Chiller Performance Curves

Dana Lindquist Metis final project

Progress Report
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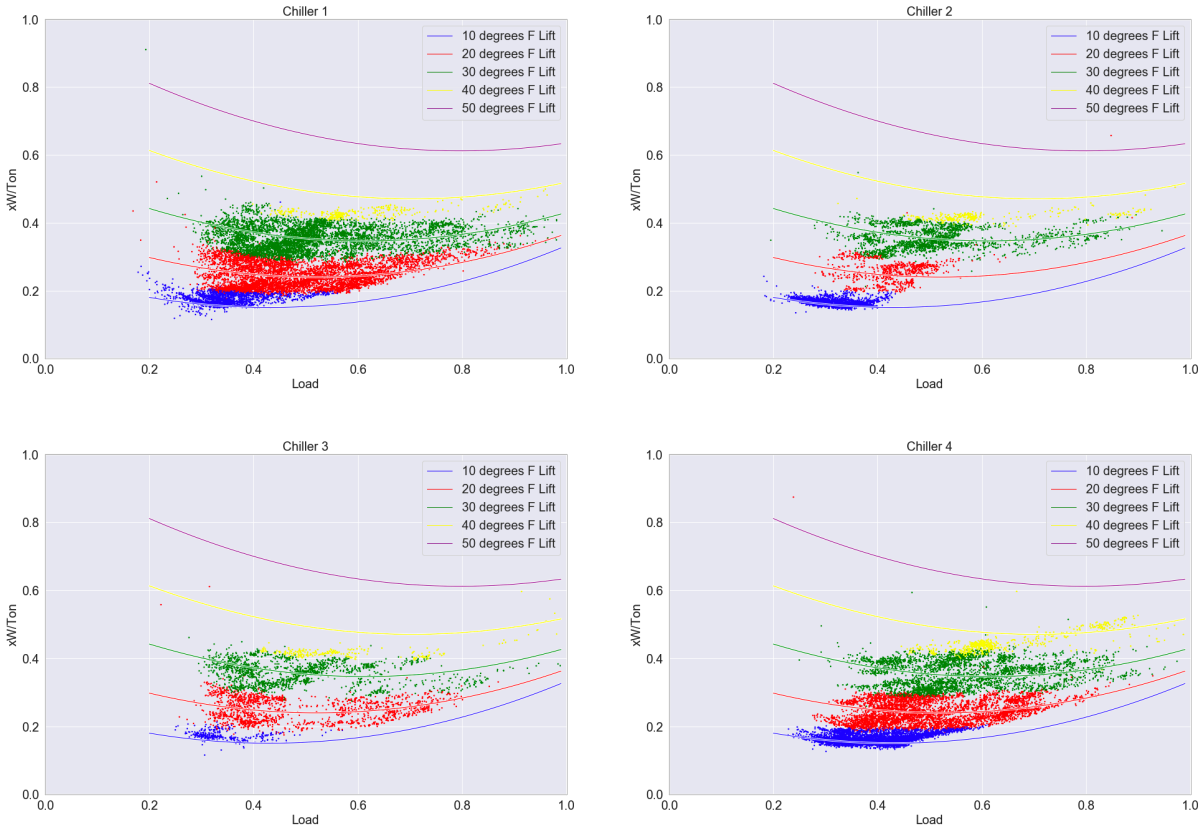
Linear Regression

Linear Regression was performed using data from the four Samford YK chillers to predict kW/Ton. Chiller 1 was used to train on and Chillers 2, 3 & 4 were used as test sets. The model using features Lift, Load, Lift^2, Load^2, Lift*Load are shown below. The lines are predictions from the model for constant Lift. The points are chiller data with the Lift colored with +/- 5 degree from the constant lift lines.

