Reliability and Affordability: Challenges and Opportunities of Integrating Renewables

Joseph Yan, Ph.D.
Principle Manager of Fundamental Modeling and Analysis
Southern California Edison

March 12, 2015

Today's Discussion

- **Overview of California Renewable Portfolio Standard (RPS) and SCE renewables procurement**

- **Reliability and Affordability Challenges of Renewables Integration**

- **Solutions & Research Opportunities**

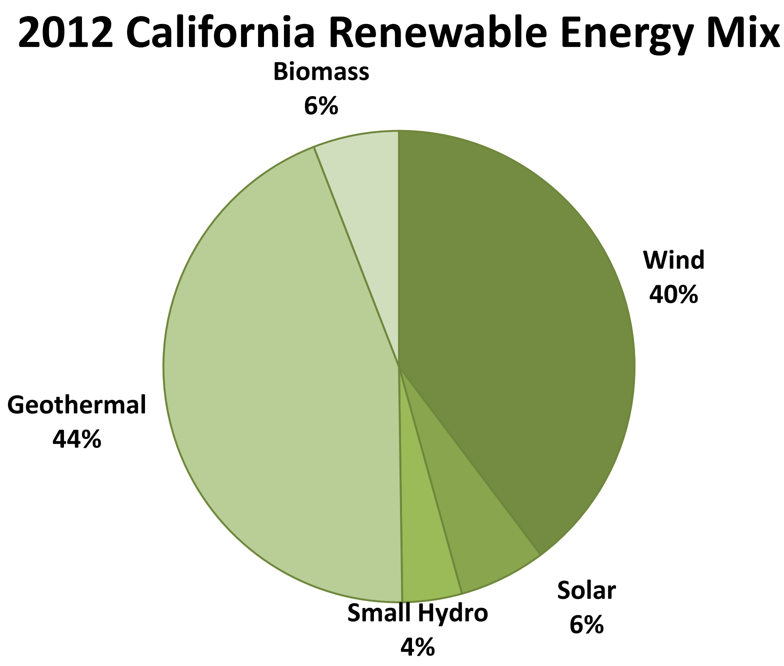
SOUTHERN CALIFORNIA EDISON

- 14 million customers: one of the largest utilities in US
- More than125 years of service
- Award-winning energy efficiency and demand response programs

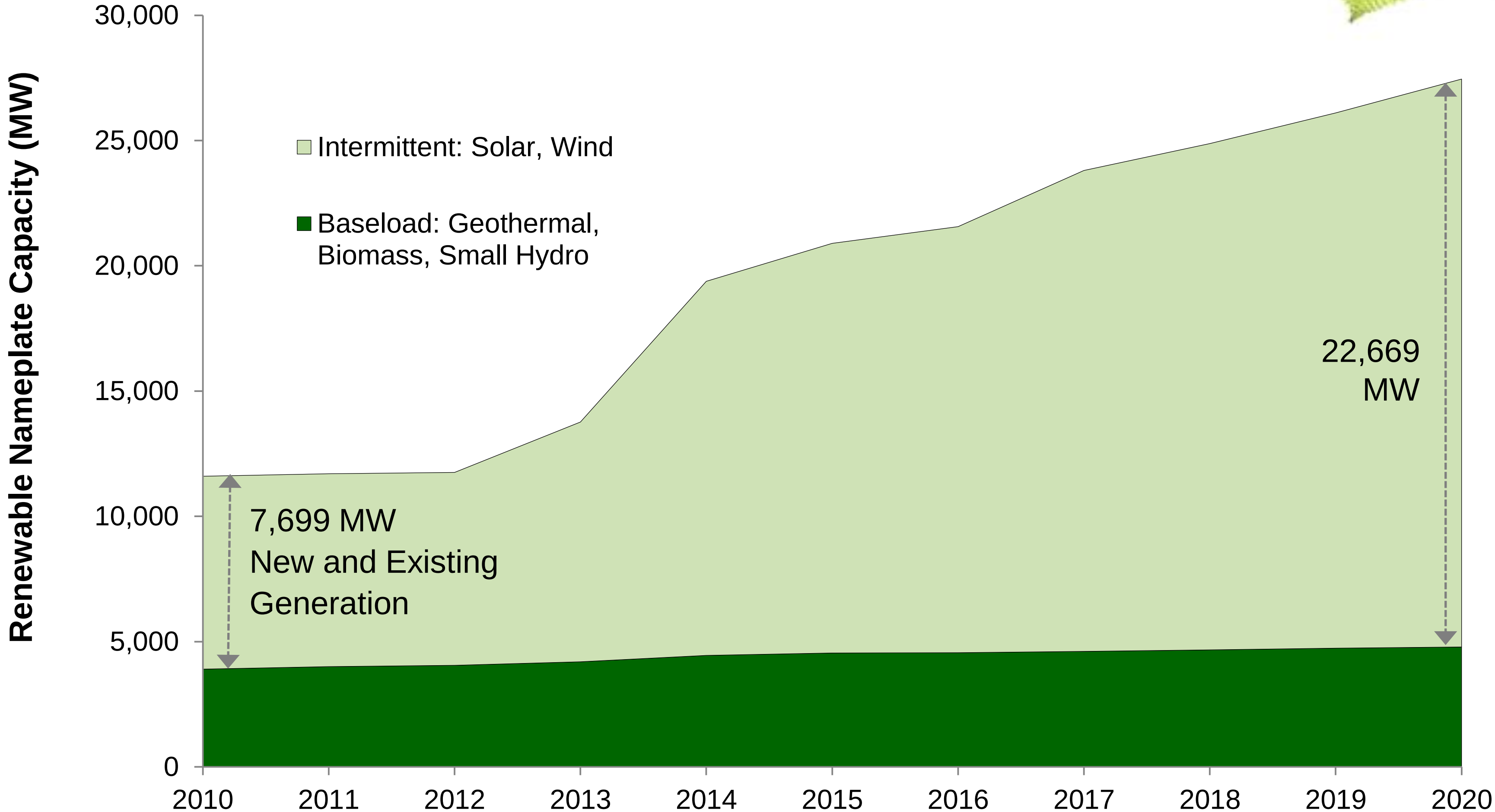
Committed to safely providing, reliable and affordable electric service

