SCE Renewable Integration

ADVANCED TECHNOLOGY
Transmission & Distribution Business Unit

March 2, 2011

Michael R. Montoya
Director, Grid Advancement

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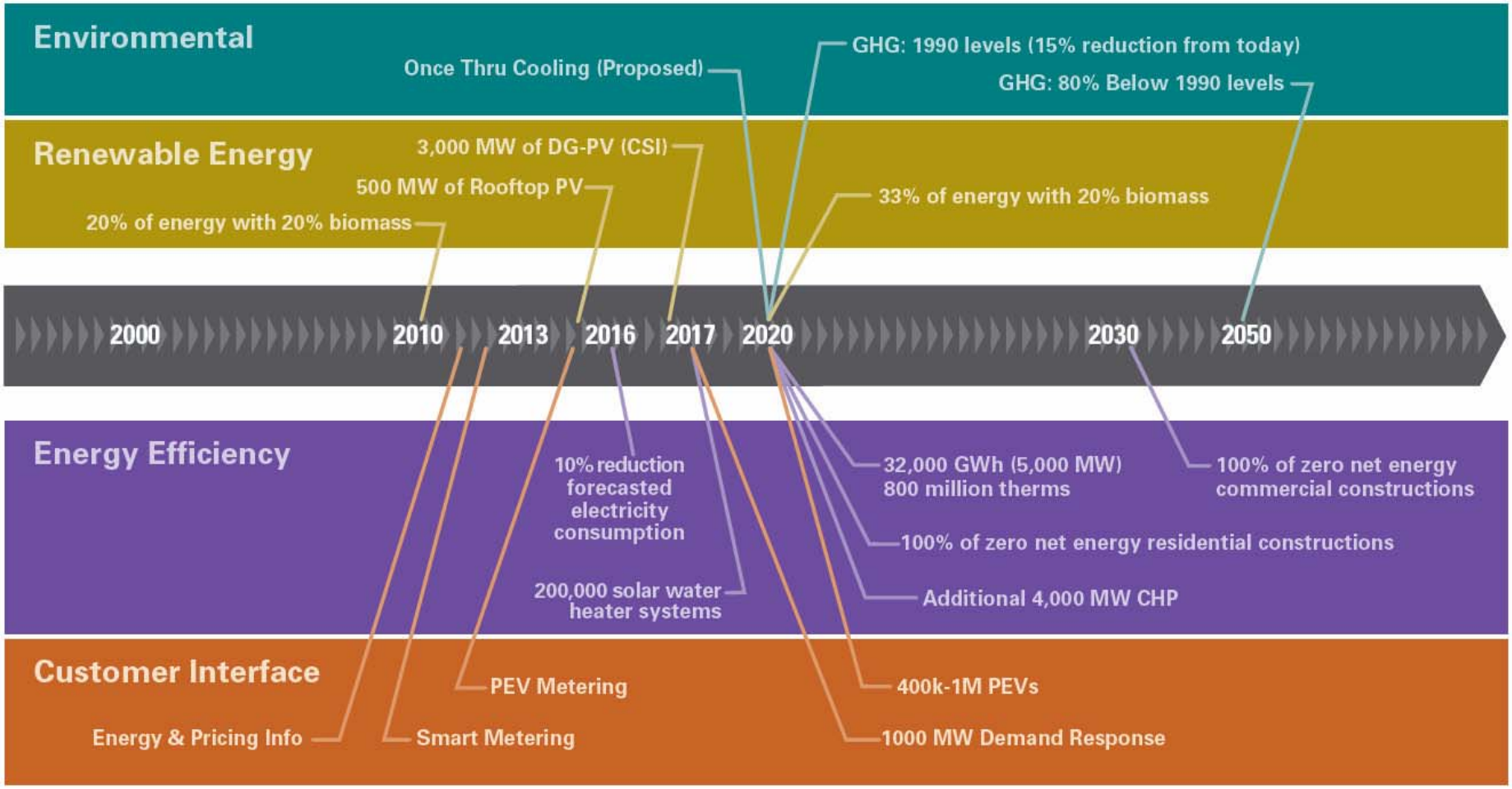
CA Policies Affecting Smart Grid Development



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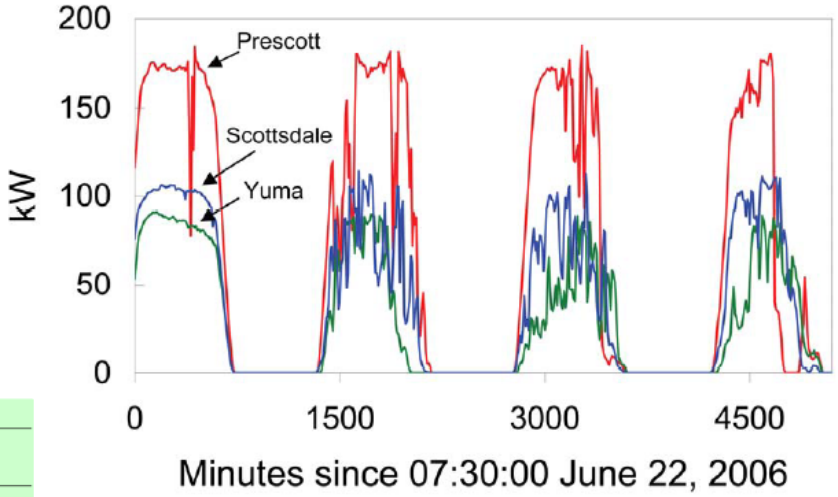
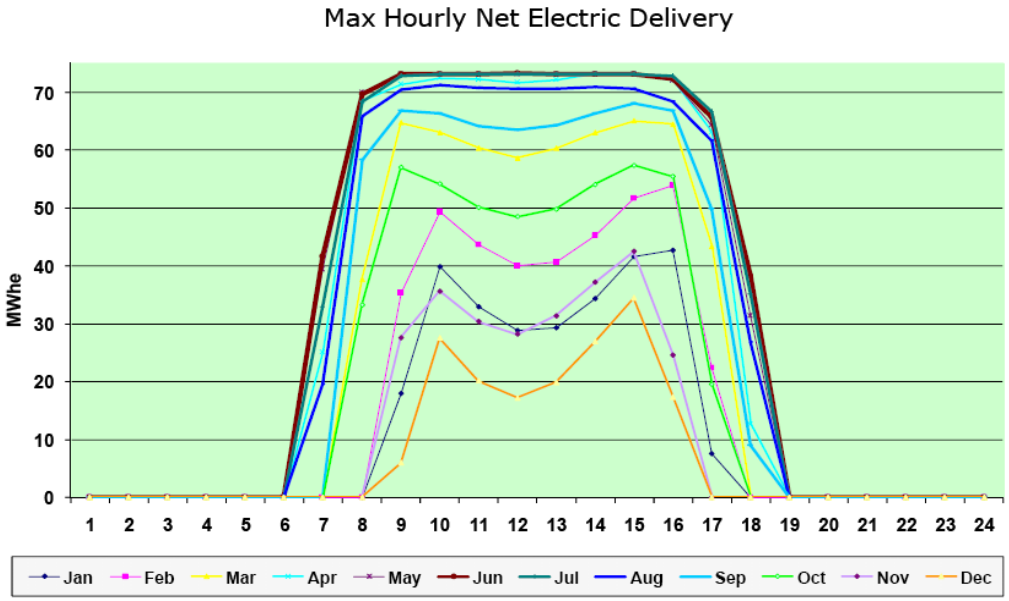
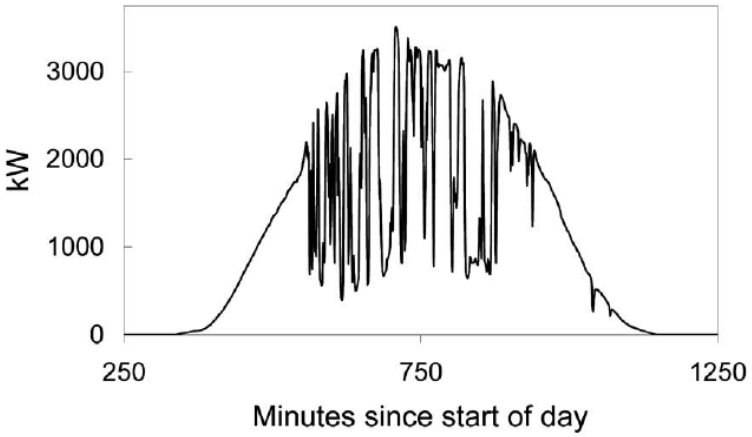
Solar Intermittencies

