Smart Inverter and DER Provision of Grid Services

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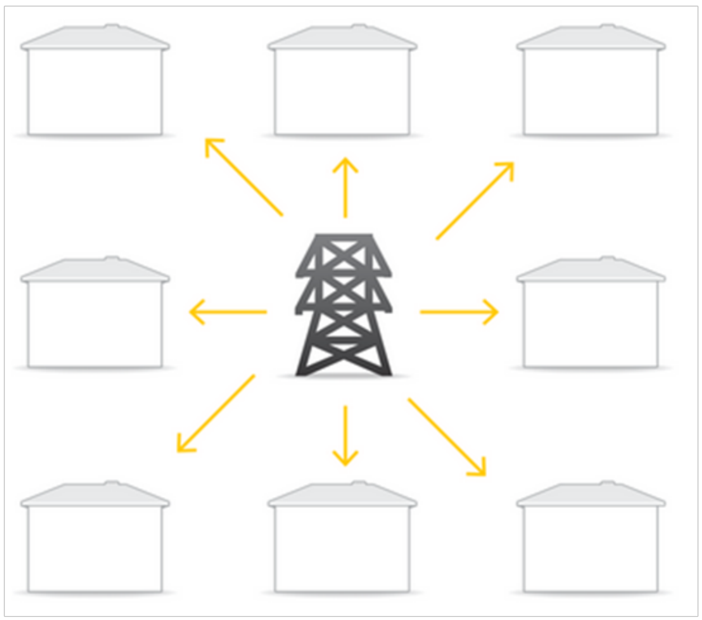
SolarCity
Power forever.

Executive Summary

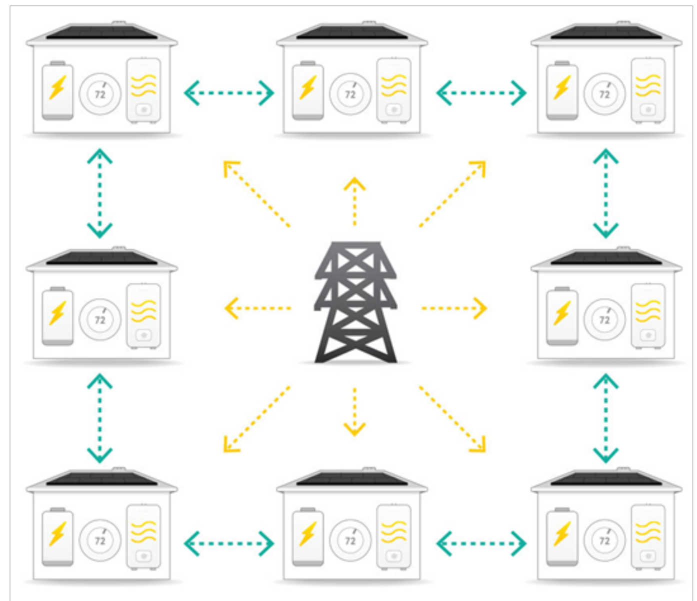
- By modernizing distribution planning, distributed energy resources (DER) can be leveraged to meet grid needs
  - *Integrated Distribution Planning* is a holistic approach to meeting grid needs and expanding customer choice by unlocking the benefits of distributed energy resources
- Smart Inverters and DERs can be utilized today to provide grid services
  - Capacity
  - Power Quality
  - Reactive Power
  - Reliability

