



Flattening the Duck

Facilitating Renewables for the 21st Century Grid

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Mission

To accelerate the transition to local energy systems through innovative policies and programs that deliver cost-effective renewable energy, strengthen local economies, foster environmental sustainability, and provide energy resilience

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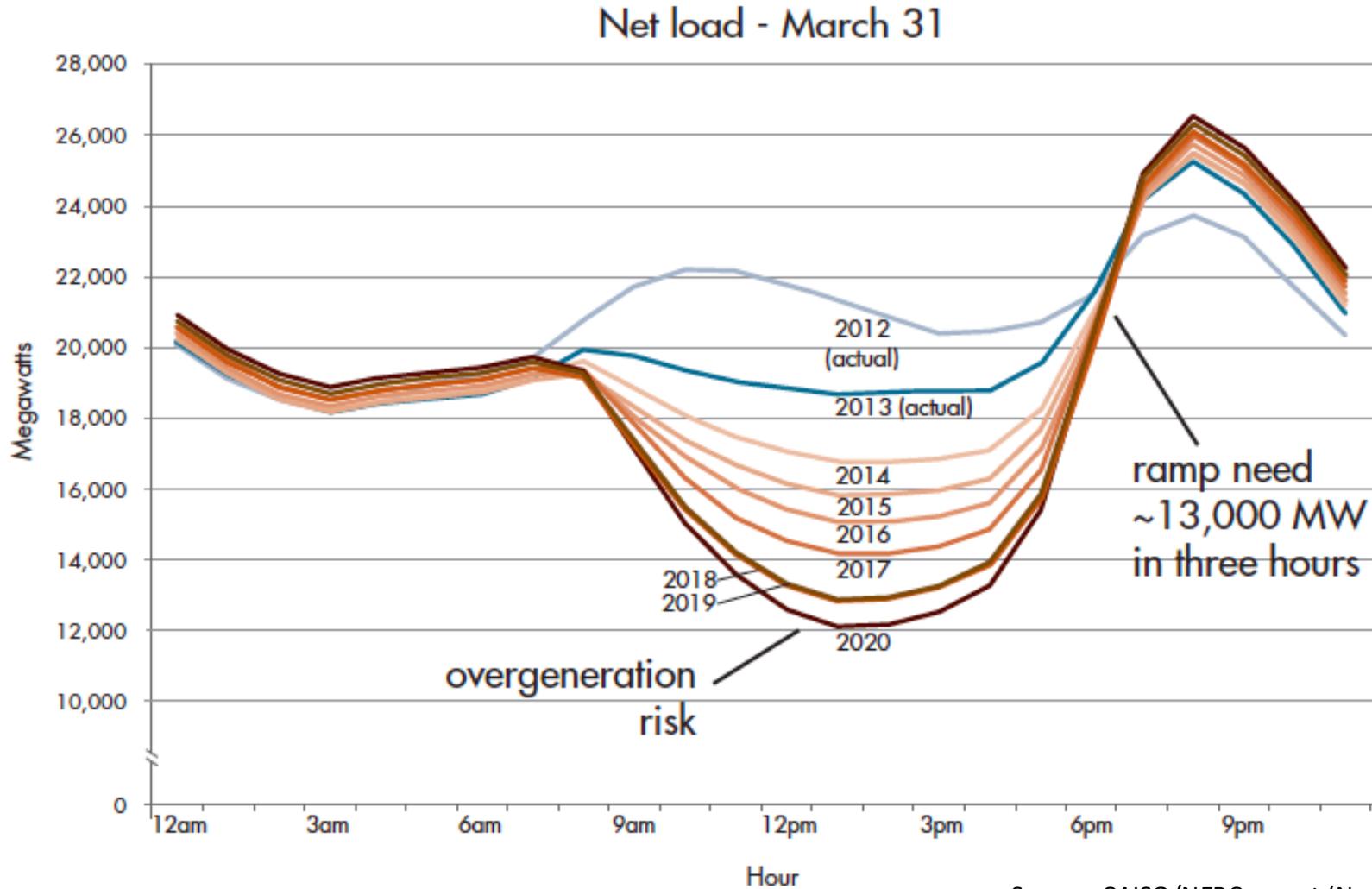
Kurt Yeager

*Vice Chairman, Galvin Electricity Initiative; Former
CEO, Electric Power Research Institute*

Service	Key to Delivering Service
Power Balancing	<u>Capacity</u> of real power (W)
Voltage Balancing	<u>Location</u> of reactive power (VAr)
Frequency Balancing	<u>Speed</u> of ramping real power (W)

The Duck Chart only addresses Power Balancing but Distributed Energy Resources deliver unparalleled location and speed characteristics

Figure 2: The duck curve shows steep ramping needs and overgeneration risk



Source: CAISO/NERC report (Nov 2013)

Future generations will be asking what we were thinking (or smoking). You allowed massive quantities of toxic chemicals to be injected into the earth, and to contaminate ungodly volumes of water, in pursuit of a highly flammable gas that would be routed through your neighborhoods and into your homes?! What were you thinking?



2010 San Bruno pipeline explosion



FOR IMMEDIATE RELEASE
February 6, 2014

Contact: Stephanie McCorkle or Steven Greenlee at (888) 516-NEWS

STAGE 1 EMERGENCY

Operating reserves forecast to fall to between 7% - 6%

STAGE 2 EMERGENCY

Operating reserves forecast to fall below 5%

STAGE 3 EMERGENCY

Operating reserves forecast to fall below 3%

TRANSMISSION EMERGENCIES

Declared when local voltage levels are at risk due to sudden power line outages or when fires threaten the arid.

ISO issues statewide *Flex Alert* ***Electricity conservation needed due to natural gas shortage curtailing fuel supplies to power plants***

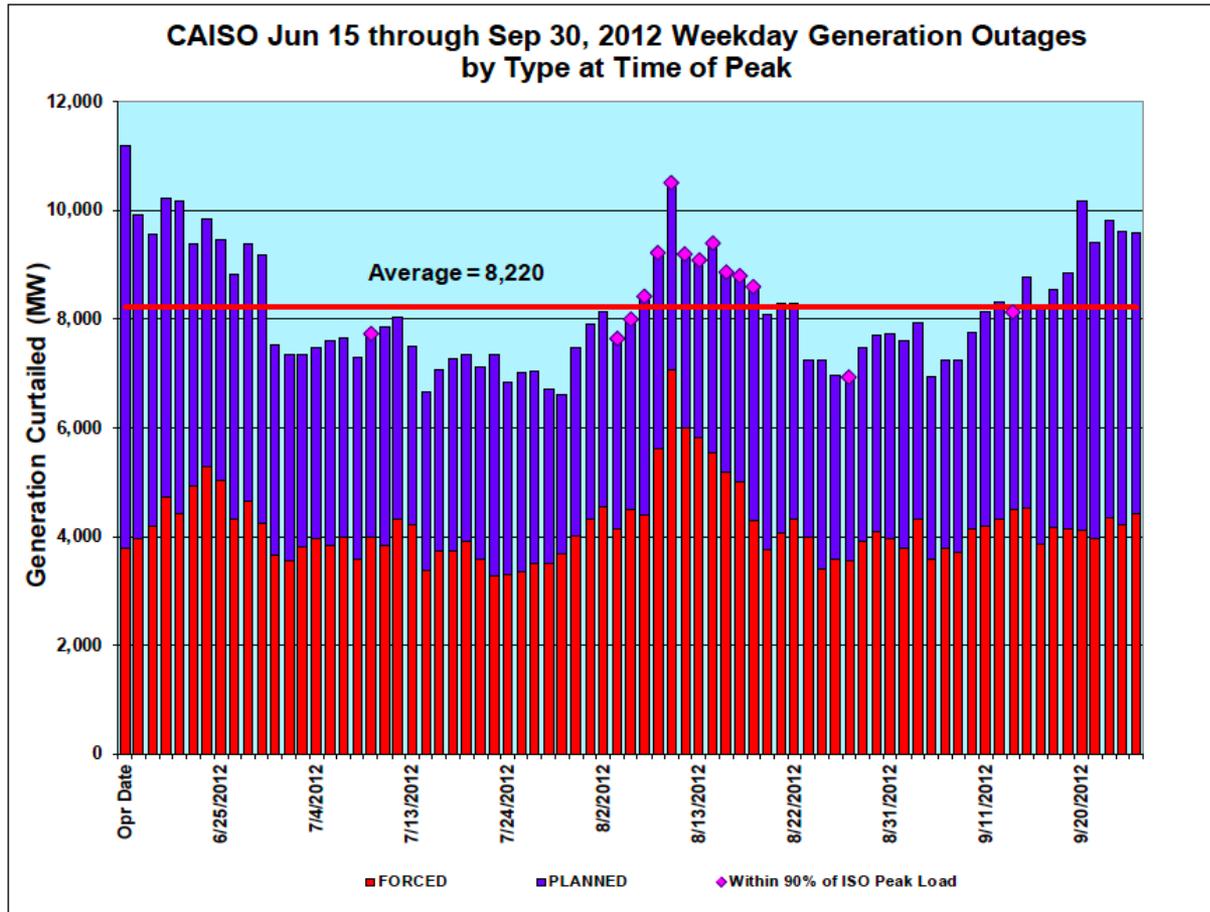
A shortage of natural gas triggered by extreme cold weather in much of the United States and Canada is impacting fuel supplies to Southern CA power plants and reducing electricity generation. The California Independent System Operator Corporation (ISO) is issuing a statewide *Flex Alert* for today, February 6, 2014.

While the natural gas shortage is only impacting Southern California power plants, statewide electricity and gas conservation will help free up both electricity and gas supplies for Southern Californians. **Customers in both Southern and Northern California are asked to reduce their energy use between 1:00 p.m. until 10:00 p.m.**

Today Thursday, February 6, is a *Flex Alert Day!*

Natural Gas Has Integration Costs

Natural gas plants often shut down unexpectedly, forcing energy consumers to foot the bill for reserves and frequency response.

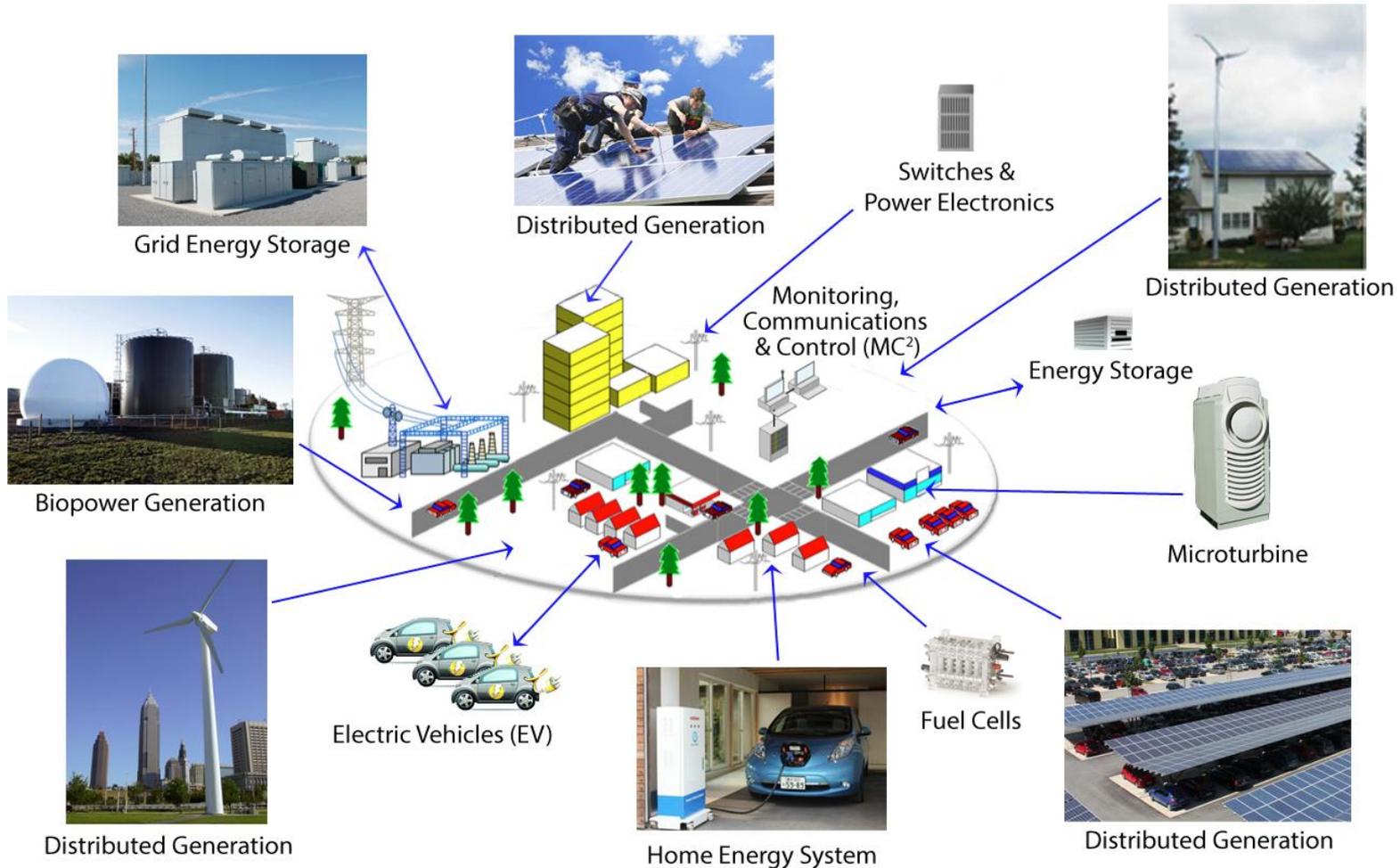


Source: CAISO Summer Loads and Resources Assessment (2013)

More than half of the outages associated with conventional generation are unplanned

Integrating Renewables in a Forward Direction

- Use cost-effective, renewables and intelligent grid solutions to modernize the grid.
- Minimize natural gas, which would move backward from California's goals.