California's 33% Renewable Portfolio Standard by 2020

- The RPS program requires investor-owned utilities (IOUs) to increase procurement from eligible renewable resources to serve 33% of their retail sales by 2020.
- California's three large IOUs collectively served 19.8% of their retail electricity sales with renewable power in 2012.



Growth of Intermittent Resources in California

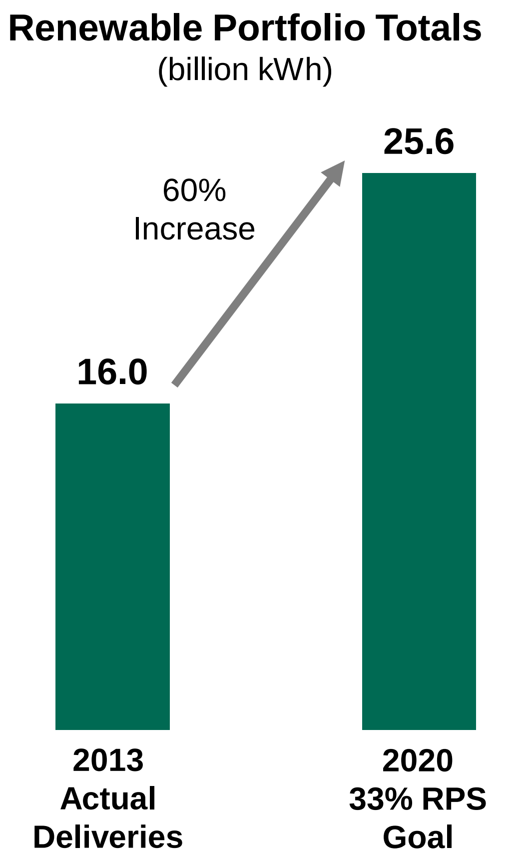


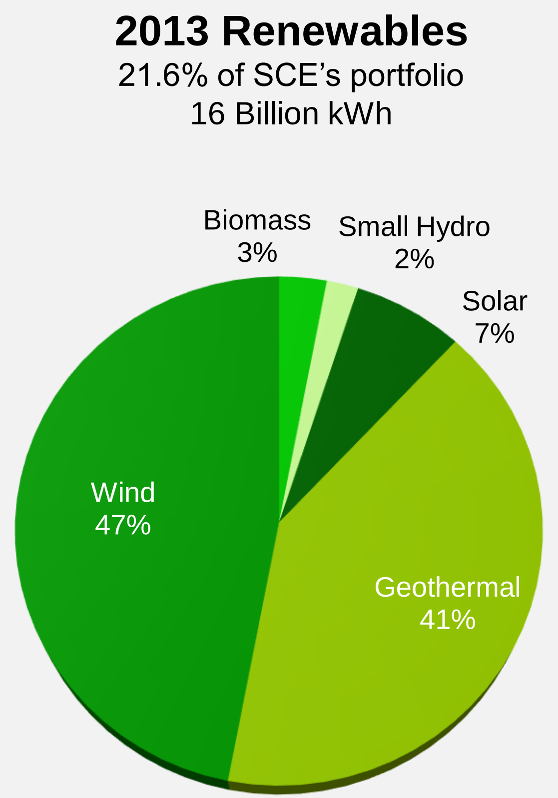
Source: 2010 LTPP Track I – Joint IOU Supporting Testimony

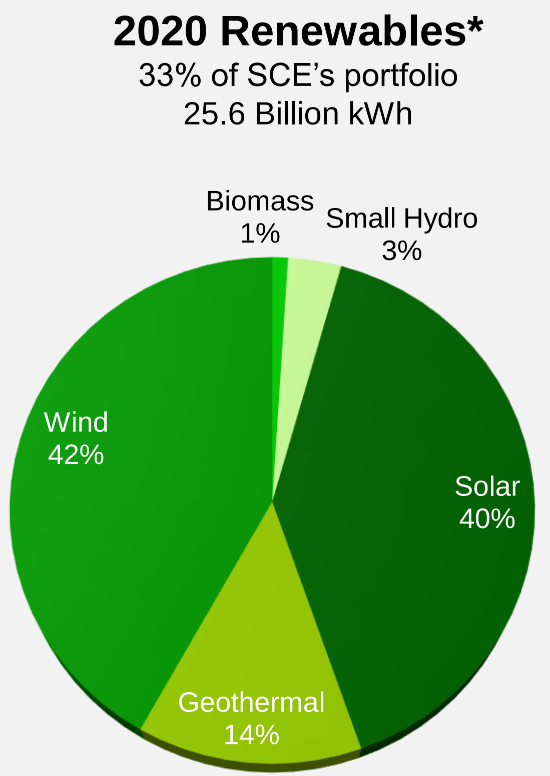
SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company

SCE Renewable Portfolio

Per the California Renewables Portfolio Standard (RPS), by 2020 SCE will increase renewables to 33% of all energy delivered







