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Conservation Voltage Reduction in the Electricity Demand Forecast

In the underlying assumptions for the upcoming Electricity Demand Forecast, we would like to advocate for the inclusion of Conservation Voltage Reduction (CVR). The attached analysis, conducted by Navigant Research, indicates that at prices coming in at under $0.01/kWh and benefit-cost ratios exceeding 4.0, CVR is poised to provide between 1/4 and 1/3 of SB-350 target of doubling EE by 2030 for CA utilities. Accordingly, we believe it would be prudent for the Commission to factor in CVR into the forecast for CA electricity demand, if California is to maintain its leadership in energy efficiency and grid innovation.

Additional submitted attachment is included below.

VOLT/VAR OPTIMIZATION AND CONSERVATION VOLTAGE REDUCTION: MARKET POTENTIAL ASSESSMENT & ECONOMIC METRICS

STATE OF CALIFORNIA

June 18, 2018

varentec

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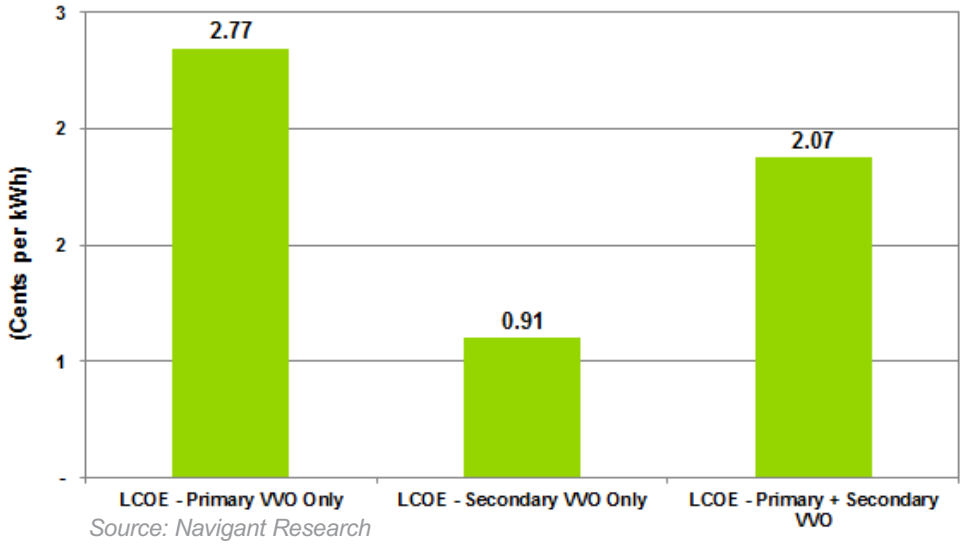
CALIFORNIA:
TRC BCR AND LCOE MODEL RESULTS

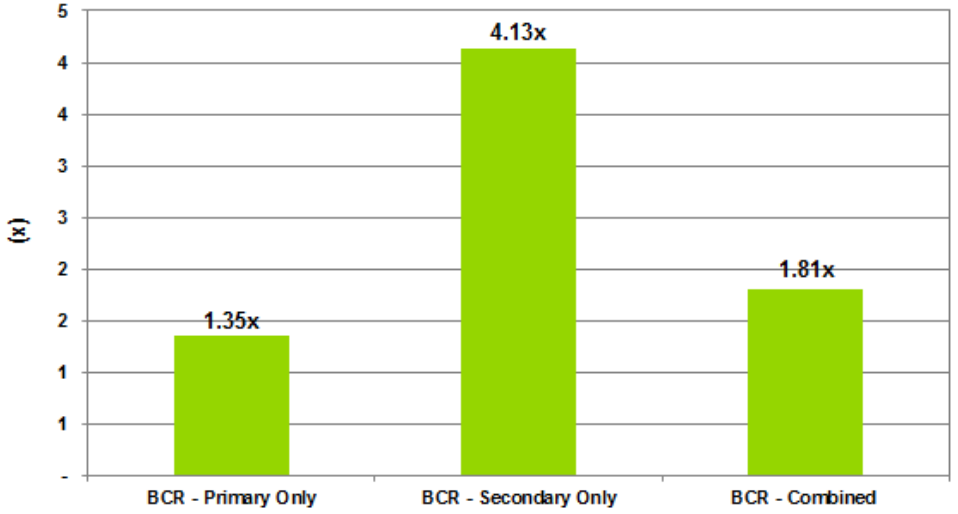
- The LCOE of energy saved via Secondary volt-VAR optimization (VVO) technologies is just **0.91 cents/kWh**, vs. 2.77 cents/kWh for Primary VVO only deployments. The addition of Secondary VVO reduces overall LCOE to 2.07 cents/kWh.
- Assuming a 1.35x total resource cost (TRC) benefit cost ratio (BCR) for Primary VVO deployments, the implied **BCR for Secondary VVO exceeds 4x** and raises the overall BCR for combined deployments to 1.8x.
- *Key Assumptions: 60% of total circuits eligible, accounting for 65% of load; 3.0% average voltage reduction with Primary VVO and 1.8% with Secondary VVO, CVR factor 0.70. 100% of Primary VVO circuits deploy Secondary VVO.*