Wholesale DG is the Critical & Missing Segment

Project Size

50+ MW

500 kW

5 kW

Retail DG

Serves Onsite Loads



Behind the Meter



Wholesale DG

Serves Local Loads



Distribution Grid



Central Generation

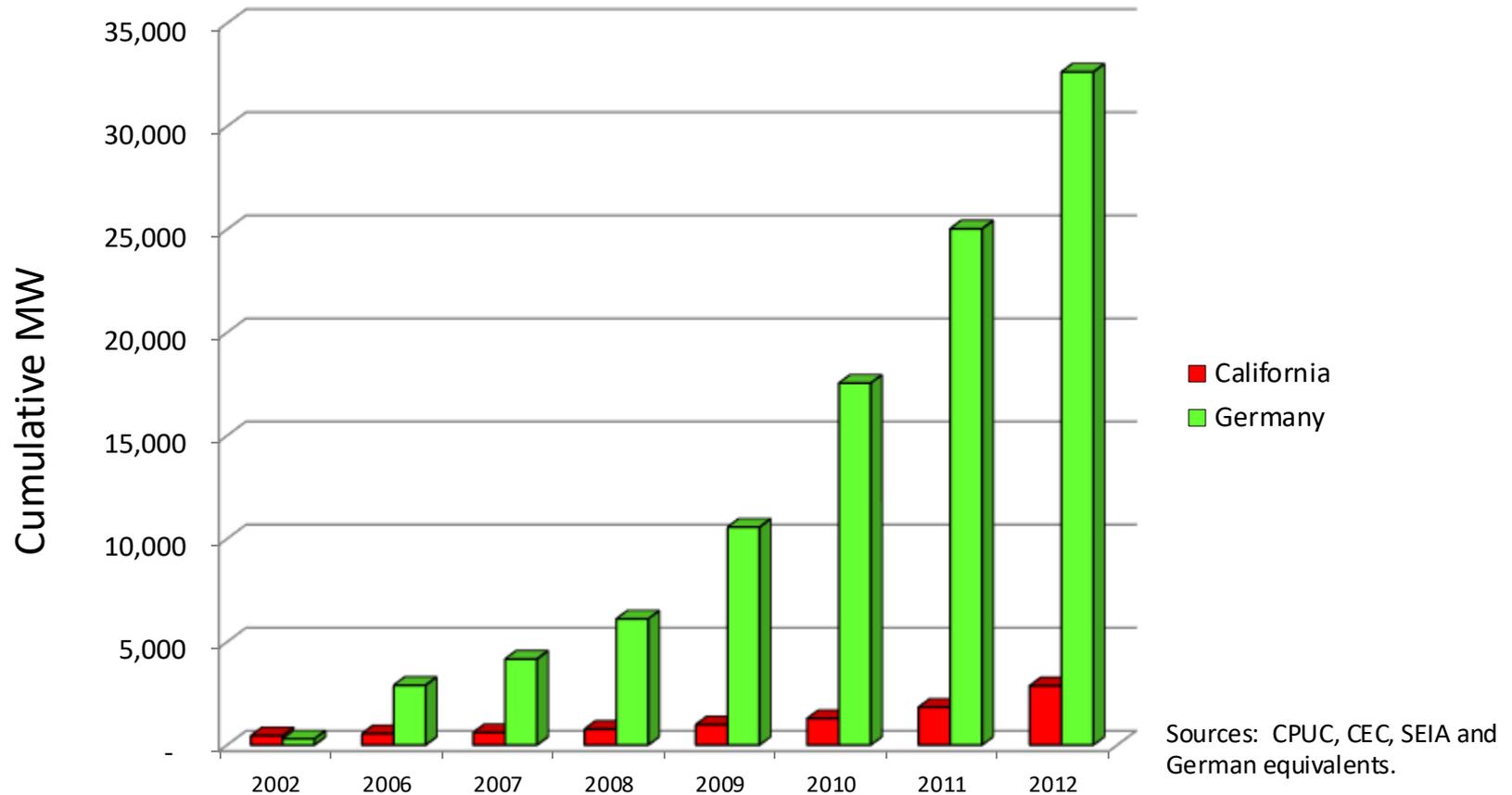
Serves Remote Loads



Transmission Grid

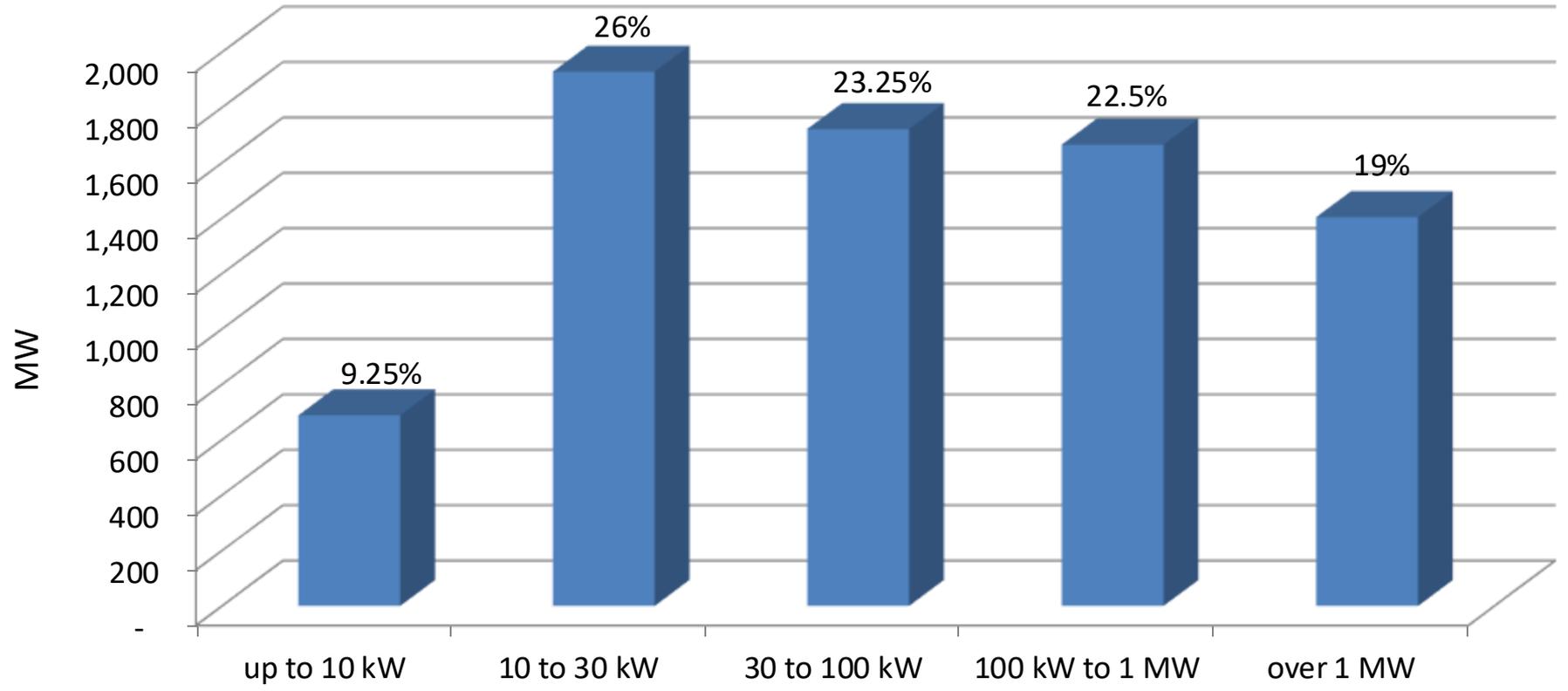


Solar Markets: Germany vs California (RPS + CSI + other)



Germany has deployed 12 times more solar than California in the last decade despite California's 70% better solar resource!!!

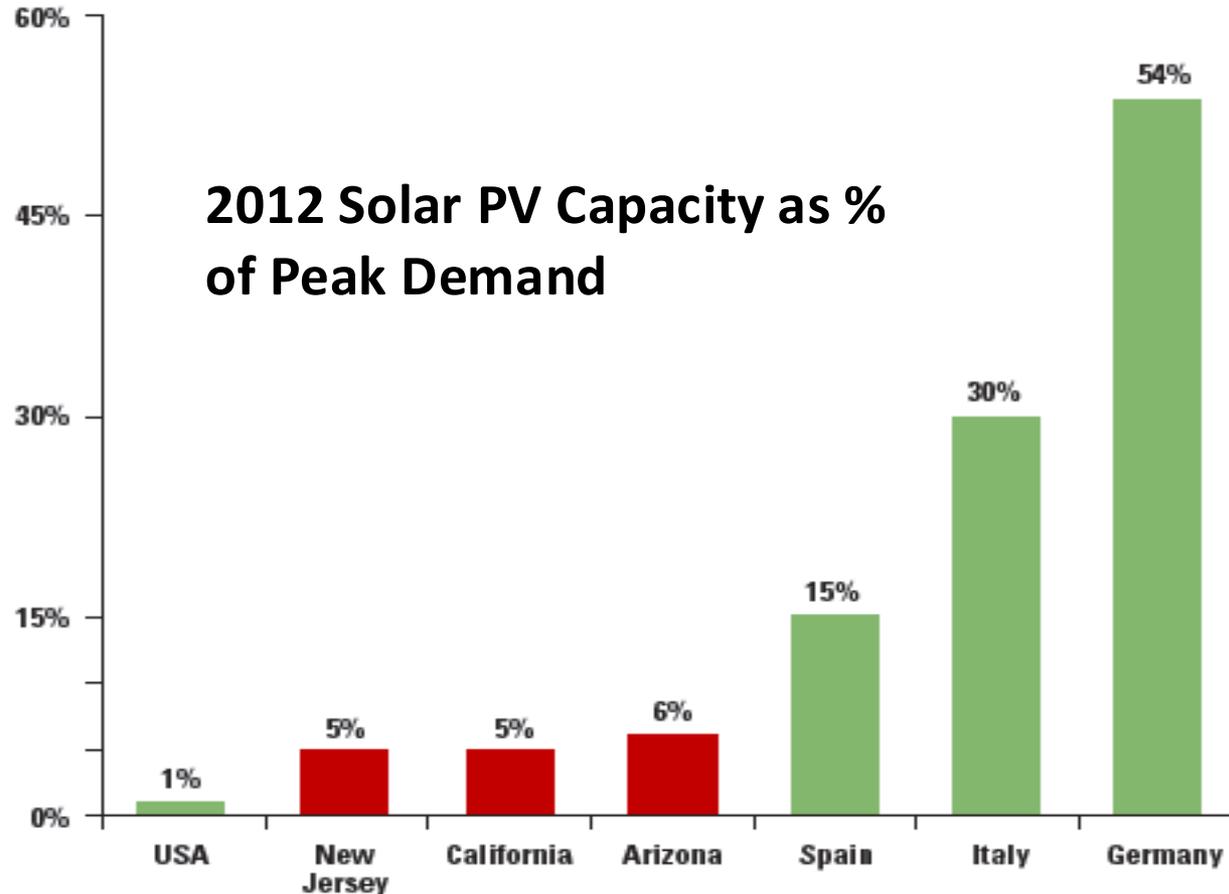
German Solar PV Capacity Installed in 2010



Source: Paul Gipe, March 2011

Germany's solar deployments are almost entirely sub-2 MW projects on built-environments and interconnected to the distribution grid (not behind-the-meter)

The German power system, which incorporates enough rooftop solar to meet half the country's peak energy needs, set a global reliability record in 2011.

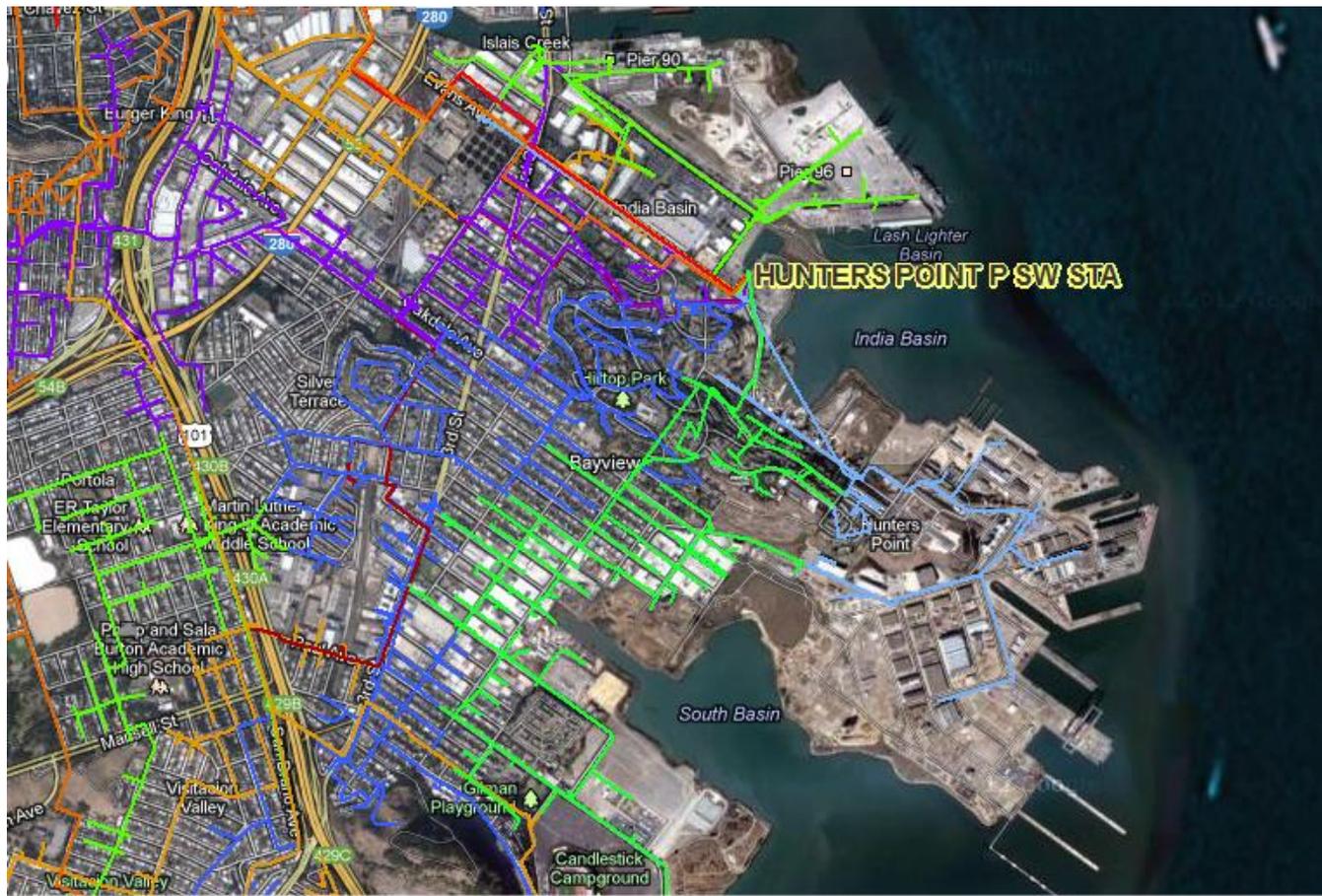


Source: Union of Concerned Scientists, SEIA 2013

- AB 32 (Reduce GHG emissions to 1990 levels by 2020)
- Loading Order (Procure cost-effective preferred resources first)
- Energy Storage Target (1.325 GW by 2020)
- Electric Vehicles Target (1.5 million EVs by 2025)
- Zero Net Energy (IOUs proposed “district” rather than building level ZNE)
 - All new residential construction ZNE by 2020
 - All new commercial construction and 50% existing commercial retrofit to ZNE by 2030



Get 25% of electric energy consumed within Hunters Point substation (Bayview and Hunters Point neighborhoods) from local renewables while at least maintaining grid reliability and power quality



\$200M in Private Investment + Operations & Maintenance Over 20 Yrs. Equals:



Photo courtesy of GRID Alternatives

Economic Benefits



\$200M: Added regional economic stimulation

\$100M: Added local wages, near-term plus annual

1,270 Job-Years: New near-term regional employment

520 Job-Years: New ongoing regional employment

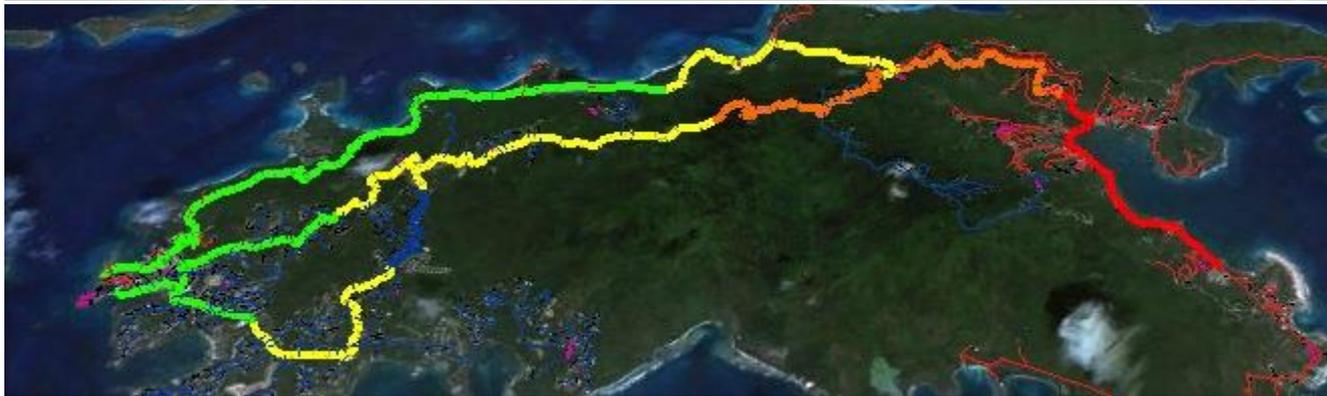
\$10M: Site leasing income for property owners

