METER DATA ANALYTICS

Enabling Actionable Decisions to Derive Business Value from Smart Meter Data

Jennifer Whaley, SAS

AEIC/WLRA Conference 8.26.2015

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WHAT IS YOUR PERCEPTION OF SAS?

SAS Programming Language

```
proc catmod order=data;
  weight wt;
  response / out=preds;
  model severity=trt hospital;
  run;
  quit;

/* Keep just the predicted values, predictors, and response */
data pred2;
 set preds;
 if _type_='PROB';
 keep severity trt hospital _pred_;
 run;

/* Find predicted response level (level with highest predicted
  probability) in each sample.   */
proc summary data=pred2 nway;
 class trt hospital;
 var _pred_;
 output out=predlvl (drop=_type_ _freq_)
       maxid(_pred_(severity))=predlvl;
 run;

/* Transpose the predicted values so that there is one observation per
  sample containing predicted values for each response level. */
proc transpose data=pred2 out=pred3 (drop=_name_);
 by trt hospital;
 id severity;
 var _pred_;
 run;
```

GUIs– SAS for Business (and Programmers)

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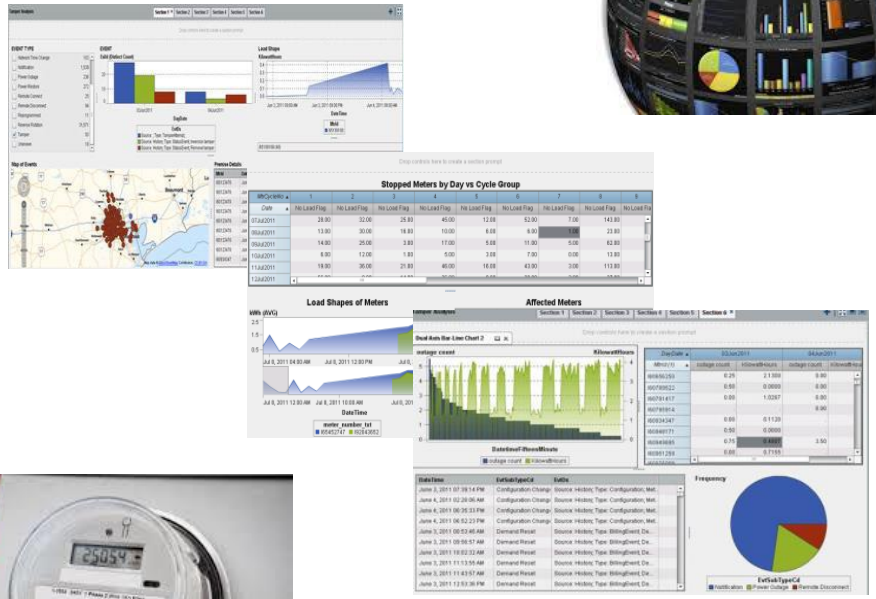
OVERVIEW

- Smart Meter Data
- Data Preparation
- Business Cases
  - Revenue Protection
  - Customer Analysis



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SMART METERS | WHAT ARE THEY?

A smart meter records consumption of electric or gas consumption in intervals of an hour or less and communicates that information to the utility for monitoring and billing. Smart meters enable one or two-way communication between the meter and the central system.

Time series data

- 15-minute interval reading
  - Usage measurements
  - Voltage measurements

Transactional data

- Sub-second Meter Events
  - Outage
  - Tamper codes
  - Time change
  - Calibration

Meter Characteristics

- Meter ID
- Manufacturer
- Service Point Identifier

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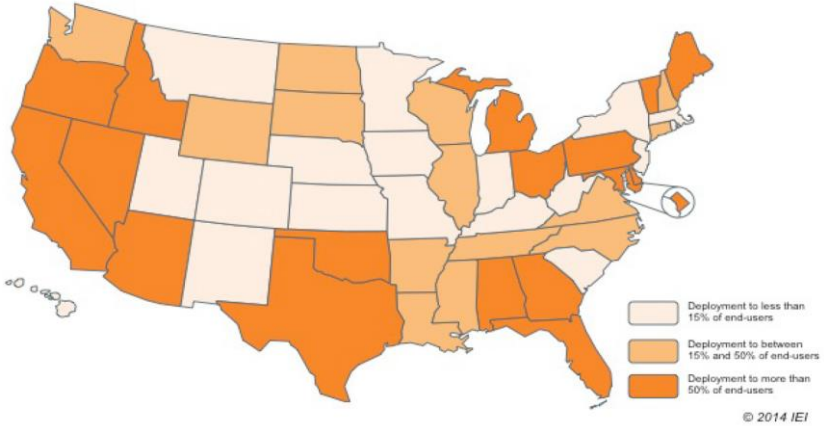
SMART METERS | WHERE ARE THEY?

- 50 million smart meters have been deployed in the U.S.
- 43% of U.S. homes have smart meters



http://www.edisonfoundation.net/iei/Documents/IEI_SmartMeterUpdate_0914.pdf

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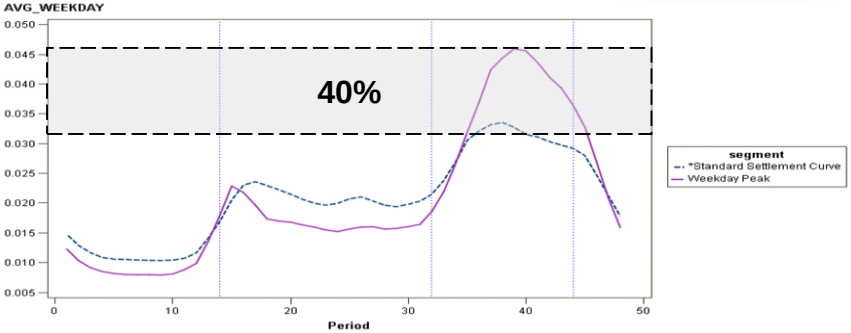
SMART METERS | HOW ARE THEY USED?

