Distribution System Highlights

Portland General Electric

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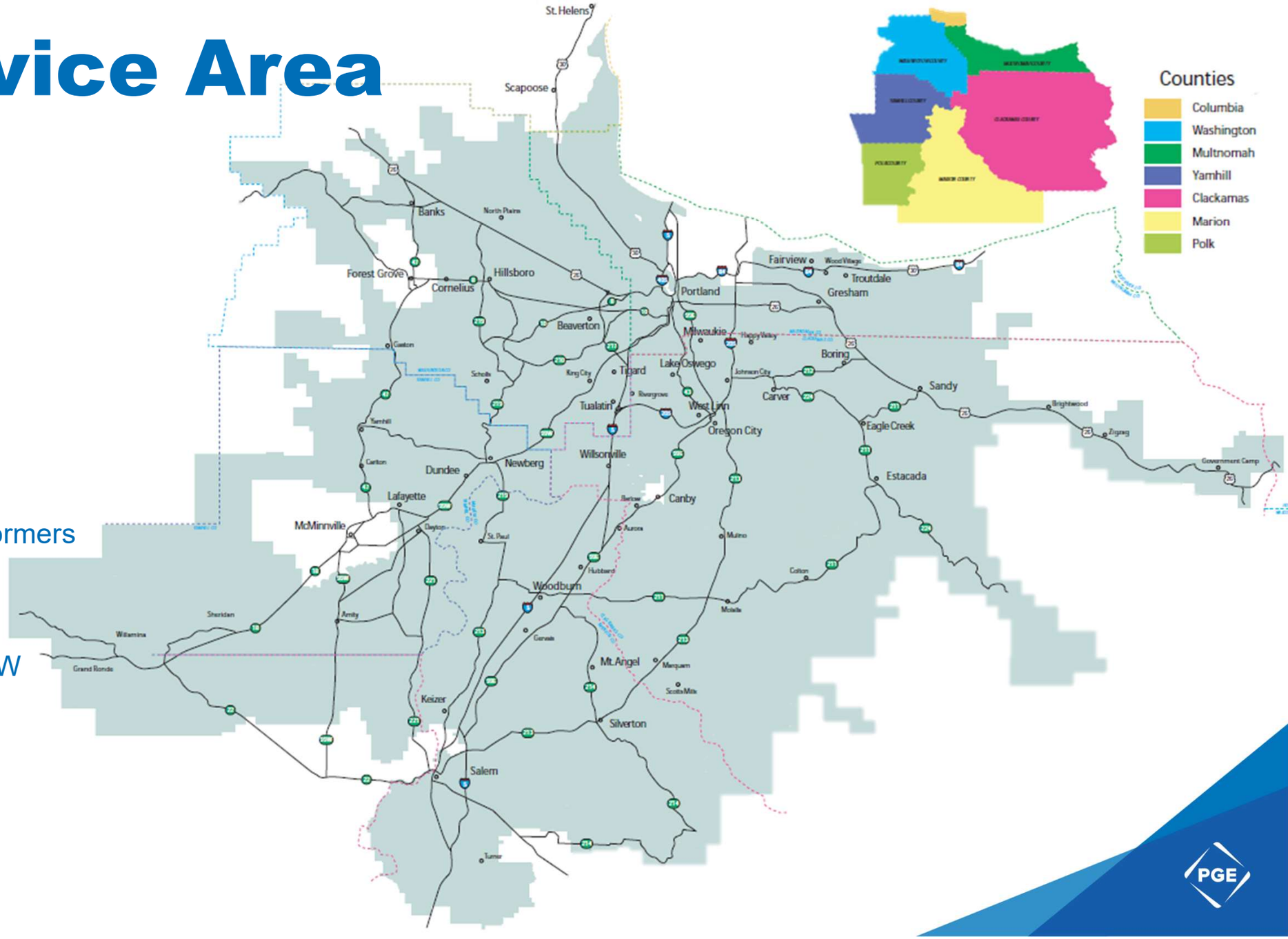
PGE Service Area

1.9 million population
4000 square miles
895,000 Customers

149 distribution substations
300 distribution power transformers
643 distribution feeders