Solar energy is expected to grow to 40% of SCE's renewable portfolio by 2020

*2020 data assumes 100% contract success rate

SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company

SCE Continues to Lead the Way in Renewables

Continuing Procurement

- SCE expects to increase renewables deliveries in the next years
- SCE procures large volumes of renewables through many different programs

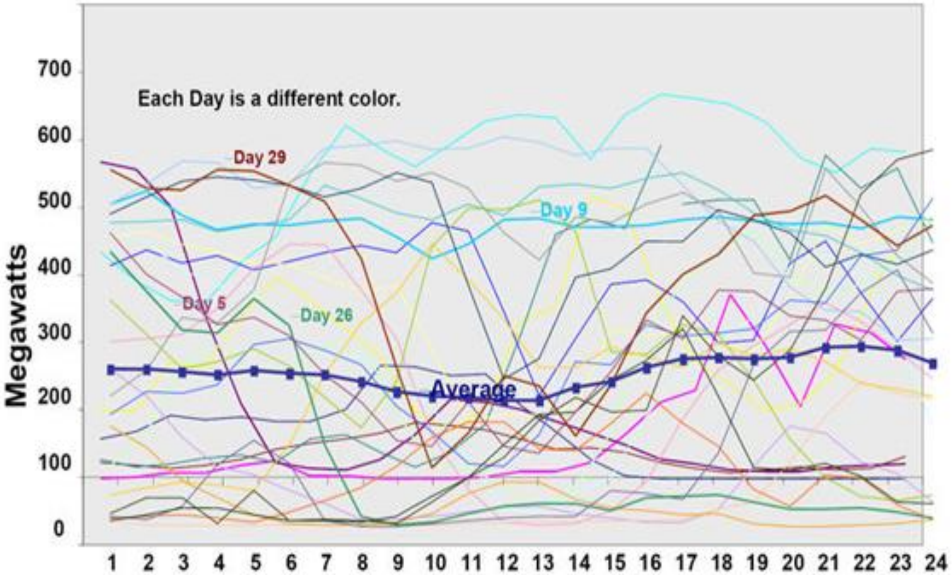
Active Infrastructure Investment

- SCE has invested **billions of dollars** in transmission and distribution upgrades to help California achieve its renewable goals
- Upgrades will expand transmission available for renewable development and reduce congestion and over-generation risks

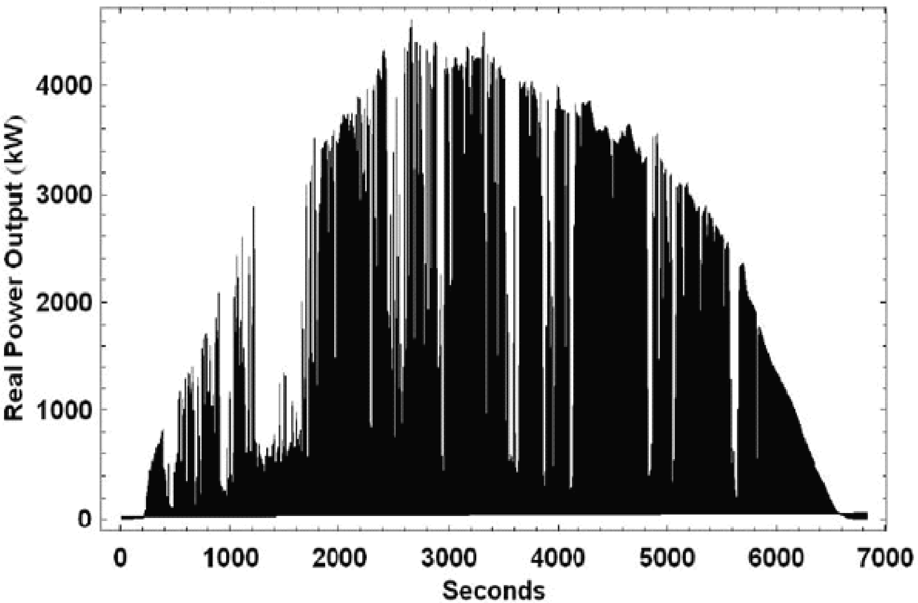
SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL® Company

Variable Output from Intermittent Resources

Wind Generation Over One Month (California)



