U.S. DEPARTMENT OF ENERGY
CHP Technical Assistance Partnerships
NORTHWEST

Case Study: University of Montana - Missoula

Combined Heat and Power – 440 kWc

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CHP CASE STUDY
CENTRAL HEATING PLANT COGENERATION PROJECT
UNIVERSITY OF MONTANA
MISSOULA, MONTANA
February, 2005

University of Montana

Physical Plant

The University of Montana in Missoula CUM) is one of two major Montana universities. UM started in 1893, almost 90 years after the Lewis and Clark Corps of Discovery first mapped the area. Like the Corps of Discovery, this case study documents the benefits and considerations of one of the first combined heat and power production projects at a State-owned facility. UM has a total enrollment of 13,352 students, 579 faculty and 1300 full time employees for the 2003 to 2004 school year. The 200-acre UM campus includes 62 buildings, a 23,000-seat football stadium, swimming pool, soccer, softball, and running tracks.

A study of past energy use shows the UM campus electrical consumption is 12,000,000 KWH in the winter and 22,000,000 KWH in the summer. Natural gas consumption for the year is approximately 2,000,000 therms.

Combined Heat and Power System

- The UM campus uses a district heating system with a central heating plant building containing three natural gas-fired boilers. Two boilers are rated at 70,000 lbs per hour, and one 30,000 lbs per hour at high pressure. The larger boilers can operate up to 200 pounds per square inch Cpsi) pressure, and the smaller at 250 psi. The boilers' efficiency improves at the higher pressures. Normal operation for the central heating plant would produce steam pressures of 80 to 180 psi before this project. Pressure reducing valves (pressure relief valve or PRV)reduce the steam pressure to 30 psi for the distribution of steam to the other buildings and processes on the UM campus. A technical analysis of energy measures in 1990 suggested the possibility of using a turbine to reduce the pressure when energy prices changed. Natural gas prices were deregulated, and the regulated electric prices had a sufficient difference in 1993 to closely examine the use of a step-down turbine to reduce pressure for the heating system and generate power at the same time. Timing allowed the project to access grant sources to make the project more acceptable into this formerly unexplored state-building-owned cogeneration territory.

- The installed steam turbine generator is a Coppus Engineering Model RLHA-24 with a 6-inch inlet and a 10-inch exhaust. The design conditions are for an inlet pressure of 165 psi and an outlet pressure of 30 psi with a steam flow of 24,978 pounds per hour.
- The induction generator is a Siemens 449TS frame induction generator rated at 480 volts, 3 phase, and 60 hertz, at 3600 rpms. The generator efficiency is 94.1 percent with a full load power factor of 85 percent (440 kW).

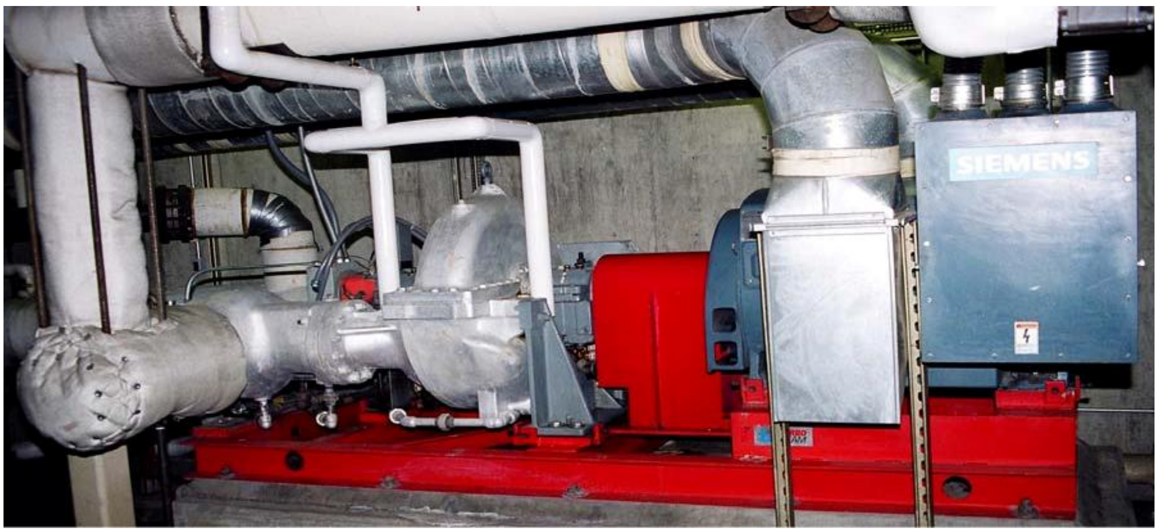


Photo of steam turbine and generator

Financial Statistics

Total Costs	$603,254
Original Goal	Payback in 25 years
Actual Performance	Payback in 25 years
Average operating savings:	Approximately $73,994
Internal Rate of Return	5 percent

A break out of project costs:

Turbine & generator package	$198,464
Installation costs including asbestos abatement and deaerator tank	$296,812
Design, construction, administration and other	$107,978*

*Note: This does not include State bond program costs.