- Seasonal, daily, minute solar power fluctuating
- PV inverter – grid interactions
- Low capacity factor < 20%
- Inaccurate forecasting
- No storage







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Identified Issues – Distribution Operations

- Voltage control
  - Multiple sources on a distribution feeder
  - Intermittency
- Protection
  - Overall circuit protection coordination
    - Potential reverse power flow
  - Inverter fault current characteristics
- System operation
  - Switching impacts resulting from large levels of PV generation
    - Don’t want to limit system operations during emergency and clearances
    - Transient over voltages after inverter disconnection
  - Interoperability of multiple inverters from various manufactures
- Power quality
  - Potential harmonic issues including inverter Pulse Width Modulation frequency
- Monitoring and control
  - As the aggregate capacity increases, additional monitoring and control may be desired or required

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Identified Issues – Transmission Operations

- Regulation
  - Load following
  - Area Control Error/Frequency Regulation (AGC)
- Reserve Capacity
  - Minimum Operating Reliability Criteria
  - Spinning Reserve
  - Fault ride-through
- Ramp Capability
  - Off-peak generation
  - Intermittent Output
- Wide Area Situational Awareness and Controls
  - Synchrophasor data for situational awareness
  - Synchrophasor data for wide area controls

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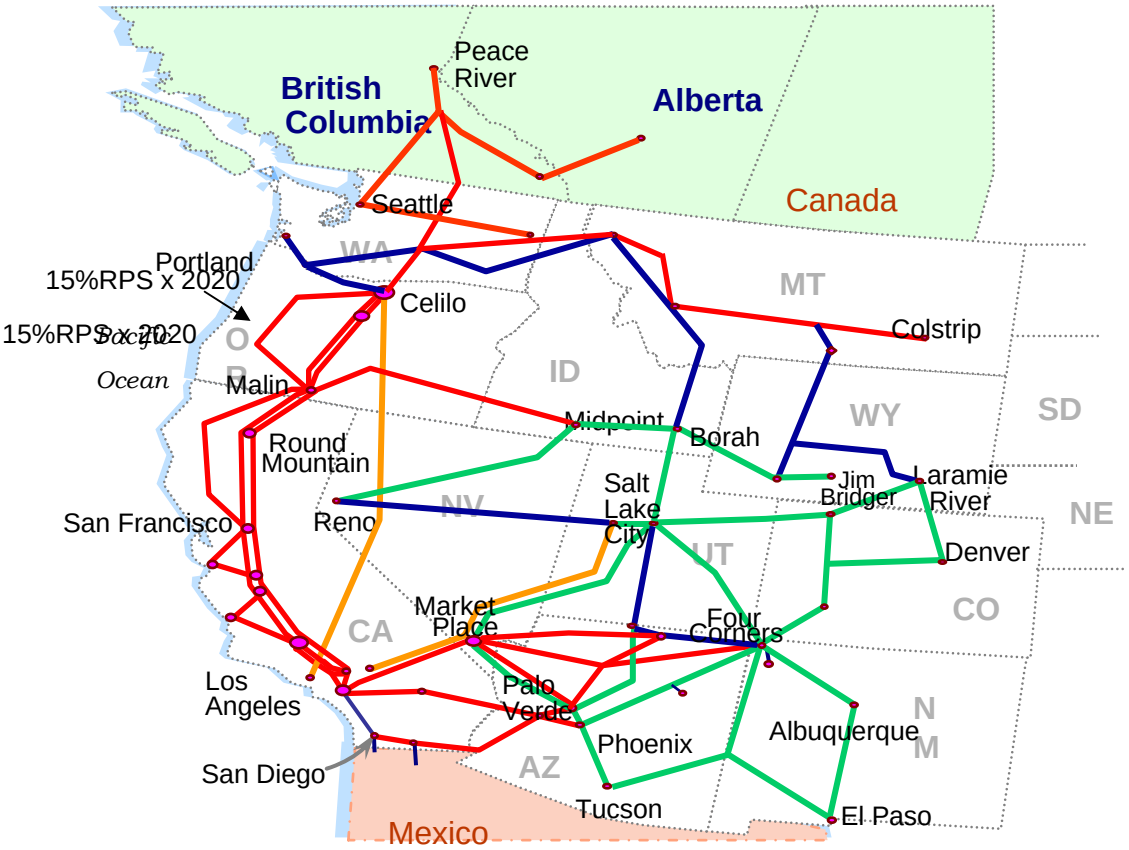
Wide Area Controls



Legend

± 500 kV DC	345 kV AC
500 kV AC	230 kV AC

Renewable Portfolio Standards By State

WA15% by 2020
OR 25% by 2025
MT15% by 2015
NV 25% by 2025
CA 33% by 2020
AZ 15% by 2025
CO 30% by 2020 [1]
UT 20% by 2025
ND10% by 2015
SD 10% by 2015 [2]

1. Electric cooperatives and municipal utilities with more than 40K customers: 10% by 2020.
2. Non-mandatory.

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For more information on SCE's Smart Grid strategy, news, and updates, go to: **www.sce.com/smartgrid**

For information on careers with Advanced Technology, please email Lee Cordner at **Lee.Cordner@sce.com**

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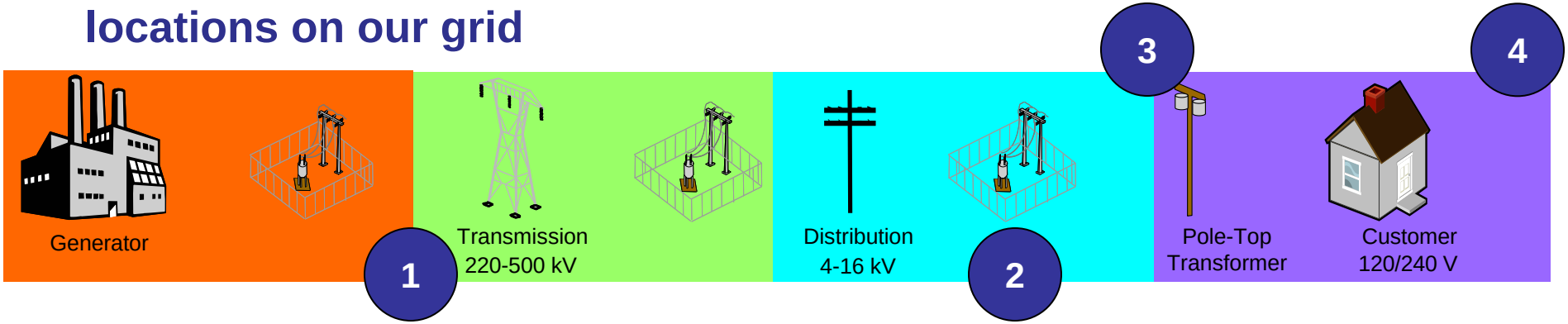
Grid-Connected Applications

In the process of evaluating the use of energy storage at various locations on our grid