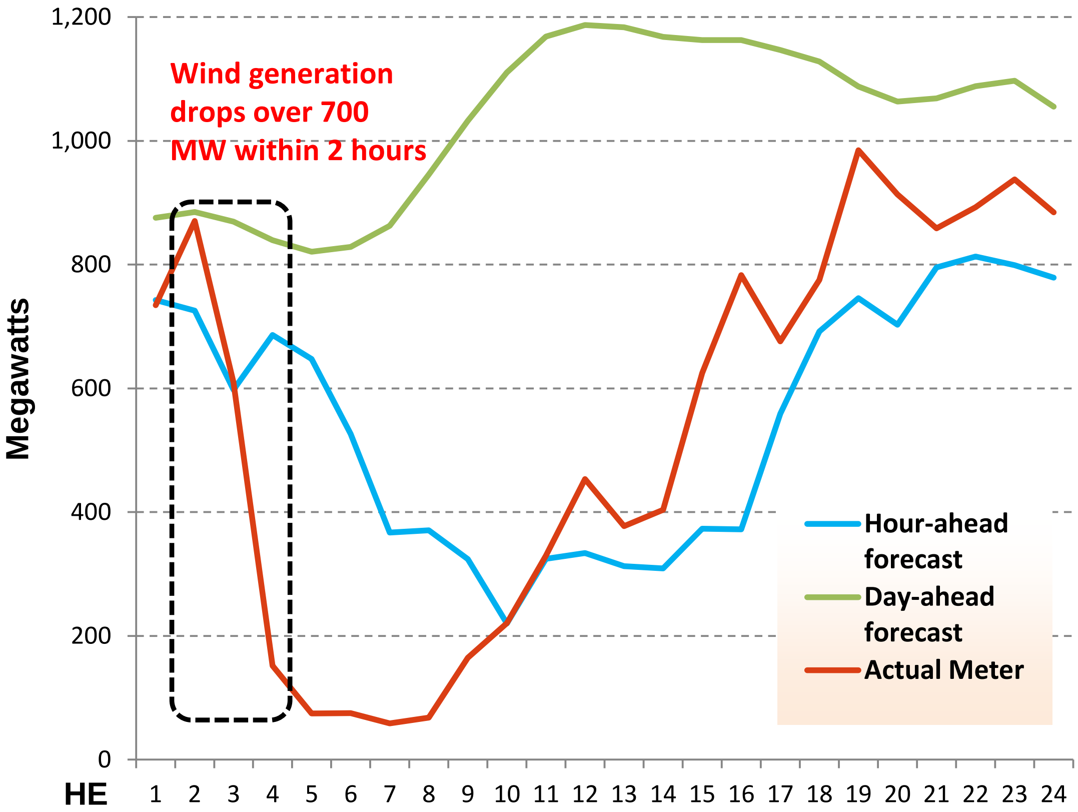
Solar PV Generation Over One Day (Arizona)



As more intermittent renewables are included in SCE's portfolio, integration will become more important and challenging to ensure reliable electricity for customers

Sources: CAISO; Carnegie Mellon Electricity Industry Center

Unpredictability Creates Reliability Challenges



Forecast and actual generation of SCE wind farms in a day

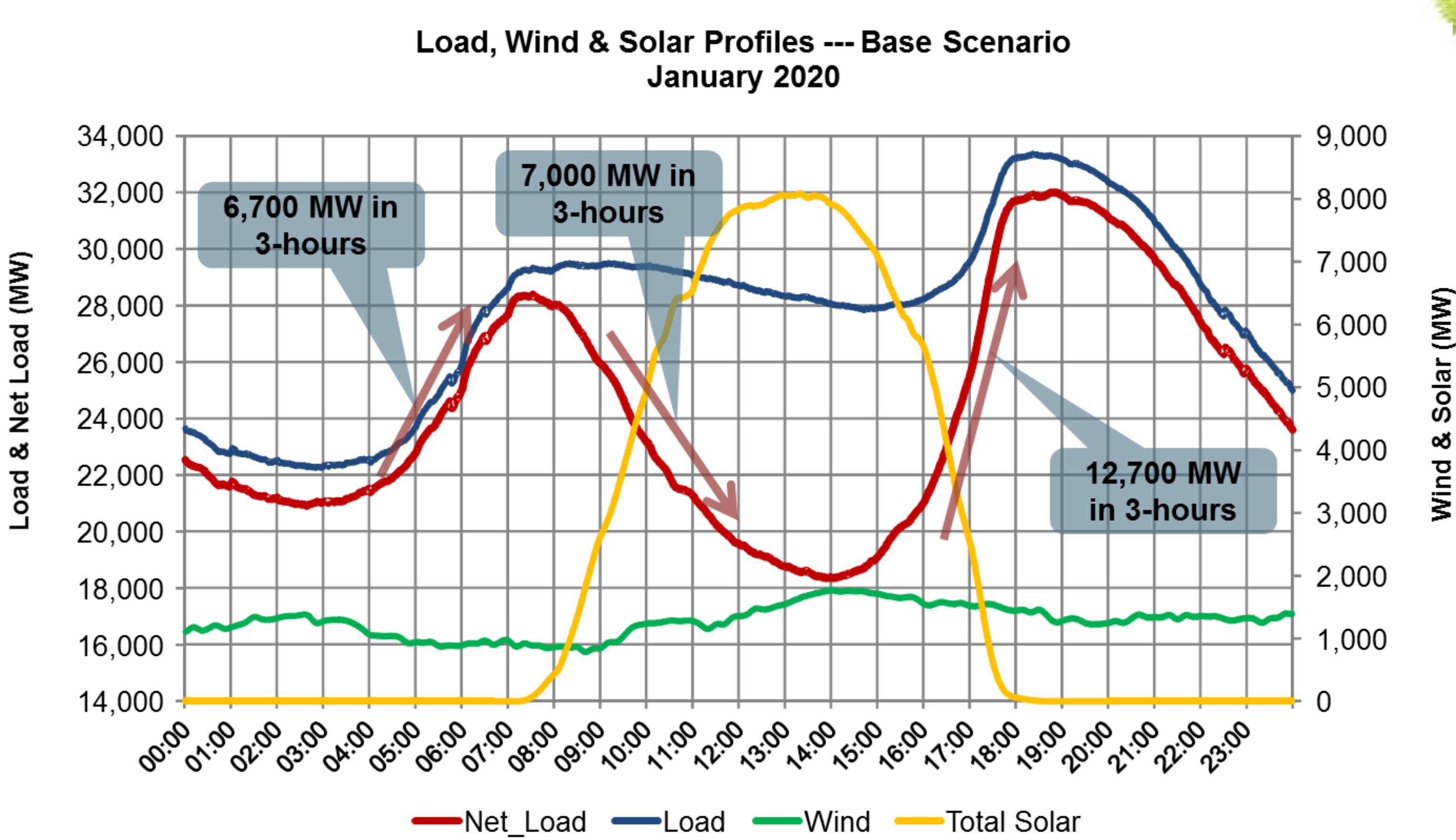
Reliability

- Difficulty in balancing power supply and demand
- Disruptions in voltage and frequency regulation

Affordability

- Additional costs for ramping services
- Inefficient operation of the other generation fleet
- Complicated market structure

Required Ramping Capability Creates Reliability Challenges



The system ramping needs based on net load may triple during evening peak hours with solar output dropping while load increasing. The system ramping needs may reverse direction in early morning ramping hours.