\$5.8M: Added construction-related state sales taxes

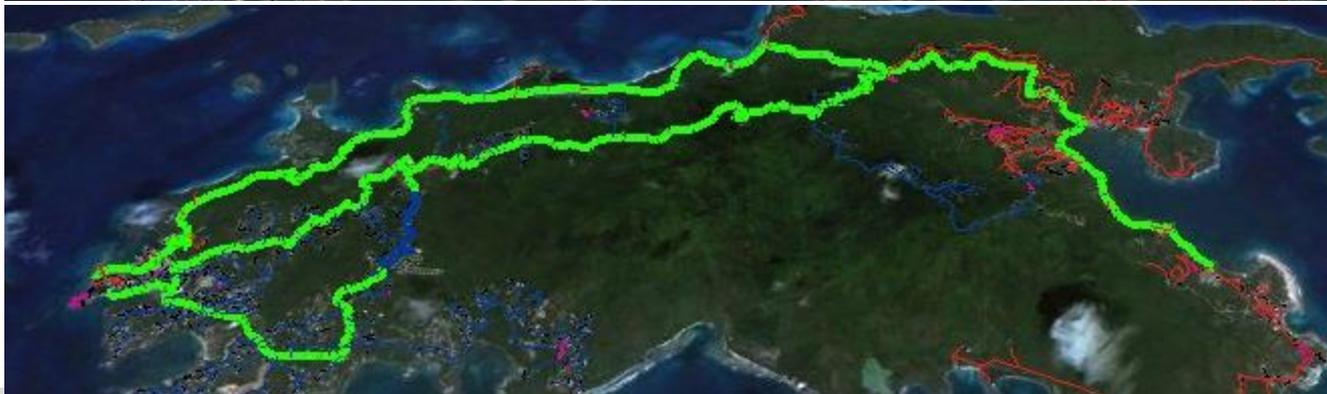
St. John Project in Virgin Islands: Local PV with Advanced Inverters to Maintain Grid Reliability



1. 6AM:
 - no PV impact



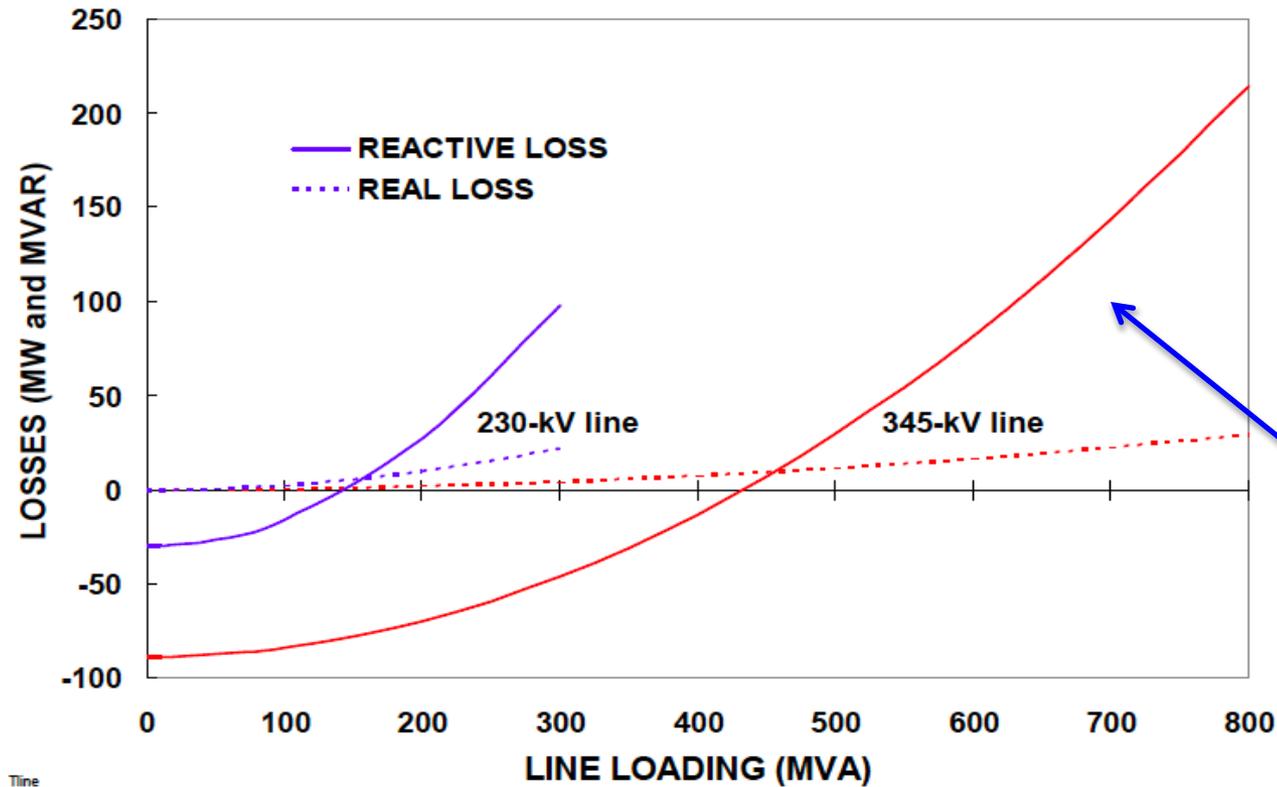
2. Noon:
 - 20MW PV causes overvoltage



3. Noon:
 - Dynamic grid solutions stabilize voltage impact from 20MW PV

“The old adage is that reactive power does not travel well.”

Oak Ridge National Laboratory (2008)



T&D lines absorb 8-20x more reactive power than real power.

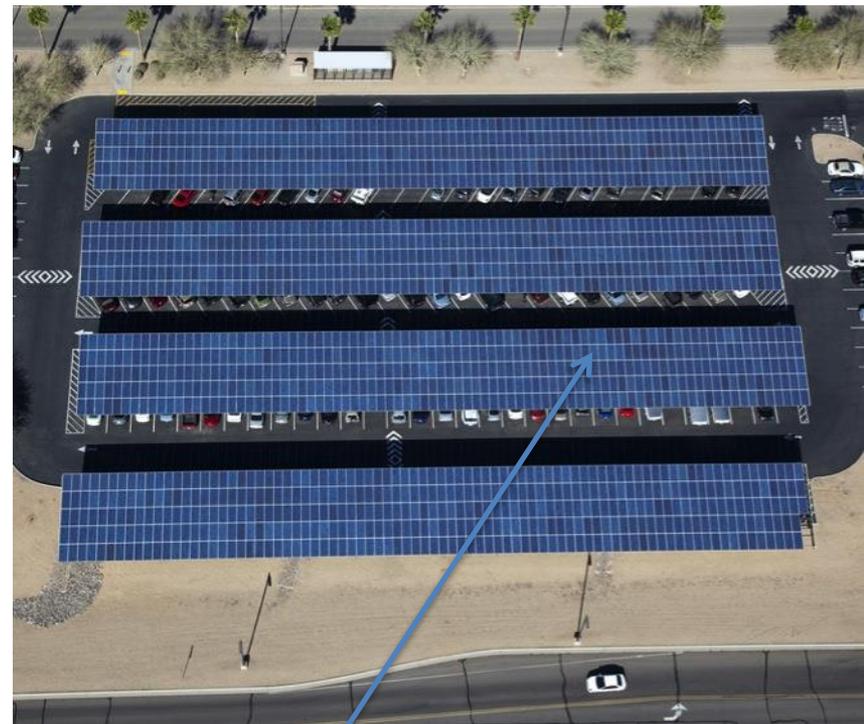
Prevent Blackouts:
When a transmission path is lost, remaining lines are heavily loaded and losses are higher.

Figure 1-1. Transmission line absorption of reactive power.

Source: Oak Ridge National Laboratory (2008)



VS.



\$80 million

2 Synchronous Condensers
San Luis Rey Substation

450 MVar

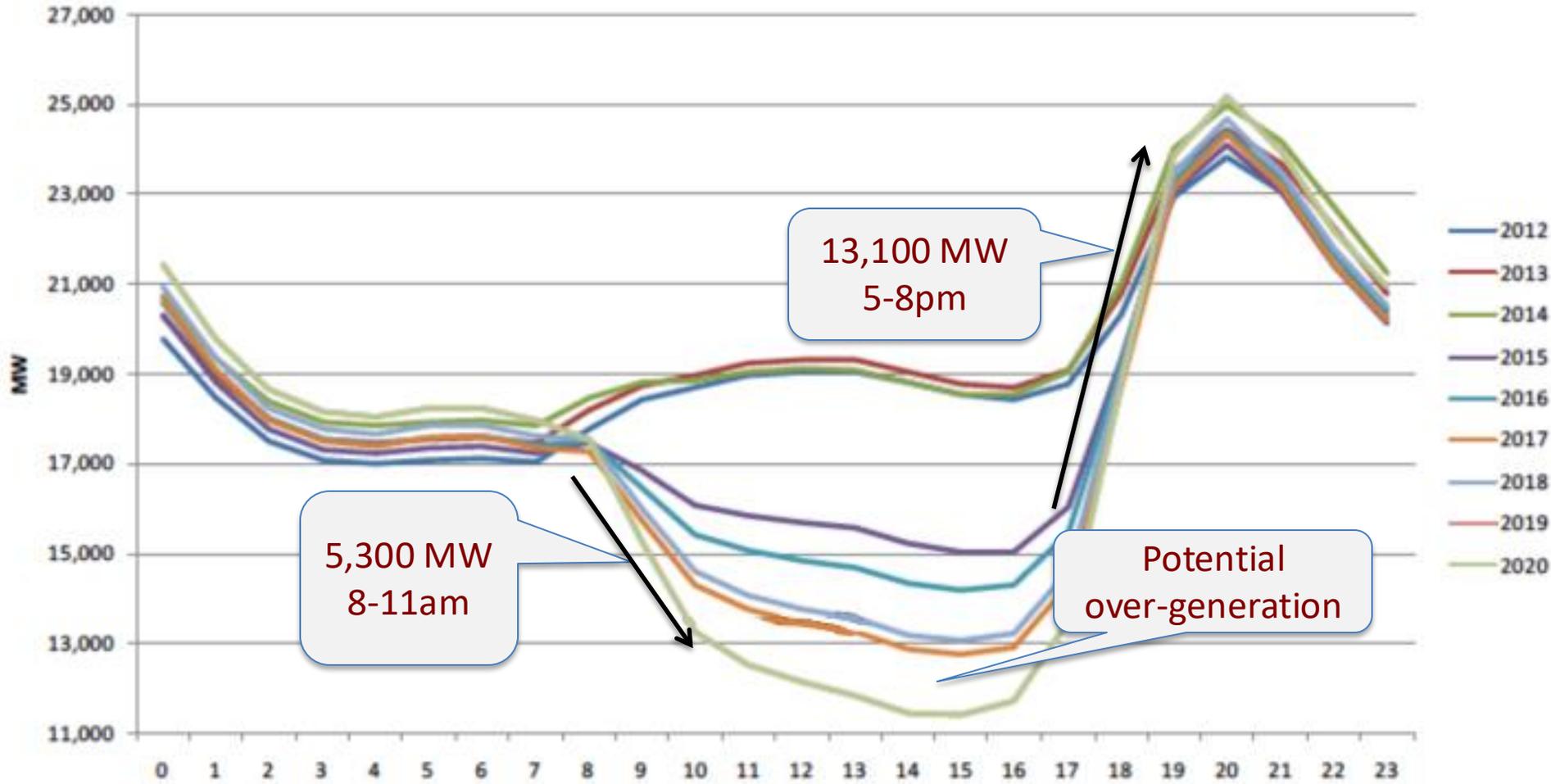
(minus line losses = **400 MVar**)

800 MW of DG solar + storage with advanced inverters, oversized by 10% set at 0.9 Power Factor = **400 MVar**

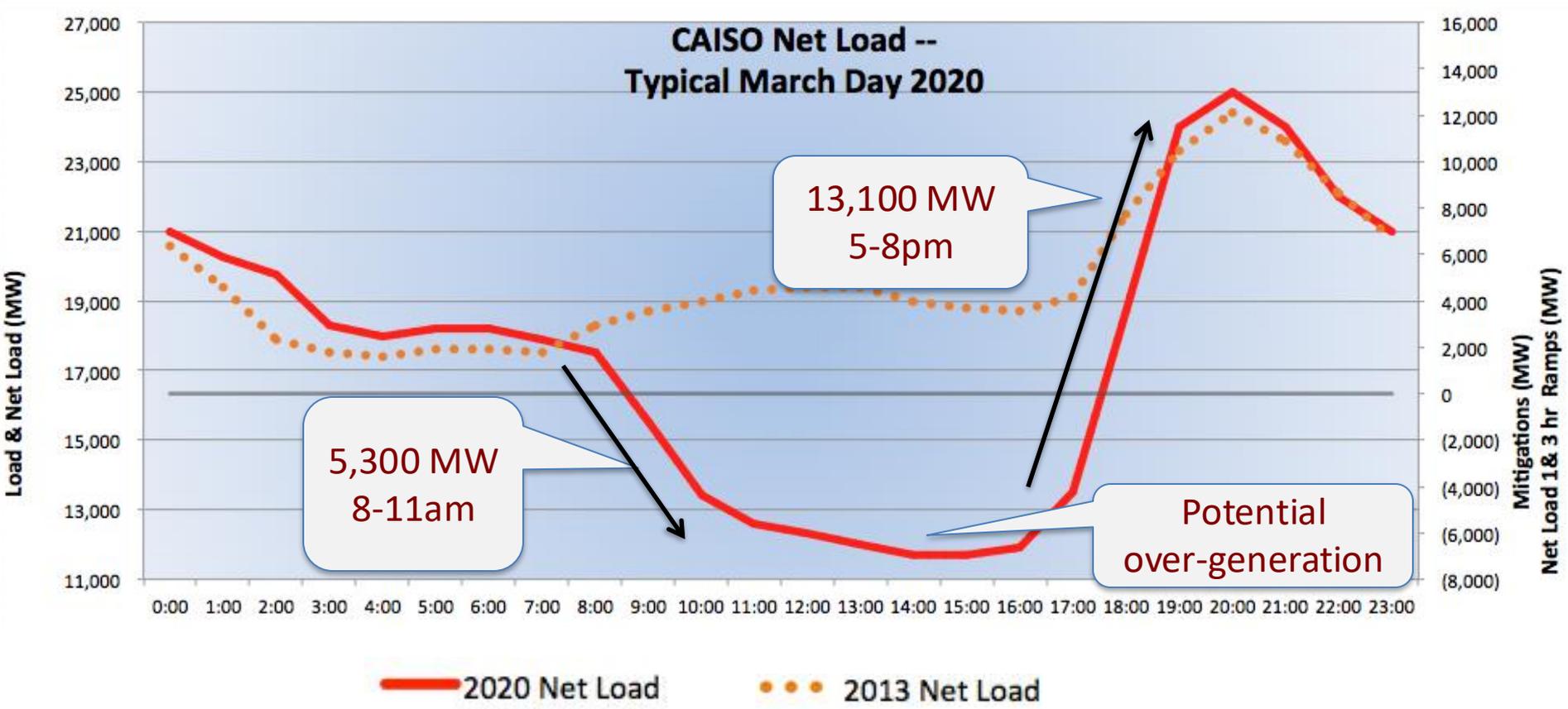
CAISO proposed 320 MW DG solar + 580 MW storage = **900 MW (plus 1,400 MW of nat gas)**

