What you should expect to learn

• Distributed Energy Resources are a key element to realizing CA’s goal of GHG emission reductions but can significantly increase the complexity of planning & operating the electric grid

• SCE’s Grid Modernization plan will prepare the grid for high penetrations of DERs and has been structured to provide significant reliability benefits in the process

• To upgrade the grid to realize this future, some incremental amount of maintenance outages will be necessary. SCE is integrating this work by bundling with other upgrade programs to minimize this customer impact.
Southern California Edison

- 15 million customers
- 50,000 mi$^2$ service area
- > 23,000 MW record peak load
- > 4,600 distribution circuits

~4,000 rooftop solar applications /month

Subsidiary of Edison International that also has unregulated subsidiaries
Achieving CA’s SB32 targets in 2030 requires a dramatic acceleration of GHG emission reductions

**California GHG Emissions**

<table>
<thead>
<tr>
<th>Source: <a href="http://www.arb.ca.gov/cc/inventory/data/data.htm">www.arb.ca.gov/cc/inventory/data/data.htm</a></th>
</tr>
</thead>
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<tr>
<td>1) Total emissions excludes 54 MMT CO2 equivalent per AB32 definition (including portions of transportation and industrial as well as military)</td>
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Key Drivers for Modernizing the Grid

- Increasingly complex grid
  - Grid Operation becomes more complex with increasing levels of distributed energy resources

- State Energy & Environmental Policy
  - Grid modernization supports state policy objectives to increase renewables and decrease GHG emissions

- Customer Choice & Reliability
  - Customers are increasingly adopting DERs and expect higher grid reliability for their electronic-dependent lives
Key Driver: Increasingly Complex Grid

As distributed energy resources are added to the grid, operating characteristics of the grid are changing, leading to increased complexity.

• Peak Time for Distribution Circuits Load and PV do not typically coincide
• The grid needs to accommodate this available power for the benefit of the customer and the grid

Shaded areas show 3-phase reverse powerflow and intermittent output from PV from an actual circuit, this appears as one-way flow to operators
• Operators need visibility to power flow magnitude and direction
Key Driver: State Energy and Environmental Policy

Achieving our expansive energy and environmental policy goals will require taking foundational steps to evolve the grid.

Today
- 1.5 million electrical vehicles
- Reduce GHG emissions to 1990 levels
- 33% of electricity sales from renewables

2020
- 1,325 MW of procured energy storage capacity by 2024
- Once through cooling
- New residential construction zero net energy

2025
- Reduce GHG emissions to 40% below 1990 levels
- 50% of electricity sales from renewables

2030
- New commercial construction zero net energy
- Double statewide energy efficiency savings

2050
- Reduce GHG emissions to 80% below 1990 levels

SCE’s Grid Modernization Program can help meet the stated goals and objectives in the DRP within 10 years.
Key Driver: Customer Choice and Reliability

Customers Are Adopting DER

- Electric Vehicles: 100,000+ in SCE territory today; targeted goal of 7 Million by 2030
- NEM Applications: In 2008, averaged 250 per month; in 2017, range of 3,000-5,000 per month
- Federal tax credit increases customer incentives for DERs

Customers Need Reliable Service

- Modern society is increasingly more dependent on electricity
- 42% of customers in the West would not accept a two-day power outage, even if they were paid as much as $1,000 for it
- 64% of customers responded that power outages cause “really significant problems” for their households
- 71% of customers with income less than $40,000, said outages cause “really significant problems”

Increasing Complexity of the Grid

Substation Load Profile with Forecast Overload

Illustrative

**Substation Z 66/12 kV Forecasted Net Load**

- **Increased Capacity Rating (Typical Wires Solution)**
- **Forecasted Load Profile**
- **Capacity Rating**

Power Flow (MW)