High Renewable Penetration Creates Affordability Challenges

- **High Procurement and Integration Cost**
  - The energy contract price of wind resources is more than twice that of conventional gas generation
  - The cost of building new transmission lines to access renewable generation add an additional cost significantly*
  - With 20% renewable penetration, the system operating cost incurred due to variability and uncertainty is significant**
- **Impact on Retail Rates**
  - The fuel and power purchase budget portion of the retail rates could rise significantly over the next 10 years.

* ERCOT (Energy Reliability Council of Texas). 2006 Analysis of Transmission Alternatives for Competitive Renewable Energy Zones in Texas. Austin: ERCOT

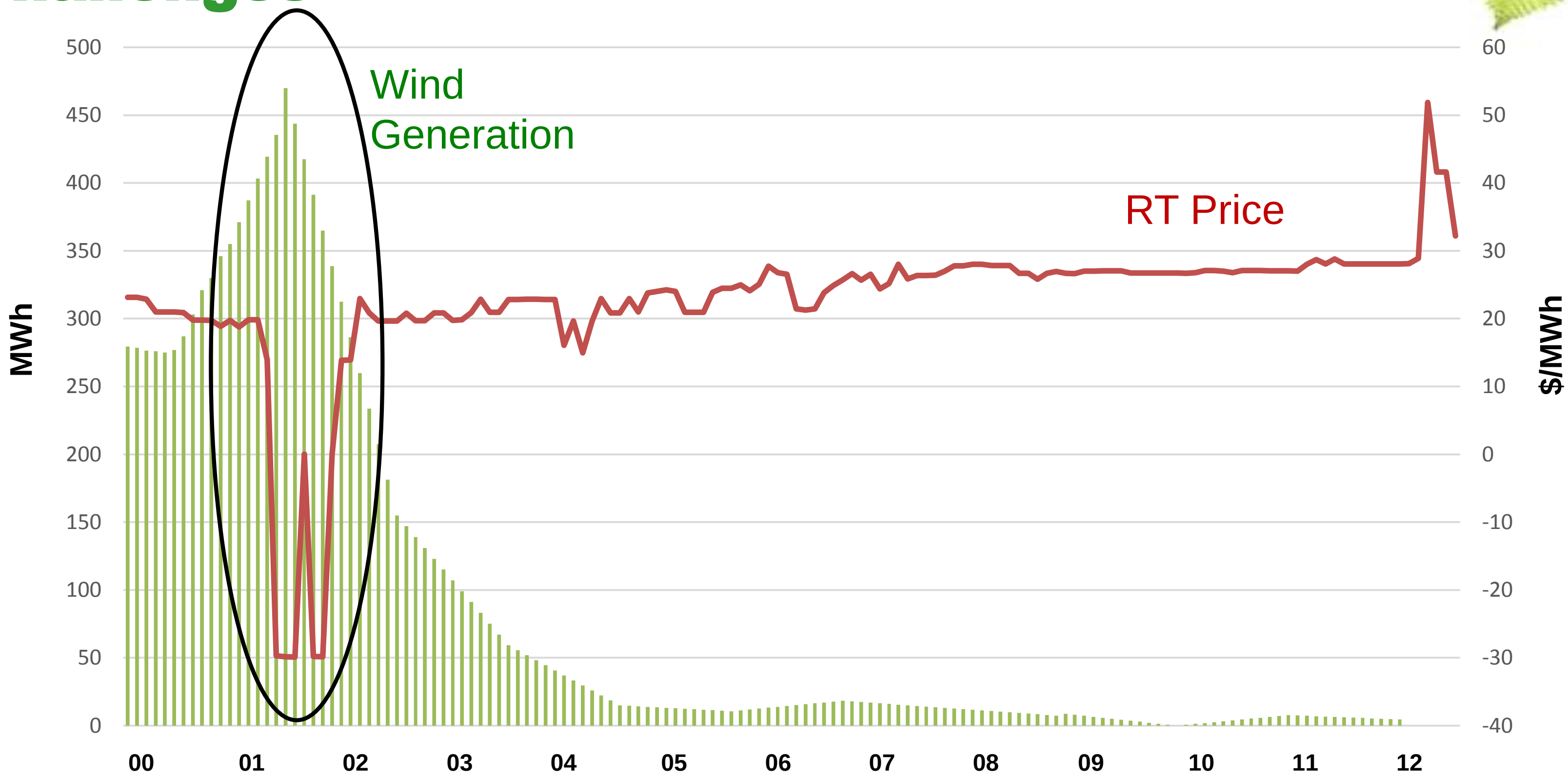
** 20% Wind Energy by 2030, U.S. Department of Energy. [Online]. Available: http://www.20percentwind.org/20p.aspx?page=Report.

