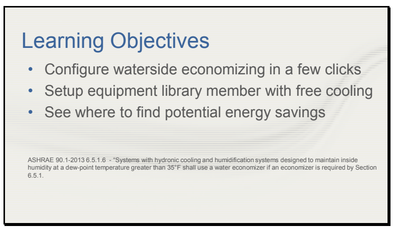
Slide 1

Hello, my name is Sarah Hilden and I am a Marketing Engineer in the C.D.S. group at Trane.

Today, we will be going over how to model waterside economizers in TRACE 700. We'll go through a few examples and I will address some of the common questions we get in the CDS Support Center when users are working on models such as these.

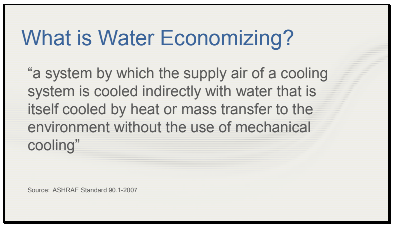
Slide 2



In this presentation, I'll show you how to configure plant equipment with a waterside economizer, as well as how to modify library members if you want to have a custom chiller/economizer configuration for later reuse. Then, we'll see where to look to determine how much energy is saved by the water economizer.

It's worth noting that ASHRAE Standard 90.1-2013 requires waterside economizers for systems with hydronic cooling and humidification systems designed to maintain DP>35F, when an economizer is required per 6.5.1.

Slide 3



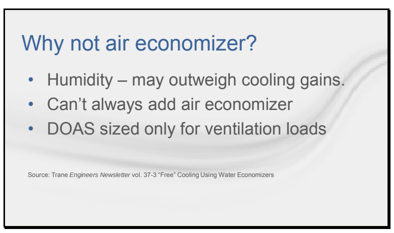
ASHRAE defines a water economizer as a system by which the supply air of a cooling system is cooled indirectly with water that is itself cooled by heat or mass transfer to the environment without the use of mechanical cooling.

In short, a system that lets you run the compressor less (or even not at all) during periods where conditions are favorable.

Typically, other equipment still must run, and may even need to work harder, so it's important to consider the system as a whole, not just the chiller's consumption.

The methods we'll consider today are applicable only to water-cooled chillers.

Slide 4



Why would I use a waterside economizer when I can just put an economizer on my AHUs, you might ask? A few reasons include the following:

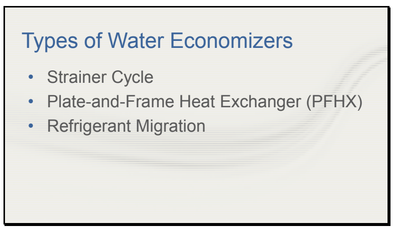
Tight Humidity requirements may negate the efficiency gains of an airside economizer – if the air is cool but humid, it may cost more to dehumidify than is gained by the in reduction cooling or if the air is dry, humidification loads could increase

Not all AHUs can be equipped with economizers due to space constraints, distance to OA intake, increased return/exhaust fan sizing, duct sizing or routing, or other application-specific constraint.

DOAS are typically sized to handle only the vent loads, so full cooling capacity cannot be achieved by an airside economizer.

Now that we've highlighted situations where we can't use an air economizer, let's talk about some different types of waterside economizers and how to model them in TRACE™ 700.

Slide 5



Three types of water economizers are considered within this presentation. Strainer cycle, plate and frame heat exchangers and refrigerant migration.

First, let's look at the strainer cycle….

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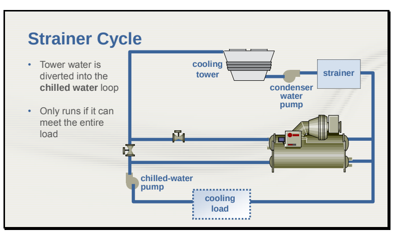
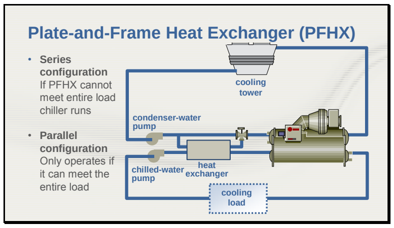


For the strainer cycle, tower water is valved directly into the chilled water loop when the OAWB is low enough. It's the most efficient water economizer option, but is not widely accepted due to fouling concerns. Typically the tower water passes through a filter (or strainer) before entering the CHW Loop, hence the name! The strainer cycle cannot run simultaneously with the chiller, so if the tower cannot meet the entire cooling load, the strainer cycle cannot operate.

This is not used much, but sometimes an existing system must be modelled for comparison purposes.

