



# An End2End (E2E) Operationalized Pipeline for Predictive Analysis for the Intelligent Grid

Presented by

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China Southern Power Grid EPRI

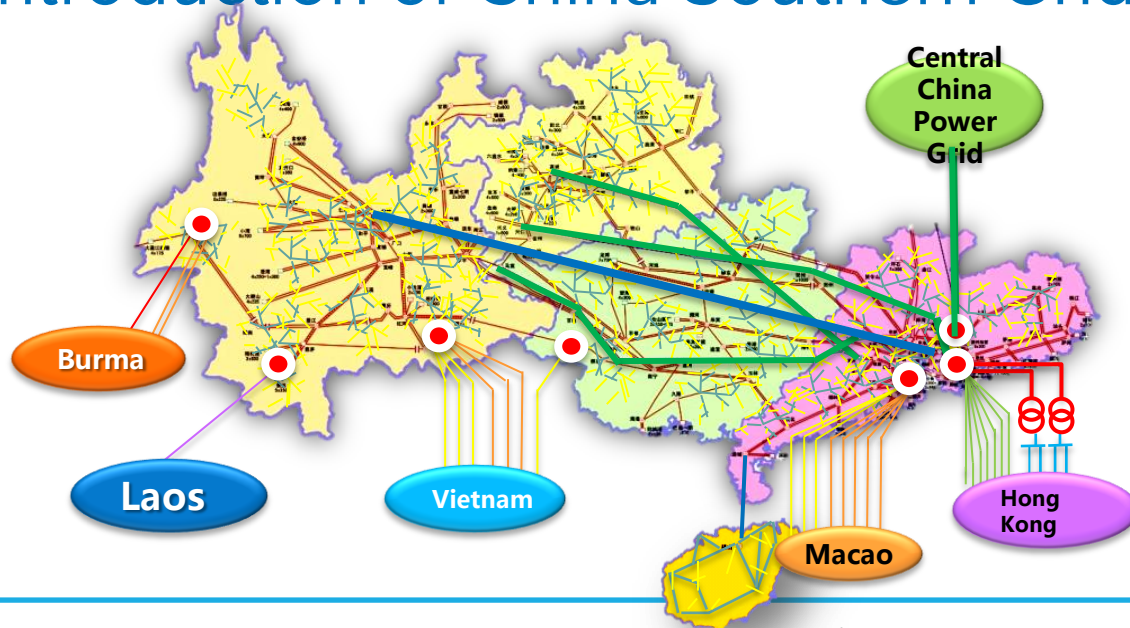


Vijay K Narayanan  
Microsoft

# Agenda

- China Southern Power Grid (CSG) Introduction
- Electric Power Research Institute, CSG Introduction
- USTDA (United States Trade & Development Agency) Funded Smart Grid Project Introduction
- Project Plan and Milestones
- Implementation and Results
- Microsoft Azure Machine Learning Predictive Analysis
- Future Plans

# Introduction of China Southern Grid



- China Southern Power Grid Co. Ltd (CSG) was established on 29<sup>th</sup> December, 2002.
- CSG covers Guangdong, Guangxi, Yunnan, Guizhou and Hainan provinces. Also it is closely connected with Hong Kong, Macao and other areas related. It supports electricity to 230 million people within 1.02 million square kilometers.
- In 2012, the CSG has generated electricity for 190,000 MW, among which the clean energy constituted 43%. The max load was 120,000 MW. The total electricity consumption was 839.6 million MWH.
- CSG has been one of the global top 500 enterprises in nine consecutive years; ranked the 134<sup>th</sup> in 2013.

# Introduction of China Southern Grid (cont'd)

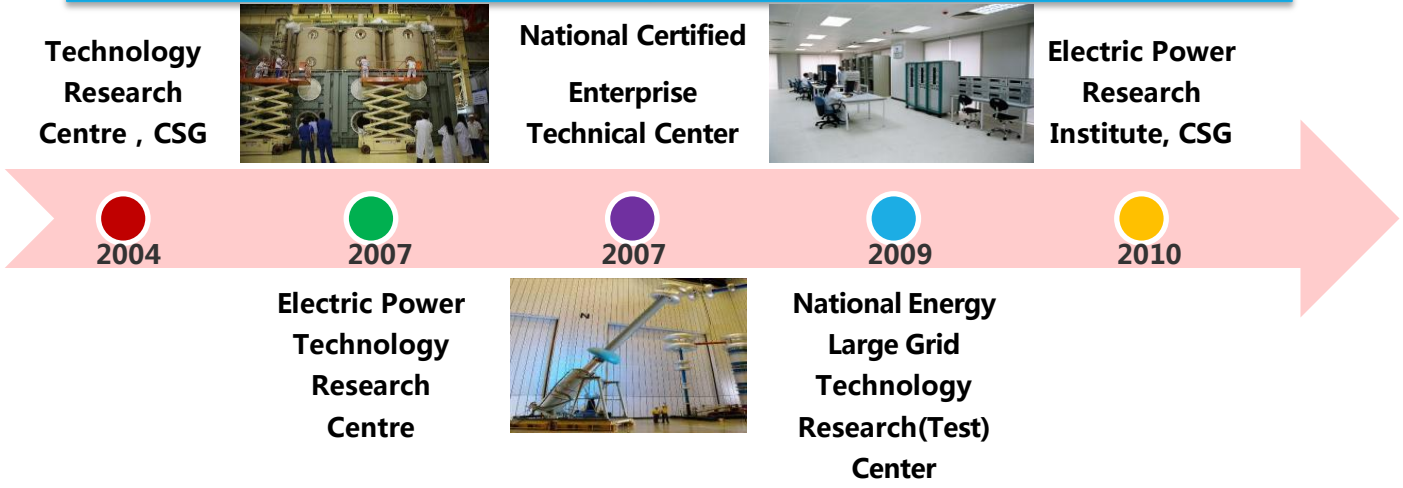
## **CSG: The AC/DC interconnected Power Grid with long distance, large-capacity electricity transmission.**

- ◆ CSG has 13 channels transmitting electricity from the West to the East with 8 AC and 5 DC channels.
- ◆ Every transmission channel is around 1,000 km, and the West-to-East span is nearly 2,000 km.
- ◆ The 500 kV AC and DC parallelly hybrid Grid, with 99 substations, 354 transmission lines, has very complicated operating features.
- ◆ In 2012, the max electricity transmitted from the West to Guangdong Province was around 24,430 MW.



# Introduction of EPRI, CSG

## History of EPRI



- The Southern Electric Power Research Institute (SEPRI), is a subsidiary of China Southern Power Grid, established on the basis of CSG Technology Research Centre on 6<sup>th</sup> August, 2010.
- The main business of SEPRI include: science research, technology support & consulting, and project integration.
- SEPRI provides technology support for the science research, grid planning, system operation and market services, etc.

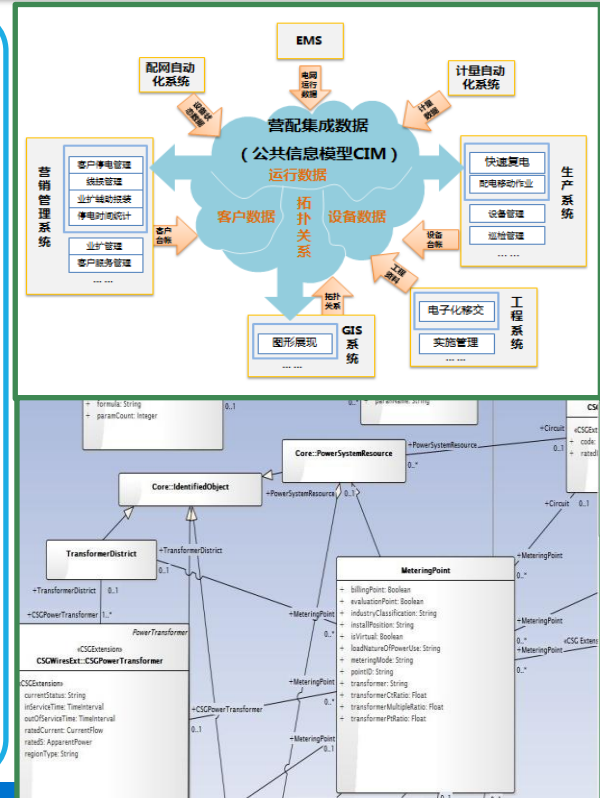
# Project Introduction

## Integration Platform of distribution and utilization information

◆ Developing the integration platform of distribution and utilization information in Guangzhou, Shenzhen and other cities since 2009.

◆ The platform integrating the information from EMS, GIS, DMS, AMS, MS (Market System), etc. to eliminate the information islands and share the information resources.

◆ The platform establishing the Enterprise Common Information Model (ECIM) based on IEC61968 and IEC61970.



# Project Introduction (cont'd)

## Integration Platform of distribution and utilization information

- ◆ Based on the integration platform of distribution and utilization information, developing advanced business applications, such as customer service monitoring, power outage analysis, line loss analysis, power quality analysis, etc.

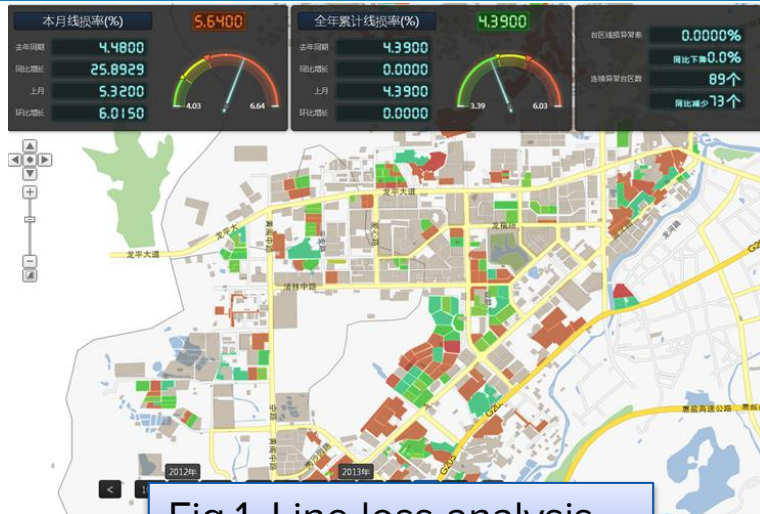


Fig.1 Line loss analysis

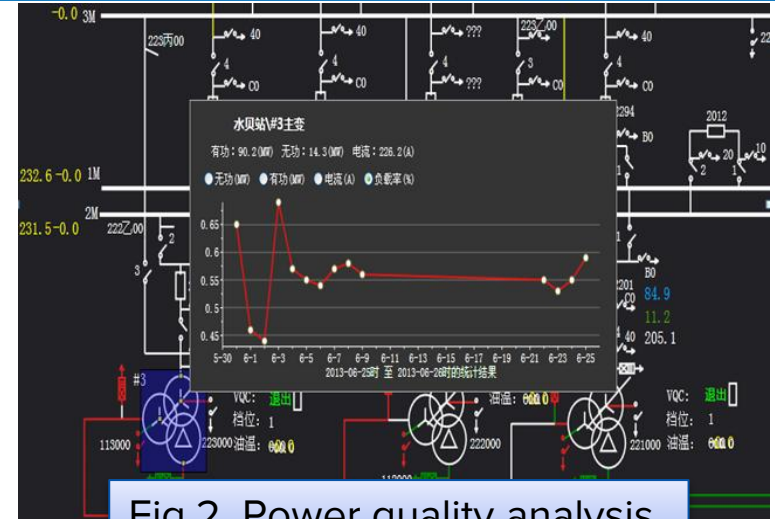
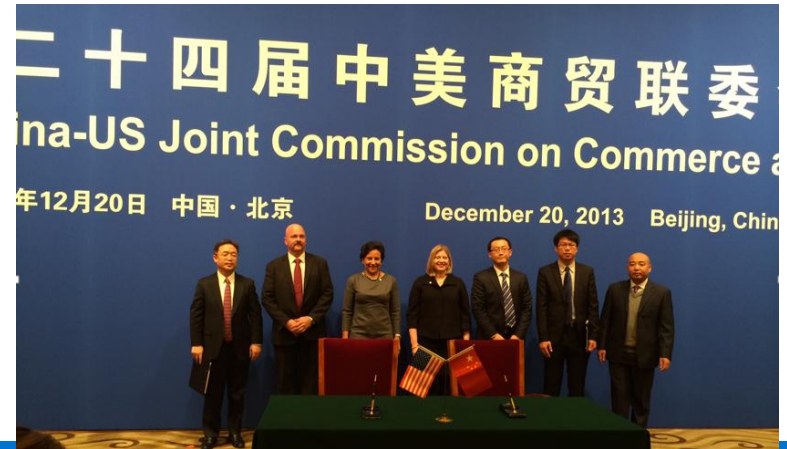