The Natural Gas Plants in California is At Risk

- Regulatory changes: Once-through cooling ban may lead to the closing of many coastal, load-centered plants; tightened standards for particulate matter emissions
- Diminished energy market revenue: Reduced payments to gas plants as renewables displace base generation
- Increasing maintenance needs: More wear on plant equipment due to frequent ramping, start-ups, and shutdowns

To support continuing renewable growth, flexible generation like natural gas needs to be supported, especially in the face of existing challenges

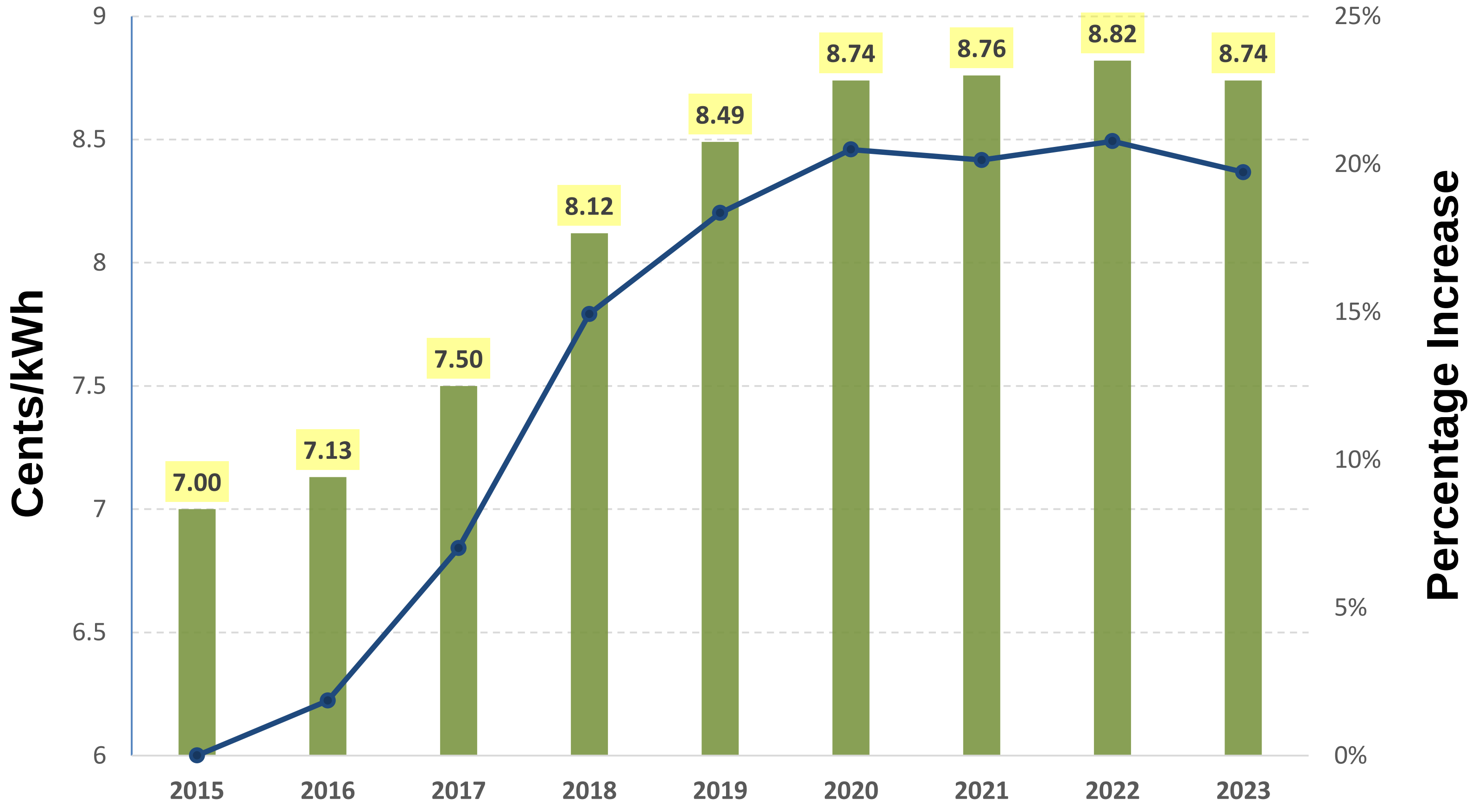
Volatile Market Prices Create Affordability Challenges



An Example on 1/3/2012:

System-wide wind gen suddenly increased 300 MWh around 1 am. The downward ramping constraint binding in the real-time market resulted in negative prices

Rate Growth of Energy Component



SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company

Opportunities – Better Operation of Intermittent Renewable Resources

- **Improve Day-ahead/Real-time Renewable Generation Forecast**
  - Reduce the risk faced by generation owners and help system operators make better unit commitment decisions and real-time operations
- **Incremental Capacity from Conventional Generation Resources**
  - Wind resources have low capacity factor and add little capacity value
  - Much of conventional resources will be needed with additional capital cost
- **Integrate Renewable Resources with Electricity Storage and Demand-Response Program**
- **Coordinated Transmission and Generation Planning**
  - Identify local and system reliability needs considering renewable integration

Opportunities – Modeling Uncertainties in Unit Commitment and Day-to-day Market Operations

- **Uncertainties in the Day-ahead and Real-time Markets**
  - Variable Energy Resources and load forecast
  - Transmission and generation outages
- **Potential Solutions**
  - ***Deterministic Unit Commitment*** - enforce additional reserve requirement, e.g. flexible ramping constraint
  - ***Stochastic Unit Commitment*** - consider the probability distribution for uncertain parameters and minimize the expected cost associated with uncertainties
  - ***Robust Optimization*** - consider uncertainty sets for uncertain parameters and minimize the worst-case cost in the uncertainty set

Opportunities – Market Changes to Incent More Flexible Generation and Regional Coordination

