Smart Grid & Planning for Renewables

OSBEELS Energy & Sustainability Symposium

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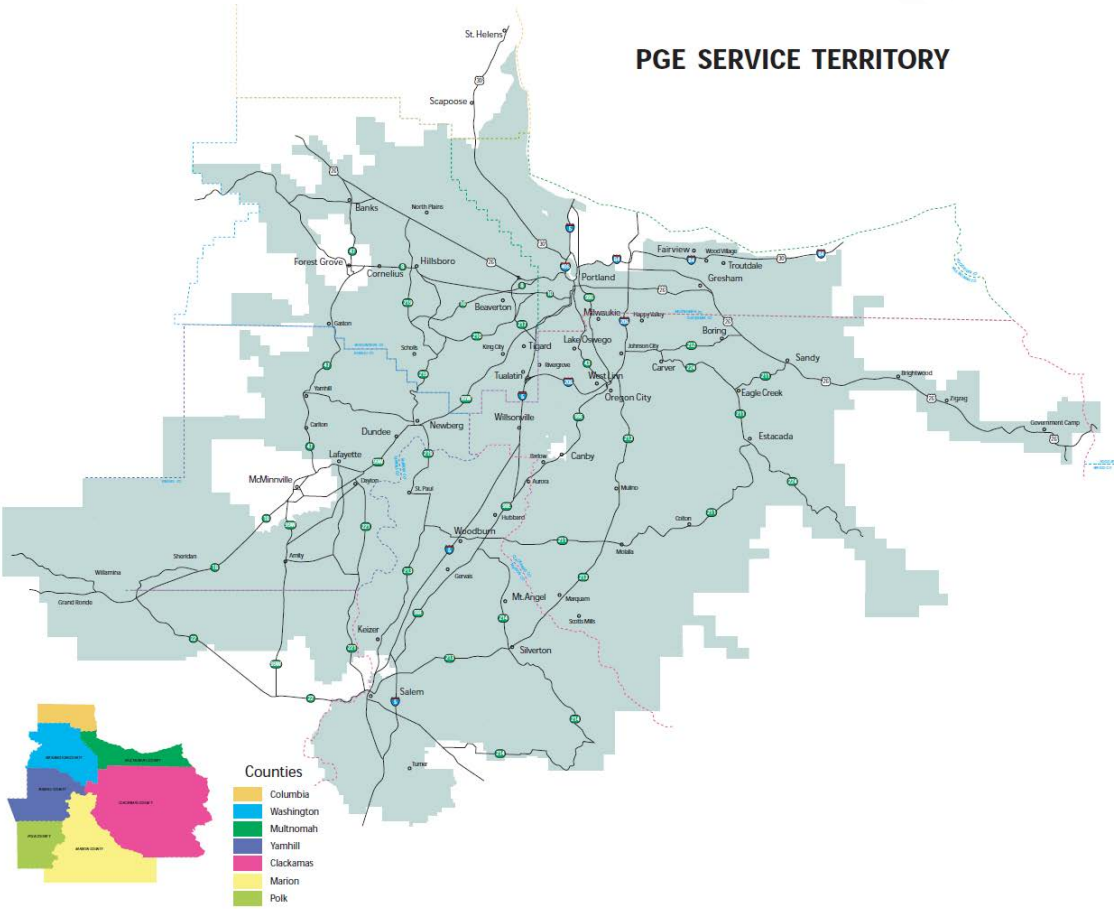
Who is PGE?

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

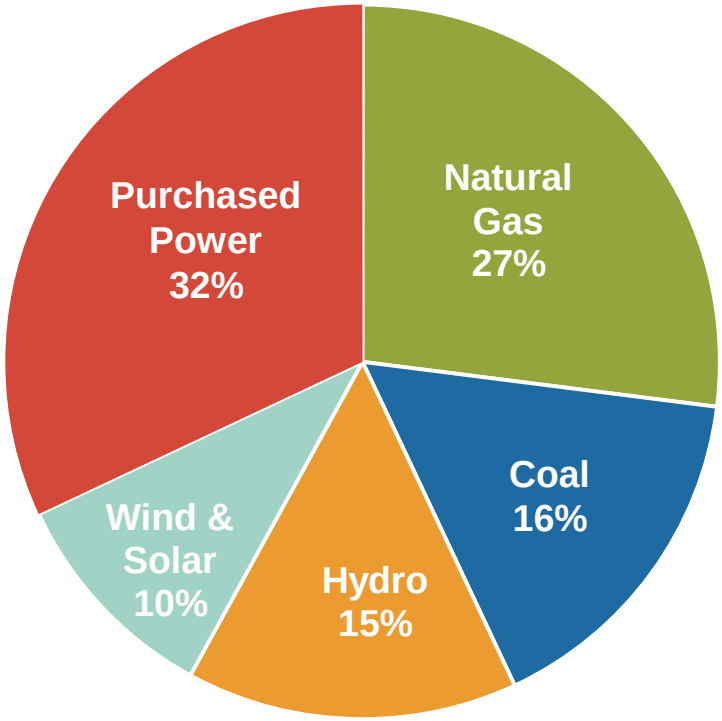
Our energy

Energy Priorities

- Safe
- Reliable
- Affordable
- Clean
- Secure

50% by 2040
Energy to come from renewable sources

2016 Power Mix



Take a tour of the smart grid with PGE

T&D System Investments

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

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

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

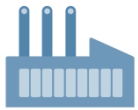
Proactive aging infrastructure replacement, risk assessment

