The Bayview Marquis Hotel and Marina

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Developing Selected Chilled Water Plant Findings

Up to this point, the exercises have focused on exercising your scoping skills. This exercise will shift the focus to developing findings by taking them from an observation of an opportunity to a project for implementation. In doing this we will be exposing you to the basic techniques you will need to employ to do the same thing for your personal project.

In general terms, this will involve the following steps.

1. Gathering data from data loggers and the control system and/or field tests to put hard metrics to your observed opportunity so you can estimate the current rate of resource consumption.
2. Identifying the options available to improve efficiency.
3. Estimate the resource savings associated with capturing the savings via the viable options identified. This typically will have three components.
   a. How much energy (or other resource) will be saved per hour of operation? For instance, if you trim a pump impeller, how many kW will you save.
   b. How many hours of operation in a typical year will you be able to save the energy? For instance, if you can save 2 kW by trimming a pump impeller and the pump runs 1,000 hours a year, then you will save 2,000 kWh.
   c. How much is the saved energy worth? For instance, if you were paying $0.10 per kWh for electricity, saving 2,000 kWh would be worth $200 per year.
4. Estimate the cost of implementing the change to capture the savings.
5. Developing the cost/benefit case for implementing the change.
6. Developing the plan for moving forward with the improvement.

For this exercise, we will focus initially on a relatively simple opportunity and develop the savings that will be achieved by getting the selector switch for the Chiller 2 Evaporator Pump back into the “Auto” position.

Then we will estimate the savings that would be achieved by optimizing the Chiller 2 Evaporator pump so that it can run with out having the discharge valve throttled.

Assumptions and Givens

For this exercise you can assume the following:

1. Assume that the existing gauges are accurate enough to perform a pump test.
2. Assume that you have worked with the operating team and control system vendor to restore the intended staging sequence for the chillers to the extent possible given the plant piping configuration. Specifically, Chiller 2 is always the lead chiller and Chiller 1 comes on line when Chiller 2 can no longer carry the load.
3. Assume that you and the operating team are making progress in eliminating issues with the economizers and preheat coils that are placing a load on the plant when the systems should be able to carry the load using outdoor air only.
4. Assume that once you fully address the economizer and preheat coil issues, you will begin to allow the chillers to shut down when outdoor conditions are suitable for cooling because you believe that at that point, you should not need chilled water for the guest rooms either.
5. Assume you can trust the rating point for the pump as reflecting the impeller size and do not need to do a dead head test.

To develop the cost/benefit for an improvement, it is necessary to do a cost projection or somehow procure a price for the work. To save you some time so you can focus on the calculations for the time being rather than trying to do a cost estimate or calling in a favor from your contractors of choice, I am providing three bids for each of the pump optimization opportunities, which are provided with the other exercise resources.

Chiller 2 Evaporator Pump Hand-Off-Auto Switch

For this calculation, assume that the pump has been throttled to design flow but that no further optimization has taken place. Restoring automatic operation for the pump is going to be a priority and this calculation will tell you the benefit associated with the simple flip of a switch.

To provide additional insight, I am asking you to calculate the savings as if the hotel existed in four different locations.

1. San Francisco, CA
2. Sacramento, CA
3. Honolulu, HI
4. St. Louis, MO

The reason for doing this is that the savings will vary with the climate and the utility rate structure.

More specifically, the amount of energy you save will likely vary with the climate, even though the measure you are considering is the same for all locations (in this case, restoring automatic operation of the evaporator pump associated with the lead chiller). The TMY2 and 3 data included with your psych chart tool will be a great resource for you in terms of understanding the different climates and how many hours a year a given improvement might yield savings.

The value of the energy saved will also tend to vary with the location because utility rates can be radically different. For this exercise, assume the following blended utility rates.

1. San Francisco, CA - $0.1621 per kWh
2. Sacramento, CA - $0.1331 per kWh
3. Honolulu, HI - $0.2917 per kWh
4. St. Louis, MO - $0.0571 per kWh

Questions

In addition to estimating the savings associated with restoring automatic operation, please answer the following questions.

5. How do you know the units of measure for the gauges on the pump?
6. Is there a low cost/no cost way we could improve the accuracy of the pump test?
7. Are there ways to cross-check the pump test data and if so, what are they?
8. How much will it cost to restore automatic operation?

9. Should you present this improvement to your Owner and if so, how?

Chiller 2 Evaporator Pump Optimization

As you have observed by now, the discharge valve on the evaporator pump for Chiller 2 is throttled. That is also true for the other pumps but for now, we will focus on the pump for Chiller 2.