- **FERC Order 764**
  - Require the 15 minute market to improve the forecast accuracy of renewables
- **Pay-for-Performance Regulation**
  - Compensate units to provide faster ramping/regulation services
- **Flexible Ramping Product in the Day-ahead/Real-time Markets**
  - Handle ramping needs between operating intervals
- **Flexible Capacity Market**
  - Special capacity payment to flexible generation units to incent investment
- **Equitable Rules for Curtailment of Variable Energy Resources**
  - Economic incentives for wind or other intermittent generation resources
- **Lower Price Floor in California**
  - Provide incentive to not generate in over-supply conditions

Questions

Advanced Technology Projects

Support
business objectives

- Infrastructure modernization
- Operational efficiency
- Regulatory demands
- Environmental stewardship

Address
trends identified in strategic plan

1. Demand growth leveling off
2. Public policy prioritizing sustainability
3. Innovation facilitating conservation and self-generation
4. Regulation driving competition

Research
areas identified in 6 strategic initiatives

1. Distribution Grid Readiness
2. Energy Storage Integration
3. Community Solar
4. Water/Infrastructure Evaluation
5. Preferred Resources Pilot
6. OPX

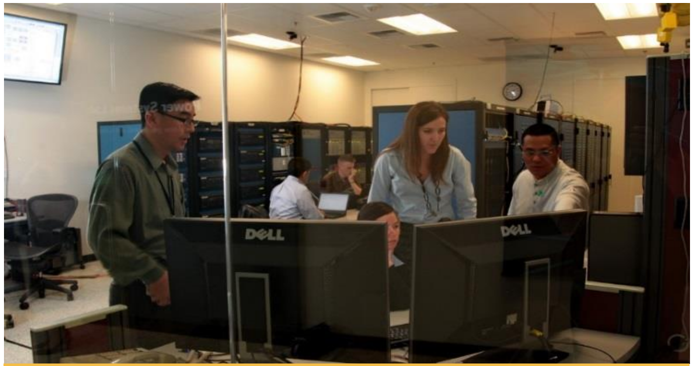
Approach

Investigate → Model → Evaluate → Demonstrate → Pilot → Deploy on the grid

Investigate | Model | Evaluate | Demonstrate | Pilot

Collaboration

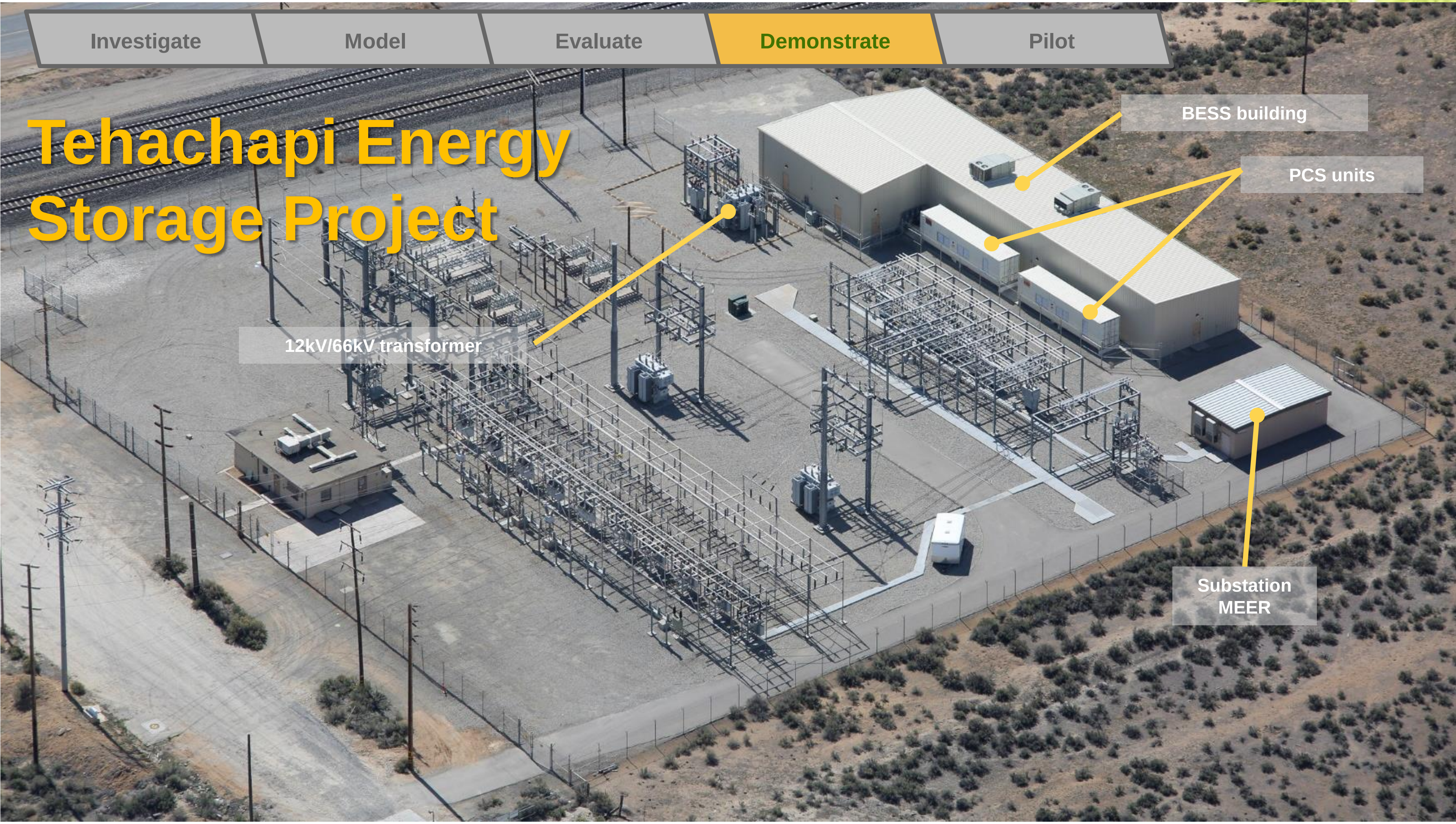
Investigate | Model | **Evaluate** | Demonstrate | Pilot



