Incorporating Predictive Models for Operational Intelligence

Presented by Curt Hertler
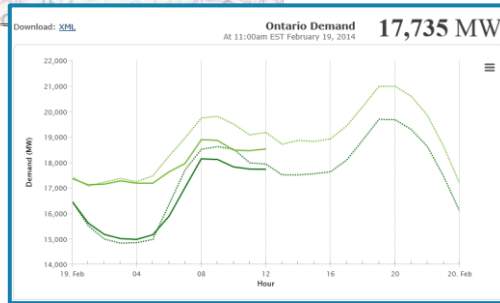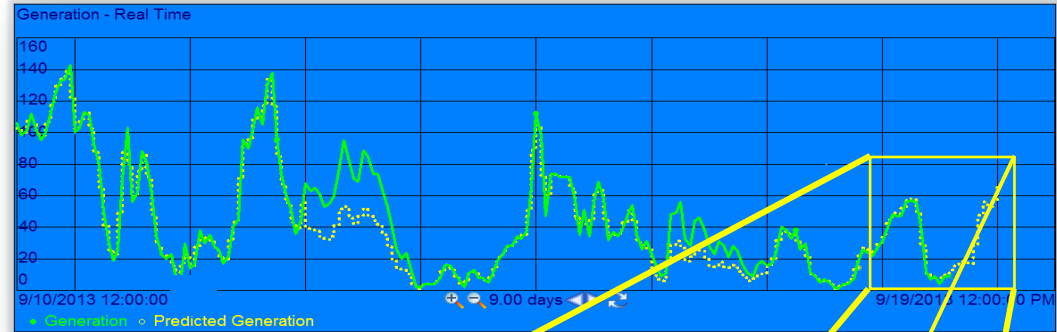
Partner Solutions Architect, OSIsoft

"History is only a way of repeating itself."

"The only thing new in the world is the history you do not know."
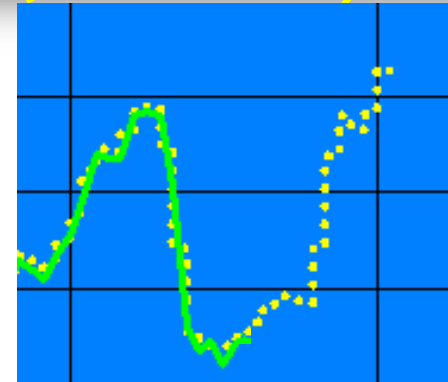
- Harry S. Truman

Operating Forecast

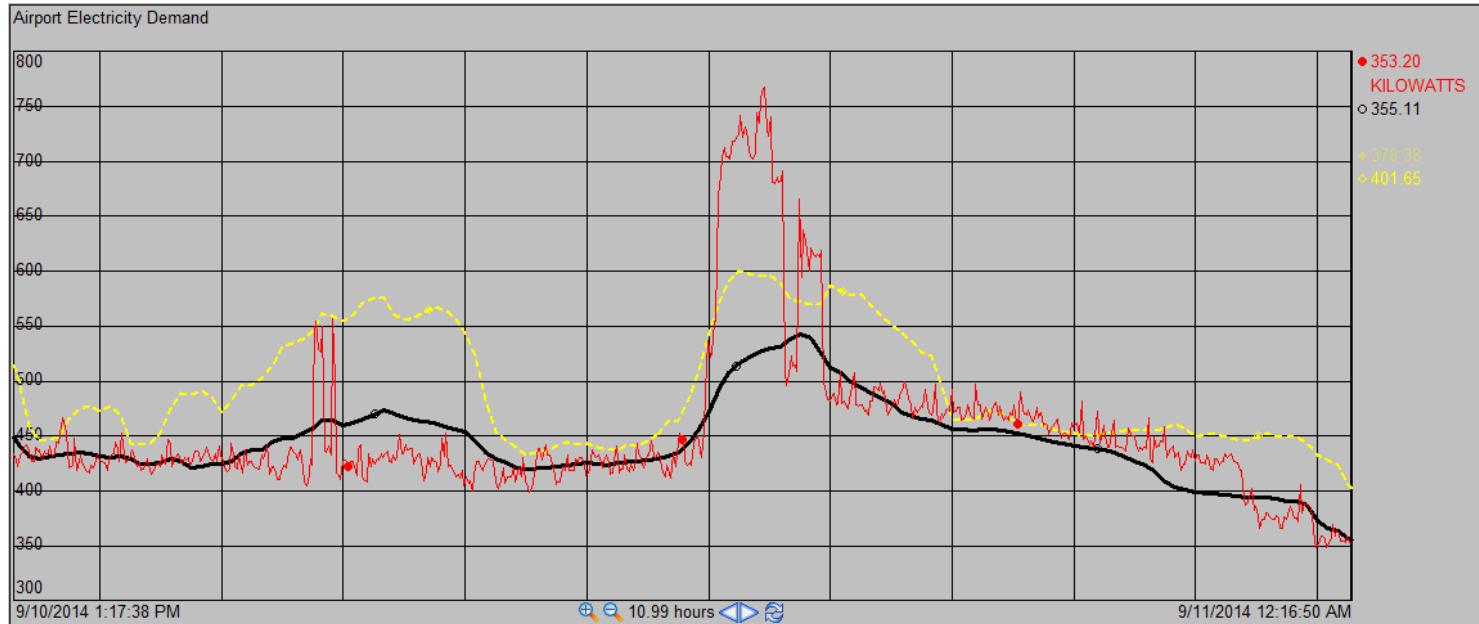Wind farm generation prediction based on weather forecast.

