed at \$0.25 per square foot per year. The charge amounts to an energy cost of about \$1.90/ $10^6$  Btu.

**Potable and Process Water Heating:** The district heating system provides potable water heating for the Gospel Mission and the Creamery Brew pub, and process water heating at the Spring Street Wastewater Treatment Plant to heat the anaerobic digesters. Potable and process water heating is metered and billed with the building heat. Greater use of the geothermal system for process heat would be beneficial because the use is less seasonal, resulting in a higher load factor.

**Power Generation:** At an estimated 6% net thermal efficiency and electric costs of \$0.07/kWh, the value of the energy used for power generation is about \$1.20/10<sup>6</sup> Btu. Compared to the value of offsetting natural gas for heat, it is clear that power generation must not be allowed to interfere with operation of the district heating system.

## DISTRICT HEATING SYSTEM LOAD GROWTH

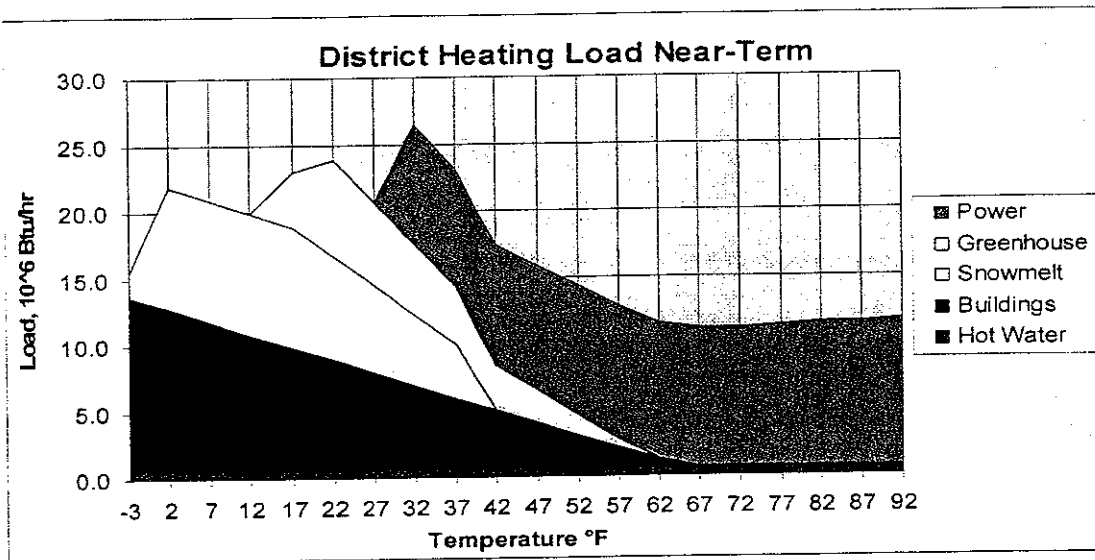
**Existing System Load:** The existing load profile is calculated based on loads that were connected to the system and operating last heating season. The calculation is based on early morning operation when buildings are generally unoccupied and there is no solar gain. The calculation of existing system loads shows a good match to the observed system operation.



During occupied periods the building heating load will be less at a given temperature due to internal gains from lights, equipment, and occupants. Solar gain will largely eliminate the heat load for the greenhouses, and will reduce the load for buildings and snowmelt systems.

**Near Term Load Projection:** The expected near term system load is based on potential customers expected to connect within one to five years. In addition to the existing customers, near-term additions include:

- 50% of Timbermill Shores Phase 1 buildings and snowmelt
- Reconnection of four buildings formerly on the system
- Installation of a 280 kW geothermal power plant in the geothermal piping ahead of the district heating system heat exchangers