Power System Lab -Westminster

Mini System -EVTC

Dynometer-EVTC


Investigate
Model
Evaluate
Demonstrate
Pilot
Tehachapi Energy Storage Project
BESS building
PCS units
12kV/66kV transformer
Substation MEER

Investigate | Model | Evaluate | **Demonstrate** | Pilot

Battery Configuration

8 MW/32MWh System

56 cells per module

18 modules per rack

604 Racks

608,832 Cells

Investigate | Model | Evaluate | **Demonstrate** | Pilot

Irvine Smart Grid Demonstration

How do we respond when every house in the neighborhood has solar panels?

Scope

Project Domains	Sub-projects
Smart Energy Customer Solutions	1. Zero Net Energy (ZNE) Homes through Smart Grid Technologies 2. Solar Shade-enabled Electric Vehicle Charging
Next Generation Distribution System	3. Distribution Circuit Constraint Management with Energy Storage 4. Distribution Volt/VAR Control (DVVC) 5. Self-Healing Distribution Circuits 6. Deep Grid Situational Awareness
Interoperability & Cybersecurity	7. Interoperability and Cybersecurity • Secure Energy Network (SENet) • SA3 – IEC 61850 Substation Automation System
Workforce of the Future	8. Workforce of the Future

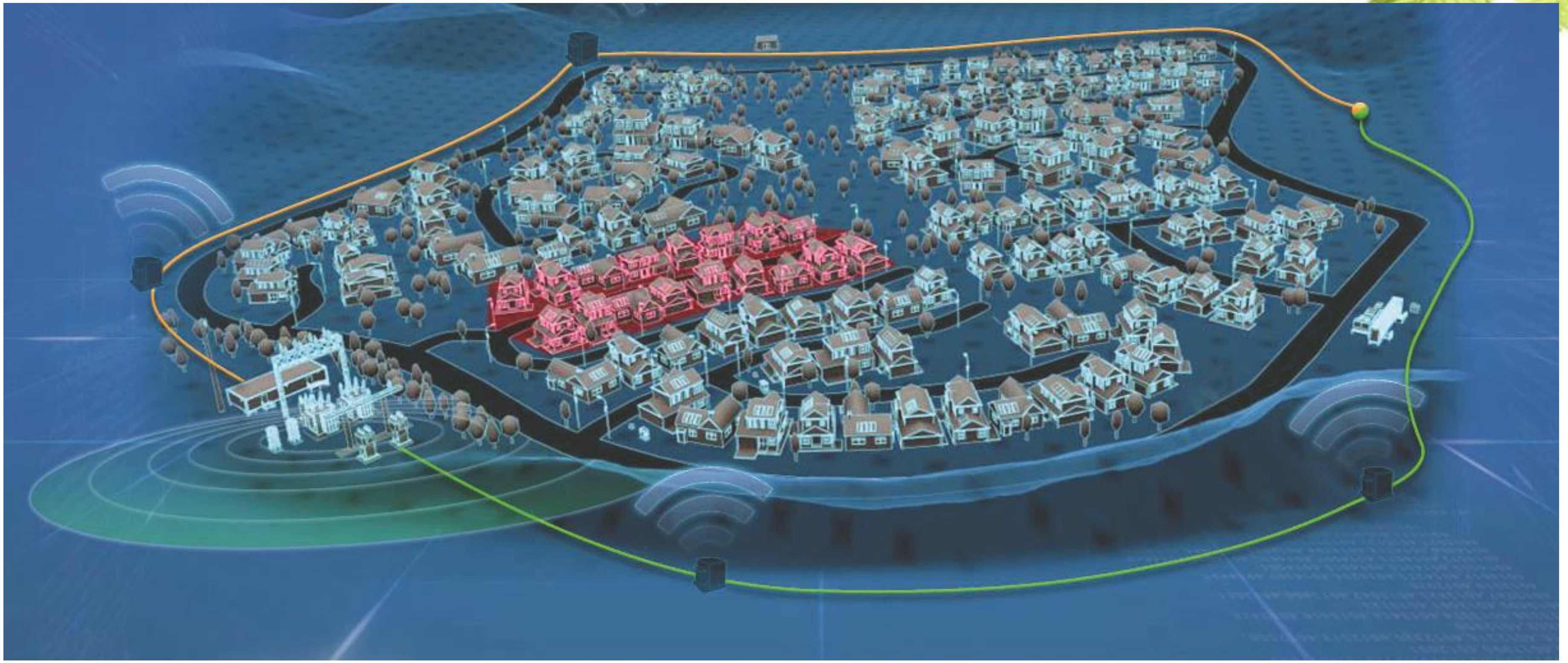
Investigate | Model | Evaluate | **Demonstrate** | Pilot

Community Energy Storage

25kW/50kWh
1 device serves 9 homes

DBESS

2 MW/500kWh
Connected to 12 kV circuit



ADVANCED TECHNOLOGY

SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company