Clean Coalition

Making Clean Local Energy Accessible Now

Community Microgrids

Energy Storage Enabling the Modern Electricity System

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Clean Coalition Mission and Advisors

Mission

To accelerate the transition to renewable energy and a modern grid through technical, policy, and project development expertise.

Board of Advisors

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Co-founder and Former ED, Clean Economy Network

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General Partner and Co-founder, New Cycle Capital

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Technology Executive

R. James Woolsey
Chairman, Foundation for the Defense of Democracies; Former Director of Central Intelligence (1993-1995)

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

Clean Coalition Objectives

- From 2020 onward, all new electricity generated in the U.S. will come from at least:
  - **80% renewable sources**
  - **50% distributed sources**
- By 2020, established policies and programs will foster successful fulfillment of the above objectives

The Modern Electricity System

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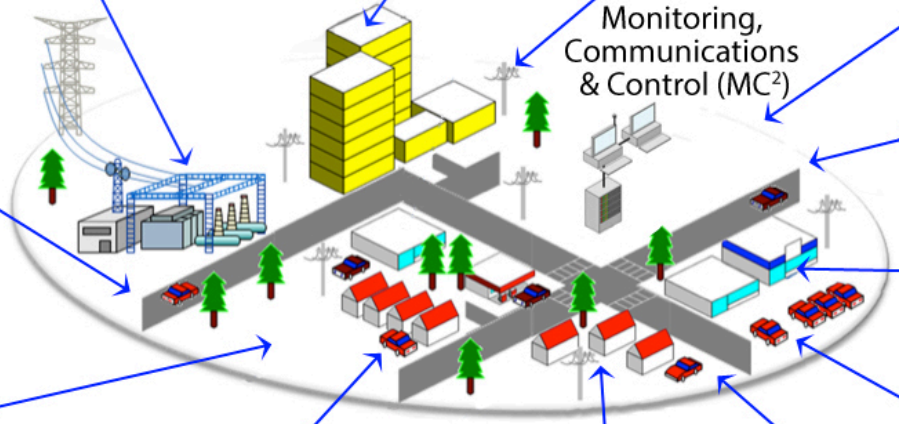
Grid Energy Storage

Distributed Generation

Switches & Power Electronics

Distributed Generation

Biopower Generation



Monitoring, Communications & Control (MC^2)

Energy Storage

Microturbine

Distributed Generation

Electric Vehicles (EV)

Home Energy System

Fuel Cells

Distributed Generation

Introducing the Dynamic Grid Council

The Dynamic Grid Council (DGC) establishes policy and market structures that modernize the distribution grid through Distributed Energy Resources (DER) like Local Renewables; Energy Storage; Advanced Inverters; Demand Response; Monitoring, Communications & Control (MC^2), Forecasting & Curtailment; and "Grid Hardening"

The DGC also establishes DER market opportunities at full value.

Electricity Systems have 3 Vital Grid Services

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

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

Is this Duck Real or a Decoy for Natural Gas?

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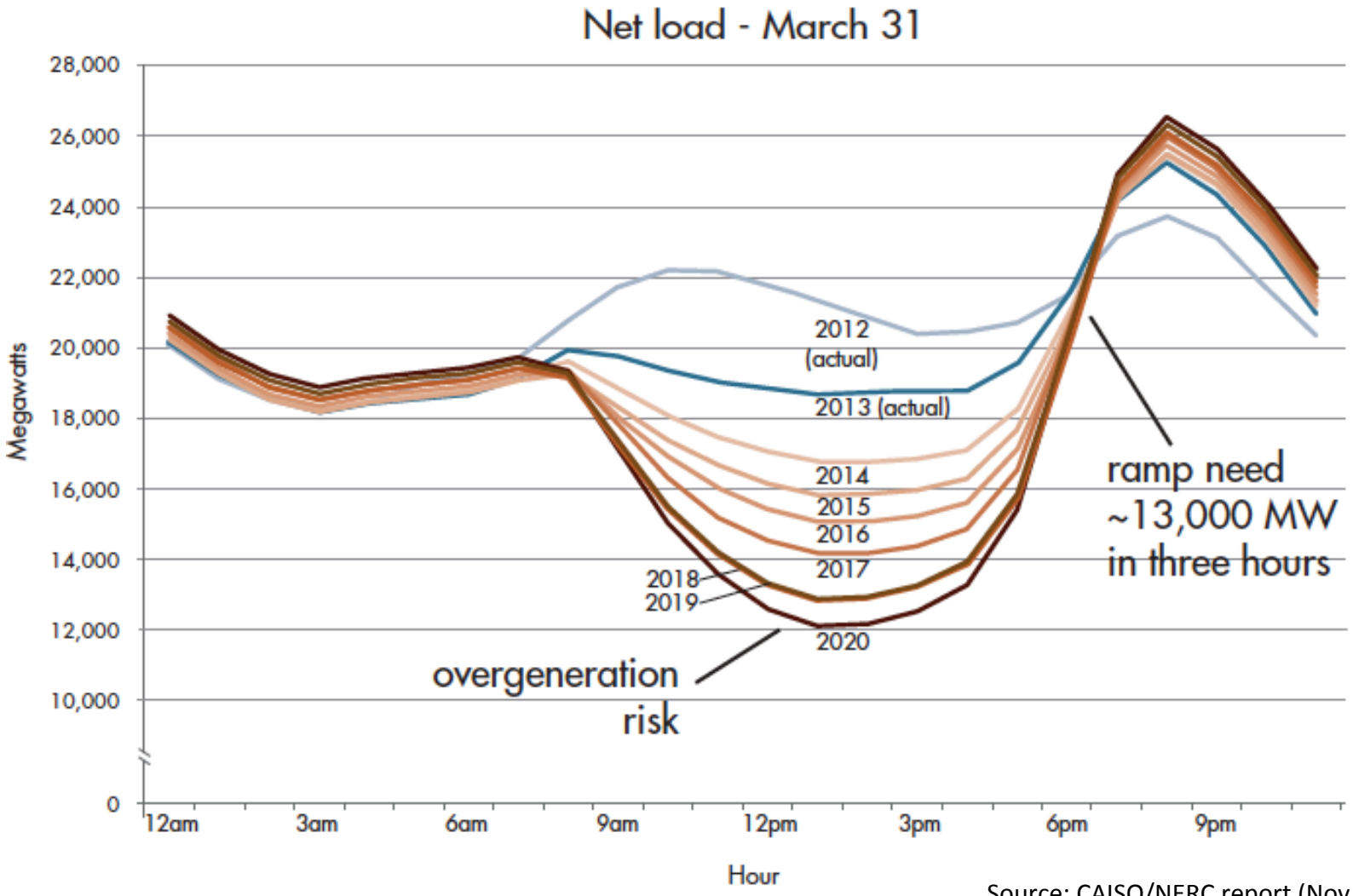
Figure 2: The duck curve shows steep ramping needs and overgeneration risk



Source: CAISO/NERC report (Nov 2013)

Wholesale DG is the Critical & Missing Segment

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Project Size

50+ MW

500 kW

5 kW

Wholesale DG

Serves Local Loads

Central Generation

Serves Remote Loads

Retail DG

Serves Onsite Loads

Behind the Meter

Distribution Grid

Transmission Grid

WDG Delivers Scale & Cost-Effectiveness Fast

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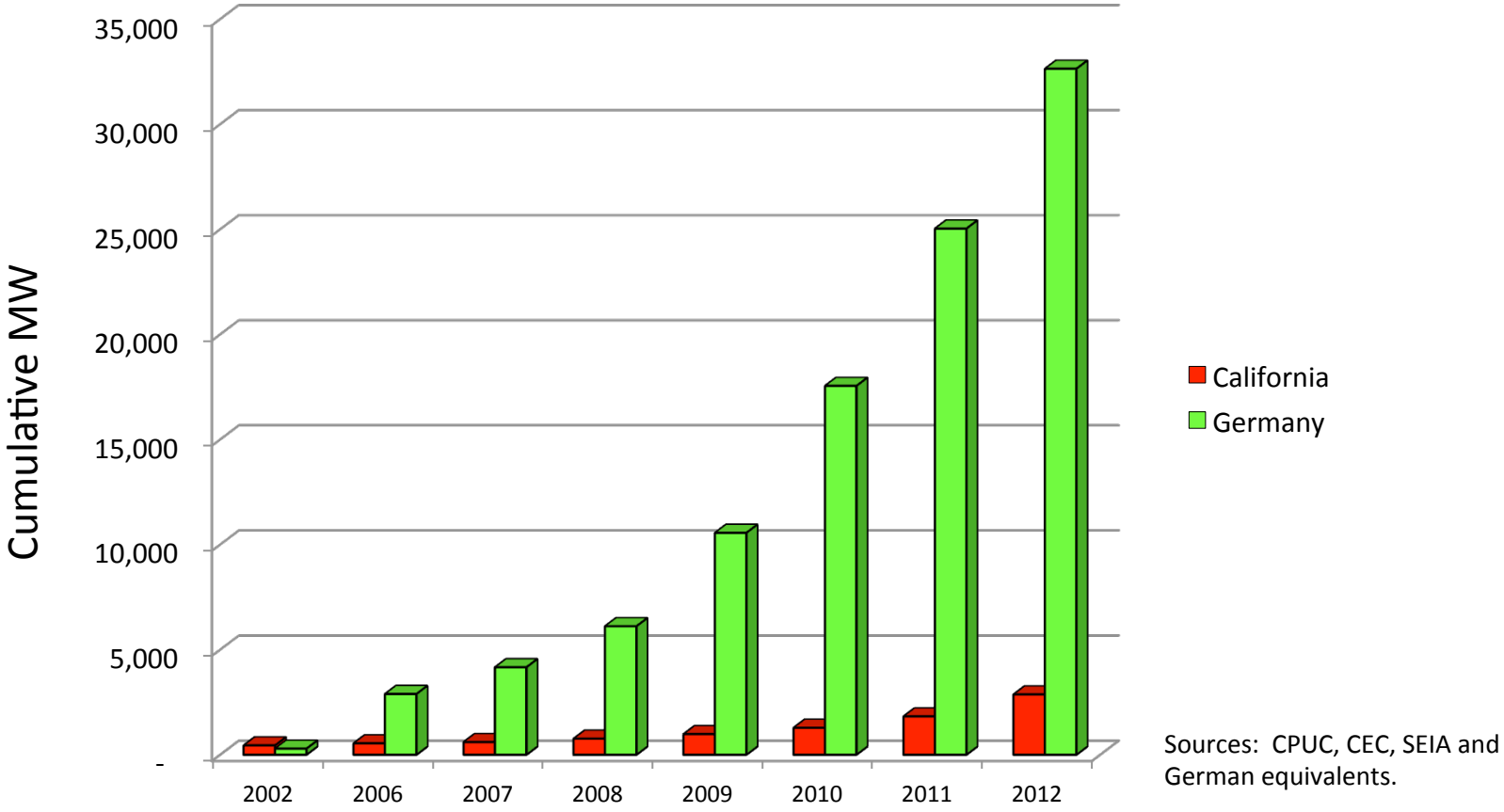
Solar Markets: Germany vs California (RPS + CSI + other)



Sources: CPUC, CEC, SEIA and German equivalents.

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

German Solar Capacity is Small WDG (Rooftops)

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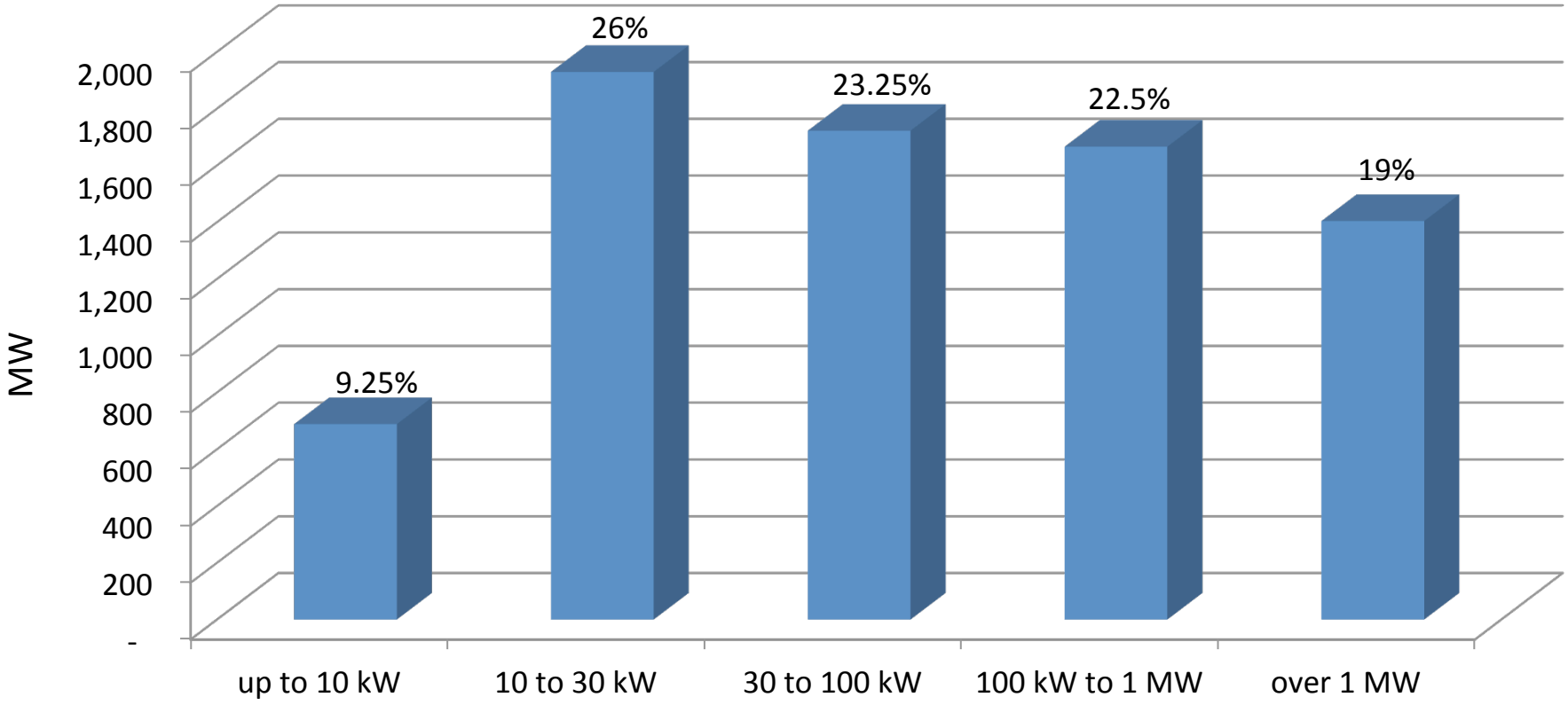
German Solar PV Capacity Installed in 2010



