

## **Repowering: A Financially Compelling Method to Improve Existing Assets**

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In a period when financial resources are constrained and there is emphasis on cost cutting and improving operations, repowering offers the potential to significantly improve existing power plant assets.\* Such improvements can include a more than 50% improvement in power plant heat rate, leading to tremendous operating cost savings.

Yet despite the potential operational benefits of repowering, Beacon Energy and ALSTOM Power have found from firsthand development activities that there are misconceptions regarding repowering economics. Those views appear to be limiting the extent to which repowering is being considered as a power supply resource option.

Two common misperceptions of repowering relate to its relative installed cost compared to greenfield construction and its comparative financial returns on a life-cycle basis. In the following, we discuss these two issues and try to make the case that repowering should be routinely included in power supply planning, along with options such as greenfield construction, power purchase agreements and spot purchasing.

### **RELATIVE INSTALLED COST**

In discussions with several utilities, we have been told on more than one occasion that “Repowering is more expensive than greenfield construction,” with the implication that repowering would not be investigated in detail. In exploring this view further, we found that the common view was that repowering was more expensive than greenfield construction on a dollar-per-kilowatt basis. A paraphrase of one such discussion was “repowering costs \$700/kW compared with \$500/kW for a new greenfield plant; therefore, we are not including it in our current system planning.”

Our belief is that this view stems from the comparison of the total cost of construction for repowering and greenfield on an incremental kilowatt basis. For repowering, we do not believe this is a fair or accurate comparison, especially if the comparison does not involve projects of comparable sizes (more later). Take, for example, the comparison outlined in Table 1. This example assumes a 100 MW boiler/steam turbine power plant is repowered by adding a 180 MW gas turbine and heat recovery steam generator (HRSG). Optimal matching of the new and existing equipment yields a 260 MW combined cycle.

**Table 1 – Comparative \$/kW Costs**

<b>Project Dimension</b>	<b>Repowering</b>	<b>Greenfield</b>
Size (MW)	260	270
Incremental Size (MW)	160	270
Total Cost (Million \$)	106.31	141.75
Total Cost (\$/kW-total)	409	525
Total Cost (\$/kW-incremental)	664	525

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\* In this context of this article, repowering means replacing existing boilers in a boiler/steam turbine power plant with a new gas turbine and HRSG to create a combined cycle configuration.

Our experience indicates that a repowering project can typically be implemented for about 70-80% of the cost of a greenfield plant, since it utilizes existing infrastructure and does not require a new steam turbine. Assuming a cost of \$525/kW for the greenfield, combined cycle yields a total project cost of about \$142 million. At 75% of that figure, the repowering project would cost about \$106 million.

While the total cost of the repowering project is less, it is apparent that some utilities are making preliminary decisions based on the view that repowering actually costs more. If the repowering project's total cost is applied to the incremental 160 MW, this yields a figure of \$664/kW compared with \$525/kW for the greenfield project. If presented only with those \$/kW figures, it is reasonable to assume that some decision-makers would not consider repowering.

In our view, however, the accurate comparison is total project cost applied against total plant MW. In the example, this would yield a figure of \$409/kW for the repowered plant versus the \$525/kW for the greenfield option. These relative costs, coupled with the potential to transform an existing plant with a heat rate likely to be well in excess of 12,000 Btu/kWh to one with a heat rate closer to 7,000 Btu/kWh, makes the case for repowering more compelling.

## **COMPARATIVE FINANCIAL RETURNS**

A second perception that we have encountered frequently is that repowering costs more than greenfield construction on a life-cycle-cost basis. We readily admit that repowering economics are site-specific, so there may be cases where this is indeed true; however, our experience leads us to conclude that this view is often derived from either:

- A view that a new greenfield combined cycle will have a better heat rate than a repowered plant; therefore, must cost less on a life-cycle basis; or
- A comparison of two projects of different sizes, typically a 500+ MW greenfield combined cycle with a 200-250 MW repowering project, which would favor the greenfield plant based on economies of scale.

While repowering may not ultimately be the preferred expansion alternative, we believe that a side-by-side comparison of comparably sized projects is the truest measure of relative financial returns. In many cases, a repowering's lower total project costs will offset its somewhat higher heat rate so that on a 20-year basis it will yield an IRR and a NPV that are both greater than those of a greenfield project.

To illustrate, we first outline a baseline comparative financial return for a 260 MW repowering project against a 270 MW greenfield project, and also for the option of retaining an existing 100 MW boiler/turbine plant with 160 MW of purchased power. For each case, the underlying economic assumptions are those outlined in Tables 1 and 2.