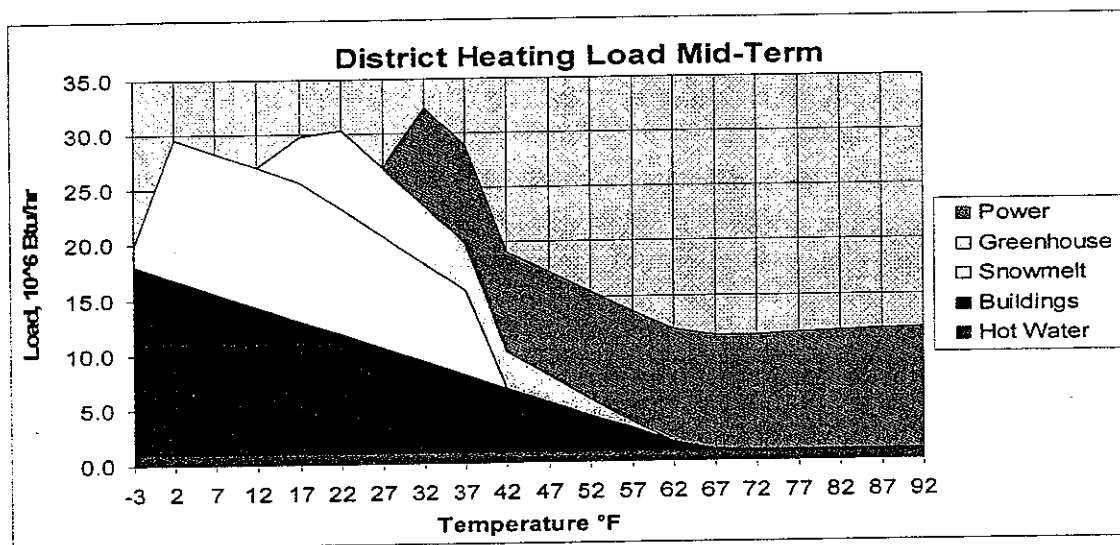


The power plant is assumed to be shut off at temperatures below 30°F to conserve heat for district heating loads. In reality, the shut-off temperature will depend on the system heating load, which will depend on the temperature profile for the day, solar effects, and other factors. It is likely that the plant could operate somewhat below 30°F most of the time, increasing the potential power generation.

**Mid-Term Load Projection:** The expected mid-term system load is based on potential customers expected to connect in 5 to 10 years. Mid-term load increases would include:

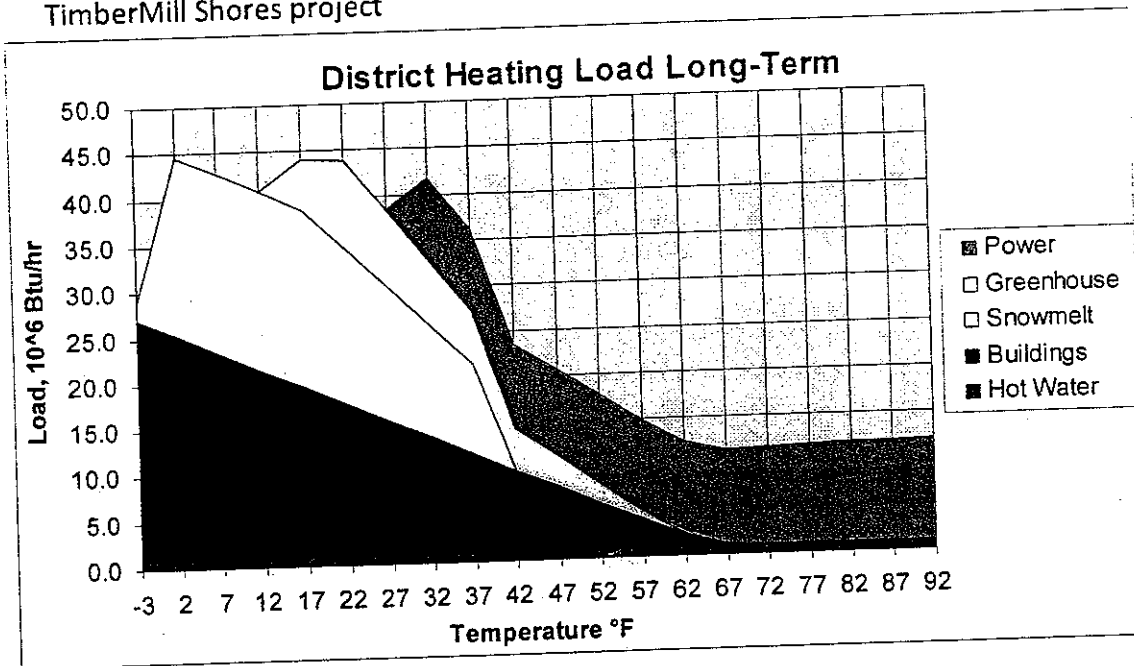
- Completion of Timbermill Shores Phase 1 and 50% of the Phase 2
- Connection of four additional buildings along the distribution pipeline

The mid-term loads can likely be handled with operation of a single geothermal pump and loop circulation pump, leaving the other pumps as standby. The load profile shows that the power plant can be operated above 30°F without affecting district heating capacity.



