Smart Grid & Planning for Renewables

OSBEELS Energy & Sustainability Symposium

Darren Murtaugh
T&D Planning

Kellie Cloud
Substation Operations Technology

September 22, 2017
Who is PGE?

For more than 125 years, we’ve proudly championed a vibrant Oregon — providing safe, reliable and cleaner energy solutions to our region.

We are deeply committed to helping our communities prosper and connecting our customers to innovative solutions they can depend on to energize their changing lives.
Snapshot of PGE

Our people

2.7K
Number of PGE employees

42K
Volunteer hours contributed by PGE employees

$1M
Philanthropic contributions by PGE and our employees
Snapshot of PGE

Our customers

862K and 756K
Number of PGE customers, total and residential

51 and 6
Number of cities and counties in our service territory

4,000
Number of square miles in our service territory
Snapshot of PGE
Our system

1,598 and 26,544
Circuit miles of transmission and distribution lines

174
Number of T&D substations

4,073 and 3,974
MW of winter and summer peak load
Snapshot of PGE

Our energy

Energy Priorities

• Safe
• Reliable
• Affordable
• Clean
• Secure

50% by 2040
Energy to come from renewable sources

2016 Power Mix

- Purchased Power 32%
- Natural Gas 27%
- Coal 16%
- Hydro 15%
- Wind & Solar 10%
Take a tour of the smart grid with PGE
T&D System Investments

Asset Management
Proactive replacement of aging infrastructure & high risk facilities

Grid Modernization
New technologies to improve system operability

Integrated Grid
Integrating distributed & renewable resources into T&D Operations

Shaping today’s grid to meet tomorrow’s needs.
# Smart Grid Foundation

## Advanced Metering Infrastructure
- > 850,000 customer meters installed

## Systems Deployment
- Geographic Information & Outage Management Systems Deployed;
  Customer Information & Meter Data Management Systems in flight

## Asset Management
- Proactive aging infrastructure replacement, risk assessment

## Analytics Capabilities
- Transmission & Distribution Analytics Pilot,
  Energy Tracker Customer Insight

## Grid Modernization Pilots
- Synchrophasors
- Volt-VAR Optimization
- Distribution Automation

## Communications Upgrades
- Spectrum procurement & infrastructure modernization

## Salem Smart Power Center
- 5MW battery testing facility

## Customer Programs/Pilots
- Dispatchable Standby Generation, Energy Partner, Smart Thermostat, Flex Pricing Pilot
Asset Management

Proactive replacement of high risk facilities
Asset Management

- Advanced System Models
- Risk Assessments
  - Likelihood of Failure
    - Age of asset(s)
    - Reliability trends
    - Exposure to outages
  - Consequence of Failure
    - Impact to customers
- Maintenance or Proactive Replacement
  - Increased capital investment
- Improved Analytics
  - Proactive failure identification
  - System model adjustments
T&D Resiliency Initiative
What it means for our customers

Our resiliency focus

- Add physical hardening to substations
- Make seismic upgrades
- Increase cybersecurity
- Strengthen and enhance our technology
- Replace and upgrade aging infrastructure
Downtown Portland Service

13

Portland General Electric
Stephens Substation

Decommission and replace network service

- Last major overhaul in the 1950’s
- Standardize distribution voltage
- Replaces river-crossings
- Lead cable replacement
- Maintenance requirements
Marquam Substation

Unique project highlights

- $80MM project
- Underground Transmission
- Gas Insulated Switchgear (GIS)
- Full network backup
- Advanced sensing & monitoring

http://www.powereng.com/visual/PGE_Marquam/#
Substation Design Changes

Traditional Air Insulated Substation

New Gas Insulated Substation
Grid Modernization

New technologies to improve system operability
Grid Modernization

- Situational Awareness
  - Synchrophasors
  - State Estimation
  - Real Time Contingency Analysis
  - Distribution Management System
- Transmission Flow Control
  - Non-wires alternatives
- Distribution Grid Improvements
  - Volt/VAR Optimization (VVO)
  - Supervisory Control & Data Acquisition (SCADA)
  - Faulted Circuit Indication (FCI)
  - Distribution Automation (DA)
- Data Network Operations
  - Wireless Spectrum
  - Communications Upgrades
- Security Operations
  - Physical & Cyber

New technologies to improve system operability
Distribution Automation

Automatically reconfigure feeders to restore power during an outage.