Peak summer NSL – 3976 MW
Peak winter NSL – 4073 MW

*Net System Load



Distribution Interconnections

Distribution System Highlights

Three Areas of Interest

- Distribution System

  Conductors, Equipment and Protective Devices

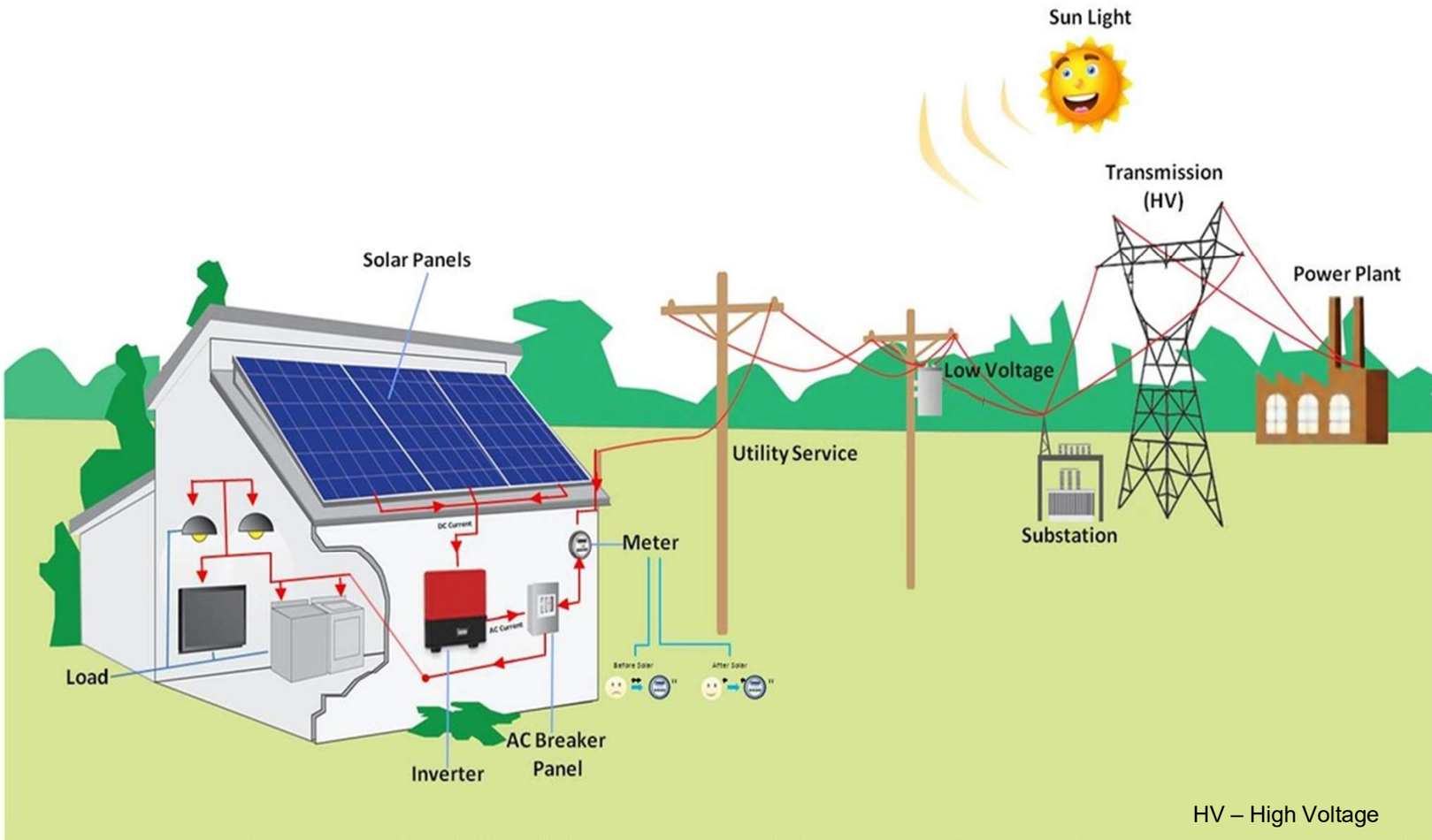
- Distribution Substation

  “Inside of the Fence”

