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Smart Meter and Distribution Data Integration and Practices

China Electric Power Research Institute

Wenpeng LUAN

Putrajaya, Malaysia, IERE Workshop

Nov 21, 2017



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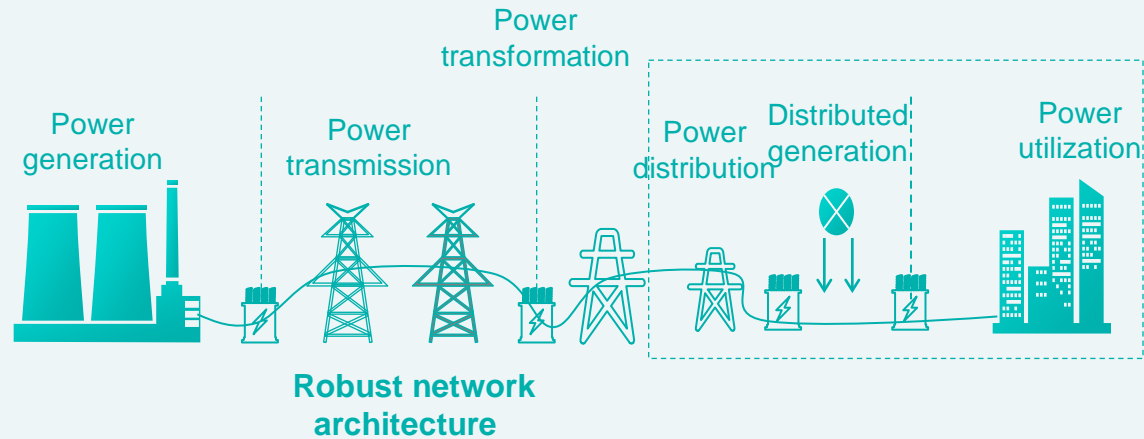
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1. SGCC Distribution System



Overview

The power distribution network plays an important role in the power grid. The State Grid Corporation of China (SGCC) attaches great importance to construction and development of the power distribution network, **proactively promotes** construction of power distribution network, **enhances** intelligence of the power distribution network, strengthen management of the power distribution network, and **continuously improves** the reliability of power supply.





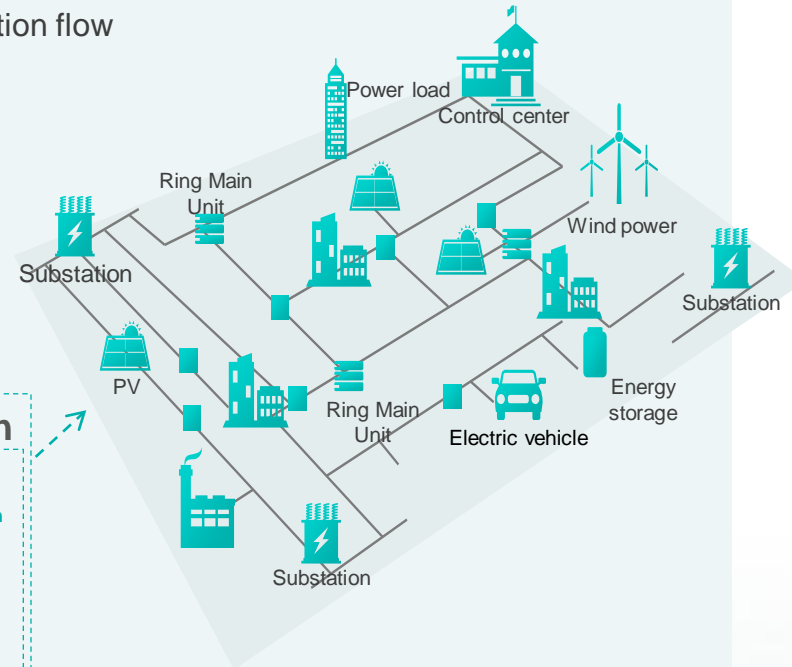
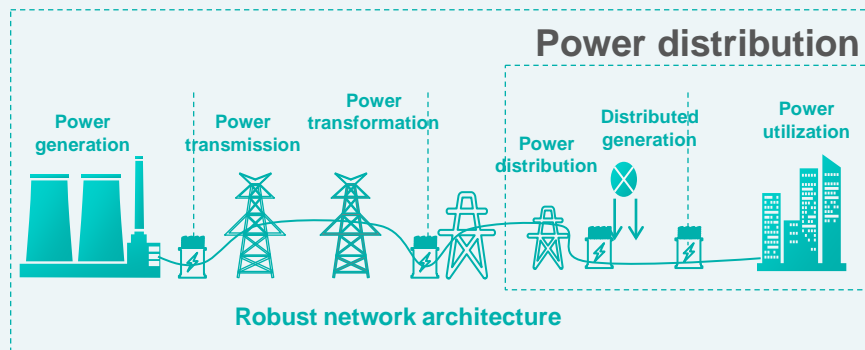
1. SGCC Distribution System



Overview

Characteristics of the power distribution network:

- › Large scale, complex structure, and wide coverage
- › High integration of the information system and physical system
- › Convergence of bi-directional energy flow and information flow





1. SGCC Distribution System



Overview

By the end of 2016, SGCC has **293,000** power distribution lines of 6 kV to 20 kV, spanning over **3.657 million km**, including aerial lines covering **3.169 million km** and cable lines covering **488,000 km**. There are a total of 4.075 million distribution transformers with the total capacity of **1.09 billion kVA**, and **3.488 million** switches including **738,000** pole-mounted switches.

