POWER Engineering

Best Practices for CHP Development

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Combined heat and power (CHP) projects promise many benefits to a wide array of large energy users, and CHP has a long history of adoption and success in many industries. Despite its wide adoption, many energy users considering the development and installation of a CHP project face a set of tasks and challenges that they are not always fully equipped to handle since their primary business is usually quite different from power and thermal energy production.

By focusing on best practices from the start of project development, to execution, and on to long term operation and maintenance, new owners of CHP systems can mitigate risks and maximize the chances of success for their project.

There are a number of good reasons to implement CHP technologies, but the first and

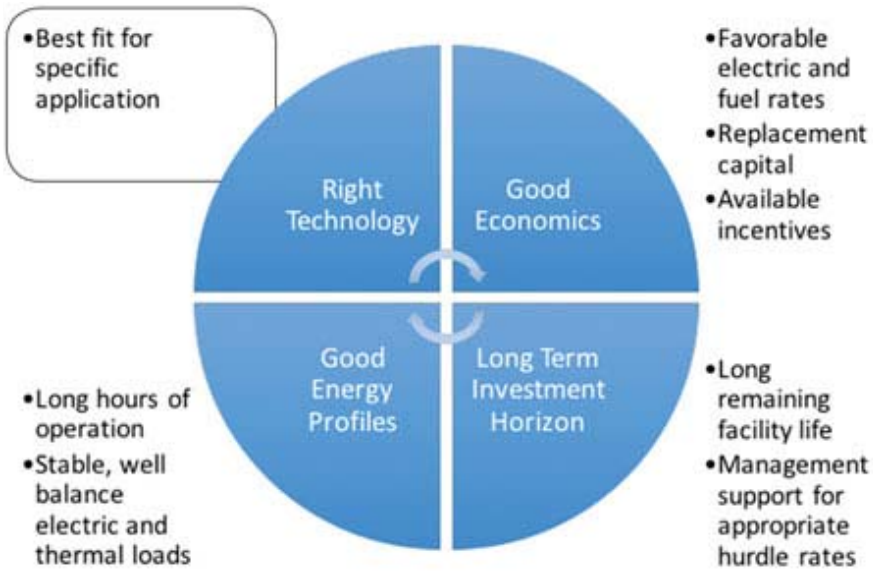
foremost driver for these systems in an industrial or commercial business setting is to earn a compensatory return on investment that is comparable to other long term capital investments being made in the business. Secondary benefits can include improving environmental performance through dramatic increases in efficiency, improving reliability or providing back up generation at site, and managing long term energy risks more effectively.

Successful CHP projects are built on strong technical and economic foundations as represented in Figure 1.

The Spiritwood Station, a CHP plant in North Dakota, began commercial production in November 2014. *Photo courtesy: Great River Energy*

All of these factors are important, and all of them must be present to achieve a successful project. Weakness in even one area can rule out an otherwise promising project, so it is important to investigate, develop, and mitigate risks in all of these areas during the development process.

Building Blocks for CHP Projects -1



Taking them in turn, having your facility in an environment that promises good long term energy economics for CHP is the start of a good project. Higher electric rates (taking into account the entire rate structure and rules) generally predict a good opportunity for CHP. A detailed rate analysis and study of the rules for interconnecting CHP systems to the utility needs to be performed early in the development cycle to identify utility costs and charges that will be imposed when the CHP system is installed and operational. Other elements of a strong economic foundation include opportunities to credit capital replacements that the CHP system can avoid. For example, an aging boiler may have only two (2) years of remaining useful life, which the CHP system can effectively replace, creating a meaningful benefit in the cash flow analysis of the project. Lastly, many utilities and jurisdictions have incentive programs for qualifying CHP technologies and projects which can offset capital costs and make projects more attractive.

Another important consideration is to understand that by implementing a CHP system, you will effectively be taking a long term position in the energy market - usually the natural gas and electricity market. CHP systems typically increase the natural gas consumption and reduce the electricity consumption at the respective facility meters, transferring some of the facility's energy price risk from the power market to the gas market. This can potentially be a benefit to the facility by opening up additional risk management options, such as hedges, which can secure longer term price stability. In any event, part of the project economic analysis needs to account for the market risks that come with the CHP operation.

A long term investment horizon is generally needed when considering a CHP investment. CHP systems are durable assets that typically have twenty (20) year useful lives (or longer) when properly maintained. This is different than many energy efficiency projects, and should be judged on an appropriate basis that is more akin to production expansions and facility improvements. It is also important that facility management have realistic and reasonable expectations for return on investments from CHP systems. They can be among the most attractive investments available to any industrial or commercial energy user, but often get lumped with energy efficiency proposals that have very fast payback thresholds which can rule out otherwise attractive projects.