The California ISO Duck Chart (2012 – 2020)

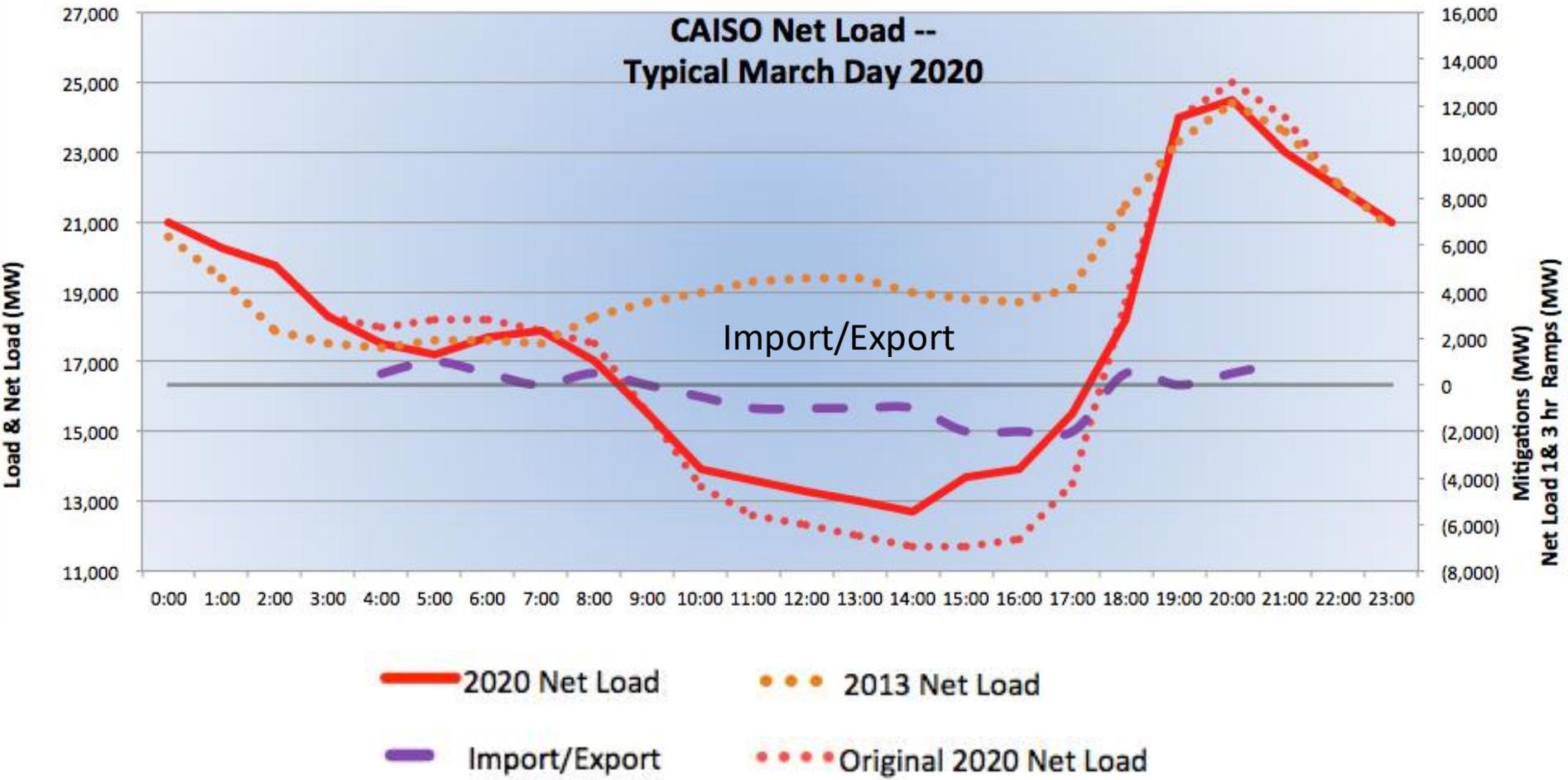
CAISO Net Load --- 2012 through 2020



CAISO Duck Chart (2020 Issues)

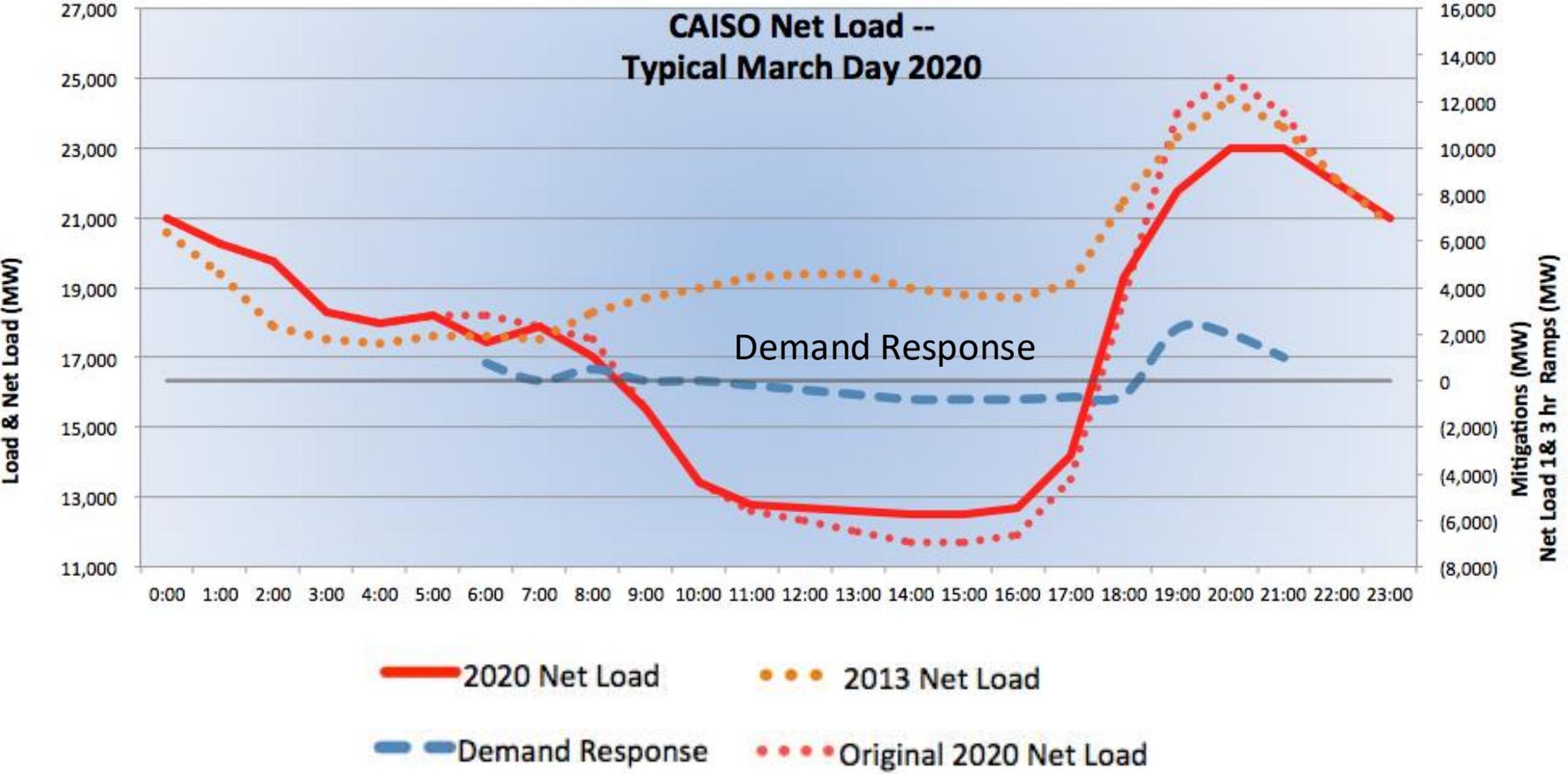


Flattening the Duck – Import/Export



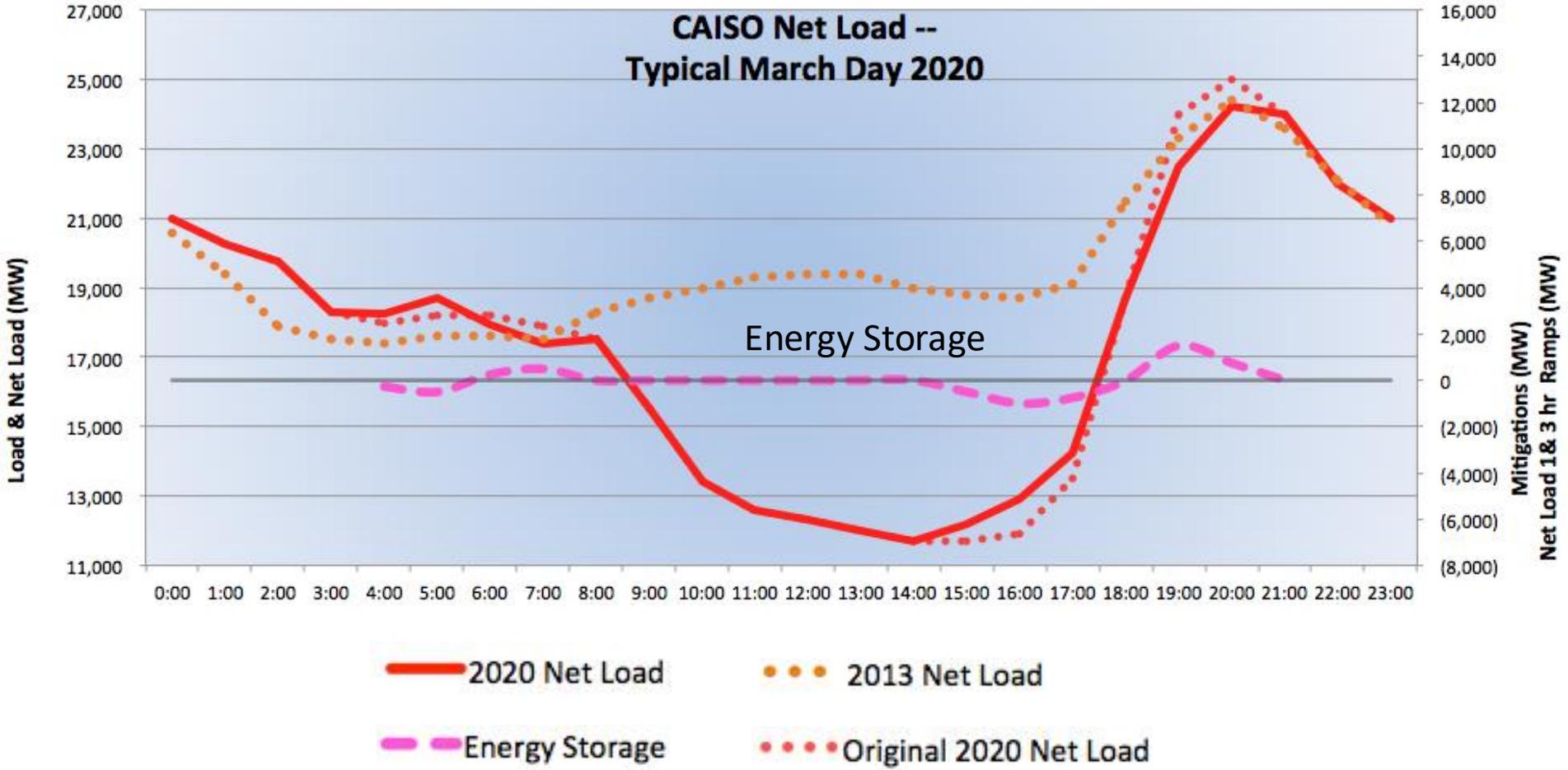
Need to study how much California can export, expected pricing, and whether additional regional coordination is advisable

Flattening the Duck – Demand Response

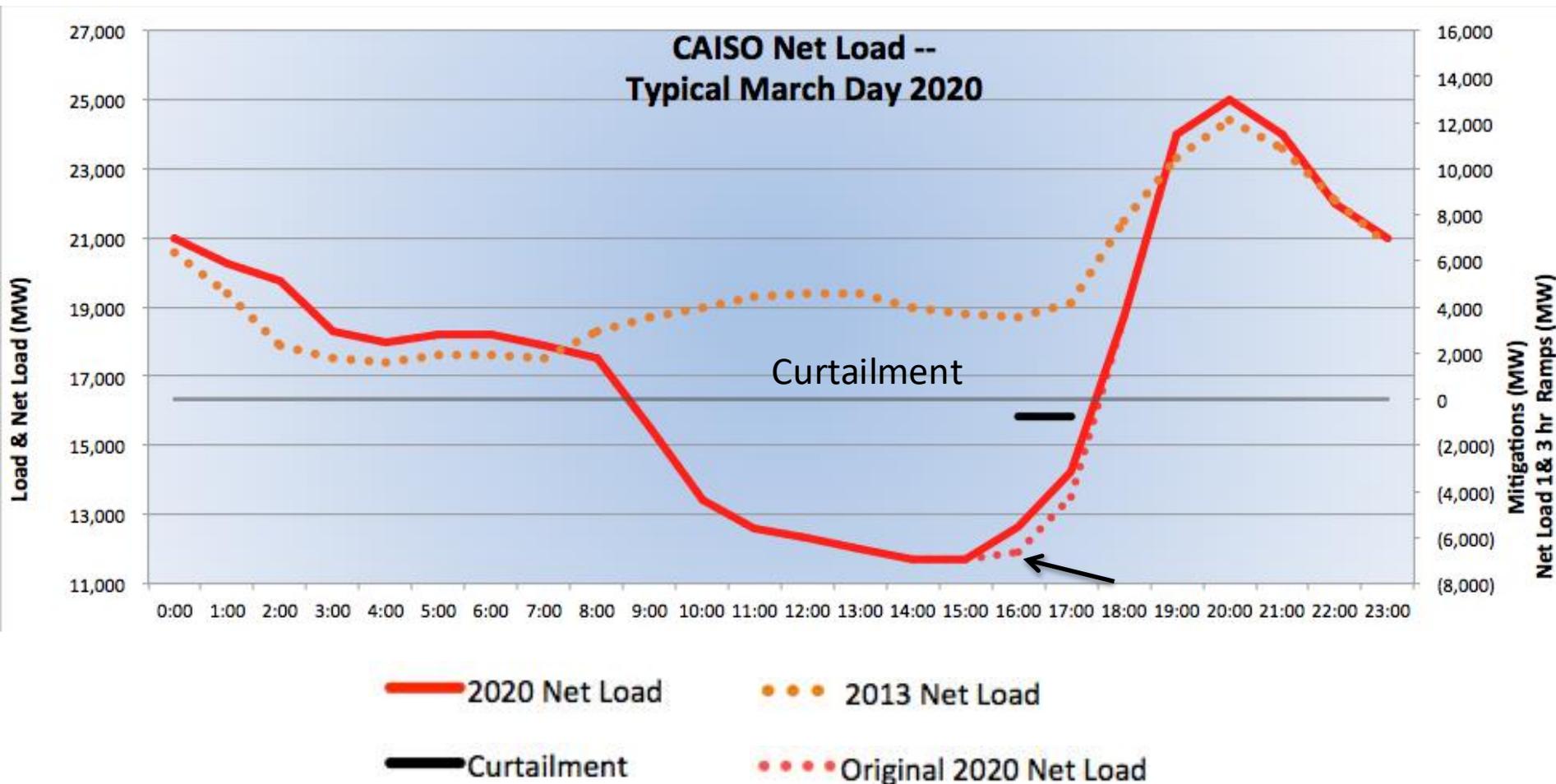


California set a target of 1.5 million electric vehicles by 2025, representing an additional load of 10,000 MW