LCOE Primary VVO, Secondary VVO, and Combined, California



Source: Navigant Research

BCR Primary VVO, Secondary VVO, and Combined, California



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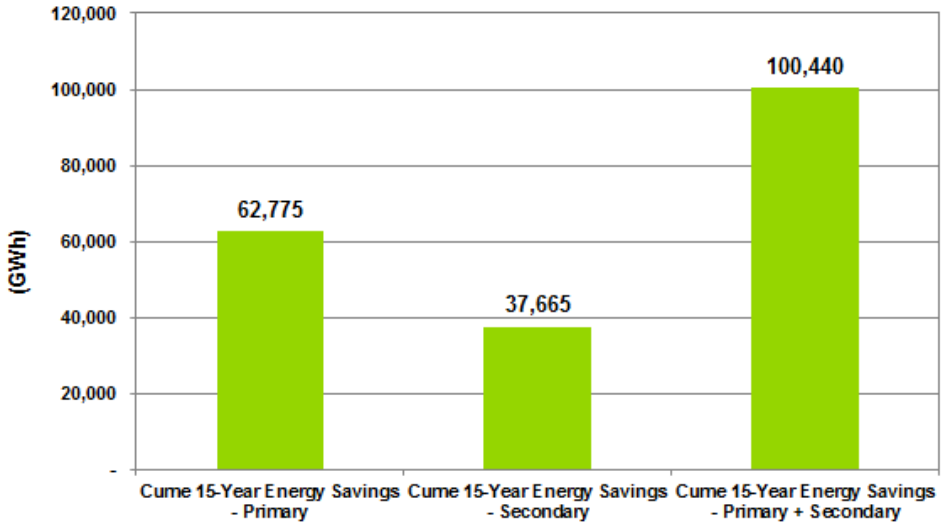
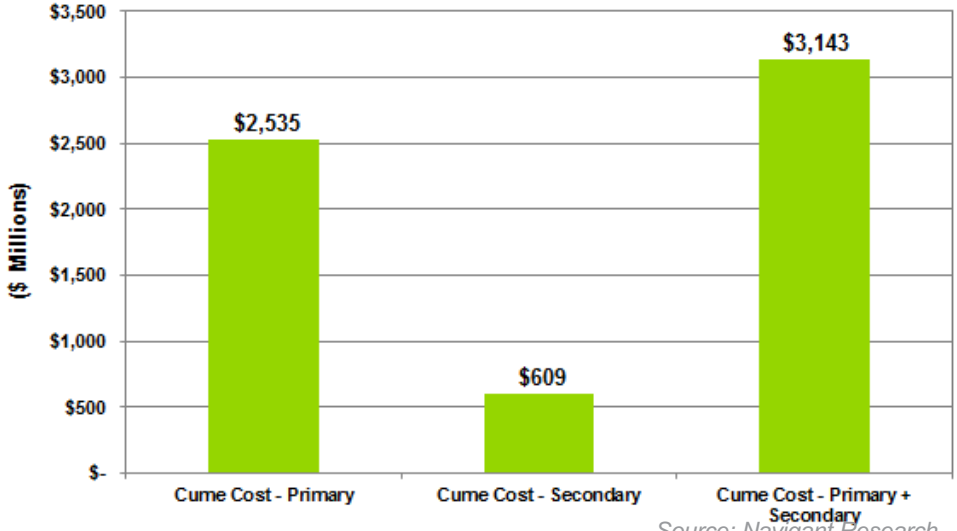
CALIFORNIA:
TOTAL POTENTIAL ENERGY SAVINGS AND COSTS WITH VVO