Predicted Generation

Electrical Spike Detection

Actual facility demand exceeds statistical significant range of prediction

Emerging Technologies

- Experimentation and Predictive Modelling
  - Microsoft Azure Machine Learning (ML)
- Shaping and Publishing PI System Data
  - Internal Alpha PI Integrator for Azure SQL
- Data Analysis and Assessment
  - Power BI Designer Preview
- Operationalization
  - PI System 2015 Future Data
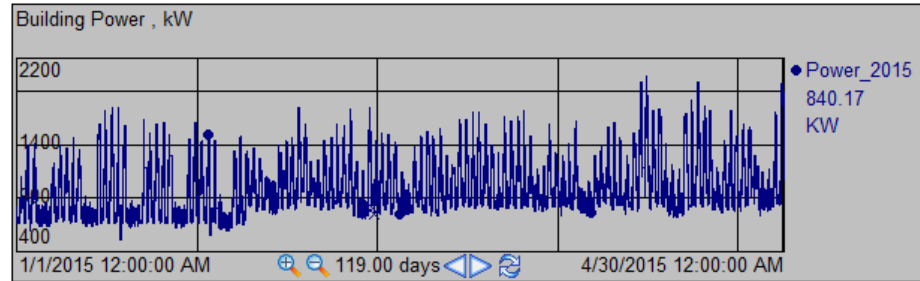
Scenario: "Predict Building Energy Use"

Develop a model to predict energy use at our Headquarters Building.
This model can be used for capacity planning, and abnormal spike detection and notification.

Actual Energy Use (red)
Predicted Energy Use (black)
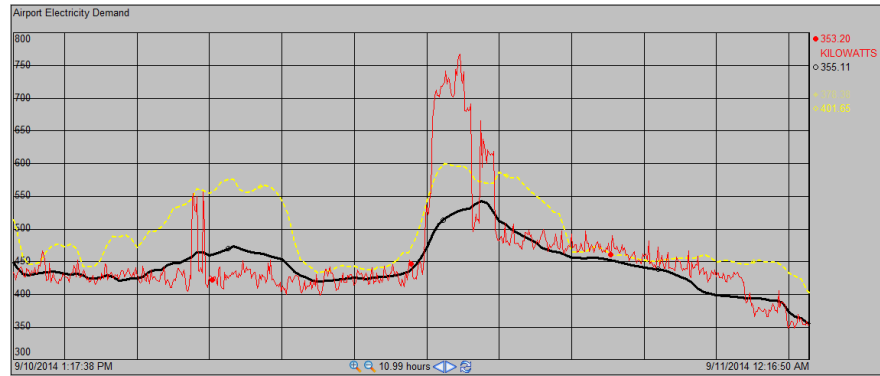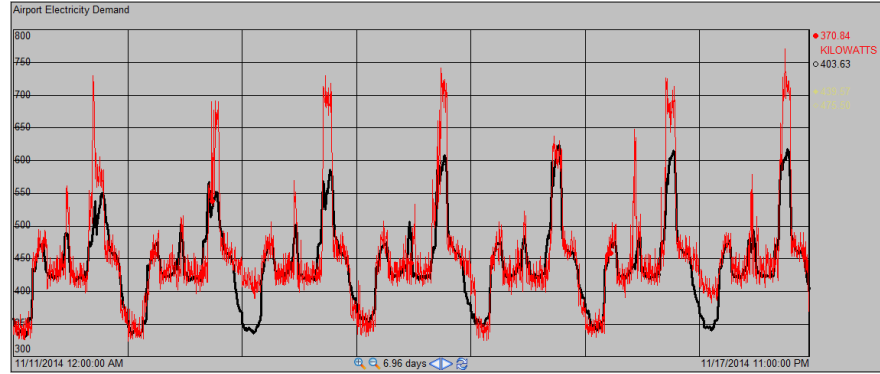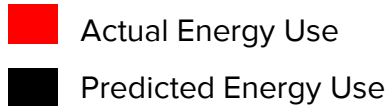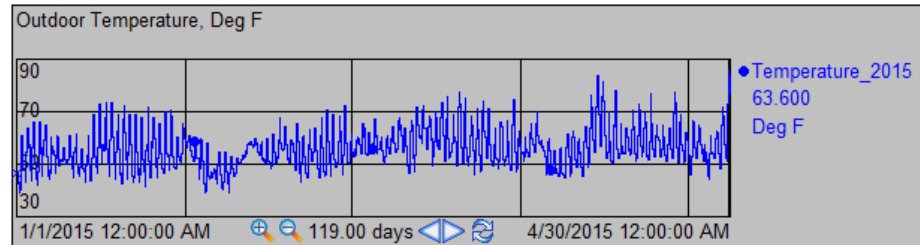
Hypothesis: Variables Affecting Building Energy