CHP Project Models -2

A CHP system is a production system which provides electricity and thermal energy to the industrial or commercial loads of the facility. It makes sense, therefore, to find applications to "sell" as much output as is possible from a system. This requires host facilities which have high, durable, and predictable

electric and thermal loads for most of the year. The best CHP projects will earn the highest returns when they run around the clock at full electrical and thermal output.

The last foundational element of good project development is selecting the best fit technology. There are a wide range of possible technologies for CHP applications, and each provides a range of cost, performance, and operational considerations. Early stage project development should sort these options against the facility energy and economic profiles to narrow the selections to a manageable number. A more detailed comparative analysis can then be run.

When considering technical options for the project, the following considerations could be important to keep in mind:

- Output and system sizing - specifying the largest system technically possible may not provide the highest return on investment. Modular systems with multiple prime movers can sometimes offer advantages to best match facility loads and provide redundancy and improved reliability.
- Heat rate - since useful heat will be an output of the CHP system, the highest efficiency equipment may not be necessary and in fact may penalize the project with higher costs and lower value.
- Load following - a properly sized system should run at full output most of the time, so ramping and load following capability may not be the most important characteristic of the equipment selection.
- Grid isolated operation - designing an onsite generation system to operate in an islanded mode can add value to the project, but brings complexity and cost, and may not be utilized that often.

Well management project development is completed in phases, which invests in engineering, permitting, and other development activities in a proportionate way as the benefits of the project become clearer and better defined. The following are some basic milestones and activities which can guide a more detailed development plan:

First Look

- Factored cost estimates
- Basic system sizing assumptions
- Basic system operating profiles
- Preliminary annual energy savings and operating costs

Feasibility Study

- Budgetary cost estimates
- Hourly facility load profiles
- Basic design and siting decisions, including system sizing
- Main equipment selection
- Hourly energy and financial model with all rate information

Financial Investment Decision (FID)

- Detailed design basis with FEED
- Engineering based cost estimates with uncertainty analysis
- Hourly energy and financial model with time of use rates
- Energy price forecasts
- ROI risk analysis

As a project matures in the development process, it is important to continuously analyze project uncertainties and risks. To this end, a probabilistic analysis can be beneficial, which characterizes the uncertainties of key input variables based on historical or market-based data, and forecasts return on investment under thousands of simulated scenarios through a Monte Carlo analysis. This can help a project team present the result as a probability in the form of a statement such as, "This project has an X% chance of earning a Y% internal rate of return or better." In this way, management can judge the risks and certainty of a proposed project in a much more informed way than static models with fixed assumptions can provide.

A variety of project execution models exist as well when the time comes for detailed engineering, procurement, and construction. The following represent just three common arrangements, with many other combinations and approaches also being possible.

Each approach offers advantages and disadvantages, along with risks to the owner.

Considerations for selecting an execution approach can include:

- How much internal staff an owner has to support project execution
- How much risk an owner is willing to take directly on equipment performance and construction
- Recognition that owners can transfer only so much risk to a turnkey EPC contractor - much of the risk in a project comes in the form of imperfect design basis information or other issues outside the control of the contractor, which creates residual risk for the owner in any event

- Collaborative approaches, such as using an open book EPC development and pricing process, followed by a closed book execution, can result in high quality projects and more predictable costs

When it comes time to present a project to management for funding approval, there are a number of important factors to take into account. The most fundamental is to understand the financial metric, such as a return on investment hurdle rate, that the project will need to meet for approval. CHP projects are by their nature long lived assets which add long term value to facilities when they are implemented and maintained properly. They should therefore be judged on par with other long term, facility expansion capital projects.

One special case that often arises in commercial and industrial CHP projects is a third party design-build-own-operate-maintain (DBOOM) structure. This often sounds like an attractive deal, especially to facility teams who believe it can be a source of financing outside of the internal capital approval process. However, these structures bring complexity and risk, and sometimes cannot achieve the financial result that owners are seeking - namely off-balance-sheet treatment of the investment. There are cases where DBOOM structures are a good fit, but it is important to analyze a project's components separately with regard to design, construction, financing, operation and maintenance. It is possible to achieve goals of outsourcing operation and maintenance responsibility without bundling it with the financing and EPC of the project.

Finally, the value of a CHP project will only be realized if a well-designed, comprehensive Enterprise Asset Management plan is implemented for this type of asset. Many facilities will not have managed a power generation plant previously, so maintenance procedures, data collection, computerized maintenance management systems (CMMS), reliability procedures, and safety procedures will all need to be designed and implemented for the plant. Starting early and getting expert input to these aspects of a plant will yield long term benefits.

CHP projects can deliver significant value for facilities that choose to develop and implement them. By following best practices for the development, design, construction, and asset management of CHP systems, a higher quality, lower risk result is more likely to be achieved.

Author

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