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)

Utility of the Future? "Distribution System Operator"

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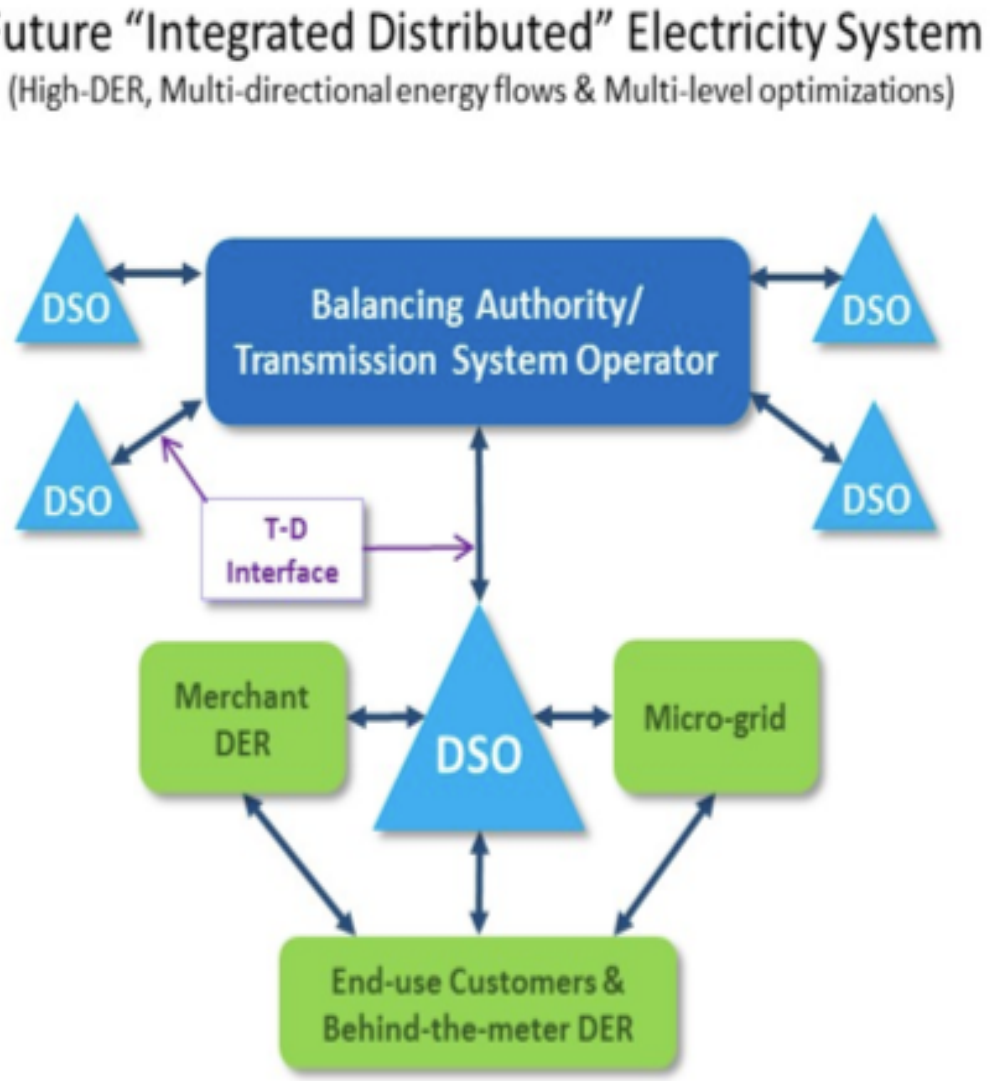
The Distribution System Operator (DSO) will:

- In real time, reliably operate the local distribution system, optimizing all Distributed Energy Resources (DER): micro-grids, diverse small-scale generation, self-optimizing customers, energy storage, power flow control devices, demand response, etc.
- Create a more stable and predictable interchange with the Transmission System Operator (TSO) that relies on more local balancing of resources



Source: 21st Century Electric Distribution System Operations, May 2014, by Lorenzo Kristov of CAISO and Paul Di Martini of the Caltech Resnick Institute

Potential Transmission Savings for California

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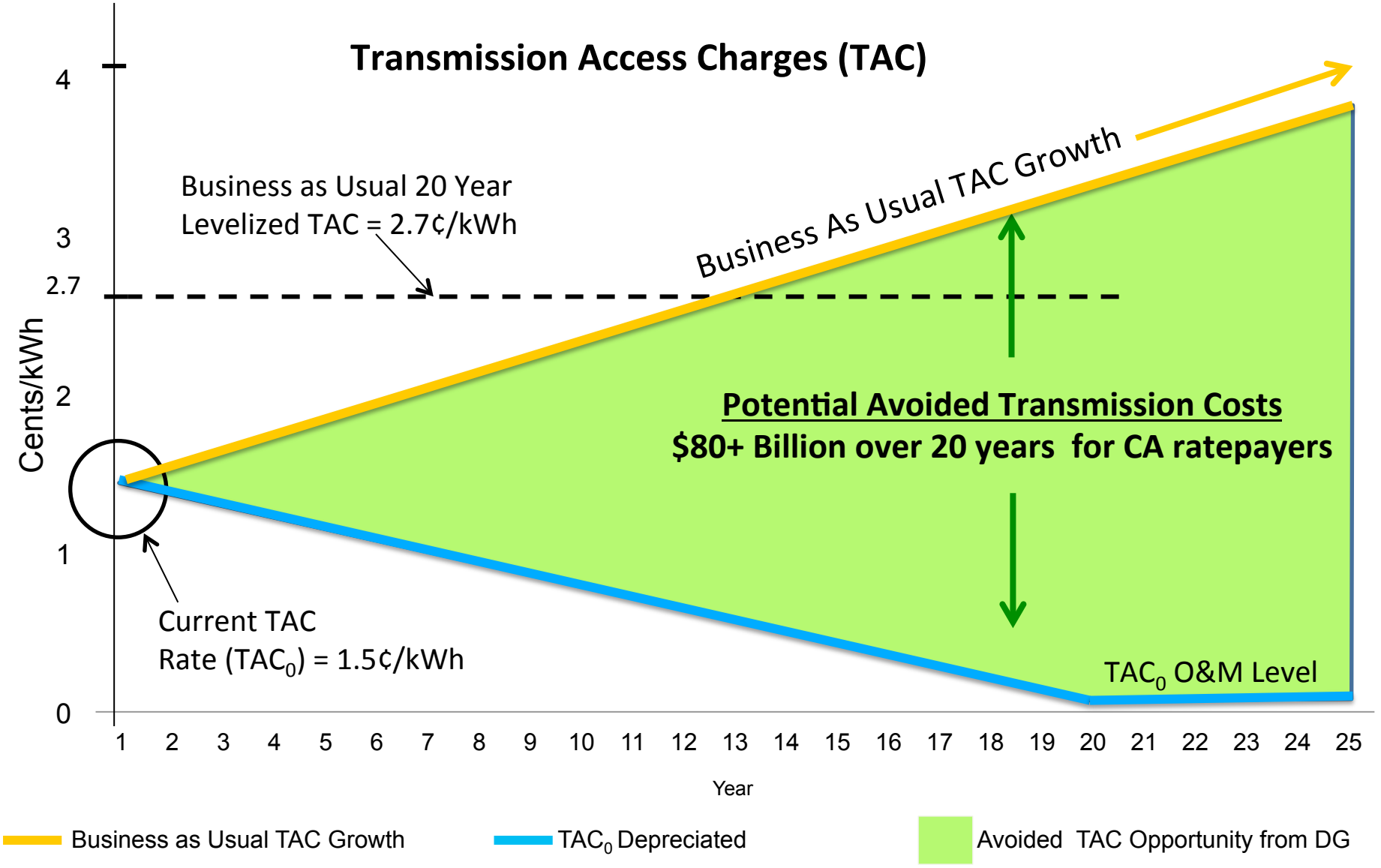

Opportunity: Shift Costs from Transmission to Distributed Energy Resources & Distribution Grid Hardening

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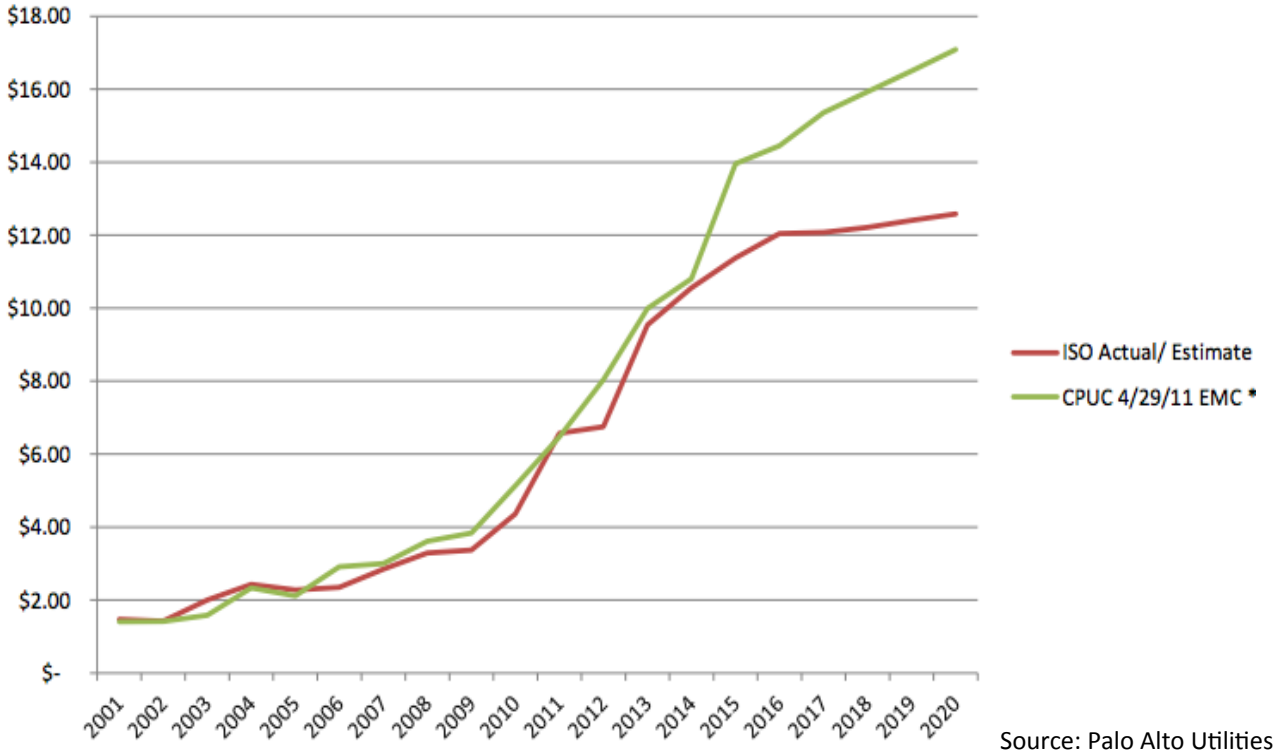
- Under a business as usual scenario, new incremental transmission investments will reach **$80 billion** over the next 20 years, imposed on California ratepayers
- Levelized over 20 years, this approaches **3 cents/kWh** – or roughly 25% of the wholesale cost of electricity, or 33% of the energy price of centralized solar
- Avoiding half of these charges, for example, would **free up roughly $40 billion** for modernizing the distribution grid incl. local renewables, storage, etc.

Historical and Projected High Voltage Transmission Access Charges ($/MWh).

Does not include Low Voltage Transmission Access Charges.