Salem Smart Power Center

5MW battery testing facility

Analytics Capabilities

Transmission & Distribution Analytics Pilot, Energy Tracker Customer Insight



Customer Programs/Pilots

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

Asset Management

Proactive replacement of high risk facilities

Asset Management

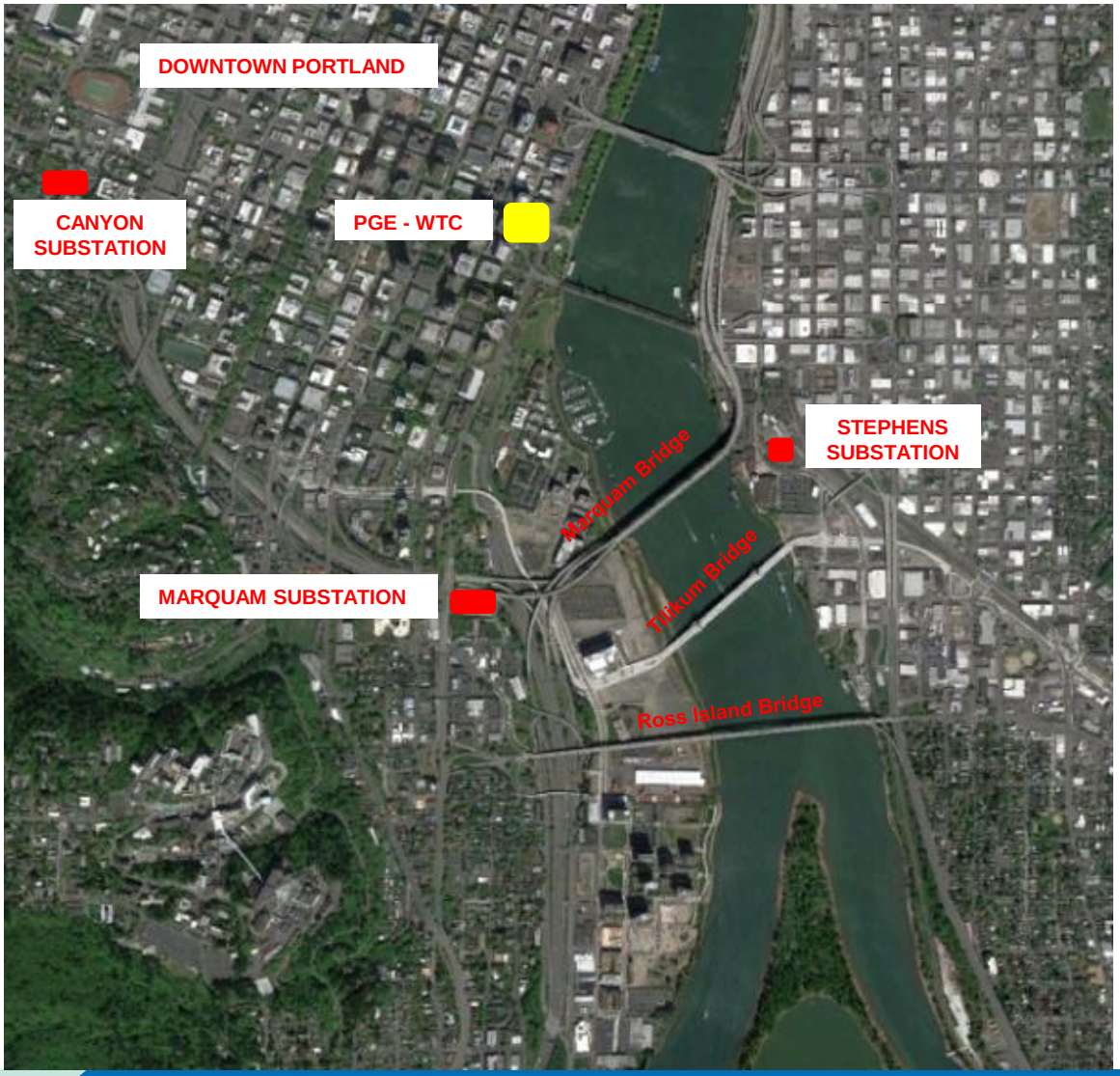
Proactive replacement of high risk facilities