Designing the 21st Century Grid

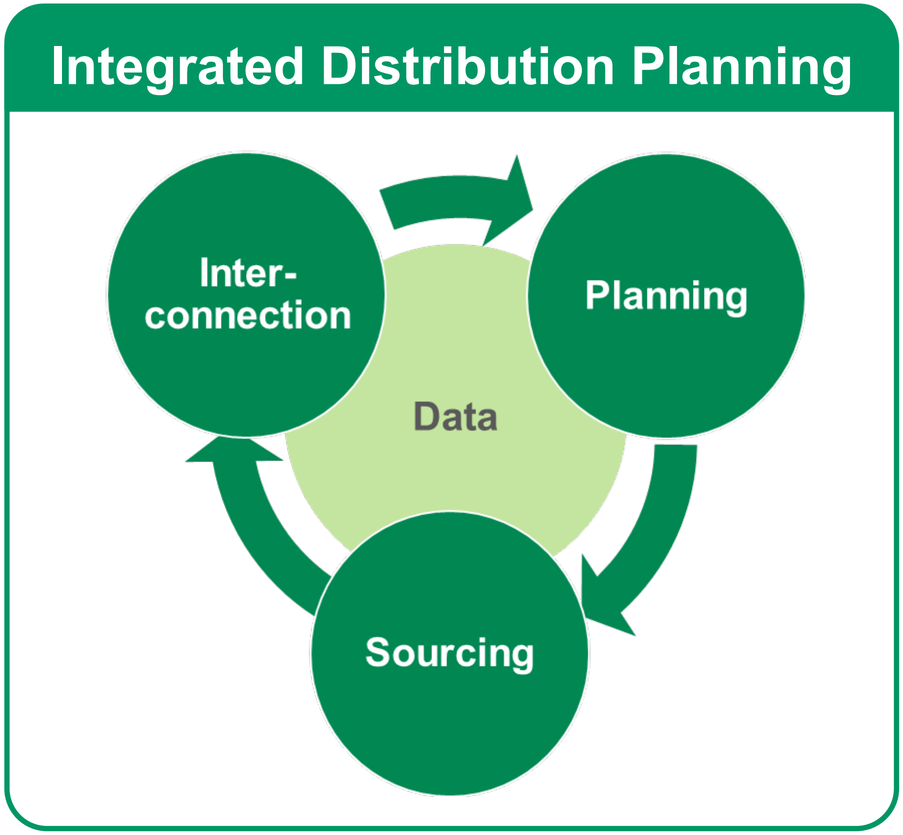
Today



Tomorrow



Modernize distribution planning to leverage DERs



A holistic approach to meeting grid needs and expanding customer choice by unlocking the benefits of distributed energy resources

SIWG Economic and Technical Use Cases for Smart DER Functions, Categorized by the DRP's More-Than-Smart "*Mutually Exclusive and Collectively Exhaustive (MECE)*" List

Utility Actions

- Static
  - Access: DER and/or PCC nameplate data
  - Access: DER/PCC capabilities and supported modes
- Monitoring
  - Monitor: DER and/or PCC operational characteristics
  - Monitor: Short term forecast of DER/ PCC energy
  - Monitor: Permitted/available DER/PCC modes
  - Monitor: DER and/or PCC status & measurements
- Controlling
  - Control: Start/stop DER
  - Control: Enable/disable modes of DER/PCC
  - Control: Set mode parameters and curves for DER/PCC
  - Control: Schedule real power and modes of DER/PCC
  - Control: Issue AGC Reg Up and Down

DER or PCC Autonomous Modes

- Real Power
  - Mode: Limit maximum DER real power output
  - Mode: Limit maximum ESS charging rate
  - Mode: Set real power output of DER or at PCC
  - Mode: Set real power (dis)charging rate of ESS or at PCC
  - Mode: Load / generation following by DER or ESS
  - Mode: Smoothing of real power spikes and sags
  - Mode: Soft-Start Reconnection
- PF
  - Mode: Fixed power factor
  - Mode: Power factor correction
- Freq. Support
  - Mode: High/low frequency ride-through or trip
  - Mode: AGC (utility sends Reg up and down commands)
  - Mode: Frequency smoothing (rapid frequency deviations)
  - Mode: Frequency-watt (Emergency)
- Voltage Support
  - Mode: High/low voltage ride-through or trip
  - Mode: Volt-var control
  - Mode: Volt-watt control (autonomous)
  - Mode: Fast var support
  - Mode: Dynamic reactive current support
- Resilience
  - Mode: Backup power
  - Mode: Provide black start
  - Mode: Convert into microgrid

ISO/RTO Balancing Authority & Market

- Fixed
  - Resource Adequacy (Capacity, Generation, Bl. Start)
  - Resource Adequacy (Flexibility, Ramping, Market)
- Variable
  - Energy (shifting in time)
  - Frequency regulation
  - Frequency smoothing
  - Spinning reserve
  - Non-spinning reserve