Flattening the Duck – Energy Storage

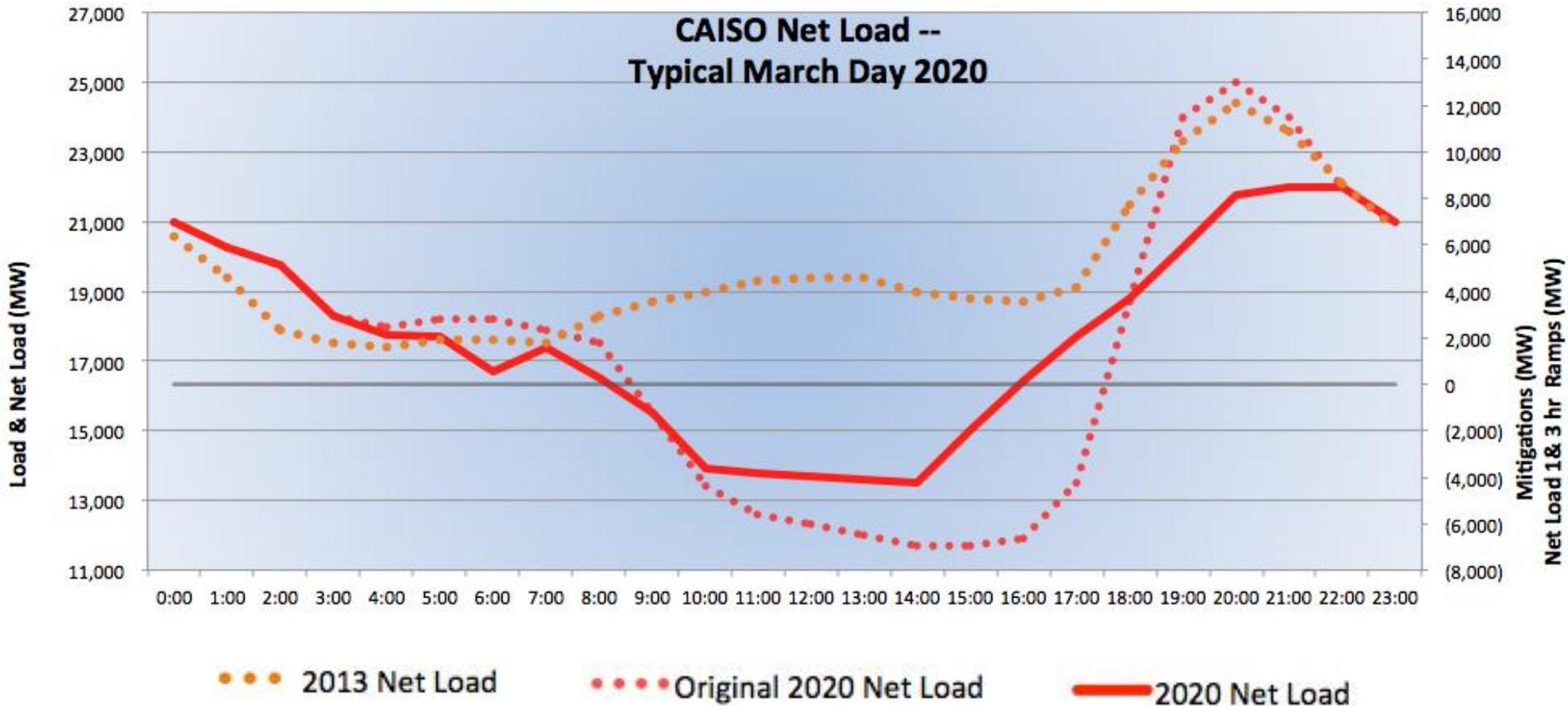


California set a target of 1.325 GW of new cost-effective storage by 2020



Can also curtail baseload by scheduling maintenance during shoulder months

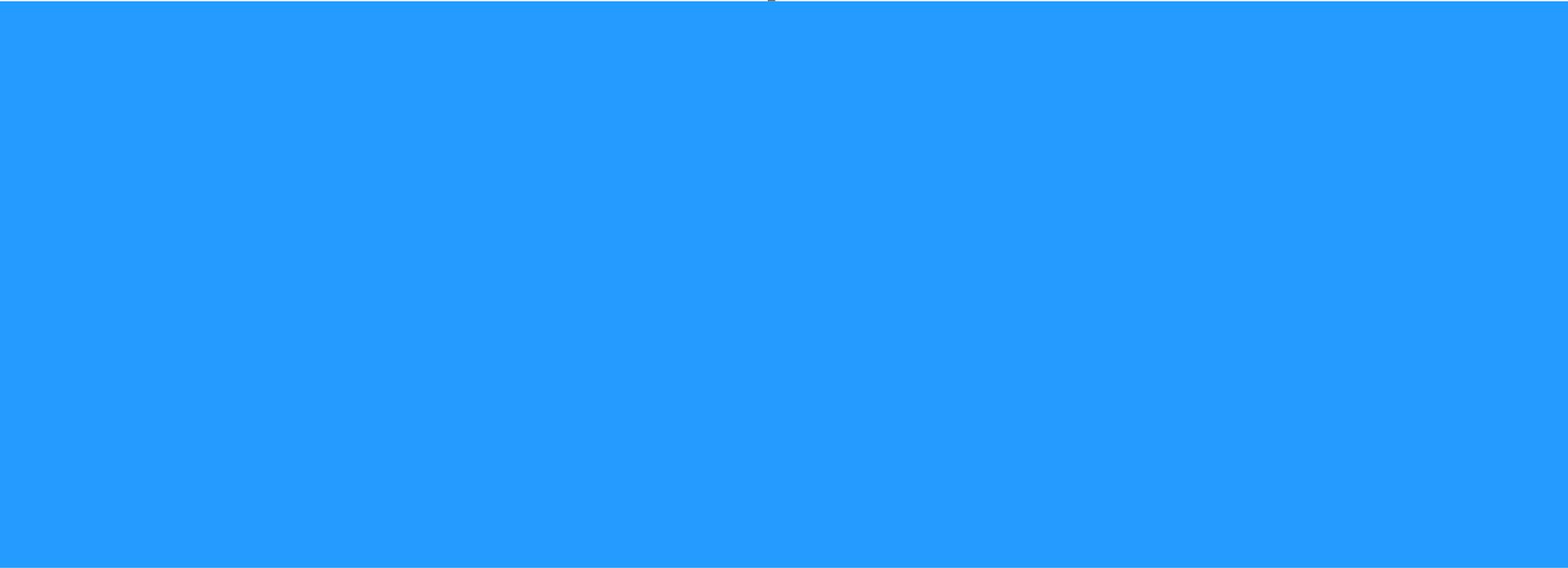
Flattening the Duck – Aggregated Solutions



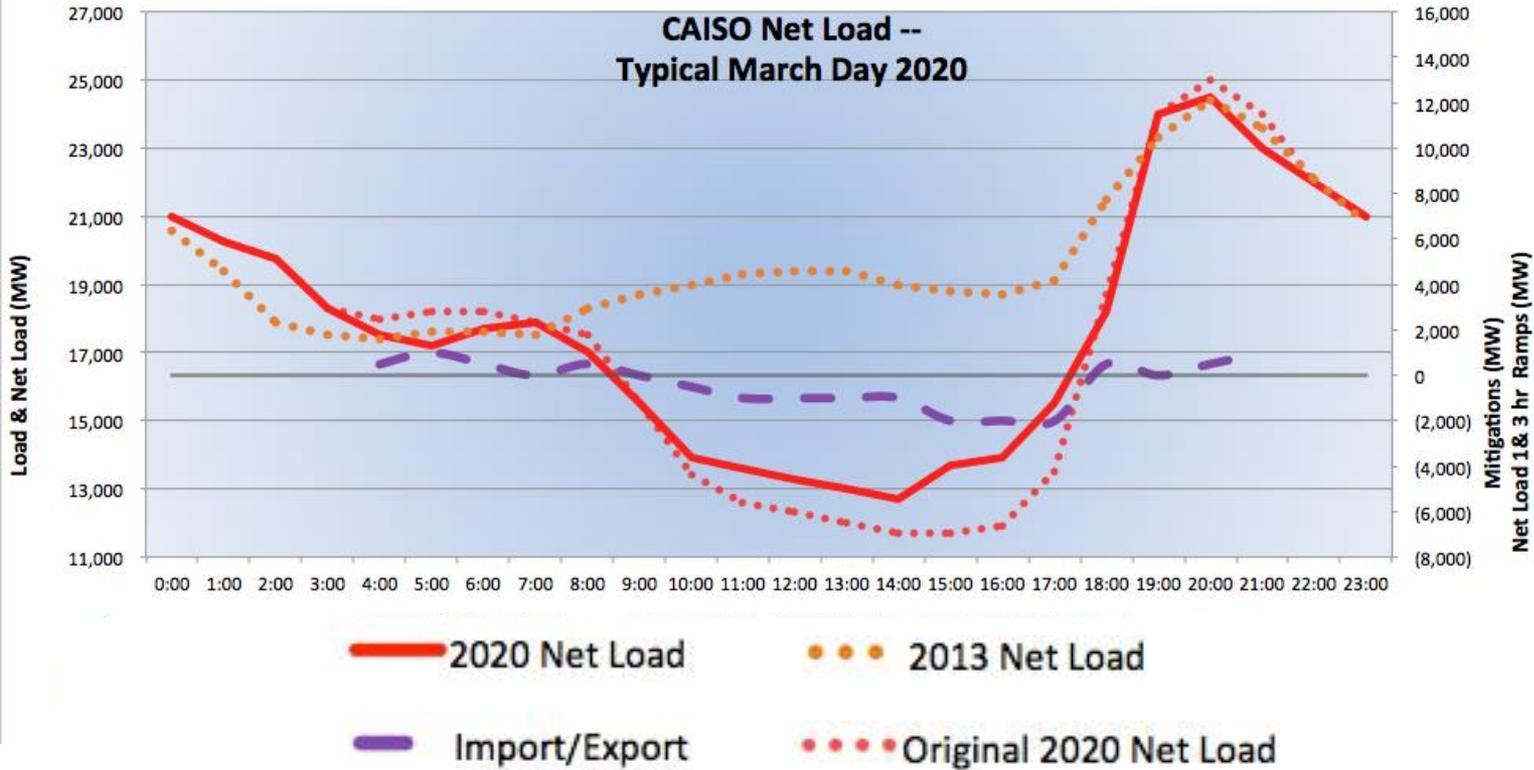
The reflected aggregated solutions include imports/exports, demand response, energy storage and solar curtailment



Back-up Slides



Import/Export Assumptions

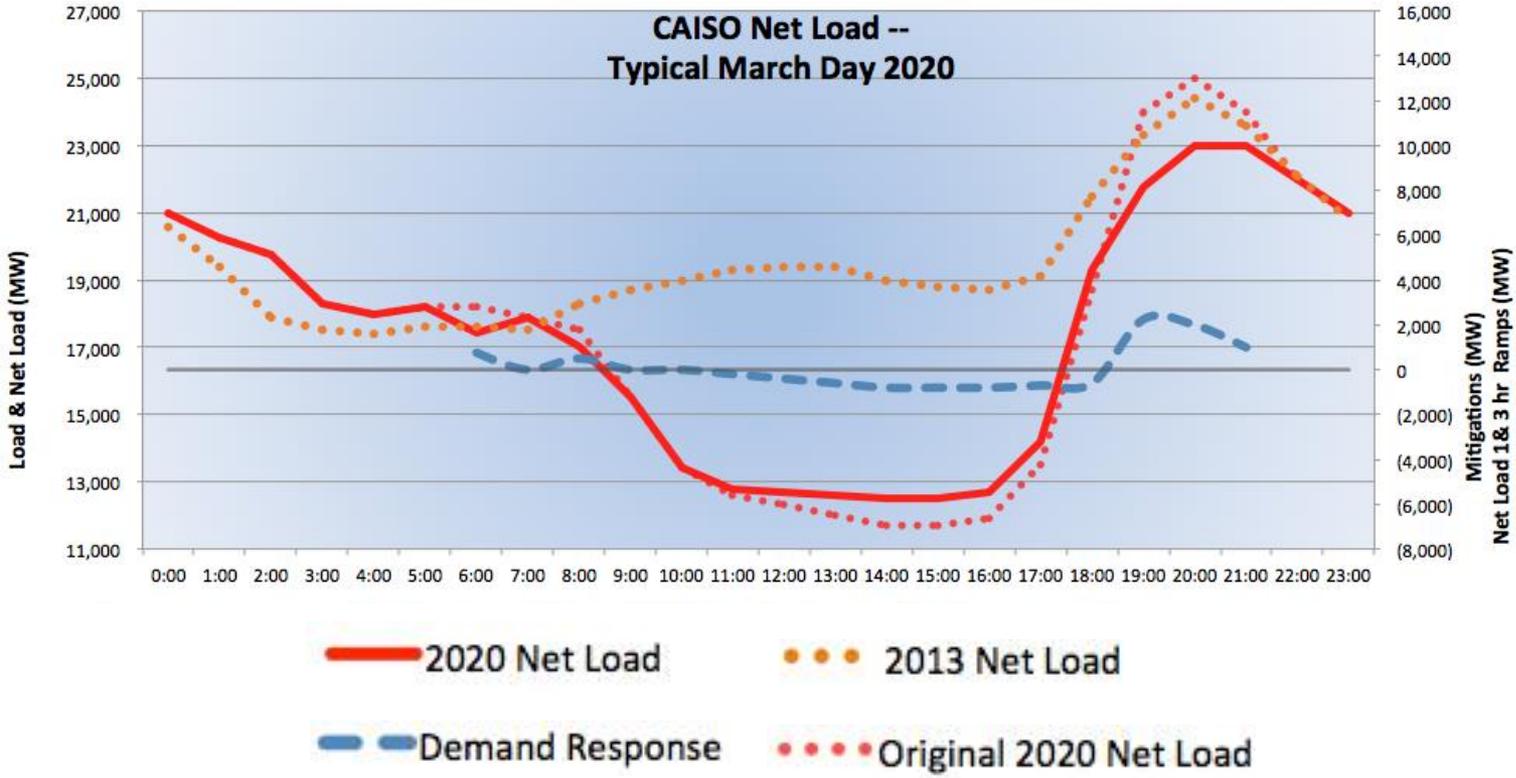


	- = Exp
	+ = Imp
<u>ToD</u>	<u>Import/Export</u>
0:00	
1:00	
2:00	
3:00	
4:00	500
5:00	1,000
6:00	500
7:00	-
8:00	500
9:00	-
10:00	(500)
11:00	(1,000)
12:00	(1,000)
13:00	(1,000)
14:00	(1,000)
15:00	(2,000)
16:00	(2,000)
17:00	(2,000)
18:00	500
19:00	-
20:00	500
21:00	1,000
22:00	
23:00	
Total Net:	(6,000)
Max:	1,000
Min:	(2,000)