**Long Term Load Projection:** The expected long term system load is based on potential customers connecting in 10 to 20 years. The analysis assumed the following development:

- Completion of the proposed TimberMill Shores development
- Additional in-fill development elsewhere in the system equal in heating load to the TimberMill Shores project



The long-term projection brings the system load close to the probable capacity limit with both geothermal wells and two circulation pumps operating. The system could still meet the core building and greenhouse loads with only one pump by shedding the snowmelt load. As with other cases, the power plant can be operated above 30°F without affecting district heating capacity.

## POWER PLANT SELECTION

This analysis of geothermal power generation is based on installation of a PureCycle® Model 280 power plant, manufactured by Pratt & Whitney Power Systems, Inc; a division of United Technologies (UTC) Inc. The PureCycle® equipment was originally developed from a Carrier centrifugal chiller and uses many of the same parts, thus reducing manufacturing costs. Other suppliers are working on small package geothermal power plants, but UTC is the only supplier currently shipping units.

**Rankine Cycle Heat Engine:** Most of the electricity generated in the world involves conversion of thermal energy to electrical energy utilizing a Rankine cycle heat engine. In a conventional power plant, the working fluid is water. The cycle is essentially as follows:

1. Cold liquid (water) is pumped from low to high pressure using boiler feed pumps
2. Heat is added to convert the water to a high temperature, high pressure vapor (steam)
3. The vapor is expanded to a lower pressure through a turbine, producing mechanical energy which is converted to electricity by a generator
4. The low pressure vapor is condensed back to cold liquid using cooling water, which is typically produced by rejecting the heat into the air in a cooling tower.

The geothermal resource at 210°F is not hot enough to use water as the working fluid. However, the same cycle can be used using a working fluid that boils at a lower temperature. The proposed PureCycle Model 280 uses the refrigerant R245fa. A Rankine cycle heat engine using an organic working fluid is termed an Organic Rankine Cycle (ORC).

**Power Cycle Efficiency:** The efficiency of a heat engine cycle is limited by the temperature difference between the source temperature and the sink (cooling) temperature. The theoretical upper limit to efficiency can be calculated based on the Carnot cycle efficiency =  $(T_1 - T_2) / T_1$  where temperatures are on the absolute scale. Based on a geothermal supply temperature of 210°F (670°R) and a cooling water temperature of 70°F (530°R), the theoretical Carnot cycle efficiency is  $(670 - 530) / 670 = 21\%$ .

A real (as compared to theoretical) machine has losses and irreversibility such as friction, temperature drop in heat exchangers, and turbine losses that reduce the actual efficiency below the theoretical maximum. The PureCycle® Model 280 power plant when operating on 210°F supply water and 70°F cooling water will have a cycle efficiency of about 6.9%, not including power use for geothermal pumping, cooling water pumping, and the cooling tower fan. To maximize the power generation efficiency, it is important to:

- Maximize the hot side temperature in the power cycle
- Minimize the cold side temperature
- Minimize the power used for pumping and cooling fans

## GEOTHERMAL SUPPLY TO THE POWER PLANT AND DISTRICT HEATING

In cold weather, the Klamath Falls district heating system is currently operated using Well CW-1 (at 220°F) to produce a district heating supply water temperature of 190°F through the heat

exchangers. In spring and autumn weather Well CW-2 (210°F) is operated to produce 180°F district heating supply water. In the summer, the district heating system is currently not operated.

Integration of power generation into a geothermal district heating system will require that the power generation be installed first in the system, making first use of the hot geothermal water. The district heating system will then be heated using geothermal discharge of the power plant and possibly hot geothermal water bypassed around the power plant. When the power plant is running, the district heating system will operate at a lower temperature than it could without the power plant.

The temperature of the geothermal water discharge from the power plant will be a minimum of about 168°F. At light heating loads, the discharge geothermal water could produce a district heating supply temperature of about 165°F through the heat exchangers. That temperature would be adequate for warmer weather heating needs. In cooler weather, the supply temperature can be boosted to about 180°F by increasing geothermal production and bypassing a portion of the production around the power plant. In cold weather, the district heating system needs 190°F supply temperature to adequately supply customer needs and meet the maximum heating capacity, likely requiring the power plant to be shut off.