- Deployment of Primary VVO to all eligible circuits (60% of total) would save 62.8 TWh of energy over 15 years, at a cost of $2.5 billion.
- The addition of Secondary VVO to all eligible circuits saves an additional 37.7 TWh of energy over 15 years, with an incremental cost of $609 million.
- Combined, California could **cut energy consumption by 100.4 TWh over 15 years**, for ~$3.1 billion. This is based on projected load for 2032. *This is the equivalent of 94 million tons of coal generation.*
- *The **average annual potential energy savings of 6.3 TWh** is more than one-fourth of California's new SB-350 2x Energy Efficiency target savings of **27.6 TWh by 2030 for IOUs and public utilities**. (The total new EE target is 82.9 TWh)*

Cume 15-Year Energy Savings with Primary VVO, Secondarv VVO and Combined. California



Cume 15-Year Costs for Primary VVO, Secondary VVO and Combined, California



Source: Navigant Research

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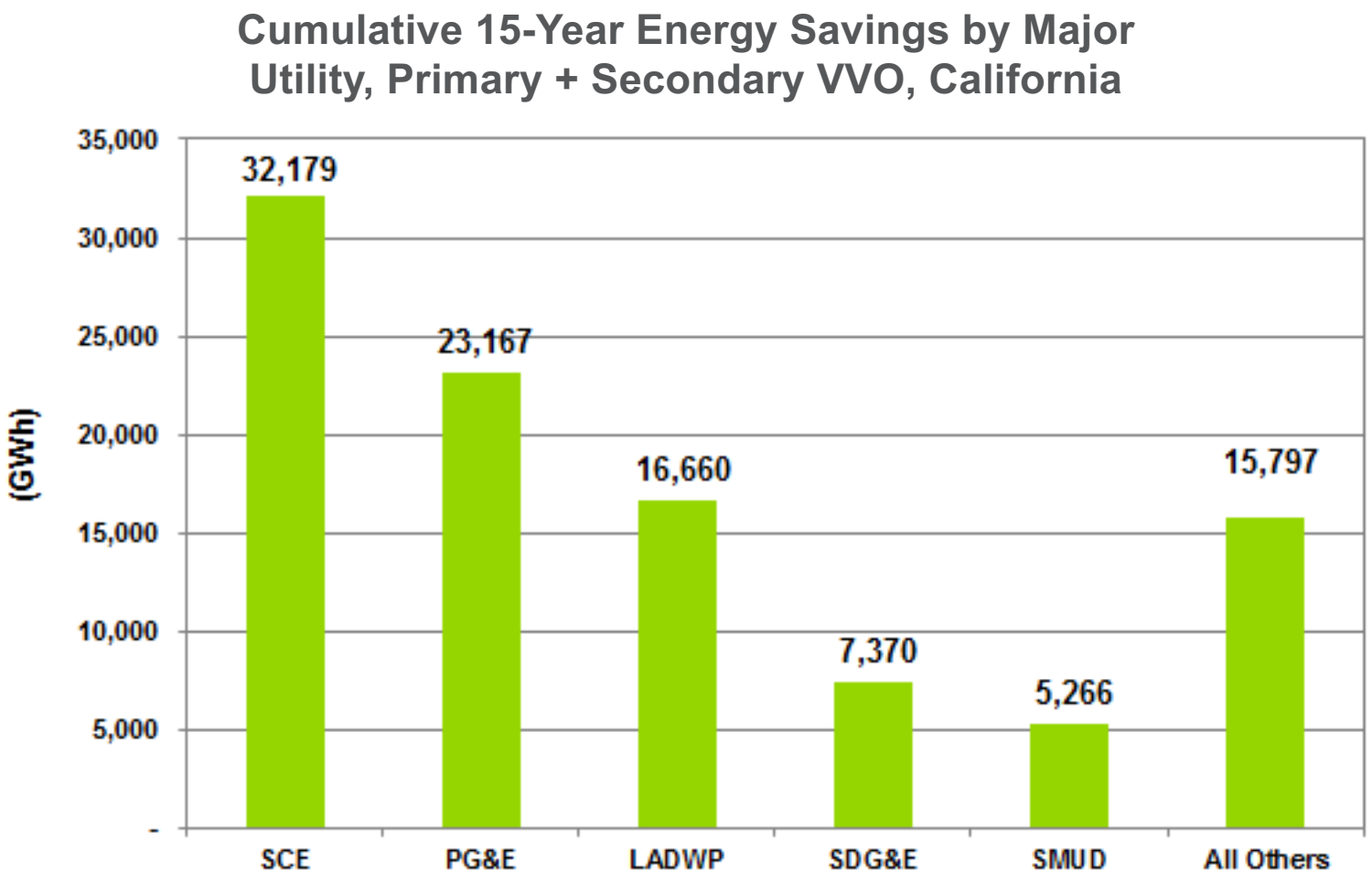
CALIFORNIA:
POTENTIAL ENERGY SAVINGS BY MAJOR UTILITY