**Table 2 – Assumptions for Financial Sensitivities**

	Repowering	Greenfield	Existing Plant+Power Purchase
Heat Rate (Btu/kWh)	7100	7000	12000
Fixed O&M (\$/kW-yr)	24	24	8
Variable O&M (\$/MWh)	1.5	1.5	0.75
Purchased Power Price (% of assumed sales price)	---	---	90
Energy Price Escalation (%)	3	3	3
Load Factor (%)	80	80	80
Debt/Depreciation Term (yrs)	20	20	---
Interest Rate (%)	6	6	---
Debt/Equity Ratio	80/20	80/20	---
NPV Discount Rate (%)	9	9	9

**Baseline Comparison**

Our baseline comparison assumed a natural gas price of \$3.25/MMBtu and a \$35/MWh power sales price. At these levels, the repowering example yields a \$28 million, 20-year NPV and a 27% IRR, compared to \$17 million and 17%, respectively, for the greenfield project. Operating the existing plant and purchasing (at 90% of the sales price) and re-selling power yields a negative NPV.

To further illustrate the viability of repowering, we outline five different financial sensitivities:

- Natural gas price versus electricity sale price
- Natural gas price versus gas price escalation
- Natural gas price versus load factor
- Repowering project cost versus greenfield project cost
- Debt interest/NPV discount rates.

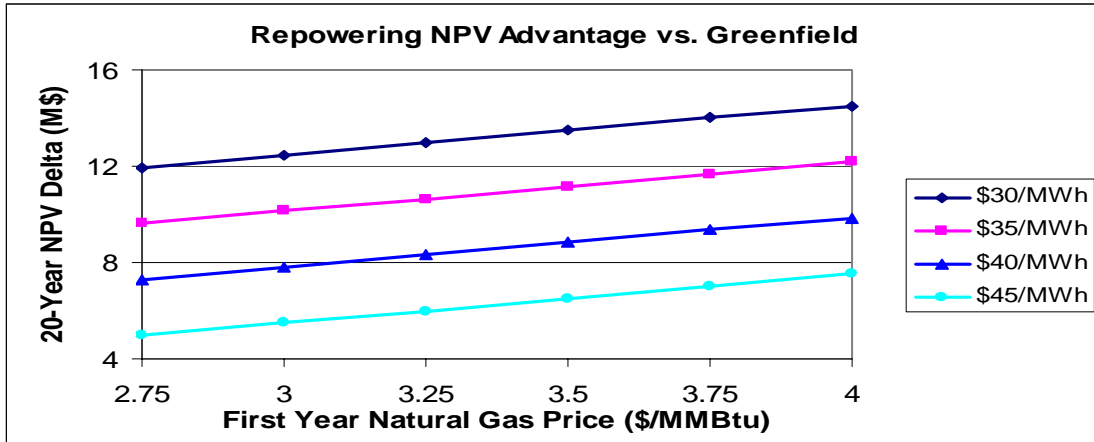
**Natural Gas Price vs. Electricity Sale Price**

The 20-year NPV of repowering was first compared with that of a greenfield project and with the option of operating the existing plant and purchasing incremental power at different natural gas and electricity sales prices. Assuming first-year natural gas prices ranging from \$2.75/MMBtu to \$4/MMBtu and power sales prices varying from \$30/MWh to \$45/MWh, and under the assumptions outlined previously (Tables 1 and 2), repowering yields a higher NPV than the greenfield project in all cases (see Exhibit 1). Repowering’s NPV advantage was about \$5-7 million at \$45/MWh power and increased to \$12-15 million at \$30/MWh power. At different power prices, repowering’s advantage was relatively constant across the range of assumed natural gas prices.

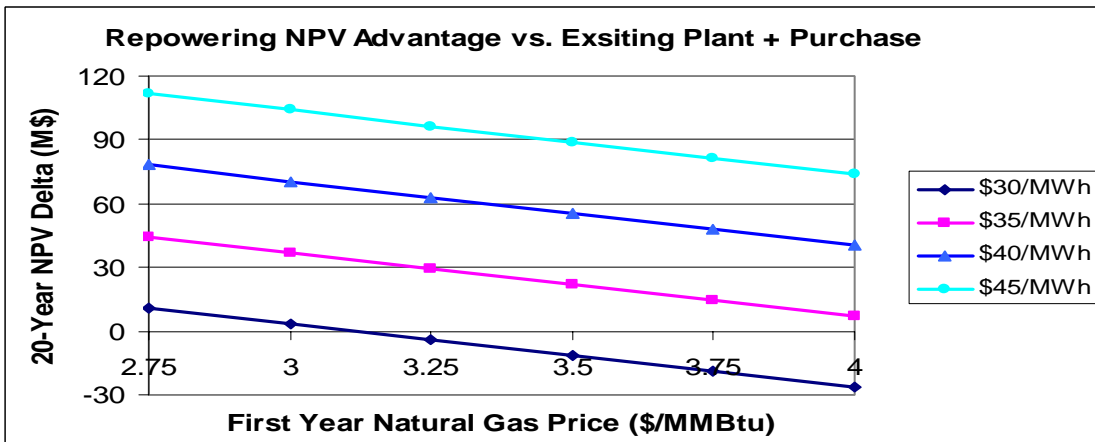
Compared with operating the existing plant and purchasing power, repowering shows a 20-year NPV advantage of about \$75-100 million at \$45/MWh power, with the advantage highest at lower natural gas prices (see Exhibit 2). Repowering maintained an