  Transformers and Protective Devices

- Transmission System

  Conductors, Equipment and Protective Devices



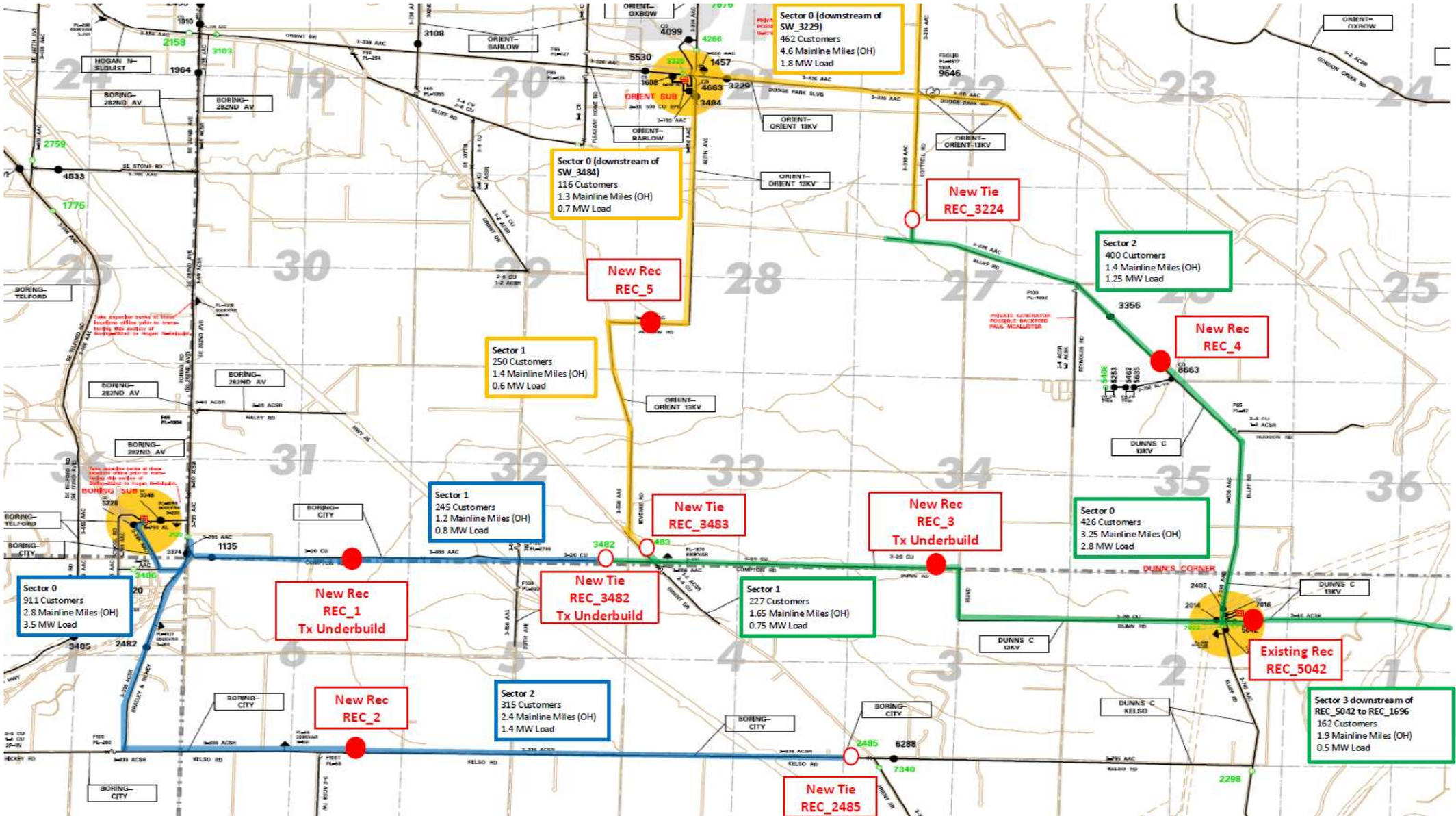
HV – High Voltage

Distribution Automation (DA)

Distribution System Highlights

- Utilizes Switching Devices to Automatically Isolate Faulted Areas and Restore Power to the Remaining Areas
- Four Active DA Fault Location Isolation and Service Restoration (FLISR) Solutions
- Enhanced Visibility – Communicating Reclosers Provide Additional Monitoring on the Distribution System
- Existing and Future Solutions to Migrate To Field Area Network (FAN)