Fig.2 Power quality analysis

# USTDA Funded Smart Grid Project

- Applied for US Trade & Development Agency Grant - September, 2012
- OSIssoft awarded - April, 2013
- Contract signed - December, 2013
- Project kick-off meeting - February, 2014





# Project Plan and Milestones

- Identified data sources and system installation (Apr, 2014)
- SISCO conducted CIM training and CSG CIM profile creation workshop (June, 2014)
- Collected and backfilled data from one city (Aug, 2014)
- Used SISCO PI CIM Adapter to create CIM in Asset Framework (Sept, 2014)
- Defined use cases (Oct, 2014)
- Worked with Microsoft on Azure Machine Learning for forecasting (Dec, 2014)
- Completed use cases (March, 2015)



## Objective - Energy Efficiency Analysis and Forecast

- Provide big data analysis about industrial customer energy usage and energy profile
- Provide energy efficiency benchmark and forecast
- Integrate with GIS based visualization
- Provide guidance for energy efficiency improvement

# Ultimate Goal - Advanced Analysis and Forecast

- Load analysis and forecast (including weather condition, temperature, etc.)
- Total energy consumption analysis and classification
- Period energy and cost analysis (peak, off peak and normal period)
- Define energy efficiency KPI
- Equipment operation condition analysis
- Industry production time suggestion
- Market and sales suggestion (different tariff /price analysis)

# Distribution City-Level End-to-End

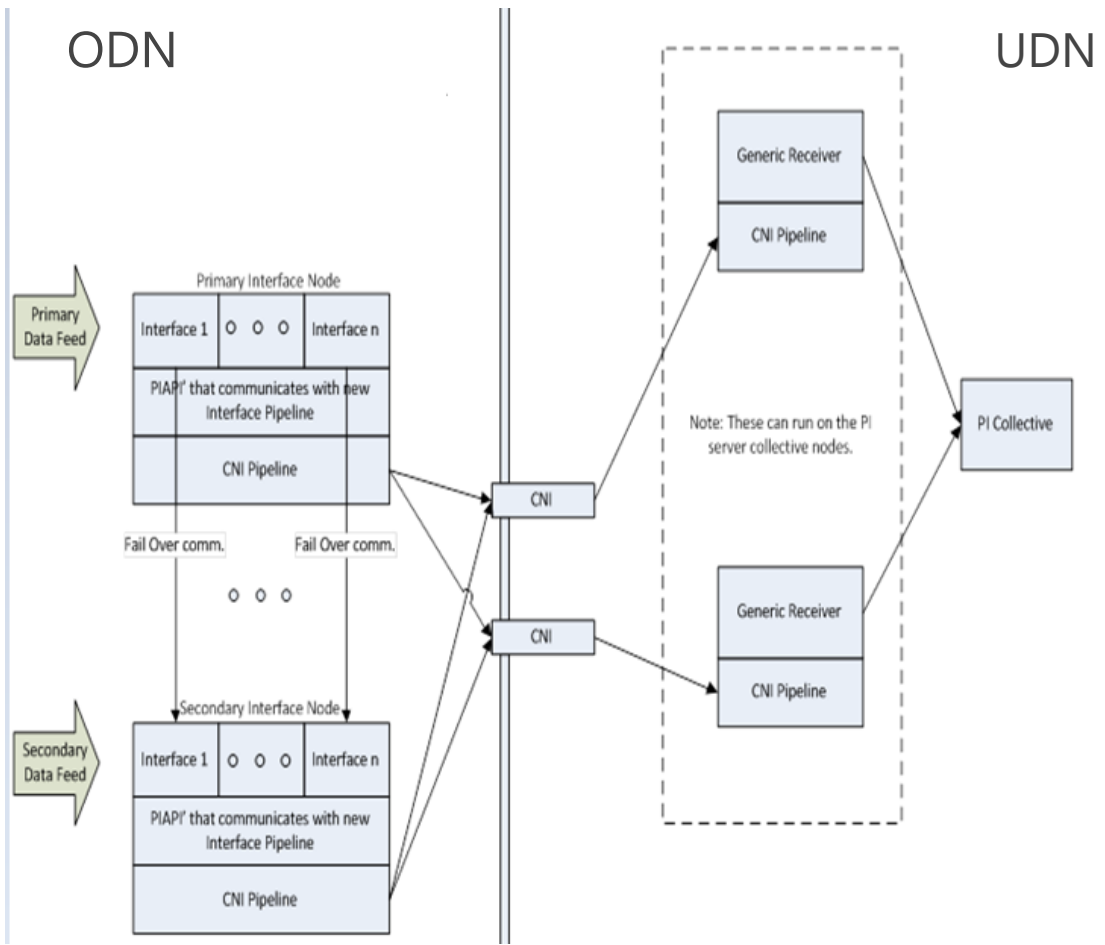
- From a typical 220kV substation, all the way down (110kV-10kV) to its commercial and industrial customer meters
- 80% industrial and commercial, 20% residential
- Two years of data
- The entire city has about 71,360 distribution transformers

# Use Cases

- Distribution loss calculation and analysis
- Distribution loading analysis
- Distribution reliability indexes calculation and analysis (SAIDI, SAIFI, CAIDI, CAIFI, etc.)
- Customer energy efficiency analysis and prediction
- Customer energy consumption behavior analysis and load forecasting

# Security

- PI CNI (China Network Isolator)
- Level I (Operation Data Network)
- Level II (Utility Data Network)
- PI HA (High Availability)
- WIS (Windows Integrated Security) or AD
- DMZ to Cloud



# Meter CIM model in Asset Framework (AF)

The screenshot displays the Asset Framework (AF) interface. On the left, a 'Library' pane shows a tree view of models, with 'CSGDatabase:AMSMeter' selected. The main area shows the configuration for this model, including fields for Name, Description, Base Template, Categories, Default Attribute, and Naming Pattern. The 'General' tab is active, and the 'Allow Extensions' checkbox is checked. The 'Find' section contains links for 'Derived Templates', 'Elements', 'Referenced Parent Template', 'Derived Elements', and 'Referenced Child Templates'.

File View Go Tools Help

Database Query Date Back Check In Refresh New Template Search

Library

- CSGDatabase:ActivityRecord
- CSGDatabase:AMSCommunicationLink
- CSGDatabase:AMSEndDevice
- CSGDatabase:AMSMeter**
- CSGDatabase:Analog
- CSGDatabase:AnalogValue
- CSGDatabase:ApparentPowerLimit
- CSGDatabase:Asset
- CSGDatabase:AsynchronousMachine
- CSGDatabase:AuxiliaryEquipment
- CSGDatabase:BaseVoltage
- CSGDatabase:BasicIntervalSchedule
- CSGDatabase:Bay
- CSGDatabase:Breaker
- CSGDatabase:BusbarSection
- CSGDatabase:BusNameMarker
- CSGDatabase:ByPassOperation

CSGDatabase:AMSMeter

General Attribute Templates Ports Analysis Templates

Name: CSGDatabase:AMSMeter

Description: Physical asset that performs the metering role of the usage point. Used for mea

Base Template: CSGDatabase:AMSEndDevice Type: Eleme

Categories: CSGDatabase;CSGDatabase:AMSEndDevice;CSGDatabase:Meter

Default Attribute: <None>

Naming Pattern:

Allow Extensions [Extended Properties](#)

Find: [Derived Templates](#) [Elements](#) [Referenced Parent Template](#)  
[Derived Elements](#) [Referenced Child Templates](#)

Elements

Event Frames

# Asset Analytics

## Outage Count

## Daily Outage Totals

## Monthly Outage Totals

The screenshot shows the configuration for the 'Outage Count' analysis. The 'Name' field is 'Outage Count'. The 'Description' field is empty. The 'Categories' dropdown is empty. The 'Analysis Type' is set to 'Expression'. The 'Expression' table is as follows:

Name	Expression	Value	Output Attribute
Count	<code>if DaySec('*') - DaySec(Prevent('AMSMeter.APhaseV','*')) &gt; 900 then ('Outage Count'+1) else NoOutput()</code>		Outage Count

The screenshot shows the configuration for the 'Daily Totals' analysis. The 'Name' field is 'Daily Totals'. The 'Description' field is empty. The 'Categories' dropdown is empty. The 'Analysis Type' is set to 'Expression'. The 'Expression' table is as follows:

Name	Expression	Value	Output Attribute
DailyOutages	<code>EventCount('Outage Count','t','*')</code>		Outage Count Daily Outages
LastDayMonth	<code>if Day('*+1d') &lt; Day('*') then 1 else NoOutput()</code>		MonthlyTrigger

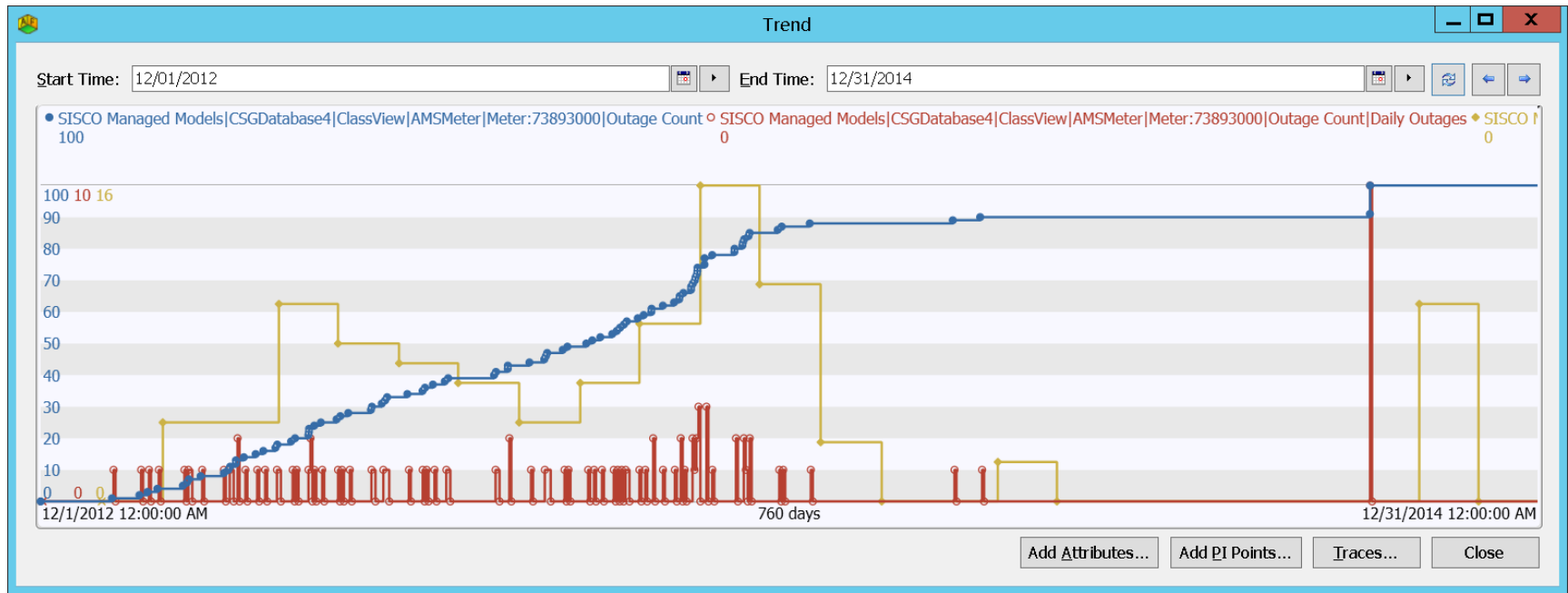
The screenshot shows the configuration for the 'Monthly Totals' analysis. The 'Name' field is 'Monthly Totals'. The 'Description' field is empty. The 'Categories' dropdown is empty. The 'Analysis Type' is set to 'Expression'. The 'Expression' table is as follows:

