

Black Hills Power Ben French Plant Replacement Evaluation February 28, 2025



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ACRONYMS

BESS	Battery Energy Storage System
BHP	Black Hills Power, Inc.
Btu	British Thermal Units
CF	Capacity factor
CTGs	Combustion turbine generators
EMD	Electric-Motive Diesel
GE	General Electric
HHV	Higher heating value
lbs/MMBtu	Pounds of pollutant per million British Thermal Units
MM/OH	Major maintenance/overhaul
MW	megawatts
NERC	North American Electric Reliability Corporation
NH ³	Ammonia
NOx	Nitrogen oxide
O&M	Operation and maintenance
PM	Particulate matter
Ppmvd	Parts per million dry volume
RICE	Reciprocating internal combustion engine
SCR	Selective catalytic reduction
West Peak	West Peak Energy

Executive Summary

Black Hills Power, Inc. (BHP) has contracted with West Peak Energy (West Peak) to perform a comparison of two options to meet BHP's near-term requirements with regards to meeting its integrated resource plan goals. The first option will be to continue to operate the aging 1970s Ben French Plant design which is inefficient compared to today's generation technologies and will require significant capital expenditures in the next few years. The second option is to construct a new generation expansion at BHP's Lange Plant to improve BHP's overall costs and response to grid requirements.

The Lange Plant expansion will be based on new reciprocating internal combustion engine (RICE) units that will add to the existing combustion turbine generators (CTGs) at the Lange Plant by increasing the Lange Plant capacity by 99.6 MW. The new Lange Plant's technology will improve its overall fuel efficiency, improve grid reaction times, and significantly reduce emissions compared to the existing Ben French Plant.

Based on our analysis below, we are of the opinion that the new Lange Plant design has significant benefits to BHP customers compared to continued operation of the existing 1970s Ben French plant.

1. Introduction

West Peak Energy (West Peak) has prepared the following desktop study in accordance with our Contract Number 49697 dated March 11, 2022. The study compares the continued operation of the existing Black Hills Power, Inc. (BHP) Ben French Plant, versus replacing the existing plant and installing six new reciprocating internal combustion engines (RICE) at the Lange Plant, designated Lange II. Both Ben French and Lange facilities are in Rapid City, SD.

The Ben French Plant has been providing needed backup and black start capabilities to the local grid and BHP is concerned about the ongoing reliability and cost effectiveness of the 50+ year old Ben French Facility. Black start capability refers to being able to start up a power generation facility in the event of a grid blackout. Many power generators rely on the grid for starting whereas certain units, like two at the Ben French Plant, can start on their own and start the remaining units. This allows the plant to be available to energize the grid when it is needed.

The Ben French Plant consists of nine existing generators: four General Electric (GE) Frame 5P combustion turbine generators (CTG) and five RICE Electro-Motive Diesel (EMD) powered generators.

The five EMD RICE diesel generators were commissioned on November 25, 1965. They are the oldest units in BHP's generation fleet. Each unit has a rated capacity of 2 MW, for a total RICE capacity of 10 MW. These EMDs have averaged approximately 96 hours per year of operation over their life for a total of approximately 5,700 hours.

The four GE Frame 5 CTGs were installed over a period of approximately two years. Units 1 and 2 were commissioned in 1977. Unit 3 was commissioned in 1978, and Unit 4 was commissioned in 1979. Units 3 and 4 are considered 'Critical Units' under the North American Electric Reliability Corporation (NERC) regulations as they are black start capable (i.e., they don't require power from the grid to startup). Each CTG is dual-fuel capable using natural gas or diesel fuel. Each Frame 5 has a rated capacity of 20 MW for a total capacity of 80 MW.

The new RICE facility to be constructed at BHP's Lange Power Plant is an expansion to the existing CTGs located there. The new RICE facility will have a gross capacity of approximately 99.6 megawatts (MWs), consisting of six new, dual-fueled (natural gas and ultra-low sulfur No. 2 oil) Wartsila 18V50DF-D2 Model units rated at 16.6 MW each (gross). We note that Wartsila rates these units nominally at 18.0 MW based on typical pipeline quality fuel properties. However, due to the fuel quality available at the plant, North Dakota-Bakken Shale, Wartsila will derate the unit and provide guaranteed performance, including emissions, at 16.6 MW.

West Peak reviewed the performance and cost data provided by BHP to compare the projected costs for the continued operation of the Ben French Facility based on historical and projected plant operation. West Peak then developed similar performance and cost comparisons for the new RICE facility, including environmental issues and compliance considerations. In addition, industry-recognized used equipment vendors were contacted to define the current salvage value of the Ben French Facility equipment.