Facilities
- Power, kW
- Hour of Day
- Weekday

Weather Station
- Outdoor Temperature

## IT Network
- Network MAC Address Count

Building Power , kW — Power_2015 840.17 KW
2200 / 1400 / 400
1/1/2015 12:00:00 AM — 119.00 days — 4/30/2015 12:00:00 AM

Outdoor Temperature, Deg F — Temperature_2015 63.600 Deg F
90 / 70 / 30
1/1/2015 12:00:00 AM — 119.00 days — 4/30/2015 12:00:00 AM

MAC Count, No of Users — MAC Count_2015 897.00 Users
1200 / 1050 / 250
1/1/2015 12:00:00 AM — 119.00 days — 4/30/2015 12:00:00 AM
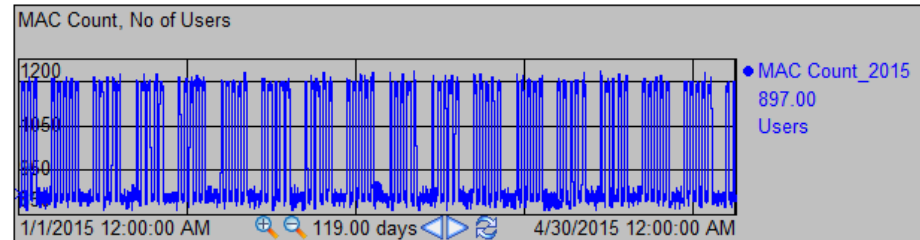
Predictive Modelling Process

Cloud Services

DayOfWeek	Hour	Avg Building Power	Avg MAC Address Count	Avg Outdoor Temperature
Thursday	0	1131.59375	897	76.699997
Thursday	1	1131.59375	897	76.699997
Thursday	2	1131.59375	897	76.699997
Thursday	3	1131.59375	897	76.699997
Thursday	4	1131.59375	897	76.699997
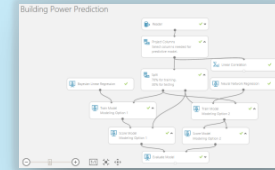
Azure SQL Database
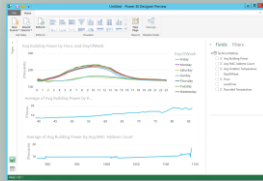
Azure ML Studio

On Premise Applications

Power BI Designer

PI Integrator for Azure
(internal Alpha)
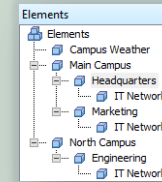
PI System 2015
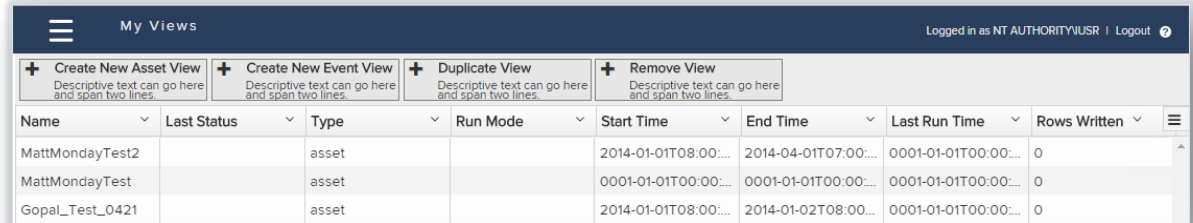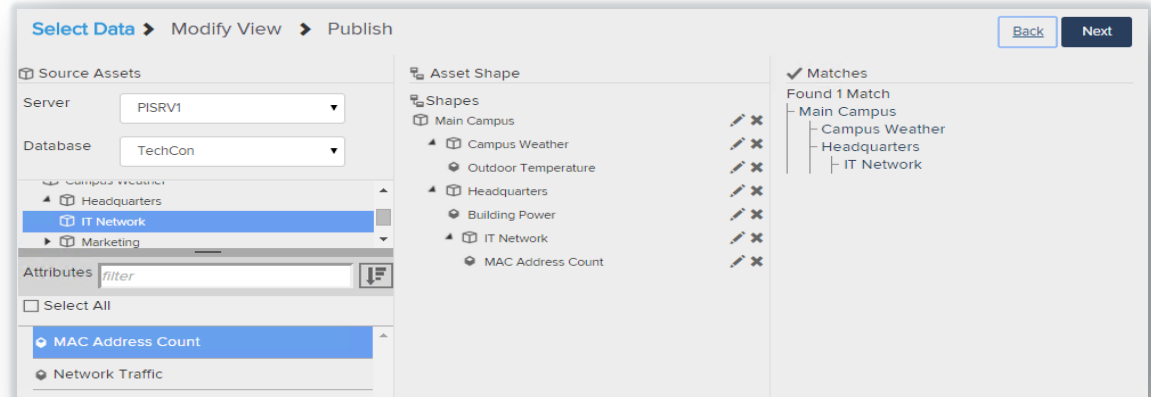
Facilities

Weather Station

IT Network

PI Integrator for Azure SQL (internal Alpha)

- Currently in OSIsoft development

- Create "PI Views"