Name	Expression	Value	Output Attribute
MonthlyOutages	<code>TagVal('Outage Count','*') - TagVal('Outage Count',bom('*')) + 'MonthlyTrigger'*0</code>		Outage Count Monthly Outages

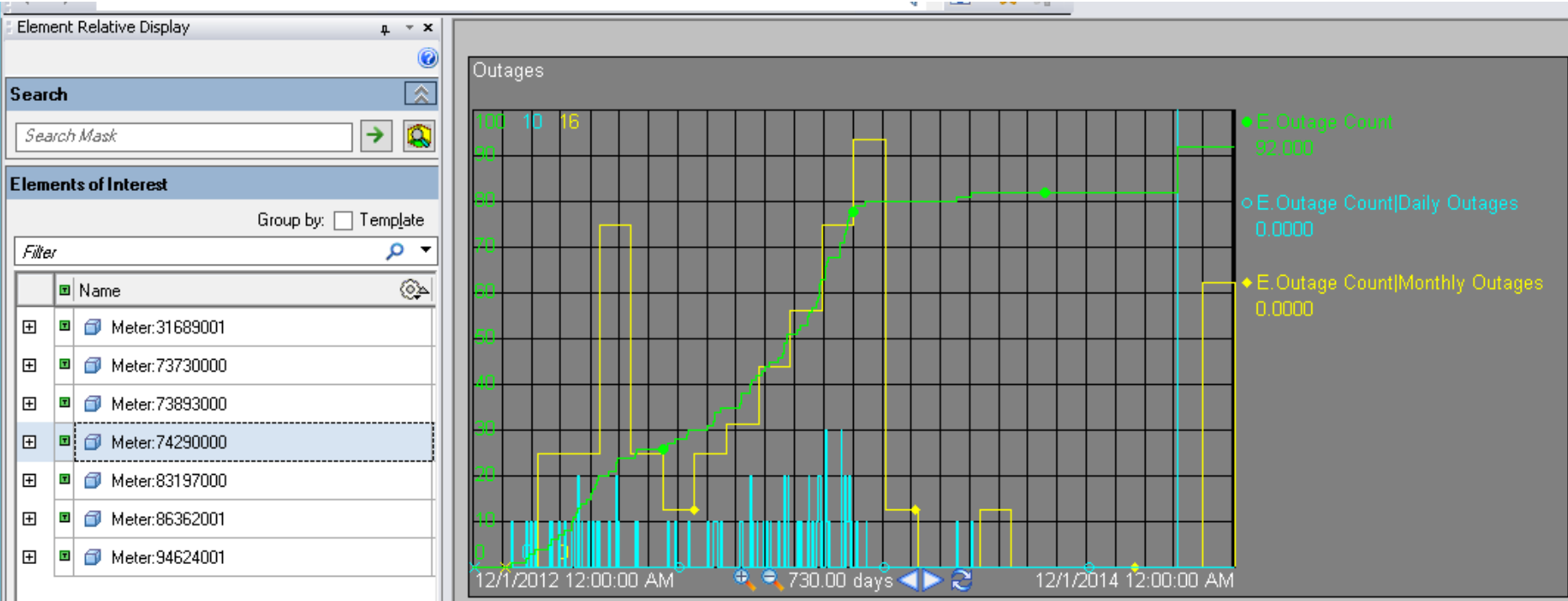


# Trend Outage Counters

## Asset Analytics: Aggregated for Daily and Monthly Outages



# Outage Calculation and Analysis



# Event Frames (EF)

- Trigger Start Condition

Name	Expression	Value
StartTrigger	<code>TagVal('Outage Count','*') - TagVal('Outage Count',PrevEvent('Outage Count','*'))</code>	

- Event Attributes
  - Duration (Start and End Time)
  - Cause
  - Calculations related to Outage

# EF for Meter Outages

Event Frames

Event Frame Searches

- Event Frame Search 1
- Event Frame Search 2
  - Meter:94624001 Downtime Event 2014-11-30 11:30:00.000
  - Meter:31689001 Downtime Event 2014-11-30 11:15:00.000
  - Meter:94624001 Downtime Event 2014-11-29 11:30:00.000
  - Meter:31689001 Downtime Event 2014-11-29 11:15:00.000
  - Meter:94624001 Downtime Event 2014-11-28 11:30:00.000
  - Meter:31689001 Downtime Event 2014-11-28 11:15:00.000
  - Meter:94624001 Downtime Event 2014-11-27 11:30:00.000
  - Meter:31689001 Downtime Event 2014-11-27 11:15:00.000
  - Meter:94624001 Downtime Event 2014-11-26 11:30:00.000
  - Meter:31689001 Downtime Event 2014-11-26 11:15:00.000
  - Meter:94624001 Downtime Event 2014-11-25 11:30:00.000
  - Meter:31689001 Downtime Event 2014-11-25 11:15:00.000
  - Meter:94624001 Downtime Event 2014-11-24 11:30:00.000
  - Meter:31689001 Downtime Event 2014-11-24 11:15:00.000
  - Meter:94624001 Downtime Event 2014-11-23 11:30:00.000
  - Meter:31689001 Downtime Event 2014-11-23 11:15:00.000

Event Frame Search 2

Filter

Name	Duration	Start Time	End Time
Meter:94624001 Downtime Event 2014-11-30 11:30:00.000	12:30:00	11/30/2014 11:30:0...	12/1/2014 12:00:00 AM
Meter:31689001 Downtime Event 2014-11-30 11:15:00.000	12:45:00	11/30/2014 11:15:0...	12/1/2014 12:00:00 AM
Meter:94624001 Downtime Event 2014-11-29 11:30:00.000	12:30:00	11/29/2014 11:30:0...	11/30/2014 12:00:00 AM
Meter:31689001 Downtime Event 2014-11-29 11:15:00.000	12:45:00	11/29/2014 11:15:0...	11/30/2014 12:00:00 AM
Meter:94624001 Downtime Event 2014-11-28 11:30:00.000	12:30:00	11/28/2014 11:30:0...	11/29/2014 12:00:00 AM
Meter:31689001 Downtime Event 2014-11-28 11:15:00.000	12:45:00	11/28/2014 11:15:0...	11/29/2014 12:00:00 AM
Meter:94624001 Downtime Event 2014-11-27 11:30:00.000	12:30:00	11/27/2014 11:30:0...	11/28/2014 12:00:00 AM
Meter:31689001 Downtime Event 2014-11-27 11:15:00.000	12:45:00	11/27/2014 11:15:0...	11/28/2014 12:00:00 AM
Meter:94624001 Downtime Event 2014-11-26 11:30:00.000	12:30:00	11/26/2014 11:30:0...	11/27/2014 12:00:00 AM
Meter:31689001 Downtime Event 2014-11-26 11:15:00.000	12:45:00	11/26/2014 11:15:0...	11/27/2014 12:00:00 AM
Meter:94624001 Downtime Event 2014-11-25 11:30:00.000	12:30:00	11/25/2014 11:30:0...	11/26/2014 12:00:00 AM
Meter:31689001 Downtime Event 2014-11-25 11:15:00.000	12:45:00	11/25/2014 11:15:0...	11/26/2014 12:00:00 AM
Meter:94624001 Downtime Event 2014-11-24 11:30:00.000	12:30:00	11/24/2014 11:30:0...	11/25/2014 12:00:00 AM
Meter:31689001 Downtime Event 2014-11-24 11:15:00.000	12:45:00	11/24/2014 11:15:0...	11/25/2014 12:00:00 AM
Meter:94624001 Downtime Event 2014-11-23 11:30:00.000	12:30:00	11/23/2014 11:30:0...	11/24/2014 12:00:00 AM



# EF Showing Outage Duration

Drill down: meter *73730000* which is part of Feeder *14265073*

The screenshot displays a software interface with two main panes. The left pane, titled 'Event Frames', shows a tree view under 'Event Frame Searches' with a sub-entry 'Event Frame Search 1'. Below this, a list of 20 items is shown, each representing a 'Meter:73730000 Downtime Event' with a date and time. The right pane, titled 'Event Frame Search 1', contains a table with a 'Filter' section and a data table. The data table has four columns: 'Name', 'Duration', 'Start Time', and 'End Time'. The table lists 20 rows of event data, with the row for '2014-05-15 03:15:00.000' highlighted in blue.

Name	Duration	Start Time	End Time
Meter:73730000 Downtime Event 2013-05-20 21:15:00.000	1:15:00	5/20/2013 9:15:00 PM	5/20/2013 10:30:00 PM
Meter:73730000 Downtime Event 2013-05-20 10:45:00.000	1:15:00	5/20/2013 10:45:00 ...	5/20/2013 12:00:00 PM
Meter:73730000 Downtime Event 2013-05-20 09:15:00.000	1:15:00	5/20/2013 9:15:00 AM	5/20/2013 10:30:00 AM
Meter:73730000 Downtime Event 2014-05-15 03:15:00.000	1:00:00	5/15/2014 3:15:00 AM	5/15/2014 4:15:00 AM
Meter:73730000 Downtime Event 2014-05-13 22:15:00.000	1:00:00	5/13/2014 10:15:00 ...	5/13/2014 11:15:00 PM
Meter:73730000 Downtime Event 2014-05-15 17:30:00.000	0:45:00	5/15/2014 5:30:00 PM	5/15/2014 6:15:00 PM
Meter:73730000 Downtime Event 2014-05-15 16:30:00.000	0:45:00	5/15/2014 4:30:00 PM	5/15/2014 5:15:00 PM
Meter:73730000 Downtime Event 2014-05-14 22:00:00.000	0:45:00	5/14/2014 10:00:00 ...	5/14/2014 10:45:00 AM
Meter:73730000 Downtime Event 2013-11-03 01:15:00.000	0:45:00	11/3/2013 1:15:00 AM	11/3/2013 1:00:00 AM
Meter:73730000 Downtime Event 2013-05-20 23:15:00.000	0:45:00	5/20/2013 11:15:00 ...	5/21/2013 12:00:00 AM
Meter:73730000 Downtime Event 2013-05-20 13:15:00.000	0:45:00	5/20/2013 1:15:00 PM	5/20/2013 2:00:00 PM
Meter:73730000 Downtime Event 2013-05-20 04:45:00.000	0:45:00	5/20/2013 4:45:00 AM	5/20/2013 5:30:00 AM
Meter:73730000 Downtime Event 2013-05-20 01:15:00.000	0:45:00	5/20/2013 1:15:00 AM	5/20/2013 2:00:00 AM
Meter:73730000 Downtime Event 2014-05-21 04:15:00.000	0:30:00	5/21/2014 4:15:00 AM	5/21/2014 4:45:00 AM
Meter:73730000 Downtime Event 2014-05-20 09:30:00.000	0:30:00	5/20/2014 9:30:00 AM	5/20/2014 10:00:00 AM
Meter:73730000 Downtime Event 2014-05-20 05:00:00.000	0:30:00	5/20/2014 5:00:00 AM	5/20/2014 5:30:00 AM

# Visualize EF in Excel via PI DataLink

The screenshot shows the Microsoft Excel interface with the PI DATALINK ribbon selected. The ribbon contains several groups of buttons: 'Current Value', 'Archive Value', 'Compressed Data', 'Sampled Data', 'Timed Data', 'Calculated Data', 'Time Filtered', 'Explore Compare Events' (highlighted with a red box), 'Search Asset Filter', 'Properties', 'Update', 'Settings', 'About', and 'Help'. Below the ribbon, the formula bar shows a complex formula: `=PIEDat("\DSISERVER\CSGDatabase4", "12/01/2012", "12/31/2014", 0, "*"7373*", "", "", "", "", "", "", "", "", "", "", "active in range", "start time ascending", "`. The main area of the spreadsheet displays a table with columns for Event name, Start time, End time, and Duration. The table contains 18 rows of data, with the 4th row highlighted. To the right of the spreadsheet, the 'Compare Events' task pane is open, showing search criteria for a database (WDSI), search start and end dates (12/0 and 12/3), and a list of events found.

