The Barn Raiser

Mid-South Engineering Company

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Approaches Used for Energy Studies

By: Eldon Doody, PE

Our team utilizes a comprehensive approach to energy evaluations to ensure the most suitable and cost-effective outcomes for our clients. Our energy studies typically involve the following steps:

Site Survey and Information Gathering:

The first step in each energy study is a visit to the client's facility by key staff members. One purpose of the site visit is to gather and review documentation such as drawings and historical operating data. The site visit allows our engineers to get a firsthand look at the facilities and equipment, to assess existing conditions and to determine opportunities for improvement. It also allows us to review potential locations for future equipment.

Perhaps most importantly, the site visit provides an opportunity for our staff to meet with facility operating and maintenance personnel to obtain their valuable input and ideas as to the facility's issues, limitations and potential.

Energy Modeling:

A key component of each energy study is the development of an energy model that represents all the energy inputs and outputs for both the existing facility and for proposed changes. We strive to have several years, preferably five years, of data to input into the models. This includes fuel consumption, electrical consumption, thermal and electrical energy in-house generation, etc. The spreadsheet format allows our clients and us to experiment with various "what-if" scenarios.

Models are developed using Microsoft Excel, have the advantage of being widely used by technical personnel, and are easily modified by us or for use by others. The model includes all the major elements of a steam plant, including: Boilers, Steam Headers, Condensate Headers, Power Turbine-Generators, Pressure Reducing Valves, Feedwater Pump Turbines, Boiler Fan Turbines, Deaerators, Feed Water Heaters, De-superheaters, Air Heaters, Blow Down Flash Tanks, Blow Down Condensate Heat Recovery, and Cooling Towers.

Models using basic thermodynamic principles allow us to balance steam flow and heat flow. Inputs to the model are typically steam header pressures and temperatures; steam flows to the manufacturing/institutional operation, percent blow down, turbine parameters (if any), etc. Turbine parameters are developed from turbine performance curves as supplied by manufacturers' turbine manuals.

For multi-boiler, multi-turbine facilities with several steam headers at different pressures, there is a very complex interaction among the elements of the model. The solution to each set of input parameters is by iterative calculations. Typically, 100 to 300 iterations are required to come to a balance. Since it is possible to generate "resonances," it is necessary to provide damping equations, much as is necessary for mechanical or electrical damping for physical systems.

For both thermal only plants and CHP plants, the model is used to determine the costs associated with different turbine operating combinations, electric vs. turbine drives for feedwater pumps and boiler fans, cost of leaking PRV's, value of returned condensate from operations, value of blow down heat recovery, etc.

Our use of the principles of steam and power modeling have been applied to a wide range of steam plants, ranging from heat plants for individual buildings, to heat plants for district heating, to commercial power plants, and to manufacturing/institutional complexes. The basic model has been modified to accommodate a variety of plants ranging from single low-pressure boilers without electrical power generation and low-pressure boilers with a single stage turbine, to multiple high-pressure boilers using different fuels and having multiple turbines operating at different inlet and extraction pressures. The model has been used to help clients with decisions regarding existing plants, as well as for design of proposed new plants or major plant modifications.

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With the large number and variety of systems that have been modeled, it is relatively easy to adapt the model to any facility. For example, where turbine parameters are not known, a good estimate can be made based on previous experience. The equations to balance deaerators, feedwater heaters, desuperheaters, etc., are fundamentally the same for any plant. The thermodynamic parameters of enthalpy, entropy, and saturation temperatures are determined by embedded macros, so that it is not necessary to use tables or to develop equations for each temperature and pressure encountered. With the large number of facilities that have been modeled, it is usually possible to find a model that is close to the existing or proposed plant, so that relatively minor modifications need to be made.

The model includes combustion air systems. Equations to determine heat capacities of combustion air and flue gas have been developed. In addition to the turbine and balance of plant model, a boiler model has been developed which uses input parameters of fuel, (heat value, moisture content, ash content, etc.) along with combustion air and flue gas temperatures and boiler excess air to estimate fuel usage per million BTU of boiler output, combustion air and flue gas mass flows and volumes, flue gas dew point, and latent and sensible heat content of the flue gas. The model has been developed for a range of fuels, such as woody biomass, coal, natural gas, light oil, heavy oil, and tire derived fuel.

In summary, we can determine the "before and after" thermal or electrical system parameters for a wide range of conditions.

Process Flow Diagrams:

An important tool for visualizing both the existing and proposed energy processes is the flow diagram. We typically begin with a simplified (overview) diagram showing the facility's existing main equipment and piping. The flow diagram also shows process data such as flows, pressures and temperatures for the key energy streams (fuel inputs, water, steam and condensate).

The overview flow diagram of the existing facility helps ensure that the existing energy process and operating conditions have been properly summarized and that any undocumented changes over the years have been captured. It is important to have an accurate base case.

Once we have completed the steps of; site visit, documentation review, and initial energy modeling, the proposed facility improvements are conceptualized. These proposed improvements (and possible alternates) are then added to the flow diagram.

The use of simplified flow diagrams throughout the energy evaluation project helps ensure that various project team members (Client, engineer, environmental engineer, vendors) can understand the proposed project scope at a glance, and are all working from the same perspective.

For clarity, several versions of the flow diagram may be prepared. The flow diagrams also have adequate information for environmental engineers to assess resource to be used, solid waste generation, and particulate and gaseous emissions.

"In the tradition of a community coming together to raise a barn, Mid-South Engineering is committed to working with our friends and neighbors as partners, knowing we can accomplish more by working together, with the common goals of lifting each other's burdens and side-by-side framing our future for the better."

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