Since the direct-use heat, when needed, is more valuable than the power generation, the power plant operation must be curtailed when it begins to interfere with heat delivery. Ideally, the power plant should have the capability to modulate operation to accommodate the needs of the district heating system. The PureCycle® Model 280 power plant does not have any modulation capability that would allow it to discharge hotter water when needed. The assumption in the analysis is that the plant would be shut off below 30°F outside air temperature to preserve heating capacity for the district heating system.

## **POWER PLANT COOLING**

About 90 to 95 percent of the geothermal heat supplied to the hot side of the power cycle must be discharged to the environment on the cold side. The remaining 5 to 10 percent of the heat is converted to power. The PureCycle® Model 280 power plant uses a water-cooled shell and tube condenser for heat rejection. The refrigerant is condensed in the shell side of the heat exchanger by water flowing through the tubes.

An open cooling tower is typically used to cool the condenser water. Cooling towers are particularly effective in dry climates such as Klamath Falls where the wet-bulb temperature is often considerably cooler than the air (dry-bulb) temperature. The Cooling design conditions for Klamath Falls are 91°F wet bulb/ 63°F wet bulb. A cooling tower can cool to about 7°F approach to wet bulb, or 70°F. It is advantageous to oversize the cooling tower compared to a typical chiller application to allow lower cooling temperatures and minimize fan power.

Cooling in a cooling tower occurs primarily by evaporating a portion of the water as it cascades through the tower, in direct contact with air blown through the tower packing. As the water

evaporates it leaves behind minerals which need to be removed by discharging a portion of the water to "blow-down". The blow-down rate is determined by the mineral content of the makeup water. Assuming a blow-down rate of 20% of the evaporation rate, the cooling tower for the power plant will require about 23 gpm of makeup water, and will discharge about 4 gpm of blow-down. On an annual basis, the tower will require about 13,800 units of water (1 unit = 748 gallons), and will discharge about 2,300 units of blow-down. Assuming the water is supplied from the Klamath Falls municipal water system, and blow-down is discharged to the sewer system, the estimated annual cost will be \$24,000 for water and \$6,000 for sewer.

It may be possible to reduce the water bill by using the geothermal water for cooling tower makeup, depending on the water quality of the geothermal water. Further evaluation is needed.

Direct dry air cooling is sometimes used where water is scarce or overly costly. Air cooling involves circulation of the refrigerant through finned-coils and blowing ambient air over the coils with fans to cool and condense the refrigerant. The condensing temperature is typically 20-30°F above ambient dry-bulb. Dry condensers are relatively more costly, require higher fan power, and operate at higher condensing temperatures compared to cooling towers. UTC does not have an option for dry cooling for the PureCycle® Model 280 power plant.

Attachment 4. PureCycle Proposal



**Pratt & Whitney**

A United Technologies Company

### **Budgetary Estimate for Equipment Only**

Pratt & Whitney Power Systems is pleased to provide the following budgetary proposal for the equipment below based on our standard component and heat exchanger offering. This rough order of magnitude price represents a conservative estimate. Actual price will be presented as part of an official response to a Request for Proposal.

<p>One (1) PureCycle® Model 280 Power Systems with Copper tube condenser and Carbon Steel tube evaporator assemblies for the City of Klamath Falls</p> <p>Ex Works, York, PA USA</p>	<p>\$387,000</p>
--	------------------



**Customer Bill of Material - PureCycle® Model 280**

Item Description	Qty	Unit
<b>PWR63850 - Power Plant Assembly, Model 280, 480 V, 60 Hz</b>	A/R	ea.
<b>Evaporator Unit:</b>		
Carbon steel Evaporator Assembly		
• SA214 Carbon Steel Tubes		
• Carbon steel tube sheets & heads		
<b>Condenser Unit:</b>		
Copper Condenser Assembly		
• Copper tubes		
• Carbon steel tube sheet & heads		
<b>Turbine Assembly</b>		
<b>Refrigerant Pump</b>		
<b>Electronic Control System (ECS)</b>		
<b>Power Plant AC Disconnect Switch</b>		
<b>Consumables (UTC Provides initial fill )</b>		
<b>Turbine Oil</b>	A/R	gal.
<b>R245fa Refrigerant</b>	A/R	lbs.
<b>Services</b>		
<b>System start-up and commissioning</b>	A/R	
<b>Operation Training (at commissioning)</b>	A/R	
<b>Scheduled Preventative Maintenance including Parts &amp; Labor</b>	A/R	
<b>-- 1 year limited warranty</b>		
<b>Documents and Manuals</b>		
<b>APP68891 - PureCycle® Model 280 Power System –</b>		
<b>Standard Electrical Installation Drawing</b>		
<b>PRMAN66798 - PureCycle® Model 280 Installation Manual</b>		
<b>PRMAN66800 - PureCycle® Model 280 Operation and</b>		
<b>Maintenance Instructions</b>		
<b>PRIM71223 - PureCycle® Model 280 Installation Completion</b>		
<b>Checklist</b>		
<b>APP70613 - PureCycle® Model 280 Standard Mechanical</b>		
<b>Drawings</b>		
<b>A/R= As required</b>		