A	B	C	D
. Event name	. Start time	. End time	. Duration
Meter:73730000 Downtime Event 2012-12-26 10:45:00.000	26-Dec-12 10:45:00	26-Dec-12 11:00:00	0 0:15:00
Meter:73730000 Downtime Event 2013-01-01 11:30:00.000	01-Jan-13 11:30:00	01-Jan-13 11:45:00	0 0:15:00
Meter:73730000 Downtime Event 2013-01-16 04:15:00.000	16-Jan-13 04:15:00	16-Jan-13 04:30:00	0 0:15:00
Meter:73730000 Downtime Event 2013-01-20 04:45:00.000	20-Jan-13 04:45:00	20-Jan-13 05:00:00	0 0:15:00
Meter:73730000 Downtime Event 2013-01-29 05:15:00.000	29-Jan-13 05:15:00	29-Jan-13 05:30:00	0 0:15:00
Meter:73730000 Downtime Event 2013-02-11 04:30:00.000	11-Feb-13 04:30:00	11-Feb-13 04:45:00	0 0:15:00
Meter:73730000 Downtime Event 2013-02-13 06:00:00.000	13-Feb-13 06:00:00	13-Feb-13 06:15:00	0 0:15:00
Meter:73730000 Downtime Event 2013-02-14 04:15:00.000	14-Feb-13 04:15:00	14-Feb-13 04:30:00	0 0:15:00
Meter:73730000 Downtime Event 2013-02-19 03:45:00.000	19-Feb-13 03:45:00	19-Feb-13 04:00:00	0 0:15:00
Meter:73730000 Downtime Event 2013-02-20 04:30:00.000	20-Feb-13 04:30:00	20-Feb-13 04:45:00	0 0:15:00
Meter:73730000 Downtime Event 2013-02-25 22:15:00.000	25-Feb-13 22:15:00	25-Feb-13 22:30:00	0 0:15:00
Meter:73730000 Downtime Event 2013-03-05 03:45:00.000	05-Mar-13 03:45:00	05-Mar-13 04:00:00	0 0:15:00
Meter:73730000 Downtime Event 2013-03-05 22:15:00.000	05-Mar-13 22:15:00	05-Mar-13 22:30:00	0 0:15:00
Meter:73730000 Downtime Event 2013-03-07 04:00:00.000	07-Mar-13 04:00:00	07-Mar-13 04:15:00	0 0:15:00
Meter:73730000 Downtime Event 2013-03-07 04:30:00.000	07-Mar-13 04:30:00	07-Mar-13 04:45:00	0 0:15:00
Meter:73730000 Downtime Event 2013-03-10 03:00:00.000	10-Mar-13 03:00:00	10-Mar-13 03:15:00	0 0:15:00
Meter:73730000 Downtime Event 2013-03-10 22:15:00.000	10-Mar-13 22:15:00	10-Mar-13 22:30:00	0 0:15:00

**Compare Events**

Database: WDSI  
Event name: \*7373\*  
Search start: 12/0  
Search end: 12/3  
Event template: \*  
Element name: \*  
Element template: \*  
 Limit to database level  
 More search options  
Preview: Events (193 found)  
Meter: 73730000 Downtime Event 2012-12-26 10:45:00.000  
Meter: 73730000 Downtime Event 2013-01-01 11:30:00.000  
Meter: 73730000 Downtime Event 2013-01-16 04:15:00.000  
Meter: 73730000 Downtime Event 2013-01-20 04:45:00.000

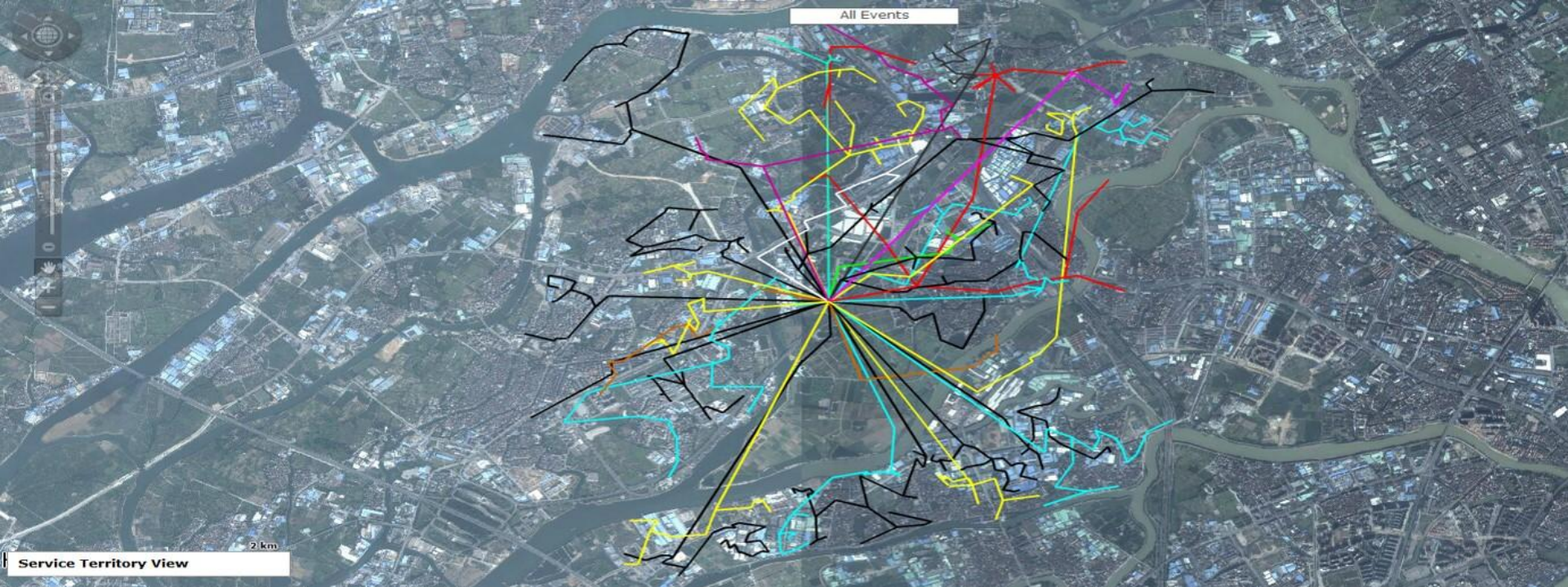
# Reports to filter through hundreds of EFs

	A	B	C	D	E
1					
2	Start Time	12/1/2012	Event Name		
3	End Time	12/31/2013	Min Duration	45m	
4					
5	<b>Event name</b>	<b>Start time</b>	<b>End time</b>	<b>Duration</b>	
6	Meter:83197000 Downtime Event 2013-01-18 09:45:00.000	18-Jan-13 09:45:00	18-Jan-13 11:15:00	0 1:30:00	
7	Meter:83197000 Downtime Event 2013-03-07 10:00:00.000	07-Mar-13 10:00:00	07-Mar-13 18:15:00	0 8:15:00	
8	Meter:83197000 Downtime Event 2013-03-15 09:30:00.000	15-Mar-13 09:30:00	15-Mar-13 16:00:00	0 6:30:00	
9	Meter:31689001 Downtime Event 2013-05-15 09:00:00.000	15-May-13 09:00:00	15-May-13 12:15:00	0 3:15:00	
10	Meter:73730000 Downtime Event 2013-05-20 09:15:00.000	20-May-13 09:15:00	20-May-13 10:30:00	0 1:15:00	
11	Meter:73730000 Downtime Event 2013-05-20 10:45:00.000	20-May-13 10:45:00	20-May-13 12:00:00	0 1:15:00	
12	Meter:73730000 Downtime Event 2013-05-20 21:15:00.000	20-May-13 21:15:00	20-May-13 22:30:00	0 1:15:00	
13	Meter:83197000 Downtime Event 2013-08-20 09:00:00.000	20-Aug-13 09:00:00	20-Aug-13 11:15:00	0 2:15:00	
14	Meter:83197000 Downtime Event 2013-12-01 03:30:00.000	01-Dec-13 03:30:00	01-Dec-13 10:30:00	0 7:00:00	
15					



# Use Case: Generic GIS Capability

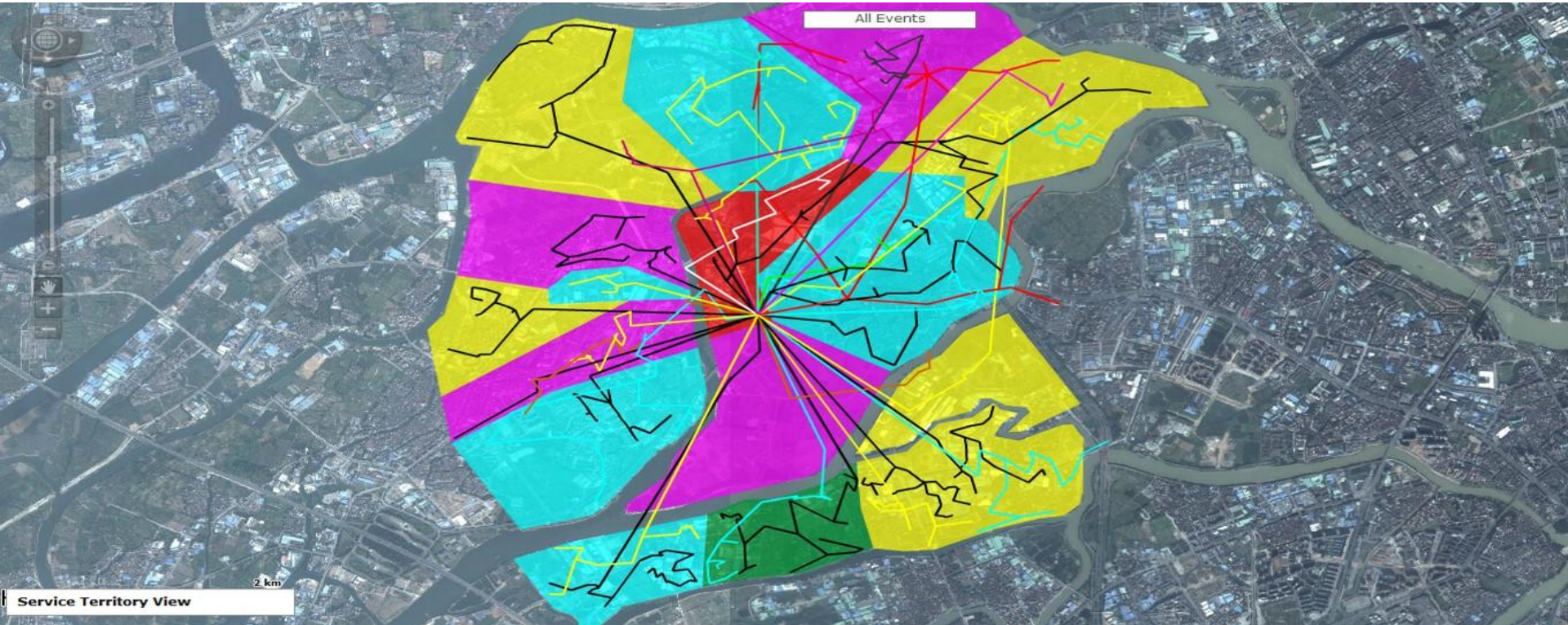
## Using CIM Model to Display Feeder Circuit in GIS