The project received partial grant funding from the U.S. Department of Energy Institutional Conservation Program CICP) and a grant through the State Alternate and Renewable Energy

Grant and Loan Program (State funds). Additional funds came from the University of Montana and bond funds from the State Bonded Energy Program (SBEP). The following is a summary of project funding:

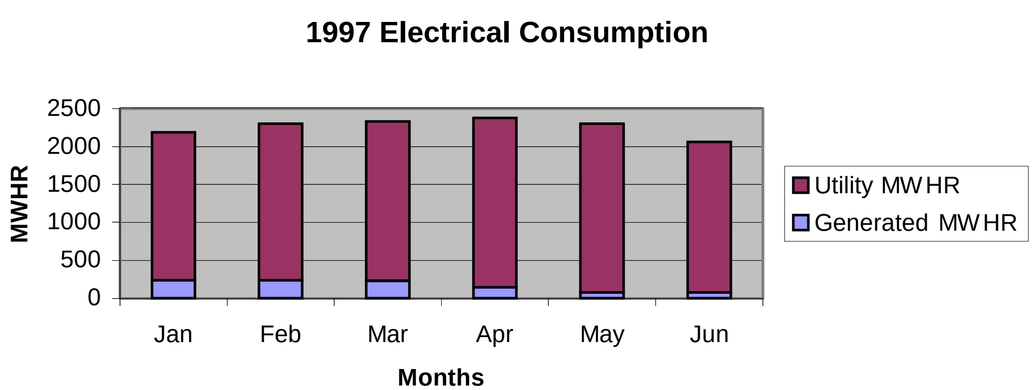
ICP	$126,948
University funds	$ 35,000
State Funds	$ 93,000
SBEP funds	$390,287**

**Note SBEP funds include State bond program (interest) costs.

Debt service on bond funds was $51,785 a year at 5.5 percent interest for ten years.

Energy/Financial Analysis Overview

- The UM central boiler plant operates 24 hours a day, 7 days a week and with an annual 10-day maintenance shut down in May.
- Physical plant staff estimates the combined heat and power project provides about 5 percent of total UM campus electrical consumption.
- Northwestern Energy Inc. CNWE) provides the remainder of the electrical requirements for the UM campus.
- NWE supplies the induction current for the generator so power production is not a stand-alone or backup power supply.
- The power generated is approximately 6,800 million BTUs CMMBTU) per year.



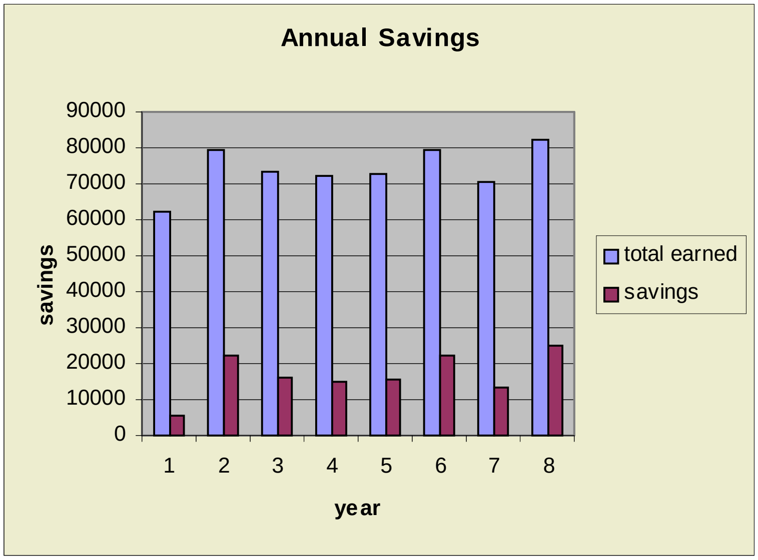
Partial year energy consumption

Actual Production:

The UM campus staff logged the following actual power production (in megawatt hours, MWHR) from 1995 until 2003 summarized below.