Transmission Operations

- Fixed
  - Upgrade deferral due to congestion mitigation
- Variable
  - Transmission voltage support
  - Transmission congestion relief
  - Efficiency (loss reduction)
  - Reliability (redundancy, inertia)

Distribution Operations

- Fixed
  - Upgrade deferral due to load levels & patterns
- Variable
  - Provide distribution voltage support
  - Maintain CVR
  - Reduce number/duration of outages
  - Improve power quality (spikes, harmonics)
  - Improve efficiency
  - Avoid equipment overload, loss of life
  - Improve equipment life
  - Support safety

Customer/End User

- Fixed
  - Procurement risk mitigation
- Variable
  - Support customer choice
  - Reduce energy costs
  - Improve power quality (spikes, harmonics)
  - Avoid equipment damage
  - Support safety
  - Improve reliability (microgrids, backup power)
  - Price & performance risk mitigation

Societal

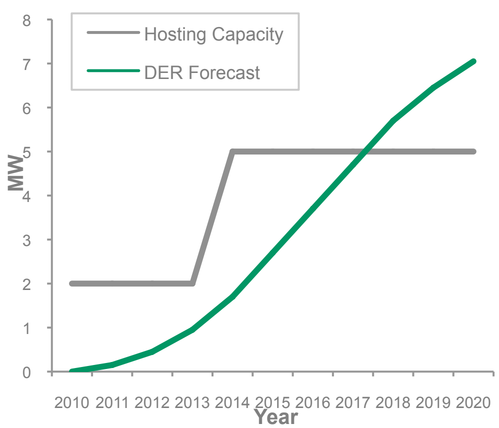
- Variable
  - Reduce CO2 emissions
  - Reduce pollutants
  - Improve energy security
  - Improve water usage
  - Improve land usage
  - Improve economy

There are many advanced inverter use cases to meet grid needs. Unlock through SIWG standards and *Integrated Distribution Planning*.

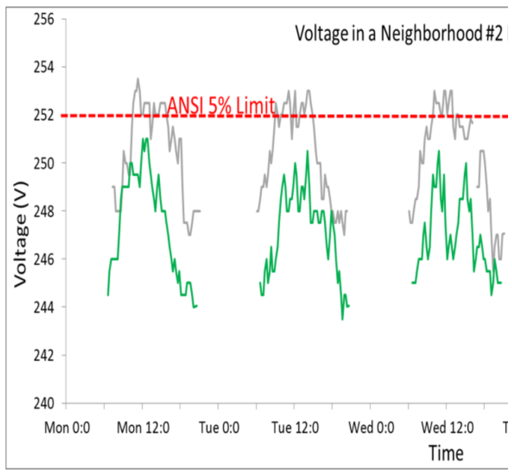
Use Cases: Modernize distribution planning and sourcing to leverage DERs

Planning

Identify Needs

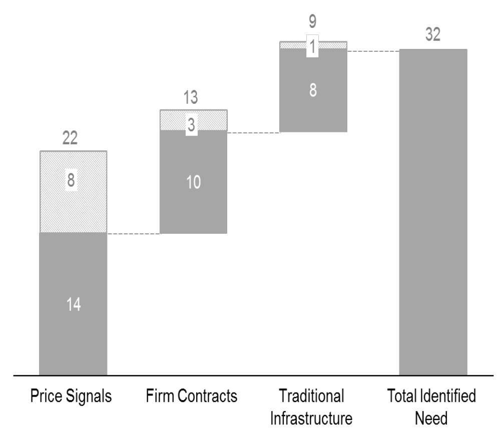


Evaluate Options



Sourcing

Deploy Resources



1

Capacity

Identify Needs → Evaluate Options → Deploy Portfolios

Identify Needs: A 10 MVA substation transformer is projected to be overloaded in 3 years

Evaluate Options: Examine traditional infrastructure and non-wires alternatives

Transformer

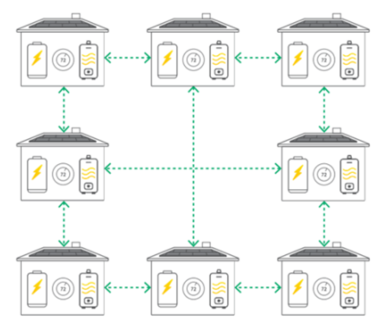
Replace with a new 30 MVA transformer.