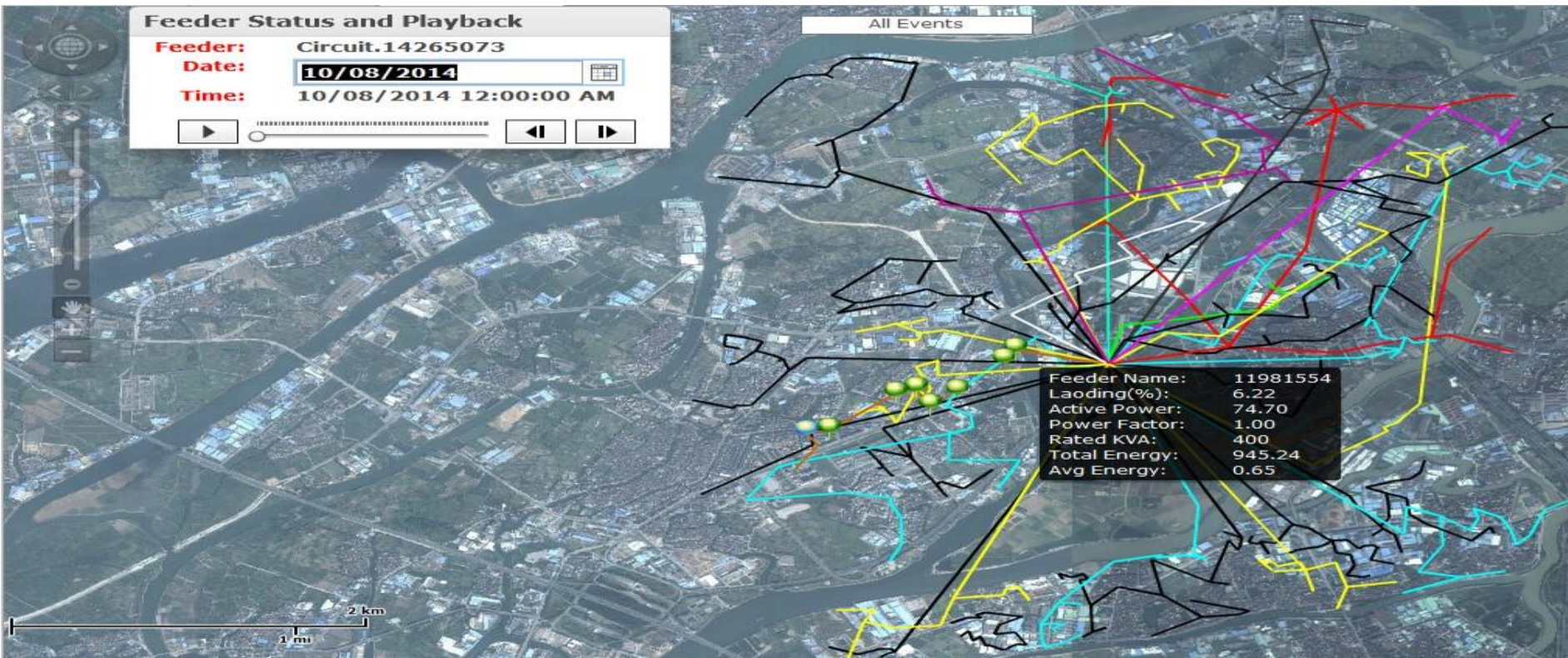
# Use Case: Generic GIS Capability

## CIM Circuit overlay with GIS Region



# Use Case 1: Feeder Loading Analysis

Using GIS to dynamically show the feeder transformer loading and playback



# Use Case 1: Feeder Loading Analysis

## Using Pull Down Menu to Access Other Functions

The screenshot displays a GIS application interface. On the left, a control panel titled "Feeder Status and Playback" shows the following information:

- Feeder:** Circuit.14265073
- Date:** 10/08/2014
- Time:** 10/08/2014 12:00:00 AM

Below the text are playback controls: a play button, a progress bar, a stop button, and a play button. The main map area shows a network of colored lines (black, yellow, red, purple, cyan) representing feeders over an aerial view of a city. A pull-down menu is open over the map, listing the following options:

- Feeder Loading Profile
- Feeder Voltage Profile
- Feeder Energy Summary
- Feeder Liability Indices
- Load Forecast(7 Day)
- Load Forecast(90 Day)
- Historic Trending
- Correlation Analysis
- Show Redraw Regions
- Debugger
- Settings...
- Global Settings...
- About Adobe Flash Player 16.0.0.305...

At the bottom left of the map, there is a scale bar showing 1 mile and 2 kilometers. A "All Events" tab is visible at the top of the map area.

# Use Case 1: Feeder Loading Analysis

## Feeder Loading Profile and Distribution

**Feeder Status and Playback**

**Feeder:** Circuit.14265073  
**Date:** 10/08/2014  
**Time:** 10/08/2014 12:00:00 AM

All Events

**Feeder Load Profile**

**Feeder Total Power:** 2558.90 KW

**Feeder Loading Profile:**

Feeder Name	Total Power[MW]	Percentage[%]	Power-A	Power-B	Power-C	Rated KVA	PF-A	PF-B	PF-C
11990556	0.00	0.00%	0.00	0.00	0.00	480	0.43	0.99	0.39
11974688	767.80	30.01%	350.50	223.50	193.80	1200	0	0	0
11990685	123.20	4.81%	44.50	37.00	41.70	1200	0	0	0
11974488	366.90	14.34%	138.40	136.50	92.00	1200	0	0	0
11981554	74.70	2.92%	13.90	22.20	38.60	1200	0	0	0
11984903	402.50	15.73%	146.60	128.40	127.50	1890	0	0	0
25479138	143.40	5.60%	95.80	0.00	47.60	945	0.936	0	0.731
11987456	667.40	26.08%	220.70	195.20	251.50	1200	0	0	0
30303706	13.00	0.51%	3.00	0.00	10.00	1200	0.26	0	1

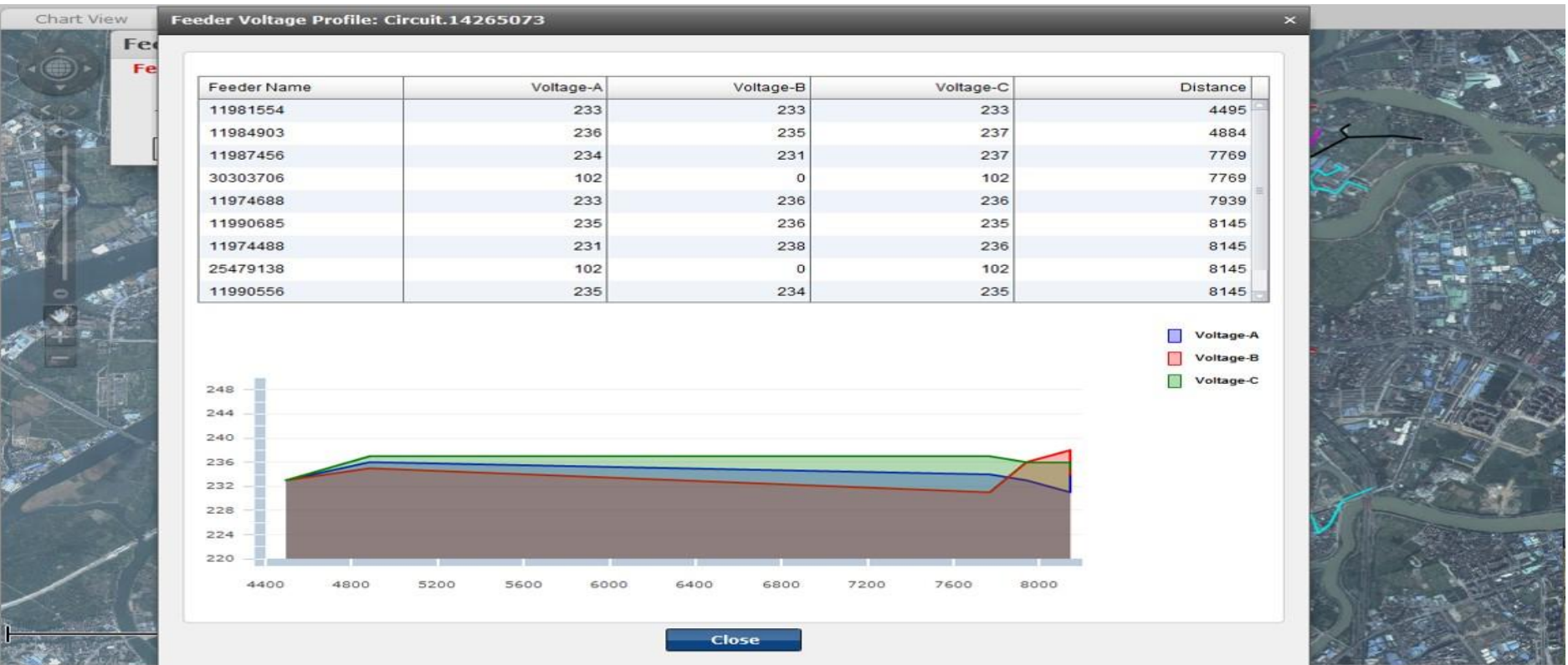
**Associated Meter:** 11990556

Meter Name  
31689001

Close

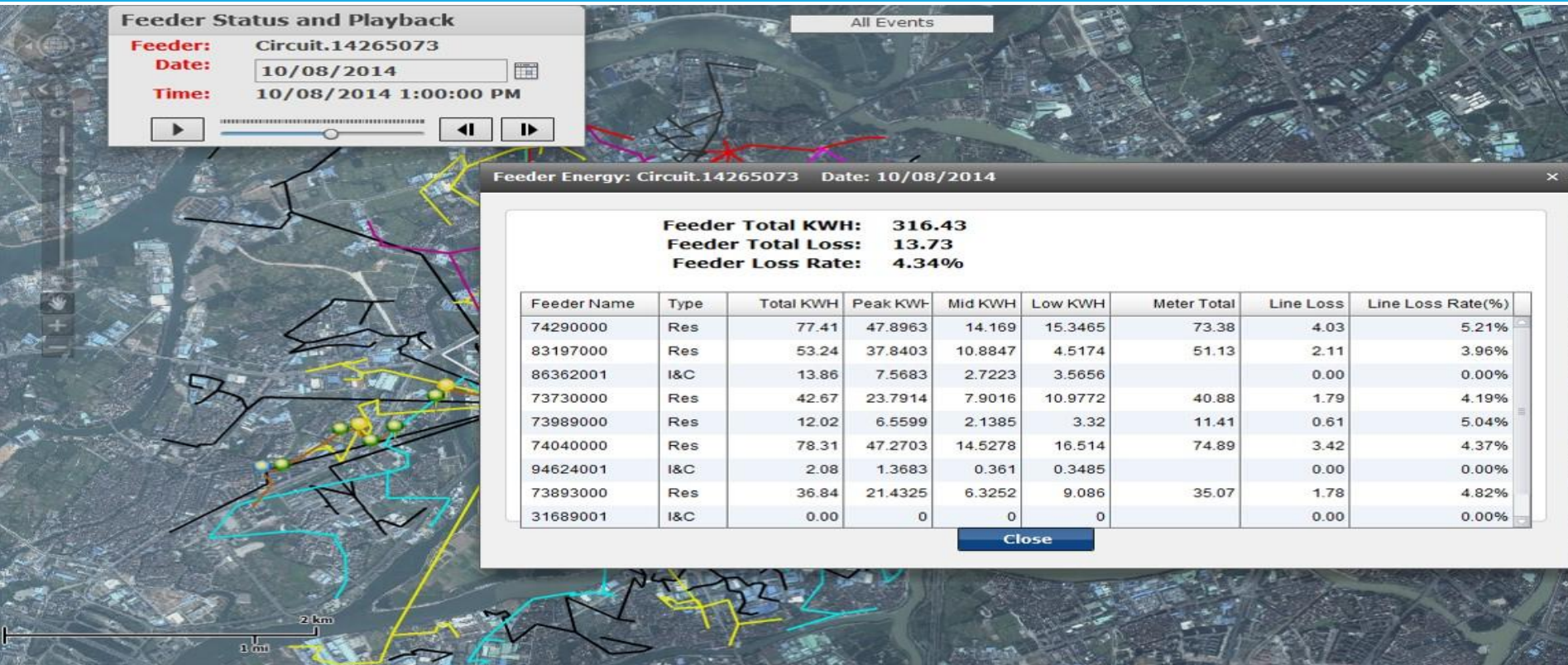
# Use Case 1: Feeder Loading Analysis

## Feeder Voltage Profile and Distribution



# Use Case 2: Line Loss Analysis

## Feeder Total KWH and Line Loss Analysis



# Use Case 3: Reliability Indices

## Feeder Reliability Indices Analysis

Chart View | Operational View | **SA View**

Feeder Name: **Feeder.14265073**  
Date: **10/07/2014**  
Time: **10/07/2014 5:45:00 AM**

**Reliability Indices Summary**

**2013 Reliability Indices Summary**

Feeder Name: **Feeder.14265073**  
Transformer Name: **11981554**  
Total Transformer: **653**