- Filtered selection of AF Elements by name, hierarchy, or category

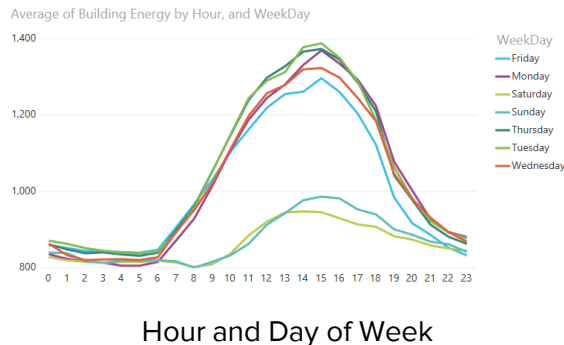# PI Integrator for Azure SQL (internal Alpha)

- Select time range and interval

- Add columns for aggregating PI System data

- Add columns for common time and date functions

- Share "PI Views"

- Publish table to Azure SQL

Power BI Designer Preview

- Provides Power BI Add-in Functionality Independent of Excel

- Free download from Microsoft

Hour and Day of Week

Outdoor Temperature
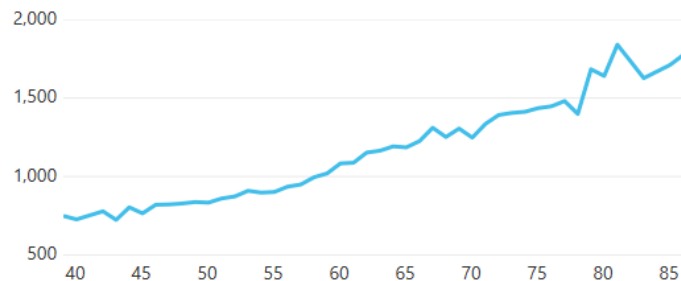
MAC Address Count
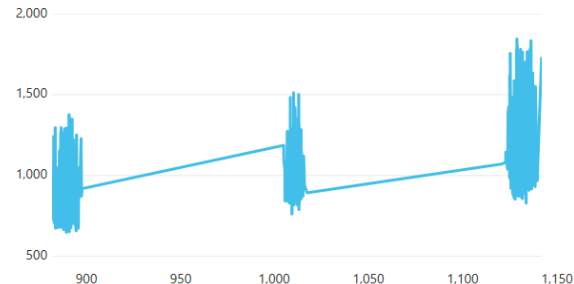
Microsoft Azure ML Studio

- Self-service data science

- Experimentation to find "best fit" prediction models

- Publish finalized models as accessible web service

- Pay as you go

Advanced Energy Prediction Model
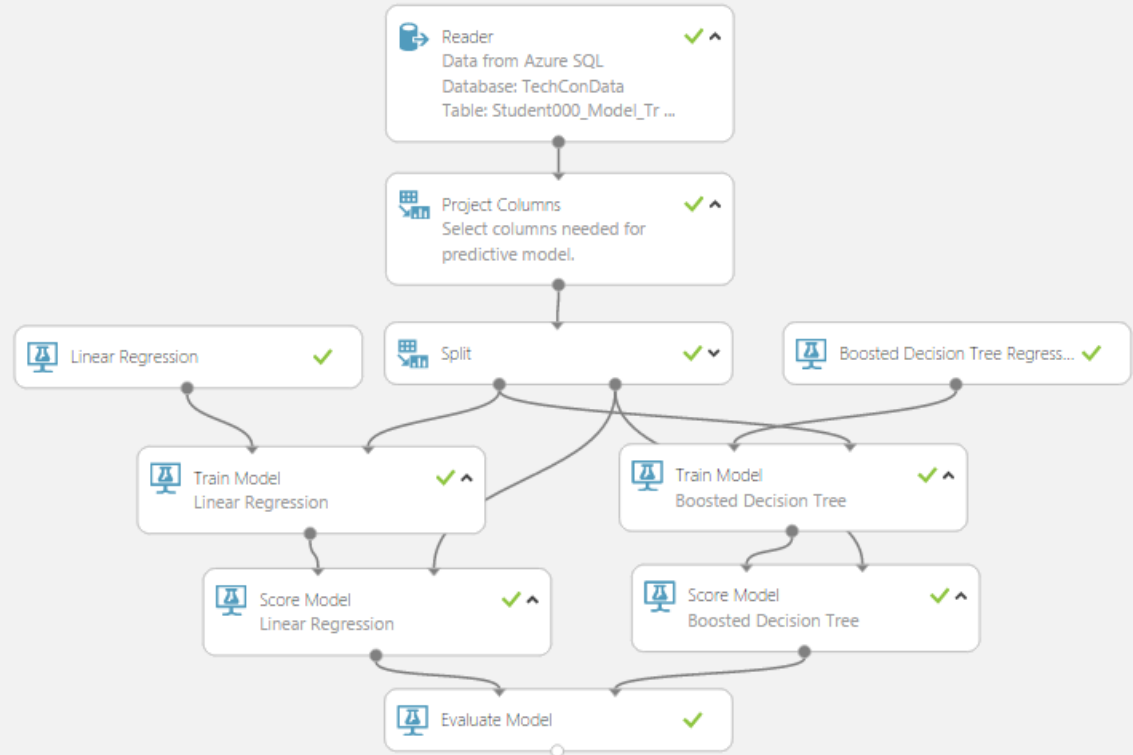
"Basic" Energy Prediction Model Experiment