Source: Palo Alto Utilities

Community Microgrid Initiative: Proving the Feasibility of High DG while Enhancing Grid Quality

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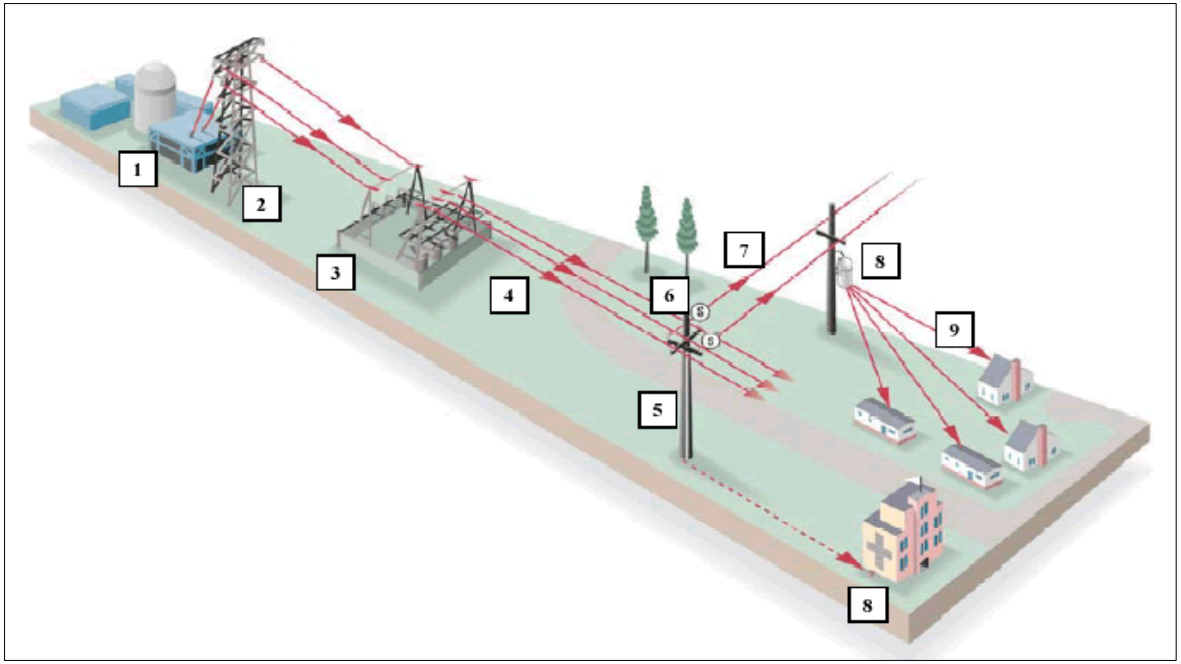
- Work with five utilities across the US to deploy a Community Microgrid demonstration project at each by yearend-2016

- Prove viability of Distributed Generation (DG) providing at least 25% of total electric energy consumed within a single substation grid area



- Integrate Intelligent Grid (IG) solutions to ensure that grid reliability is maintained or improved from original level
  - IG solutions include diversity and Energy Storage for sure, and potentially, advanced inverters, forecasting & curtailment, and/or Demand Response

Virgin Islands Example: Island of St John

1. 6AM:
   - No PV impact

2. Noon:
   - 20MW PV causes overvoltage

3. Noon:
   - Advanced inverters set at 0.9 power factor stabilizes voltage

St. John Role for ES: Keep Fossil Generators OFF

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Feeder	Avg Load	Solar Nameplate	ES Power	Estimated Cost (millions)		
	MW AC	MW DC	MW AC	15 min	30 min	60 min
Feeder 7E	3.5	4.9	2.0	$2.4	$3.6	$5.58
Feeder 9E	4.8	6.7	3.0	$3.6	$5.5	$8.37
Water Plant	2.1	2.9				
Feeder 7E & 9E	8.3	11.6	4.0	$4.8	$7.28	$11.16
Feeders 7E, 9E & WP	10.4	14.4	5.0	$4.8	$9.1	$13.95

The California ISO Duck Chart (2012 – 2020)

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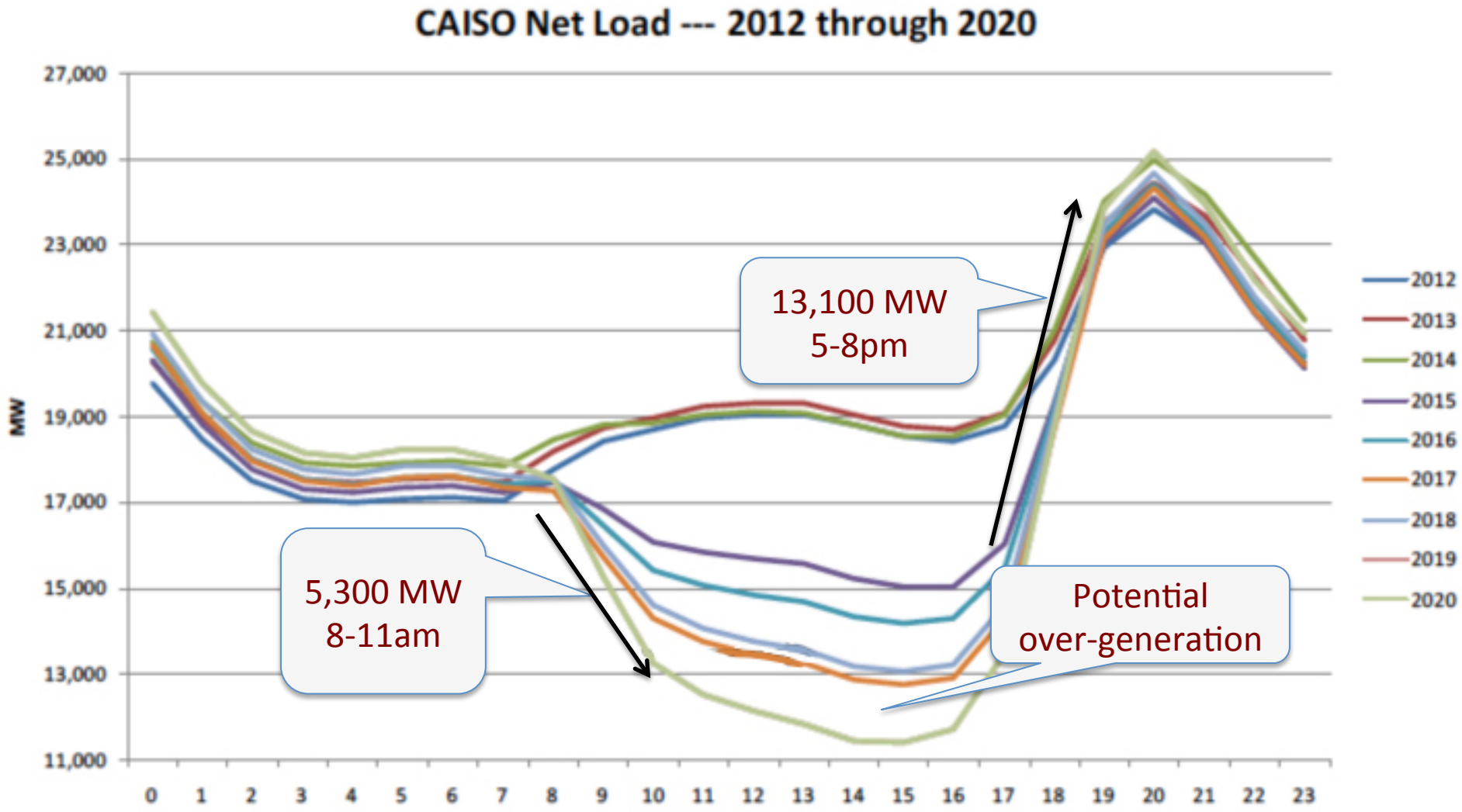
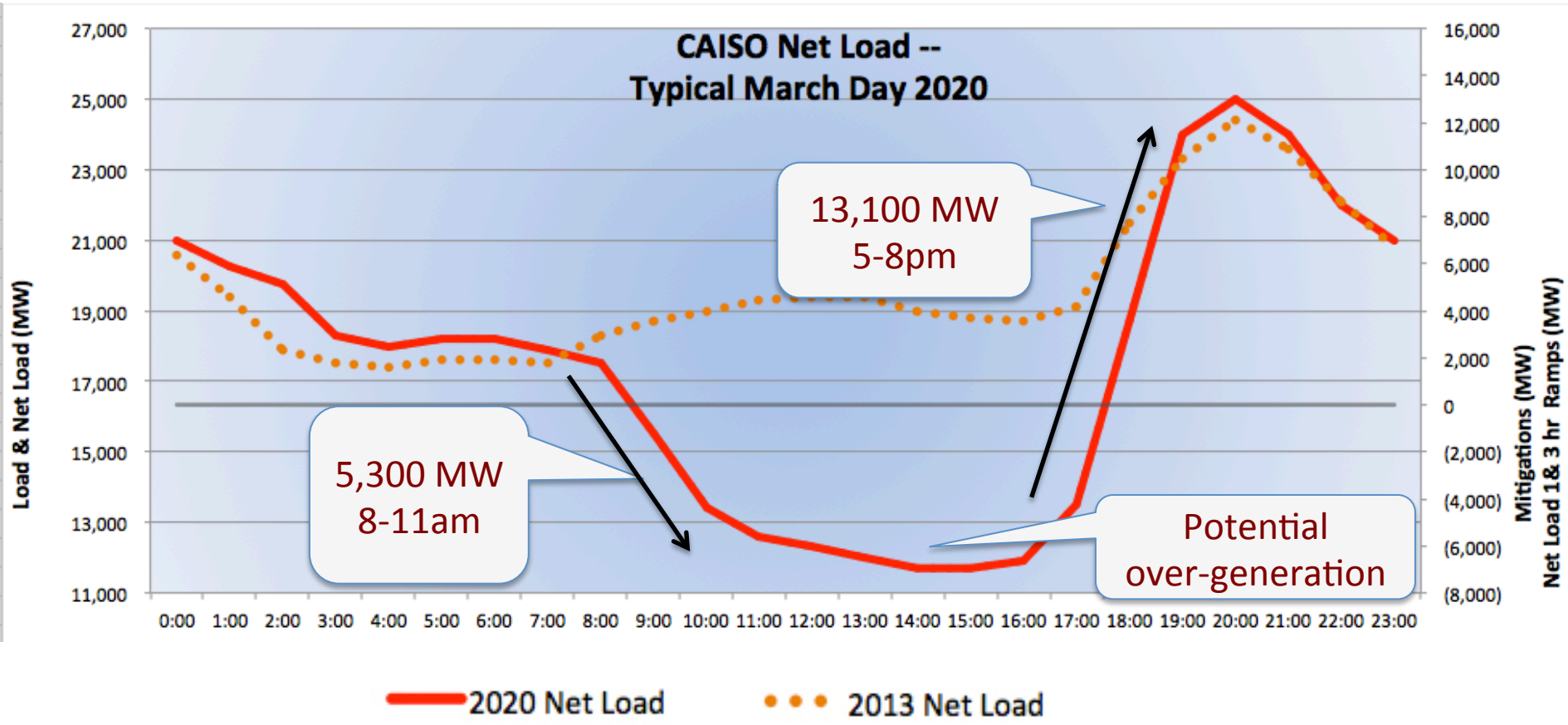
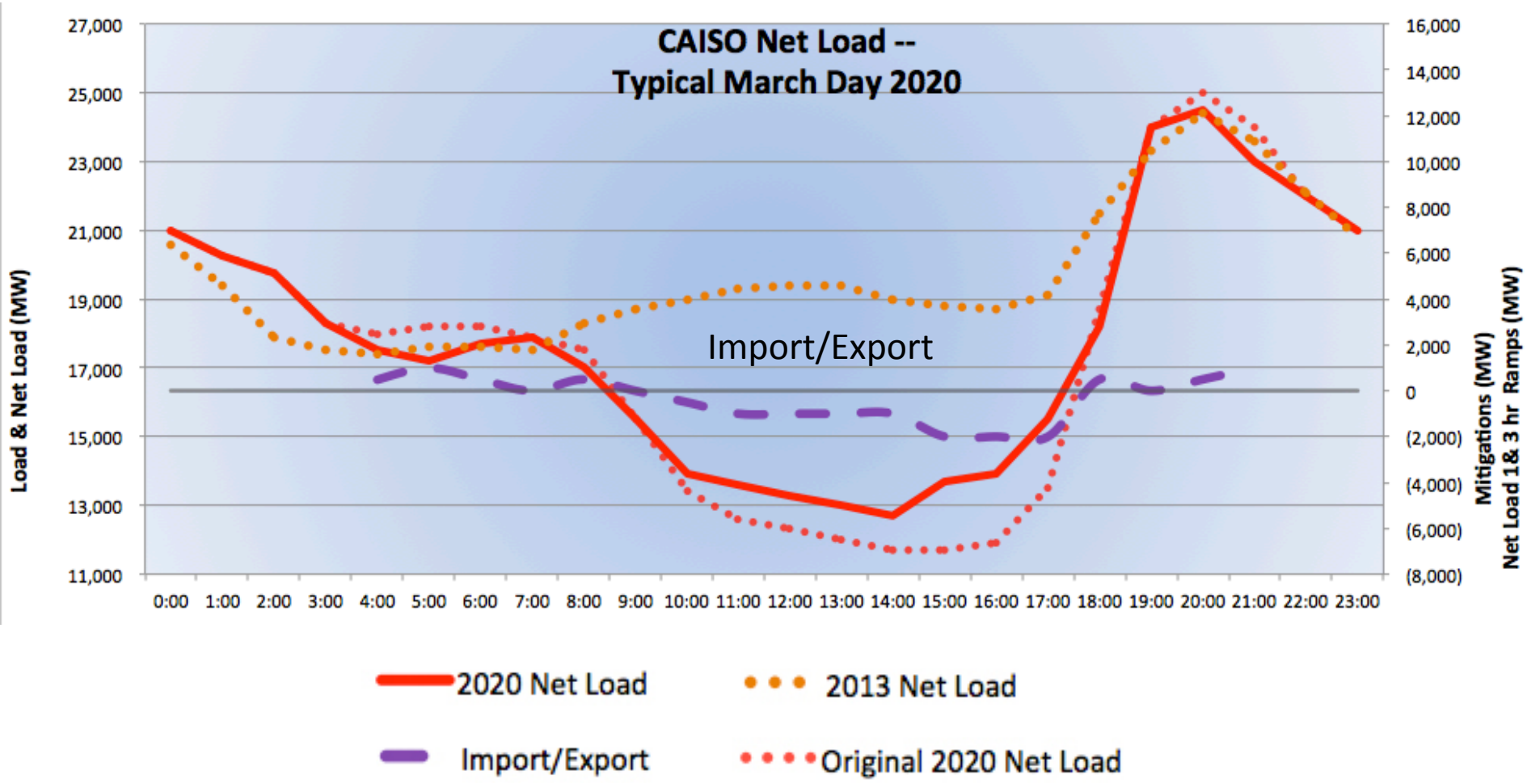


CAISO Duck Chart (2020 Issues)