Project	Line Length (km)	Transformer Capacity (MVA)	Quantity (Set)
Urban	689,715	466,385	2,280,634
Rural	2,967,623	623,216	1,207,699
Total	3,657,337	1,089,601	3,488,333



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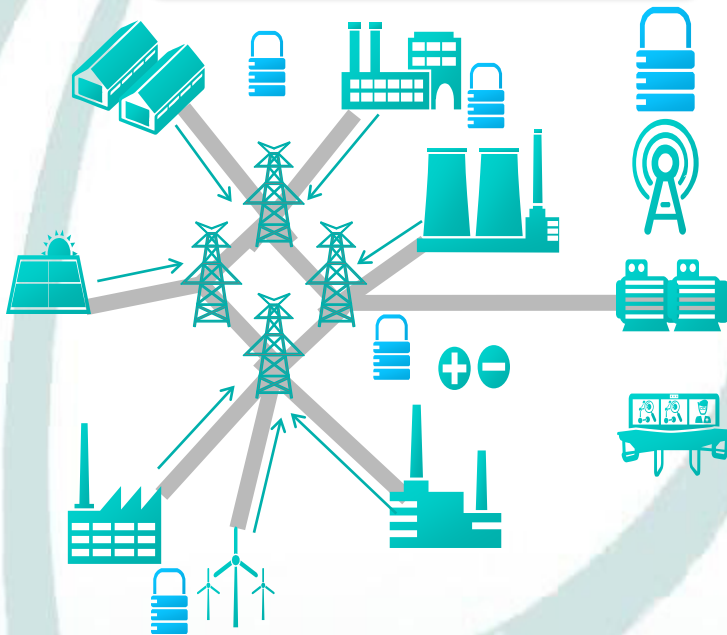
2. Industry Situation & Trends

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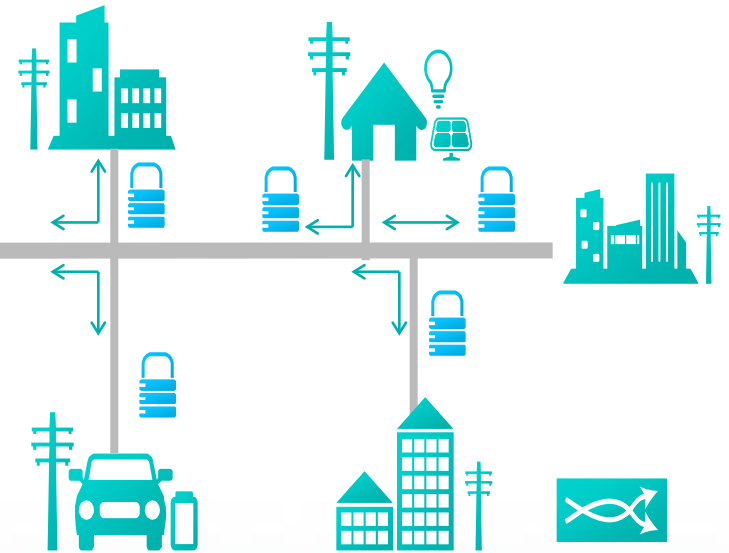


Integrated grid

Power generation & transmission



Power distribution



Source: EPRI

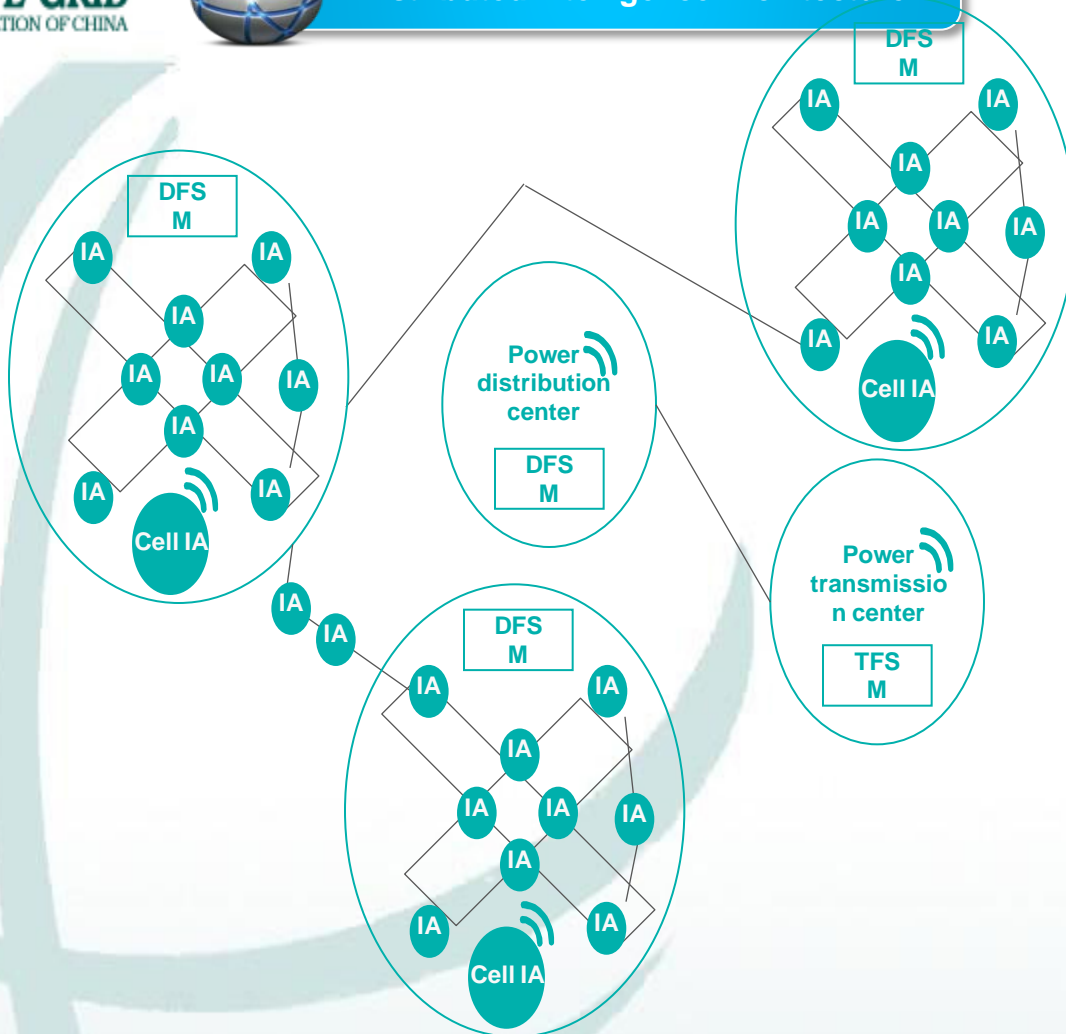


2. Industry Situation & Trends

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Distributed Intelligence Architecture