- Reliability
- Billing
- Voltage Control
- Critical Pricing
- Energy Theft
- Rate and Program Design
- Consumption Trends
- Outage and Restoration Management
- Transformer overloads

Weekday Worker Load Profile



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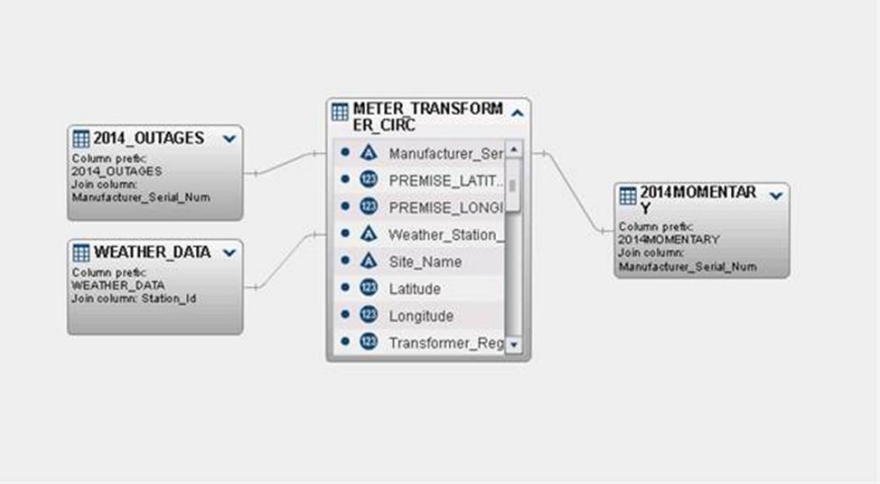
SMART METER DATA INTEGRATION

Analyzing transformers for system reliability has the potential to involve hundreds of GBs of data consisting of the following:

- Transformer lookup (meters/transformers/circuits)
- Momentary (disturbance in service)
- Outages (system downtime)
- Weather (station hourly reads)
- Potential repairs (workflow/order systems)

These data sources are combined into a single view from a star schema.



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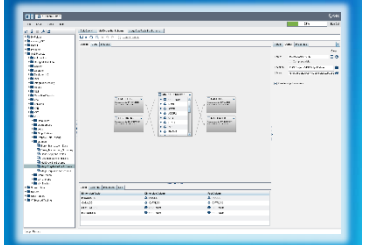
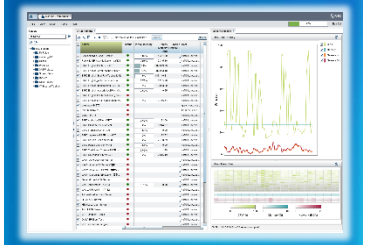
VISUALIZATION PROCESS FLOW

FROM DATA TO DECISIONS



DATA BUILDER

- Join data from multiple sources
- Create calculations

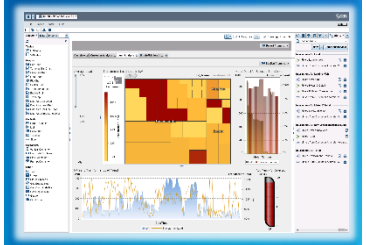


ADMINISTRATOR

- Monitor environment
- Manage security

EXPLORER

- Perform ad-hoc analysis and data discovery
- Apply advanced analytics



REPORT DESIGNER

- Create dashboard style reports for web or mobile

MOBILE ACCESS

- Deliver interactive reports to mobile devices

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Collaboration and Information Sharing

MOBILE

COLLABORATION APPLICATIONS

DESKTOP APPLICATIONS

WEB

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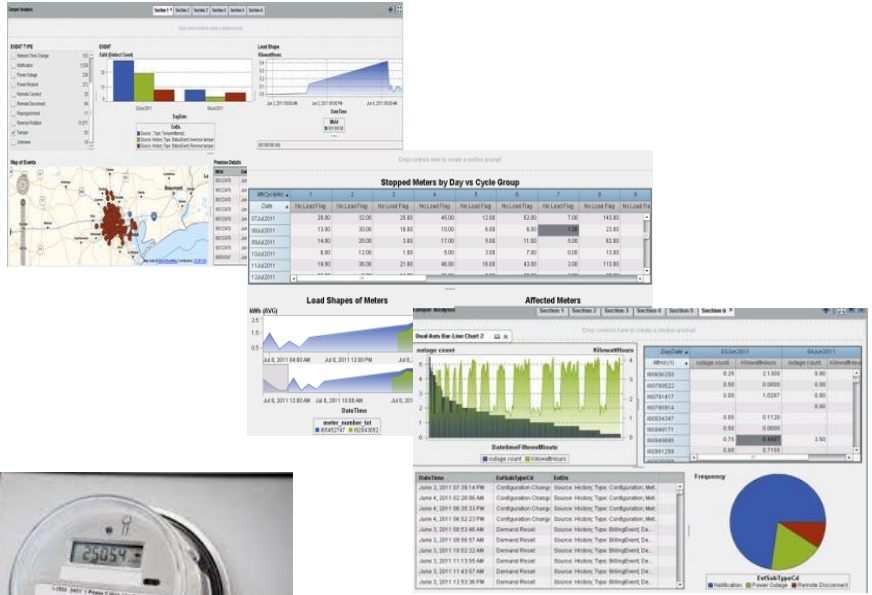
USE CASES | VISUAL DISCOVERY FOR SMART METERS

