Slide 1

Hello, my name is John Sustar and I'm a marketing engineer in the C.D.S. group at Trane.

Today, we will take a look at modeling heat recovery chillers in TRACE™ 700.

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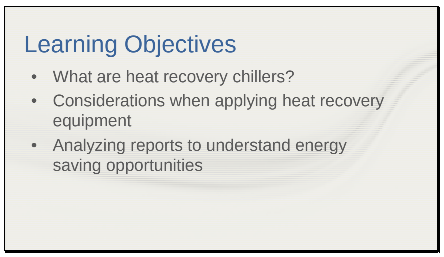

In this video, I'll start with defining heat recovery chiller equipment.

Next, we'll identify some application and design considerations when applying the equipment in a building to meet both cooling and heating loads.

We'll go through a quick example on how to input the equipment into a TRACE™ model where the heat recovery chiller is supplementing domestic hot water loads. We'll go through some output reports for analyzing the performance of the heat recovery chillers along with the pumps and heat rejection equipment.

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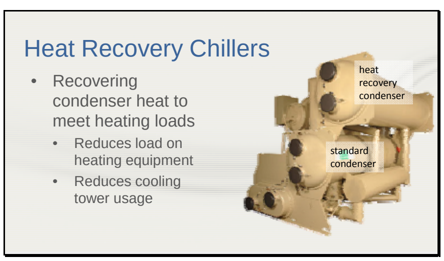

As the name implies, heat recovery chillers collect heat that would normally be rejected to a cooler tower for the purpose of meeting heating loads in the building.

This gives a double energy benefit to the building owner.

First, recovered heat reduces the need to create heat from heating equipment.

Second, it reduces the cooling tower usage.

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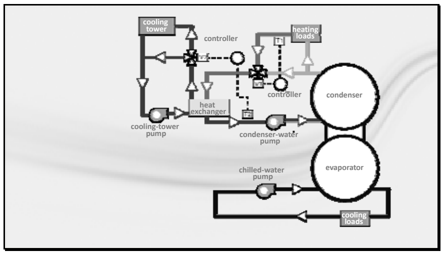

There are a couple different types of heat recovery chillers. For instance, heat may be recovered from chillers with only one condenser. In these cases, a heat exchanger is required to isolate the cooling tower loop and the heat recovery loop to eliminate the potential for tube fouling in the heat recovery coil.

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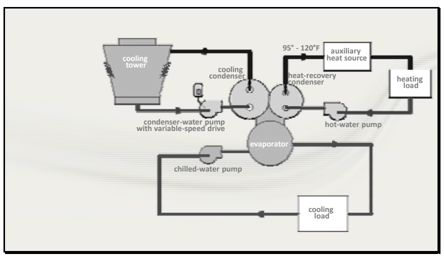

There are also chillers that have an additional heat-recovery condenser.

Here, I show a schematic for a chiller that utilizes a second condenser bundle with full capacity. These units are capable of relatively high leaving-water temperatures when operating in heat recovery mode. The heat recovery leaving water temperature with double bundle condensers is typically 105 to 110 degrees.

These chillers have the advantage over single condenser chillers in that they can also operate in cooling-only mode at normal condenser leaving temperatures when rejecting heat to a cooling tower.

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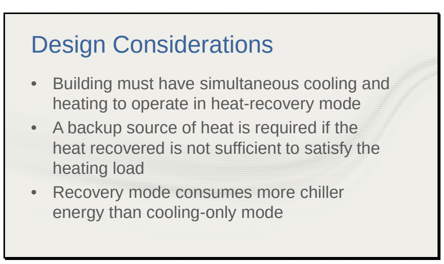

In terms of design considerations, here are a couple items to remember.

In order to recover heat, there must be simultaneous heating and cooling loads. In TRACE™, this means simultaneous cooling and heating loads during a given hourly timestep. To check loads in TRACE™, you can look at the analysis reports and visualizer to determine simultaneous cooling and heating loads. Additionally, the availability of recovered heat is dependent on cooling loads being met by the chiller.

Next, a backup source of heat is required if the heat recovered from the cooling load and compressor is not sufficient to satisfy the entire heating load.