- 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

Grid Modernization

New technologies to improve system operability

- 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

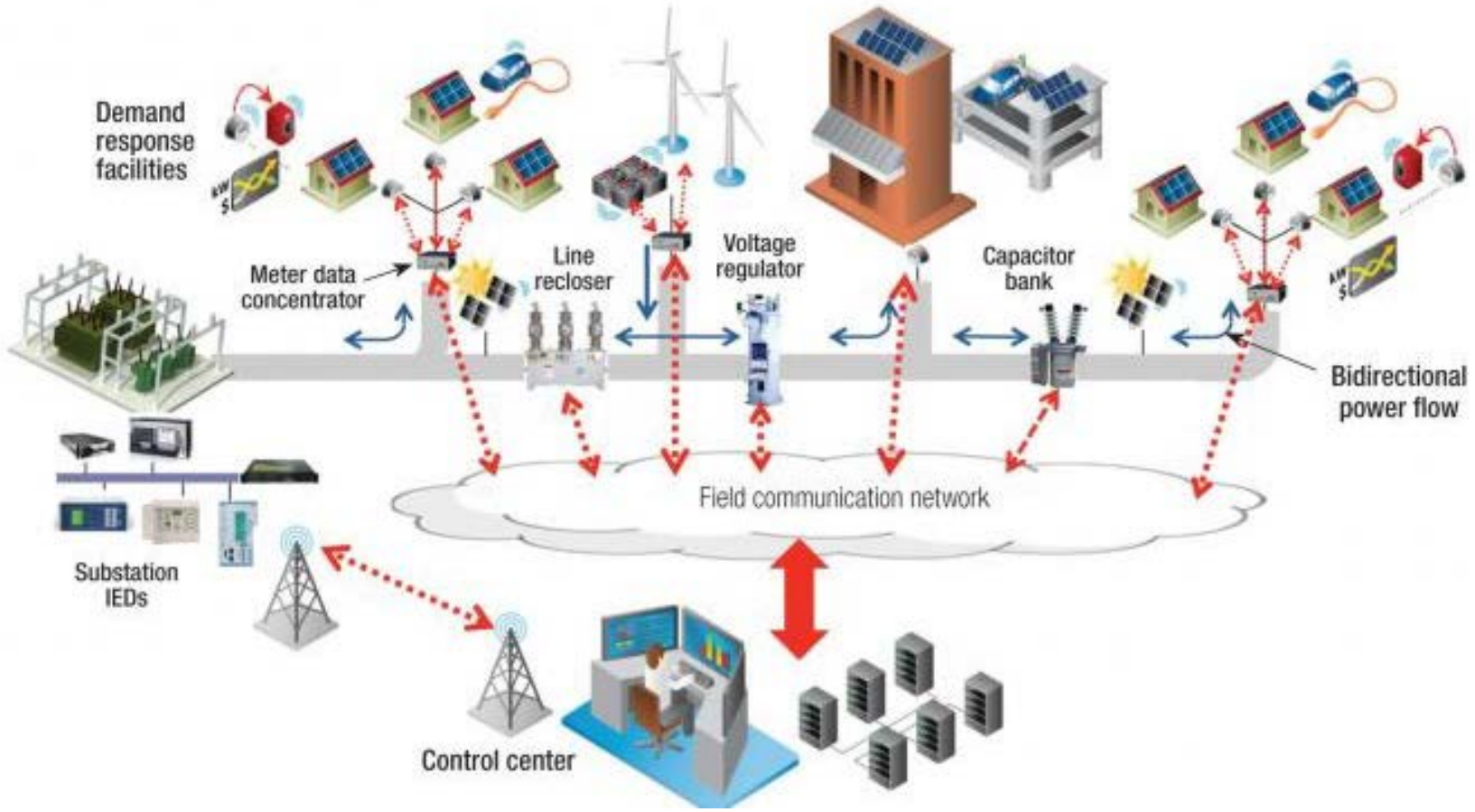
2018 Plans

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

Future Plans

6-10 schemes per year

Data Network Operations



Source: Public Utilities Fortnightly

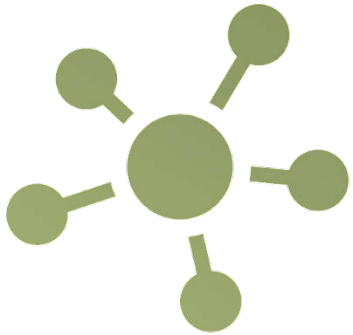
Communications Upgrades

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

Rawpixel/Thinkstock

Integrated Grid

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

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