- Interval Analysis
- Inactive Meters
- Energy Theft Analysis
- Customer Segment Analysis
- Load Profile Analysis



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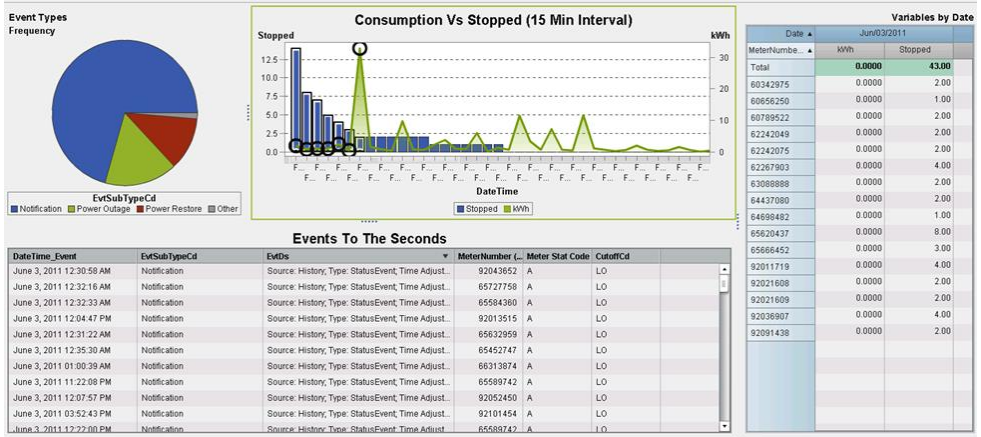
INTERVAL ANALYSIS

A daily report provides alerts and insight to operations engineers about what is occurring and where incidents may be likely.

Various intervals of data can be displayed in one dashboard, combining transactional and time series data.

Event counts correlate with outages and event descriptions.



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Inactive Analysis - Internet Explorer provided by SAS IT

http://sasva.demo.sas.com/SASVisualAnalyticsViewer/VisualAnalyticsViewer.jsp

Inactive Analysis

Inactive Analysis

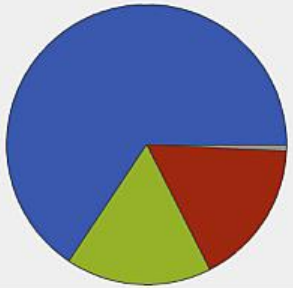
File Help

Sign Out

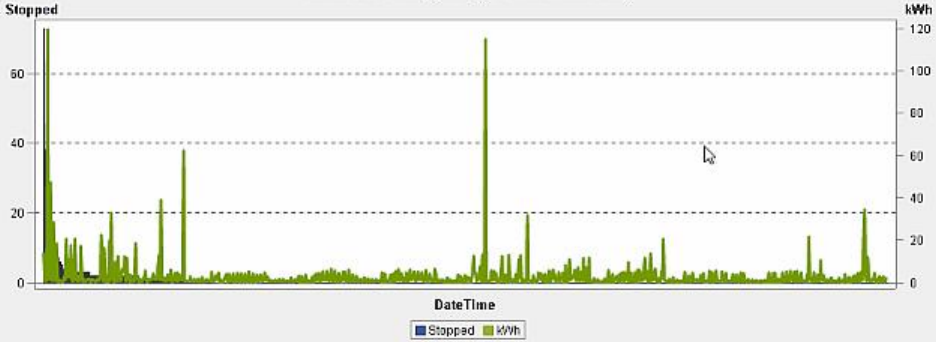
Inactives with kWh | Transformeres with Inactive Meters | Events Identified | Section 4 | Section 5 | Section 6 | Section 7

Date

Event Types
Frequency



Load Vs Stopped (15 Min Interval)



Variables by Date

Date	May/29/2011		May/30/2011	
MeterNumbe...	kWh	Stopped	kWh	Stoppe
Total	0.0000	71.00	0.0000	
60340063	0.0000	6.00	.	
60342975	.	.	.	
60856250	.	.	.	
60709522	.	.	.	
61332839	.	.	.	
61336191	.	.	.	
62242049	.	.	.	
62242075	.	.	.	
62253850	0.0000	3.00	.	
62259292	.	.	.	
62263074	.	.	.	
62263473	0.0000	5.00	.	
62263488	0.0000	5.00	.	
62264002	0.0000	5.00	.	
62264005	0.0000	3.00	.	
62264011	0.0000	4.00	.	
62264018	0.0000	6.00	0.0000	
62267903	0.0000	4.00	.	
62268550	.	.	.	
62268601	.	.	.	
62269899	.	.	.	
62269733	.	.	.	
62269749				