- ◆ Edge computing
- ◆ Sensors and AI
- ◆ Cloud edge coordinated operation

IA Basic intelligent agent that can send and receive signals, including power generation protection, distributed power generation, energy storage unit (ESU), power distribution scheduling with distributed power, and check-in machines

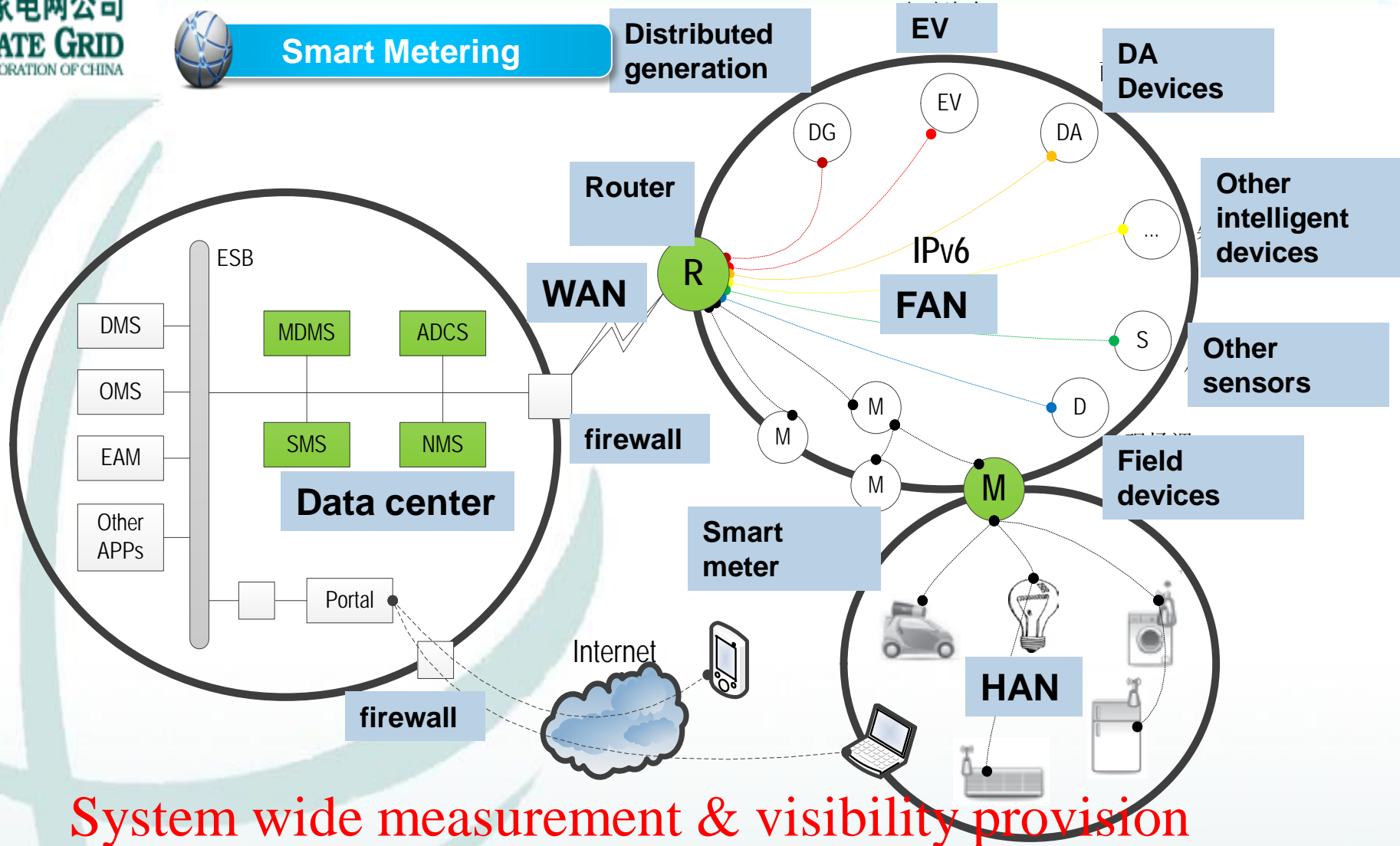
Cell IA **DFSM** Intelligent agent of power distribution

Source: EPRI



2. Industry Situation & Trends

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System wide measurement & visibility provision