Source: Navigant Research

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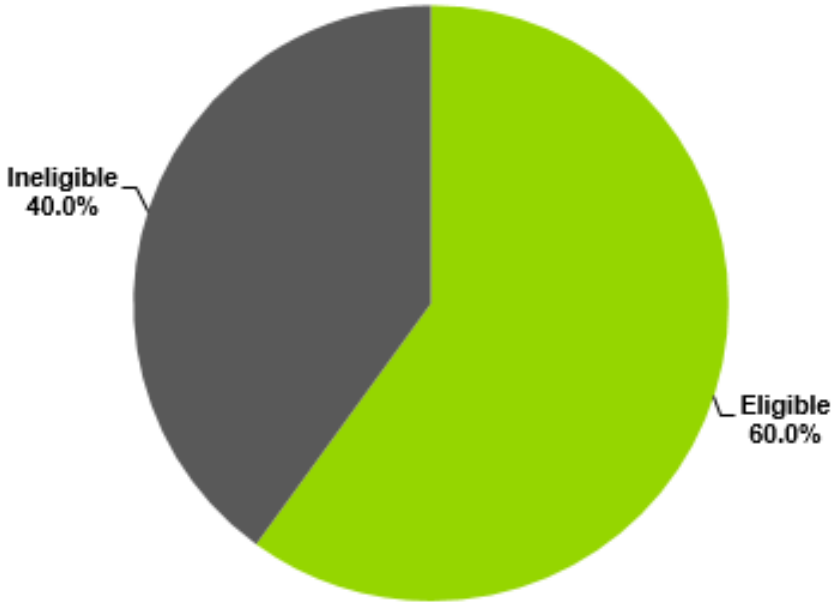
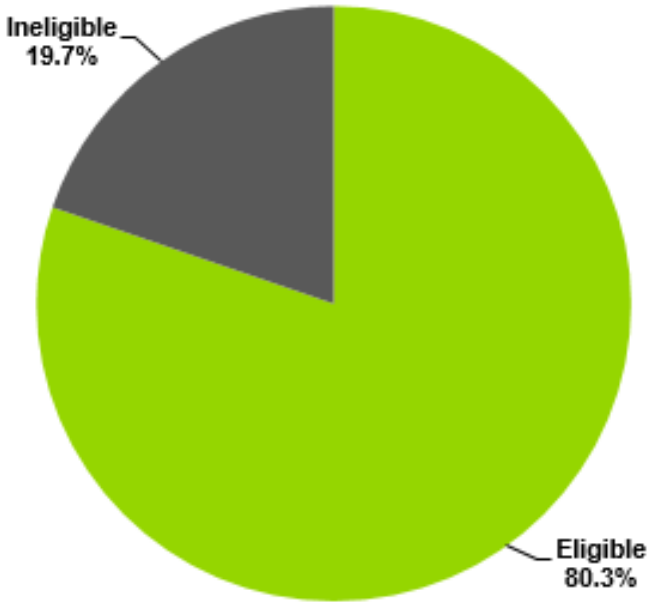
CALIFORNIA:
SECONDARY VVO RAISES THE NUMBER OF ELIGIBLE CIRCUITS

- The addition of Secondary VVO increased the BCR by 38% versus Primary only (1.81/1.35).
- In California, this means an additional ~3,100 circuits are eligible, or 20.3%.
- *The potential energy savings under this expanded deployment scenario would be another 36.3 TWh over 15 years, or 2.4 TWh per year on average. If all eligible circuits were built out under this expanded scenario, VVO (Primary + Secondary) could save ~8.7 TWh per year, or 31.5% of the 2x Energy Efficiency target savings of 27.6 TWh for IOUs and public utilities.*

VVO Eligible Circuits with Primary Only



VVO Circuits with Primary + Secondary VVO



Source: Navigant Research

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CALIFORNIA: CIRCUITS BY UTILITY

- The **top five utilities** in California account for >84% of distribution circuits in the state.