Battery

Site a battery at substation.

DER Portfolio

Targeted, controllable DER Aggregation



1

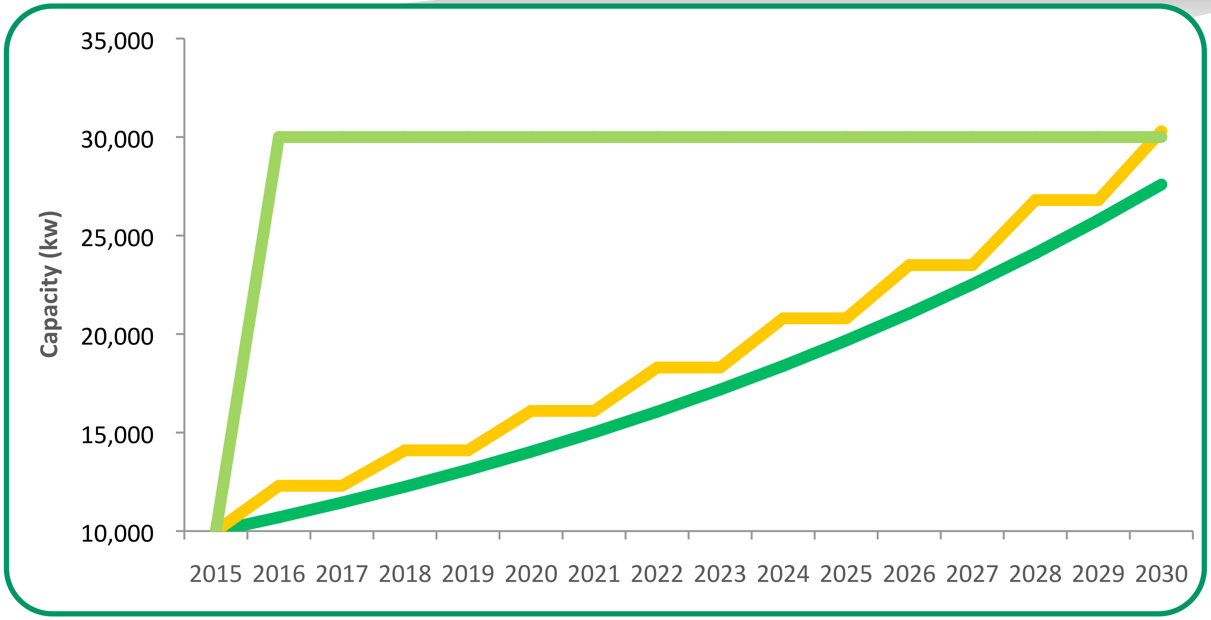
Capacity

Identify Needs → **Evaluate Options** → **Deploy Portfolios**

A 10 MVA substation transformer is projected to be overloaded in 3 years

Examine traditional infrastructure and non-wires alternatives

Utilize least cost / best fit option