Lastly, reducing the amount of energy consumed for heating via heat recovery comes at a cost. Operating in heat recovery often consumes more chiller energy than a cooling-only chiller because the chiller operates at an elevated condensing pressure and temperature.

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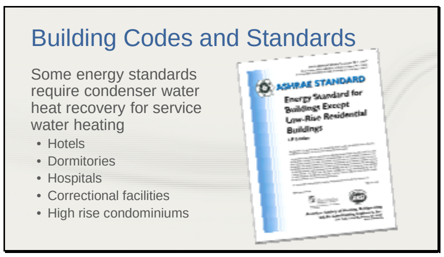

When it comes to energy codes, some standards and building codes, including ASHRAE standard 90.1, require condenser water heat recovery for certain service water heating applications, where there's a relatively large heating load throughout the year.

A few applications that meet these criteria are hotels, dormitories, hospitals, correctional facilities, and high-rise condominiums with central-cooling systems.

Now, that we understand design considerations, let's look at an example for a hospital application.

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For this example, let's consider a 4-story, 400,000 square foot hospital located in Madison, WI. The peak cooling load is 1000 tons and the peak service hot water load is 3,000 Mbh.

To demonstrate performance, we are going to be comparing a heat recovery chiller alternative versus using cooling-only chillers.

In our example, alternative 1 will be modeled with 2 cooling only chillers in parallel with a capacity of 500 tons each.

For alternative 2, I'll walk-thru how to setup a model with a chiller with a heat recovery condenser to help satisfy the hot water load. Alternative 2 will also have a cooling-only chiller as the 2^{nd} chiller in parallel.

Let's go into TRACE™.

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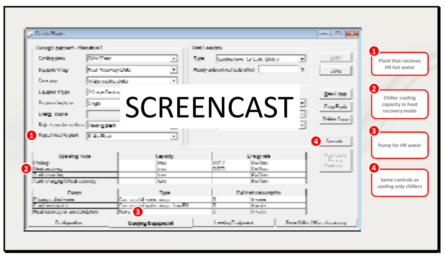

So, I've already set up the baseline first alternative as having 2 cooling-only 500 ton chillers to meet the cooling loads. Additionally, there are 2 heating plants, one serving the heating loads in the heating coils for space loads, and the other to meet the 3000 mbh service hot water load. I've modeled the service hot water load as a base utility. No chiller heat recovery is modeled in this alternative.

In the 2nd alternative, I'm going to keep everything the same with the exception of modifying the cooling plant so that the lead chiller in chiller plant is a chiller with heat recovery that serves the service hot water load.

To set this up, the first thing I'm going to do is copy Alternative 1. To do this, I'm going to right click on alt 1 and select Copy alternative.

Next, I'm going to come down to Create Plants for Alt 2 and right click, select Plants, and select the radio button to Create plants for alternative 2 based on alternative 1, so I can modify the plants. Next, I'll click OK.

After making that selection, I can now go into Alternative 2's create plants, so I can add a heat recovery chiller as the baseload chiller.

Click on Alterative 2's create plants, and then go to the cooling equipment tab. You can see that there are 2 chillers in this alternative, both of which are currently cooling only chillers.

For the first chiller, I'm going to change the equipment type. From the dropdown list, I can select a heat recovery chiller. The 2-stage Centrifugal with heat recovery chiller is one of the standard TRACE™ heat recovery chillers that we can select. You can identify heat recovery chillers in this list of equipment based on the reject condenser heat being set to Heating Plant and the heat recovery mode in the operating mode table being populated with an energy rate.

After selecting the equipment type, next, I'm going to change this chiller as being the base load chiller which means that it's the lead chiller. Therefore, whenever there's a cooling load met by the lead chiller and a simultaneous service hot water load, heat recovery will be possible. For more information on chiller sequencing, check out the eLearning video on chiller sequencing and controls on the tranecds.com website.

Second, I'm going to change the reject heat to plant to my "Service water heating" heating plant, which is dedicated to serve the hot water base utility load. The "service water heating" plants is tied to the service hot water load as shown here in the base utility tab.

Going back to the cooling equipment tab, if I had selected reject condenser heat to Domestic Hot Water, the condenser heat would be rejected to the first base utility listed on the base utilities tab that has the energy meter set to process hot water load in the base utilities library. This would achieve the same outcomes as selecting reject heat to heating plant and selecting the heating plant tied to the service hot water load.