Utility Name	Distribution Circuits	Percent of Total
Southern California Edison	**4,510**	**32.0%**
Pacific Gas & Electric	**3,247**	**23.1%**
Los Angeles Department of Water & Power	**2,335**	**16.6%**
San Diego Gas & Electric	**1,033**	**7.3%**
Sacramento Municipal Utility District	**738**	**5.2%**
Imperial Irrigation District	320	2.3%
Modesto Irrigation District	173	1.2%
City of Santa Clara, California	168	1.2%
City of Riverside, California	129	0.9%
City of Pasadena, California	126	0.9%
City of Burbank Water and Power	116	0.8%
Turlock Irrigation District	110	0.8%
City of Anaheim, California	109	0.8%
City of Glendale, California	108	0.8%
City of Roseville, California	100	0.7%
All Others	755	5.4%
Total California	**14,077**	**100.0%**

Source: EIA, December 2016 data.

CALIFORNIA:
CIRCUIT PENETRATION OF VOLTAGE OPTIMIZATION

- Upwards of 30% of California's distribution circuits have some level of voltage optimization technology installed today.
- Many of these are traditional hardware-based solutions.
- *Known/believed software-based solutions are in **bold**.*

Utility Name	Distribution Circuits	Circuits with Voltage Optimization	Penetration
City of Anaheim, California	109	109	100.0%
City of Healdsburg, California	4	4	100.0%
City of Lodi, California	29	29	100.0%
Merced Irrigation District	19	19	100.0%
City of Riverside, California	129	129	100.0%
Truckee Donner P U D	17	17	100.0%
City of Alameda	26	24	92.3%
Lassen Municipal Utility District	18	16	88.9%
City of Shasta Lake, California	8	6	75.0%
Los Angeles Department of Water & Power	2,335	1,693	72.5%
City of Lompoc, California	10	7	70.0%
San Diego Gas & Electric	1,033	605	58.6%
City of Banning, California	21	11	52.4%
Southern California Edison	**4,510**	**899***	19.9%
Sacramento Municipal Utility District	**738**	**118**	**16.0%**
City of Glendale, California	**108**	**13**	**12.0%**
Modesto Irrigation District	**173**	**11**	**6.4%**
Plumas-Sierra Rural Elec Coop	29	1	3.4%
Pacific Gas & Electric	**3,247**	**14**	**0.4%**
All Others	1,514	0	0.0%
Total California	**14,077**	**3,725**	**26.5%**

**SCE's VVO deployment covers a subset of these circuits.*

Source: EIA, December 2016 data.

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CALIFORNIA:
MARKET DYNAMICS AND REGULATORY ENVIRONMENT

- **A progressive PUC and high renewables penetration make California a leading state in terms of VVO activity and market potential.**
  - Southern California Edison (SCE) and Sacramento Municipal Utility District (SMUD) are moving forward with relatively aggressive VVO deployments.
  - Pacific Gas & Electric (PG&E) and San Diego Gas & Electric (SDG&E) are doing more limited trials; their filings indicate a belief that smart meter and smart inverter data can be used to effectively manage voltage issues in a majority of circuits.
- **SB-350: As part of Senate Bill (SB) 350, the California public utilities commission (PUC) will include conservation voltage reduction (CVR) in its definition of energy efficiency.**
- This is a historic precedent which should incent utilities to reconsider more conservative VVO plans and programs. *Navigant Research has relied heavily on this legislation in forecasting aggressive (40+%) penetration for VVO programs by 2032*.
  - Historically, CVR has not been considered as a qualifying energy efficiency program by state PUCs.
  - Actions taken by the CPUC often set a precedent for other state PUCs.
- California is doubling its energy efficiency targets, to 82,870 GWh by 2030. CVR can play a substantial role in meeting those targets—at a LCOE of under 1 cent per kWh.
- **Smart Solar Inverters.** CPUC has mandated smart inverters for new solar installations as of September 2017 (details of Rule 21 follow on the next slide).