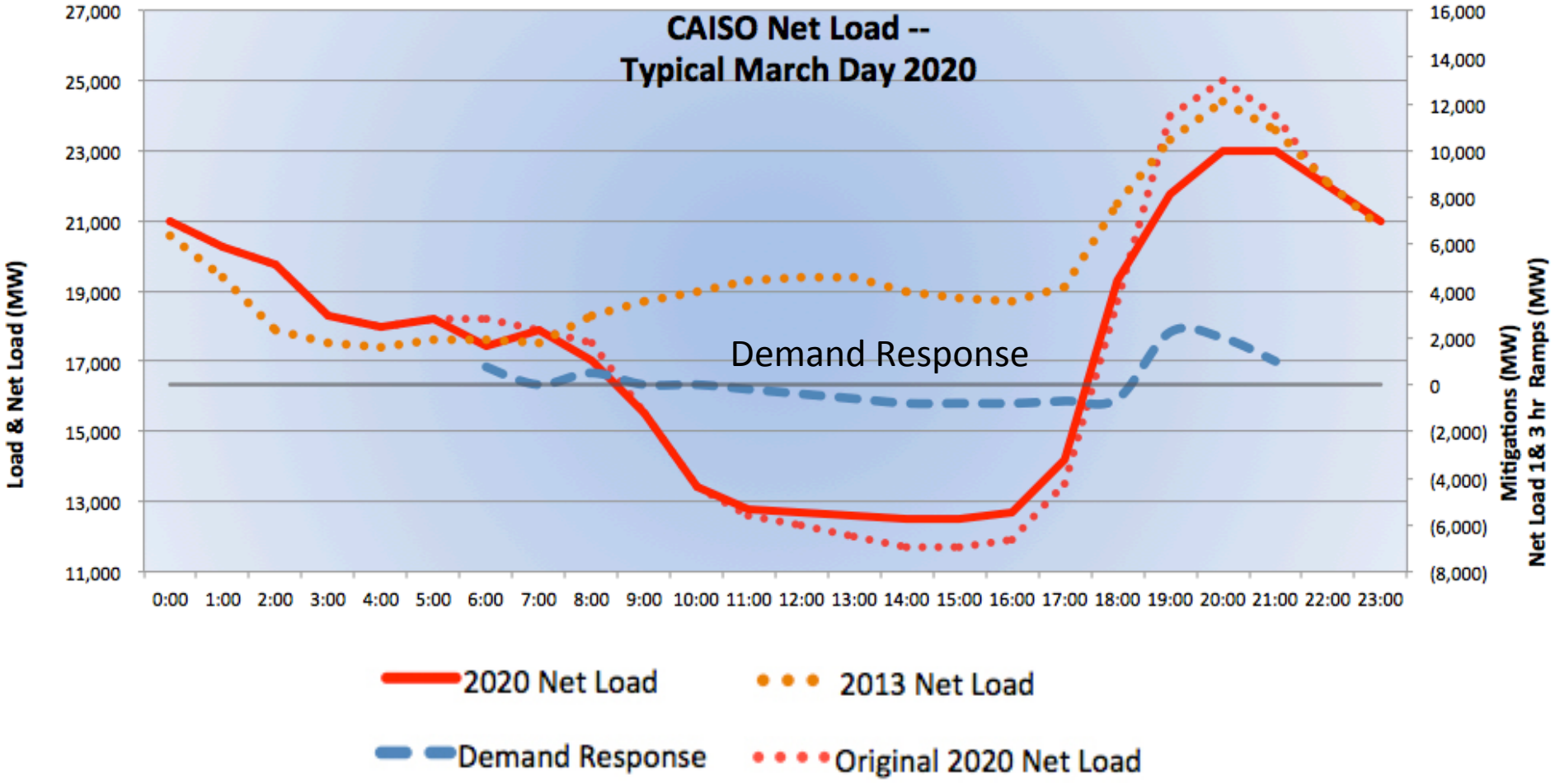


Flattening the Duck – Import/Export



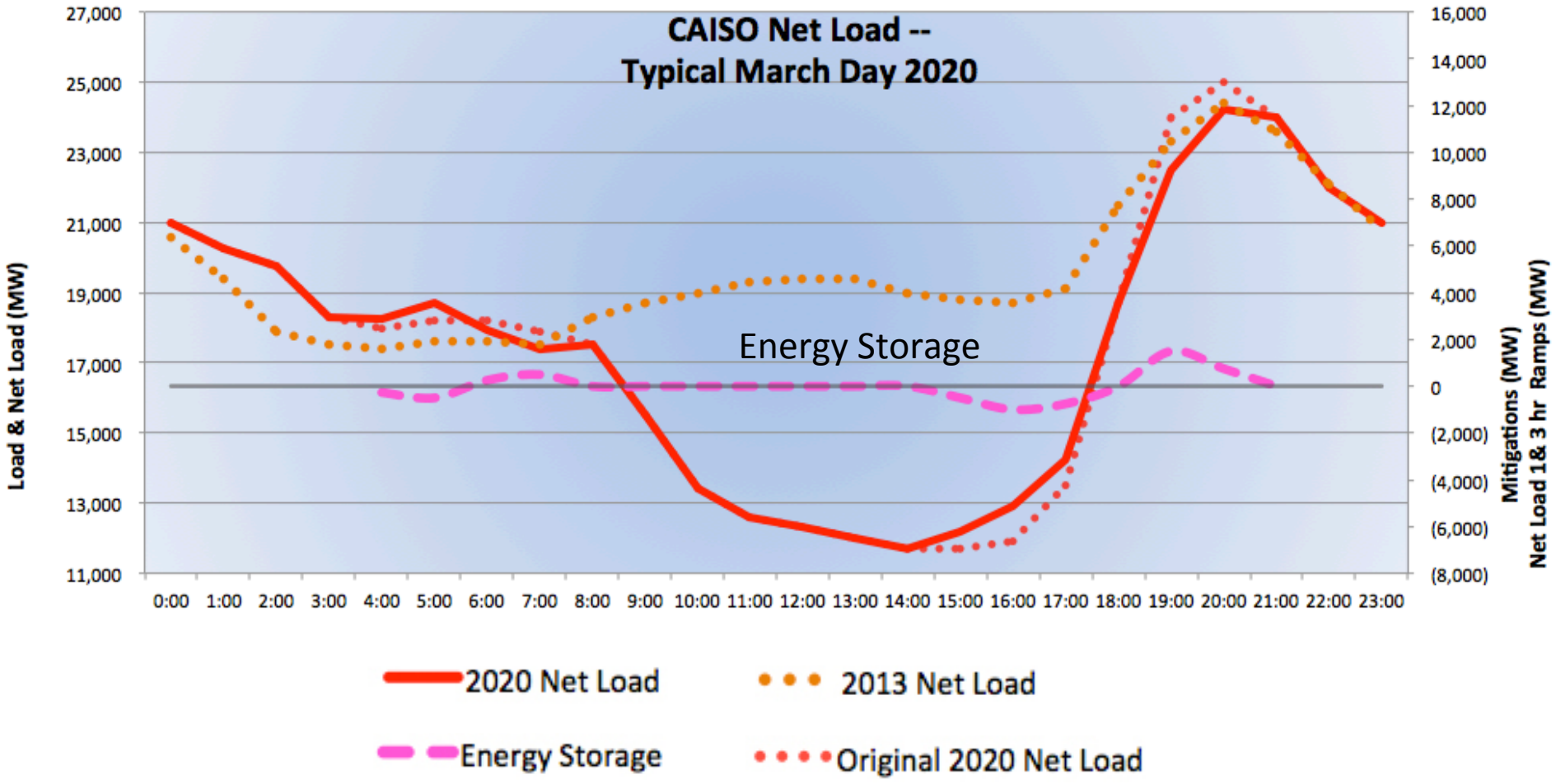
Need to study how much California can export, expected pricing, and whether additional regional coordination is advisable

Flattening the Duck – Demand Response



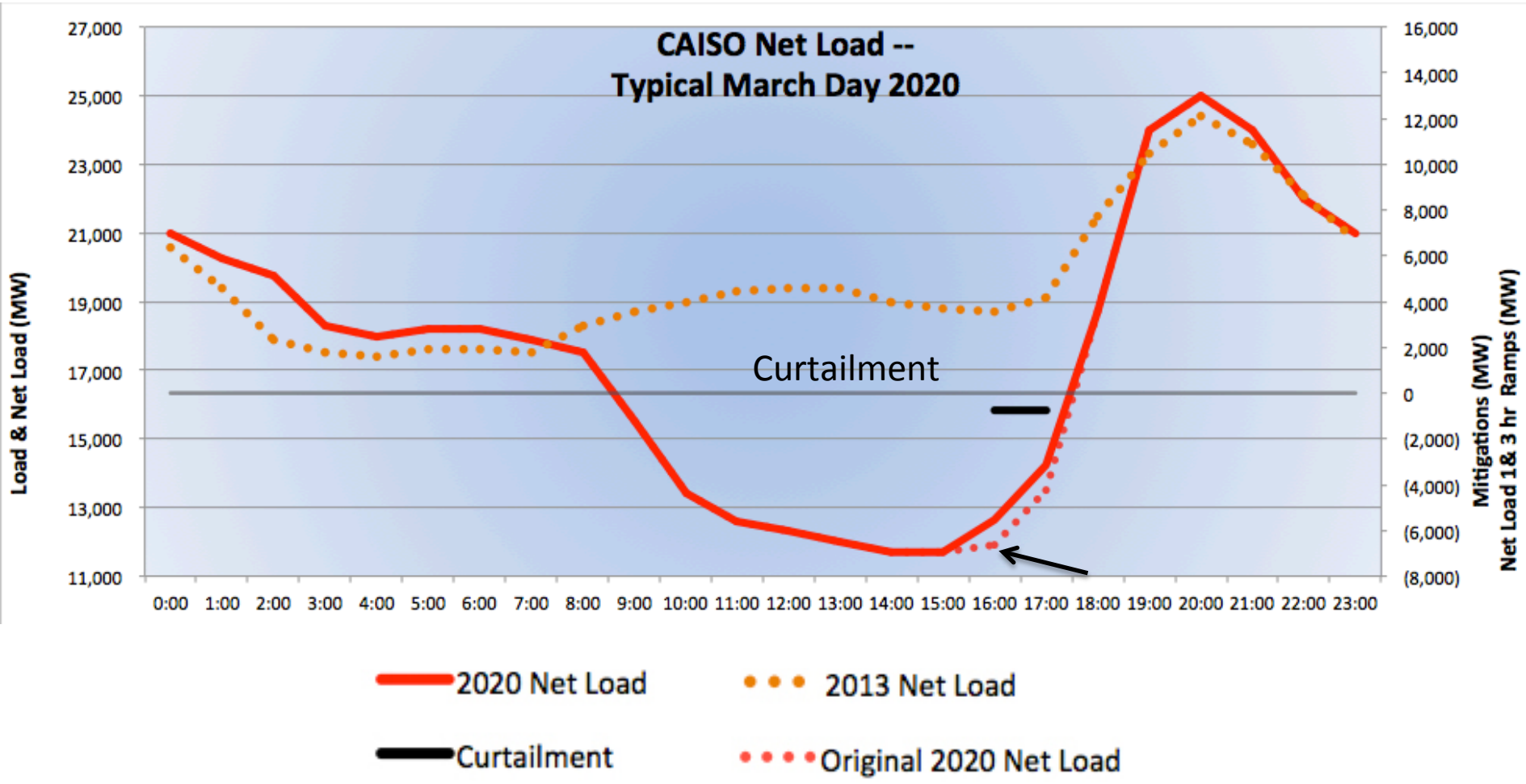
California set a target of 1.5 million electric vehicles by 2025, representing an additional load of 10,000 MW

Flattening the Duck – Energy Storage



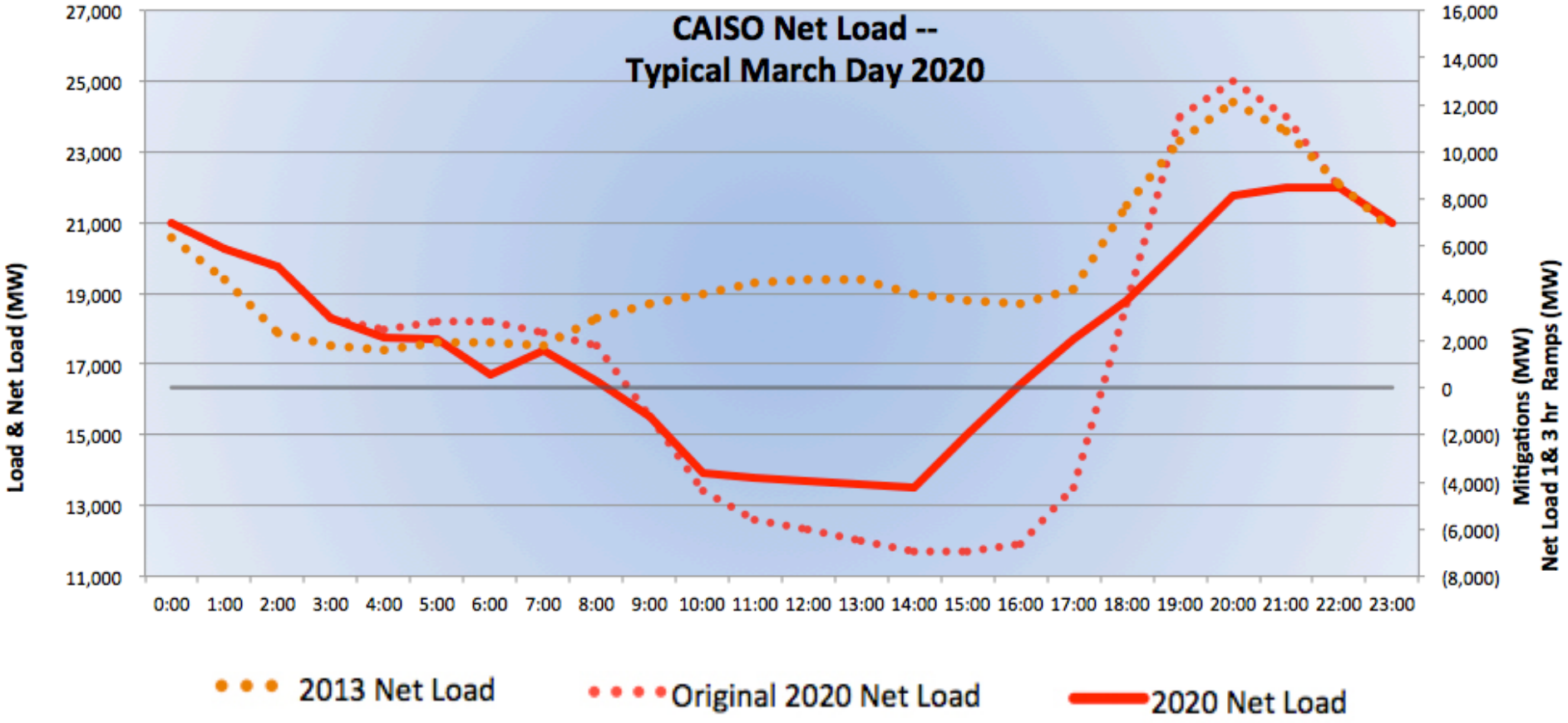
California set a target of 1.325 GW of new cost-effective storage by 2020

Flattening the Duck – Curtail Solar



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

Replace SONGS – DG/Storage + Advanced Inverters

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VS.