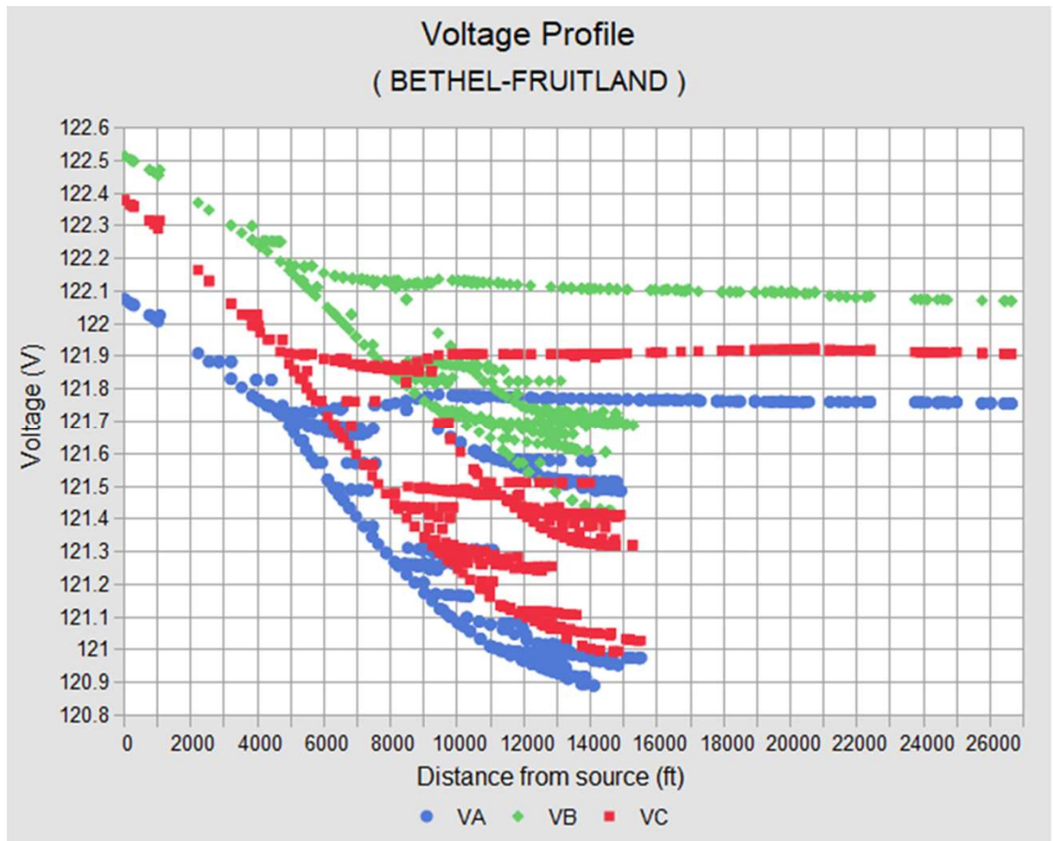
Example DA Solution



Distribution System Highlights

Volt-VAR Optimization

- Voltage Control Devices
  - Load Tap Changers
    - Load Drop Compensation
  - Substation Capacitor Banks
  - Field Capacitor Banks
  - Voltage Regulators



Distribution System Highlights

System Monitoring

- 100% AMI Meters
- Distribution Substation Monitoring
  - 82.5% SCADA Enabled
  - 16.7% MV90
  - 0.8% Unattended

Communicating Devices

- Fiber Network
- Leased Services
- Microwave Systems
- Cellular Services
- Field Area Network

Distribution System Highlights

Performance

- 99% of customer outages originate at the distribution level
- Inspection programs aim to proactively address risk and avoid outages
- PGE does not permit equipment to load beyond its maximum thermal loading capability as established by PGE's facility ratings methodology and standards.
  - Load-serving capacity is reserved on feeder mainlines, transmission circuits, and major equipment so that no system element will exceed its max thermal loading following disruption to any other single T&D element, enabling quick restoration of service.
  - Performance is evaluated to see if a system element may be physically limited beyond what has been defined as its thermal loading capability. When modeled or demonstrated performance violates PGE's standards for power quality and reliability, PGE sets a capacity limit to mitigate concerns of power quality or reliability.
- Outage response
  - Dispatch an Eagle (Single-Man Line Truck) via Outage Management System (OMS)
  - Eagle Assesses Scenario and may a) perform repair, or b) request assistance for repair
- PGE's performance over the past 6 years

Outage Year	SAIDI	SAIFI	MAIFI	CAIDI
2014	95	0.7	1.3	136
2015	75	0.48	1.2	156
2016	97	0.59	1.1	163
2017	113	0.62	1.4	181
2018	88	0.52	1.3	172
2019	98	0.61	1.3	160