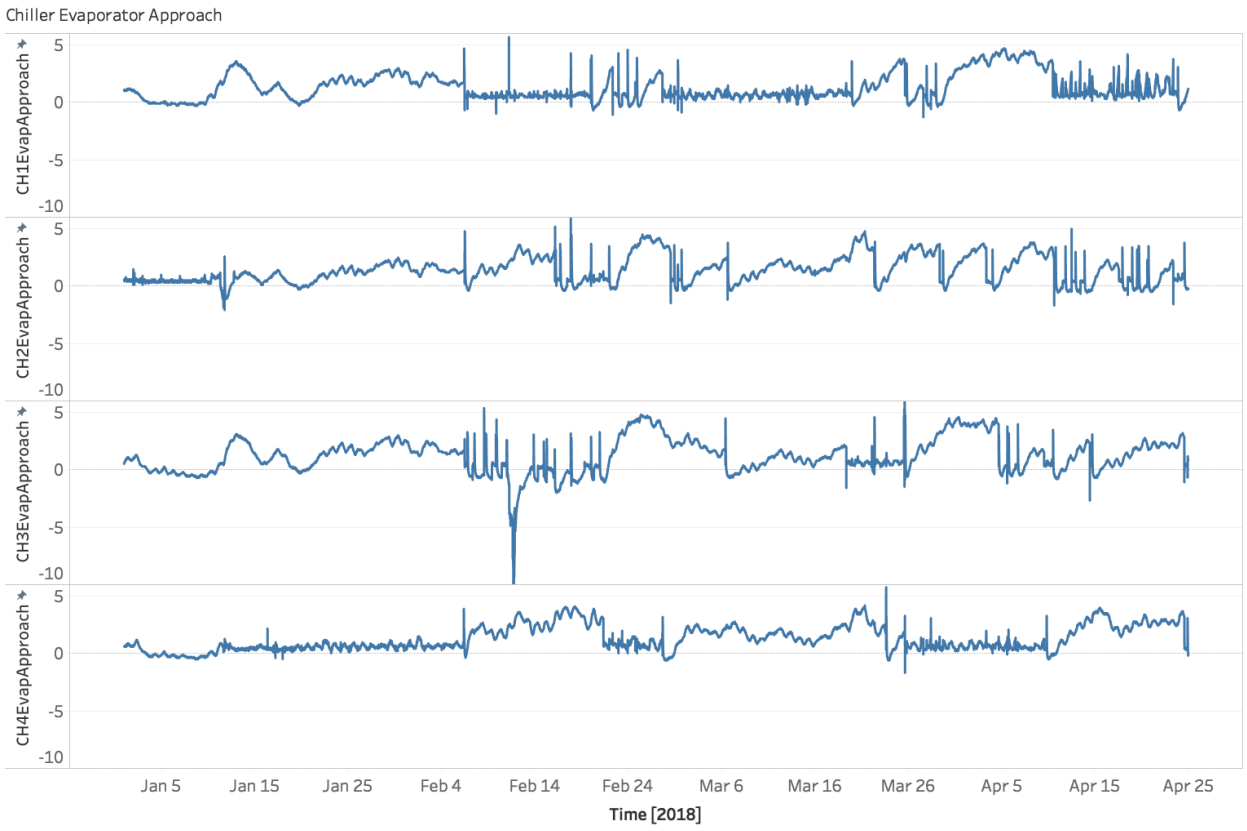


The accuracy of the model is show below. I need to look deeper to understand why Chiller 2 and Chiller 3 accuracy is so poor. The model does an impressive job at predicting the accuracy on Chiller 1 so the curves accurately predict the operation of this chiller. I was surprised to see that the curves for Load from 0.5 to 1 had as much curve to them.

	Accuracy
Chiller1 (training set)	98.2%
Chiller 2	61.2%
Chiller 3	64.0%
Chiller 4	97.3%

I need to look further at why the accuracy for Chillers 2 and 3 are so poor as the curves from seem to model the chiller quite well. Again, the curves are from the training set which was Chiller 1. There may be some bad data points which need to are corrupting the accuracy

Fred mentioned that the Evaporator Approach on one of these chillers is slightly negative which may be an indication of a bad sensor. The evaporator approach should not be negative. I plotted the Evaporator Approach for all chillers over the time period of the data and they all dip negative at some point. Chiller 3 does seem to dip negative more than the other chillers.



I did look briefly at adding other features to the model and did not see any improvement in the accuracy. This feature engineering will be part of the next step in the project.