CALIFORNIA:
RULE 21 FOR SOLAR GRID INTERCONNECTION

Phase 1 (in effect since September, 2017):

- **Automated and centralized voltage control meets Rule 21 compliance that inverters are:**
  - Voltage ride-through capable
  - Frequency ride-through capable
  - Expanded power factor capable (1.0+/-0.15)
- **Dynamic Volt/VAR operating capable**
  - Ramp-up control capable at 1% increments

Phase 2 and 3 (timing not yet established):

- **Will require devices to comply with the following:**
  - Phase 2 will establish communications protocols
  - Phase 3 will require additional inverter functions such as data monitoring, remote connection and disconnection, and maximum power controls

CALIFORNIA:
KEY UTILITY VVO PROGRAMS

- PG&E intends to extend its conservation voltage reduction (CVR) trial to 510 circuits—out of 3,250 (16%).
  - The utility believes smart solar inverters and smart meters will provide adequate support for voltage optimization in a majority of circuits.
- SCE plans to deploy CVR, through its patented DVVC initiative, to a total of 313 substations by the end of 2018.
  - **This represents nearly half of SCE's 677 distribution substations.**
- SMUD is pursuing CVR and VVO for both peak demand reductions and electricity conservation.
  - Its project includes 109 feeders and uses 180 automated capacitor banks which cover about 18% of the system.
  - The CVR objective for peak demand reduction is 10.4 MW; the CVR objective for electricity conservation is 36,520 MWh per year of energy savings. The latter objective is achieved by implementing CVR over several additional hours during the days when the peak demand reduction capabilities have been activated.
  - The VVO objectives include peak demand reduction of 6.1 MW and energy savings of 11,150 MWh per year by improving the efficiency of the distribution feeders.
  - SMUD's method of implementing CVR is utilizing the voltage reduction feature of the LT control at the distribution substation. A command is issued to the LTC control by a distribution system operator via SMUD's energy management system, which implements one of three levels of voltage reduction available in the control. The percent reduction at each level is a configurable value which SMUD has initially set at 1%, 2%, and 3%, for evaluation purposes.
- Neither SDG&E nor Los Angeles Department of Water and Power have committed to significant VVO/CVR programs.

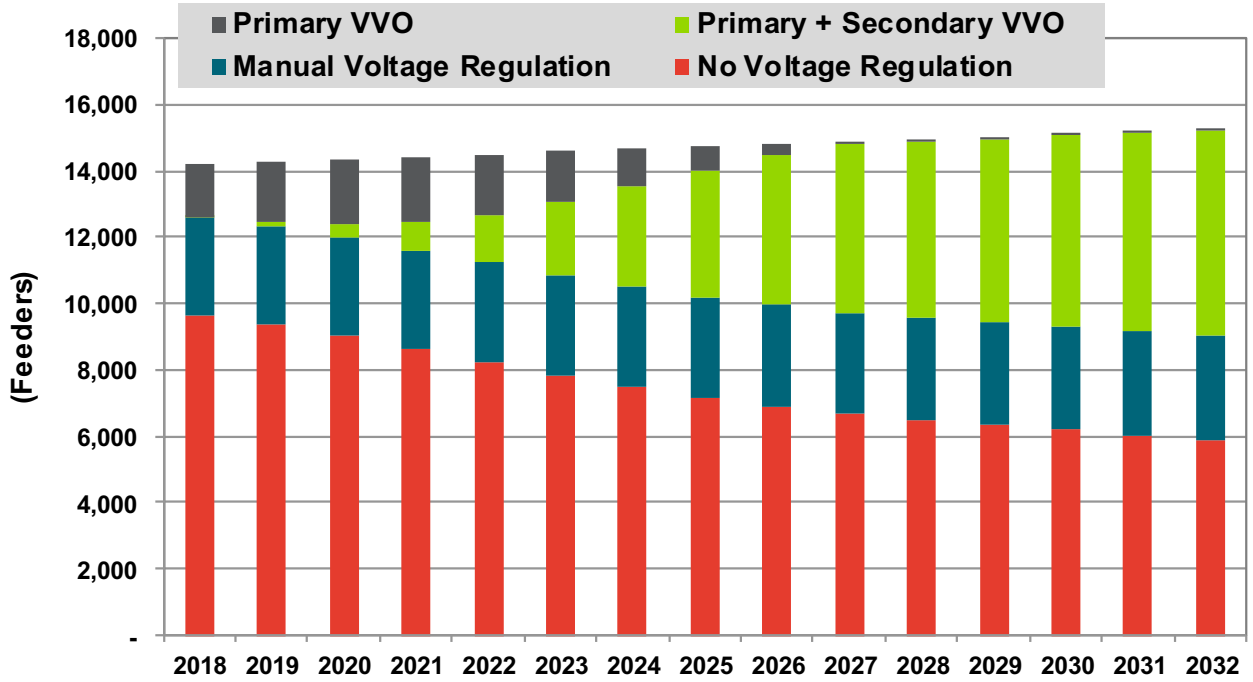
CALIFORNIA: FACTORS WHICH IMPACT VVO DEPLOYMENT