Distribution System Highlights

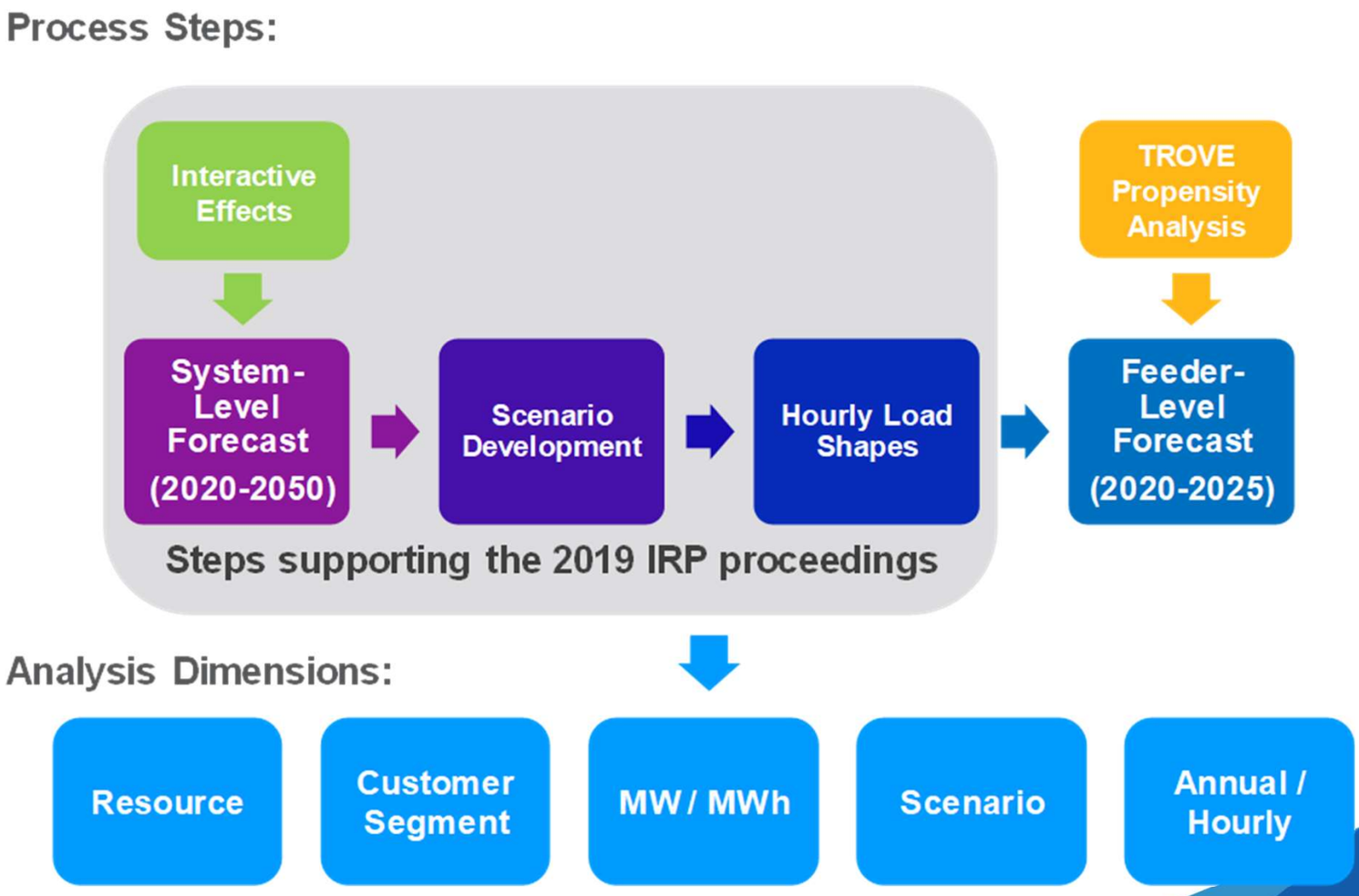
DERs: Current Deployment

DER Type	Value	Units
Diesel	152.2	MW
Solar PV	117.3	MW
Other	5.6	MW
Distributed Energy Storage	81	Batteries
Demand Response	35.4	MW (as of May 2019)
Energy Efficiency	368,713	MWh at bus bar (2018)
Electric Vehicles	13,894	Vehicles (year end 2018)

- Sources: Interconnection, customer programs, Energy Trust, Clean Fuels Tracking