As you are aware from your self-study efforts and our discussions in class, there are several ways you can optimize a pump. Typically, they include:

1. Throttling
2. Trimming the impeller
3. Reducing the speed
4. Replacing the pump with a properly sized pump.

All of these scenarios have different pros and cons associated with them. For instance:

1. Throttling is something that is quick and easy to do but often yields the least savings as compared to the other options. But it can be a good first step that begins to accumulate savings while you develop and implement one of the other strategies.
2. Trimming the impeller is very straightforward and persistent, especially if you have mechanics on your staff. But it is also harder to reverse it you need the capacity back at some point. And it will typically reduce the pump efficiency.
3. Reducing speed with a motor change is very straight-forward but only applies in very special circumstances where, for instance, changing from a 1,750 rpm motor to an 1,150 rpm motor puts you at or near the desired operating condition. Potentially, this option can garner some additional energy savings if you are able to improve the motor efficiency with the new motor relative to the existing motor efficiency.
4. Reducing speed with a variable speed drive allows you to adapt the pump to varying requirements. For example, in the San Diego Marriott Condenser Water System case study, using a variable speed drive allowed the pump it was installed on to operate at reduced speed when only one chiller was on line. But

it also allowed the pump to return to its original performance point if it needed to run with the other non-modified pump when both chillers were running.

5. Frequently, procuring a right sized pump tailored to the field established operating condition will yield the most savings. But it will also tend to cost the most, especially if a pump is added instead of installed in place of an existing pump.
6. However, if a pump is to be added to the system anyway, perhaps for the sake of redundancy, then this option can be very attractive since the energy savings only need to justify the incremental cost difference for a best efficiency pump vs. a pump that is identical to the pumps that are already in place.

For the exercise, I am asking you to compare the various optimization options, including calculating the savings achieved by throttling in the first place. In other words, if the balancer had not throttled the pump when the plant was started up, how much could you save by throttling it to the current condition while you figured out what to do next.

As was the case for the Hand-Off-Auto switch, I am asking you to calculate the energy and cost savings for the same four locations (San Francisco, CA, Sacramento, CA, Honolulu, HI, and St. Louis, MO).

And, while we will reserve our discussion of filling out the ROI form for our next meeting, I am providing you with three bids for each option (speed reduction with a VFD, an impeller trim, and adding a new pump) so you can begin to think about what the best solution might be for a given situation and location based on simple payback.

Note that the bids have been adjusted to reflect the cost of doing the work at the different locations, which varies for a number of reasons. And for now, I am just providing the bottom lines to you. I will provide the itemized take-offs as part of the answer key. But I am also happy to share them ahead of time if your team wants to see them for some reason.

Questions

In addition to doing the calculations, please answer the following questions.

1. If the pump had not been throttled, how much would it cost you to make that initial adjustment?

2. Even if it is only a first step, should you present the throttling adjustment to your Owner and if so, how?
3. Is there a reason you would want to defer making any improvement to the pump, including throttling, even if there were significant savings to be achieved immediately by adjusting the balance valve?
4. For each optimization option, in general terms list the technical requirements that should be included in the scope of work above and beyond any standard Marriott "boiler plate".
5. By their nature, bid prices will vary. Is there ever a reason that would set aside the lowest bid and select one of the other higher bids instead?
6. If simple payback was the only criteria for making the decision, for each location, which optimization option would you choose to improve upon the savings already achieved via throttling.
7. If one of your technicians was a machinist and had access to a metal lathe, could that change the cost of the impeller trim significantly?

   Similarly, if one of your technicians was a licensed electrician, could that change the cost of the variable speed drive option significantly?

   Finally, if some of your technicians were competent with your control system in terms of understanding what you need to buy and install and how to program and commission it but were not licensed to run conduit and wire under local codes and work rules, could you leverage their expertise to reduce the cost of some of the optimization strategies?
8. If you were a chief presenting the impeller trim as a project you wanted to implement to your DOE, but the DOE (having not attended AEP and transitioning in to engineering from Administration) was reluctant to physically modify what they considered to be a working piece of machinery, would you have an option you could use that would address their concern while delivering the savings and simple payback you had targeted or something close to that target?
9. As you may have observed in your assessment of the chilled water plant, while there is some measure of redundancy (two of everything and the pumps are cross-piped so either evaporator pump can serve either chiller) if you were to

loose a chiller, pump, or cooling tower cell on a day when you needed two machines, you would be in trouble.

For this plant, in San Diego, the load profile is such that the plant only requires a second chiller in operation about 20% of the time. However, if a failure were to happen on a design or near design day and the house was full, things will go down-hill very quickly.