Events To The Seconds

DateTime_Event	EvtSubTypeCd	EvtDs	MeterNumber (...	Meter Stat Code	CutoffCd
June 6, 2011 11:33:31 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	65452747	A	LO
June 6, 2011 11:32:43 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	65564360	A	LO
June 6, 2011 11:30:36 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	92043652	A	LO
June 6, 2011 11:28:44 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	65727758	A	LO
June 6, 2011 11:27:34 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	65632959	A	LO
June 6, 2011 11:26:29 PM	Load Voltage Present	Source: ; Type: LoadVoltagePresent;	65678951	A	ED
June 6, 2011 11:23:00 PM	Network Time Change	Source: History; Type: Configuration; Time Cha...	92112220	A	LO
June 6, 2011 11:22:12 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	65569742	A	LO
June 6, 2011 11:22:00 PM	Notification	Source: History; Type: StatusEvent; Load Voltag...	65678951	A	ED
June 6, 2011 11:08:25 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	92052450	A	LO
June 6, 2011 11:02:40 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	92013515	A	LO
June 6, 2011 10:50:30 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	92101454	A	LO
June 6, 2011 10:33:34 PM	Notification	Source: History; Type: StatusEvent; Time Adjust...	65452747	A	LO

Start | SAS Web Clients | Inactive Analysis -...

105%

12:34 PM
4/20/2015

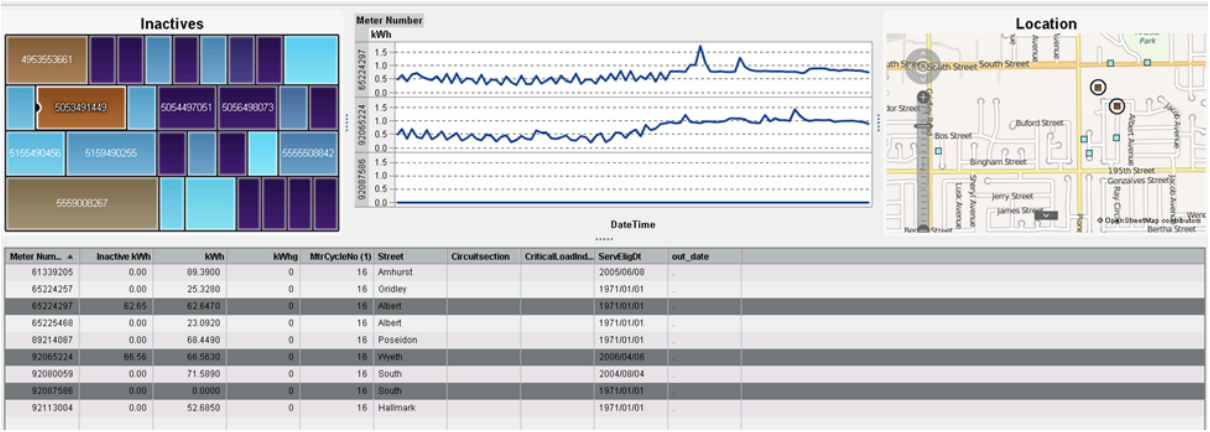
REVENUE PROTECTION

INACTIVE METERS

Recover lost revenue by identifying consumption on inactive meters.

Determine a list of premises where meters should be turned off or removed, yet still have energy consumption.

- GIS
- Meter management
- Billing systems



Meter Num...	Inactive kWh	kWh	kWhg	MtrCycleNo (1)	Street	Circuitsection	CriticalLoadInd...	ServEligDt	out_date
61339205	0.00	89.3900	0	16	Amhurst			2005/06/08	.
65224257	0.00	25.3280	0	16	Oridley			1971/01/01	.
65224297	62.65	62.6470	0	16	Albert			1971/01/01	.
65225468	0.00	23.0920	0	16	Albert			1971/01/01	.
89214087	0.00	68.4490	0	16	Poseidon			1971/01/01	.
92065224	66.56	66.5630	0	16	Wyeth			2006/04/06	.
92080059	0.00	71.5890	0	16	South			2004/08/04	.
92087586	0.00	0.0000	0	16	South			1971/01/01	.
92113004	0.00	52.6850	0	16	Hallmark			1971/01/01	.

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Inactive Analysis - Internet Explorer provided by SAS IT

http://sasva.demo.sas.com/SASVisualAnalyticsViewer/VisualAnalyticsViewer.jsp

Inactive Analysis

File Help

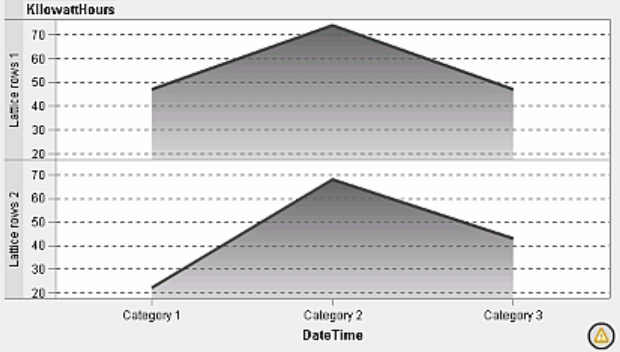
Sign Out

Inactives with kWh | Transformeres with Inactive Meters | Events Identified | Section 4 | Section 5 | Section 6 | Section 7

