Improving Distribution Reliability with Smart Fault Indicators and the PI System

Presented by Cameron D. Sherding, Sr. Software Engineer
Mark R. Blaszkiewicz, Manager IT
DTE Energy is an Integrated Energy Company

**Strong, Stable and Growing Utilities**

**DTE Electric**
- Electric generation and distribution
- 2.1 million customers
- Fully regulated by Michigan Public Service Commission

**DTE Gas**
- Natural gas distribution
- 1.2 million customers
- Fully regulated by Michigan Public Service Commission

**Complementary Non-Utility Businesses**

**Gas Storage & Pipelines (GSP)**
Transport and store natural gas

**Power & Industrial Projects (P&I)**
Own and operate energy related assets

**Energy Trading**
Generate economic value and provide strategic benefits

Utility / non-utility earnings mix of 80% / 20% evolves to 70% / 30% by 2018
Profile of DTE Electric

- Twelfth largest US electric utility with 2.1 million customers
- ~$5 billion in revenue, $17 billion in assets
- Regulated by the Michigan Public Service Commission (MPSC)
- Contributed nearly 64% of DTE’s 2014 earnings

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<th>Customer</th>
<th>Count</th>
<th>Load</th>
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<td>Residential</td>
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<tr>
<td>Commercial</td>
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<td>44%</td>
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<td>Industrial</td>
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Generation Capacity by Fuel Type
- Coal 63.4%
- Gas/Oil 17.3%
- Nuclear 10.4%
- Pumped Storage 8.9%

Total Capacity = 10,425MW

Service Territory / Generating Facilities
- 7 Fossil fuel generating plants
- 1 Nuclear power plant
- 1 Hydroelectric pumped storage facility

Distribution Assets
- 7,600 square-mile service area
- 671 distribution substations
- 12 Service Centers
- 46,000 miles of power lines

Customer Count Load
Residential 1,920k 34%
Commercial 197k 44%
Industrial 1k 22%

By 2015, DTE Energy will generate 10 percent of the electricity we provide for our Southeastern Michigan customers from renewable energy sources.

Initiatives like the Echo-Wind Park will help to produce energy from renewable sources like wind.
History of the PI System at DTE

1997
- Generation Fleet

2002
- Nuclear Generation

2004
- Distribution per Tag PI System

2007
- Enterprise Agreement
  - Fossil Fleet
  - 1M tags
  - Distribution SCADA historian
  - 500K tags

2010
- AMI Meters
- 8 PI Servers
- Dedicated AF
- 40M tags

2011
- Renewable Generation

2012
- Distribution PI System platform
  - AF
  - Web Services
  - PI Coresight

2013
- Gas Operations
  - PI Cloud Connect

2014
- Fossil Fleet AF
  - PI Integrator for Esri ArcGIS
Business Challenge

DTE is actively working to reduce customer outage minutes (CAIDI) on the distribution system.

1. Fault Locating
   – Many outages are result of faults on the line caused by vegetation, animals, cable, or equipment failures
   – Quickly locating the source of these faults is critical to minimizing restoration time

2. Low Cost Monitoring
   – Aging substations aren’t cost-effective to install full SCADA. Basic load data can provide valuable visibility into the system at these locations.
Fault Locating

Minimizing patrol distances can improve restore time
DTE Electric’s Distribution Operations

• 450,000+ tags in SCADA historian
• 29,000,000 tags and growing in AMI PI System

• PI to PI APS SCADA and DR historian to DO-PI

• PI Server 2012
• AF 2012
• PI Coresight 2013

HA configuration
(upgrading to 2014)
(upgrading to 2014)
Distribution PI System

- SCADA / EMS
- PI Server
- Firewall
- Distributed Resources
- PI Server
- Firewall
- PI to PI (APS)
- DO-PI
- PI Tools
- PI Integrator for Esri ArcGIS
- GIS
- Enterprise Service Bus
- Asset Management
- DMS
- AMI PI Server
- AMI
- Enterprise Service Bus
Fault Locating

SCADA / EMS → PI

Fault Sensors

Distributed Resources

PI to PI (APS)

Firewall

PI Integrator for Esri ArcGIS

DO-PI

Enterprise Service Bus

PI Tools

GIS

Notifications (XML)

Mobile Map

Device Health

DMS

Asset Management

Faulted Line, etc.