## **Exclusions**

For equipment only, site engineering and construction, equipment installation, electrical interconnects and balance of plant will be the responsibility of the City of Klamath Falls with final review by Pratt & Whitney Power Systems. Also excluded from the equipment only pricing are transportation costs and any applicable customs, duties and taxes. Transportation to Klamath Falls Oregon is estimated at \$7,000/unit.

## **Production Schedule**

The factory lead times for our standard product are considered to begin after receipt of 1st deposit.

- **Factory Lead Time** **14 Weeks**
- **Transportation Lead Time (estimate)** **1 Week**



### Performance Estimates:

Please find Pratt & Whitney Power Systems' performance estimates in Table A, based on the hot water resource inlet temperature and flow rate provided by Evergreen Energy.

The Equipment delivered under this budgetary proposal shall produce the power output at the approximate levels set forth in Table A, as appropriate, at the time of Initial Start Up, subject to the City of Klamath Falls providing the hot and cooling water conditions specified in Table A below.

**Table A – Equipment Only Performance summary**

Condition Number	Units	1	2
Brine Inlet Temperature	°F	210	220
Brine Outlet Temperature	°F	165	170
Brine Flow (min)	GPM	650	490
Cooling Inlet Temperature	°F	60	60
Cooling Outlet Temperature	°F	78	78
Cooling Flow	GPM	1160	1160
Total # of Machines	ea.	1	1
Net Power Per Machine	KW	260	260

Note: Power output includes only the parasitic power within the boundary of the PureCycle® Model 280 machine(s) and not any component associated with the balance of plant.

The City of Klamath Falls is responsible for providing and installing instrumentation to measure flow rates, temperatures, power output, and any other responsibilities set forth in this proposal. Notwithstanding anything herein, Pratt & Whitney Power Systems shall not be responsible for meeting the requirements in Table A in the event Pratt & Whitney Power Systems determines that the equipment has been improperly installed.



**Pratt & Whitney**

A United Technologies Company

## **Proposal Validity**

The pricing offered herein is valid for Ninety (90) days from the date of issue of this budgetary proposal. If Pratt & Whitney Power Systems is not in receipt of this Agreement executed by the City of Klamath Falls by the Offer Expiration Date, this Agreement, including the offer of the Proposal Price, shall have no force and effect.

## **DISCLAIMER**

All assumptions and results contained herein are nonbinding to Pratt & Whitney Power Systems. Actual performance, economic return and environmental benefits are subject to change based upon, among other things, economic variables, actual operating and environmental conditions, capacity utilization, maintenance and availability of government incentives. This budgetary planning estimate is for customer informational purposes only and does not constitute any equipment, installation or maintenance quotation or a commitment, representation or warranty that the forecasted savings or performance will be achieved. All commitments, representations and warranties with respect to Pratt & Whitney Power Systems' equipment and services shall be solely as stated in the final contract for such equipment or services.

This document is the property of United Technologies Corporation (UTC). You may not possess, use, copy or disclose this document or any information in it, for any purpose, including without limitation to design, manufacture, or repair parts, or obtain FAA or other government approval to do so, without UTC's express written permission. Neither receipt nor possession of this document alone, from any source, constitutes such permission. Possession, use, copying or disclosure by anyone without UTC's express written permission is not authorized and may result in criminal and/or civil liability.

**Pratt & Whitney Power Systems, Inc**  
400 Main Street, Building G  
East Hartford, CT 06108, U.S.A  
Phone: + 1-860- 565 5776  
Web Site: [www.pw.utc.com](http://www.pw.utc.com)



**Pratt & Whitney**  
A United Technologies Company

Wednesday, May 13, 2009

Steve Anderson, P.E.  
Evergreen Energy

**RE: DETAILED BUDGETARY PROPOSAL - PureCycle® Model 280 for the City of Klamath Falls, OR**

Dear Mr. Anderson:

Thank you for your interest in Pratt & Whitney Power Systems and our innovative geothermal power solutions. Based on our initial conversations and project analysis, Pratt & Whitney Power Systems is eager to do business with you and the City of Klamath Falls. We are pleased to provide a budgetary proposal for the PureCycle® Model 280 power system. Upon acceptance of this budgetary proposal and approval to proceed, I will engage our applications engineering group to complete a detailed analysis to more accurately assess the optimal system configuration and performance for your project. Upon completion of an engineering assessment, a final proposal and purchase contract shall be submitted, subject to Pratt & Whitney Power Systems' standard terms and conditions of purchase.

