Thermal Tracking Cogeneration— A New or Old Idea?

Cogeneration for Multi-Thermal Loads

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The concept of cogeneration has been around for decades. European communities have been successfully using the idea for many years. The idea of designing a cogeneration project that produces electricity based on the existing heating load is common to many cogeneration projects, but may be limiting the ultimate potential to the end user. Cogeneration which is developed as a power generator producing a small amount of steam for a host load is also common. However, the idea of designing a cogeneration facility to track multiple utility loads is not as common. Where the concept has been used, the projects have been very successful.

After decades of excellent books, articles, and conferences, many energy professionals still focus their effort on the heating loads. They evaluate this one factor to determine if a project is worthy of serious consideration. What has been amazing is the lack of expertise and knowledge of multiple load evaluations. The thermal loads include both steam and high temperature hot water used for heating, chilled water for air conditioning, refrigeration, process, compressed air and other special uses. In many cases, the overall benefit to the project owner and host tenant far exceeds the increase in the capital costs.

This article has been written as a primer for professionals looking for ideas when performing analysis of a potential cogeneration project, and as a thought-provoker for end users. We will look at each of the possible loads, outline various technical considerations and factors, look at the factors impacting the economics, and lay out an approach that would provide assistance to those trying to analyze a cogeneration project without specialized engineering assistance. Regulatory, legal and financing issues are covered in other sources.

THERMAL LOADS

The common approach of using only the heating loads to determine if a project is worthy of serious consideration needs to be reevaluated and, in my opinion, changed. What has concerned me and other energy professionals is the lack of basic knowledge of multiple thermal load evaluations. When a project produces all of the economical thermal energy, the overall benefit to the project owner and host tenant far exceeds the increase in the capital costs. Maximizing the use of all thermal output of a cogeneration system increases the overall system efficiency and project economics. Any limitations in capital are easily paid back by the added efficiency.

For purposes of reference, the following thermal loads should be considered. There may be special loads at specific sites which can be added to the evaluation.

A. Steam
B. High-temperature Hot Water
C. Chilled Water
D. Compressed Air
E. Refrigeration
F. Process Loads
G. Domestic Water

The evaluation of thermal loads must start with a thorough search for the thermal loads which can be candidates for a possible cogeneration facility. This search will involve both interviews with site personnel and a field survey of the energy systems and the equipment associated with these systems.

In connection with this work task, the review of new future loads must be factored into the effort. The on-site personnel will normally be hesitant to discuss these loads since they never know when or if these loads will be built. However, the sizing of the cogeneration equipment and building space will be dependent on this information. Many cogeneration systems need to be designed with maximum flexibility while others are for a single small load. The 100-1,000 kW micro-systems fit into this type of project.

The evaluation of the thermal loads would be easy if every end user had hourly, peak, and annual load data already in a usable data base. As with most end users, the database is not very good and an extensive evaluation process is required to screen the data, develop load profiles and generate an overall thermal load profile for weekdays, weekends, holidays and shutdowns. These profiles would include seasonal data since many loads are seasonal. The "valleys" or low usage periods in these load profiles can usually be filled by reviewing the loads and their individual load profiles. For instance, electric-driven chillers can be supplemented by steam-driven chillers or similar electric-to-steam conversions. The goal of a steady thermal load is the key to any highly efficient project.

To say this effort is simple would be a mistake. My experience indicates that even when some of the critical data is available, the remaining data collection and evaluation can be time consuming. In addition, the normal bias of on-site personnel can prevent the use of certain equipment, such as absorption chillers. All of this requires a careful approach and flexibility in working with each client. As with many projects there are the normal politics and people concerns.

TECHNICAL FACTORS

There are many technical factors impacting the feasibility study and concept design. A full discussion is beyond the scope of this article, but I will, however, attempt to point out the major factors and offer some suggestions on how to improve the overall cogeneration economics. What is needed is innovation and a willingness to consider any option that would enhance each project. There will be some compromises somewhere in every project.

The first technical factor would involve the energy-producing equipment, whether centralized or decentralized. Field engineering would include collecting nameplate data, load profiles, maintenance records, utility bills, utility contracts, site master plan and similar data. All of this data would be analyzed and further site visits would fill-in any gaps in the information. This information should be summarized and the important documents included as appendices in the preliminary and final report.

This approach ensures that future studies will be able to build on this study and data collection can be focused on updating the older data. Important factors include the age and efficiency of the equipment, replacement projects, space for new equipment, heating versus cooling equipment, distribution systems and their interconnections, utility control systems, operating and maintenance personnel qualifications, training programs and other information.

The second technical factor would be the distribution systems that can include all of the energy sources outlined above. These systems can be extensive or very simple in a single building complex. However, the efficiency and capacity of these systems can be a critical factor in the overall life cycle costing programs. In my experience I have seen steam lines with over 14 percent in system losses. These losses should be reduced or the new cogeneration facility will be oversized and the economics reduced. A simple one-line diagram of each system should be developed if not already available.

The third technical factor would be the energy-consuming equipment or processes that can be using more energy than the average consumption levels. These loads should meet their design criteria but many times the energy consuming equipment is very inefficient or is operated based on criteria that is inappropriate. We have seen electric loads as high as 4,000 hp that did not need to be operated but could not be turned off due to the political position one engineer had established. In other cases, the on-site personnel did not have the data required to evaluate the proper operation. Reduction of on-site demands and consumption can easily approach 30 percent when all of the parties work together to a common goal.