- 0
- 500
- 1000
- 1500
- 2000
- 2500
- 3000
- 3500

0:00, 0:45, 1:30, 2:15, 3:00, 3:45, 4:30, 5:15, 6:00, 6:45, 7:30, 8:15, 9:00, 9:45, 10:30, 11:15, 12:00, 12:45, 13:30, 14:15, 15:00, 15:45, 16:30, 17:15, 18:00, 18:45, 19:30, 20:15, 21:00, 21:45, 22:30, 23:15

*Unadjusted 15-min Interpolated Load (A)*
Increasing Complexity of the Grid

Customized DER Portfolios Can Address Capacity Needs On Distribution but leave gaps in visibility downstream of targeted asset level.

Illustrative

**Substation Z 66/12 kV Forecasted Net Load**

- **Increased Capacity Rating (Typical Wires Solution)**
- **Forecasted Load Profile**
- **Capacity Rating**
- **Net Load Profile with DER Portfolio Solution**

![Graph showing load and capacity profiles](image-url)
Increasing Complexity of the Grid

DERs Sized to Offset Energy Can Create Grid Concerns

- Energy is consumed 24 hours a day
- Solar can only generate during daylight hours
- Solar must be oversized to account for non daylight hours
- May result in significantly higher generation loading during daylight hours
Increasing Complexity in System Planning with DERs

DER solutions can address some capacity constraints while producing new concerns at more granular levels.

Net Load Profile at a feeder level

Net Load Profile at a service transformer level
Grid Modernization Objectives

Grid Modernization can address anticipated concerns by improving real time visibility and usage of grid analytics for proactive maintenance.

- **Monitor**
  - Real Time Situational Awareness

- **Control**
  - Grid Reconfiguration
  - DER Dispatching

- **Analyze**
  - Short Term & Long Term Grid & DER Forecasting

- **Optimize**
  - Optimizing Voltage, Power Flow, & Protection

What this means to Distribution Planning and Operations.

- New automated equipment on the distribution system
- Increased levels of inbound data to operations
- New software solutions for operations and planning organizations
- Requires more granular Demand Side Management data for Grid Planning
Grid Modernization Elements

Enhance capabilities through advanced field automation, back office upgrades, and technology software solutions for planning & operations.
Distribution Automation Offers Large Reliability Potential

Reliability can be improved by targeting the red line via acceleration of troubleshooting activities.

Reliability can be improved by targeting the black line via further segmentation of circuitry with automated switches.

>50% of all mainline CMI contribution occurs prior to crew repairs and can be reduced with additional Distribution Automation.

Duration: 0 Min

1) System Operator Responsibility
2) Troubleman Responsibility
3) Crew Responsibility

Initial Fault: CB + Automation
Gather Data
Remote Troubleshooting
Dispatching
First PLU: Travel/Response Time
Local Troubleshooting
Second PLU: Repairs
ALU: Duration: 10-24 Hrs
The future grid will be increasingly sensor and data driven, providing foundational capabilities to expand the role as a DSO.
System Planning Shapes the Grid of the Future

- **Long-term system planning overview**
  - **Time frame:** 1-10 Years
  - **Focus of system planning:**
    - Capacity
    - Reliability
    - Resiliency
  - **Objective:**
    - Maintain long-term safety, reliability and affordability of the power grid
    - Holistic planning to bundle construction efforts, minimizing community impacts

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**The Future Power Grid**

- **Load Growth**
- **DERs**
- **Contingency Plans**

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**Long-Term Planning (1-10 Year)**

- **Reliability Planning**
  - SAIDI/SAIFI
  - Infrastructure Replacement
  - **Automation Schemes**

- **Capacity Planning**
- **Resiliency Planning**

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**Energy for What’s Ahead™**
Key Take Aways

• DERs support pathway to reducing GHG emissions in CA, but also increase grid complexity

• SCE’s Grid Modernization is a long term strategy that will improve grid reliability and prepare for our DER future

• Maintenance activities are necessary to evolve the grid to support CA’s vision