Date

Transformer

Meter Number



Meter Number	Circuitsection	Inactive kWh	Street	Tamper3	cause_code	MtrStatusCd	out_date	MtrCycleNo	Critical Load Indicator
65592492		0.00	Durango	37		A	.	31064	
65611589		0.00	Carolyn	37		A	.	31064	
65611614		0.00	Point Arena	37		A	.	31064	
65678951		1,216.19	Point Arguello	37		I	.	31064	
65611571		0.00	Acoro	37		A	.	31064	
65594291		0.00	Destino	37		A	.	31064	
65594109		0.00	Yucatan	37		A	.	31064	
63061693		0.00	Bertha	35		A	.	38712	
64713758		0.00	Wendy	35		A	.	38712	
63066946		0.00	Jacob	35		A	.	38712	
63062437		0.00	Gonzalves	35		A	.	38712	
63068612		0.00	195th	35		A	.	38712	
63062151		0.00	Gonzalves	35		A	.	38712	
63070813		0.00	17th	34		A	.	50032	

105%

Start | SAS Web Clients | Inactive Analysis -... | 5:40 PM 4/20/2015

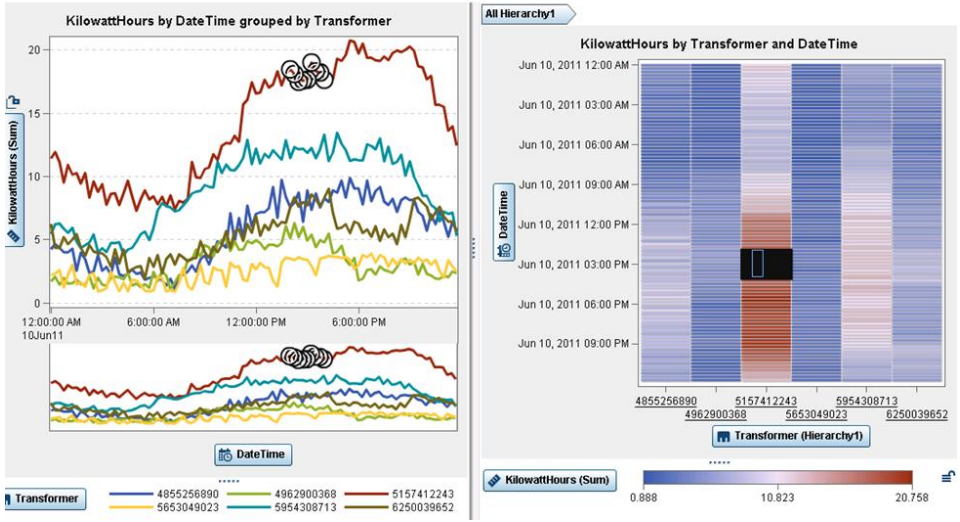
ENERGY THEFT ANALYSIS

EPRI estimates that US electric utilities lose over $6 billion in revenue due to non-technical losses.

Advanced analytics work with complex patterns and can identify suspect usage patterns.

Detect anomalous patterns of usage to track of new diversion practices.

Visualization is used to confirm and further investigate fraudulent activity.



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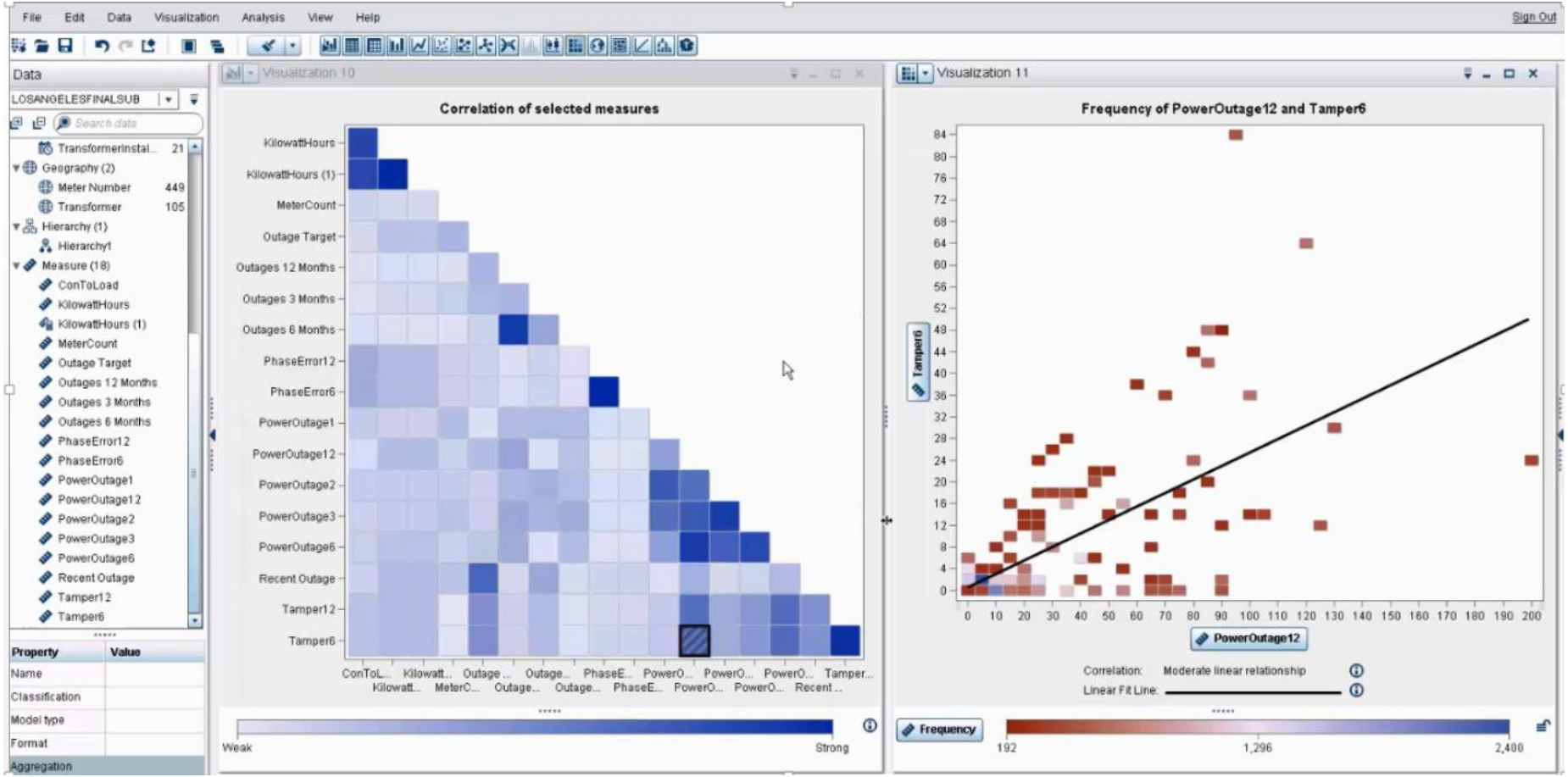