$80 million
2 Synchronous Condensers
San Luis Rey Substation
450 MVAr
(minus line losses = **400 MVAr**)

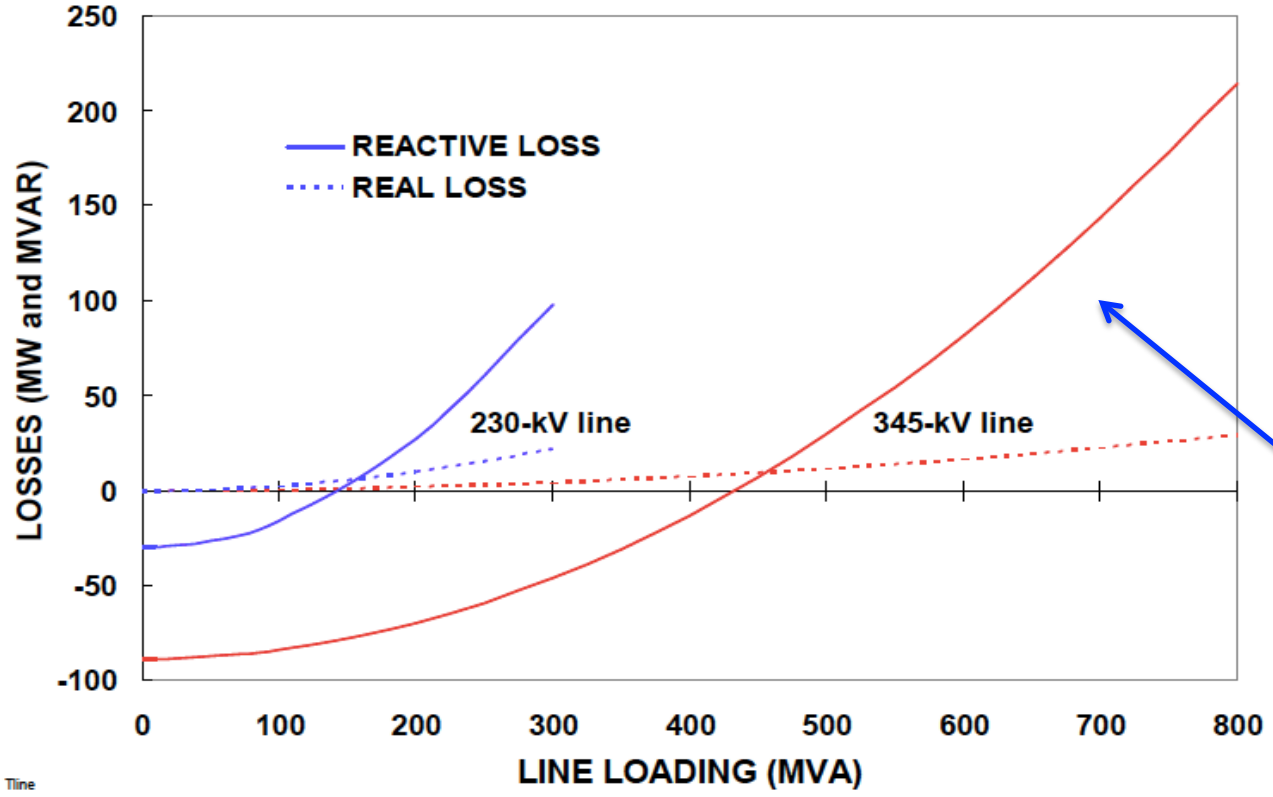
800 MW of DG solar + storage with advanced inverters, oversized by 10% set at 0.9 Power Factor = **400 MVAr**

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

Distributed Voltage Regulation – Location Matters

"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)

Hunters Point Community Microgrid Project

Clean Coalition

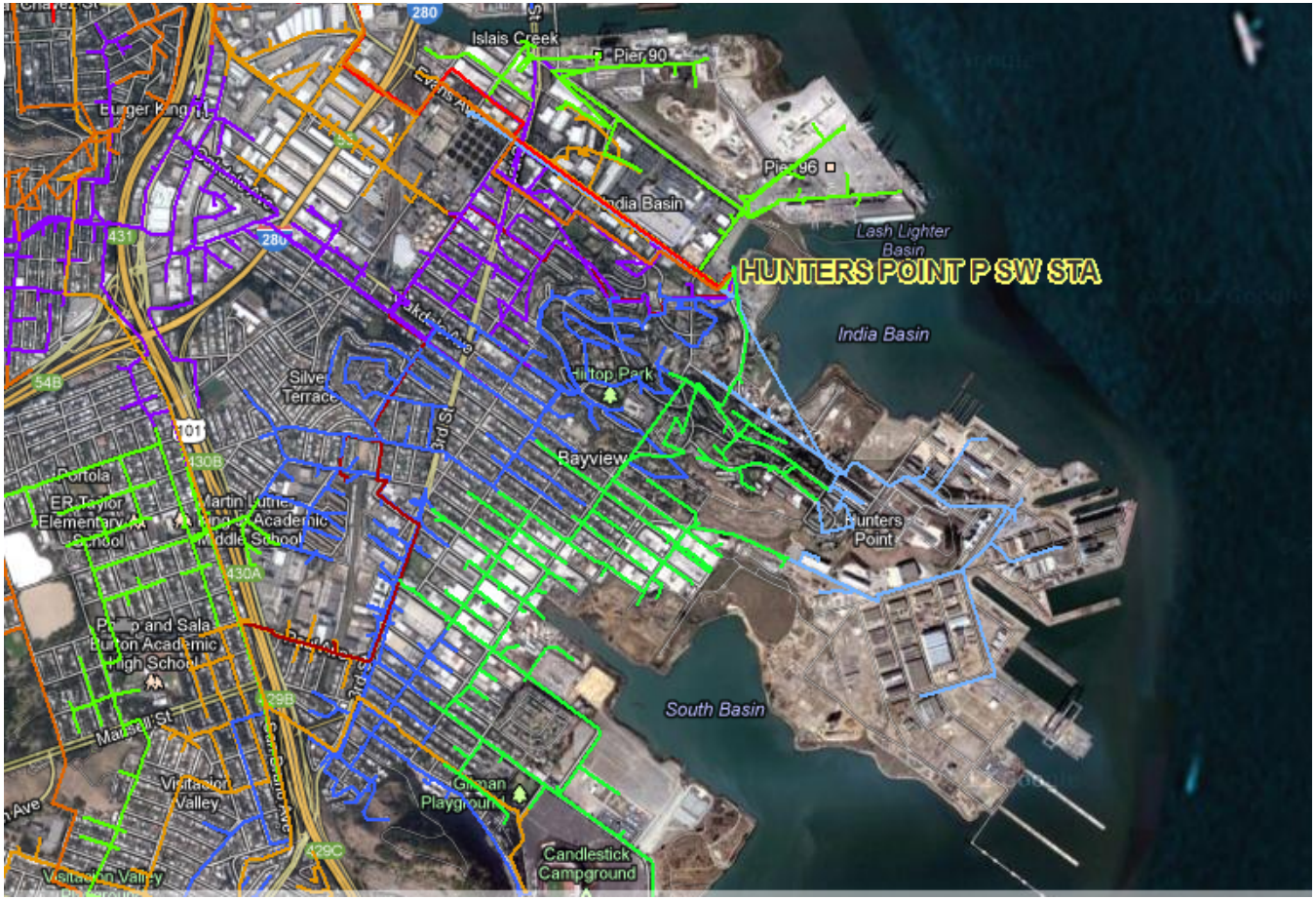
Overview

- Innovative project in the Bayview-Hunters Point area of San Francisco, in collaboration with Pacific Gas & Electric
- Model for achieving 25% of the total energy consumed in the area from local renewables, while maintaining or improving grid reliability and power quality using dynamic grid solutions
- The Hunters Point substation serves ~20,000 customers (about 90% residential, 10% commercial/industrial)

Hunters Point Project in San Francisco

Clean Coalition

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



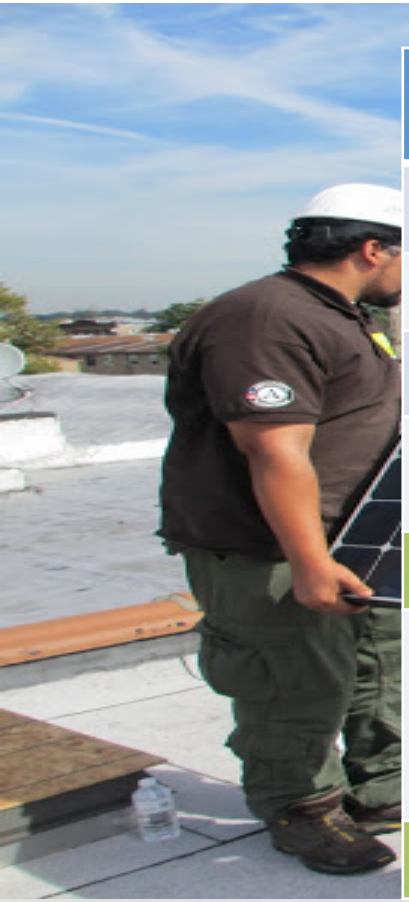
Hunters Point Substation Boundary

Hunters Point Reasonable DG Potential = 58 MW, Over 25% Total Energy

Clean Coalition

DG Potential: **Over 25% of Total Load (320,000 MWh)**

- **New PV in Bayview** = 30 MW, or 46,000 MWh
- **New PV in HP Redev Zone** = 20 MW, or 32,000 MWh
- **Existing DG** = 8 MW (PV equivalent), or 13,000 MWh



Type	Capacity (Avg. MW)	Output (Annual MWh)
New PV: Commercial + MDUs	14	21,000
New PV: Residential	13.5	21,000
New PV: Parking Lots	2.5	4,000
New PV: Redev Zone	20	32,000
Total New PV	**50 MW**	**78,000**
Existing PV Equiv. * Includes 2MW biopower from wastewater plant @ 60% capacity	8	13,000
Total DG Potential:	**58 MW**	**91,000**

Hunters Point Economic Benefits from 50 MW New DG

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$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

Source: NREL JEDI calculator. Based on average installed cost of $2.75/W(dc) before taxes & incentives using PG&E rates/region.

Hunters Point Project Deliverables

Clean Coalition

DG Survey	• Identified 50 MW of new PV potential: commercial, residential, parking lots • Existing DG includes 2 MW wastewater biopower (6.5 MW PV equiv.)	✔
Benefits Analysis	• DG Economic: $200M in local stimulus, $100M going to local wages • DG Environmental: 78M lbs. of GHG eliminated per year, 15M gallons of water saved per year, 375 acres of land preserved	✔
Baseline Model	• Required data sets and circuit model from PG&E • Model of existing powerflow, validated by PG&E	2Q 2014
Optimized Scenarios	• Optimal mix of DG, dynamic grid solutions, and physical locations • Cost-optimized scenarios	3Q 2014
Results	• Standardized reports, modeling, and methodologies, setting the stage for implementation (Phase 2) and industry-wide scalability • Streamlined & scalable procurement & interconnection	4Q 2014

Peek at the Future of Bayview-Hunters Point

Ecoplexus project at the Valencia Gardens Apartments in SF. ~800 kW serving ~80% of the total annual load.

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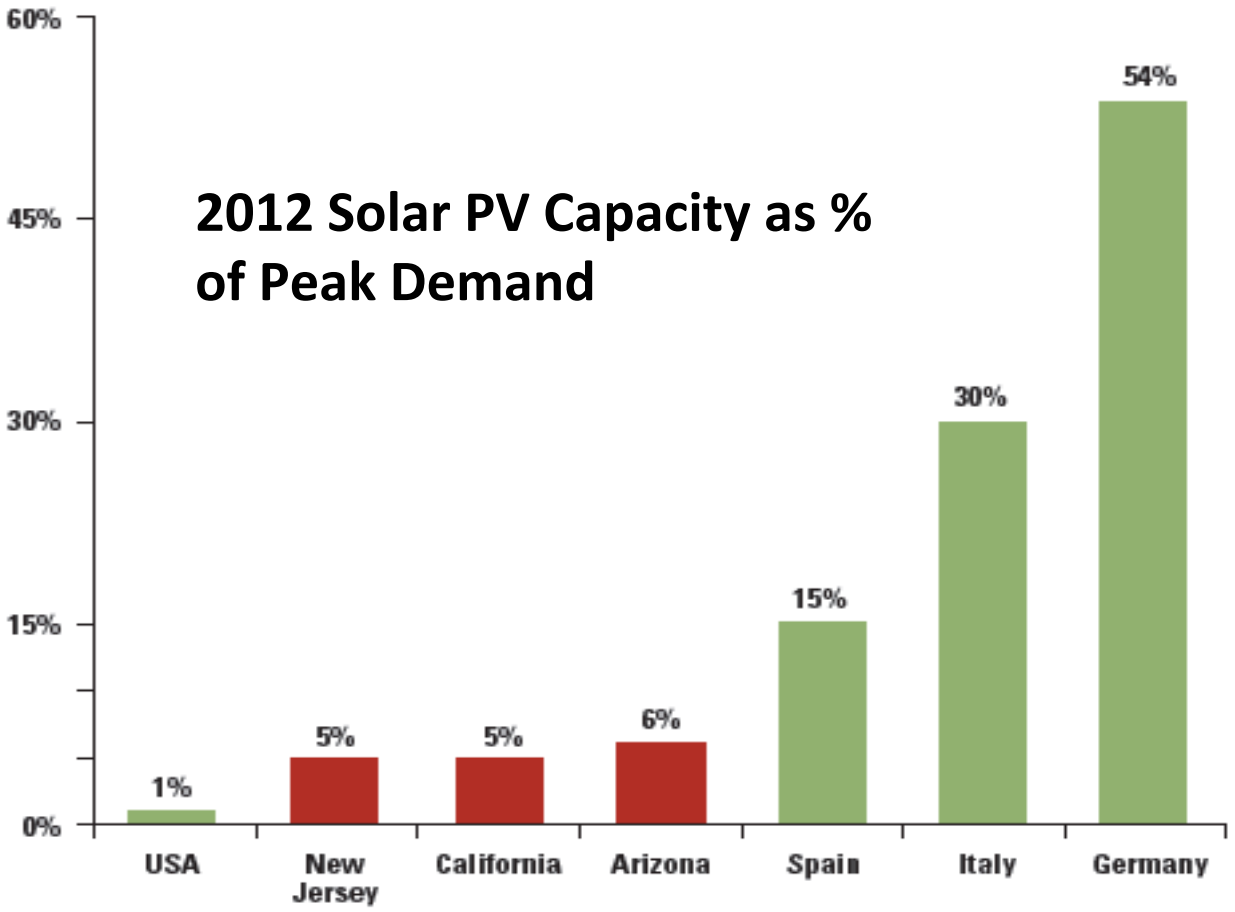
Making Clean Local Energy Accessible Now

Back-up Slides

Renewables + Intelligent Grid Solutions = Reliable

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.