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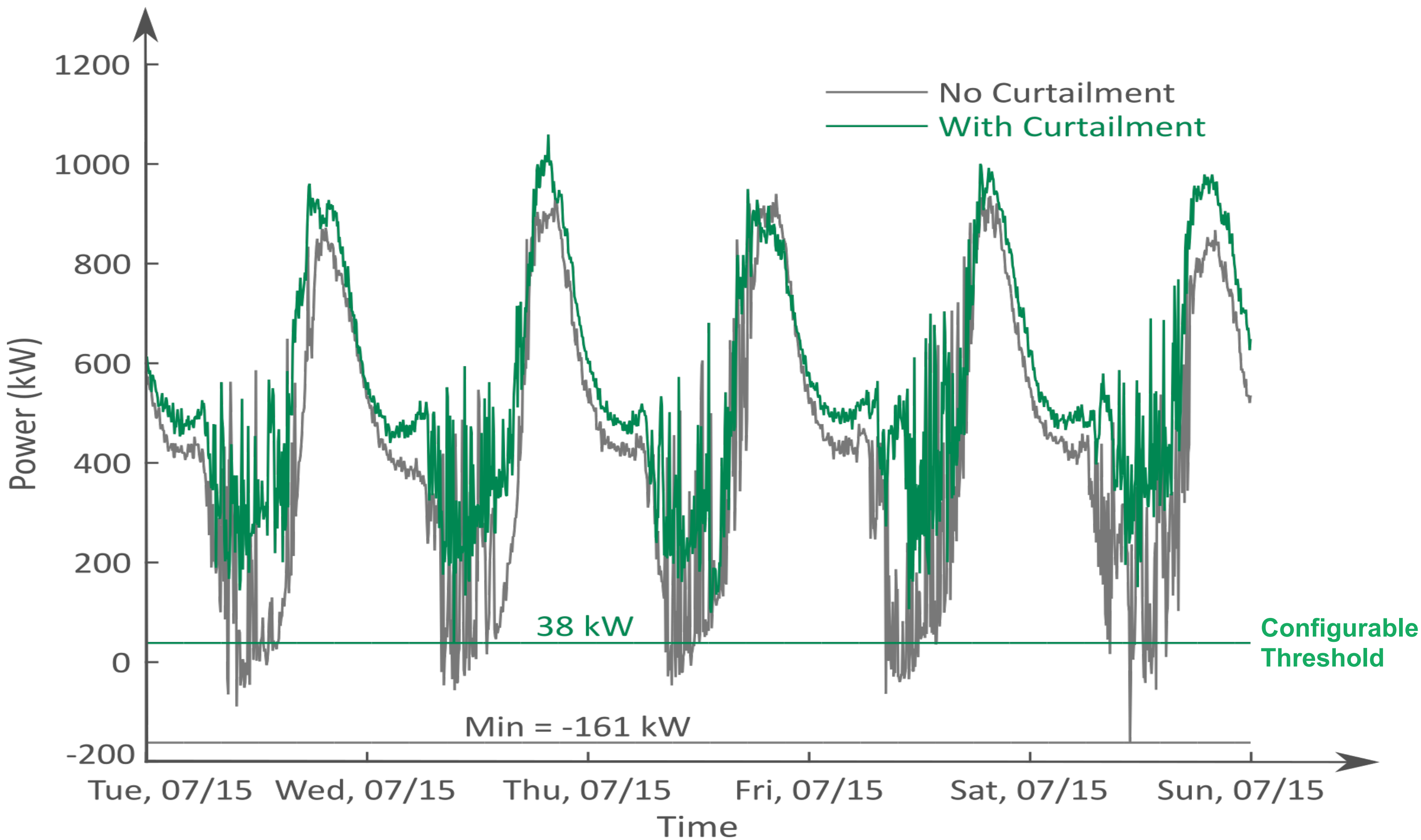
Additional Advanced Inverter Dynamic Control Features

190 inverters and 1.8MW PV



2

Power Quality

Identify Needs → Evaluate Options → Deploy Portfolios

Identify Needs

1200 kVAR in feeder voltage support needed

Evaluate Options

Examine traditional infrastructure and non-wires alternatives

Shunt Capacitor

Conventional shunt capacitor can provide 1200 kVARs.