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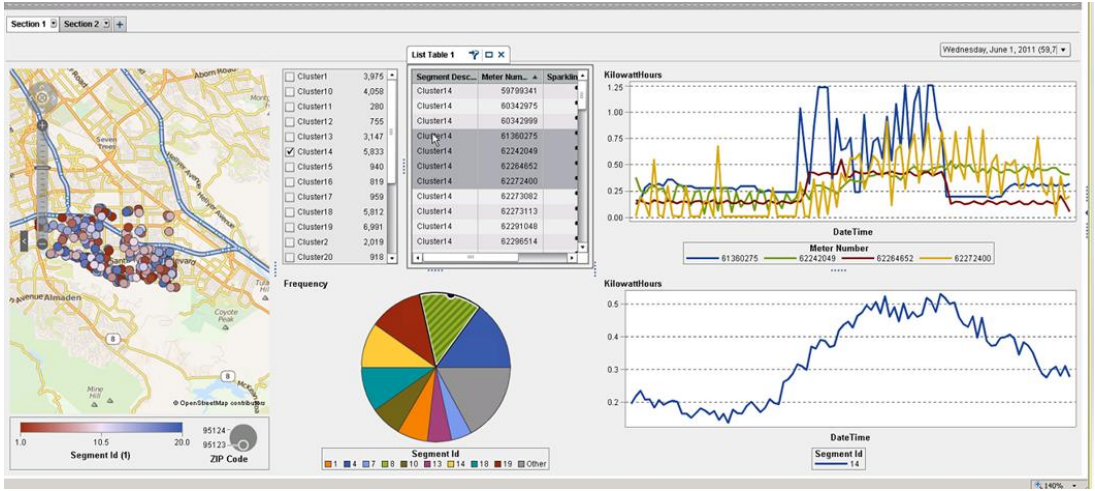
CUSTOMER SEGMENT ANALYSIS

Load shape segmentation and cluster analysis.

Customer classification by cluster and segments can be selected to display the segment's overall load shape definition and the detailed load shapes of its members.

This type of analysis is used to display and validate segmentation modeling. The analyst can view the customer segment definition and the details of its members.



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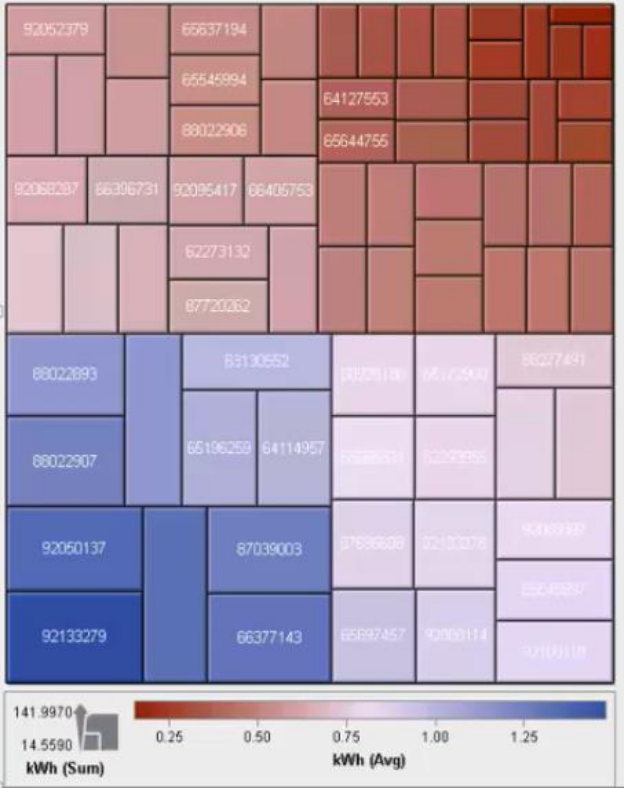
Tiered Base Plan | Time of Use | Net Energy Metering | Outliers | Section 1 | Comparison | Segements | Clusters

Jun/03/2011 (219,810)