In our imaginary world, this very thing happened to the Bayview Marquis a little over a year ago. Over the course of the record three-day heat wave (a.k.a. facility engineer's nightmare):

- The hotel spent on average, $50,000 a day in room comps, food and beverage comps, and other expenditures made in the hope of minimizing guest dissatisfaction.
- Despite the expenditures, the facility's Yelp rating plummeted significantly into the 2 star range, and it took nearly 9 months to regain their 4-star rating.
- A mid-sized company who had been holding their annual meeting at the facility for 17 years left, swearing they would never come back (which so far, has proven to be true) despite significant compensation and concessions from the event planning department.

As a result of this, the Owner revisited Marriott Engineering's annual request for a capital project to add a redundant chiller and associated auxiliary equipment including pumps and a cooling tower cell. In the current fiscal year, they provided budget to add redundant chilled and condenser water. The funding for an additional tower cell and chiller is in next year's budget.

Ecstatic, one of the previous DOE's last efforts prior to their transfer was to begin coordinating with contractors to one new pump for each system (evaporator pumping, distribution pump and condenser water pumping). The current technical scope of work is fairly simple;

> *Furnish and install one condenser water pump, one evaporator water pump and one chilled water distribution pump identical to the existing pumps at each location including all necessary wiring and trim.*

The contractors are scheduled to come on site for a walk-through next week so they can begin to put their bids together.

Given what you now know, is there anything you should be doing differently in terms of this procurement and if so, what is it?

10. What steps could you take in the course of implementation to improve your team's skill set and ensure the persistence of the improvement you are recommending once it is in place?

Exercise Resources

In addition to this document, the following items may be useful in terms of supporting this exercise

1. The Chiller Plant Model and related scene guide and answer key will be required to pick up some of the field data you need.
2. The San Diego Marriott Marquis Hotel and Marina Condenser Water System Pump Optimization case study may provide some insight by way of illustrating the approach taken to assessing a similar opportunity.
3. The *Centrifugal Pump Application and Optimization* design brief on the Energy Design Resources web site discusses the various optimization strategies in detail along with other information about pumps.
4. Similarly, the *Pumping System Troubleshooting* design brief provides case studies illustrating analysis techniques that can be used to optimize pumps in a number of common situations. (Note that you may have already encountered these briefs in your self-study effort as they are linked from the Resource list.)
5. The Square Law Spreadsheet tool on the FDE Cx Resources web site may be helpful for some of your calculations along with the discussion of the Square Law that you will find under the Useful Formulas page of the web site.
6. Plot Digitizer and the related Plot Digitizer Pump Curve example may be useful for doing your pump analysis ifhttp://www.av8rdas.com/plot-digitizer-pump-curve-example.html you are into using spreadsheets. But doing it the old-fashioned way with paper and pencil is just fine too.

   Or you could compromise and use PowerPoint, an image of your pump curve, and the drawing tools in PowerPoint to do the analysis.

FYI, I illustrate how you can load an image into a PowerPoint file and then draw on it in the blog post I did about using the basic, free PG&E version of the psych chart you all have since with the free version, you have limited capabilities in terms of plotting things like the Sensible Heat Ratio line. I mention it here because those same techniques can be used to load any image into PowerPoint (a pump curve for instance) and manually plot data on it (a trimmed impeller line or system curve for instance).

7. The bid summary for the various options in the various locations are as follows:

Bid Results - San Franciso, CA			
	Bidder 1	Bidder 2	Bidder 3
Impeller Trim	$2,941	$4,253	$4,466
Variable Speed Drive	$9,017	$17,244	$16,813
Right Sized Pump	$87,140	$95,854	$85,397

Bid Results - Sacramento. CA			
Item	Bidder 1	Bidder 2	Bidder 3
Impeller Trim	$2,297	$2,766	$2,905
Variable Speed Drive	$9,450	$16,312	$15,904
Right Sized Pump	$74,794	$82,274	$73,298

Bid Results - Honolulu, HI			
Item	Bidder 1	Bidder 2	Bidder 3
Impeller Trim	$2,152	$2,591	$2,721
Variable Speed Drive	$8,852	$15,280	$14,898
Right Sized Pump	$70,061	$77,067	$68,660

Bid Results - St. Louis, MO			
Item	Bidder 1	Bidder 2	Bidder 3
Impeller Trim	$2,046	$2,463	$2,586
Variable Speed Drive	$8,414	$14,524	$14,161
Right Sized Pump	$66,595	$73,254	$65,263

8. Even though you are not needing to put together a cost projection or obtain a bid for this exercise, you will need to do it for your personal project. Thus, you may find the blog post I wrote titled *Developing Retrocommissioning Implementation Budgets; Focusing on Individual Findings* to be helpful.