Next, I'm going to enter the cooling mode tons as 500 tons and the energy rate as 0.52 kW/ton.

For heat recovery mode, I'm going to enter a lower capacity of 400 tons and a higher energy rate of 0.6 kW/ton. The kW/ton is higher in heat recovery because the chiller operates at an elevated pressure and temperature during heat recovery mode.

For the pumps, I'm going to enter pumps for the primary chilled water, condenser water, and the heat recovery pump. The heat recovery pump will run there's simultaneous cooling loads and service hot water loads. Also, don't forget to enter in static head values for all three pumps.

In terms of rejecting heat during hours when the heat rejected exceeds the service hot water loads, any excess heat is rejected from the system via the cooling tower entered in the heat rejection type field.

If we go into cooling equipment controls, I also want to show you an input called Load Shedding economizer. By selecting Yes, TRACE™ will model airside economizer controls. However, the economizer controls using this input will be different than applying an economizer in the systems section in that, TRACE™ will base the outdoor air intake to control to chiller cooling load where the heat rejected from the chiller's condenser is equal to the heating demand on the heat recovery chiller. We'll leave this control Off for this example.

Next, if we go to the heating equipment tab, a gas-fired boiler provides backup heat to the service water heating using a hot-water pump rated for 50 feet of static head.

In the base utility tab, notice that there is a 3000 Mbh service hot water load connected to the “Service Water Heating, which is utilizing the heat recovered from the chiller to heat the mains water. We are now done setting up the heat recovery alternative.

Now, let’s close out of Create plants and calculate the file.

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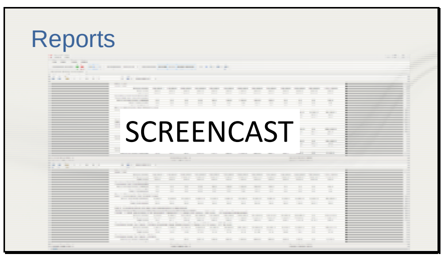

After the file is calculated, I can open the results to analyze the energy savings with the heat recovery chiller.

I’ll open 2 reports to analyze the results, “Equipment Energy Consumption” and the “Energy Cost Budget”.

In the Equipment Energy consumption report, I’ll use the comparison tool, which is green + icon, so I can compare Alt 1 versus Alt 2.

The top report will be Alt 1 and the bottom will be Alt 2. The 4^{th} item in the equipment is the base utility for domestic hot water load. Notice that the load is the same between Alt 1 and Alt 2 and that it’s a load which occurs year round which makes it ideal for heat recovery.

If we scroll down a little further, notice the chiller 1 consumption in the heat recovery alternative is larger than the chiller 1 consumption in the cooling only alternative. This is because the heat recovery mode in Alternative 2 draws more kW per ton than the Alternative 1 cooling only chiller.

Next, notice the cooling tower consumption is in Alternative 2 is significantly smaller than in Alternative 1. This is because the heat recovery chiller is rejecting a portion of its condenser heat to the hot water load.

If we go to the next page, you will notice that there is a condenser energy transfer pump in Alt 2 which is operating in conjunction with the heat recovery. This pumps energy is an indicator for how much heat is being recovery from the chiller in Alt 2.

Now, let’s go to the last to show the difference in service water heating equipment consumption. Notice that the therms usage in Alt 2 is significantly lower than the therms usage in alt 1.

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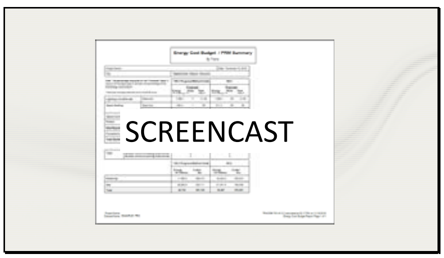

Next, let’s look at the Energy Cost Budget report to show a summary of the savings between Alt 1 and Alt 2. You can see that Alt 2 offers savings in gas heating and heat rejection electricity consumption. Meanwhile, alt 2 is consuming more energy with cooling equipment. Overall, the heat recovery option is saving approximately 3,000 Mbh.