MONTH	Transformer Outage[N]	Feeder Outage[N]	Outage Duration[M]	Affected Customer[N]	SAIDI	CAIDI	SAIFI	CAIFI	CIII
JAN	1038	7017	15570	1	23.844	15.000	1.590	0.360	1
FEB	4	3086	60	1	0.092	15.000	0.006	0.001	1
MAR	81	3131	1215	1	1.861	15.000	0.124	0.028	1
APR	14	2940	210	1	0.322	15.000	0.021	0.005	1
MAY	7	3164	105	1	0.161	15.000	0.011	0.002	1
JUN	7	2927	105	1	0.161	15.000	0.011	0.002	1
JUL	5	3022	75	1	0.115	15.000	0.008	0.002	1
AUG	17	3041	255	1	0.391	15.000	0.026	0.006	1
SEP	8	2894	120	1	0.184	15.000	0.012	0.003	1
OCT	5	119	75	1	0.115	15.000	0.008	0.002	1
NOV	6	97	90	1	0.138	15.000	0.009	0.002	1
DEC	33	58	495	1	0.758	15.000	0.051	0.011	1

Close

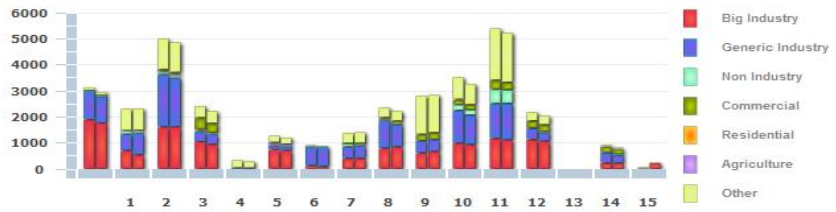
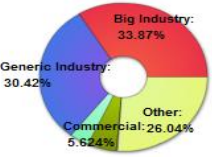
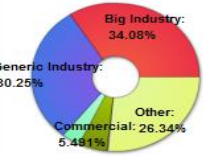
# Use Case 4: Energy Efficiency

## Energy Efficiency Analysis

### Region Energy Analysis

**Total Energy:** 33080.01

**Historic Energy:** 34241.03

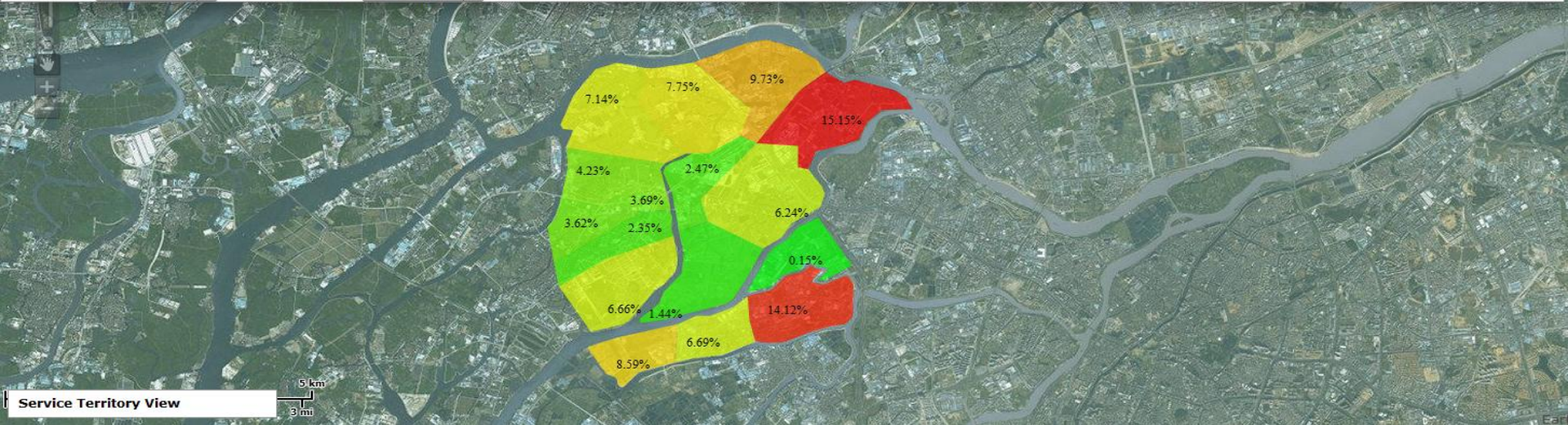


### Region Energy Consumption List:

Region	Energy	Percent(%)
R12	5266.20	15.15
R3	4906.59	14.12
R11	3380.99	9.73
R1	2984.15	8.59

Period:

Historic:





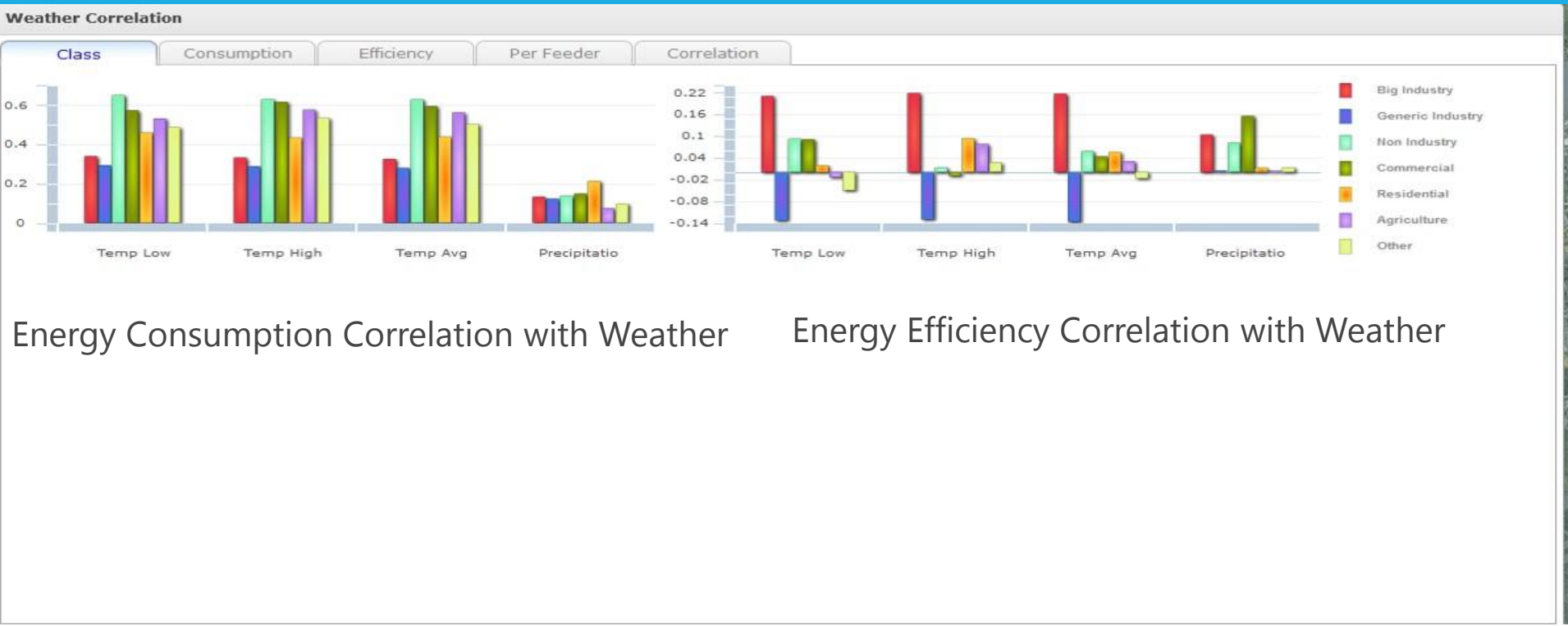
# Use Case 4: Energy Efficiency

## Energy Efficiency Heatmap



# Use Case 4: Energy Efficiency

## Weather Impact to Energy Usage Type

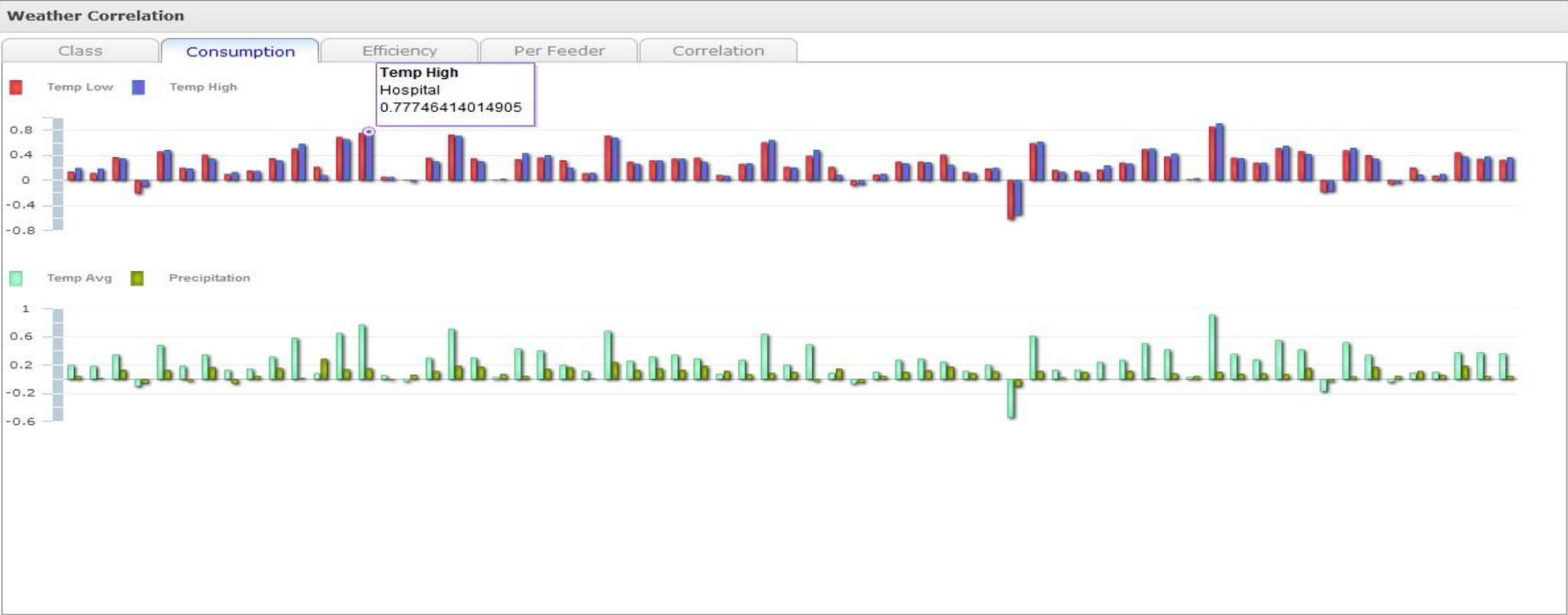


Energy Consumption Correlation with Weather

Energy Efficiency Correlation with Weather

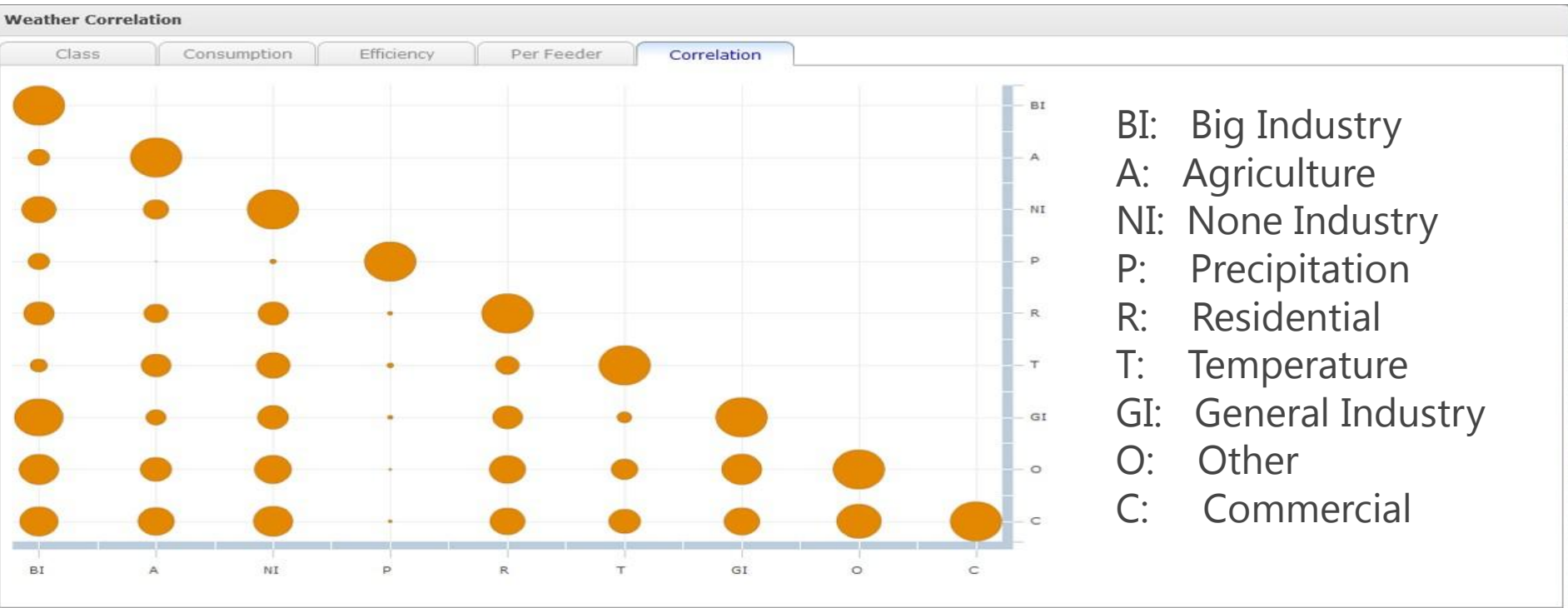
# Use Case 4: Energy Efficiency

## Weather Impact to Industry



# Use Case 4: Energy Efficiency

## Industry Correlation



- BI: Big Industry
- A: Agriculture
- NI: None Industry
- P: Precipitation
- R: Residential
- T: Temperature
- GI: General Industry
- O: Other
- C: Commercial

# Use Case 4: Energy Efficiency

## Region Energy Usage Detail

**Region Energy Analysis**

**Total Energy:** 33080.01      **Historic Energy:** 34241.03

Big Industry: 34.08%  
Generic Industry: 30.25%  
Commercial: 26.34%  
Other: 5.48%

Big Industry: 33.87%  
Generic Industry: 30.42%  
Commercial: 26.04%  
Other: 5.62%

Period:

Historic:

- Big Industry
- Generic Industry
- Non Industry
- Commercial
- Residential
- Agriculture
- Other

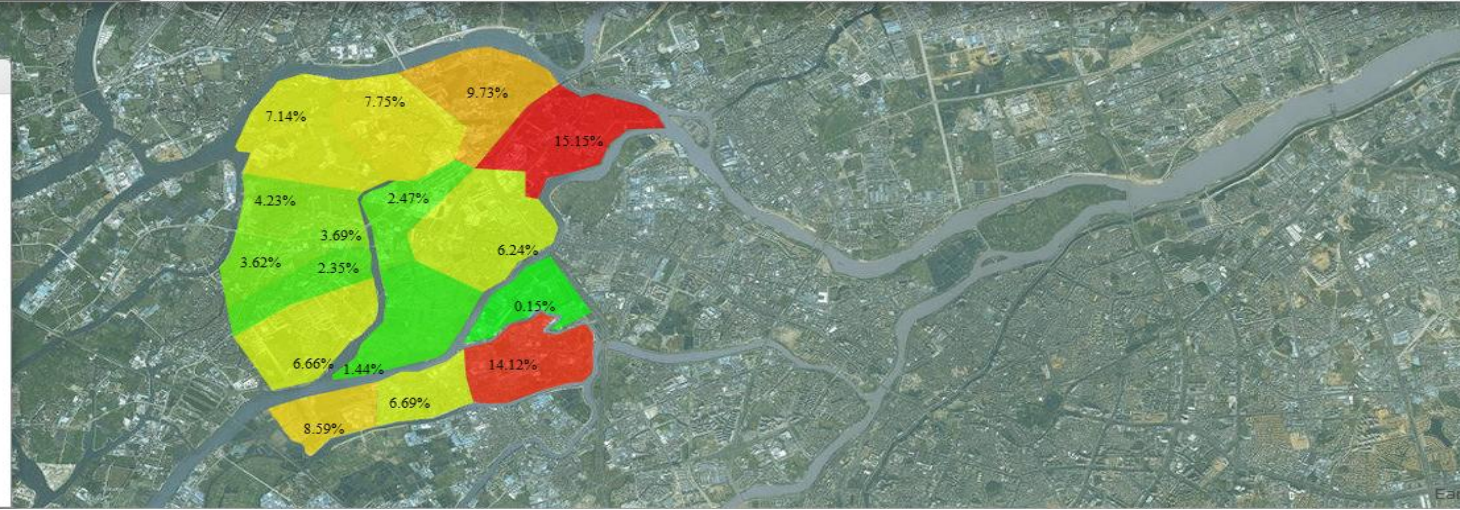
**Region Energy Consumption List:**

Region	Energy	Percent(%)
R12	5266.20	15.15
R3	4906.59	14.12
R11	3380.99	9.73
R1	2984.15	8.59

**Region Energy Usage Detail:R9**      Date...

Big Industry: 38.10%  
Generic Industry: 38.86%  
Commercial: 6.353%  
Other: 17.07%

**Service Territory View**      18 20 22





# Microsoft

An E2E Operationalized pipeline for Predictive Analysis  
with PI Server 2015 and Microsoft AzureML, Power BI



Microsoft

# Introduction: Azure ML

# Azure Machine Learning



Hosted, fully-managed cloud service for operationalized machine learning and data science

## ML Studio –

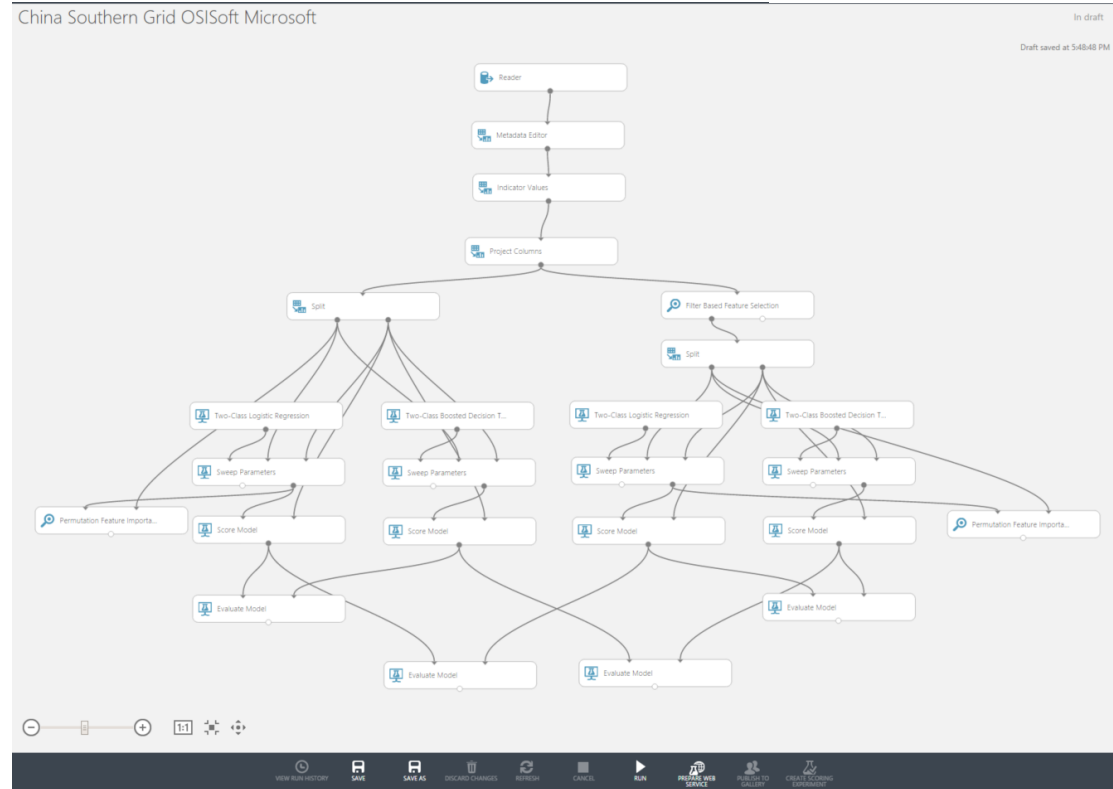
- Experiment and build ML based solutions
- Deploy solutions as web service APIs on the cloud

## Services

- Request/Response and Batch web services of the solutions

## Marketplace

- Monetize intelligent APIs on the cloud





# Forecast Temperature and Energy Consumption

1. Collect data in Real-Time using the PI Server

2. Train model for each meter to predict temperature and energy consumption at

- different horizons – 7 and 90 days
- 15 min. intervals

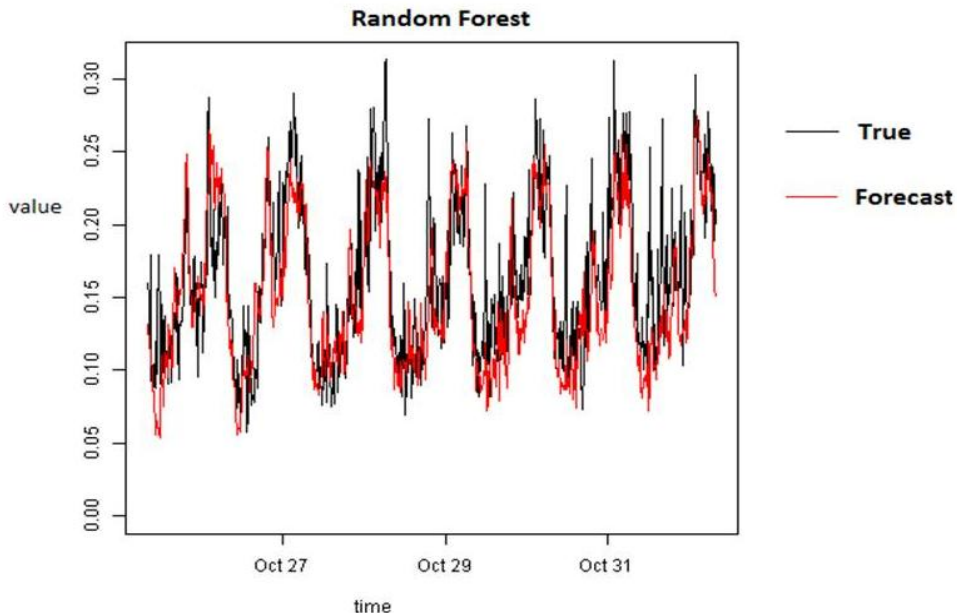
3. Detect potential energy savings

- \* Over-Cooling/Heating
- \* Space conditioned without occupancy

4. Corrective Actions :

- \* Adjust Control Logic
- \* Turn Off systems

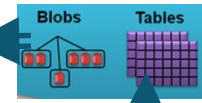
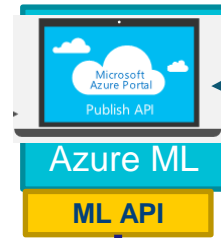
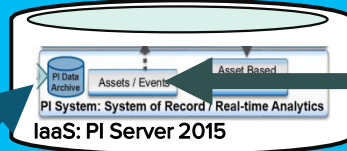
Meter 73730000, APhaseP, 10/25/2014 - 10/31/2014