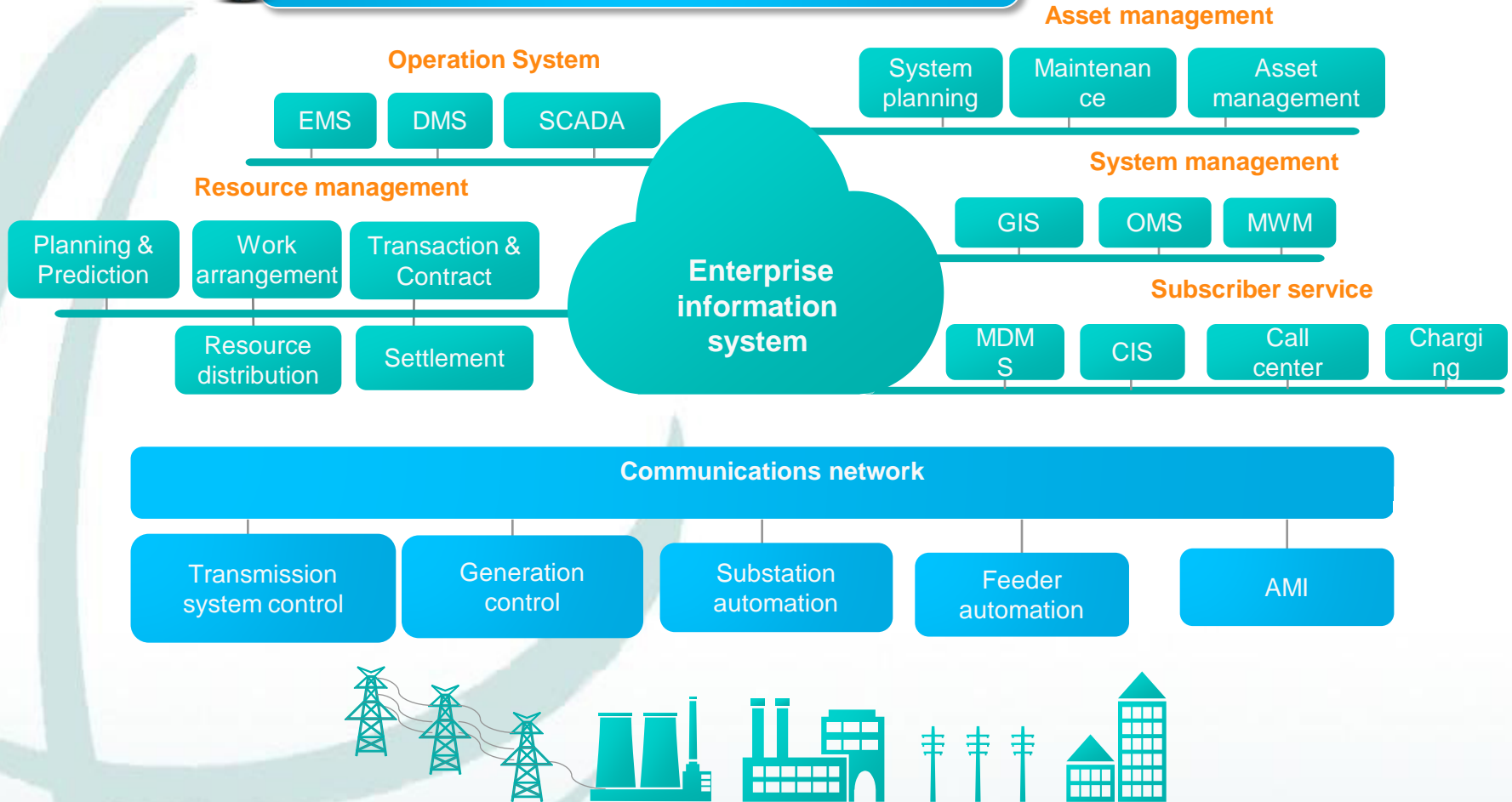


2. Industry Situation & Trends

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Enterprise wide Information System Integration & Big Data Analytics





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3. Metering & Distribution Data Integration

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Beyond Metering

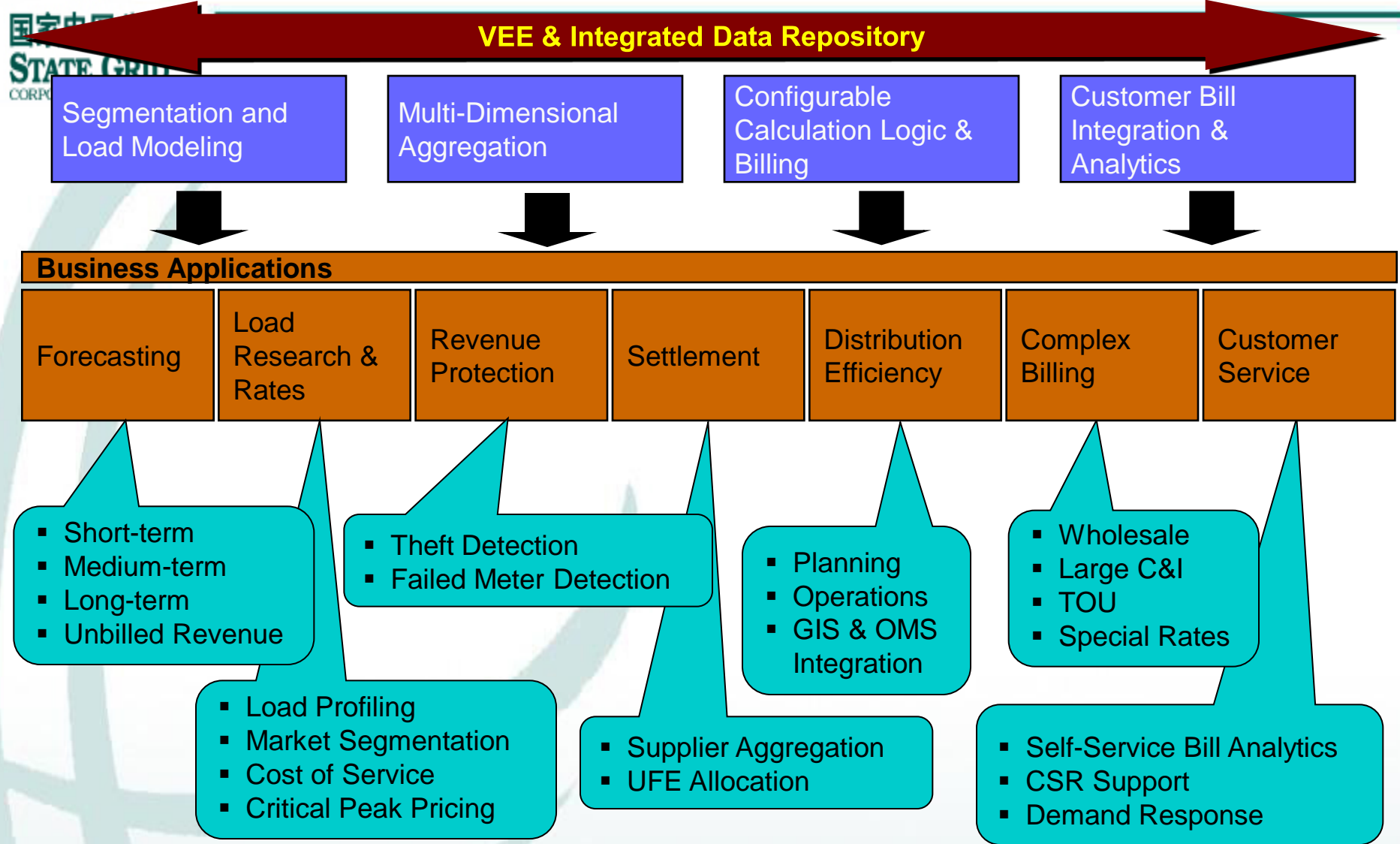
- ◆ Smart meter
 - Smart grid sensor at end of distribution network
 - Connection point of customer and power company
 - Enabling technologies