Requirements:
• Additional feeder capacity
• Substation SCADA
• Intelligent switching devices
• Fault location capability
• Reliable communications
• Centralized logic & control
• Safety procedures & training
Distribution Automation

Current Installations

One installation at Gales Creek
Two pending in Gresham

2018 Plans

$2M reserved for Non-Asset Risk
Average cost: $500k/installation

Future Plans

6-10 schemes per year
Data Network Operations

Source: Public Utilities Fortnightly
Communications Upgrades

Field Voice System
- 220 MHz spectrum
- Digital Mobile Radio
- Entire service territory
- Safety & Efficiency Improvements

Field Data System
- 700 MHz spectrum
- Distribution Automation
- Volt/VAR Optimization
- Other Grid Modernization efforts

Digital Conversion
- Conversion to MPLS network (packet)
- Termination of leased analog circuits
- Enables bandwidth management & service prioritization
Integrated Security Program

Protecting the power system, customer information and employees

- Integrated approach to cybersecurity and physical security
- Information Technology (IT), Operational Technology (OT) and the interface with Customer Technology (CT)
- Legacy and modern technologies
Integrated Grid

Integrating distributed and renewable resources into the T&D planning process
Integrated Grid

- Renewable Energy Integration
  - Energy Imbalance Market (EIM)
- Distributed Energy Resources (DERs)
  - Rooftop & community solar
  - Smart Inverters
  - Energy storage
  - Dispatchable Standby Generation (DSG)
  - Microgrids & islanding
- Demand-side Management
  - Flex Pilot Pricing
    - Time of Use (TOU)
    - Peak-time rebates
  - Demand Response (DR)
- Transportation Electrification
Current & Future Landscape

- **79 → Over 220 MW_{DC}**
PV on distribution system

- **13 / 107 → 250 MW / 150 MW**
Enabled Demand Response & Dispatchable Standby Generation

- **7,000 → 200,000**
EV in service territory

- **2,600 → 100,000**
Integrated Customer Devices

- **717 → Over 2,000 MW**
Wind Generation

- **1.25 → 100 MWh**
Available Energy Storage

- **865 → 6,500**
Public EV Charging Stations

- **75 / 0.48 → < 75 / 0.48**
Reliability: SAIDI / SAIFI*
Energy Imbalance Market (EIM)

- Automatically dispatches lowest-cost electricity
- Helps balance energy supply and demand
- Makes it easier to add more renewables into our mix
- Keeps our grid stable, secure and reliable

- Joining EIM in 2018
- Currently participating in EIM
Distribution System Evolution

Model & Monitor
Grid Modernization
DER Integration
DER Optimization

Customer Adoption

DER Penetration

Time

PGE Today

T&D System

Portland General Electric
Distribution Resource Planning

Determining hosting capacity and locational value

- Accurate distribution system model
  - Capacity
  - Two-way power flow
  - Resource output forecasting

- Grid modernization status
  - Data Network
  - SCADA & Protection
  - Potential resource value streams

Source: OATI
Energy Storage

Batteries can provide up to 13 services to three stakeholder groups.

Source: Rocky Mountain Institute

Source: Project Design Engineers
Storage: Activities Underway

**Salem Smart Power Center**
- 5 MW/1.25 MWh battery in Salem, OR
- Frequency Regulation
- Reactive Power Support
- Voltage Control Utilizing VAr Control

**Residential Energy Storage**
- Testing two utility-controlled residential batteries
- 14 kW/45 kWh
- Ability to aggregate distributed resources for local or system benefit
- Customer Reliability

**Vehicle to Grid**
- Testing utilization of customers’ vehicle batteries
- Demonstration project with 1 10-kW bidirectional charger
- Potential to shift loads and generation over time and place
Storage: Looking Forward

- PGE is currently evaluating options:
  - Substation
  - Mid-Feeder
  - Residential programs
  - Solar/renewables integration
  - Microgrids for community resiliency

- Long-term: a diverse mix of energy storage assets will be a critical piece to support increase flexibility on our system and support realization of 50% renewables mandate.

In 2015, the State of Oregon legislature directed Oregon’s large electric companies to submit proposals for qualifying energy storage systems with the capacity to store at least 5MWh of energy no later than January 1, 2018.
“One cannot be prepared for something while secretly believing it will not happen.”

- Nelson Mandela
Questions?
Appendix: Smart Grid Roadmap
125 Years of Innovation:
For more than 125 years, we’ve been modernizing our grid and building one of the most reliable systems in the country.