Demand Response Assumptions

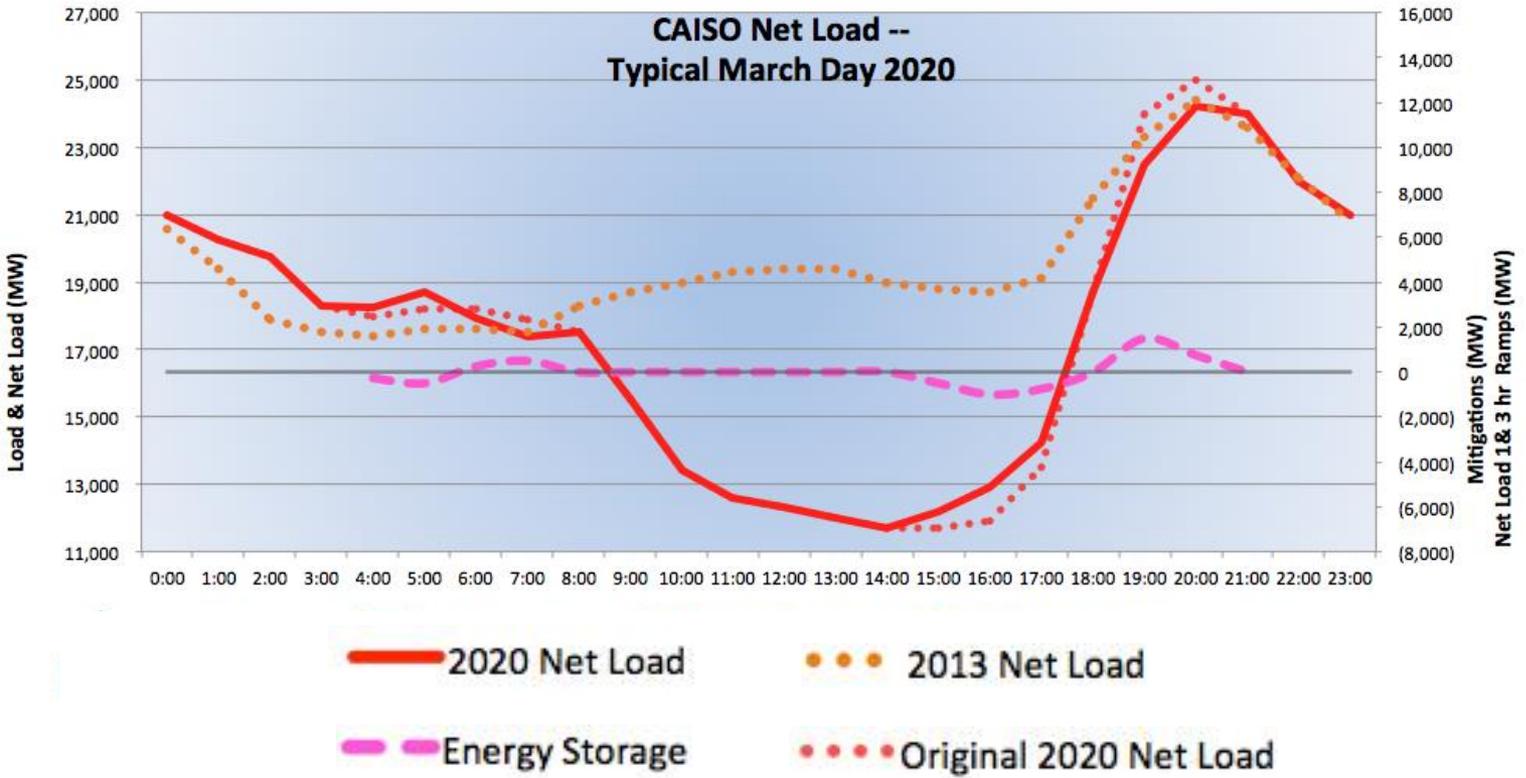


CAISO Net Load -- Typical March Day 2020



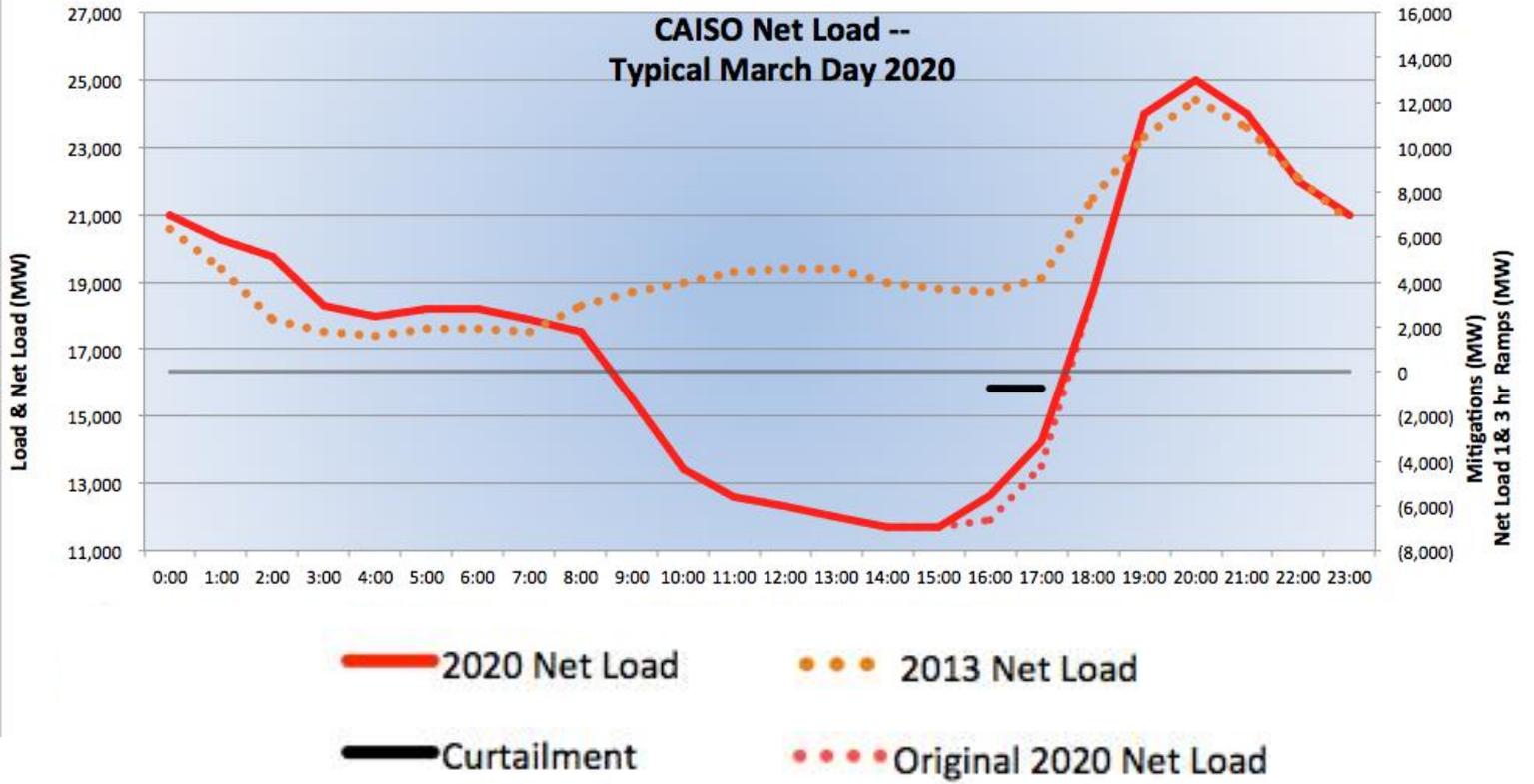
ToD	DR
0:00	
1:00	
2:00	
3:00	
4:00	
5:00	
6:00	750
7:00	-
8:00	500
9:00	-
10:00	-
11:00	(200)
12:00	(400)
13:00	(600)
14:00	(800)
15:00	(800)
16:00	(800)
17:00	(700)
18:00	(600)
19:00	2,250
20:00	2,000
21:00	1,000
22:00	
23:00	
Total Net:	1,600
Max:	2,250
Min:	(800)

Energy Storage Assumptions

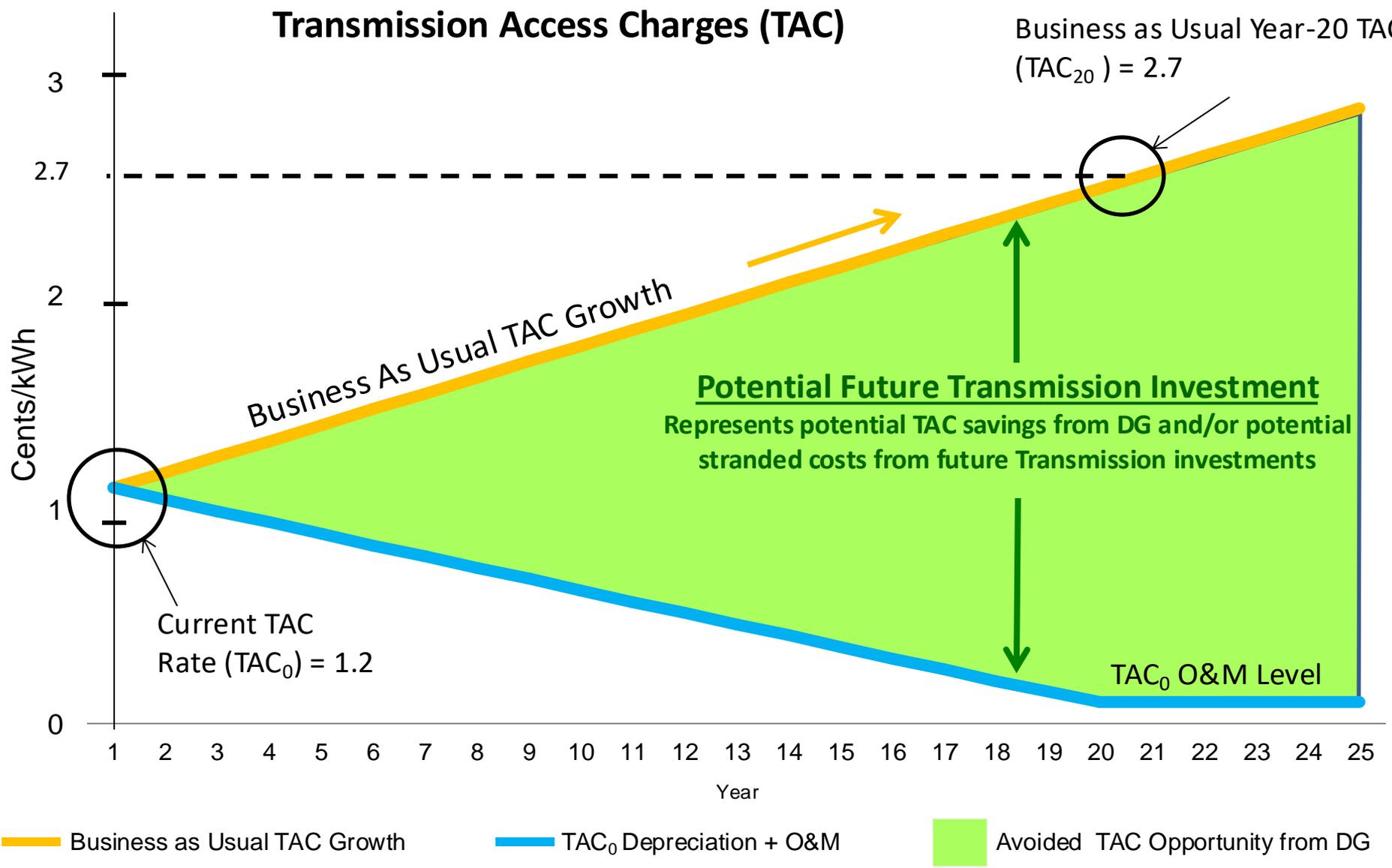


	- = Charge
	+ = Gen
<u>ToD</u>	<u>ES</u>
0:00	
1:00	
2:00	
3:00	
4:00	(250)
5:00	(500)
6:00	250
7:00	500
8:00	-
9:00	-
10:00	-
11:00	-
12:00	-
13:00	-
14:00	-
15:00	(500)
16:00	(1,000)
17:00	(750)
18:00	-
19:00	1,500
20:00	750
21:00	-
22:00	
23:00	
Total Net:	-
Max:	1,500
Min:	(1,000)

Curtailment Assumptions



	+ = Gen
<u>ToD</u>	<u>Curtailment</u>
0:00	
1:00	
2:00	
3:00	
4:00	
5:00	
6:00	
7:00	
8:00	
9:00	
10:00	
11:00	
12:00	
13:00	
14:00	
15:00	
16:00	(750)
17:00	(750)
18:00	
19:00	
20:00	
21:00	
22:00	
23:00	
Total Net:	(1,500)
Max:	(750)
Min:	(750)