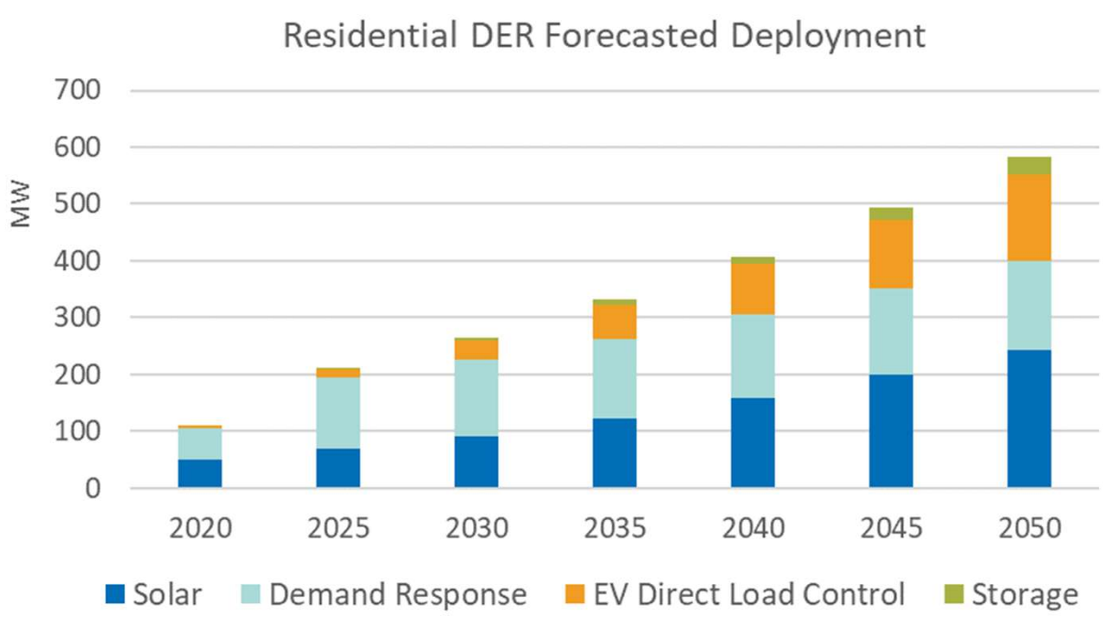
Distribution System Highlights

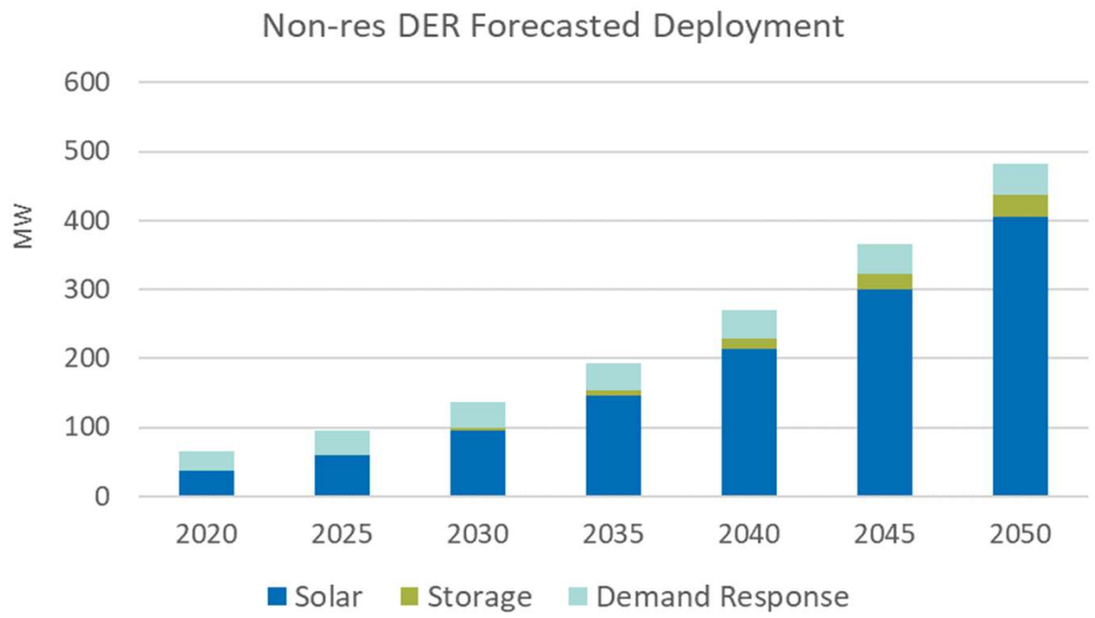
DERs: IRP Methodology



DERs: Forecasts by Type

Distribution System Highlights





Source: Navigant DER Forecast for 2019 PGE IRP

Distribution System Highlights

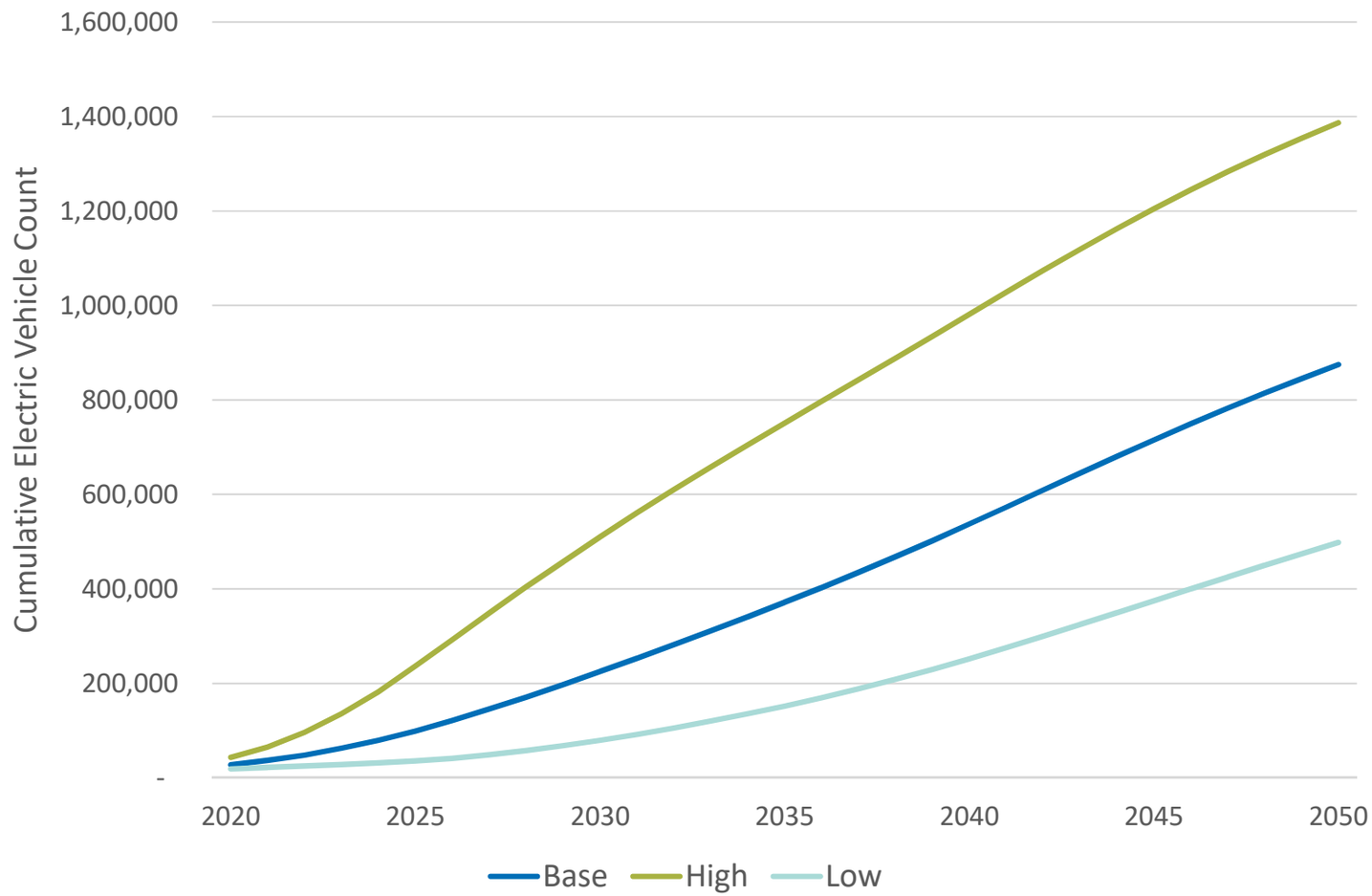
DERs: Sensitivity Scenarios

Technology / Driver	Technology Costs	Policies	Carbon Prices	Pricing
Overall Effect	Higher technology costs	Less favorable policies for DER	Lower carbon prices in electricity and gasoline	No TOU participation
EE	Energy Trust Cost-Effective Scenario (same as Base Case)			
DR	-50% by 2030		No change*	0% residential TOU
Solar	High PV $	Decreased marketing	Low carbon $	
Storage	High Li-Ion $			
EV		Decreased vehicle availability + vehicle production + marketing		