Computed Fault Location

Notifications (email/SMS)

Display Device Status
Asset Framework

Site-level Template
- Aggregate of all 3 phases at a location
- Notification Target

Sensor Base Template
- FAULT_INDICATOR

Sensor Child Templates
- FAULT_INDICATOR_Lighthouse_MV_SENSOR
- FAULT_INDICATOR_OUTAGE_ADVISOR_V1
- FAULT_INDICATOR_OUTAGE_ADVISOR_V2

X, Y, Z Phases
Asset Framework Details
Site-level Template

FAULT_INDICATOR_SITE

Attribute References:

Formulas:
Asset Framework Details

Sensor-level Templates

- **FAULT_INDICATOR**
- **FAULT_INDICATOR_LIGHTHOUSE_MV_SENSOR**
- **FAULT_INDICATOR_OUTAGE_ADVISOR_V1**
- **FAULT_INDICATOR_OUTAGE_ADVISOR_V2**

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Visualizing Data Using PI System Tools

PI System Tools like PI ProcessBook and PI Coresight allow engineers to easily view sensor data for planning and analysis.
Visualizing Data Using PI System Tools (cont’d)

- Web-based dashboard (PI AF SDK) gives quick overview of circuits
- Element-relative displays allow users to drill-down into sensor data

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Cooper GA2 Sensor Data

Communication Status

- Web-based dashboard (PI AF SDK) gives quick overview of circuits
- Element-relative displays allow users to drill-down into sensor data
Notifications

Email notifications

From: drsogcload-watch.com
To: sherding@load-watch.com
Subject: ALERT! SUSTAINED FAULT detected: REDFD1064
Date: 2015-04-09 01:40:00
Priority: Low

Character encoding: Western European (ISO-8859-1)

ALERT! Sustained Fault Detected

4/9/2015 1:40:45 PM Eastern Daylight Time (GMT-04:00:00)

Station: REDFD
Circuit: 1064
Location: NW HAZELTON 1PH PILGRIM
OH/UG: OH

Fault Status X: 1
Fault Status Y: 0
Fault Status Z: 0
Fault Current: 1617 Amps

Lat/Long: 42.405733, -83.266818
Sensor Type: FAULT_INDICATOR_OUTAGE_ADVISOR_Y1
Notifications

SOAP XML notifications

```xml
<soapenv:Body>
  <dms_ref>13</dms_ref>
  <device_id>REDFD1064</device_id>
  <fault_current_g>243</fault_current_g>
  <fault_current_max>1617</fault_current_max>
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  <notification_trigger_time>2015-03-25 01:05:19</notification_trigger_time>
</soapenv:Body>
```
Mapping Fault Status

- Initial proof of concept: Developed Windows service using PI AF SDK to push fault events into the GIS database
Mapping Fault Status (cont’d)

• Next steps: Moving from PI AF SDK service to PI Integrator for Esri ArcGIS
• This has also been through proof-of-concept phase
• Expecting full roll-out Q2 or Q3

Normal
Abnormal
PI Integrator for ArcGIS Configuration

- Template and root element is selected in PI Integrator
- Key fields are identified (key, Latitude, Longitude)
- StreamServer is created and started
Operationalizing the Data

- Circuit Level outage on MANDY0308 at 6 AM
- Based on previous circuit history, initial response from SOC was to treat circuit outage as a cable fault
- Overhead supervisor had access to data from a rapid experiment utilizing mobile map overlaid with fault data from intelligent field devices
- Overhead supervisor guided crew to the section of the circuit impacted by the fault, reducing patrol time
- Cause was a tree taking down XY phase on overhead
- Determination could have been made within 5 minutes of initial outage to send crew to do restore before repair
- Sensors currently installed on 95 circuits as part of efficient frontier fault locating program
DTE Energy: Reliability Through Innovation

“As an innovative utility, we were looking for solutions to get more real-time reliability data out of our distribution grid, particularly on older legacy and poorly performing circuits.”

“Now that we have better real-time visibility into our grid, we can safely restore power faster and better plan our capital investments around aging assets before they cause outages.”

Vince Dow
Vice President, Distribution Operations, DTE Energy

Business Challenges

• Determining where to send crews during outages to minimize patrol time
• Integrating data from different types of sensors with multiple backend systems
• Allow crews to visualize real-time sensor data in the field and engineers to visualize historical data in the office

Solution(s)

• Feed all sensor data into PI System using PI Interface for DNP3
• Utilize Asset Framework and Notifications to push events to field and DMS
• PI Coresight and PI ProcessBook to visualize historical data
• Utilize PI integrator for Esri ArcGIS

Results and Benefits

• Visualization of sensor status on circuit map allows crews to divide circuit into segments and narrow search for faults. Expecting to eliminate at least 500k customer outage minutes annually
• History of device operation and circuit data gives valuable visibility into legacy parts of the system. Savings estimated at $25k per circuit.
Cameron D. Sherding
sherdingc@dteenergy.com
Sr. Software Engineer, Power Systems Technology
DTE Electric Company

Mark R. Blaszkiewicz
blaszkiewicz@dteenergy.com
Manager, IT
DTE Energy
Questions

Please wait for the *microphone* before asking your questions

State your name & company
THANK YOU