SCE Share of 12,000 MW Goal

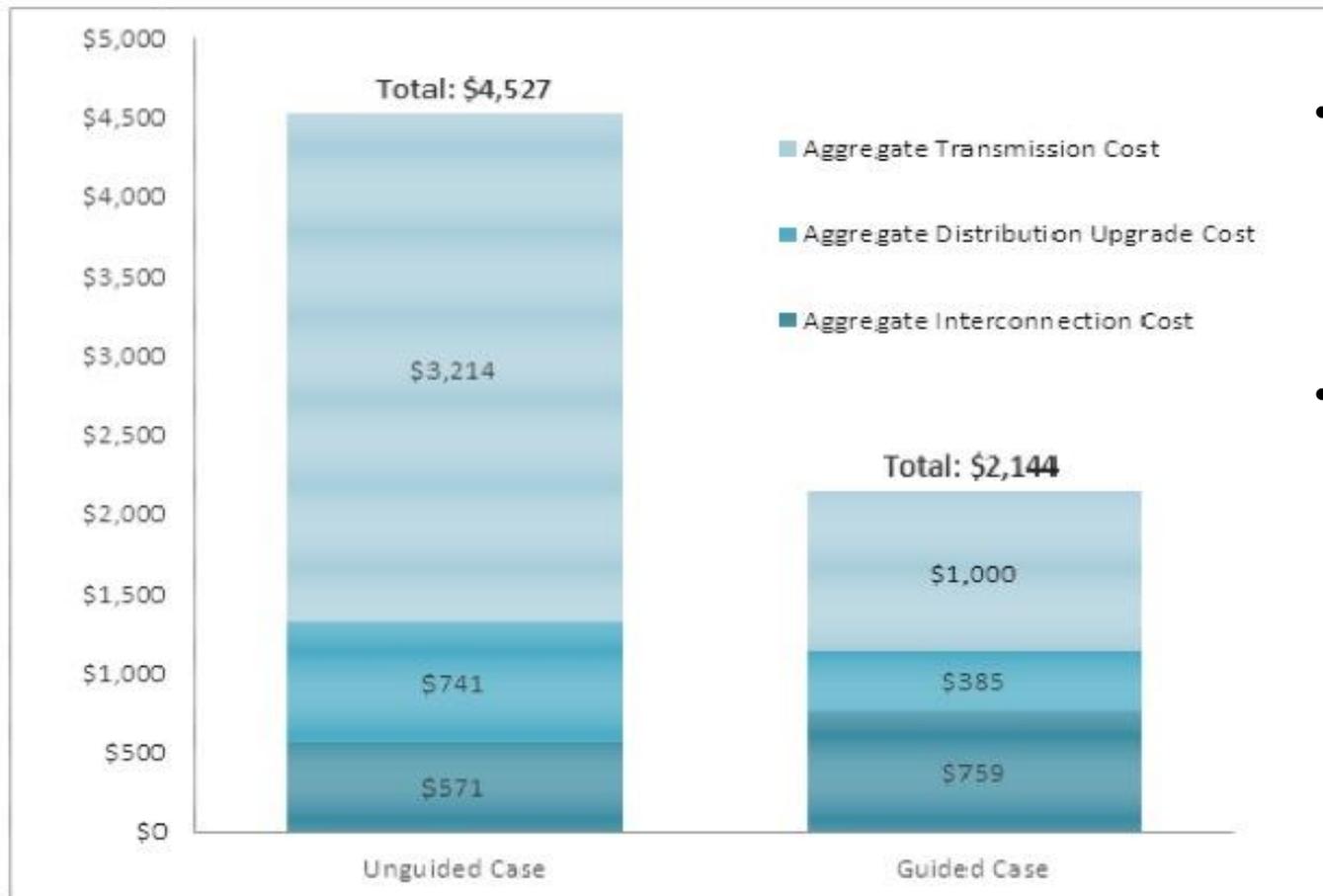
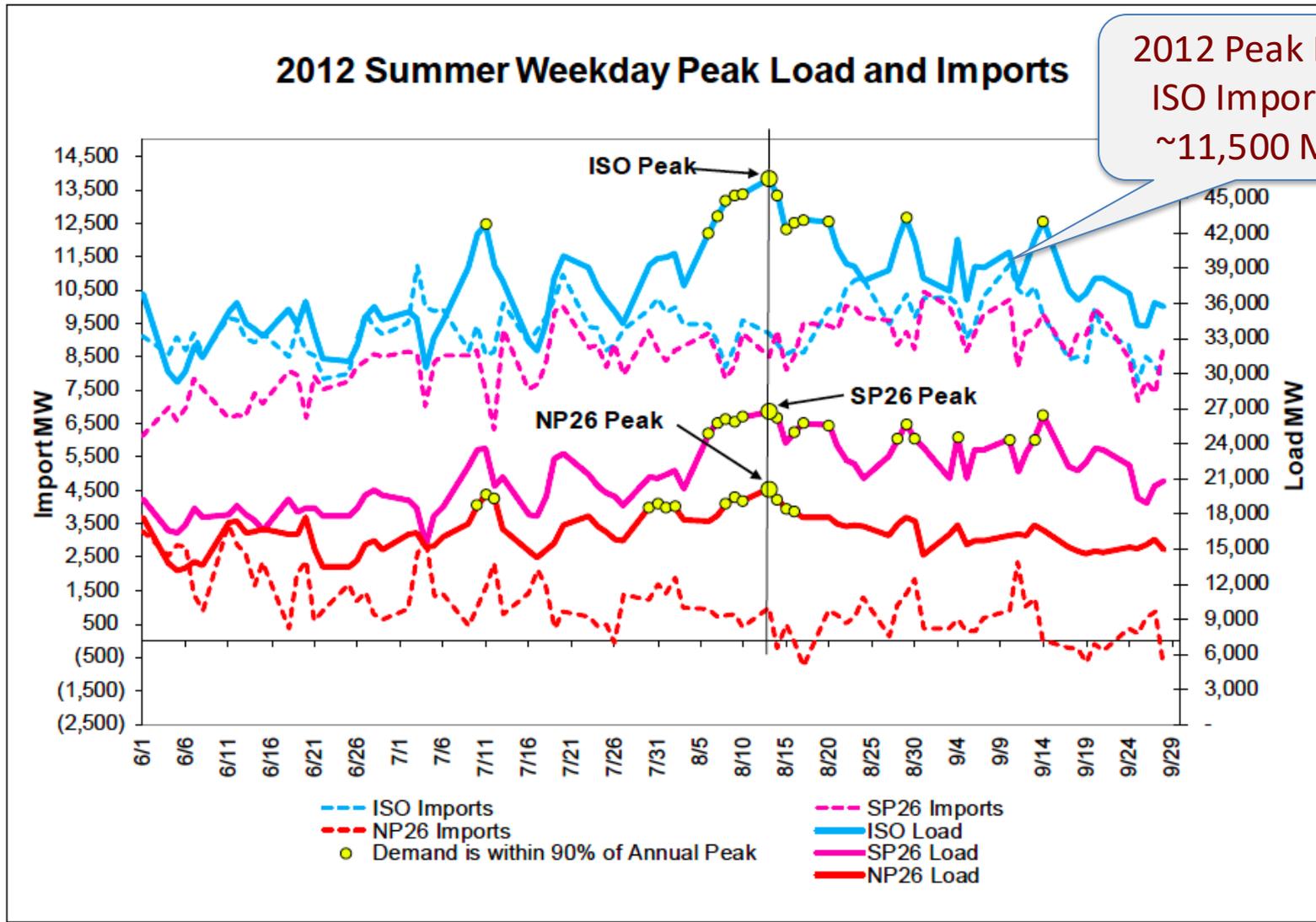


Figure 8: Total SCE System Costs of LER Proposal (Million USD)

Guided Siting Saves Ratepayers 50%

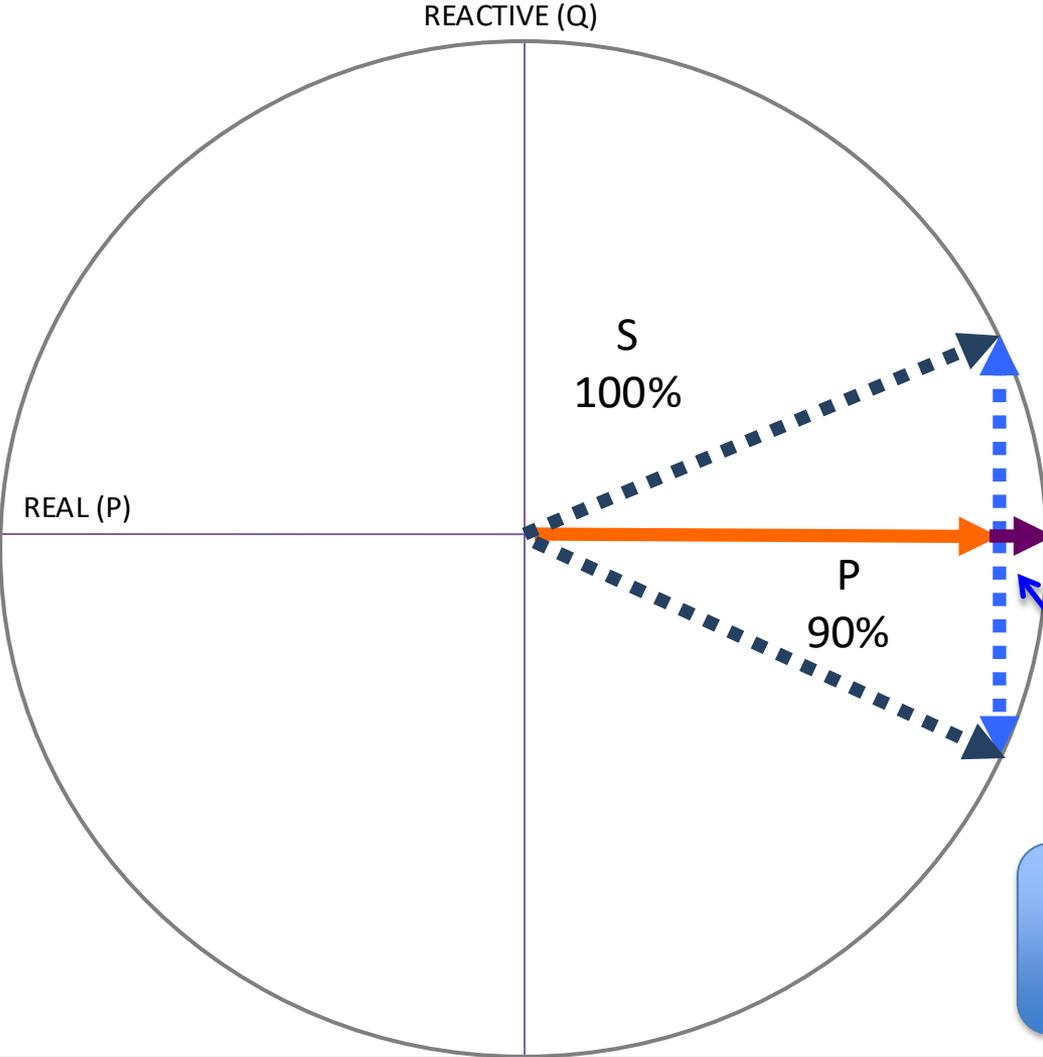
- **Locational Value** methodology should include transmission costs.
- **Interconnection** policies should favor high value locations, reduce cost uncertainty for developers.

Source: SCE Report May 2012



Source: CAISO 2013 Summer Loads & Resources Assessment (May 6, 2013)

Advanced Inverter at 0.9 Power Factor = 43.6% reactive power

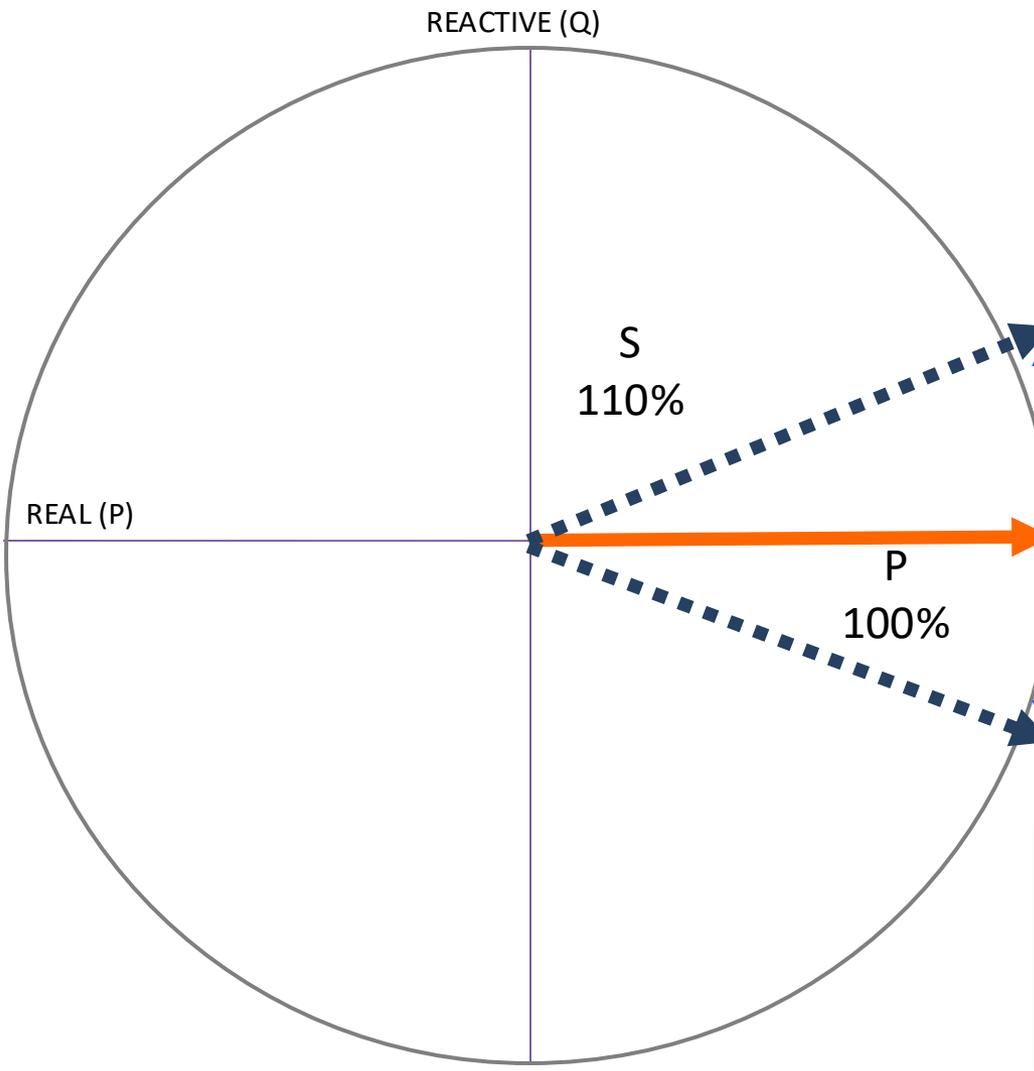


P: Real power (kW)
Q: Reactive power (kVAr)
S: Total power (kVA)

100 kW solar PV AC power
100 kVA inverter capacity
0.9 power factor
43.6 kVAr reactive power
90 kW real power

Standard-sized inverter:
Diverts up to 10% solar capacity to provision reactive power

Advanced Inverters – Reactive Power (Oversized)



P: Real power (kW)
Q: Reactive power (kVAr)
S: Total power (kVA)

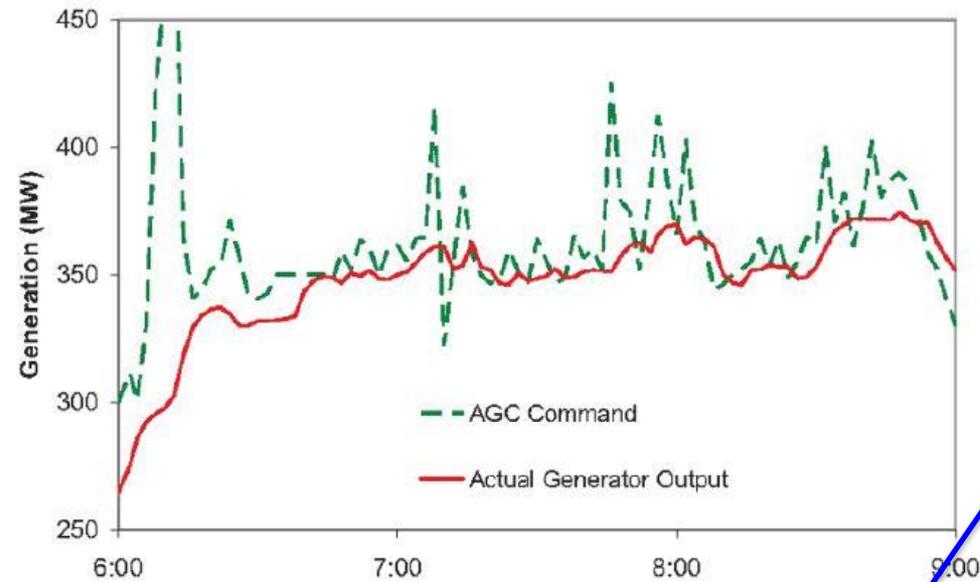
100 kW solar PV AC power
110 kVA inverter capacity
0.9 power factor
45.8 kVAr reactive power
100 kW real power

- Oversized inverter:**
- No reduction of PV real power
 - Draws up to 10 kW real power from the grid
 - Provides reactive power 24/7/365

Regulation: Faster, More Accurate Solutions

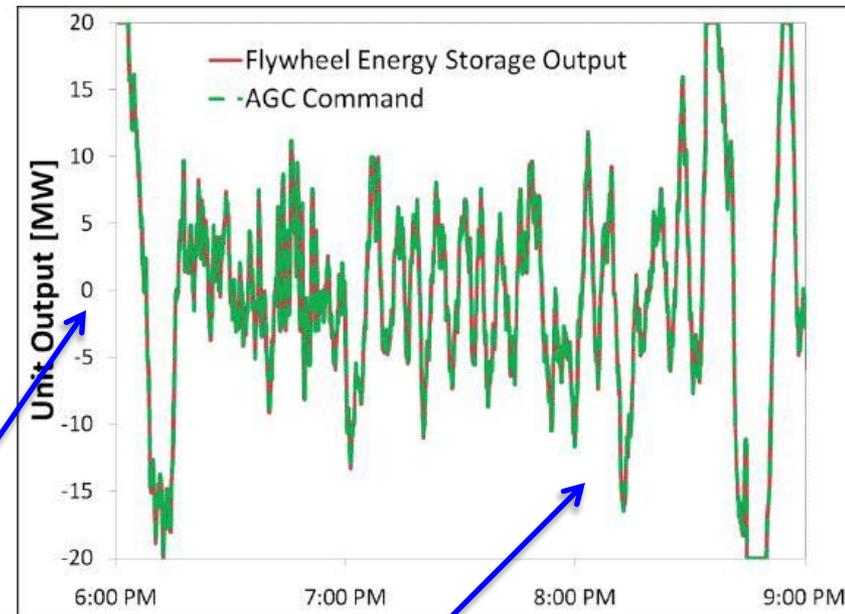
Ideal flexible resources should look like storage, not natural gas – faster, more accurate, cleaner, and full capacity to dispatch and absorb power.