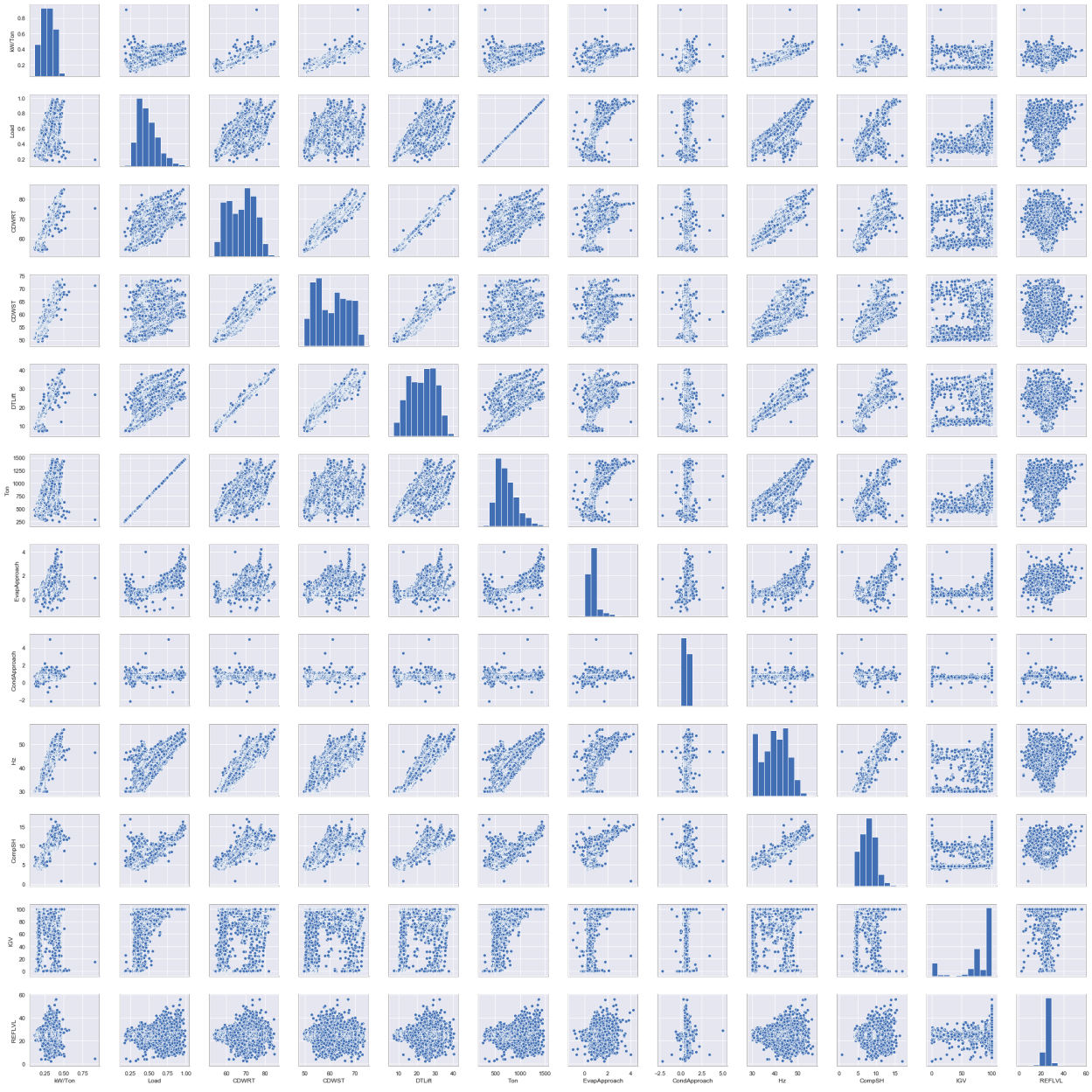
Additional Features

The Features I have pulled from the data are:

Feature	Description	Units
CondApproach	Condenser Approach Temperature	degrees F
EvapApproach	Evaporator Approach Temperature	degrees F
kW/Ton		kW/Ton
IGV	Inlet Guide Vanes	%
Load	Tons/Rated Tons	%
REFLVL	Refrigerant Level	
Hz	Variable Speed Drive (VSD) Speed, 60Hz = 100%	Hz
CompSH	Discharge Superheat	degrees F
Lift	CDWRT - CHWST	degrees F
CDWRT	Condenser Water Return Temperature	degrees F
CHWST	Chilled Water Supply Temperature	degrees F
Rated Tons	Rating for the chiller	Tons

I have mostly used Load and Lift as well as higher order combinations of these features (Load ^2, Lift^2, Load*Lift) for modeling. But this is not going to explain why the curves vary from one chiller to another. With more chiller data I will be able to experiment with combinations of features.