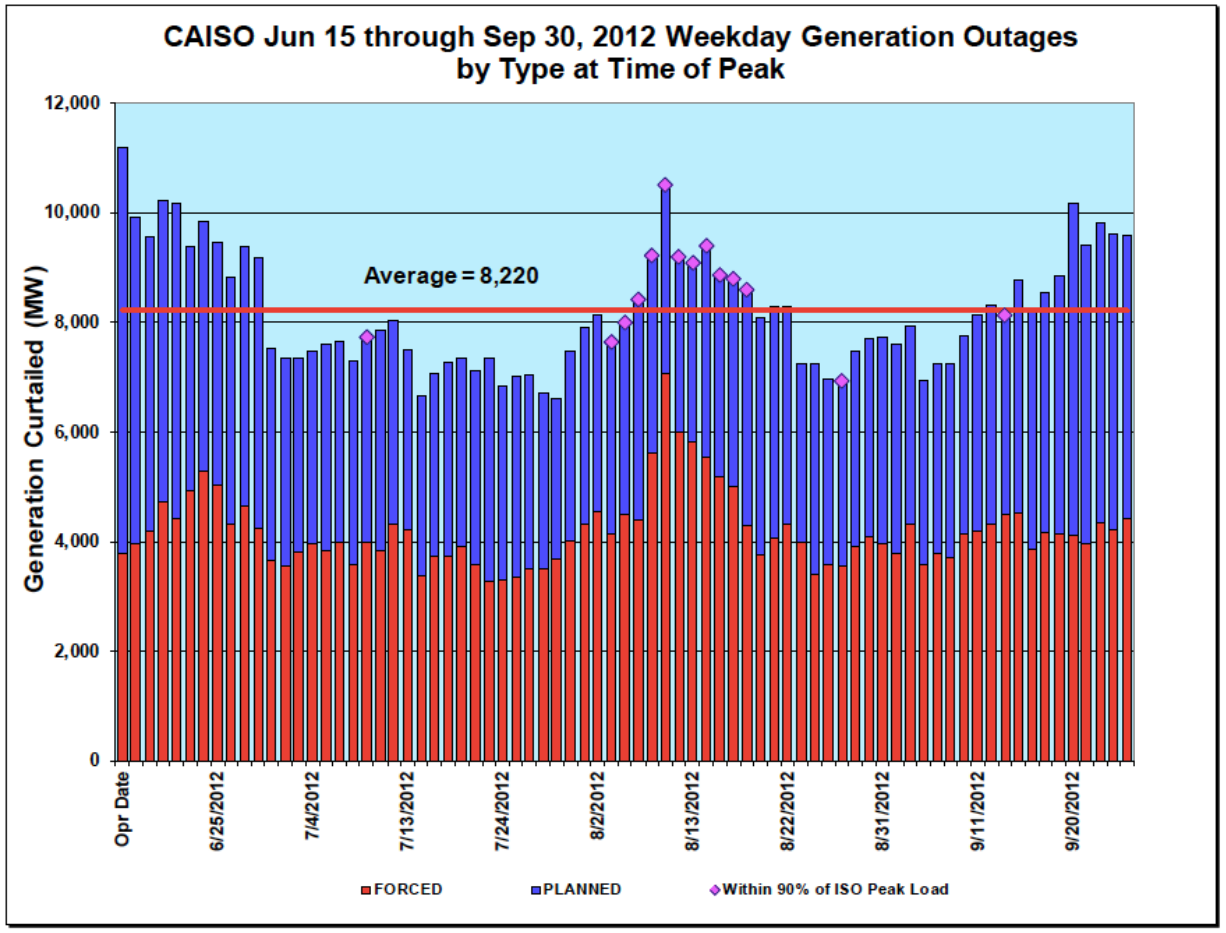


Source: Union of Concerned Scientists, SEIA 2013

Natural Gas Has Integration Costs

Clean Coalition

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

Natural Gas Is Not The Solution

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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?! WTF?

2010 San Bruno natural gas pipeline explosion

Natural Gas Is Not Reliable

Clean Coalition

FLEXALERT.ORG **FLEX ALERT**

California ISO
Shaping a Renewed Future
250 Outcropping Way, Folsom, CA 95630

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 grid.

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!

Hunters Point Solar LCOE is less than CCNG

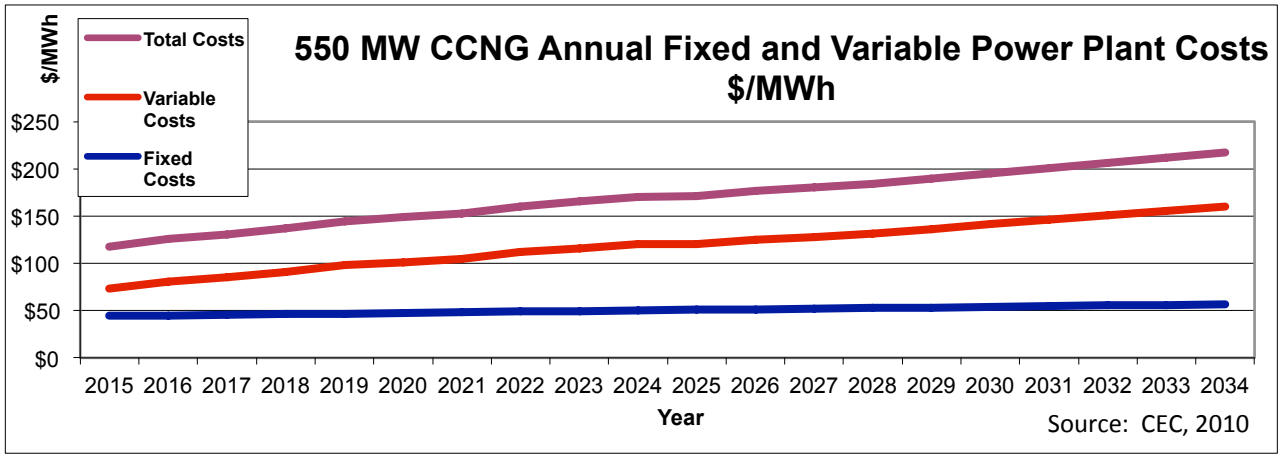
Clean Coalition

500 kW Solar achieves lower LCOE than new natural gas generation – Hunters Point average expected commercial size = 650 kW

SOLAR

System size (example only)	Installed cost $/W(ac)	Initial output kWh(ac)/kW(ac)-yr	20 year fixed PPA price	LCOE
1 MW ground	$3.50/W	2,305	15.35¢/kWh	13.00¢/kWh
1 MW roof	$2.85/W	1,823	16.36¢/kWh	13.86¢/kWh
500 kW roof	**$3.15/W**	1,823	**17.65¢/kWh**	**14.95¢/kWh**
100 kW roof	$3.50 /W	1,823	19.03¢/kWh	16.12¢/kWh
50 kW roof	$3.75/W	1,823	20.38¢/kWh	17.26¢/kWh
5 kW roof	$4.60/W	1,823	24.37¢/kWh	20.64¢/kWh

NATURAL GAS



Busbar wholesale cost from plant
2015: $11.7 ¢/kWh
2024: $17.1 ¢/kWh
2034: $21.7 ¢/kWh

LCEO: $15.4 ¢/kWh

Zero Net Energy is Key Driver for Smart Buildings

Clean Coalition

"Big Bold" Goals for ZNE in California

Exploratorium | San Francisco, CA

1. All new commercial construction will be ZNE by 2030
2. 50% of existing buildings will be retrofit to ZNE by 2030
3. All new residential construction in California will be ZNE by 2020

The California Efficiency Strategic Plan (Sep 2008) californiaenergyefficiency.com/docs/EEStrategicPlan.pdf

Guided Siting: Locational Value, Interconnection

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SCE Share of 12,000 MW Goal

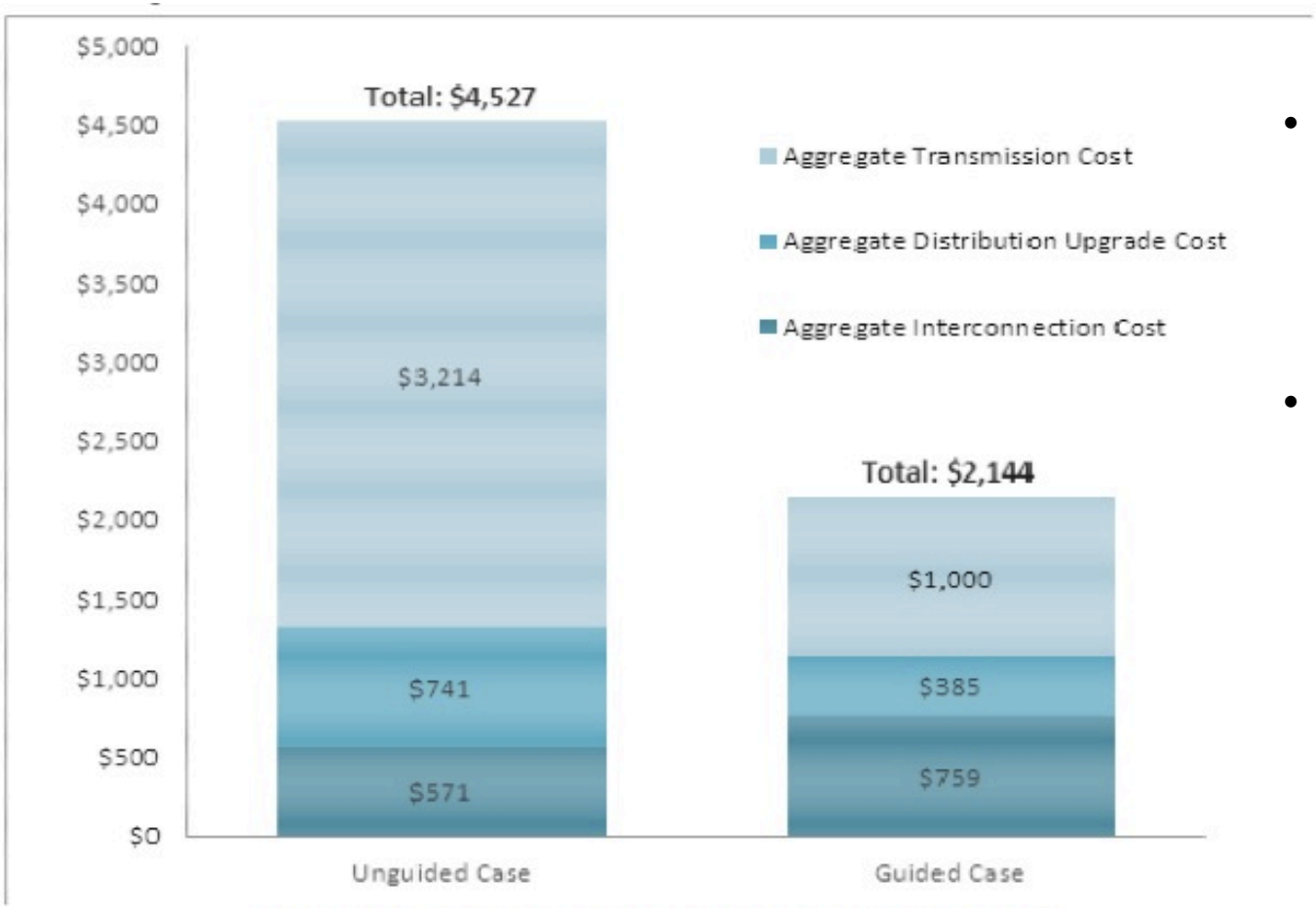

Figure 8: Total SCE System Costs of LER Proposal (Million USD)

