How to get the most out of upgrades

TAILOR THEM TO THE OPERATING REGIME OF THE TURBINE

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Even though your gas turbine might be old in calendar years, it is still likely a viable workhorse in your system. To stay up-to-date, there are numerous upgrades available.

Because there are so many upgrades, the question of, "What upgrade is best for me?" may be daunting.The following is a comprehensive list of upgrades that will address your objective (Table 1). When considering a change, you need to examine your situation and ask yourself, "What am I trying to achieve?"

The choices are:

- To increase profits, power output (MW and hp), efficiency (Btu/Kw), turbine life, reliability, availability, loading flexibility, and serviceability
- To decrease manpower and NO_X

Deciding upgrades

You will need to do your engineering economic analysis first, however, to spend your money wisely. It will be a balancing act between your objectives and options for your situation. You need to answer a number of questions:

- How many hours per year do I operate? (perhaps only 100 of the 8,760 hours per year)
- How much money do I lose if my turbine will not start when called upon or if it breaks down?
- What is my manpower situation? (Current and future)
- What are my emission requirements? (Current and future)
- What are my budget constraints?
- What is the cost of power? (Selling and buying)

The choice of upgrade could depend on situations such as:

- The turbine is a black start unit used only in emergency. Therefore, availability is paramount
- The turbine is used in a process making over a million dollars per day. Therefore reliability is essential
- The turbine runs 24/7 selling power. Therefore, efficiency and reliability are important
- Upper management slashes manpower. Therefore, a control system upgrade would allow one operator to run the entire plant
- The power dispatcher calls for varying amounts of load. Therefore, loading flexibility is the key

Upgrade overview

Once you know what you want in an upgrade, you can make a wise selection. The following is a list of upgrades.

➤ Re-powering is the term when steam from a HRSG (Heat Recovery Steam Generator) is used to drive a steam turbine previously attached to a conventional boiler, which was coal-, oil- or gas-fired. The general rule of thumb is that if you are driving a 25 MW steam turbine, it will require a 50 MW gas turbine to generate the required steam via the HRSG. In this example, you would get 25MW by recovering the exhaust gas heat. Re-powering increases profit, MW, efficiency, loading flexibility, turbine life, and generally reduces emissions.

➤ In the past, when materials technology was not advanced, Inlet Guide Vanes (IGV) had to be slightly "fatter" in order to be strong enough. This shape reduced airflow slightly. Changing to a newer high-flow IGV increases airflow and power output by as much as 2 percent. If you are planning an outage it is a worthwhile modification.

➤ Inlet cooling increases mass flow, MW and efficiency during hot summer days.

	Increase Profit	Increase Power	Increase Efficiency	Increase Turbine Life	Increase Reliability	Increase Availability	Increase Serviceability	Decrease Manpower	Decrease No_x
Repowering	X	X	X	X					X
High Flow Variable Inlet Guide Vanes	X	X	X	X					
Inlet Cooling	X	X	X						
SSS Clutch	X				X	X	X		
Inlet Filtration	X	X	X	X	X	X			
Compressor Wash	X	X	X	X					
Steam Injection	X	X	X						X
Water Injection	X	X	X						X
Coatings	X	X	X	X	X	X			
Fuel Conversions	X								X
Controls Upgrades	X			X	X	X	X	X	
Instrumentation Upgrades	X			X	X	X	X	X	
Hot Section Upgrades	X	X	X	X	X	X			X
Black Start & Isochronus	X				X	X			
Operations & Changes	X			X	X	X		X	

Table 1: Selecting the upgrade depends on how much relative value the benefits have for your plants

This can be accomplished with one of the following: inlet fogging, evaporative cooler or an inlet chiller. Fogging is more effective than an evaporative cooler: however, fogging requires de-mineralized water. "Off the shelf" fogging systems are expensive. A do-it-yourself system saves a great deal of money but some amount of engineering is required. Be careful not to "over spray," which can damage the compressor. Inlet chilling which can recover as much as 25% power lost on a hot summer day can be costly but cheaper than installing a new turbine.