- In developing the market forecasts for California, for both Primary and Secondary VVO, Navigant Research reviewed utility data and filings, the outlook for solar installations and a variety of additional Secondary information.
- In addition to announced utility plans, Navigant Research considered the availability of:
  - **Smart Meters:** Penetration estimated at 83%
  - **Field Area Networks:** Widespread deployment of smart meters in California means that there are commonly field area networks in place to carry Primary/Secondary VVC data.
  - **Solar Penetration:** An estimated 328,000 solar installations could be found in California at the end of 2017, including 323,000 residential installations.
  - **Smart Solar Inverters:** Very low penetration today, but CA Rule 21 means that all new residential installations must employ a smart inverter. Navigant Research estimates that smart solar inverter penetration of solar installations will hit 28% by 2020.
  - **Connectivity at Distribution Substations:** D-Sub connectivity in California is estimated to be >50% (relatively high for the US).
  - **D-SCADA and Advanced Distribution Management Systems**

CALIFORNIA:
MARKET OUTLOOK: VOLTAGE REGULATION

- Primary VVC penetration in California is expected to grow from 11% at the end of 2017 to 40.9% by the end of 2032.
- Secondary VVC penetration is forecast to hit 40.6% of all feeders by 2032 (99% of Primary VVC feeders).

Voltage Regulation Status in Distribution Feeders, California: 2018-2032



Source: Navigant Research

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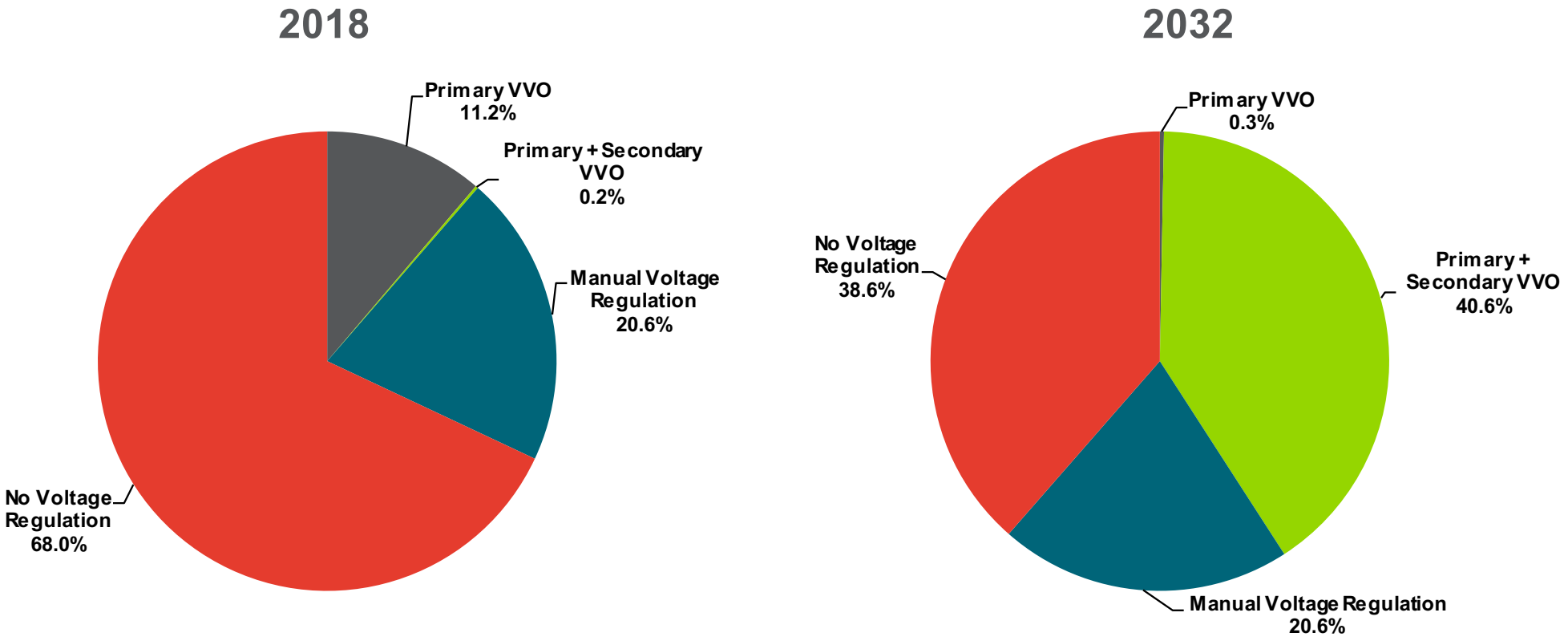
CALIFORNIA:
MARKET OUTLOOK: VOLTAGE REGULATION