1. Large Energy Storage Plan (32MWh / 8MW)	**2. Transportable Storage System** (1MWh / 4MW)	**3. Community Energy Storage** (50kWh / 25kW)	**4. Residential Energy Storage** (10kWh / 4kW)
• Tehachapi Wind Energy Storage Project (TSP) – The TSP will involve the largest ever grid-applied lithium-ion Energy Storage System (8MW-4hr or 32-MWhr) coupled with a Smart Inverter – The project intends to test & demonstrate 13 Research Objectives, both individually and "stacked"	• SCE acquired two 2MW - 0.5MWh energy storage units from A123 • The battery system will be evaluated for distribution support applications • Potential testing scenarios are: – Buffering for fluctuating output of renewable resources (PV or Wind) – Short period load support for switching operations or line load relief – Fast response voltage support for sensitive load customers	• Irvine Smart Grid Demonstration (ISGD) – Demonstrate an integrated, scalable Smart Grid system that includes all of the interlocking pieces of an end-to-end Smart Grid system - from the transmission and distribution systems to consumer applications like smart appliances and electric vehicles – Community energy storage units will be deployed as part of this demonstration program	• Home Battery Pilot (HBP) – This pilot program is funded through a specific a CPUC application – The objectives of the program are to test and evaluate the suitability of lithium-ion batteries of the type and size proposed for PEV production for use in residential/small commercial energy storage applications

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Facility with Battery & Inverter System

Racks of batteries will be installed inside a new climate controlled facility at Monolith

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Utility Perspective on High Penetration PV

Thomas Bialek, PhD, PE

San Diego Gas & Electric Co.

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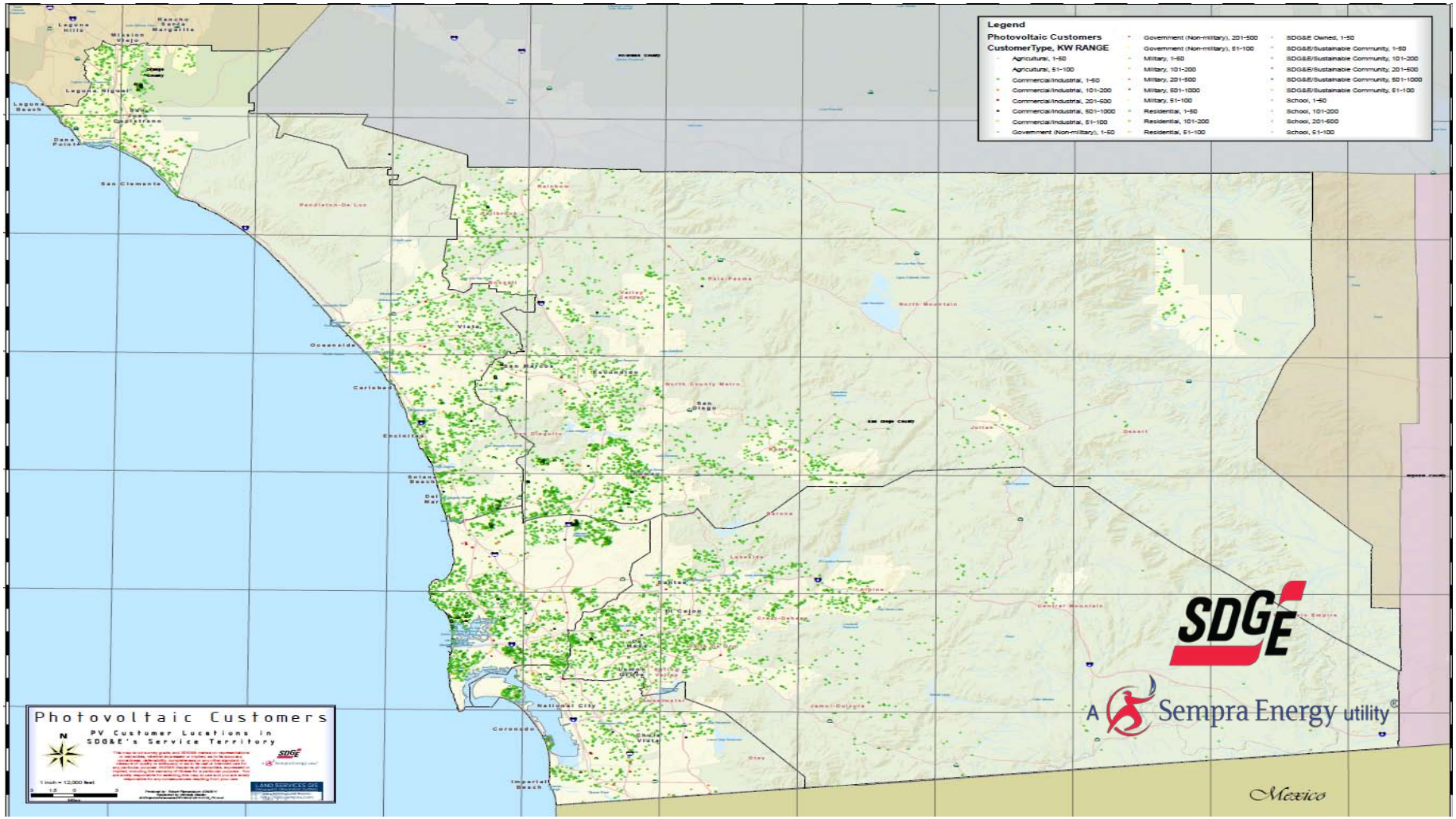

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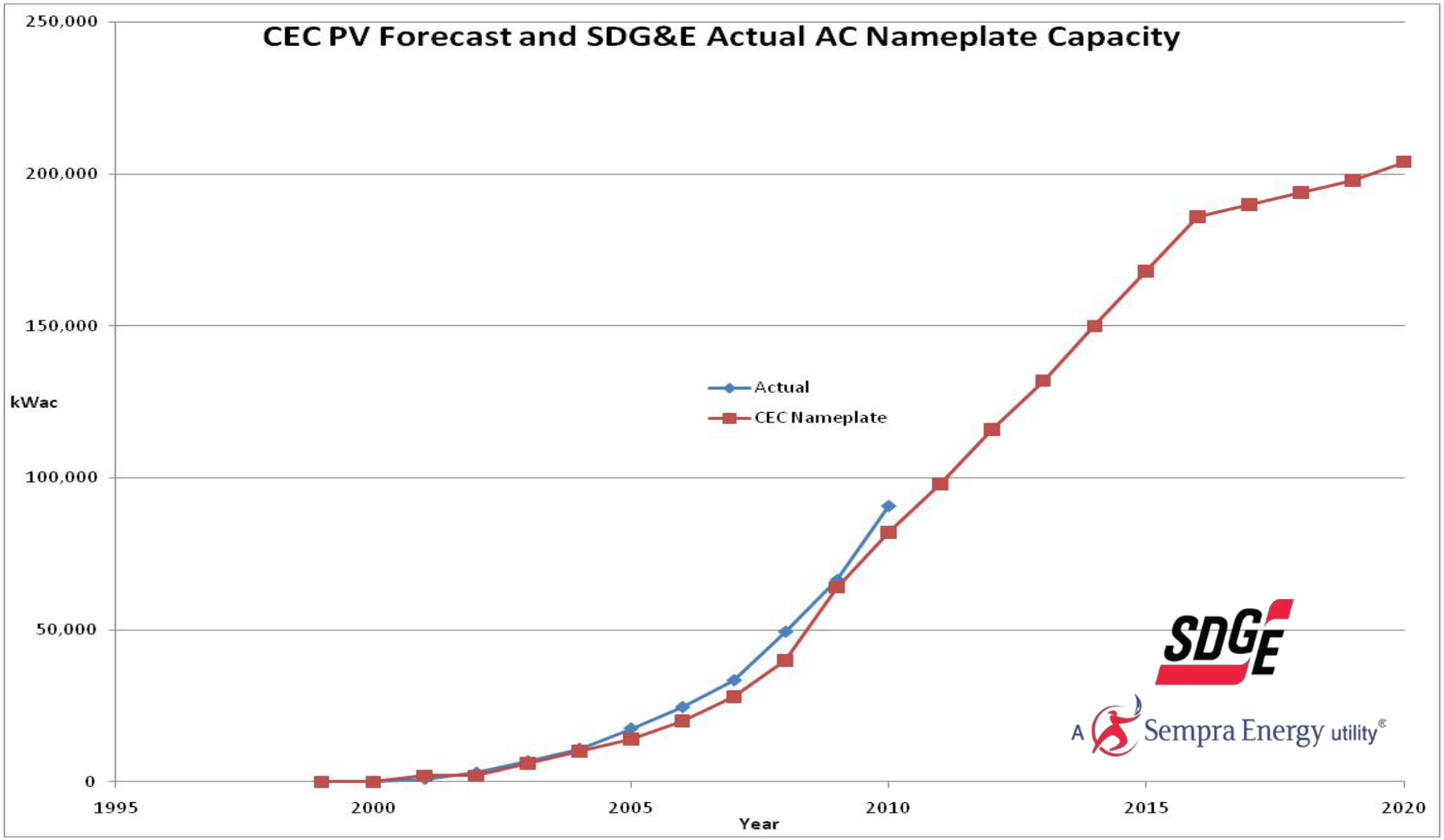