➤ The Synchronizing Self Shifting (SSS) clutch can replace the starting jaw clutch. The SSS clutch eliminates a solenoid valve, hydraulic actuators, sliding spline, jaw clutch and position switch. Additionally, the SSS clutch allows a restart during coast-down at 500 rpm. The SSS clutch can also be used to uncouple the turbine from the generator allowing the latter to be used as a synchronous condenser for voltage control.

➤ Many turbines have been installed without compressor inlet filtration. If the turbine is only used for black start, there are usually minimal problems. If the turbine is operated frequently, the compressor can foul, which will dramatically reduce output and efficiency. Filtration systems fall into two categories: high efficiency and low efficiency. If your unit operates several thousand hours a year, high efficiency is the best choice. If your turbine only runs a few hundred hours per year, low efficiency is more economical.

Note: If you operate at night, do not have a light near the inlet. It will attract insects which will quickly foul the compressor.

➤ Compressor washing can be accomplished online (operating at 100% speed) or offline (operating at 20% speed). It is a relatively inexpensive modification, which can recover lost output and efficiency. Imagine saving 5% of your annual fuel bill.

Note: Be certain that any hardware in the inlet plenum is securely mounted and failsafe.

➤ Assuming you have extra steam available, steam injection is a good way to increase power output as much as 5%. The drawback is that the steam (and makeup water) is lost forever. However, if the power price is high, this is an easy way to increase total output. It also has the fringe benefit of reducing NOX.

➤ Water injection is another easy way to add 5% output and reduce NOX but it needs demineralized water.

➤ There are many coatings available for your compressor, turbine buckets, nozzles or high wear areas. If you run thousands of hours per year, then many of the coatings can be a good investment. Even on units that run infrequently, coatings can extend the compressor life by reducing corrosion or extend rotor life correcting "bucket rock" problems.

➤ There are a variety of fuel conversions available. Converting a liquid- or gas-only unit to dual-fuel to burn flare gas or even coal gasification can be desirable. Adding dual fuel allows you to run on the fuel with the lowest price. Running on flare gas reduces fuel cost but often increases maintenance costs to the turbine and gas compressors. Coal gasification reduces fuel cost but maintenance, reliability and availability suffer due to the complexity of the process.

Note: Syn-gas has a very low BTU content. Therefore, a very large volume of gas must enter the combustors to deliver the required BTUs. So the mass flow is greatly increased, which increases the overall MW output (30-40%) requiring a larger generator.

➤ If you have a small budget ($50,000), you can add a small microprocessor to perform specific tasks such as temperature control, overtemperature protection or combustion monitoring. If you have a large budget ($500,000), you may decide to do a complete upgrade with all the latest features. The big advantage of a distributed process control is that one operator can control several units remotely. This can reduce manpower. Fringe benefits include: automatic data logging, trending and Continuous Emissions Monitoring.

➤ Upgrading the instrumentation can improve reliability by minimizing troubleshooting time. Upgrading the vibration system will allow you to distinguish between balance or alignment problems. Pressure switches can be replaced with pressure transducers, which will allow trending. Temperature switches can be replaced with thermocouples or RTDs, which allow trending.

➤ Numerous hot section upgrades are available to improve MW output, efficiency or longevity. Increasing output involves increasing the firing temperature and hence requires improved cooling and metallurgy. There are a few modifications available to improve sealing and efficiency. These improvements are minor at best; therefore, it will be difficult to recover the costs. There are a number of modificatioins to improve parts-life by using improved metallurgy, cooling, plasma sprays, coatings and design changes. These changes are relatively inexpensive and usually pay for themselves. The key is to find the "weakest link" in your hardware and make improvements.

➤ Operational changes can be the least expensive with the most benefit. Reducing the starts-to-fired-hour ratio, fired shutdowns, and soft-starts reduce maintenance costs and extend turbine life. Improving maintenance practice that can come from training can improve reliability. TI

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