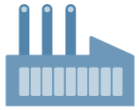
Current & Future Landscape

79 ➡ **Over 220 MW_{DC}**

PV on distribution system

717 ➡ **Over 2,000 MW**

Wind Generation



13 / 107 ➡ **250 MW / 150 MW**

Enabled Demand Response &
Dispatchable Standby Generation

1.25 ➡ **100 MWh**

Available Energy Storage

7,000 ➡ **200,000**

EV in service territory

865 ➡ **6,500**

Public EV Charging Stations

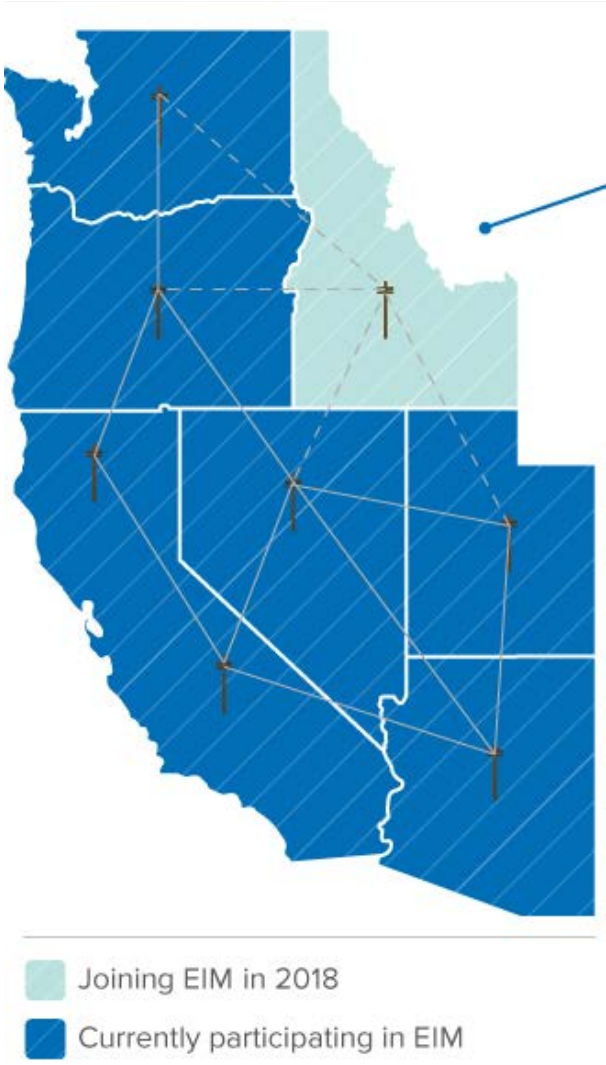
2,600 ➡ **100,000**

Integrated Customer Devices

75 / 0.48 ➡ **< 75 / 0.48**

Reliability: SAIDI / SAIFI*

Energy Imbalance Market (EIM)



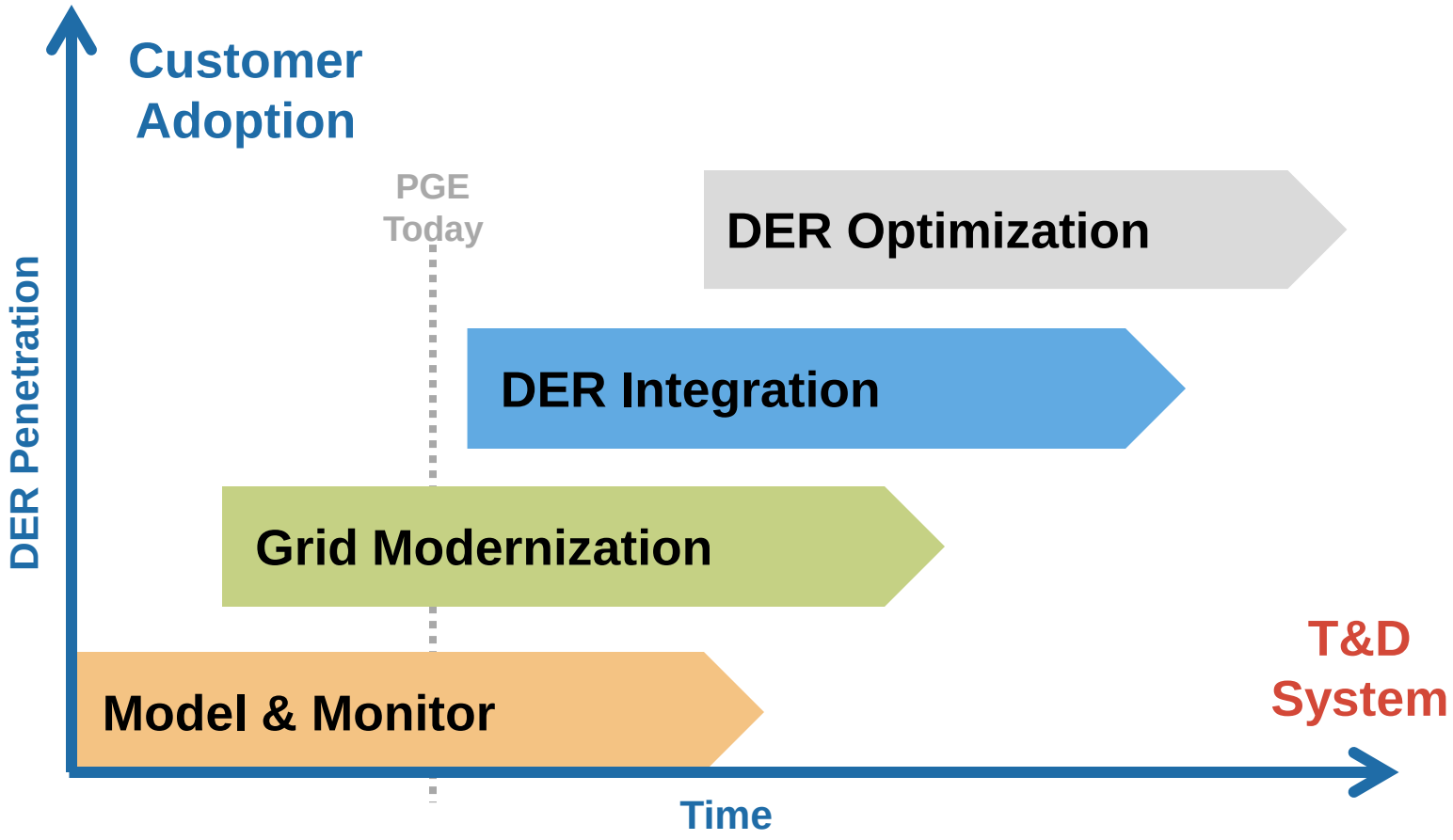
Automatically dispatches lowest-cost electricity