Distribution

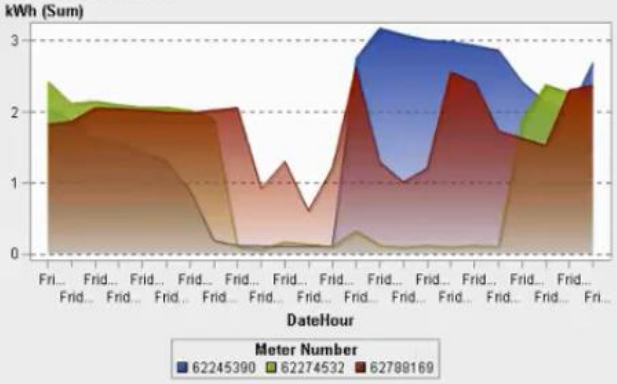
Meter Number



Parameters

Segment Id	Meter Number	kWh (Avg)	kWh (Max)	kWh (Median)
25	60342973	0.4726	0.8260	0.6595
25	60928180	0.7939	1.0230	0.8495
25	60944181	0.6513	1.7800	0.6655
25	62245390	0.4335	0.8980	0.4250
25	62268192	0.5767	1.2670	0.6330
25	62269262	0.2482	0.5580	0.1270
25	62273132	0.6317	1.6910	0.4990
25	62274532	0.2828	0.6670	0.1275
25	62293955	0.7916	1.2930	0.8150
25	62788169	0.4439	0.9460	0.4975
25	62867229	0.1982	0.9600	0.0000
25	63060023	0.6171	1.6010	0.6515

Individual Load

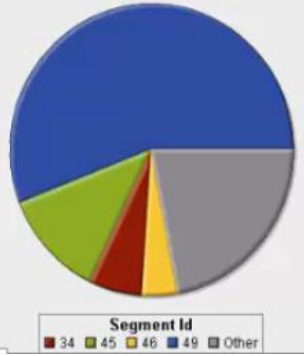


Clusters

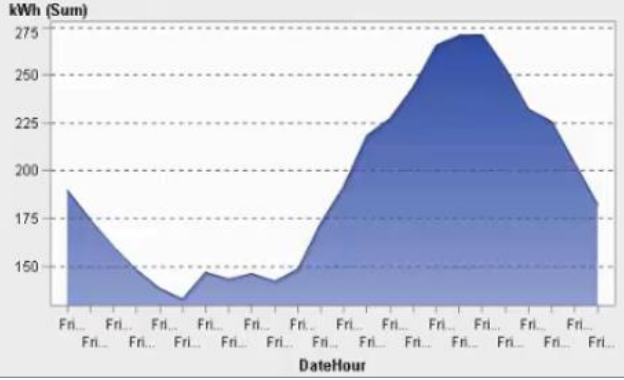
Cluster23	96
Cluster24	6,432
☑ Cluster25	7,680
Cluster26	96
Cluster27	96
Cluster28	96
Cluster29	96
Cluster3	192
Cluster30	96
Cluster31	96
Cluster32	96
Cluster33	96
Cluster34	13,248
Cluster35	96

Segments

Frequency



Cluster Load



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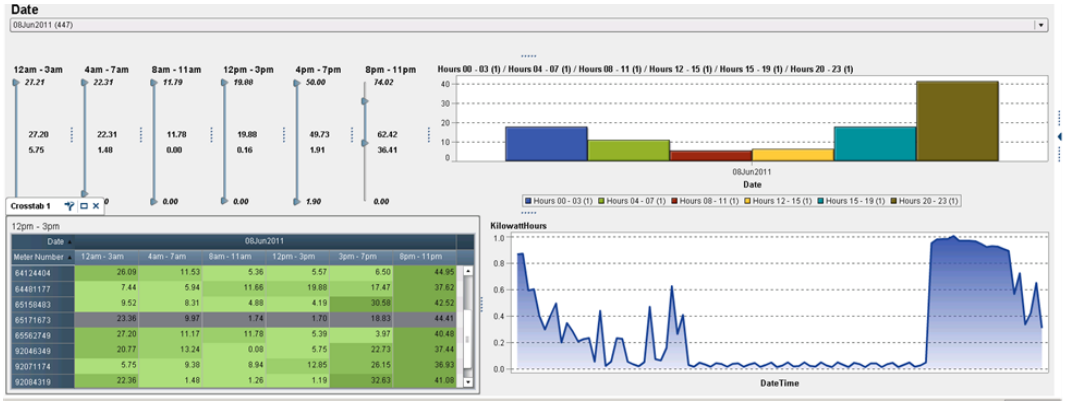
LOAD PROFILE ANALYSIS

Look for trends and seasonal variation in load patterns.

Draw a load shape and find all the customers that fit that shape.

The analyst can change the interval values using slide bars to define the load shape desired. The meters that match that profile are displayed in a crosstab on the bottom left.

Selecting one or more meters from the crosstab displays the load shapes.