Description:
Hardware and software that
• Enable deployment of smart grid initiatives
• Allow customers to realize maximum value of smart grid initiatives
• Improve system cybersecurity

Goals:
Ensure all necessary hardware and software is in place to enable effective deployment of smart grid initiatives

Considerations:
Timelines are approximate and contingent on project funding, viability, and necessary regulatory approvals.
Schedule will change as necessary.
### Smart Grid Roadmap: Grid Optimization

#### Description:
System hardware, tools, and customer programs that automate processes and improve situational awareness to reduce system risk and improve reliability of the transmission & distribution networks by:
- Improving restoration time
- Avoiding outages
- Informing investment & design

#### Goals:
Maintain and improve high-level of reliability despite changing conditions on grid (i.e. penetrations of DERs, RPS, etc.):
- Expanding SCADA to 100% of substations
- Improve reliability metrics
- Reduce system risk
- Expand CVR deployment
- 5 MWh Energy Storage Deployed

#### Considerations:
Timelines are approximate and contingent on project funding, viability, and necessary regulatory approvals. Schedule will change as necessary.

<table>
<thead>
<tr>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategic Deployment of SCADA (Supervisory Control and Data Acquisition) and Substation Automation (Automated Switching &amp; Protection Schemes)</strong>&lt;br&gt;• At new and existing substations as a part of system upgrades or risk reduction efforts</td>
<td><strong>Substation Remote Access Server</strong>&lt;br&gt;Communications Pilots&lt;br&gt;• Operational Efficiency&lt;br&gt;• Cyber Security</td>
<td><strong>Distribution Automation Pilots</strong>&lt;br&gt;Strategic Deployment of Distribution Automation&lt;br&gt;• Investment designed to reduce system risk</td>
<td><strong>Conservation Voltage Reduction Pilots</strong>&lt;br&gt;Strategic Deployment of CVR&lt;br&gt;• Deployed where feasible and necessary to meet IRP goals</td>
<td><strong>Salem Smart Power Center Use Case Demonstration</strong>&lt;br&gt;Storage Planning (HB 2193)&lt;br&gt;Storage integrated into asset mix&lt;br&gt;New Storage Procurement</td>
</tr>
</tbody>
</table>

Legend:  
- **Model & Monitor:** Plan Ahead  
- **Engage:** Successfully Pilot  
- **Integrate:** Move to Scale
**Smart Grid Roadmap: Customer Engagement**

**Description:**
Customer programs and grid resources that save customer money by:
- Enhancing the ability to integrate renewable resources and distributed generation
- Promoting wise and efficient use of energy
- Increasing capacity utilization on existing assets
- Enabling integration of smart devices

**Goals:**
Develop an effective portfolio of demand-management and grid resources to effectively optimize new and existing system resources.
- 77 MW of customer-enabled demand response by 2021
- 5 MWh Energy Storage Deployed
- Accelerate transportation electrification

**Considerations:**
Timelines are approximate and contingent on project funding, viability, and necessary regulatory approvals. Schedule will change as necessary.

---

<table>
<thead>
<tr>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demand-Side Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distributed Standby Generation (DSG) Strategic Program Growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Partner Pilot</td>
<td>Energy Partner Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm Load Reduction Program (Curtailable Tariff); Product Development</td>
<td>C&amp;I Curtailable Tariff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rush Hour Rewards</td>
<td>Smart Thermostat Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Thermostat DR</td>
<td>• Possible expansion beyond Nest and inclusion of other smart devices &amp; customer classes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flex Pricing Pilot</td>
<td>Flex Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Res. Behavioral DR, Time-of-Use Rates (TOU), Peak Time Rebates (PTR)</td>
<td>• Most effective options scaled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microgrid Planning</td>
<td>Microgrid (MG) Demonstration</td>
<td>Storage/MG Customer Program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Demonstration Projects &amp; Program Planning</td>
<td>Potential Storage Customer Pilot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPA Smart Water Heater Research &amp; Demonstration Project</td>
<td>New Smart Water Heater Standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Test the technology (~100 customers)</td>
<td>• New communications socket on all new water heaters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Electric Vehicles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation Electrification Plan</td>
<td>Transportation Electrification Plan Pilots (SB 1547, AR599)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EV Charging DR Demonstration</td>
<td>Potential Smart Charging Pilot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle to Grid, Resiliency, Ancillary Services, and 2nd life battery R&amp;D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:  
- **Model & Monitor:** Plan Ahead  
- **Engage:** Successfully Pilot  
- **Integrate:** Move to Scale