Helps balance energy supply and demand

Makes it easier to add more renewables into our mix

Keeps our grid stable, secure and reliable

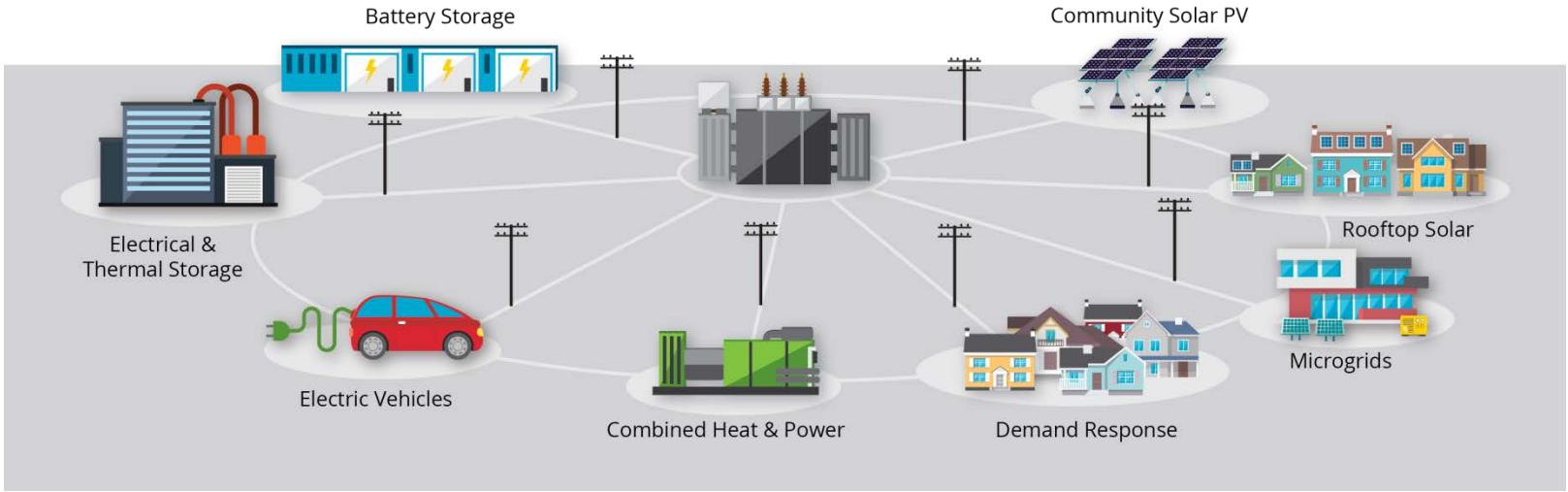
Distribution System Evolution



Distribution Resource Planning

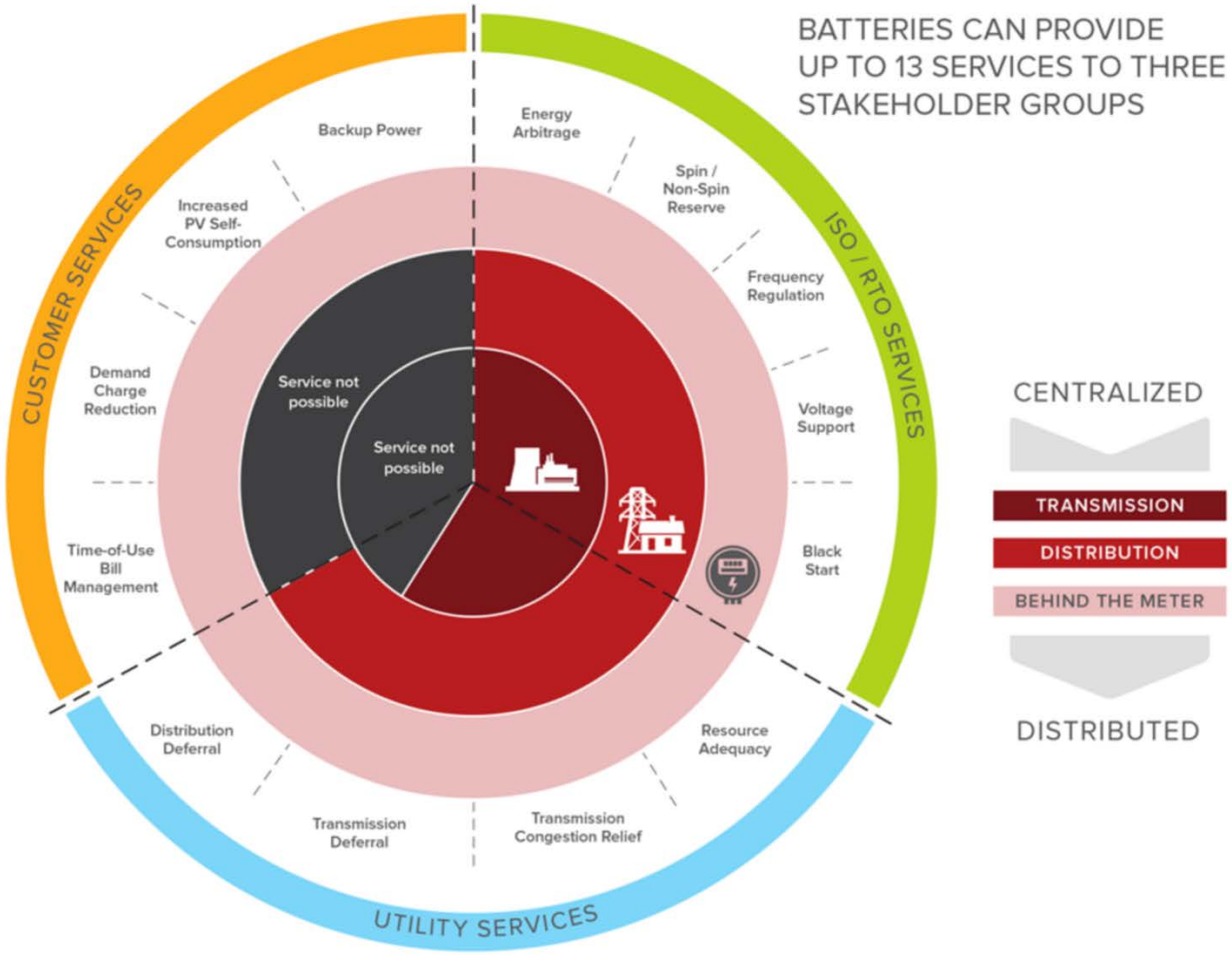
Determining hosting capacity and locational value