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Load Forensics - Internet Explorer provided by SAS IT

http://sasva.demo.sas.com/SASVisualAnalyticsViewer/VisualAnalyticsViewer.jsp

Load Forensics

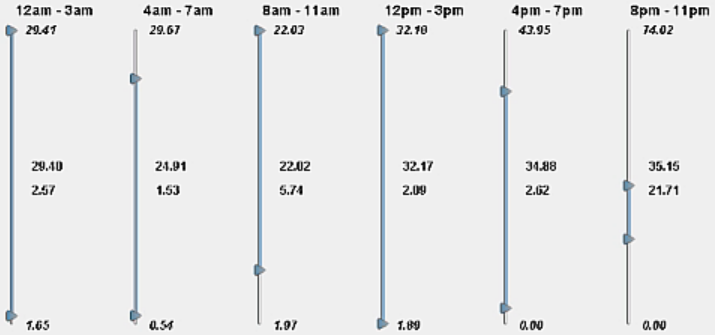
File Help

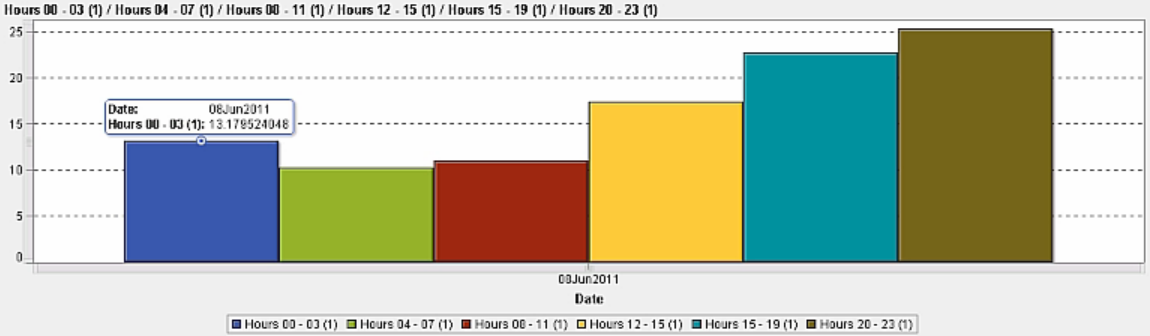
Sign Out

Loadshape | Circuit Load | Event Analysis

Date

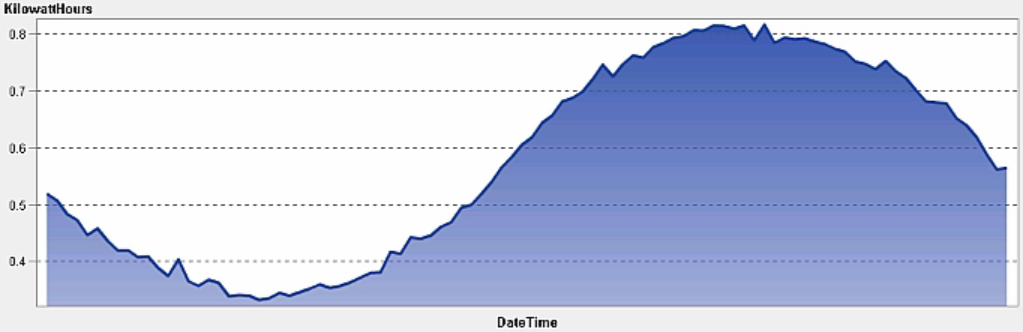
08Jun2011 (447)





12pm - 3pm

Date	08Jun2011					
Meter Number	12am - 3am	4am - 7am	8am - 11am	12pm - 3pm	3pm - 7pm	8pm - 11pm
61344892	10.79	5.59	7.20	32.17	20.41	23.85
62239842	11.24	9.88	12.67	18.76	23.74	23.71
62244675	13.89	10.56	12.05	15.88	23.53	24.09
62259292	8.64	5.56	10.99	25.19	26.99	22.63
62284899	17.29	5.67	9.96	15.12	25.07	26.88
62271771	12.06	3.20	12.60	26.55	17.20	28.38
62287611	17.59	9.81	11.76	25.22	12.31	23.31
62291048	12.99	13.75	10.13	20.23	20.97	21.93
62291687	16.27	12.97	10.59	15.72	22.43	22.02
62293955	11.03	9.79	16.82	18.57	20.80	22.99
62785642	13.10	15.98	16.30	10.90	15.47	28.25



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Start | SAS Web Clients | Load Forensics - In... | 11:51 AM 4/24/2015

CONCLUSION

Smart meters now produce massive quantities of customer usage data that is overwhelming in terms of volume and velocity. Visualizing the data can drive business decisions by:

- analyzing consumption trends to spot trends earlier than ever before
- identifying demand patterns that can improve load forecasting
- targeting various customer segments
- combining detailed data from disparate sources

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FOR MORE INFORMATION

SAS GLOBAL FORUM 2015 PROCEEDINGS

Paper SAS1957-2015

Meter Data Analytics—Enabling Actionable Decisions to Derive Business Value from Smart Meter Data

Tom Anderson and Jennifer Whaley, SAS Institute Inc.

ABSTRACT

A utility's meter data is a valuable asset that can be daunting to leverage. Consider that one household or premise can produce over 35,000 rows of information, consisting of over 8 MB of data per year. Thirty thousand meters collecting fifteen-minute-interval data with forty variables equates to 1.2 billion rows of data. Using SAS® Visual Analytics, we provide examples of leveraging smart meter data to address business around revenue protection, meter operations, and customer analysis. Key analyses include identifying consumption on inactive meters, potential energy theft, and stopped or slowing meters; and support of all customer classes (for example, residential, small commercial, and industrial) and their data with different time intervals and frequencies.

suug

SAS Utilities Users Group

http://support.sas.com/resources/papers/proceedings15/SAS1957-2015.pdf

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THANK YOU

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