Using a default electricity and gas utility rate that I included in the economics, the cost savings comes to about $15,000 per year with the heat recovery chiller.

Note that these savings will vary from project to project and will be a function of heat recovery availability, energy rates for chillers, cooling tower, pumps, boilers, as well as the utility rates entered.

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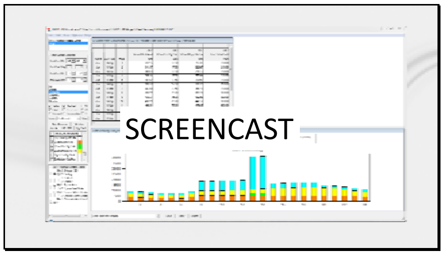

We can also open the graph profiles and energy visualizer to look at a couple of the output variables that display heat recovered to meet heating loads. First, after opening the tool, make sure that Table, Chart, Settings, and Advanced are all selected in the View menu. Then go down to the clear button to clear all existing output variables.

Next, on the cooling plant tab, you can select Qcondenser heat available to display the tons of heat being rejected from the condenser available for heat recovery. Selecting Qcondenser to htg coils displays the tons of heat recovered for the heating load, and Qcondenser display the tons of heat rejected to the cooling tower. The sum of Qcondenser to heating coils and Qcondenser to tower should equal Qcondenser heat available. After selecting these variables, you can select Draw. Next, you can manipulate the Time, daytype, and demand/consumption selection to change the display of output data.

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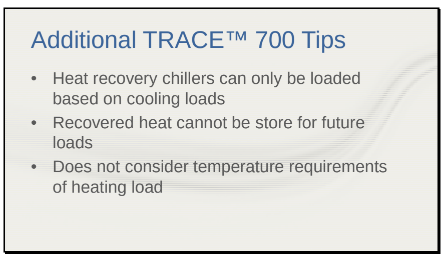

Here are some additional modeling tips when applying heat recovery chillers:

First, these chillers can only be loaded if there's a cooling load on the chiller. In other words, if there is a heating load during a given timestep, but no cooling load, the chiller will not operate to meet the heating load.

Along the same lines, heat recovered cannot be stored from one timestep to the next for future heating loads.

Lastly, when recovering heat, TRACE™ only considers btu's when calculating the heat recovery rate for transferring heat from the condenser to the heating load. In other words, if the heating load requires 105 degree water but the condenser only provides 85 degree water during heat recovery mode, TRACE™ doesn't consider the temperature difference when determining the amount of heat recovered for the heating load. It only consider btus from the condenser and btus of load to determine the amount of heat recovery.

If you are modeling this scenario, you could work around the temperature issue by splitting up the service water load into 2 base utilities, 1 to represent the load that can utilize heat recovery for preheating mains water and the other to represent the portion of the load met by only a boiler.

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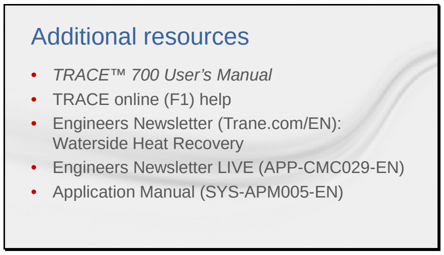

Here are some additional resource to look at when modeling heat recovery chillers. Page 3-52 of the user's manual goes though some more modeling tips on heat recovery chillers

As always, remember to press F1 for help on specific field explanations.

We have an excellent engineers newsletter on Water-side heat recovery system that can be downloaded for free on the trane.com/en website.

Or a complete 90-minute program on DVD and application manual that can be ordered.

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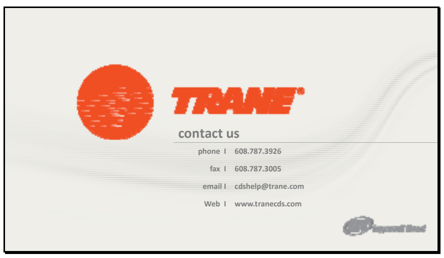

That concludes this short video on modeling heat recovery chillers. If you have any questions about modeling this equipment or any other modeling or CDS software questions, please feel free to contact CDS support. Thanks and have a nice day.