- Read data from Azure SQL table

- Select model input variables

- Split data for training and testing

- Train model using a selected algorithm

- Score (Test) model

- Evaluate model

Basic Energy Prediction Model
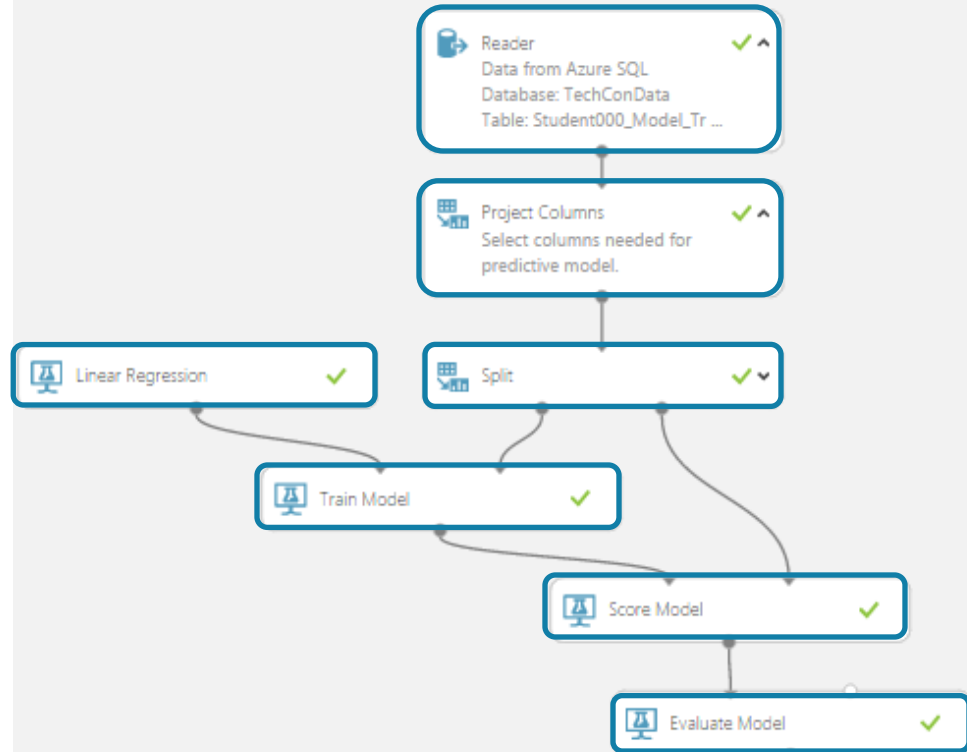
"Basic" Energy Prediction Model Evaluation Results

- Visual and Statistical Analysis of Model Scoring

- "Coefficient of Determination" a.k.a. R-Squared = 0.63

Mean Absolute Error	Root Mean Squared Error	Relative Absolute Error	Relative Squared Error	Coefficient of Determination
102.021831	126.771506	0.610971	0.37002	0.62998

Energy Prediction Model › Score Model › Scored dataset

columns
5

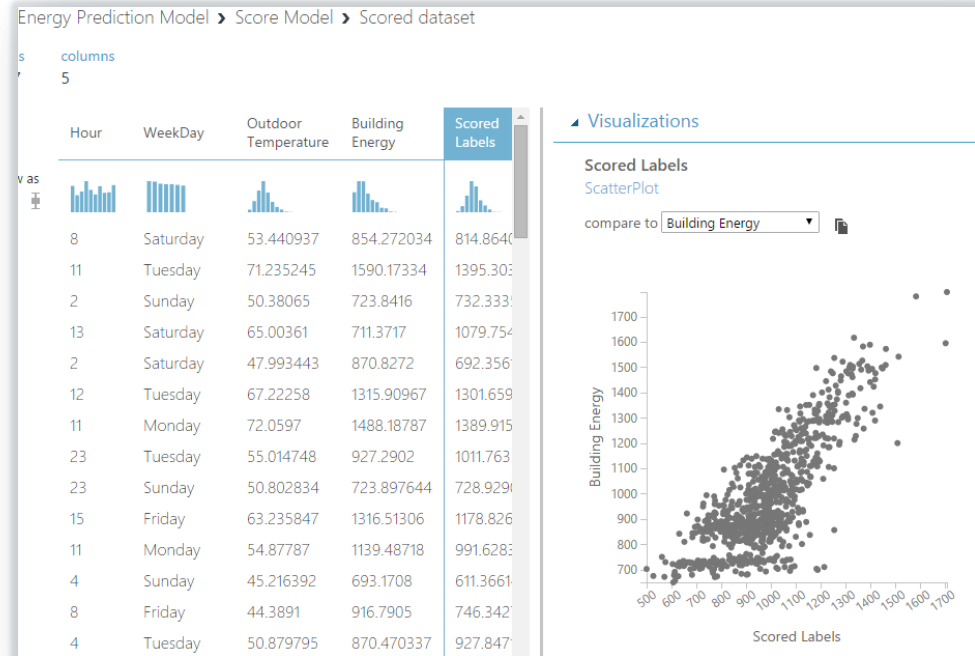| Hour	WeekDay	Outdoor Temperature	Building Energy	Scored Labels
8	Saturday	53.440937	854.272034	814.8640
11	Tuesday	71.235245	1590.17334	1395.303
2	Sunday	50.38065	723.8416	732.333!
13	Saturday	65.00361	711.3717	1079.754
2	Saturday	47.993443	870.8272	692.356!
12	Tuesday	67.22258	1315.90967	1301.659
11	Monday	72.0597	1488.18787	1389.915
23	Tuesday	55.014748	927.2902	1011.763
23	Sunday	50.802834	723.897644	728.9290
15	Friday	63.235847	1316.51306	1178.826
11	Monday	54.87787	1139.48718	991.6283
4	Sunday	45.216392	693.1708	611.3661
8	Friday	44.3891	916.7905	746.342
4	Tuesday	50.879795	870.470337	927.847