Year	Dates	Production	
1	**1995-96**	**1,547.40**	**MWHR**
2	**1996-97**	**1,948.00**	**MWHR**
3	**1997-98**	**1,776.01**	**MWHR**
4	**1998-99**	**1,696.94**	**MWHR**
5	**1999-2000**	**1,676.06**	**MWHR**
6	**2000-01**	**1,876.09**	**MWHR**
7	**2001-02**	**1,664.46**	**MWHR**
8	**2002-03**	**1,712.04**	**MWHR**

Highest monthly production to date **278.83 MWHR** in Dec 1996
Highest daily total to date: **10.02 MWHR**



This graph represents the total dollars earned Minus the bond payment. 1997 to 2003

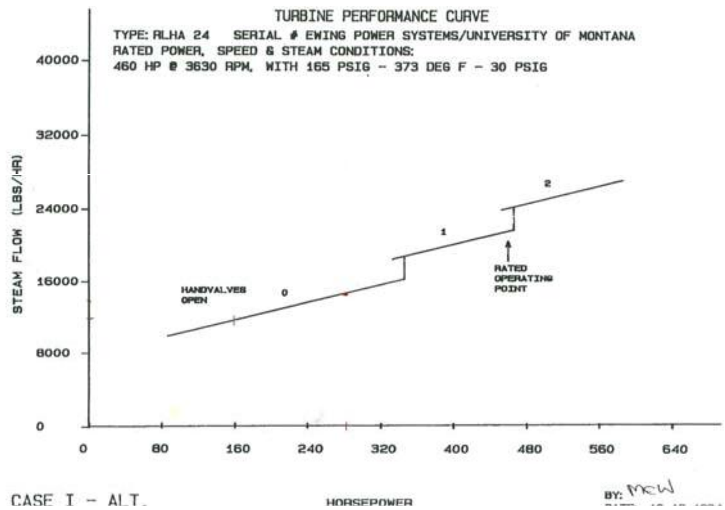
The total power produced from 1995 to 2003 was valued at $591,958 (includes energy and estimated demand for individual years). The UM campus realized $134,646 in savings, or an average of $16,830 per year, after payment of the annual bond.

Performance Results:

The performance goal of the central boiler plant is to supply heat to the UM campus first, with increases in efficiency and savings in power second. UM central heating plant staff indicated there have been minimal problems with the combined heat and power system. Routine maintenance provides oil changes to the turbine. Estimated maintenance hours for this system are less than 8 hours a month.

The step-down steam turbine generator project provides the UM campus electrical system with an additional benefit of helping to balance each leg of delivered 3-phase utility power. Each of the generators' three phases closely equals each other in terms of voltage (or amps), more so than the utility power. The turbine power connects directly to the main campus meter entrance where the utility power also enters the campus. The turbine-generated power, with its equal phases, helps to reduce any differences in the utility power resulting from changes in utility load while the power travels the grid to the UM campus.

Two items may improve a similar project. This turbine is equipped with two hand valves that allow increased turbine performance with pressure changes. As steam flow increases to match demand, opening one of the valves would increase to the turbine through another nozzle. This allows more power to the generator. The operator stated control would improve on a new step-down turbine by adding a third (hand) control valve, or as many as the block would allow. The additional valves would help balance the steam flow variation of up to 7,000 lbs of steam(see turbine performance curve) to smooth performance. This results in a steadier supply of steam with less fluctuation and fewer operating problems.



TURBINE PERFORMANCE CURVE WITH HAND VALVES

The second item for improvement is the machining of the hand valves into the casing. The bore into the casing was not straight and true. No provision exists for easy valve seat maintenance. If there were a provision, valve seat repair would have been a few hundred-dollars. As built, valve seat replacement is a major task requiring between $7,000 and $9,000 because the valves will have to be re-sleeved. To quote the plant operator, "…Pay now or pay later, better to pay more up front."

Results and Findings:

The co-generation project reduced the operating costs of the facility over the years, and was not a problem for the plant staff. The UM central plant facility already required a high-pressure boiler engineer operator on staff. This project would not have been cost effective to implement if additional FTE had been required to operate the boilers or generator.

In addition, future project feasibility analyses should use conservative estimates given the seasonal nature of energy production resulting in a long equipment payback. For example, the initial energy analysis for this project used 97.5 percent of the theoretical annual electric production of 2,269.74 MWHR, as would be the practice at a commercial facility. Actual logged maximum energy production is 1,947.99 MWHR. The difference results partly from the mild winters that reduced steam loads, compared to 30-year average climatic data and heat load. Additional energy conservation measures further reduced the steam loads. Therefore, the use of an estimated 85 percent of the theoretical power production would have more closely matched the actual production.