Voltage Regulation Status in Distribution Feeders, California: 2018 vs. 2032



Source: Navigant Research

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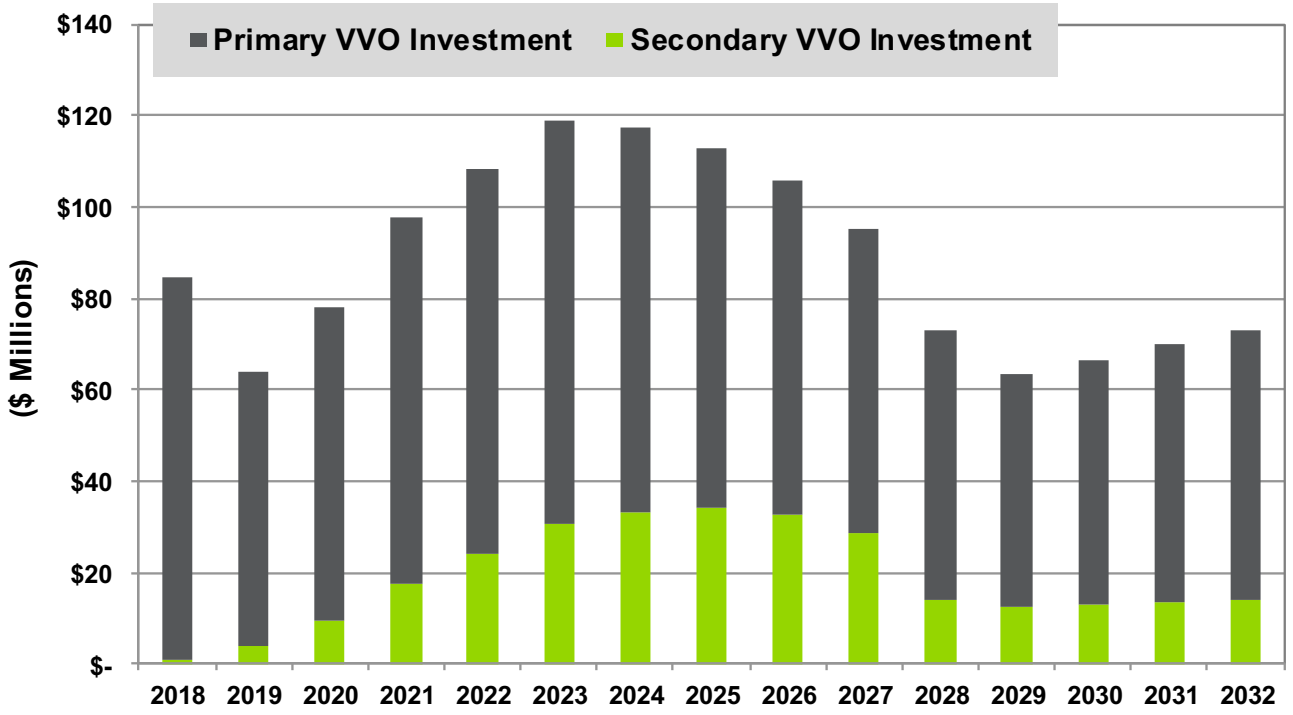
CALIFORNIA:
TOTAL VVC MARKET POTENTIAL

- Annual investment in Primary and Secondary VVO in California is expected to grow to more than ~$100 million annually by 2022, and to peak in 2024 at $117 million in 2024.
- Cumulative investment in Primary and Secondary VVO will amount to $1.05 billion and $283 million, respectively, through 2032.

Annual Investment in VVC Technology, California: 2018-2032



Source: Navigant Research

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