Another technical factor is the existing electric and natural gas services to the site. These services can impact the type of cogeneration plant since improvements to these services may be needed. In the instance of electric service, the capacity of the electric generators may be larger than the transformer capacity, switchgear configuration and the criteria for paralleling the local utility requires significant capital investment. The natural gas service, if any, for the site needs to have sufficient capacity if natural gas is selected as the primary fuel source. The higher the gas pressure (i.e., 250 psia or higher), the more likely the need for extra compression inside the plant is reduced. Negotiating utility agreements with a local utility requires consultant support in most cases.

ECONOMIC FACTORS

This work task involves the critical evaluation of the economics, which will be used as the basis for management decisions. Basically a conservative approach is recommended since the expenditure on a cogeneration plant is a long-term investment. This approach applies even when the expenditure is in the hundreds of thousands of dollars, to many millions. With the number of variables and assumptions made in the technical, load projections and economic areas, it is very important to ensure that any cogeneration operation will produce the return needed by the end user. This applies whether the end user owns the plant or not.

There are many life cycle programs which can vary from poor to those flexible enough to handle the differences in the various cogeneration projects. The selection should be made based on the use of demo's and interviews with actual program users.

One of the most important economic factors is the projections of energy rates for a 10-year, 15-year or longer time period. If an electric utility has produced a cost-of-service study with a projection of electric rates, this can be very important to the overall life cycle analysis. One must be sure these rates reflect the future market since the era of competition is very close to reality. The projection of gas rates is very difficult since the past 15 years has proven many of the economic projections wrong. I would recommend a range of rates be chosen and a sensitivity analysis be accomplished.

Since a recommendation is normally required in a study, the Project Manager must evaluate all of the variables and make a decision. This recommendation must include the assumptions made.

TECHNICAL APPROACH

If a cogeneration feasibility study has been authorized, the approach to take will vary depending on many factors including the size of the thermal load. However, most studies establish the following work tasks. A concept design is needed when the project schedule requires a fast-track approach. Accomplish as many tasks in parallel as possible.

A. Schedule and manage a kickoff meeting with all of the key personnel on the Project Team and on-site personnel. If possible, include the decision makers in this first meeting.
B. Perform as many field engineering visits as necessary, keeping in mind the impact this workload can cause on the site personnel. It is normal for some personnel to be negative concerning any cogeneration project because of concerns that this type of project will impact their job.
C. Collect data on the equipment, systems, boiler logs, loads, utility bills, maintenance records, training records, site master plan and similar data.
D. Develop a set of cogeneration alternatives that would generate the thermal loads as they are now and would be after equipment and system improvements.
E. Perform cogeneration modeling with one of the available software programs. Run the analysis with various alternatives using different equipment with changes in the variables as needed.
F. Develop the capital, operating and maintenance costs that can be used in the life cycle program.
G. Perform the life cycle costing analysis. Keep in mind the need to perform the critical sensitivity analysis to project the range of payback, savings-to-investment ratios and overall rate of return.
H. Evaluate the results of the modeling and life cycle costing efforts and identify any additional analysis needed. Determine the top two or three cogeneration alternatives that may require a more in-depth analysis.
I. Prepare a preliminary report with all of the field data, computer outputs and cost estimating included as appendices. The report should include a stand-alone executive summary that could be packaged as a separate document.
J. Present the report results in a formal presentation to the management team.
K. Prepare a final report based on any comments and suggestions provided by the client.
L. Develop a scope of services for any follow-on work tasks. Provide a basic project schedule.

MAJOR ISSUES TO CONSIDER

A. **Financing**
If internal financing is the only option, the rate of return required by this type of project should be known from the beginning. If outside financing is an option, the parameters surrounding this type of financing should also be included in the analysis and recommendations. Other factors affecting the financing should be identified and used throughout the study process.

B. **Energy Companies**
Over the last few years, more energy companies are entering the field of project financing along with project ownership, operation and maintenance. Internal capital limitations can be overcome by turning to qualified energy companies looking for solid energy projects. As with any use of outside expertise, a careful approach must be made during the selection process.

C. **Utilities**
There have been a number of changes in the utility industry. Mergers, organizational changes, and influx of new personnel have brought new opportunities and challenges. Changes in the utility rate structures can provide advantages to a cogeneration project. The most important aspect of these changes is the upcoming deregulation of the electric industry, which needs to be assessed on a local and regional basis.

SUMMARY

Turning back to the thermal load issue, the overall economics of any project will be enhanced by including the thermal loads which make sense. With maximum thermal load, many cogeneration projects will achieve simple paybacks in less than 5 years. What is needed is a willingness by the Project Team and on-site personnel to include any thermal load without bias. I am still looking for the client who wants the maximum return and will allow the total team the liberty to bring the best project to the decision makers. Everyone needs to keep their eyes open for all opportunities.

ABOUT THE AUTHOR

James R. Geers is president of PLM Technologies, Inc., and Software Evolutions, LLC. Mr. Geers is a 1970 BS-EE graduate of the University of Missouri-Rolla, having 27 years of energy, facility, utility and maintenance experience. His experience includes: energy management programs, alternate energy studies, performance contracting, facility management programs, design/build, utility rate analysis and contract negotiations. He has exceptional experience in the development of integrated procurement programs in both natural gas and electric. Mr. Geers has planning, study, and design experience with many different central energy plants including plants with cogeneration. These plants vary from 700 kW to 225 MW. Mr. Geers is a senior member of AEE and Cogeneration Institute and a charter member of the DMS Society of AEE. He has P.E. licenses in Ohio, Colorado, and Florida.