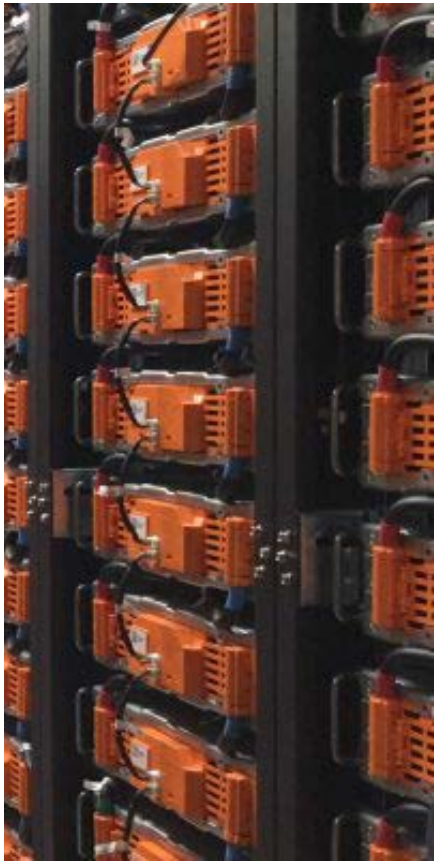
- Accurate distribution system model
  - Capacity
  - Two-way power flow
- Resource output forecasting
- Grid modernization status
  - Data Network
  - SCADA & Protection
- Potential resource value streams



Source: OATI

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 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

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.

- 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.

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

- Nelson Mandela

Questions?