Slide 7



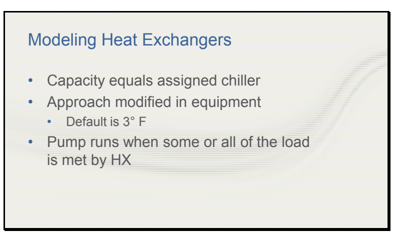
Next up, the PFHX. Now the water loops are isolated, keeping the chilled water loop 'clean', with a slight decrease in heat transfer efficiency due to the heat exchanger itself. The heat exchanger typically requires annual maintenance, adding the expense of cleaning and reassembly, so it's important to include this recurring cost in the LCCA of this option.

This slide shows a simplified depiction of a series-connected PFHX.
When the heat exchanger is configured in series with the chiller, TRACE first tries to have the PFHX meet the entire load. If it can't the chiller handles the remaining load – also known as integrated operation.

When piped in a parallel configuration, TRACE™ 700 assumes non-simultaneous operation, condenser water is routed to either the chiller or the HX - there is no mixing.

An advantage of parallel configuration is that the chiller can be isolated for seasonal cleaning and maintenance.

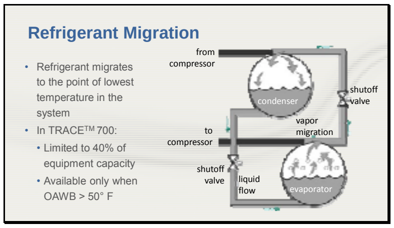
Slide 8



A few important things to note about modelling heat exchangers in TRACE™ 700:

TRACE assumes the capacity of PFHX equals that of the chiller to which it is assigned.
HX approach is modified in the equipment library, and then placed in the project via the chiller on which it was configured. The default is 3F, by the way.
And lastly, the free cooling pump runs when some or all of the load is satisfied using free cooling.

Slide 9



Finally, there's Refrigerant Migration. When returning tower water is colder than the CHW, refrigerant pressure in the condenser is lower than that of the evaporator, driving the boiled off vapor into the condenser. Once the refrigerant condenses, it flows back to the evaporator by gravity so compressor operation is not needed.

When modelling RM in TRACE™ 700, keep in mind that the free cooling available in the model is limited to 40% of equipment capacity and that if the cooling load for the hour cannot be met by Refrigerant Migration (RM), the load is satisfied using the conventional cooling cycle.

The free cooling capacity is a function of the ECWT (leaving tower) and the RM Free cooling model in TRACE™ 700.

Slide 10

In advance of this video, I created a building model using the new file wizard. If you are interested in learning how to use the new file wizard, please watch our other YouTube video that explains how to create a quick block building for analysis.

For this example we'll consider a 25,000 square foot, five zone building in Boise, ID, which is in climate zone 6B. I created the 'base model' with no free cooling in advance of this video. Let's go into the program now, and I'll show you how to get started on setting up the waterside economizer alternatives.

Slide 11

I'm going to show you a couple ways to setup a waterside economizer in TRACE 700. You can include free cooling in a custom equipment library member for ease in reuse, or just add it to the project alternative you're working with, if the default heat exchanger works for you.
To configure the custom equipment, click on the Library/Template Editor and select Libraries, Equipment, Cooling. Remember, you can only modify custom equipment, so in this case, I'll COPY the Default Water-Cooled Chiller and rename it (Economizer Demo).
Next, click the options tab where free cooling type, pump and full load energy rate can be specified. Once the free cooling type has been changed from "none", the PFHX approach field is no longer read-only. Again, the default value for PFHX approach in TRACE is 3 degrees F. Strainer cycle, of course, does not use the PFHX approach field.
For either parallel or series PFHX, you select the pump and its full load energy rate here as well. No pump is required for strainer or refrigerant migration. I'll create a parallel configured PFHX, with the high Efficiency constant volume condenser pump at 30 ft. Then, back on the main tab, I'll save this new chiller WITH it's free cooling already built right in. I'll use it in the example to come.
Back in the project navigator screen, I'll copy the first alternative that was created with no free cooling. In order to determine savings, there must be a 'plain jane' alternative to compare to, as there is no specific report that reflects the savings from a waterside economizer.
To modify the plant, you'll need to right-click in alternative 2, then select Plants>Create plants based on alternative 1, allowing modification of the Plant input data. Then in Create Plants, on the Cooling Equipment tab, I'll go ahead and click on the Controls Button. From here, I'll apply Strainer cycle (using the first method I described earlier) to this plant. I hit okay, apply and it's done. It's not a bad idea to rename this alternative as well.