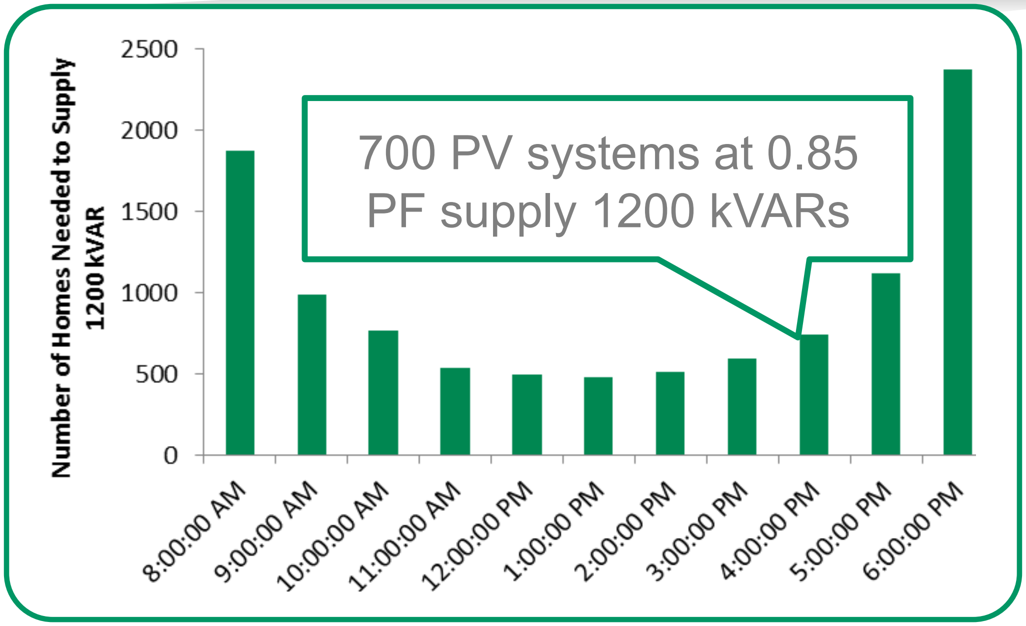
Advanced Inverters

Aggregated portfolio of inverters can dynamically provide kVARs.

Deploy Portfolios

2 Power Quality

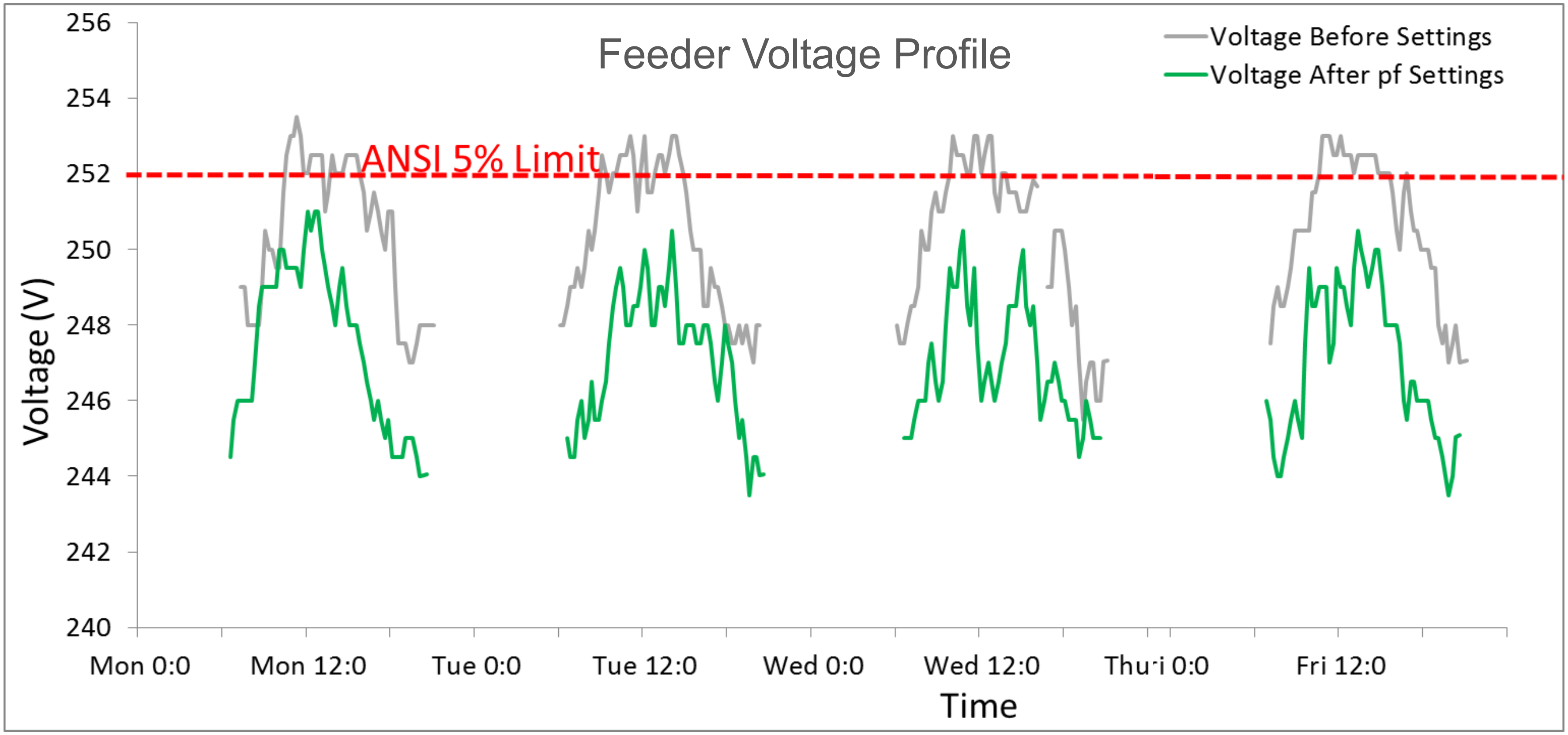
Identify Needs	Evaluate Options	Deploy Portfolios
1200 kVAR in feeder voltage support needed	Examine traditional infrastructure and non-wires alternatives	Utilize least cost / best fit option



