Smart Grid & Planning for Renewables

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Darren Murtaugh T&D Planning

Kellie Cloud Substation Operations Technology

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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



2016 Power Mix

Take a tour of the smart grid with PGE



T&D System Investments



Asset Management

Proactive replacement of aging infrastructure & high risk facilities

Shaping today's grid to meet tomorrow's needs.



Grid Modernization

New technologies to improve system operability



Integrated Grid

Integrating distributed & renewable resources into T&D Operations

Smart Grid Foundation



Advanced Metering Infrastructure

> 850,000 customer meters installed



Grid Modernization Pilots

Synchrophasors Volt-VAR Optimization Distribution Automation



Systems Deployment Geographic Information & Outage

Management Systems Deployed; Customer Information & Meter Data Management Systems in flight



Communications Upgrades

Spectrum procurement & infrastructure modernization



Asset Management Proactive aging infrastructure replacement, risk assessment



Salem Smart Power Center 5MW battery testing facility

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Analytics Capabilities

Transmission & Distribution Analytics Pilot, Energy Tracker Customer Insight



Customer Programs/Pilots Dispatchable Standby Generation, Energy

Dispatchable Standby Generation, Energy Partner, Smart Thermostat, Flex Pricing Pilot

Asset Management

Proactive replacement of high risk facilities





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



Downtown Portland Service



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

PGE



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

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

PGE



Integrating distributed & renewable energy resources



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







13 / 107 ➡ 250 MW / 150 MW Enabled Demand Response & Dispatchable Standby Generation









865 ➡ 6,500 Public EV Charging Stations

1.25 **→** 100 MWh

Available Energy Storage

75 / 0.48 > < 75 / 0.48 Reliability: SAIDI / SAIFI*

Energy Imbalance Market (EIM)



Currently participating in EIM

Distribution System Evolution



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



Energy Storage



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 utilitycontrolled 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

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.

Storage: Looking Forward

- PGE is currently evaluating options:
 - o Substation
 - o Mid-Feeder
 - Residential programs
 - o Solar/renewables integration
 - o 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.

"One cannot be prepared for something while secretly believing it will not happen."

- Nelson Mandela



Questions?



Appendix: Smart Grid Roadmap



Smart Grid Roadmap: Foundation PGE

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.

	2017		2018	201	9	2	020	2021	
vare	AMI Fully Deployed								
Hardv	Comm. Pilots	Continuc • Strategi	ous Communic c expansion of	ations Upg infrastructu	jrades ure mode	rnization	at all substa	ations	
Software	New Systems Outage Man Transmission 	a Deployed Dagement S Doutage N	d & Integrated System, Geogra Management Sy	l phic Inform /stem	nation Sys	stem			
	T&D Tools De • Energy Mgmt Real-time Cor	e ployed 8 . System Sta ntingency A	ι Integrated ate Estimator, nalysis Tool						
	Dis (Di •	stribution MS) Use Case	Management Planning	System	Potenti Procure	al DMS ement			
	Energy Inforr Replacement	nation Sys	stems (EIS) Int • Ene aunch • Ene	e grated ergy Tracker ergy Expert					
	CET Customer Touch Points Project Customer Information & Meter Data Management Systems Build/Design/Test Launch								
	Expansion of Analytics Cap • T&D Analytic	abilities cs Pilot	Advanced Gr • Expanded	id Analytic Utilization &	s १ Use Cas	ses •	n tegrated G Expanded Use Cases	irid Analytics Utilization &	
									3
еде	nd: Model & N	Monitor: Pl	an Ahead	Engage: Suc	cessfully	Pilot	Integrate:	Move to Scale	

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Smart Grid Roadmap: Grid Optimization

Model & Monitor: Plan Ahead

Legend:

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.

	2017	2018	2019	2020	2021	
	Strategic Deploym Substation Autom • At new and existin	nent of SCADA (Sup ation (Automated S ng substations as a p	pervisory Control an Switching & Protect part of system upgra	nd Data Acquisition tion Schemes) des or risk reduction	and efforts	
Control	Substation Remot Communications Pilots	 Access Server Operational Eff Cyber Security 	ïciency			
nation & (Distribution Automation Pilots	Strategic DeploynInvestment design	nent of Distributior ned to reduce syster	n Automation n risk		
Auton	Conservation Voltage Reduction Pilots	Strategic Deploy Deployed whe 	ment of CVR re feasible and nece:	ssary to meet IRP gc	pals	
	Salem Smart Powe	er Center Use Case I	Storage integrate	d into asset	o asset	
	Storage Planning (HB 2193)	New Storage Proc	curement	mix		
tuational Awareness	Synchrophasor Pilot • At 3 Subs	Synchrophasor De • Deployment at ac	ployment Iditional substations			
	Distribution Fault Detection Pilot	Strategic Deployn System • Deployment at 10	ent of Fault Circuit	t Indicators on Dist	ribution	
	 Smart Inverter Planning/Standard Development Monitor UL1741 & IEEE1547 Anticipated involvement in OPUC workshops Potential Customer Smart Inverter Pilot Deployment and Volt-Var Optimization					
Si		Assess Utilization Risk Reduction	of DERs for T&D	Locational Distrib Resources Pilot	uted Energy	37
					-	

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.

	2017	2018	2019	2020	2021		
Demand-Side Management	Distributed Standby Generation (DSG) Strategic Program Growth						
	Energy Partner Pi	lot	Energy Partner Pr				
	Firm Load Reduct	tion Program (Curta	ilable Tariff);	Curtailable			
	Proc	luct Development	C&I Curtailable Ta	ariff			
	Rush Hour Rewards • Thermostat DR	mart Thermostat Pro Possible expansion b customer classes	ogram eyond Nest and inclu	usion of other smart	devices &		
	Flex Pricing Pilot • Res. Behavioral DR (TOU), Peak Time F	, Time-of-Use Rates Rebates (PTR)	Flex Program • Most effective op	tions scaled	:		
	Mass Market Wat Heater DR Pilot Development	ter Mass Market W Response (ADR	/ater Heater Autom 3) Pilot	nated Demand	Water Heater ADR Program		
	Microgrid Planning		Microgrid (MG) Demonstration		Storage/MG		
	Storage Demonstr Program Planning	ration Projects &	Potential Storage	Customer Pilot	Program		
	BPA Smart Water Demonstration P • Test the technolo	r Heater Research & roject ogy (~100 customers	New Smart Wat • New communic heaters	er Heater Standard ations socket on all	new water		
venicies	Transportation Electrification Plan	Transportation Ele (SB 1547, AR599)	ectrification Plan Pi	lots	Transportatior Electrification Programs		
	EV Charging DR I	Demonstration	Potential Smart Charging Pilot				
-	Vehicle to Grid, R	Resiliency, Ancillary	Services, and 2 nd lif	e battery R&D			

Engage: Successfully Pilot

Electric