Smart Metering + D-SCADA





3. Metering & Distribution Data Integration





•3. Metering & Distribution Data Integration

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Data Analytics

By target:

- **Customer analytics**
 - ✓ Meter data analysis; demand correspondence; customer types
- **Asset Optimization Analytics**
 - ✓ Substation management; transformer management
- **Grid Optimization Analytics**
 - ✓ Energy quality management; distribution management; fault management; transmission management

By characteristics

- **Descriptive analytics:** analysis of past information, explanation of past scenarios
- **Predictive analytics:** analysis of the future
- **Prescriptive analytics:** recommended optimization programs



•3. Metering & Distribution Data Integration

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- **Distribution network topology model**
 - Auto-generate secondary network branch parameters
 - System topology and connectivity verification
 - Device phase detection
- **Overload detection**
 - Guide transformer and asset upgrade
 - Overvoltage detection
- **Nontechnical loss detection**
 - Energy theft detection
 - Abnormal meter detection



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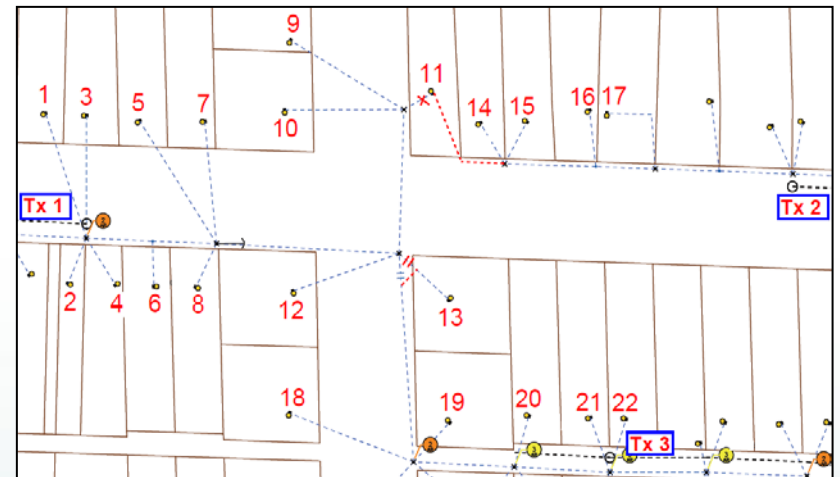
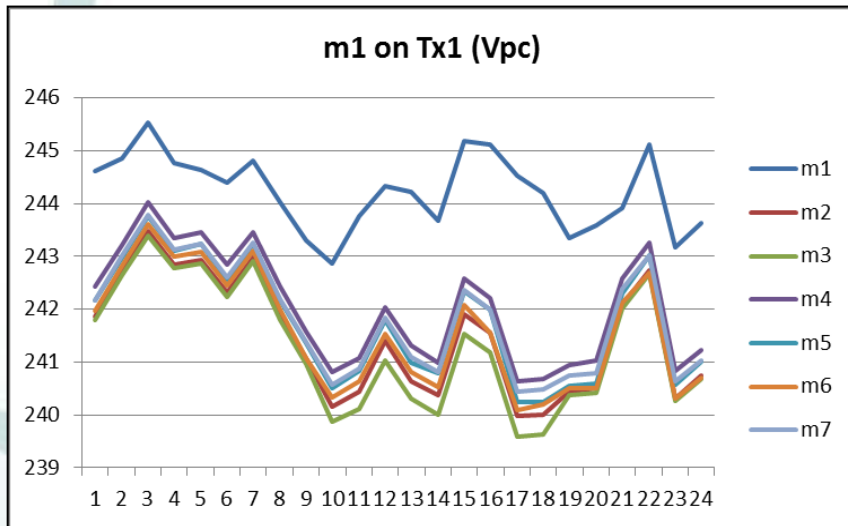
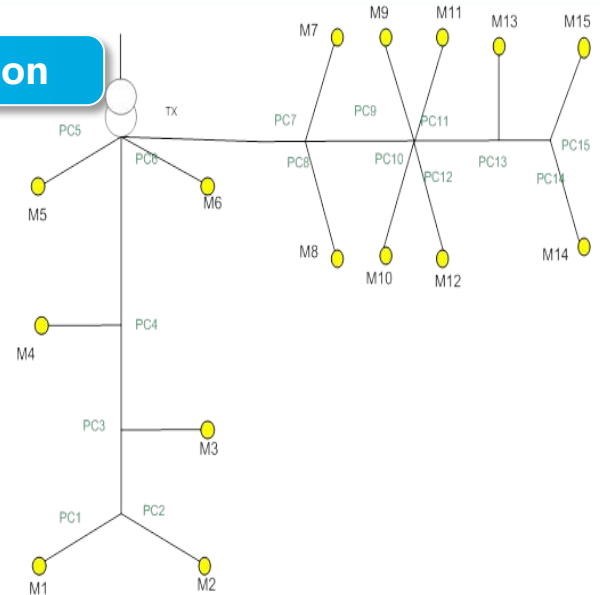


