Project Kojak Proposal
Chiller Performance Curves (new title tbd)

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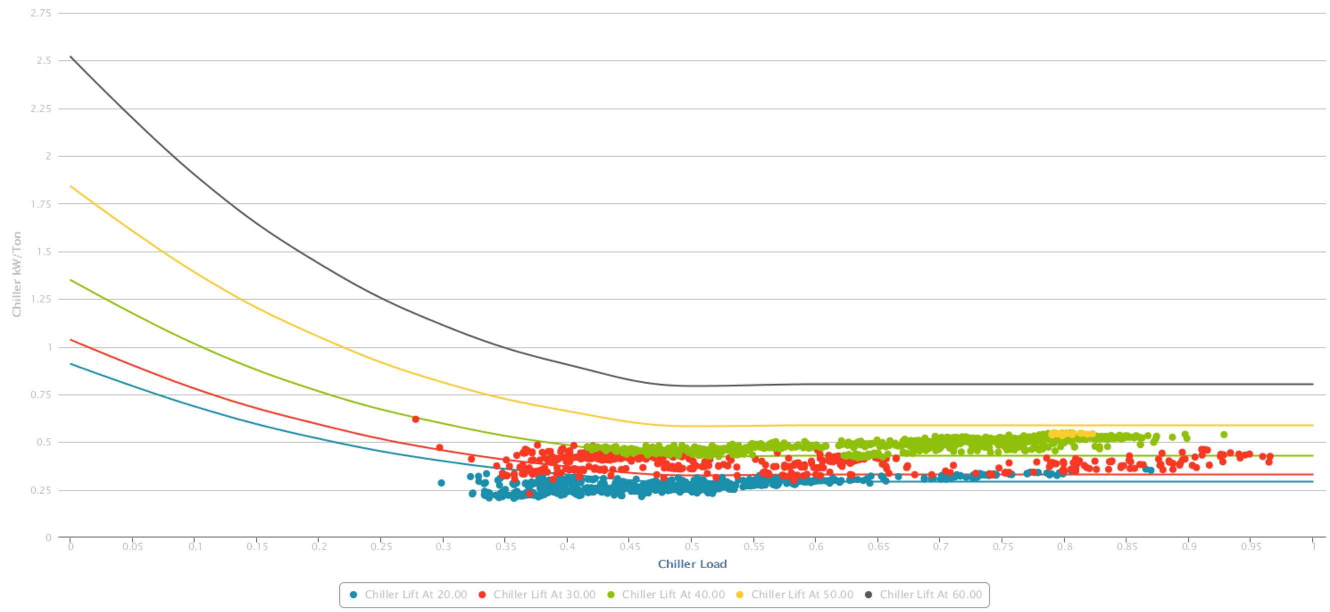
<u>Project Overview</u>

Complex systems do not have obvious relationships between inputs and outputs. It's often hard to tell what the influence is of a feature in the system. Machine learning is a tool for modeling these complex systems to help understand the relationships between features.

For my project I will study a chilled water heat exchanger or chiller. This is a large machine used to exchange heat from one water system to another. The first water loop provides chilled water for air conditioning or production cooling. The water leaves cold and returns some degrees warmer. The second water loop expels the heat to the environment. The warm water leaves the chiller and dumps the heat through a cooling tower, returning to the chiller cooler then when it left. The two water systems don't mix but they do exchange heat with each other.

Below is essentially a 3D plot collapsed to 2D for the performance of a York YK chiller. The x-axis is the percent load on the chiller. For a 1000 ton chiller running at 500 tons this would be 50%. The y-axis is the energy required to run the chiller per unit of cooling in kW/ton. The colored bands represent the third axis which is the amount of cooling the chiller provides or lift.

The lines represent a calculated performance curve and the dots represent data collected from the chiller. As you can see the dots in each colored band approximately represent the band but there is a distinct trend that does not follow the band. The goal of this project is to provide better performance curves based on the characteristics of a given chiller.
Optimum Energy optimizes chilled water plants and in this capacity has collected a large amount of data from the plants. They have offered to provide this data for analysis in this



project. The York YK chiller is quite common and in various configurations exists in several plants.

The chillers which will be examined are two pass York variable speed chillers. They will have a range of capacities which is measured in Tons. One Ton is the amount of energy required to make one ton (2000 pounds) of ice in a day (24 hours). They will vary in condition which is often a measurement of the refrigerant level or cleanliness of the tubes in the chiller.

Data

For each chiller, the following data will be used:

Feature	Description	Unit of Measure
kW/Ton	A unit of energy	
DTLift	Lift is the work the chiller has to do. Condenser Water Return Temperature - Chilled Water Supply Temperature	Degree F
Load		%
Ton	The current output of the chiller	
EvapApproach	Evaporator Approach	Degree F
CondApproach	Condenser Approach	Degree F
CompSH	Discharge Superhead	Degree F
Hz	Variable Speed Drive Speed. Measured as hertz where 100% = 60Hz no 50% would be 30Hz.	%

Feature	Description	Unit of Measure
IGV	Inlet Guide Vane Position	%
CHWST	Chilled Water Supply Temperature	Degree F
CHWRT	Chilled Water Return Temperature	Degree F
CDWST	Condenser Water Supply Temperature	Degree F
CDWRT	Condenser Water Return Temperature	Degree F

Methodology

I propose to proceed in the following manner. The ground truth will be the data from the plants. I plan to fit the models to a collection of chillers and test to a completely different chiller.

1. I will start by fitting a linear regression model to the data. First to just Lift, Load and kW/Ton. At this point I propose adding higher order features such as Load**2 as well.
2. I will then add other features such as Evaporator Approach, Discharge Superheat, etc. to the model. L1 Regularization (LASSO) will help determine which features are important.
3. I would like to look at not just creating a model but creating new chiller performance curves. Like a variation on the existing curve so you can actually see what the model is doing. Have he model predict coefficients for a curve.
4. Once there is a model it ill be possible to look at the effect a change in Lift has on the kW/Ton and Load.
5. The project may lead to a larger scale model such has creating a collection of chillers and looking at the energy required as a chiller is added or shed to meet a defined load.

Additionally, I would like to use Spark for the computations and potentially create a Flask app so an engineer could input what they know about the chiller and the app would generate performance curves.