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

Import/Exports – Transmission Not the Issue

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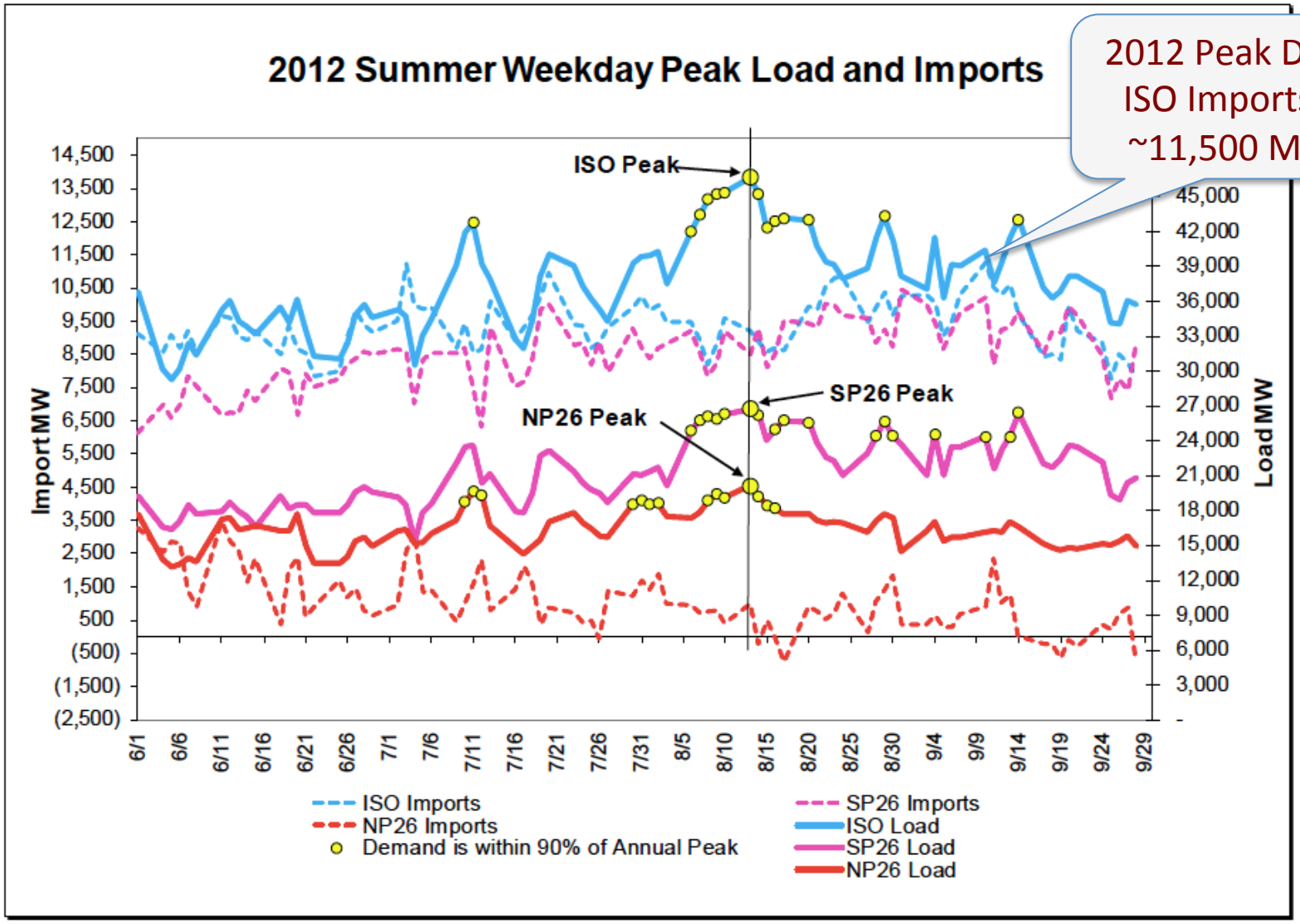
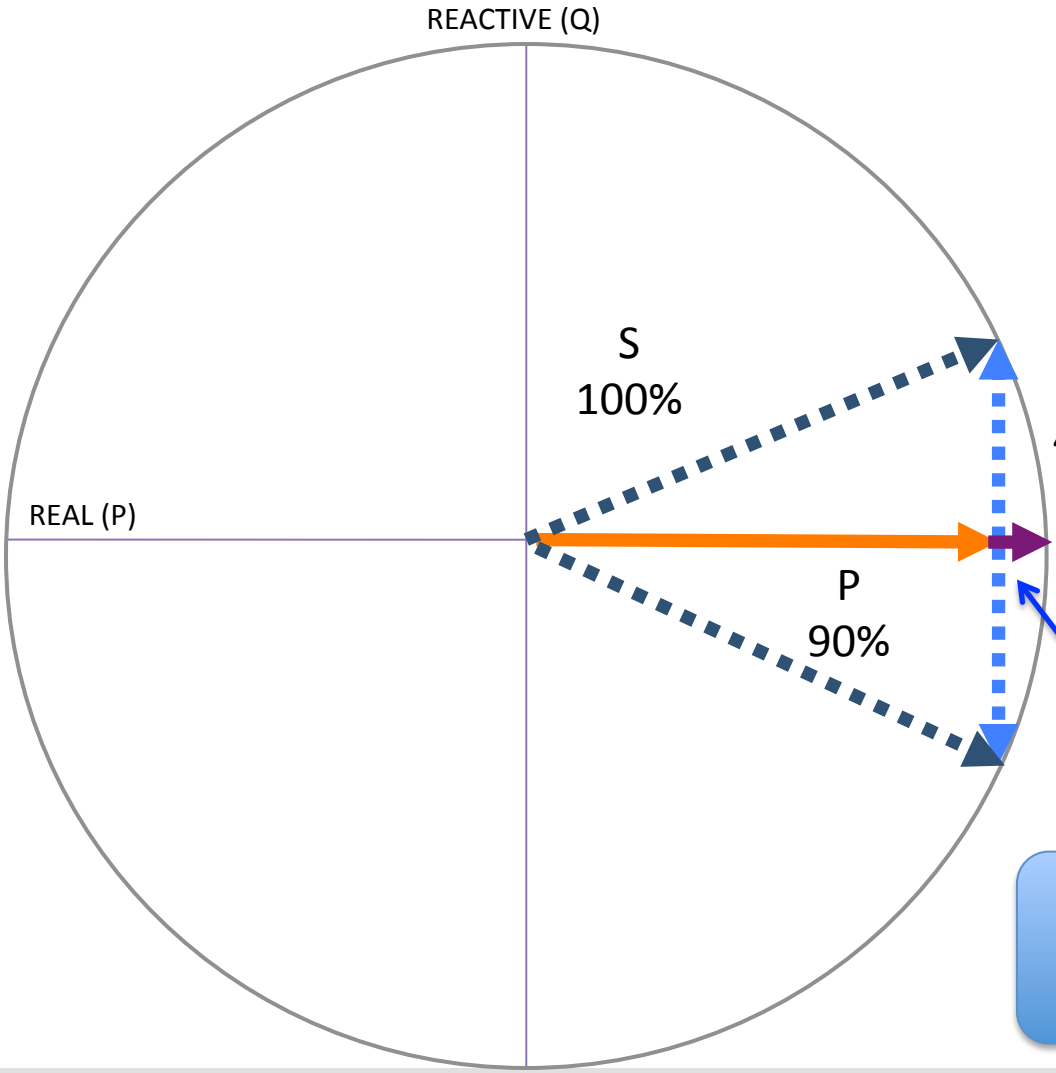


Source: CAISO 2013 Summer Loads & Resources Assessment (May 6, 2013)

Advanced Inverters – Reactive Power

Advanced Inverter at 0.9 Power Factor = 43.6% reactive power

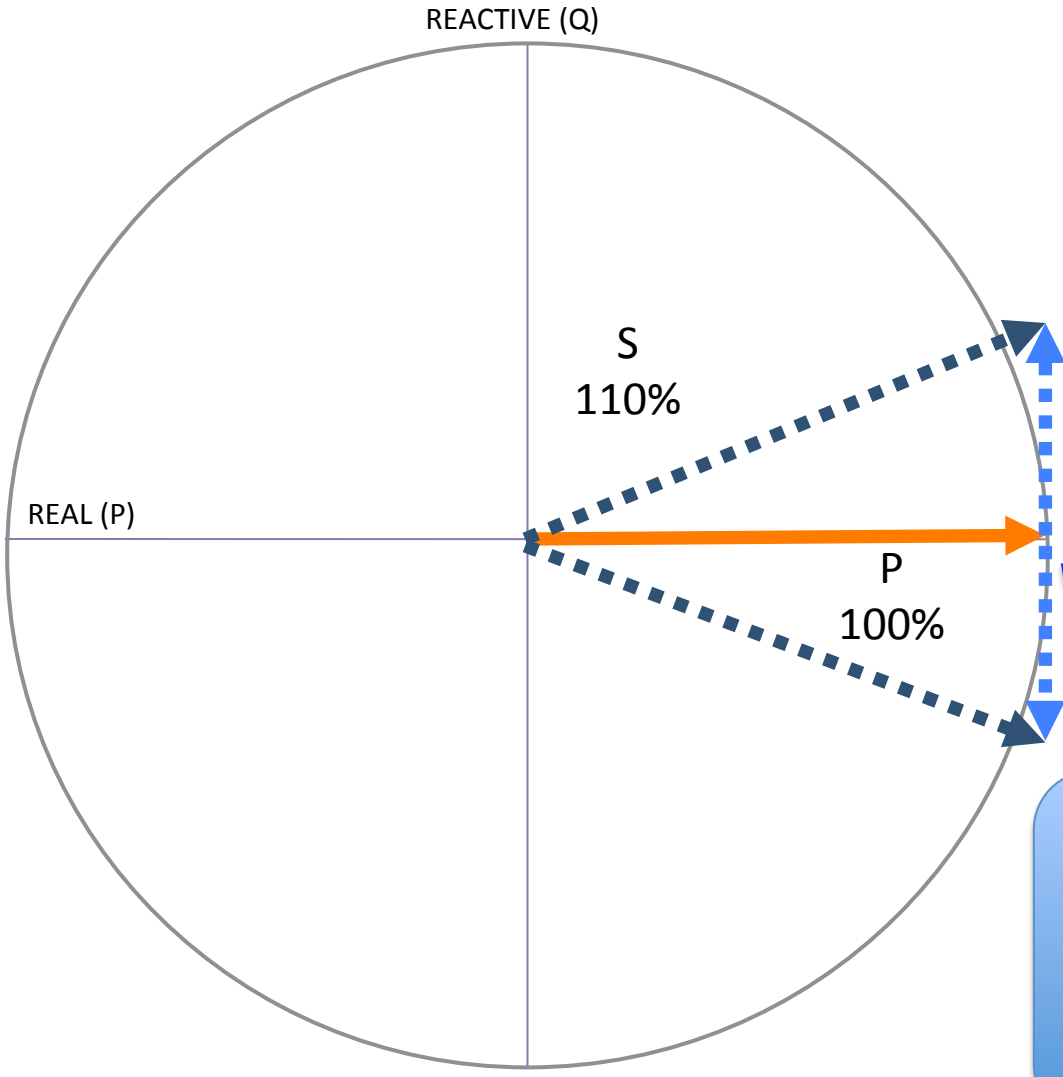


P: Real power (kW)
Q: Reactive power (kVAr)
S: Total power (kVA)

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:

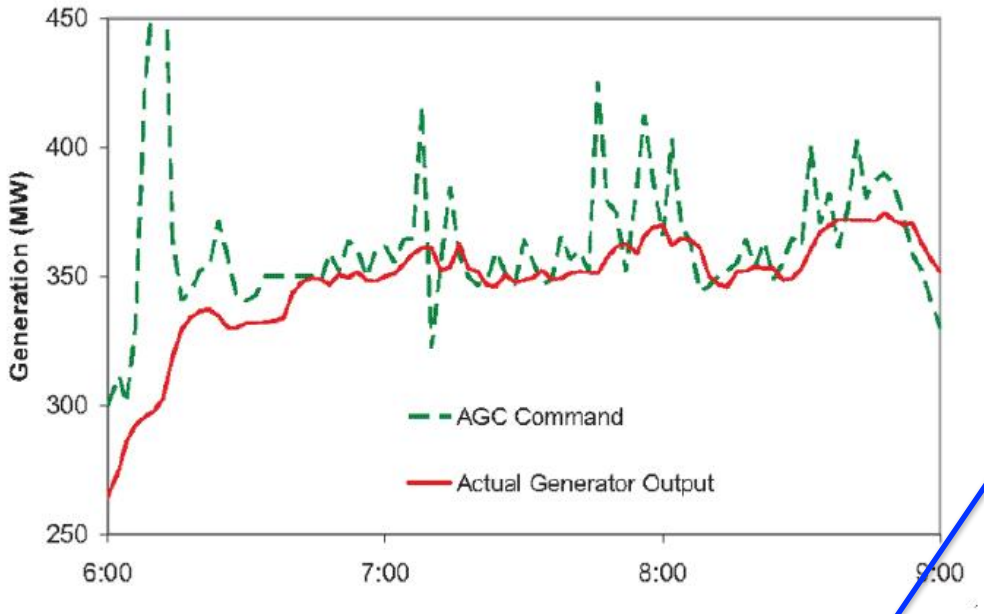
- No reduction of PV real power
- Draws up to 10 kW real power from the grid
- Provides reactive power 24/7/365