4. Data Analytics & Applications



Network topology generation & verification

- Based on meter, GIS, & SCADA data analysis
- Meter-transformer-feeder connectivity
- Transformer & feeder phase





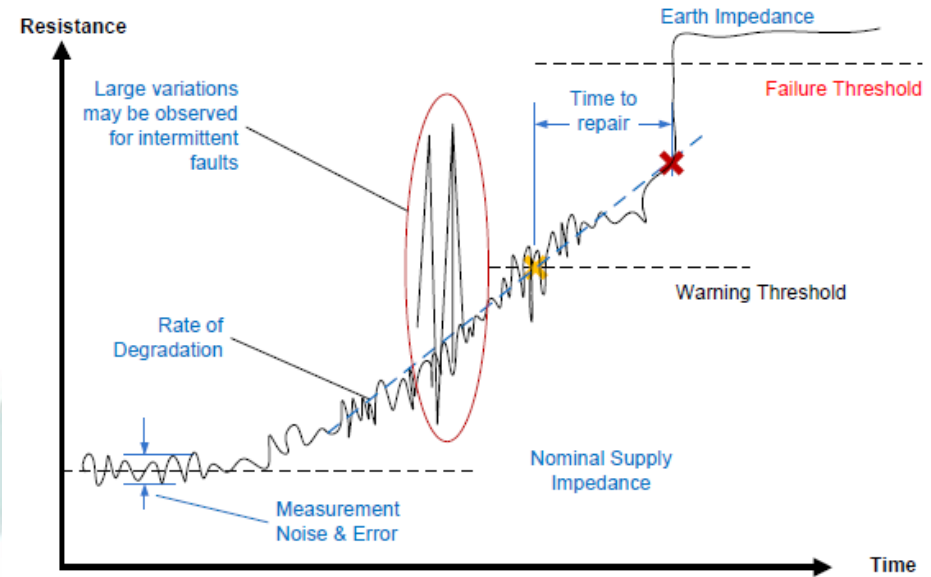
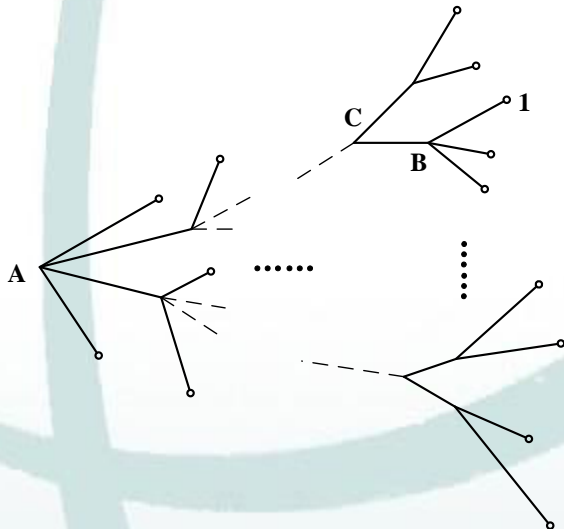
4. Data Analytics & Applications

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Secondary circuit parameter generation

- Using smart meter interval data and GIS to calculate branch impedance ($R+jX$)
- Circuit and device condition monitoring
- Assisting asset management



Source: Jemena



4. Data Analytics & Applications



Outage response & restoration

- Last gasp/first breath
- On-demand read
- Customer call verification

JEA NMR - Duval County School Board Facilities Outage Map

Map | Satellite | Hybrid

Zoom In

Monard Blvd N

Akers Dr S

Creeks Edge Rd

Star Rd

Miller Dr

Jonck Rd

W.D. Boyd

Lone Star Elementary School

100 ft

Mod data ©2006 Tele Atlas - Terms of Use

Last Reporting
Date/Time: 04-03-2006
15:00:15
Facility: Arlington Middle #213
Address: 10400 LONE STAR RD, JACKSONVILLE, FL, 32225
Status: on
Lat/Long: -81.528579,30.337631

Meter Status	Filter
Off	<input checked="" type="checkbox"/>
On	<input checked="" type="checkbox"/>
No Response	<input checked="" type="checkbox"/>

#66

- *Almacani Elementary #257
- *Andrew A. Robinson Elementary #262
- *Andrew Jackson High #35
- *Annie R. Morgan Elementary #21
- *Arlington Elementary #46
- *Arlington Heights Elementary #240
- *Arlington Middle #213
- *Atlantic Beach Elementary

Done

Start | 4 Windows ... | Microsoft Acti... | JEA NMR - D... | MDMS Web Vi... | Unread Mail ... | Microsoft Po... | 3:42 PM



4. Data Analytics & Applications

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Voltage and transformer load monitoring

Control Panel:

- Filter: []
- Filter: []
- Station: STATION_1, STATION_2, STATION_3, STATION_4, STATION_5, STATION_6, STATION_7, STATION_8
- Feeder: FDR_1, FDR_2, FDR_3, FDR_10, FDR_11, FDR_12, FDR_13, FDR_14

Monthly Transformers Loaded >80% 30T1

Month	Count
Jan	200
Feb	150
Mar	150
Apr	150
May	200
Jun	350
Jul	450
Aug	450
Sep	450
Oct	350
Nov	150
Dec	250

Transformer Loading

Transformer ID	Power	Description	Flow (kVA)	Rating (kVA)	Loading %
TRB_FX_77043020170	FDR_10	STATION_1	22172	7500	295.14
TRB_FX_77043020170	FDR_0	STATION_1	37544	7500	500.57
TRB_FX_77043020170	FDR_11	STATION_2	19086	7500	254.48
TRB_FX_77043020170	FDR_10	STATION_2	9676	6000	161.26
TRB_FX_77043020170	FDR_0	STATION_2	18400	7500	245.33
TRB_FX_77043020170	FDR_16	STATION_1	18636	7500	248.18
TRB_FX_77043020170	FDR_A	STATION_1	10004	7500	133.39
TRB_FX_77043020170	FDR_13	STATION_1	17660	7500	235.47