2. Comparison of Energy Costs

2.1 Existing Units

In general, GE Frame 5s are known to be rugged, reliable units as evidenced by their long-term service in BHP's territory. However, GE has reduced its support of the older Frame 5 engines in favor of newer and more efficient aero-derivative blade designs that are able to operate at higher temperatures, which results in higher thermodynamic efficiencies (lower heat rates). Heat rates for the older Frame 5 CTGs are 60-80% higher than the newer aero-derivative CTG units or the modern RICE units. In general, all CTGs are most efficient (have their best/lowest heat rates) at or near full load and operation at reduced loads significantly degrades their heat rate. In addition, the EMD diesels are considered obsolescent and inefficient RICE technology with no minimal effective upgrades.

Table 1 below summarizes the total fuel expenses for the past four years as well as the five-year forecasted fuel expenditures with BHP's current operational forecast. Fuel pricing herein is based on BHP estimates.

Because of the much higher fuel costs and heat rate of the existing Frame 5 CTGs, they are rarely dispatched and have experienced an average capacity factor (CF) of 1% over the past five years. BHP assumes this trend will continue based on the average annual expenditure which is shown in Table 1.

Table 1. Ben French Fuel Expenses for a 1% CF

Actual				Forecasted					
2021	2022	2023	2024	2025	2026	2027	2028	2029	3-Yr Forecast
\$450,500	\$339,047	\$276,281	\$445,969	\$517,000	\$517,000	\$517,000	\$517,000	\$517,000	\$1,551,000

BHP assumes that a new more efficient RICE plant will likely be dispatched much more often due to its significantly lower operating costs over a wide range of power output. The Lange expansion's CF is estimated to increase by upwards of 30%, according to BHP. BHP projects that this type of facility could be in operation as soon as the third quarter of 2026 with full year operation beginning in 2027 as noted in Table 2.

Table 2. Lange RICE Fuel Expenses vs CF

	Actual				Forecasted					
	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-Yr Forecast
30%							\$9,164,000	\$9,164,000	\$9,164,000	\$27,492,000
1%							\$305,000	\$305,000	\$305,000	\$915,000

The fuel expenses projected above include estimates for a high CF and a low CF. The low CF would compare to the projections of the current Ben French Facility. All costs are based on an assumed natural gas fuel price of \$4/million British Thermal Units (MMBtu) that was not escalated.

For a given capacity factor, a new RICE facility at the Lange Plant will provide significant fuel savings estimated at \$630,000 per year.

2.2 Performance Comparison

In general, the CTGs are in fair condition for their age, however, due to the age of the Ben French Plant, both generators and electrical ancillary systems are in need of major maintenance or capital investments such as major overhauls including hot gas path repairs, blade replacements, generator rotor and stator rewinds, relay and other balance of plant upgrades as needed. These typically cost more than their salvage value. With only 1% CF, their standby manpower and maintenance costs likely exceed their revenues. In addition, BHP notes that spare parts are becoming increasingly difficult to procure, which seems consistent given the age of these CTGs and the decreasing number of units that are expected to remain in operation. To keep overhaul costs low, one option available to BHP is to purchase remanufactured parts; but as these would be weld-repaired, they may not have the same life as newly manufactured parts. Reduced spare parts availability and use of refurbished parts will impact future BHP capacity reliability and may lead to additional costs.

As noted above, the new Lange RICE facility will consist of six dual-fueled, compression ignition engines. These units will be black-start capable and be configured with selective catalytic reduction (SCR) and oxidation catalyst (oxicat) which will meet present emission regulations. The RICE units will be housed in a new, stand-alone facility designed for ease of operation and maintenance of the engines.

A comparison of the relative performance of each facility is shown in Table 3 below. In addition to heat rates, other operational benefits over the CTG's older technology are the start-to-full-load times, ramp rates, and part load operations.