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Substation	Circuit	Total PV Connected (kW)	# Applications	High Load - Sept. 3, 2009 4 p.m. Peak (Amps)	High Load - Sept. 3, 2009 4 p.m. Peak (kW))	High Load - Sept. 3, 2009 4 p.m. Peak (kW)) + PV	% PV of Circuit @ High Load	Light Load - April 1, 2010 1 p.m. Peak (Amps)	Light Load - April 1, 2010 1 p.m. Peak (kW)	Light Load - April 1, 2010 1 p.m. Peak (kW)) + PV	% PV of Circuit @ Light Load
POWAY	175	491.10	45	272	5440	5,931.10	8.28%	160	3200	3,691.10	13.30%
IMPERIAL BEACH	531	758.40	2	386.6	7732	8,490.40	8.93%	237.88	4757.6	5,516.00	13.75%
MISSION	142	335.50	24	176.28	3525.6	3,861.10	8.69%	104.6	2092	2,427.50	13.82%
LILAC	350	385.90	43	264	5280	5,665.90	6.81%	120	2400	2,785.90	13.85%
MURRAY	404	507.00	4	275.6	5512	6,019.00	8.42%	153.07	3061.4	3,568.40	14.21%
MURRAY	402	466.20	6	285.57	5711.4	6,177.60	7.55%	137.87	2757.4	3,223.60	14.46%
MISSION	147	500.90	1	312.24	6244.8	6,745.70	7.43%	147.48	2949.6	3,450.50	14.52%
MURRAY	88	503.00	4	273.44	5468.8	5,971.80	8.42%	148	2960	3,463.00	14.52%
BORDER	533	1,016.00	3	286.48	5729.6	6,745.60	15.06%	298.4	5968	6,984.00	14.55%
BORDER	535	435.00	4	250.2	5004	5,439.00	8.00%	127.2	2544	2,979.00	14.60%
POMERADO	925	769.40	4	377.48	7549.6	8,319.00	9.25%	203.84	4076.8	4,846.20	15.88%
SAN YSIDRO	462	657.10	8	300.3	6006	6,663.10	9.86%	173.48	3469.6	4,126.70	15.92%
KYOCERA	348	250.00	1	94.4	1888	2,138.00	11.69%	64	1280	1,530.00	16.34%
POWAY	176	568.00	84	324	6480	7,048.00	8.06%	144	2880	3,448.00	16.47%
BERNARDO	292	343.90	5	160.08	3201.6	3,545.50	9.70%	77.44	1548.8	1,892.70	18.17%
BERNARDO	540	999.00	1	207.08	4141.6	5,140.60	19.43%	164.48	3289.6	4,288.60	23.29%
AVOCADO	520	2,265.00	41	466	9320	11,585.00	19.55%	266	5320	7,585.00	29.86%
ESCONDIDO	1010	276.90	1	44.44	888.8	1,165.70	23.75%	28.48	569.6	846.50	32.71%
POWAY	177	664.90	54	360	7200	7,864.90	8.45%	60	1200	1,864.90	35.65%
DESCANSO	73	85.00	14	90	1800	1,885.00	4.51%	6	120	205.00	41.46%
VALLEY CENTER	909	1,022.00	10	108.84	2176.8	3,198.80	31.95%	69.6	1392	2,414.00	42.34%
BORREGO	170	591.70	24	93.08	1861.6	2,453.30	24.12%	40.2	804	1,395.70	42.39%
ARTESIAN	1104	440.50	125					28.56	571.2	1,011.70	43.54%
DEL MAR	1082	960.00	1	175.2	3504	4,464.00	21.51%	56.6	1132	2,092.00	45.89%

- 740 of 956 circuits have PV YE 2010
- 90 MW 12,000 installations as of YE 2010
- Residential approximately 14 MW/year

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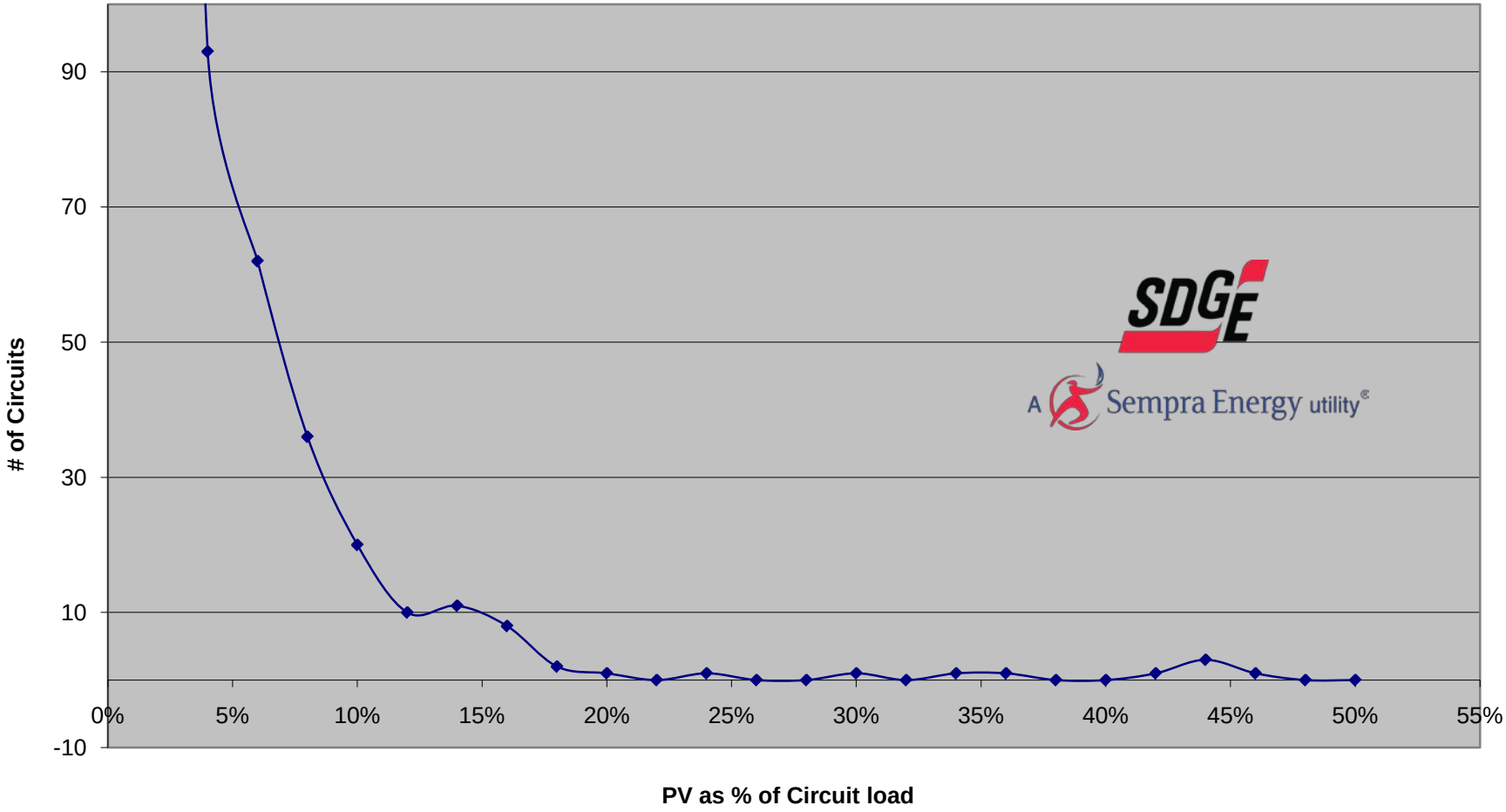
PV Penetration 2009