Transformer Loading Duration (TRB_FX_77043020170)

Transformer Profile (TRB_FX_77043020170)

Zoom: [All] [D] [W] [H] From: Dec 25, 2015 To: Jan 1, 2016

Profile (kVA)

Time: 25 Dec, 25 Dec, 30 Dec, 1 Jan



4. Data Analytics & Applications

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Device fault prediction

- Transformer failure early prediction

FPL is analyzing the history of each high-voltage transformer to identify the root cause

High-voltage Transformer Example

Enter an address, then select from the drop down that appears

Start: 1-10-2013 End: 03-08-2013 Premise/Address/TLN: [2114607] 19755 SW 302ND ST, 33030

Premise	Meter	Transformer	Lateral	Feeder	Phase	Substation	Address
2114607	[ACD1934] Q0205461934 - Bin	85233278401	85233317406	811361	A	ANHNGA	19755 SW 302ND ST HOMESTEAD, 33030

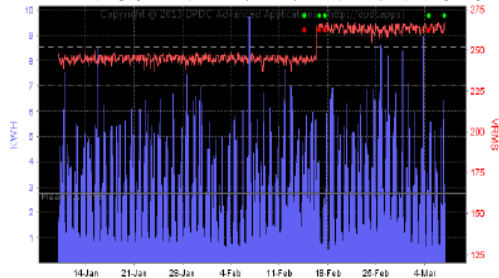
Event Summary: 2114607 [View All](#)

Count	Event Type
5	Power Restored
4	Power Down

Event Detail

Time	Event Type
3/7/13 4:14:37	Power Restored
3/4/13 22:08:55	Power Restored
3/4/13 22:08:50	Power Down
2/17/13 22:06:40	Power Restored
2/17/13 22:02:55	Power Down
2/17/13 2:03:43	Power Restored
2/17/13 2:03:38	Power Down
2/14/13 22:13:28	Power Restored
2/14/13 22:13:24	Power Down

ACD1934 Hourly Usage [Mean: 2.6 | StDev: 1.7 | Max: 9.7 | Min: 0.5 | Total: 3,701 | Daily Avg: 64.9]



Using voltage information, FPL can proactively identify and replace transformers before they cause an outage



High-voltage Transformer Replacement Program

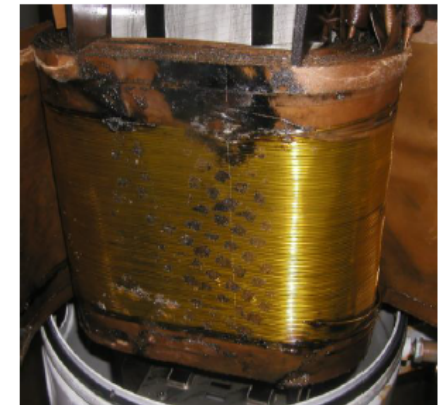
high-voltage transformers tied in November of 2012

high-voltage transformers only in the system

replaced since January

pending replacement of units | voltage above 252

priority of the units identified more than 15 years old



Damage to primary winding of high-voltage transformer identified through smart meters

Scheduled replacements reduce outage times by more than 93 minutes

Source: FPL



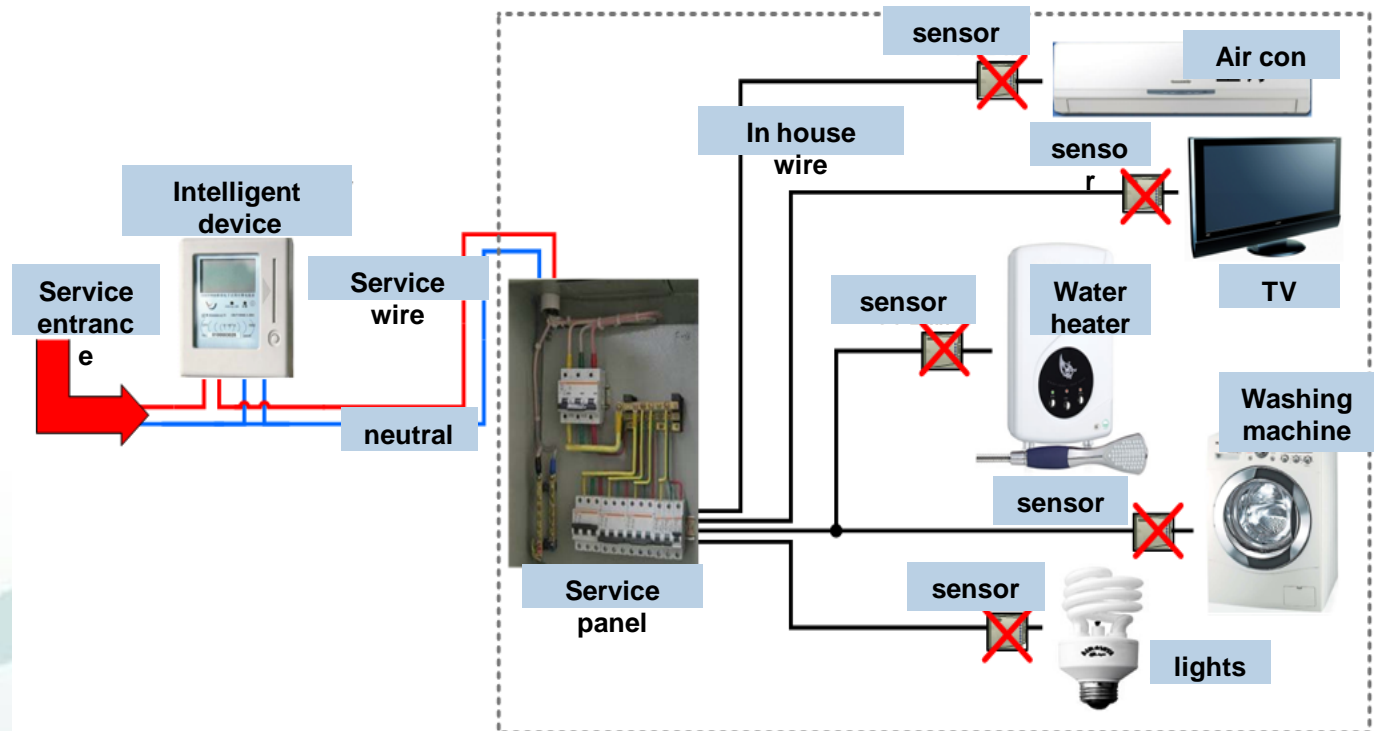
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Non-intrusive load monitoring