2

Additional Advanced Inverter Power Quality Features

275 inverters and 5 MW PV

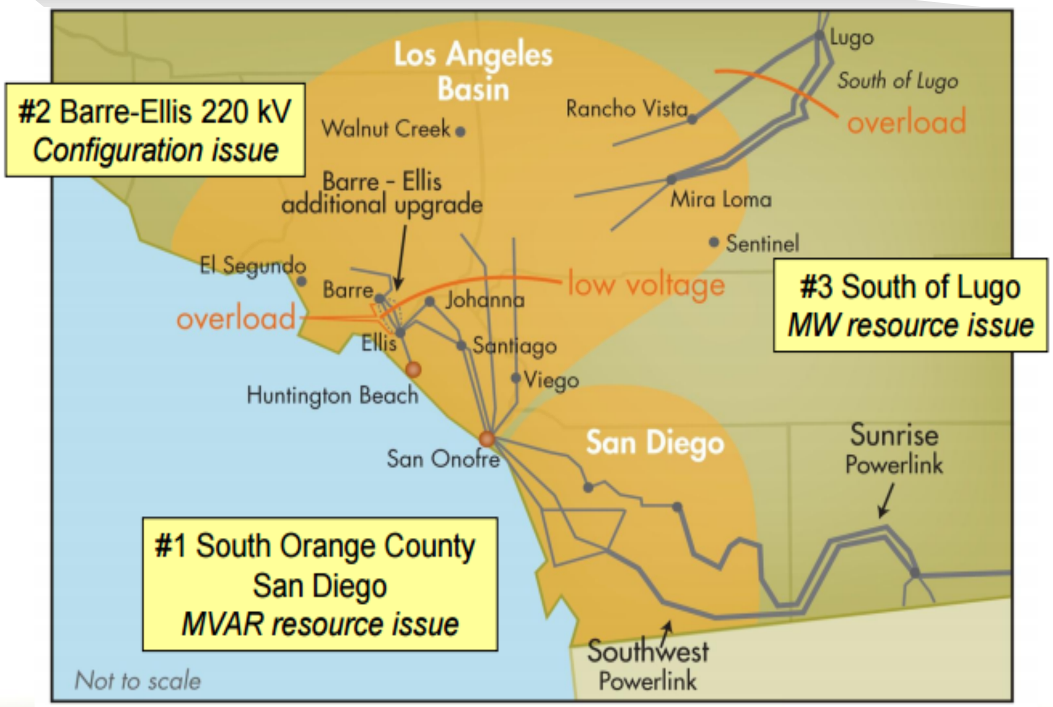


3

Reactive Power

Identify Needs → Evaluate Options → Deploy Portfolios

SONGS retirement necessitated new reactive power support



3

Reactive Power

Identify Needs → Evaluate Options → Deploy Portfolios

Identify Needs: SONGS retirement necessitated new reactive power support

Evaluate Options: Examine traditional infrastructure and non-wires alternatives

Synchronous Condenser

Synchronous condenser capable of dynamically providing up to 250 MVAR

Advanced Inverters

70,000 advanced inverters can provide required VARs

3

Reactive Power

Identify Needs → **Evaluate Options** → **Deploy Portfolios**

Identify Needs	Evaluate Options	Deploy Portfolios
SONGS retirement necessitated new reactive power support	Examine traditional infrastructure and non-wires alternatives	Utilize least cost / best fit option