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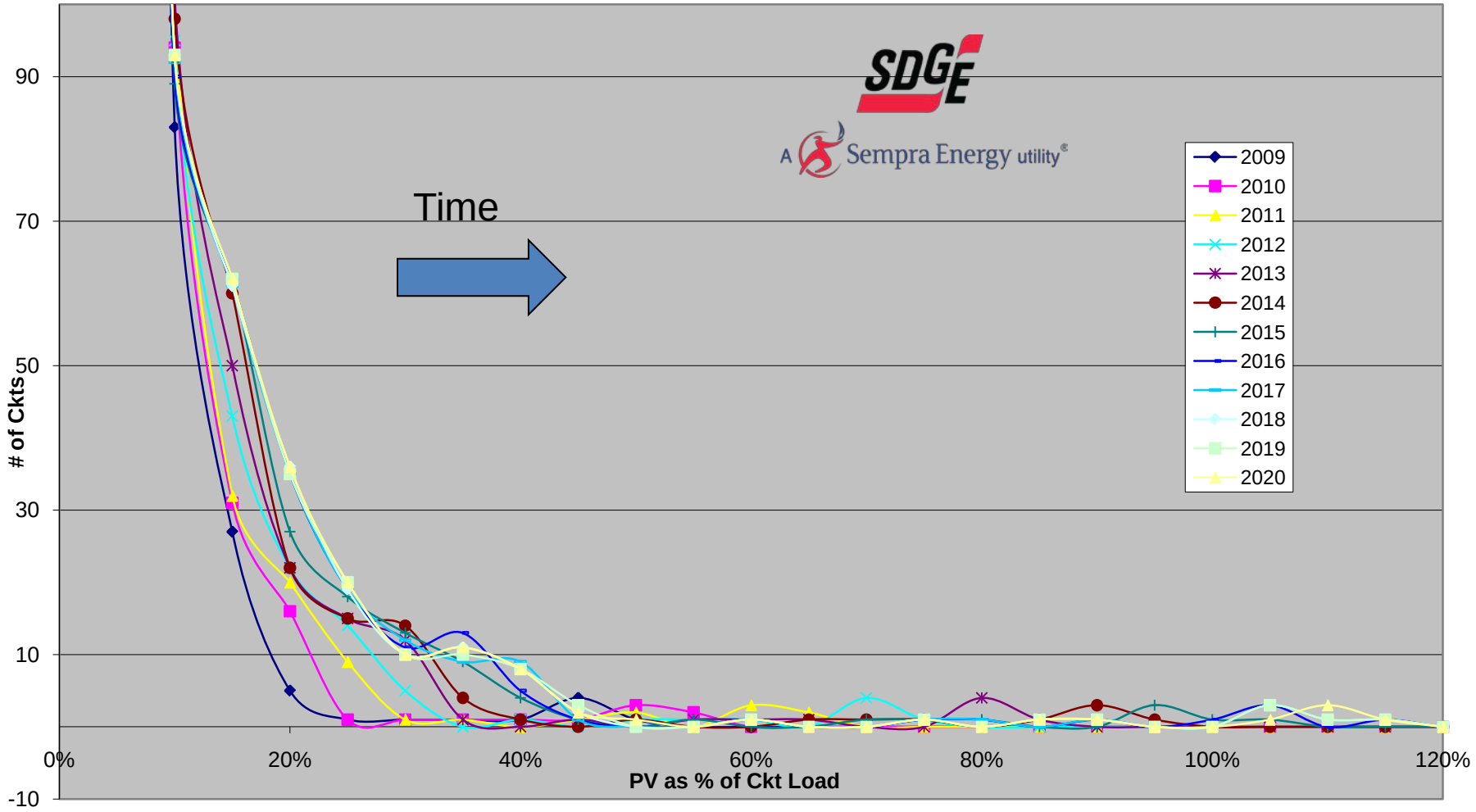

Values are for illustration only and do not represent forecasts

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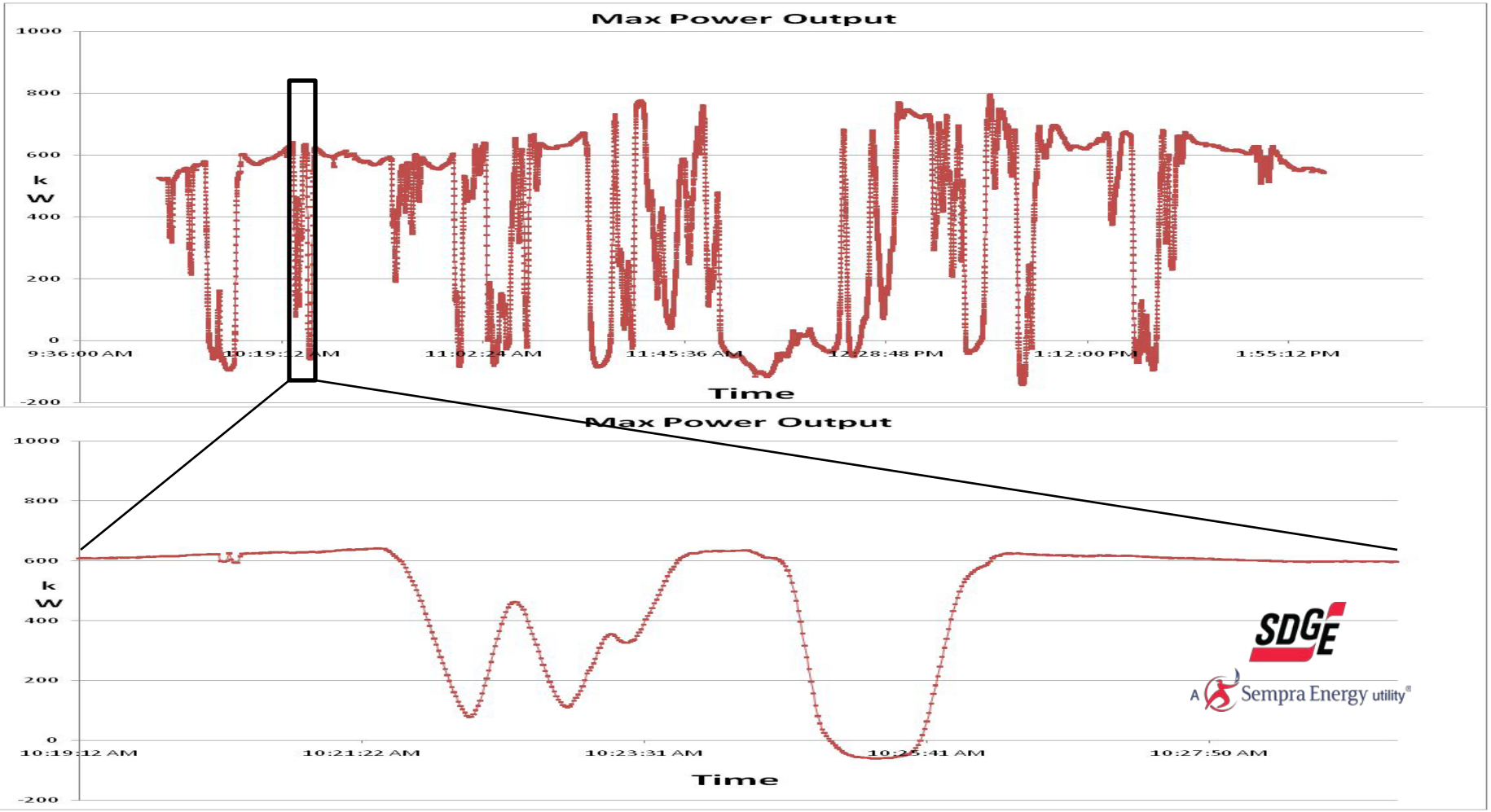