Table 3. Performance Comparison

Metric	GE Frame 5	Wartsila RICE
Net Facility Heat Rates, Btu/kilowatt hour (kWh ¹)	15,000-18,500	8,600
Avg. Net Facility Heat Rate, Btu/kWh ²	17,200	8,600
Typ. Minimum Heat Rate, Btu/kWh ³	22,300	10,860
Time to Full Load, Min.	>15	5
Minimum Load, % ³	50%	40%
Ramp Rate (%/Min.) ⁴	20-50	60

Notes: ¹ Higher Heating Value (HHV)

² 5-Yr. Average

³ Typ Load 50% for CTGs to Maintain Emissions

⁴ % of full load

Another benefit of RICE is the partial load heat rates which have a flatter heat rate curve versus the Frame 5s. This means as the CTGs reduce load, the heat rates (which are already significantly higher than RICE) increase at a faster rate, compounding the fuel consumption difference. Typically, the limiting factor on minimum loads is the load at which the unit, whether a CTG or a RICE unit, can maintain emissions limits. CTGs generally operate down to approximately 50% load whereas a modern dual fuel RICE, when used with back-end emissions controls, can reduce load to 40%. This means a RICE plant would not be required to shut down and then restart as quickly. Since the RICE heat rates are better at low loads than the CTGs, there is less financial pressure to shut down a unit at partial load.

RICE units are capable of starting up and reaching full load capacity more quickly (when they are kept in a warm/standby condition) than the Frame 5s and there are no maintenance penalties for frequent and significant changes in load or for frequent starts and stops. When load changes are required, the ramp rates in both the up and down direction are significantly higher for RICE units than for CTGs, another benefit when used to balance the system. While CTGs can respond in a similar manner, their response is slower. In addition, frequent starts and stops of a CTG will negatively impact their maintenance intervals, thus increasing their maintenance costs.

2.3 Comparative Emissions Evaluations

BHP reports that the RICE replacement facility at the Lange Plant will require a New Source Review Minor Construction Permit and will require the installation of an SCR and oxidation catalyst emission controls in compliance with South Dakota Air Quality Standards and Regulations as well as all National Emission Standards.

Comparative plant emissions rates are presented in Table 4 below between the existing Frame 5s and proposed RICE units. Due to their age and installation date, the Frame 5 units were not required to have emissions control systems installed. Emission rates for the Frame 5s in Table 4 are based on AP-42 emission factors, except for nitrogen oxide (NO_x) which is based on actual U.S. Environmental Protection Agency-permitted emission rates for a recently tested non-water injected Frame 5 CTG with which we are familiar. The EMD units operate so infrequently that they were excluded from this analysis.

Table 4. Criteria Pollutant Emissions Comparison, lb/MMBtu

Emission	Frame 5	RICE
NO _x as Nitrogen Dioxide	0.585	0.0275
Carbon Monoxide	0.082	0.0421
Volatile Organic Compounds	0.0021	0.0709
NH ₃ , ppmvd ¹ , 15% O ₂	N/A	10
Particulate Matter (PM), Total	0.041	0.0350

Note: parts per million dry volume (ppmvd)

Wartsila's dual-fuel RICE emission rates listed in Table 4 are consistent with BHP's South Dakota Department of Agriculture and Natural Resources air permit application values with a small margin added over the Wartsila guarantees.

Emission rates are pounds of pollutant per million British Thermal Units (lbs/MMBtu) except ammonia (NH₃) slip which is pounds per million, by volume, dry, corrected to 15% oxygen (O₂) (ppmvd, 15% O₂). PM total represents both PM_{2.5} and PM₁₀ (2.5 microns and 10 microns).

Based on Table 4, the proposed RICE expansion will provide a significant reduction in criteria emissions for BHP and its customers over continued operation of the Ben French Plant.

2.4 O&M Cost Comparison

Operation and maintenance (O&M) costs are commonly broken into three main categories: fixed costs, variable costs, and major maintenance/overhaul (MM/OH) costs. MM/OH and capital expenditures are used interchangeably herein. Fuel costs are not included in this comparison.

A summary of the existing facility's O&M costs are shown in Table 5. Fixed and variable costs are based on actual and expected continued operation of the Ben French Plant. Due to the Ben French Plant's age, BHE plans on significant capital expenditures over the next five years that include hot gas path inspections and refurbishments, electrical equipment replacements, and generator rewinds.

RICE O&M expenses were based on busbar costs for the new Lange Facility provided by BHP and escalated to 2025 dollars. Variable costs were based on a CF of 30%, as noted above. In both cases, fixed and variable O&M costs were combined for simplicity of comparison.

The O&M costs for the proposed RICE facility are broken into fixed, variable, and MM/OH costs estimated by Wartsila.

While these costs vary from technology to technology, the definitions of each category can be summarized as follows:

Fixed O&M: Fixed O&M costs are not dependent on the actual operation of the plant and generally include plant operating and maintenance staff, contract services and administrative costs.

Variable O&M: Variable costs will vary as the operation of the plant varies. These costs include routine maintenance of the power generation units and balance of plant, and consumables such as filters and lubricating oils, chemicals and ammonia for emissions control.