NPV advantage as power prices were decreased to \$40/MWh and \$35/MWh. Only at power prices of \$30/MWh and gas prices above \$3.25/MMBtu did repowering not maintain a positive advantage.

**Exhibit 1**



**Exhibit 2**

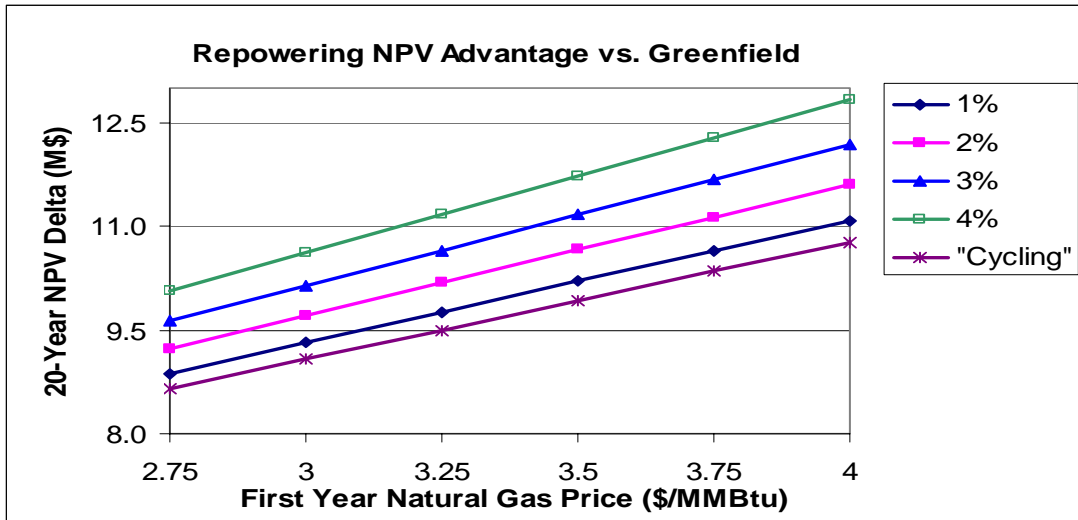


**Natural Gas Price vs. Gas Price Escalation**

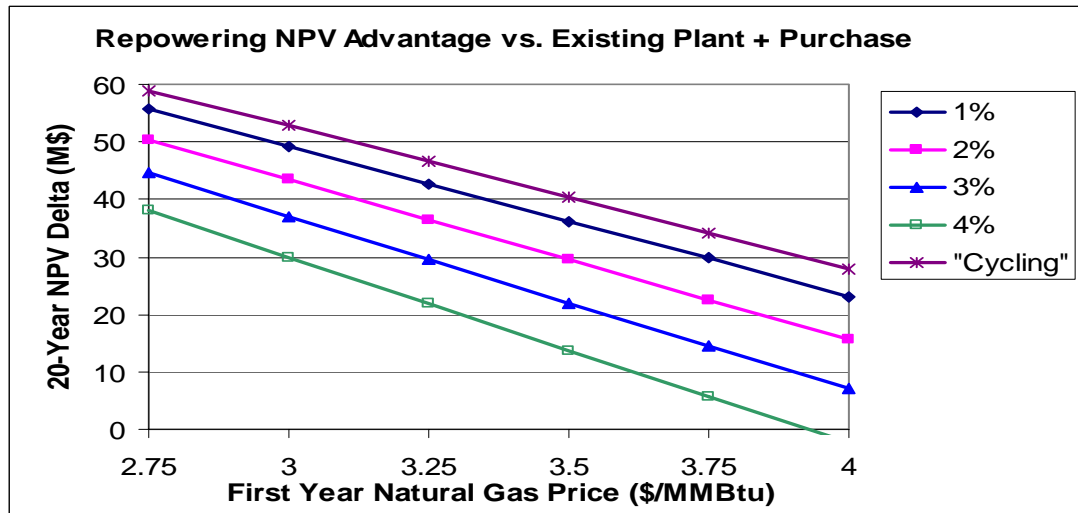
Because of recent volatility and future uncertainty in natural gas prices, we next looked repowering’s relative NPV as a function of first-year price and 20-year escalation rates. We examined first-year prices ranging from \$2.75/MMBtu to \$4/MMBtu and escalation rates of 1%/year to 4%/year. We also examined a “cycling” gas price scenario that assumed a four-year cycle of prices where the second year increased 50% over the first year, third year decreased 50% over the first year, and fourth year equaled the first year, with this pattern repeating over the 20-year evaluation period. In all cases, an electricity price of \$35/MWh was assumed.