FlexNet
240V 30TA 1Kh FM2S 60Hz
Portland General Electric
22 266 672

Appendix: Smart Grid Roadmap

Smart Grid Roadmap: Foundation

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

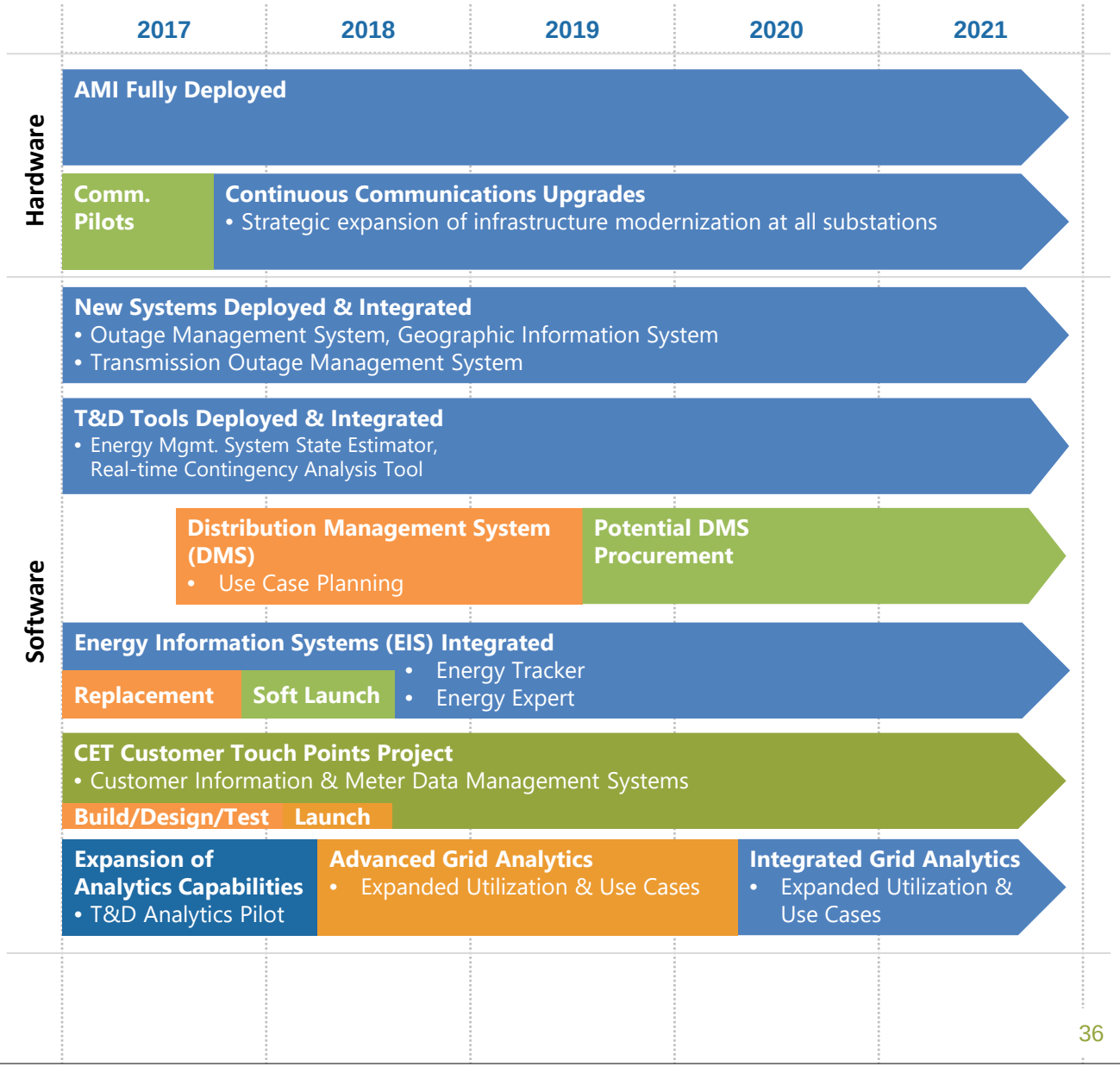
- Enable deployment of smart grid initiatives
- Allow customers to realize maximum value of smart grid initiatives
- Improve system cybersecurity

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.



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

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:

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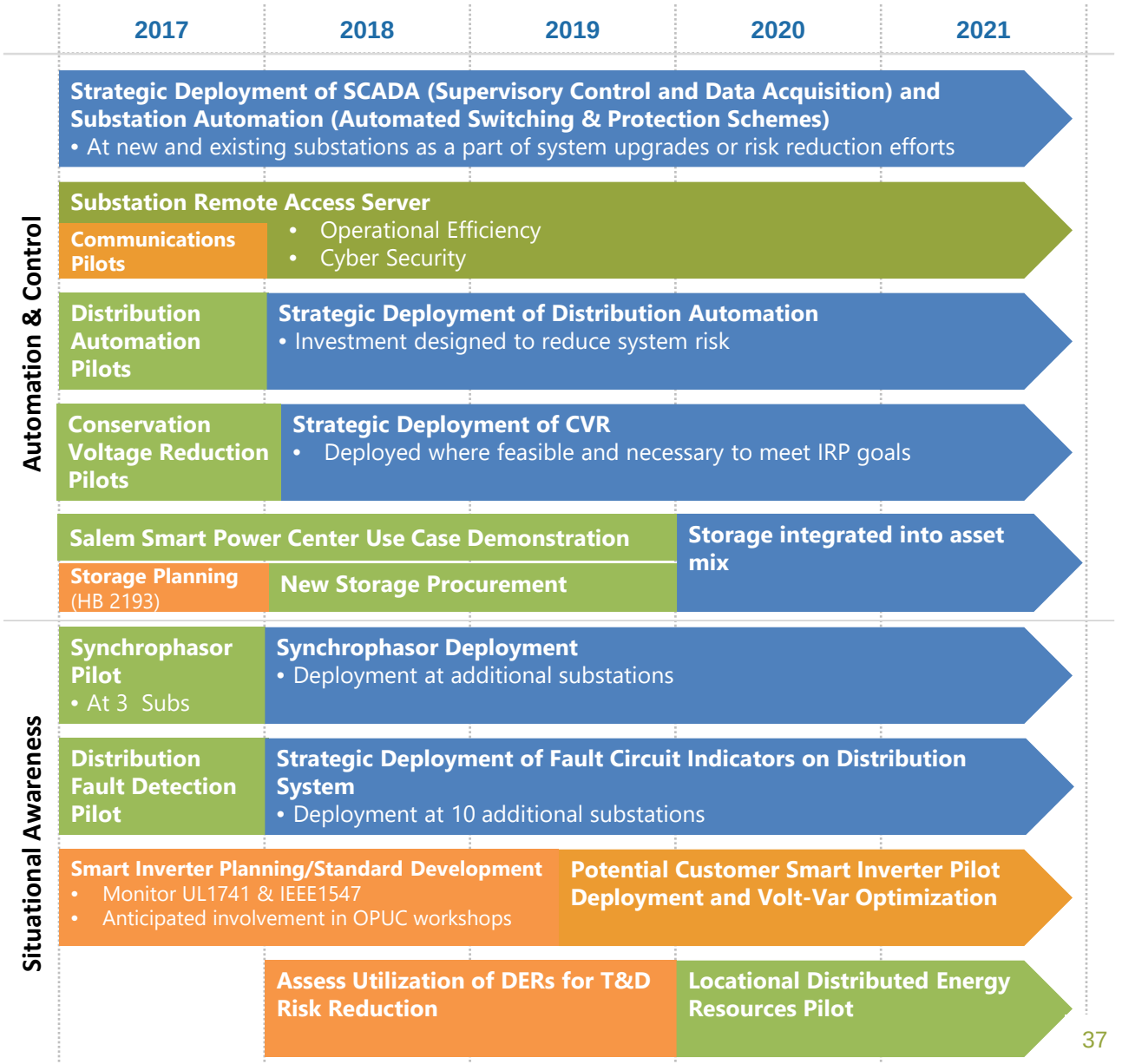