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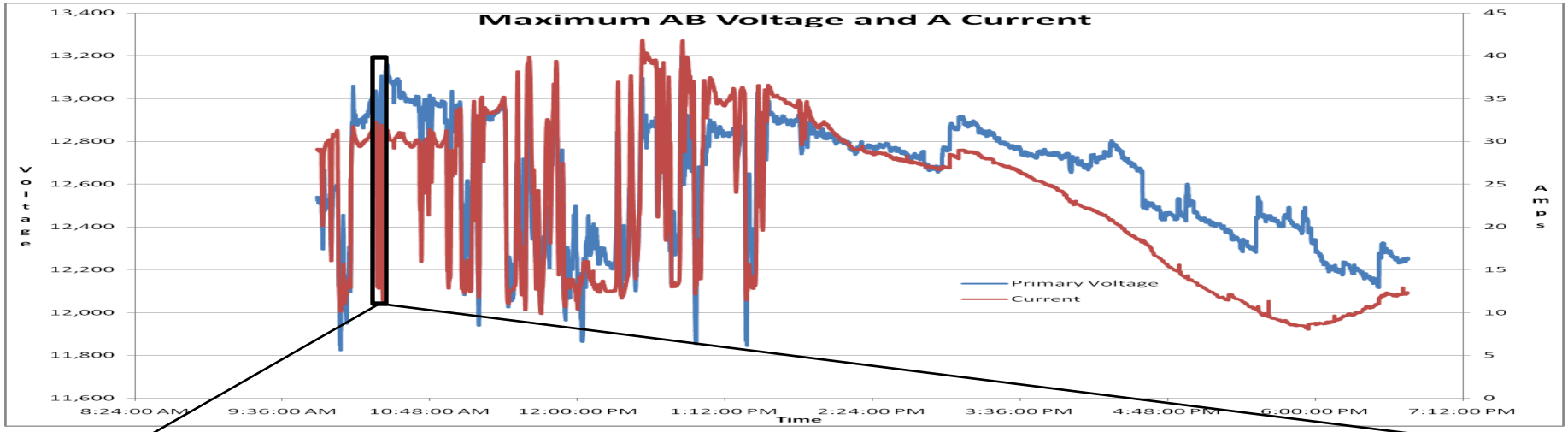

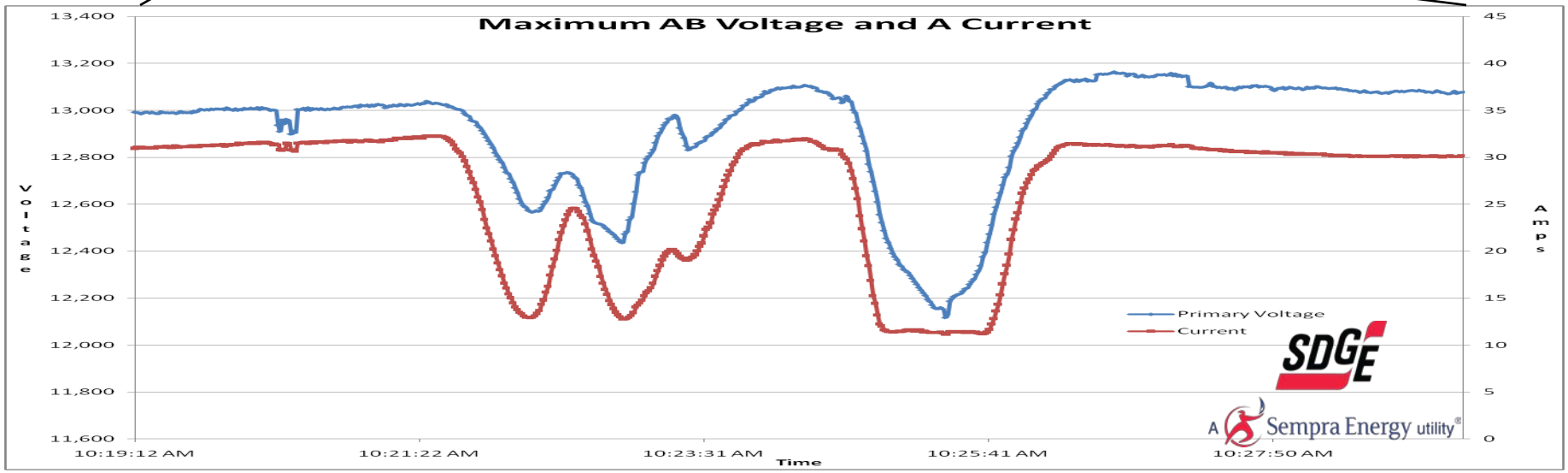

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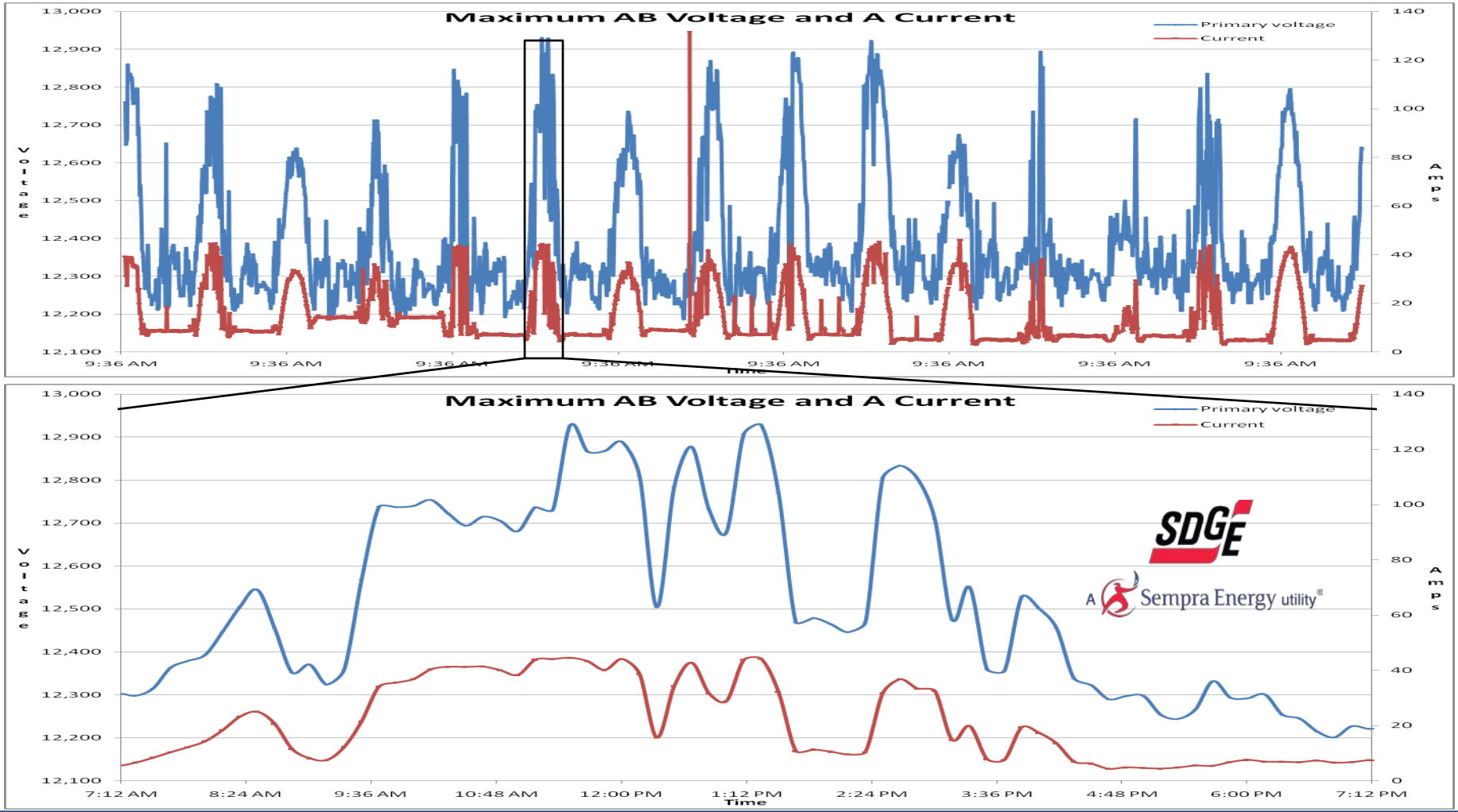