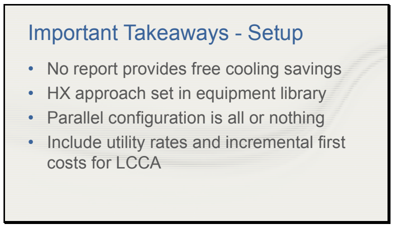
For the third alternative, I'll simply copy the 1st alternative again. This time, I want to use my Economizer Demo Chiller for the cooling equipment, so I'll , create plants based on alt 2. Now, since I had created that (Economizer Demo) chiller, I can use that as my cooling equipment, and as you can see, the free cooling is already built in. RENAME

For the final alternative in the model, again, I'll copy the first alternative, create plants based on alternative 3, then in the cooling equipment tab, I can click on controls to simply change the free cooling from parallel to series PFHX. The pump tags along for the ride and we're done. RENAME

Finally, a utility rate must be added to the project in order to run the economics calculations, if you choose to do so. This along with any incremental equipment and maintenance costs are entered in in the Define Economics section of the program. I'm using of $50/ton for the heat exchangers at 175 tons for $8750 along with annual maintenance of $300 for all three methods of the free cooling, as a generic example. I've selected the Northern Power Utility rate. Be sure to get accurate costs for each of these items as well as the proper utility rate structure for the area where the building is located.

We're ready to calculate.

Slide 12



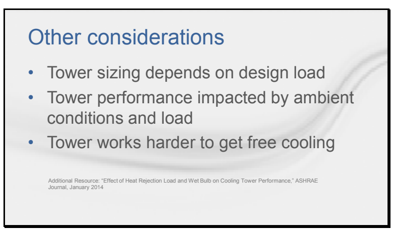
Setting up the free cooling is easy, but remember, there must be a base alternative created in order to determine savings due to free cooling.

The default HX approach can be modified in the cooling equipment library and defaults to 3F.

When a heat exchanger is configured in parallel, it operates ONLY when it can meet the entire cooling load in any given hour.

And, finally, if LCCA is to be performed, the proper costs and utility rates must be entered for the project alternatives.

Slide 13



A few things that must be kept in mind……the tower must reject the heat of compression in addition to the design cooling load, this is what it will be sized for.

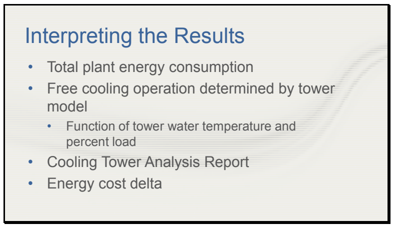
When the plant operates in Free Cooling mode, the building is not typically going to be at design load and ambient conditions are cool.

Also, tower approach increases as OAWB decreases (it's really enthalpy), and tower performance is based also on the cooling load.

As a result, the tower may need to work harder to get free cooling.

Now let's look at how to understand what we'll get out of TRACE^{TM} 700

Slide 14



It’s important to look at all the associated equipment, not just the chiller, to determine the NET energy savings as the tower operation will vary and additional pumps are required for certain configurations of waterside economizing. Depending on the efficiency of each component within the system, it’s up to the you to use this information to determine whether it makes sense to implement the waterside economizer, when the model is used for design. The load profile and ambient conditions play a role in how much benefit is gained from free cooling.

In the next screencast, we’ll see where to look for the energy consumption information, we’ll discuss a caveat to the Cooling Tower Operation Report and see where to find out if there’s really a payback.

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Looking at the Energy Cost Budget summary is a quick way to compare the net building consumption for each alternative in the model. Notice here that the consumption for Cooling Equipment, Pumps and Heat Rejection are all separate line items. The sum of these three line items is what must be compared to determine the savings resulting from adding FC to your design. While the total building savings in this example is around 3.5 - 4% for the heat exchangers, we can see the chiller electric use is reduced significantly for each of the FC methods. Note the heat rejection for the series is 119% of the no economizer version in alternative 1. The nice thing about the ECB report is that all the numbers are all in one spot for all of the alternatives. Obviously, alternative 2, the strainer cycle had the greatest energy savings, with the heat exchanger configurations right behind.

If you wanted to know WHEN the FC is benefitting the chiller, you should be checking the Equipment Energy Consumption Report. In this case, I can quickly go between the alternatives using the tree on the Left Hand Side of the

Screen to compare quickly the annual chiller consumption of each alternative, since it's in the same location on the page.
Take note of the annual consumption values for the chiller and the tower, over here, as I switch between the alternatives. Notice that for no free cooling, the chiller consumption is about 380,000 kWh. The tower used around 92,000 kWH. There's cooling in the the winter season as wel -, Jan shows 26,000 kWH, remember that.

