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Repowering Power Plants to Remain Competitive

The success of low-cost renewable energy and sustained low price of natural gas have contributed to making the power sector extremely price competitive. This has pushed oil-fired, coal-fired and older generation gas-fired power plants to consider retiring or look into options to remain competitive in the ever-evolving market. Repowering with combined cycle has become one of those options.

Heat Recovery Repowering involves installing a new Gas Turbine (GT) and Heat Recovery Steam Generator (HRSG) power train while keeping the existing Steam Turbine Generator (STG) and some of the Balance of Plant (BOP) equipment. The idea is to keep as much of the well maintained existing equipment as possible to minimize capital expenditures (CAPEX). In the case of a coal or oil-fired power plant the boiler is replaced with a GT+HRSG power train, while in a gas-fired plant the existing GT+HRSG are replaced with a new, more efficient system. The benefits from combined cycle repowering often include increased power output and efficiency, as well as reduced emissions, fuel usage, and O&M costs.

The repowering approach also poses a set of challenges due to the number of factors that come into play, ranging from technical to legal and permitting issues. Therefore, feasibility evaluations should be done on a case-by-case basis. Nonetheless, there are some key technical considerations that are common among these projects. This article briefly discusses such key considerations to provide insight into these types of projects. Please note that this article is meant to be a brief review of some of the key technical considerations and is not an exhaustive review of combined cycle repowering projects.

Key Project Development Considerations

There are four noteworthy technical considerations: matching HRSG and STG steam conditions, minimizing downtime, understanding new environmental regulations, and site-specific GT de-rates.

1- Matching new GT+HRSG steam production capacity to existing STG requirements:

    A new GT+HRSG train may have a different steam production capacity (lower or higher) than that of the existing STG. Operating the STG at conditions for which it was not designed will result in inefficient energy production (i.e., very high Heat Rates). However, there are a few approaches to tackle this problem. Ideally one needs to investigate available GTs in the market and find one that has a consistent energy balance to the original configuration of the plant, mainly with the existing STG. Alternatively, steam conditions may be matched through the following approaches:

    a. If GT exhaust energy is too large, then the STG may be uprated to take the additional steam production from the HRSG.

b. If GT exhaust energy is insufficient, then varying levels of supplemental firing may be added to the HRSG to increase the HRSG's steam production and match the STG steam requirements.

However, these alternative approaches are only reasonable within a relatively narrow plant operating range. If the existing STG is too small, an uprate will not be feasible. Similarly, if the existing STG is too large, HRSG supplemental firing becomes impractical and significantly impacts the facility's Heat Rate.

2- Minimizing downtime:

An extended plant downtime period can result in hundreds of thousands of dollars in lost revenue per day. Avoiding or postponing the demolition of existing equipment to minimize downtime can make or break the feasibility of a repowering project. The recommended approach is to install most of the repowering equipment on unoccupied property space, while the existing plant continues to generate power. Plant downtime will only occur during the project interconnection phase (steam, power, and/or control system), which can take a few months. This is a significant reduction of downtime as compared to the entire construction project that can take anywhere from 18 to 36 months, depending on the project scope. For example, a loss of up to USD$45 million may be avoided when comparing the downtime from a relatively small scope 18-month construction project to a 6-month interconnection period. For this comparison, we considered the following plant characteristics: 350 MW capacity, 75% capacity factor, \$50/MWh power sale price, and \$20/MWh power net revenue (i.e., excluded expenses from fuel and variable operating costs at \$30/MWh).

$$Lost\ Revenue = 730\frac{hours}{month} \times 12\ months \times 20\frac{\$}{MWh} \times 350MW \times .75 \approx \$\ 45\ M$$

3- Air Emissions

This particular consideration is heavily dependent on site location. Revisions to the air emissions permit (and/or water use permit) may prohibit specific project development. Typically, newer GT technologies will have improved air emission performance, which can also be supplemented with post-combustion emission control equipment such as Selective Catalytic Reduction (SCRs) and CO Catalysts. However, some project areas such as California, US have very stringent emission requirements that can make gas-fired repowering projects not feasible. On the other hand, projects outside of the U.S. can have air emission limits that are more lenient. For example in the case of Mexico, NOx emission limits for new installed equipment in power plants with an output greater than 147 MW are the following: 25 ppm for Mexico City and its surroundings, 110 ppm for Mexico's largest metropolitan areas (Guadalajara, Monterrey, Ciudad Juarez & Tijuana) and 220 ppm for the rest of the country.

4- Site-Specific GT De-rates:

A fairly straightforward but noteworthy consideration is the site-specific power correction factors used to estimate GTs' performance (power output, Heat Rate, and exhaust flow). The site's elevation and temperature have the most significant impact on output. For example, based on generic correction curves a 3000 ft (914 m) elevation can result in approximately 10% power output reduction while a 90 F (32 C) inlet temperature results in about 10% reduction. These GT de-rates are cumulative, so in this case such site conditions would result in a combined output reduction of approximately 18 to 20%. Additionally, temperature and elevation also affect fuel consumption, heat rate and exhaust flow. Humidity also plays a role in power output, but its effect is not as significant as from temperature and elevation.

Combined cycle or Heat Recovery repowering is the most common repowering option being implemented in the U.S. due to their plant performance benefits at relatively low CAPEX investments. However, there are a few other major repowering alternatives, two of which are described next:

- Cogeneration to Combined Cycle Repowering: This approach applies to cogeneration facilities that have terminated their supply of steam to the neighboring host facilities. In this case, the excess steam can be used to generate additional power by repowering or replacing the STG.
- Full Site Repowering: A completely new gas turbine combined cycle (GTCC) power plant is built at an existing site, while keeping the existing cooling system, fuel supply, and electrical interconnection switchyard.

Feasibility assessments for repowering existing power plants require a significant level of site specific review due to the complexity of these projects. However, the key technical points discussed in this article are likely to play a relevant role in most projects and can be used as high-level guidance at the conceptual stage of project development.

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