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Mitigation

- Regulatory
  - Rule 21 modification
    - Threshold for periods of low load high PV output
  - Rule 2 modification
    - Harmonics
    - Voltage
  - Cost Causation
    - Rates & incentives
- Technical
  - SynerGee load flow analysis
  - Transient analysis
  - PV and PEV models

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Solutions?

- Circuit modifications
  - Impedance modification
  - Controls
- Demand response
  - Slower dP/dt events?
- 4 quadrant control
  - Utility dynamic VAr devices
  - Utility storage
  - Customer inverters/storage

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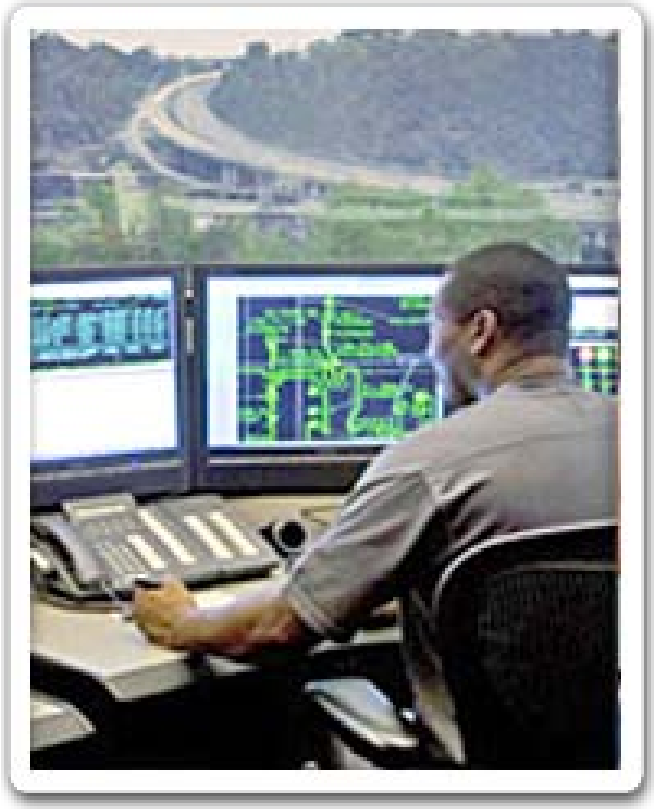

Questions?

Thank you.

Thomas Bialek

Chief Engineer, Smart Grid

tbialek@semprautilities.com
www.sdge.com/smartgrid/

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PG&E Perspective on High Penetration PV

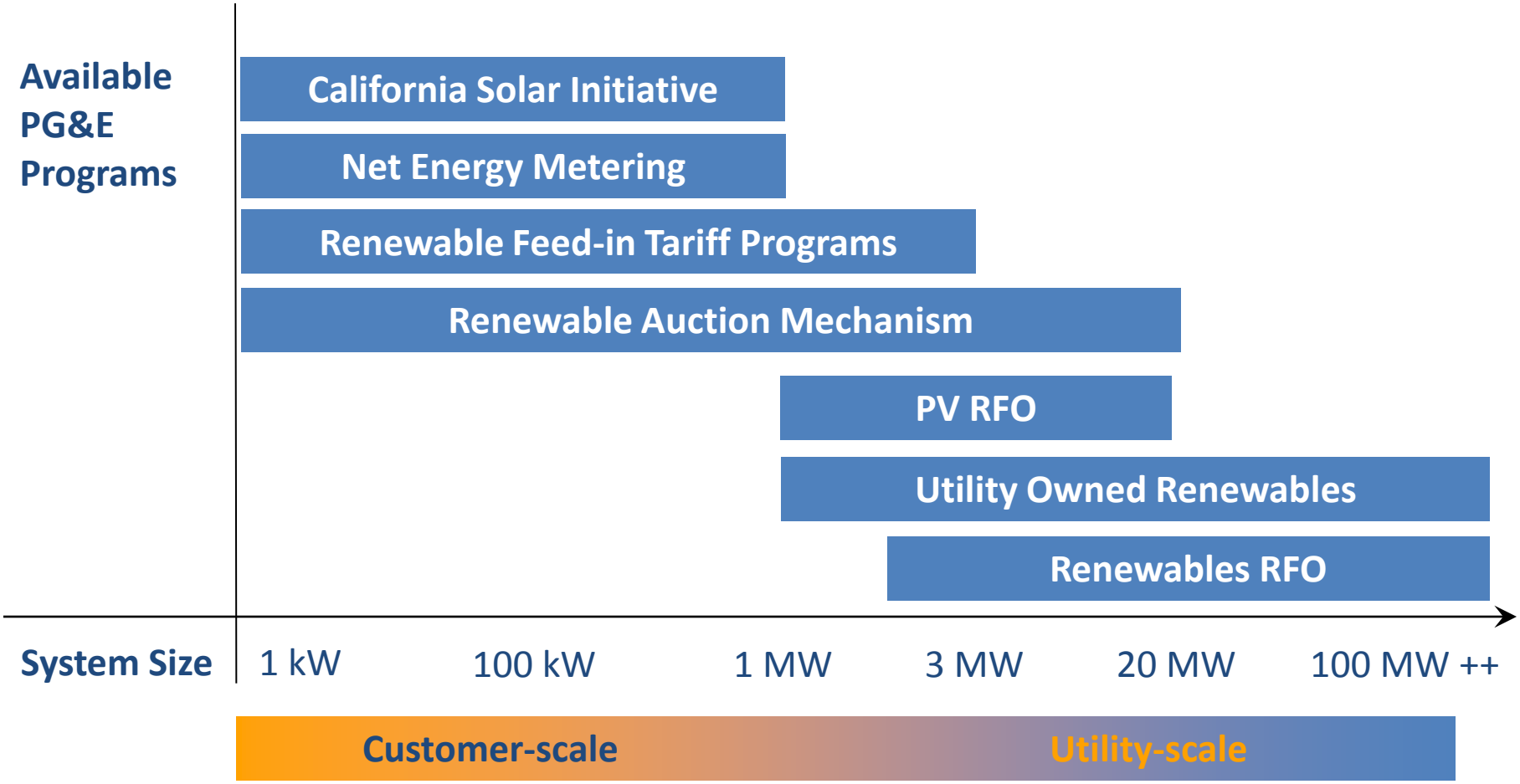
Andrew Yip

Pacific Gas and Electric Company

Pacific Gas and Electric Company

- Energy services to 15 MM people:
  - 5.1 MM Electric accounts
  - 4.3 MM Natural gas accounts
- 70,000 square miles with diverse topography
- 20,000 employees
- A regulated investor-owned utility
- Serves 5% of U.S. population, but produces only 1% of utility sector CO_2 emissions
- The most grid-connected PV systems in the U.S.