Under all these cases, repowering’s relative NPV advantage over a greenfield project was relatively constant at about \$9-12 million (see Exhibit 3). Compared to operating the existing plant and purchasing incremental power, repowering’s NPV advantage was generally in excess of \$20 million (see Exhibit 4).

**Exhibit 3**



**Exhibit 4**



**Natural Gas Price vs. Load Factor**

Because plant operating cycles can change based on prices and demand, we next analyzed relative NPV as a function of different gas prices (and power prices) and load factors. Under cases with natural gas prices ranging from \$3.5-4/MMBtu, power prices of \$35/MWh or \$40/MWh, and load factors of 60%, 70% and 80%, repowering showed a consistent NPV advantage over greenfield construction of about \$8-12 million (Table 3).

**Relative Total Project Cost**

A primary benefit of repowering is the ability to expand capacity and improve the efficiency of existing assets with less investment than is required for a new greenfield plant. Because each project is site-specific and there is uncertainty in relative project costs, we examined the potential advantage of repowering at different power and gas prices and at different levels of relative project cost.

**Table 3**  
**Repowering NPV Advantage vs. Greenfield**

First Year Power Price (\$/MWh)	First Year Gas Price (\$/MMBtu)	20-Year NPV Delta (M\$)		
		Load Factor		
		60%	70%	80%
35	3	12.5	11.3	10.1
	3.5	13.3	12.2	11.2
	4	14.0	13.1	12.2
40	3	10.8	9.3	7.8
	3.5	11.5	10.2	8.8
	4	12.3	11.1	9.9

Our baseline assumption was that repowering could be implemented for 75% of the total cost of a greenfield project and we also examined cases where total repowering costs were only 80%, 85% and 90% of total greenfield costs. Under the cases analyzed, we found that repowering can generally maintain a positive NPV advantage over greenfield construction as long as its total project cost is about 90% or less (see Table 4).

**Table 4**  
**Repowering NPV Advantage vs. Greenfield**  
*(assuming 80% load factor)*

Repowering Project Cost (% of Greenfield)	20-Year NPV Delta (M\$)			
	First Year Power Price (\$/MWh)/Gas Price (\$/MMBtu)			
	35/3.5	40/3.5	35/4	40/4
75%	11.2	8.8	12.2	9.9
80%	7.8	5.5	8.9	6.5
85%	3.9	1.5	4.9	2.6
90%	0.5	(1.8)	1.6	(0.8)
"Breakeven" % (*)	91%	87%	92%	89%

(\*) Repowering cost which yields 0 NPV delta

**Debt Interest Rate**

Based on currently low interest rates, and because many of our ongoing projects involve municipal and public utilities (entities with a strong motivation to improve existing assets), our baseline financial comparisons centered around a debt interest rate of 6% and an NPV discount rate of 9%. Recognizing, however, that these conditions will not prevail for all prospective utility and power project developers, we also looked at several cases involve a debt interest rate of 9% and an NPV discount rate of 12%.

As shown in Table 5, repowering consistently maintains an NPV advantage of \$9-13 million at the different debt interest/NPV discount rates and with different natural gas and power prices.

**Table 5**  
**Repowering NPV Advantage vs. Greenfield**  
*(assuming 80% load factor)*

Debt Interest/ NPV Discount Rate	20-Year NPV Delta (M\$)			
	First Year Power Price (\$/MWh)/Gas Price (\$/MMBtu)			
	35/3.5	40/3.5	35/4	40/4
6% / 9%	11.2	8.8	12.2	9.9
9% / 12%	12.6	10.8	13.4	11.6

**CONCLUSION**

When misconceptions are stripped away, repowering can offer attractive financial benefits over greenfield and purchased power scenarios. However, repowering costs are case specific and require relevant engineering to properly evaluate their magnitude and the resulting potential financial returns. Still, our experience suggests that the potential benefits (both operational and financial) of repowering are such that it should be more routinely considered as a supply expansion option along with greenfield development and purchased power.