▲ Visualizations

Scored Labels
ScatterPlot

compare to Building Energy ▼

OSIsoft. **USERS CONFERENCE 2015**

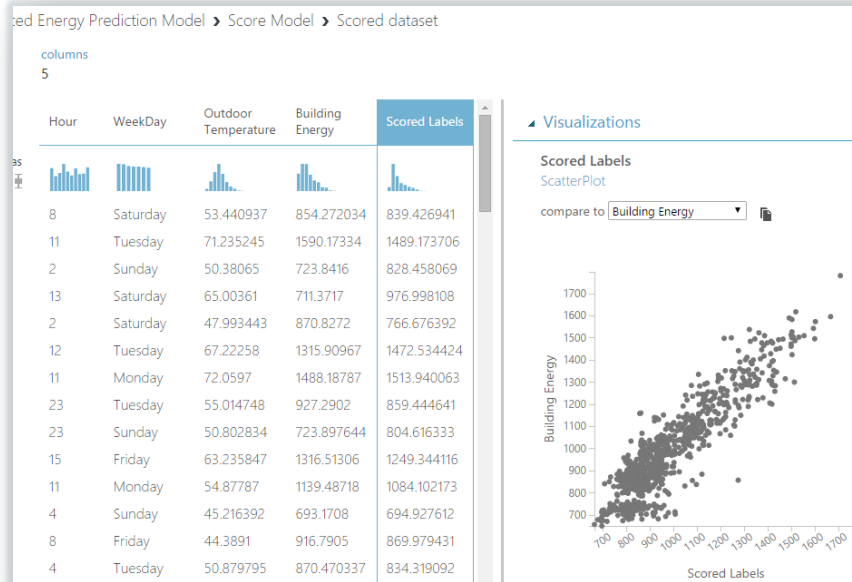# "Advanced" Energy Prediction Model Experiment