Conventional Spinning Generator



Storage provides both supply and demand

Flywheel Storage

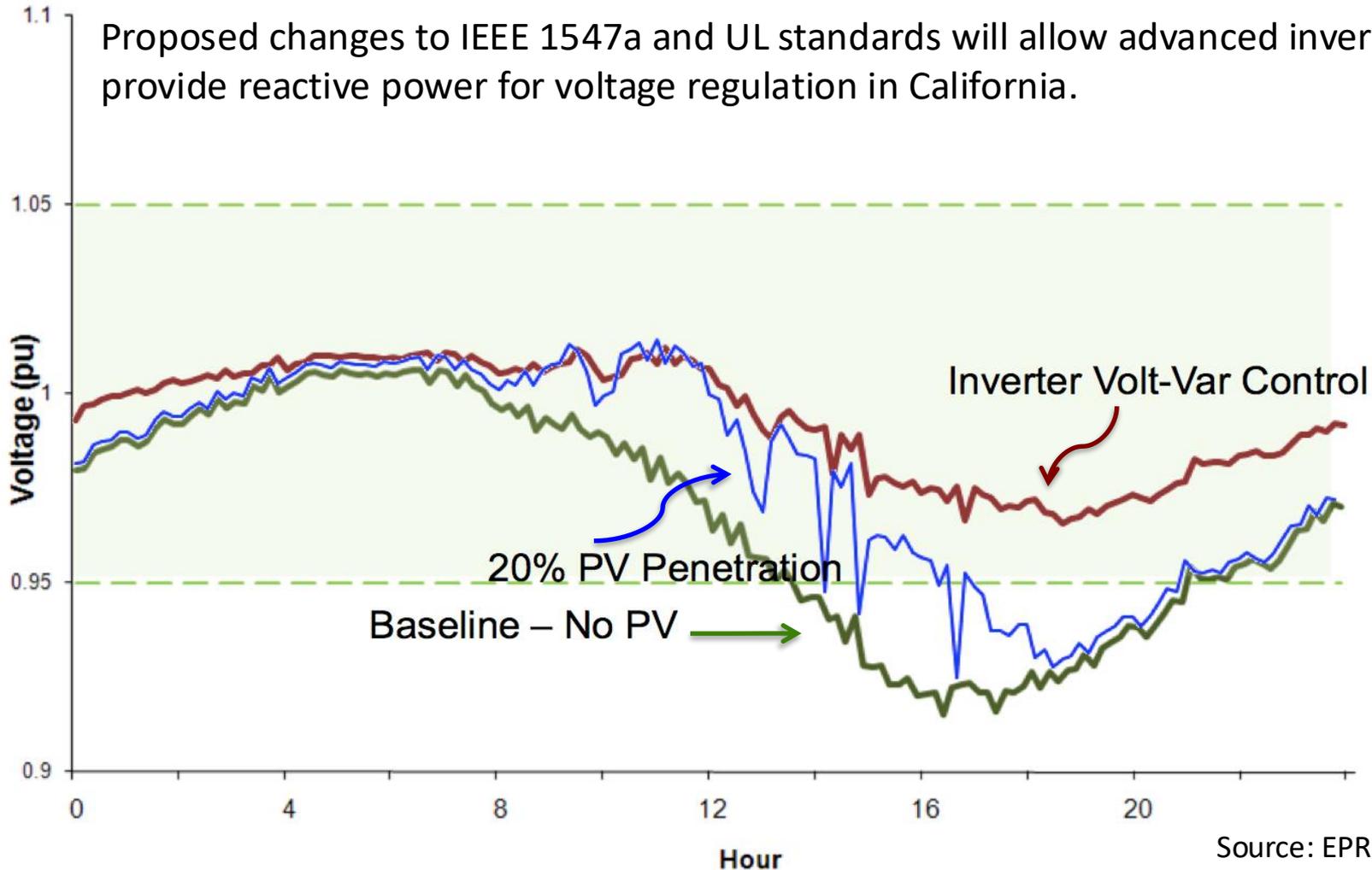


Faster and more accurate regulation = less MW required

Advanced Inverters Keep Voltage in Balance

Advanced inverters have been programmed to deliver reactive power in Germany and Georgia Power's territory.

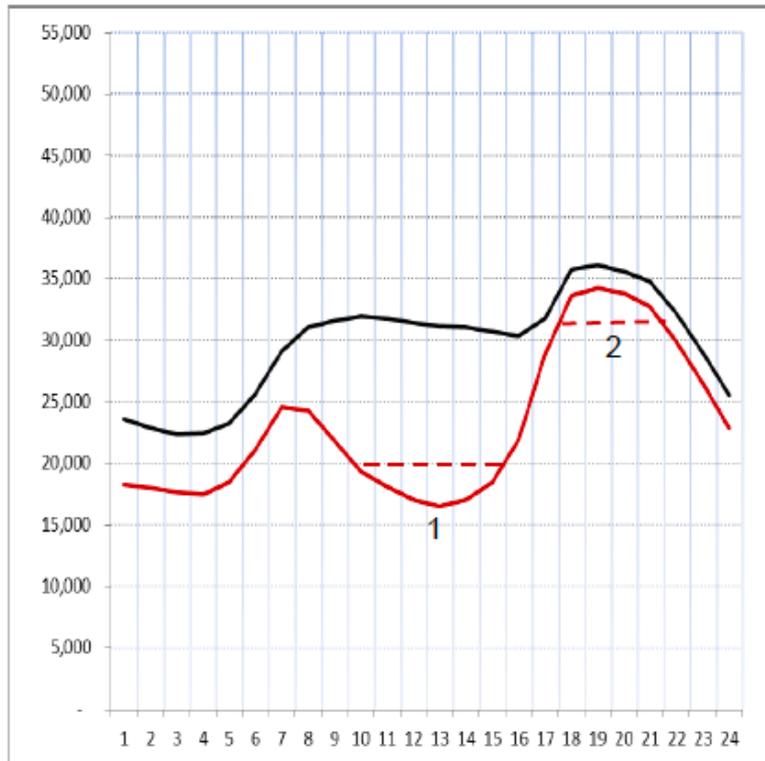
Proposed changes to IEEE 1547a and UL standards will allow advanced inverters to provide reactive power for voltage regulation in California.





How DSM can help with the “duck curve” – Part 2

A Duck: The Highest 3-hour Ramp-Up in the Year (Dec.6)



Source: PG&E and CPUC meeting 12/11/2013

Even in spring and winter “duck-like days”, DSM can help:

1. Increasing consumption in the middle of the day, or when there is surplus and potential overgen (reducing the belly of the duck), or
2. Reducing the neck of the duck (the peak), or
3. 1) + 2).
4. DSM including DR, EE, PLS, Rates, DG, EVs, etc. can change the load shape and thus the “duck”
5. PG&E is conducting studies to better characterize non-summer load opportunities

Project Size	Euros/kWh	USD/kWh	California Effective Rate \$/kWh
Under 10 kW	0.145	0.1903	0.0762
10 kW to 40 kW	0.138	0.1805	0.0722
40.1 kW to 1 MW	0.123	0.161	0.0644
1.1 MW to 10 MW	0.101	0.1317	0.0527

Source: <http://www.wind-works.org/cms/index.php?id=92>, 10 September 2013

- Conversion rate for Euros to Dollars is €1:\$1.309
- California's effective rate is reduced 40% due to tax incentives and then an additional 33% due to the superior solar resource

Replicating German scale and efficiencies would yield rooftop solar at only between 5 and 7 cents/kWh to California ratepayers

PV Potential of Top 25 Roofs in LA is Over 75 MW

Rank	Potential Size (kW)	Address	Description
1	6,987	300 WESTMONT DR	Warehousing, Distribution, Storage
2	6,296	3880 N MISSION RD	Warehousing, Distribution, Storage
3	4,797	400 WESTMONT DR	Warehousing, Distribution, Storage
4	4,524	20525 NORDHOFF ST	Lgt Manf.Sm. EQPT. Manuf Sm.Shps Instr.Manuf. Prnt Plnts
5	4,402	2501 S ALAMEDA ST	Warehousing, Distribution, Storage
6	3,771	4544 COLORADO BLVD	Lgt Manf.Sm. EQPT. Manuf Sm.Shps Instr.Manuf. Prnt Plnts
7	3,629	1800 N MAIN ST	Warehousing, Distribution, Storage
8	3,597	5500 CANOGA AVE	Heavy Manufacturing
9	3,596	20333 NORMANDIE AVE	Food Processing Plants
10	3,366	8500 BALBOA BLVD	Heavy Manufacturing
11	3,351	6600 TOPANGA CANYON BLVD	Shopping Centers (Regional)
12	3,313	401 WESTMONT DR	Warehousing, Distribution, Storage
13	3,052	9301 TAMPA AVE	Shopping Centers (Regional)
14	2,806	11428 SHERMAN WAY	Warehousing, Distribution, Storage
15	2,703	3820 UNION PACIFIC AVE	Heavy Manufacturing
16	2,693	1601 E OLYMPIC BLVD	Warehousing, Distribution, Storage
17	2,673	9120 MASON AVE	Lgt Manf.Sm. EQPT. Manuf Sm.Shps Instr.Manuf. Prnt Plnts
18	2,672	12745 ARROYO ST	Lgt Manf.Sm. EQPT. Manuf Sm.Shps Instr.Manuf. Prnt Plnts
19	2,431	5525 W IMPERIAL HWY	Heavy Manufacturing
20	2,430	8201 WOODLEY AVE	Lgt Manf.Sm. EQPT. Manuf Sm.Shps Instr.Manuf. Prnt Plnts
21	2,404	8900 DE SOTO AVE	Heavy Manufacturing
22	2,201	3410 N SAN FERNANDO RD	Lgt Manf.Sm. EQPT. Manuf Sm.Shps Instr.Manuf. Prnt Plnts
23	2,171	12820 PIERCE ST	Warehousing, Distribution, Storage
24	2,149	4024 RADFORD AVE	Motion Picture, Radio & Television
25	2,126	3020 E WASHINGTON BLVD	Heavy Manufacturing

100+ GW of Built-Environment Solar Potential in California vs 60 GW of Peak Load

Base Load Scenario

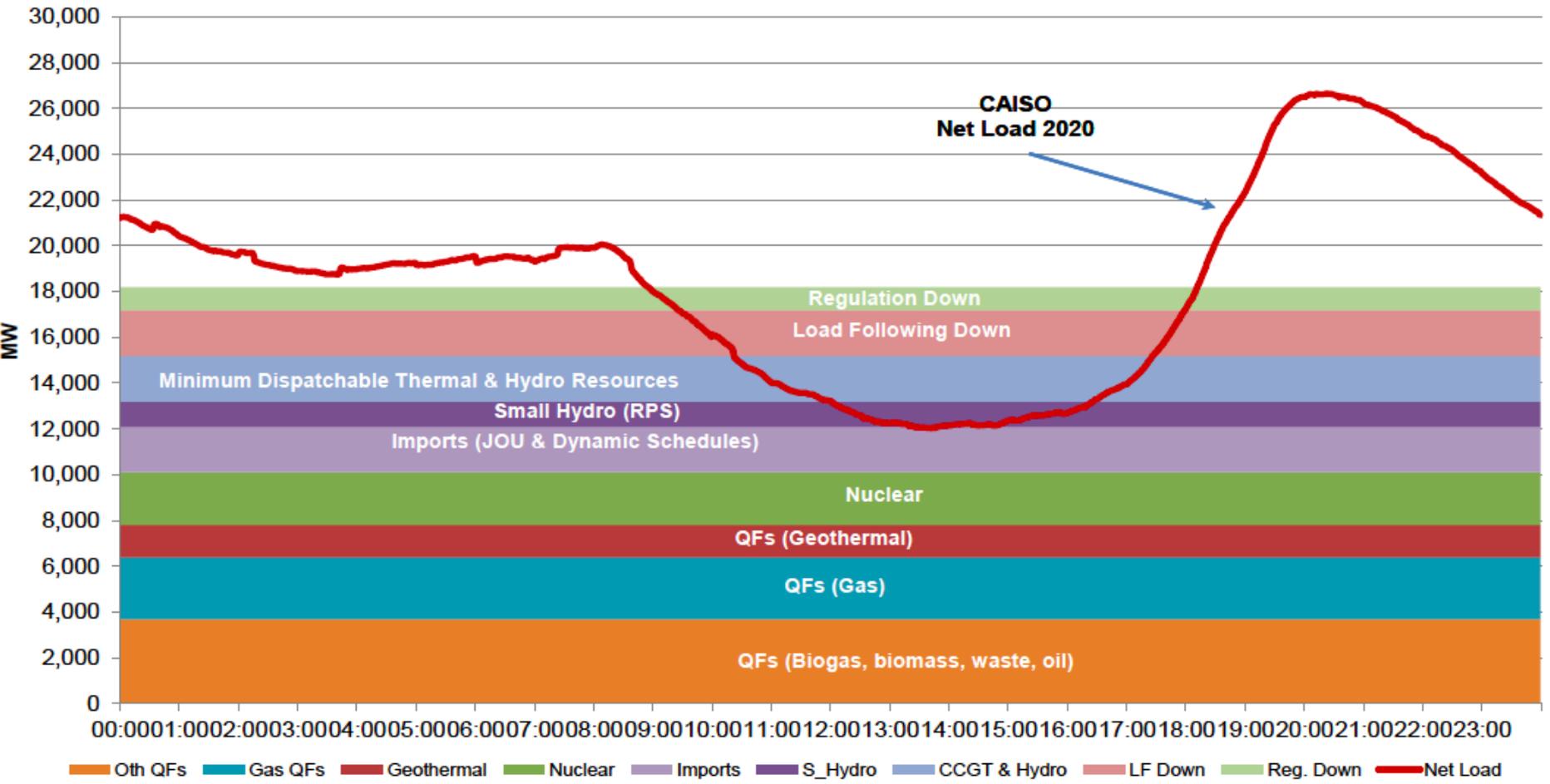


Figure 5: Potential Overgeneration Conditions – March 2020

Source: CAISO/NERC variable resources integration report (Nov 2013)

Benefits of Modernizing the Grid



- ▶ **Power Quality, Reliability & Resilience benefits**
 - ▶ Increased customer satisfaction
 - ▶ Improved equipment longevity
 - ▶ Sustained vital services in otherwise complete blackout scenarios
 - ▶ Avoided transmission & central generation vulnerabilities
- ▶ **Economic benefits**
 - ▶ Significant private-sector investment
 - ▶ Substantial local job creation
 - ▶ Fixed electricity prices for 20+ years
 - ▶ Localized energy spending
 - ▶ Avoided inefficiencies of central generation & transmission
- ▶ **Environmental benefits**
 - ▶ Avoiding dirty power generation, including nasty peaker plants that are often sited in underserved communities
 - ▶ Utilizing built-environments and disturbed lands for generation projects
 - ▶ Preserving pristine environments from transmission lines and other infrastructure

Replace SONGS – Solar PV + Advanced Inverters



VS



Huntington Beach
290 MVars
(minus line losses =
261 MVars)

570 MW of local solar with advanced inverters,
oversized by 10% set at 0.9 Power Factor = **261**
MVars

The Fossil Free Future is Arriving