Project	Capacity	In-Service Date	Project Cost
Huntington Beach Synchronous Condensers	280 MVAR	6/1/2013	$4.75M
Johanna and Santiago 220 kV Capacitor Banks	160 MVAR	7/1/2013	$1.1-10M $10-50M
Viejo 220 kV Capacitor Banks	160 MVAR	7/1/2013	$1.1-10M $10M $10-50M
Talega Area Dynamic Reactive Support	250 MVAR	6/1/2015	$58-72M
South Orange County Dynamic Reactive Support	400 MVAR	12/1/2017	$50-75M
Penasquitos 230 kV Synchronous Condenser	240 MVAR	5/1/2017	$56-70M
TOTAL			**$171-322M**

4

Reliability

Identify Needs → Evaluate Options → Deploy Portfolios

Identify Needs: An isolated feeder with high SAIDI/ CAIDI

Evaluate Options: Examine traditional infrastructure and non-wires alternatives

Underground Lines

Feeder is converted from overhead to underground to decrease frequency of outages.

Automated Restoration

Automation isolates the fault while automatically restoring customers.

Microgrid

Local microgrid provides backup power to entire circuit / line segment.

Customer Backup

Home and/or community batteries with advanced inverter provide backup power.

4

Reliability

Identify Needs → **Evaluate Options** → **Deploy Portfolios**

An isolated feeder with high SAIDI/ CAIDI

Examine traditional infrastructure and non-wires alternatives

Utilize least cost / best fit option

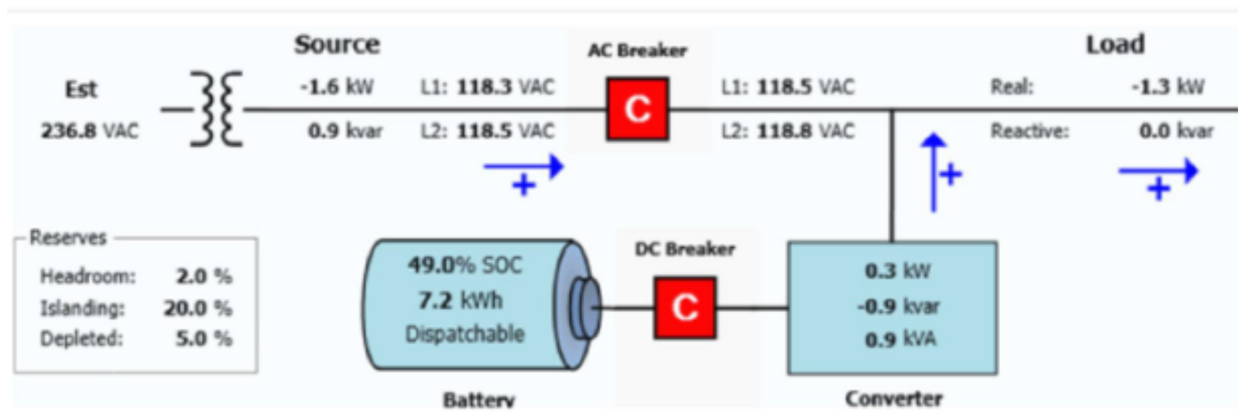


Image Sources: SDG&E

Potential Additions

- **Upgrade Deferral**
  - Equipment Utilization/Load Factor
  - Hosting Capacity
  - Power Quality – Capacitors, regulators, and reconductoring.
  - Reliability – Implement microgrids or self-powered homes in lieu of traditional reliability program expenses
  - AMI – Utilize DER AMI in lieu of investing in SmartMeters.
- **Improve Reliability**
  - Emergency Capacity Deferral
  - Virtual Load Transfer
- **Improve Situational Awareness**
  - Remotely identify, investigate, and solve power quality problems
  - Replace AMI
  - Virtual Line Sensors
  - Improved Modeling Accuracy
  - Distribution State Estimation

Thank You

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