- Copy "Basic" Model

- Add "Boosted Decision Tree Regression" algorithm

- Train both algorithms with Training Dataset

- Score both models with Scoring Dataset

- Evaluate algorithms
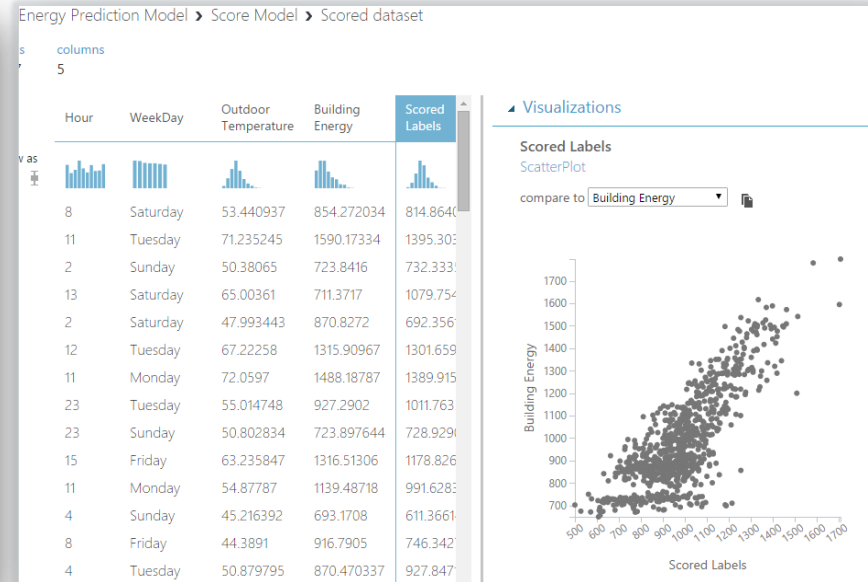

Advanced Energy Prediction Model

"Advanced" Energy Prediction Model Evaluation Results

"Boosted Decision Tree Regression"
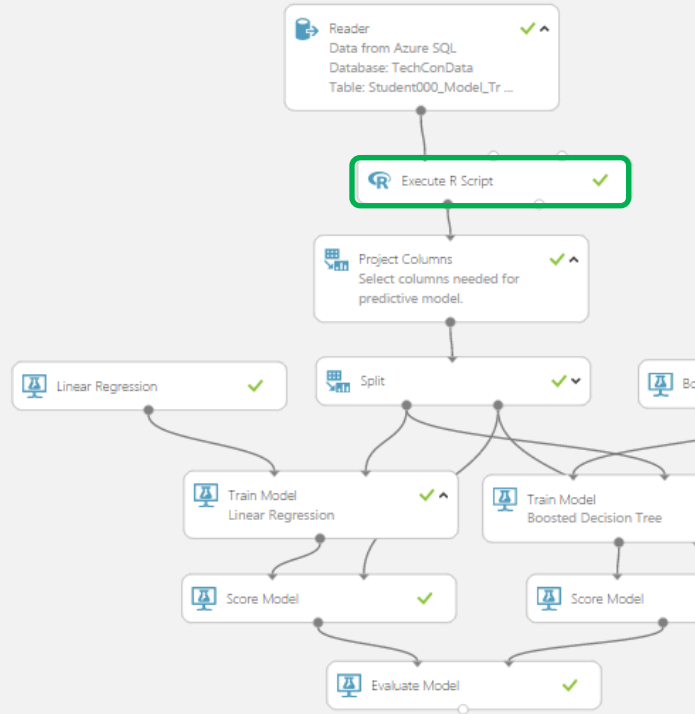R-Squared = 0.83

"Linear Regression"
R-Squared = 0.63

"Best" Energy Prediction Model

- Consider Seasonal Effect on Building Energy Demand

- Added feature, "Week Number" of the Year

- Insert "R" Script to "Week of Year" column

- R-Squared 0.96

Energy Predictions in PI System 2015
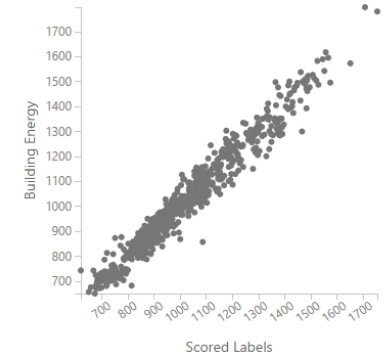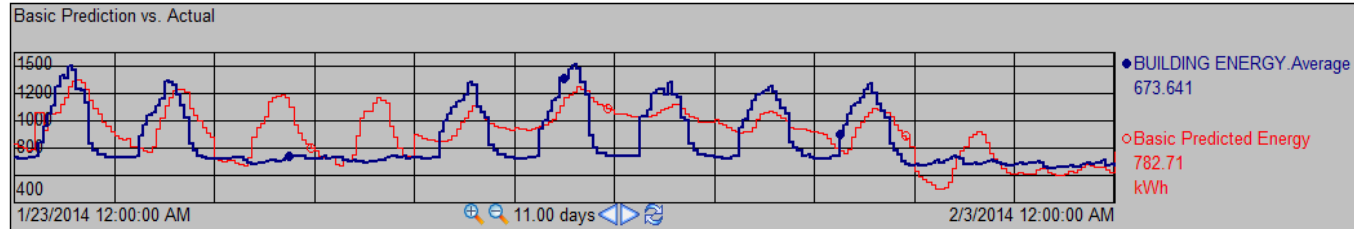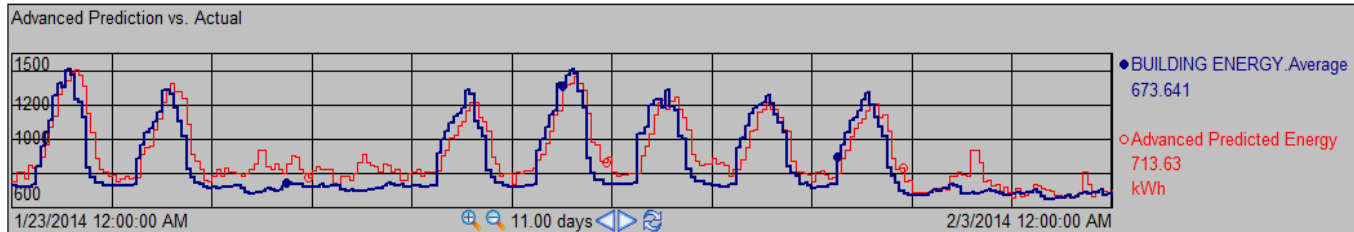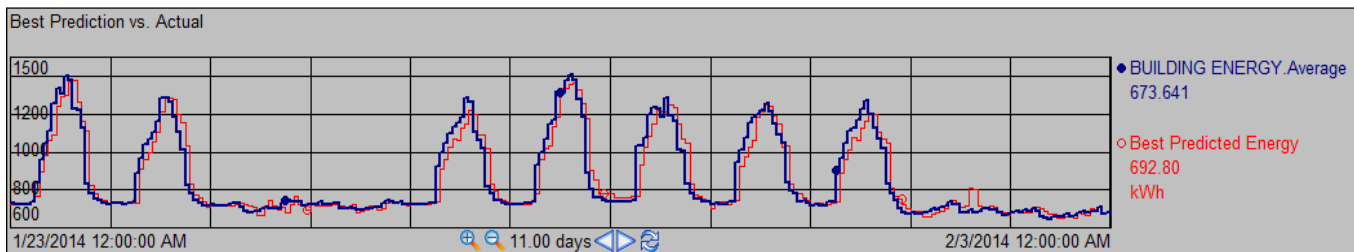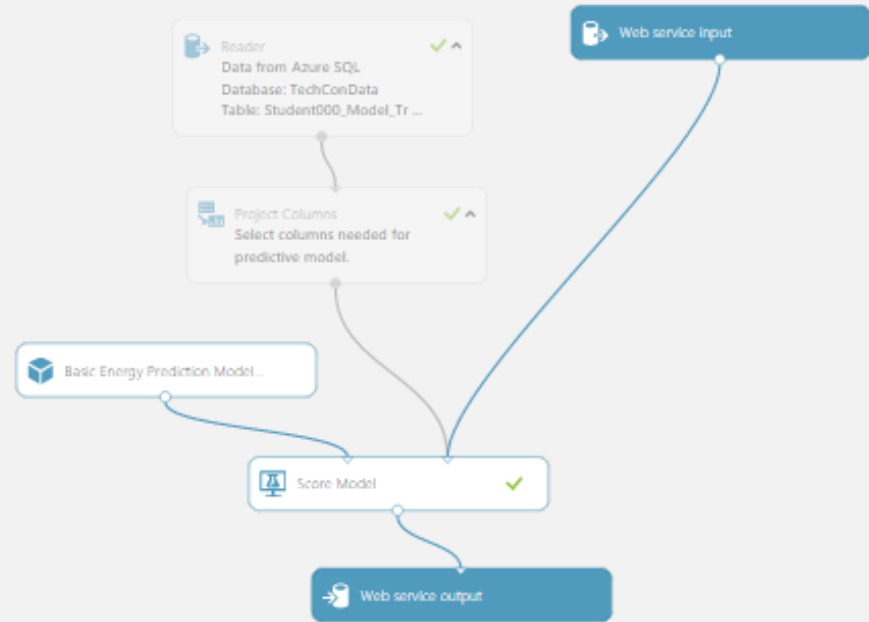