MM/OH Costs, or Capital Expenditures: These costs represent periodic, large expenditure costs, typically based on operating hours, and are replaced at the same time. Factors other than operating hours can affect CTG MM intervals.

Table 5. Ben French Non-Fuel O&M Expenses

	Actual				Forecast					
	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-Yr. Sum
F&V	\$883,517	\$942,625	\$828,511	\$677,849	\$937,000	\$1,166,700	\$997,100	\$1,062,300	\$1,033,900	\$5,197,000
Capital Expenditures					\$3,215,200	\$10,739,700	\$12,349,700	\$11,178,000	\$11,426,000	\$48,908,600
Total	\$883,517	\$942,625	\$828,511	\$677,849	\$4,152,200	\$11,906,400	\$13,346,800	\$12,240,300	\$12,459,900	\$54,105,600

Notes: Ben French fixed and variable (F&V) O&M include both the Frame 5s and the EMDs.
Capital expenditures include major maintenance items discussed above.

Table 6. Lange RICE Non-Fuel O&M Expenses

	Actual				Forecast					
	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-Yr. Sum
F&V							\$477,000	\$477,000	\$477,000	\$1,431,000
Capital Expenditures							\$1,179,000	\$1,179,000	\$1,179,000	\$3,537,000
Total							\$1,656,000	\$1,656,000	\$1,656,000	\$4,968,000

While the Ben French Plant has a low CF and associated low fixed and variable operating costs, its age will require a significant amount of capital expenditures to keep the plant in operation into the near future.

We note that the capital cost of the RICE expansion of the Lange Plant will be required for an economic comparison of the two options, however, given the performance and emissions metrics, the RICE option provides many benefits to BHP and its customers.

3. Evaluate Aftermarket Value of Units

West Peak contacted a few aftermarket vendors of power generation equipment regarding the current value of the Frame 5 units. Given the current state of repair, these units will require a hot gas path inspection/overhaul in 2-3 years, the value as complete units are minimal. It may be equally cost effective to decommission these, cut them up for salvage value. However, with the current projected demand increases that are projected for various utilities in the US, their value may increase in the next few years given the lead times of obtaining new CTGs. As the market changes, it would be prudent to periodically check the value of these units up until the time when the preparations for decommissioning are being implemented.

In the event that it is preferable to decommission and remove all equipment and structures on site, BHP has prepared a decommissioning cost estimate for the Ben French Plant that includes the following.

- four (4) xGE Frame 5 CTs and associated generators
- five (5) EMD generating sets including reciprocating engines and generators
- Two (2) each million-gallon tanks and associated piping, pumps, heaters, and loading stations
- Removal of electrical facilities including four (4) transformers, generator breakers and electrical switchgear
- Complete environmental decommissioning
- Complete concrete demolition
- Import topsoil for site restoration including seeding and straw

It is assumed that the scrap value of the steel and copper from the CTGs will offset the costs to cut and remove the material.



Figure 1 – Ben French Plant Equipment and Structures for Decommissioning

BHP estimated that the removal of the scope above is approximately \$1.355M. in addition to investigating the aftermarket value of these units, West Peak prepared a desktop analysis of the costs to demolish the structures at the Ben French Plant. Based on our desktop analysis, we concur that these costs are within the range of what we estimate.

	<u>Estimated Cost, (\$000)</u>
Foundation Removal	\$1,000 - \$1,250
Tank Demolition and haulage	\$75 - \$100
<u>Contractor Indirect</u>	<u>\$125 - \$150</u>
Total cost	\$1,200 - \$1,500

Indirect costs include mobilization, contractor insurance, site restoration, profit, etc.

Note this estimated cost do not include BHP costs.

Our estimate was based on the following assumptions:

- No asbestos, lead remediation or other costs are included in this estimate.
- No above ground piping is associated with this demolition.

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- Only the physical foundation(s) are removed. If caissons are present, they are left in place.
 - Any separation of steel rebar from concrete is assumed to be performed at the recycler.
 - Fuel tanks were assumed to be a nominal ½" thick. The steel in these tanks could have a salvage value of approximately \$65,000 at a typical steel salvage price of \$200 per ton.
 - Tank foundations were assumed to be 1 foot larger in diameter than the respective tank.
 - Foundations for the CTGs, transformers, truck unloading and fire pump house will be removed to a minimum of 42 inches.
 - Foundations for the two storage tanks and the day tank will also be removed to a minimum of 42 inches.
 - All concrete rubble will be hauled six miles to a recycler for reuse.