When I move to the strainer cycle, it's easy to see the chiller consumption was reduced almost in half to 200,000 kWH but the tower increased by almost 20%. And look, no chiller consumption in the winter.

Alternative 3, with the parallel heat exchanger used more cooling that the strainer and less heat rejection than the strainer, but look at the free cooling pump, shown here at almost 14,000 kWH. We see also, there are some months in the winter where the cooling load wasn't met by the free cooling, so the chiller had to run for some hours in that month.

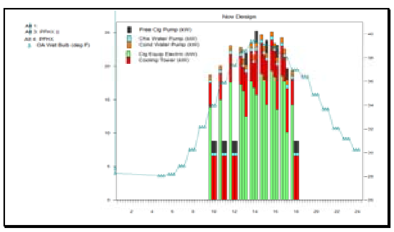
Finally, the series configuration saved a bit more on the chiller, at 212,000 kWH, but the tower consumed the most energy of the four alternatives. Note, that the chiller consumed less in the cool season than it did in the parallel configuration.

Now, let's take a look at the economic summary report. Looking at lines 2 and 3 here in the comparison, we can see that the heat exchangers both pay back in this example. At the bottom of the report, the annual savings versus no economizer are shown for each alternative, along with the plant's kwh/ton-hour. This value applies only to the cooling plant electric consumption.

I want to point out that the Cooling Tower Analysis report shows only tower hours coincident with chiller operation. Clearly, the tower is running more in the free cooling modes, which is not reflected in this report. But since the tower is off more hours in the free cooling alternatives, it can be inferred that the chiller itself is running fewer hours.

Will discuss how the total energy must be compared to determine the gains of the entire system. –equipment energy report and ECB
Will take a look at the tower report to show that it is not applicable due to the way the data is reported ie) only reports tower operation hours that occur when the chiller is also operating.
Show the visualizer a bit, and how to glean more data out of that.

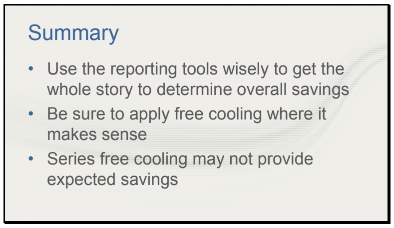
Slide 16



I used the TRACE Visualizer to look at one day in November, from the simulation we just ran. You can see in hour 10 that both the series and parallel connected heat exchangers are able to handle the entire load. However, in hour 13, the series free cooling operates in integrated mode, and in this case, among others, the series-configured heat exchanger plant actually consumes more energy overall. This why the series option doesn't always provide the expected savings.

In hours where the free cooling pump runs when the chiller also runs, we can see the integrated operation of the series-connected heat exchanger. While it's apparent that total chiller energy consumed during these hours is indeed less than parallel, the combination of the harder working tower with the free cooling pump offsets the energy saved by turning off the chiller.

Slide 17



So, what did we learn?

The chiller's operation alone doesn't necessarily provide the net savings over the course of the year. Be sure to consider the tower and ancillary pumps to get the whole picture.

Typical building profiles where Waterside Economizing make sense include Hospitals and Large Office building in Climate zones 4 and colder. Generally, the coincident cooling loads with moderate OA conditions enable benefits to be gained from waterside free cooling.

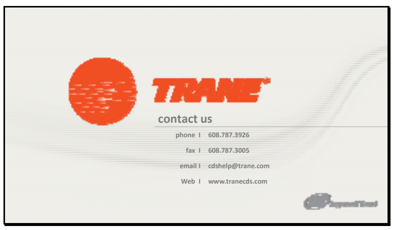
And here's our most commonly asked question about TRACE free cooling modeling. Why doesn't TRACE show more savings from series than parallel?

Series free cooling has the chiller picking up any remaining load that the free cooling cycle can't meet, yet the tower and free cooling pumps continue to run as hard as they can for the free cooling cycle to continue. But, because the free cooling cycle is "stealing" so much of the cooling load, the chiller is at a typically inefficient operating condition. We can see this effect a few hours of the year, as we saw on the visualizer graph in the previous slide. The free cooling pump and tower energy go up, and may even exceed the overall plant energy consumption of the parallel free cooling option which turns free cooling off once the cycle cannot meet the entire load.

Slide 18

This completes today's demonstration on modelling Waterside Economizers. Hopefully, we've given a basic understanding of how to enter them in TRACE™ 700 and how to evaluate whether their use in your model will yield appropriate savings. If you need some assistance in other areas of the program or just want a better understanding of some of the concepts we talked about today, here are some additional resources available to you.

Slide 19



As always, please feel free to contact the C.D.S. Support Center by phone or email with any comments, questions or modeling issues you may be experiencing.

Thank you for your time and happy energy modeling!