Legend: **Model & Monitor:** Plan Ahead | **Engage:** Successfully Pilot | **Integrate:** Move to Scale

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

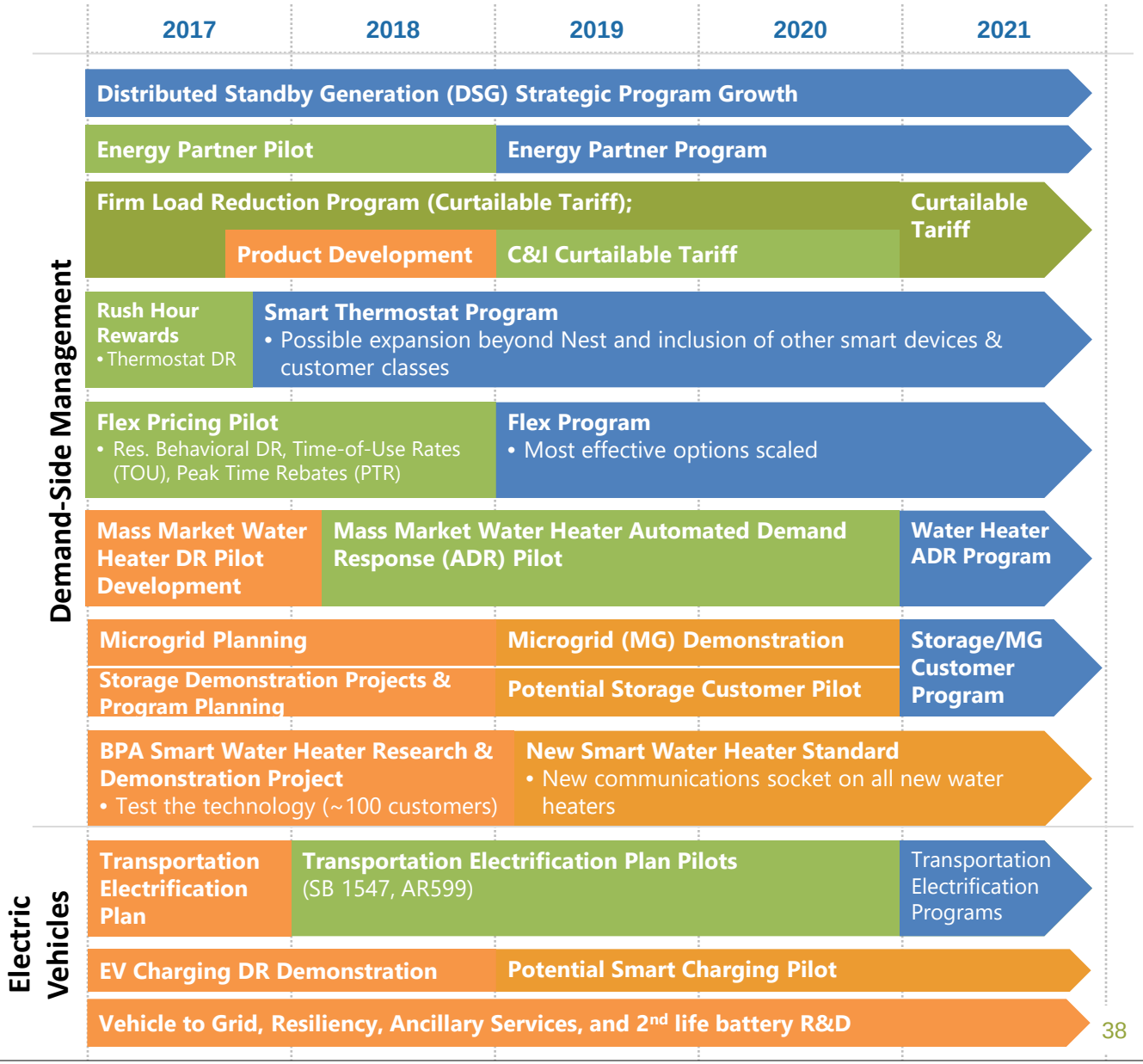
Goals:

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.



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