# Microsoft Azure Machine Learning Architecture

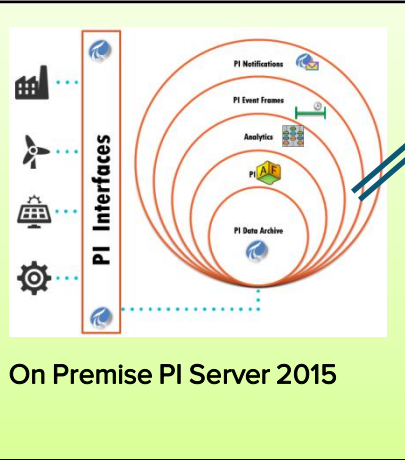
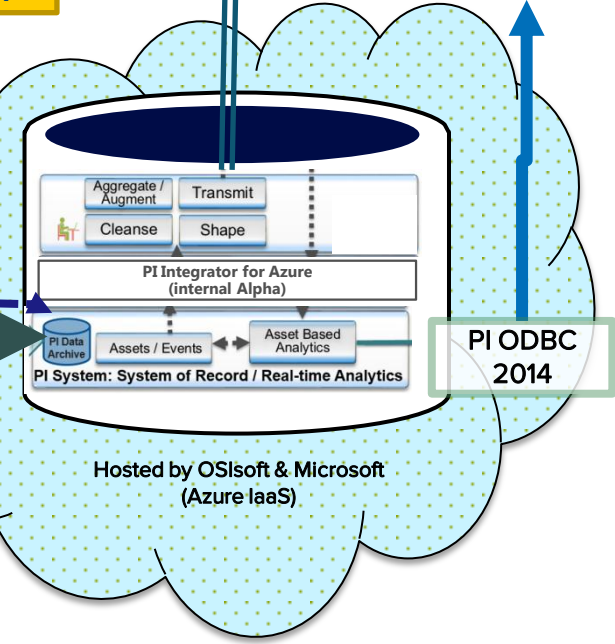
China Azure

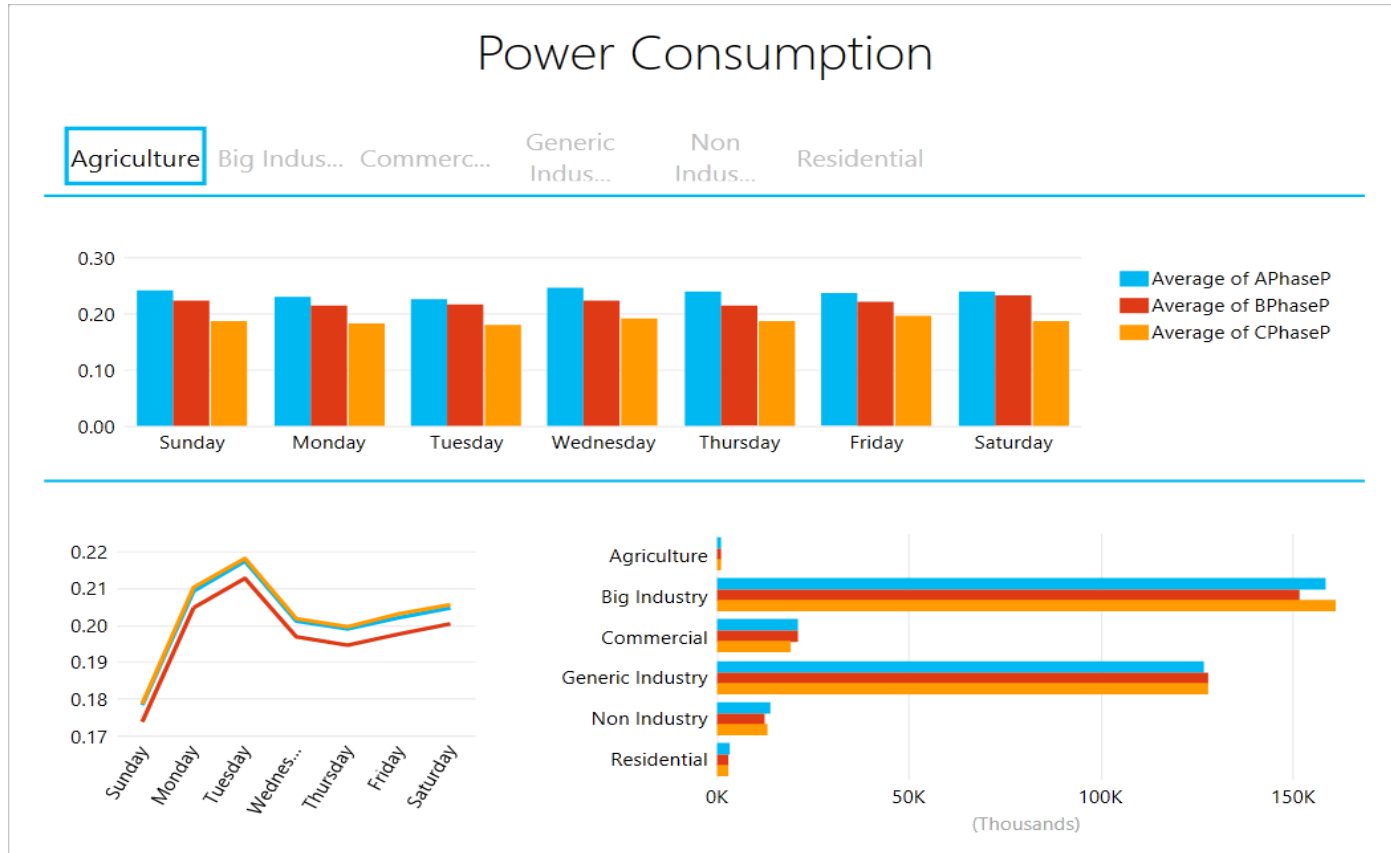
Transfer via offline PI Backup



Write predictions back to PI 2015 as future data

PI Cloud Connect

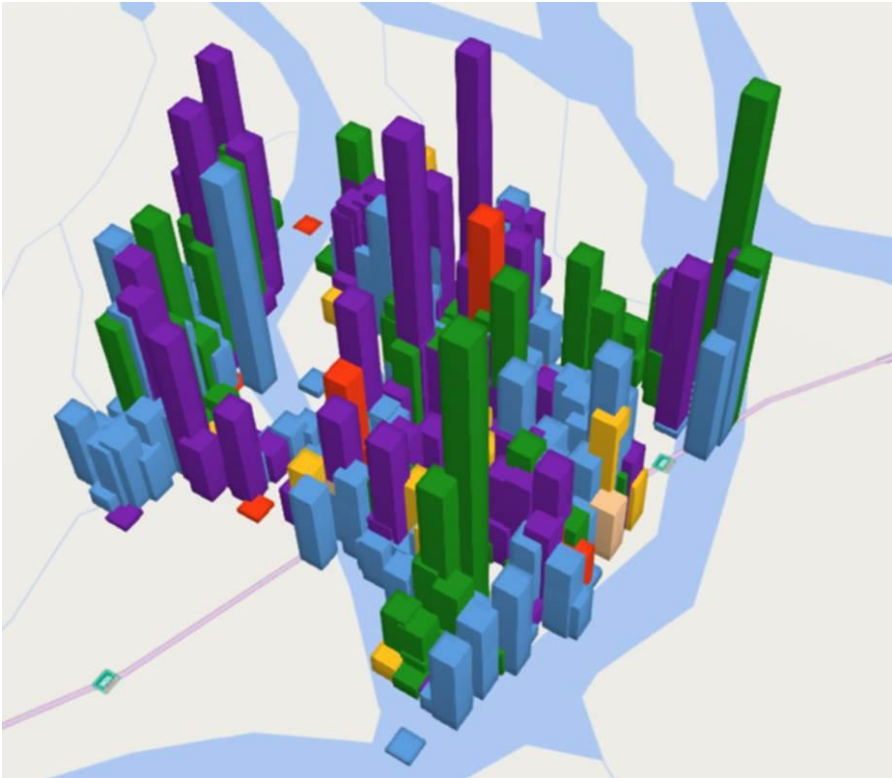
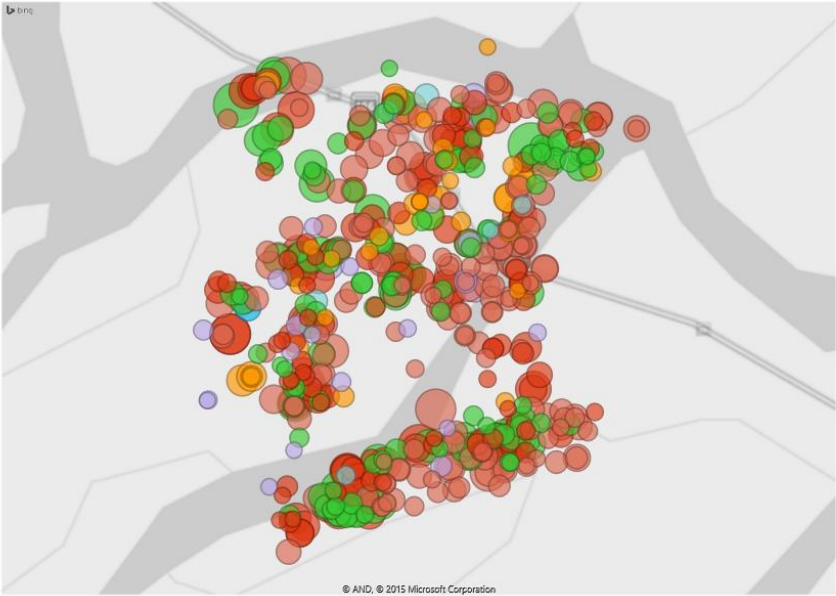




# PowerBI Consumption Reports



Meter Location by Industry

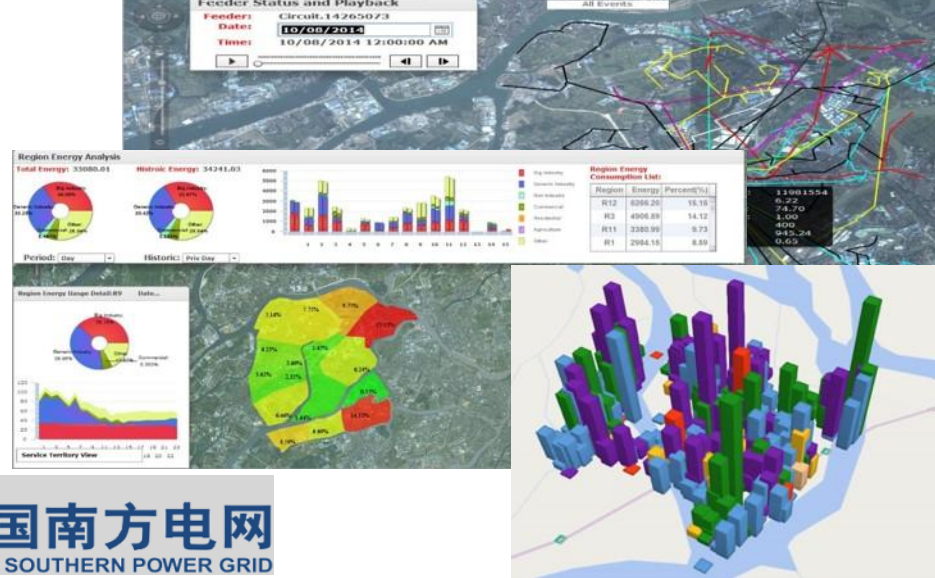


<http://www.powerbi.com>

# E2E for Intelligent Grid

CSG EPRI is establishing an E2E big data technology in R&D, standards, and demonstration to approach our goal: an intelligent, efficient, reliable and green grid.

Dr. Li Peng, VP, CSG EPRI



## Business Challenges

- A. A need for an End-to-End integrated “big data” infrastructure with unified models and standardizations
- B. The same infrastructure to enable application development with visualization and analytics
- C. Advanced technology such as predictive analytics technology can be utilized in the infrastructure

## Solution(s)

- A. PI System as the “big data” integration infrastructure
- B. PI System to integrate data and power system topology model
- C. PI System to integrate with GIS visualization and advanced predictive analytics technology

## Results and Benefits

- One-stop shop for accessing and visualizing data for situational awareness
- End-to-End data integration to improve system reliability and customer service
- Enhanced prediction and forecasting for better planning and operations and more competitive to prepare for open market

# Future Plan

- Enhancing visualization for big data analysis
- Adding non-structured data into CIM model
- Integrating PI System with Hadoop
- Expanding the architecture and implementation to 3 more cities

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# Questions

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

State your  
**name & company**







THANK  
YOU