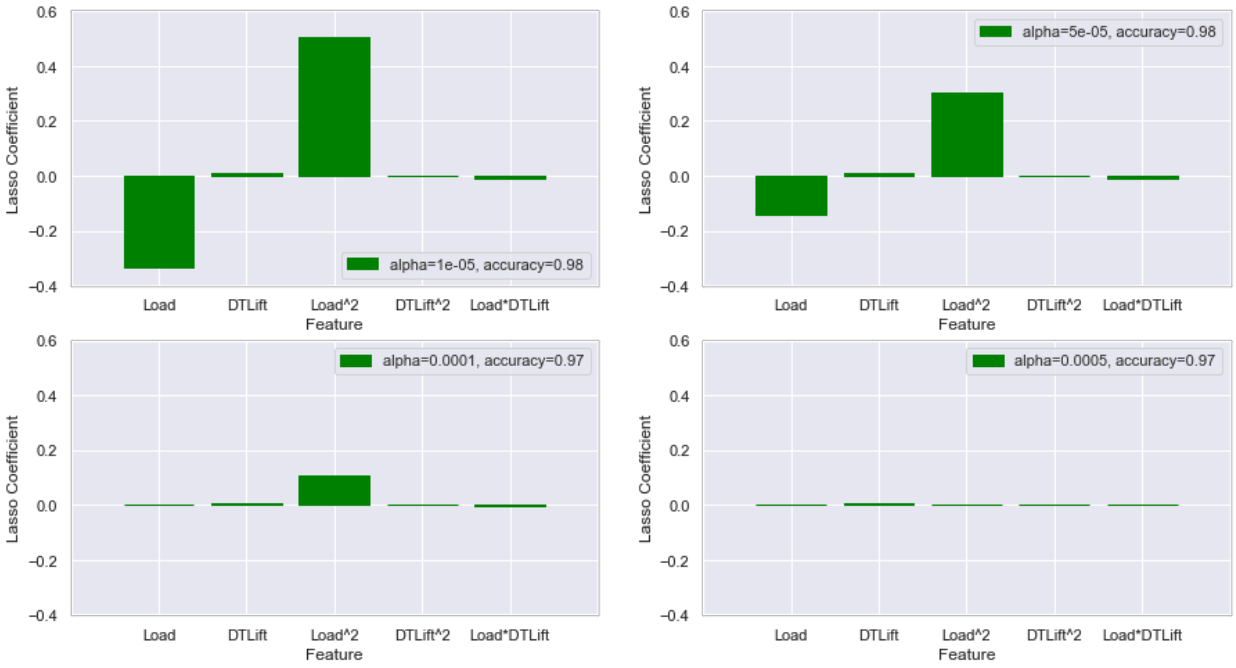
As part of an early exploration I looked at the correlation between these features which is shown the chart below. I'm wondering if what I really want is a ratio of features or maybe an average over the time period to represent the chiller.


kW/Ton
Load
CDWRT
CDWST
DTLift
Ton
EvapApproach
CondApproach
Hz
CompSH
IGV
REFLVL

LASSO L1 Regularization

LASSO L1 regularization can be used to determine which features are most important. LASSO will drop the least important features. LASSO has an input, alpha. The value of alpha will effect the impact of the regularization. For alpha=0 the regularization drops out and the model is a simple linear regression. For alpha large the feature coefficients are all zero

Load and Load^2 are the most important features. DTLift and Load*DTLift are the next most important features. Lift^2 is not as important



Future Work

The next steps are to add chiller data from other size chillers running under other conditions. All four chillers at Samford are 1500 Tons. It would be nice to have chillers that have a higher lift or are running under higher load.

With the data from other chillers I would like to look at how the performance curves change under different operating conditions and chiller configurations. Can I predict what the curves would be for any chiller? What are the important features that characterize the performance curves? I need to see if I can find features which would improve the accuracy of the Samford chillers 2 and 3. What is causing the low accuracy and is there a feature that can better predict chiller curves for all 4 chillers?