Included in this detailed budgetary proposal are the following:

- Budgetary Estimate for Equipment Only
- Estimated Performance
- Production Schedule
- Exclusions
- Service Plan Options

Thank you for giving Pratt & Whitney Power Systems the opportunity to provide this budgetary proposal. Should you have further questions or inquiries regarding the offer, qualifications and references, please feel free to contact Mike Ronzello (Email: [michael.ronzello@pw.utc.com](mailto:michael.ronzello@pw.utc.com) or Ph. 860-565-3617). We look forward to working with you. Please do not hesitate to contact us if we can provide you with additional information.

Respectfully submitted,

Mike Ronzello  
PureCycle® Sales/Business Development Manager  
Pratt & Whitney Power Systems



**Pratt & Whitney**

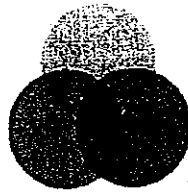
A United Technologies Company

## Service Plan Options

See below for a description of typical service plan offerings and estimated costs. These offerings are for informational purposes only; alternative service plans may apply.

- Silver Service Level **\$24,000.00/unit/yr**
- Bronze Service Level **\$12,000.00/unit/yr**
  - (year to year increases will be based on an agreed-upon escalation index)

Items listed under any task in Tables 1 and 2 of document TP-0015 marked "A/R" or "As Required" are to be performed, if required, as determined by Pratt & Whitney Power Systems' best judgment based on actual operating conditions, analysis and/or equipment monitoring. Remote equipment monitoring requires high speed internet service and a static IP address. Upon request, Pratt & Whitney Power Systems may provide Customer with a proposal for its approval to include Tasks outside the Scope of Service of the contracted agreement, and to provide for any corresponding adjustment in the Contract Price.



# MODEL 280 PureCycle® System

Release Date: 11/2008

Service Plan Offerings

## Silver Service Level (2 to 5 Years)

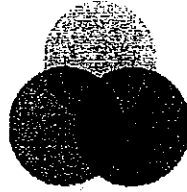
- Annual preventative maintenance (*Tables 1 and 2*) (parts and labor included for preventative maintenance and unplanned events), 24/7 remote monitoring
- Next business day response to unplanned events
- Excludes turbine overhaul and the repair of corrosion-related damage to the evaporator and condenser.

## Bronze Service Level (2 to 5 Years)

- Annual preventative maintenance (labor and parts included) and 24/7 remote monitoring (*Tables 1 and 2*)
- Excludes turbine overhaul and the repair of corrosion-related damage to the evaporator and condenser.



Service Plan Offerings



MODEL 280  
PureCycle® System

Release Date: 11/2008

Table 1. Preventative Maintenance Tasks

Maintenance Task	Every 3 Months	Every 6 Months	1st Year	Annual	Every 3 Years	Every 5 Years
Turbine Oil Analysis	X					
Turbine Oil and Filter — Inspect/Change as Required		X				
Working Fluid Filter/Drier — Inspect/Change as Required				X		
Oil Recovery System Filters — Change as Required After First Year			X			X
Working Fluid Pump Seal — Inspect/Change as Required						X
Evaporator Internal — Inspect/Clean as Required				X		
Condenser Internal — Inspect/Clean as Required				X		
Powerplant Overhaul						X
Electrical Maintenance				X		
Pressure Relief Valves — Inspect/Change as Required				X		

Table 2. PureCycle® Preventative Maintenance Parts and Consumables List

Qty	Component	Description
4	Plant	Core, Filter Drier
10	Plant	Lubricant
1	Plant	Strainer
2	Evaporator	Gasket, Body Flange
20	Evaporator	Gasket, Waterbox Partition
2	Condenser	Gasket, Body Flange
10	Condenser	Gasket, Partition Plate
1	Turbine	Filter, Oil
4	Plant	Sample Bottles With Pre-Paid Analysis
1	Pump	Grease, Pump Motor
AR	Plant	Refrigerant

Pratt & Whitney