- Load modelling
- PQ monitoring and source identification
- Device condition monitoring
- EV and DG connection identification





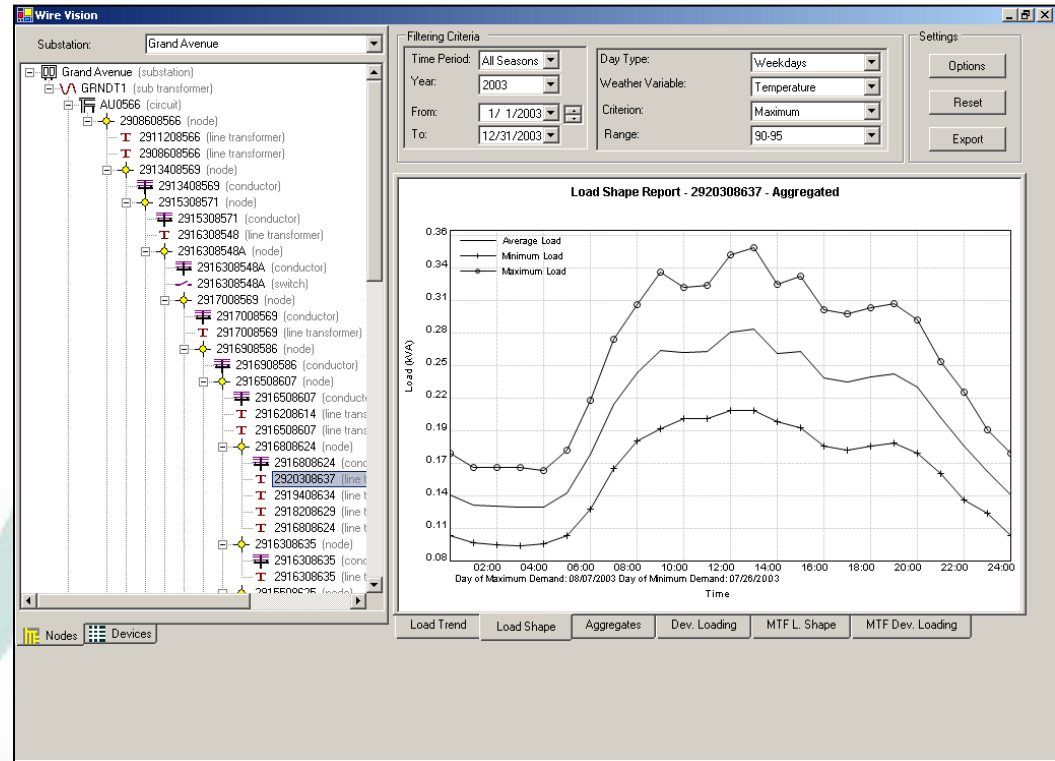
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Virtual metering to derive load profiles for any system point

- Optimize system improvement & capital investment
- Improve load balance and asset utilization
- System risk assessment
- Extreme weather response planning and resource allocation

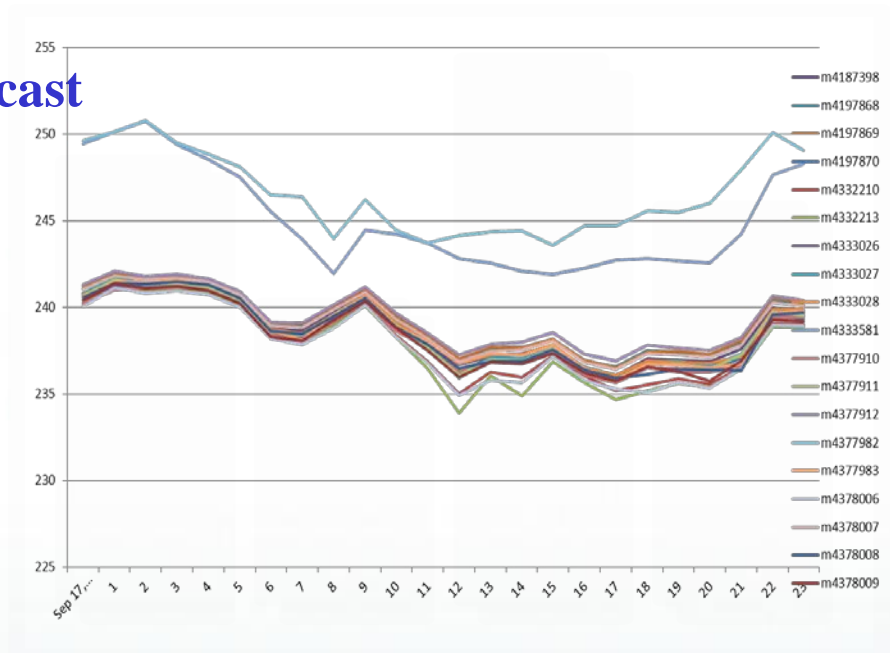




4. Data Analytics & Applications

■ Combine GIS and grid measurements

- Distribution station estimation
- Loss analysis
- Spatial load forecast
- etc





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Thank You !