R Squared
0.63

R Squared
0.83

R Squared
0.96

"Basic Energy Prediction Model" Web Service

- Create Scoring Experiment
  - Trained Model
  - Configure Web service input and output parameters

- Publish Web Service
  - Sample access code
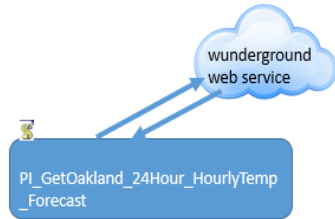 - Testing dialog
  - Excel spreadsheet

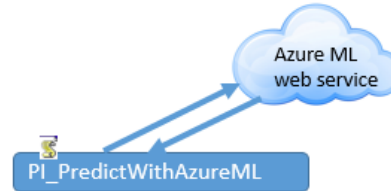Basic Energy Prediction Model [Scoring Exp.]

Operationalization with PI System 2015

- Programmatic
  - Develop application to call the Azure ML web service
  - Example script generated by Azure ML Studio

- PowerShell Scripting
  - Temperature forecast from Weather Underground
  - PI Interface for Universal File and Stream Loading (PI UFL)

- Azure Data Factory
  - Azure orchestration engine
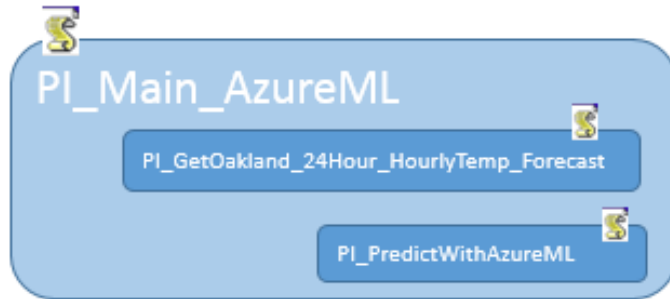 - PI Interface for Relational Database (RDBMS)

PowerShell Scripting

wunderground web service

PI_GetOakland_24Hour_HourlyTemp_Forecast

OutsideTemperature Forecast RestAPI call for a given location

http://api.wunderground.com/api/8b3ebc8ba1df734a/hourly/q/CA/Oakland.json

Azure ML web service

PI_PredictWithAzureML

BldgEnergy_kWh = f(
    OutsideTemperature,
    HourOfDay,
    DayOfWeek,
    WeekNumber
)

PI_Main_AzureML

PI_GetOakland_24Hour_HourlyTemp_Forecast

PI_PredictWithAzureML

PredictedValues.CSV

PI – UFL

PI System 2015

Azure Data Factory

Cloud Services

Azure Data Factory

Azure SQL Database

Azure ML Web Service

On Premise Applications

PI Interface for Relational Database

PI Integrator for Azure
(internal Alpha)

PI System 2015

Curt Hertler

curt@osisoft.com

Partner Solutions Architect

OSIsoft, LLC

Questions

Please wait for the **microphone** before asking your questions

State your **name & company**