* Given no energy impacts estimated

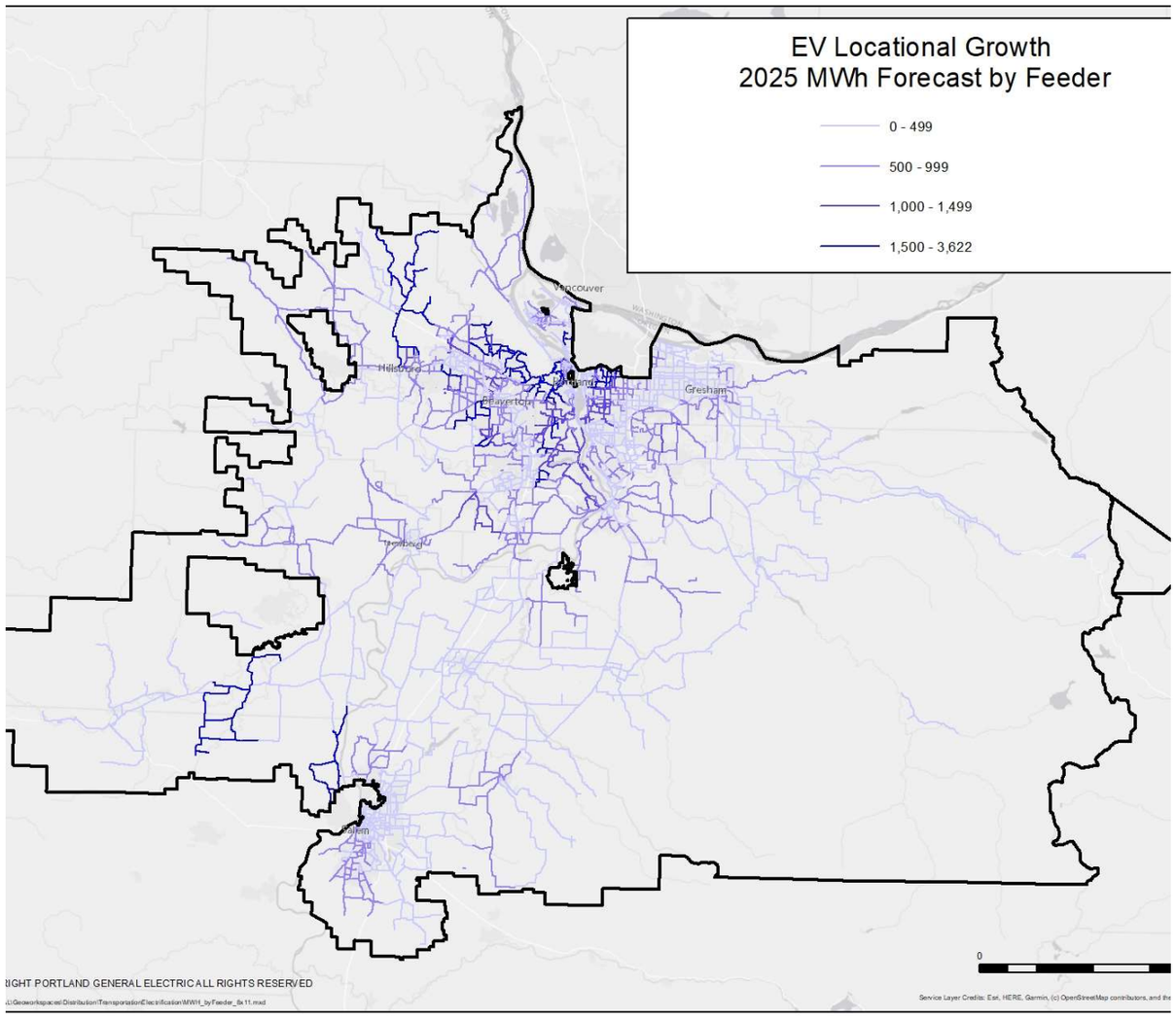
Distribution System Highlights

DERs: EV High & Low Forecast



Source: 2019 PGE TE Plan

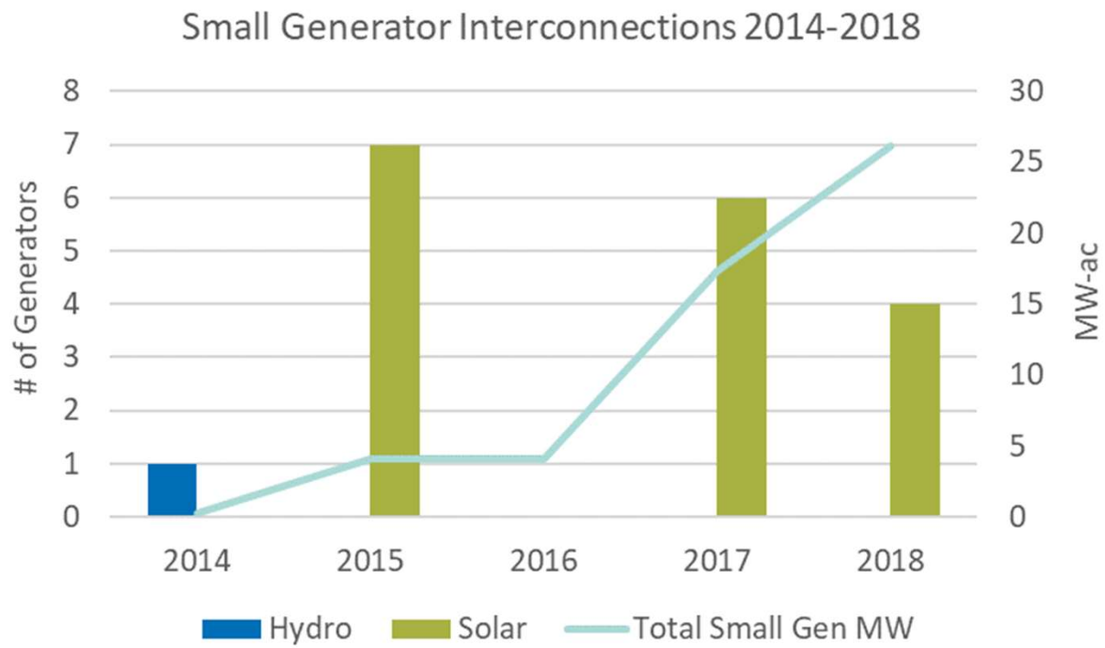
DERs: Locational Adoption



Source: 2019 PGE TE Plan

Distribution System Highlights

DERs: Small Generators



- Active interconnected small generators: 41
- Current, active interconnection requests that have:
  - Not yet executed an interconnection agreement: 18
  - Executed agreement, not yet in operation: 58

Distribution System Highlights

DERs: Microgrids

- Features of a microgrid:
  - Under normal conditions it is connected to the main grid.
  - Provides stability and support to main grid during disturbance.
  - Isolates itself and operates independently in the event of an outage (I.e., “islanding”).
- PGE has 52 single customer microgrids under Distributed Standby Generation program
- HB 2193 projects:
  - Beaverton Public Safety Center – 250 kW, 4-hour battery storage.
  - Anderson Readiness Center – 500 kW, 2-hour battery storage.
  - Considering others outside HB 2193 in conjunction with review of customer needs at strategic grid locations.

Questions