PG&E Solar Electric Programs



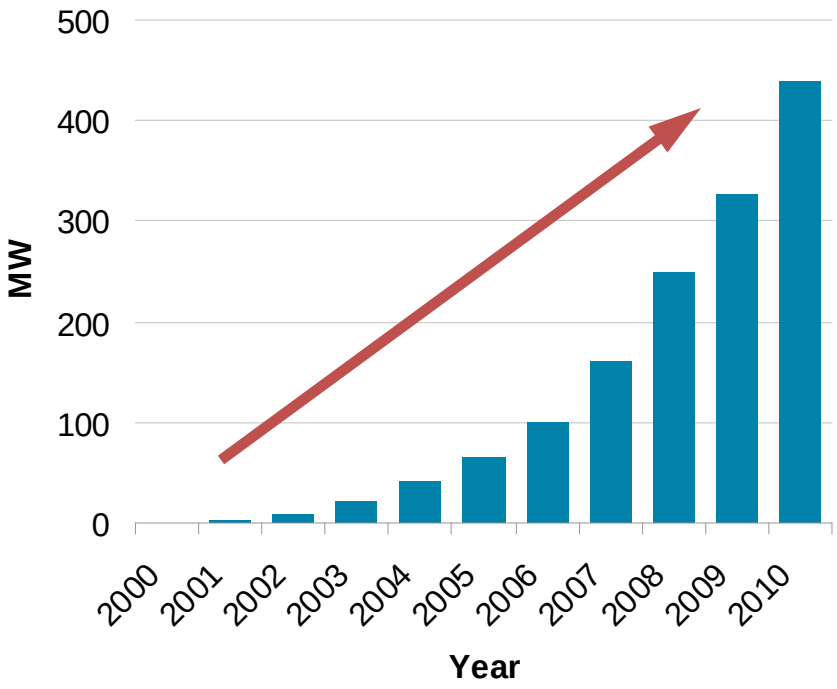
PG&E and Distributed PV

PG&E is a leader in distributed PV

- Over **45,000 installations**
- Over **400 MW** (CEC AC)
- Approx. **35% of US total**
- PG&E serves ~5% of US population

Distributed PV Installed in PG&E Territory by Year

(MW; CEC AC; Cumulative)



Integration Challenges

- Examples of grid impacts of distributed PV and employed mitigation strategies

Concern	Mitigation Strategy
A facility's 10-kW PV system (inverter) trips off-line when customer load is light due to high service voltage	Adjust voltage regulator settings
Generators at a facility downstream of a 1-MW PV system trip off-line due to high service voltage	Adjust capacitor bank settings

- To-date, integration of distributed PV in the distribution system has not represented a major barrier to penetration.
- *However*, new strategies may be needed to accommodate increased PV penetration.

Future Strategies

- In the future, impacts of PV on the grid may be mitigated in a variety of ways
- Each approach would impact various stakeholders in different ways
- The goal is to implement the most cost-effective and efficient solution(s) for the particular issue(s) being addressed

Reconductor lines

Distribution Management Systems (DMS) (e.g., Volt/Var Optimization (VVO)

Require curtailment of PV generation

Install new equipment (e.g., voltage regulators

"Smart" inverters

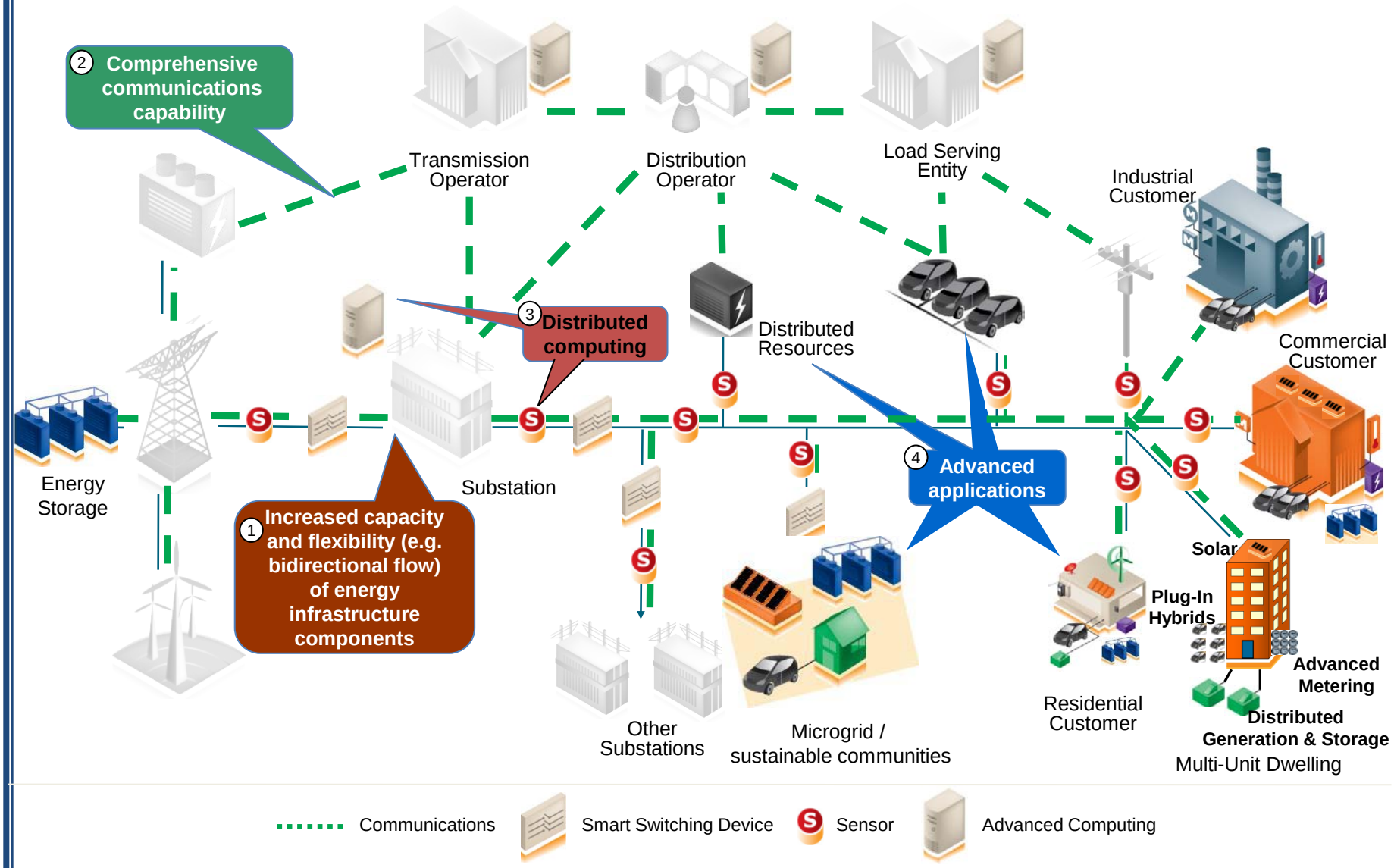
Other technologies and capabilities

Potential “Pieces to the Puzzle”

- Volt/Var Optimization (VVO)
- Energy storage
- Home Area Networks (HAN)
- Advanced solar forecasting capabilities
- DG/inverter code updates (e.g., IEEE 1547)
- Dynamic pricing
- Grid automation
- Enhanced communication

Continued collaboration and coordination among stakeholders to develop solutions and ‘best practices’ is critical to facilitating further integration of solar generation

Enabling Technology - SmartGrid



Andrew Yip
AXY4@pge.com
Pacific Gas and Electric Company