Regulation: Faster, More Accurate Solutions

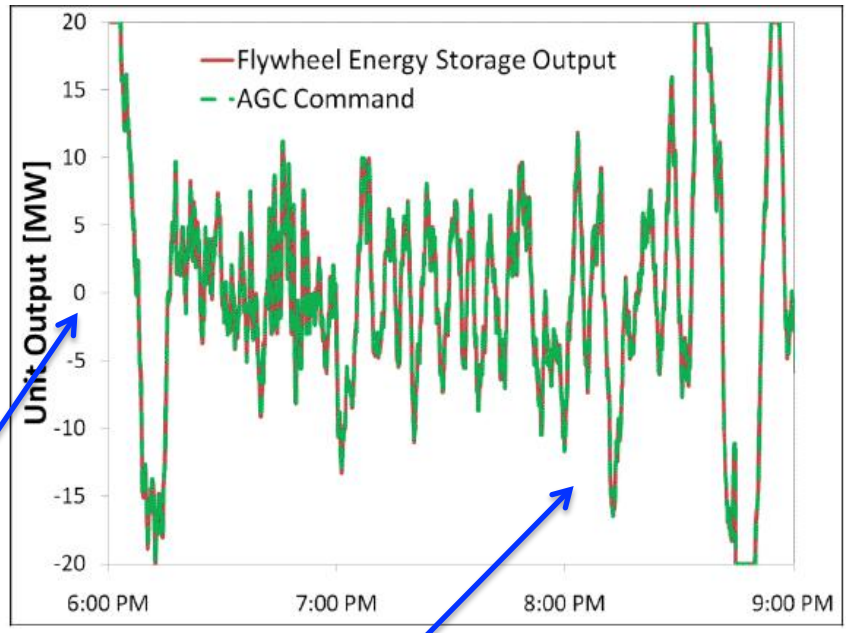
Clean Coalition

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



Flywheel Storage



Storage provides both supply and demand

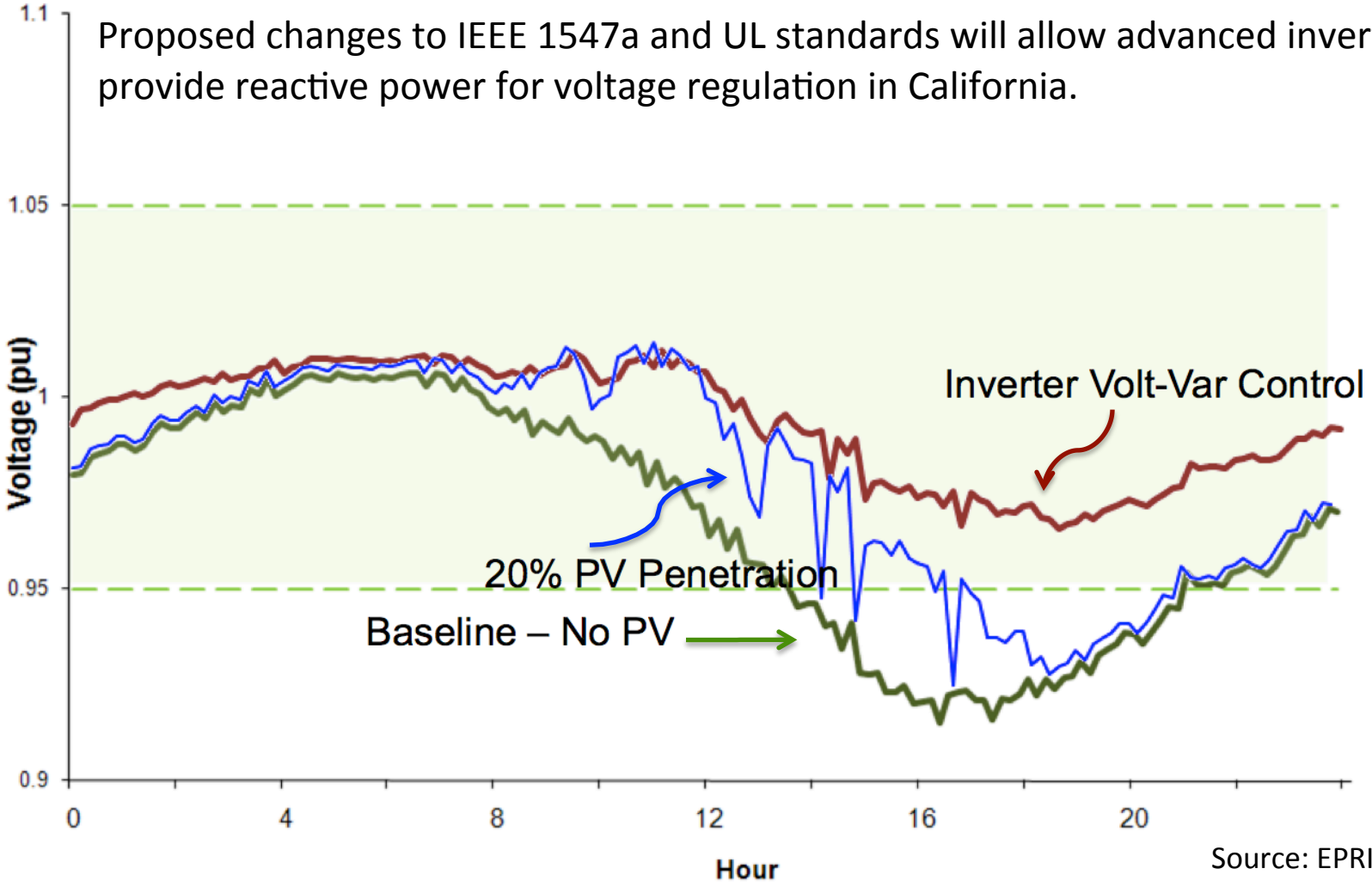
Faster and more accurate regulation = less MW required

Advanced Inverters Keep Voltage in Balance

Clean Coalition

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.

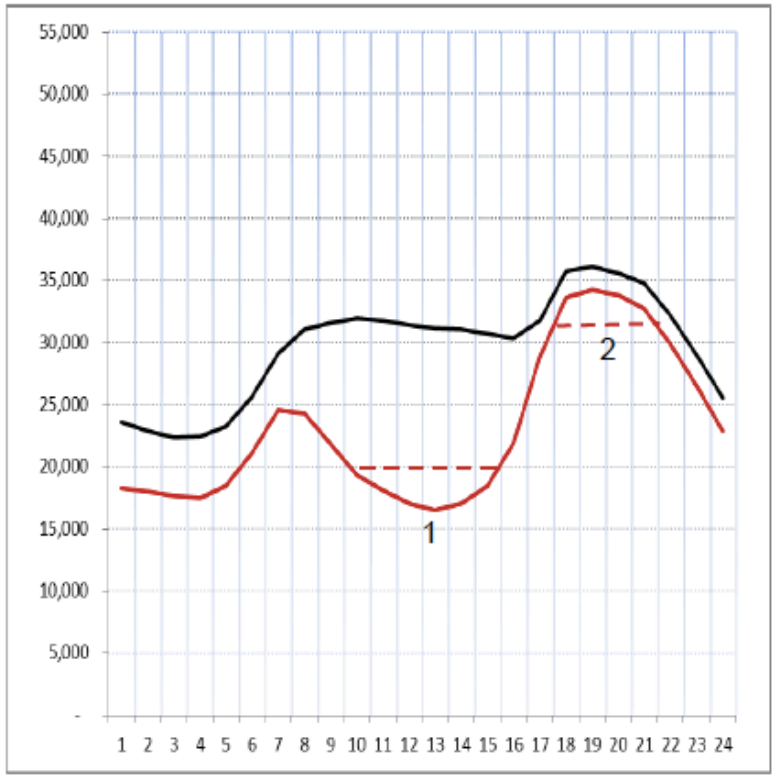


Source: EPRI (2011)

Flattening the Duck – Demand Response

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

German Solar Pricing Translates to 5 cents/kWh

Clean Coalition

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

Flattening the Duck – Curtail Baseload

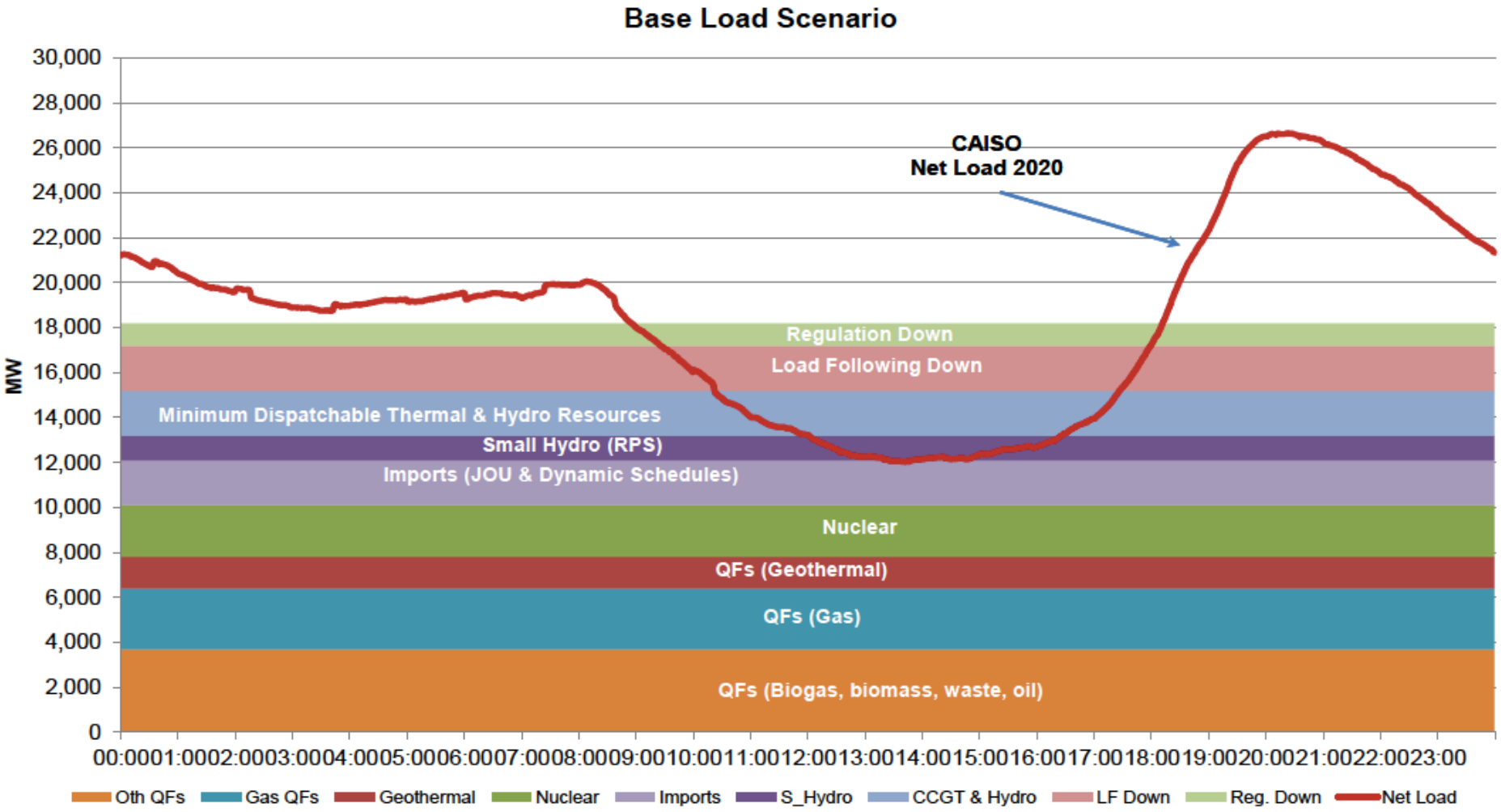
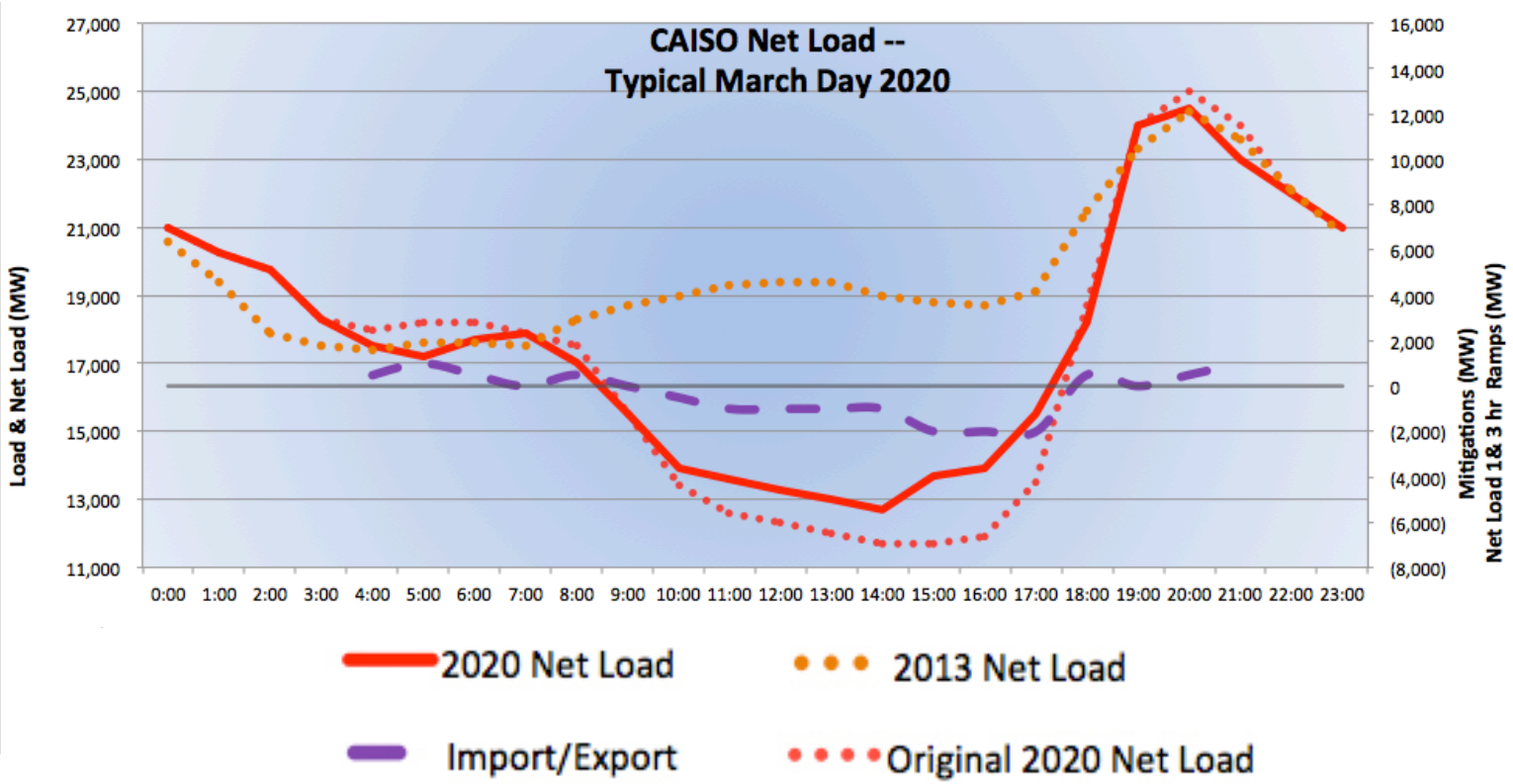


Figure 5: Potential Overgeneration Conditions – March 2020

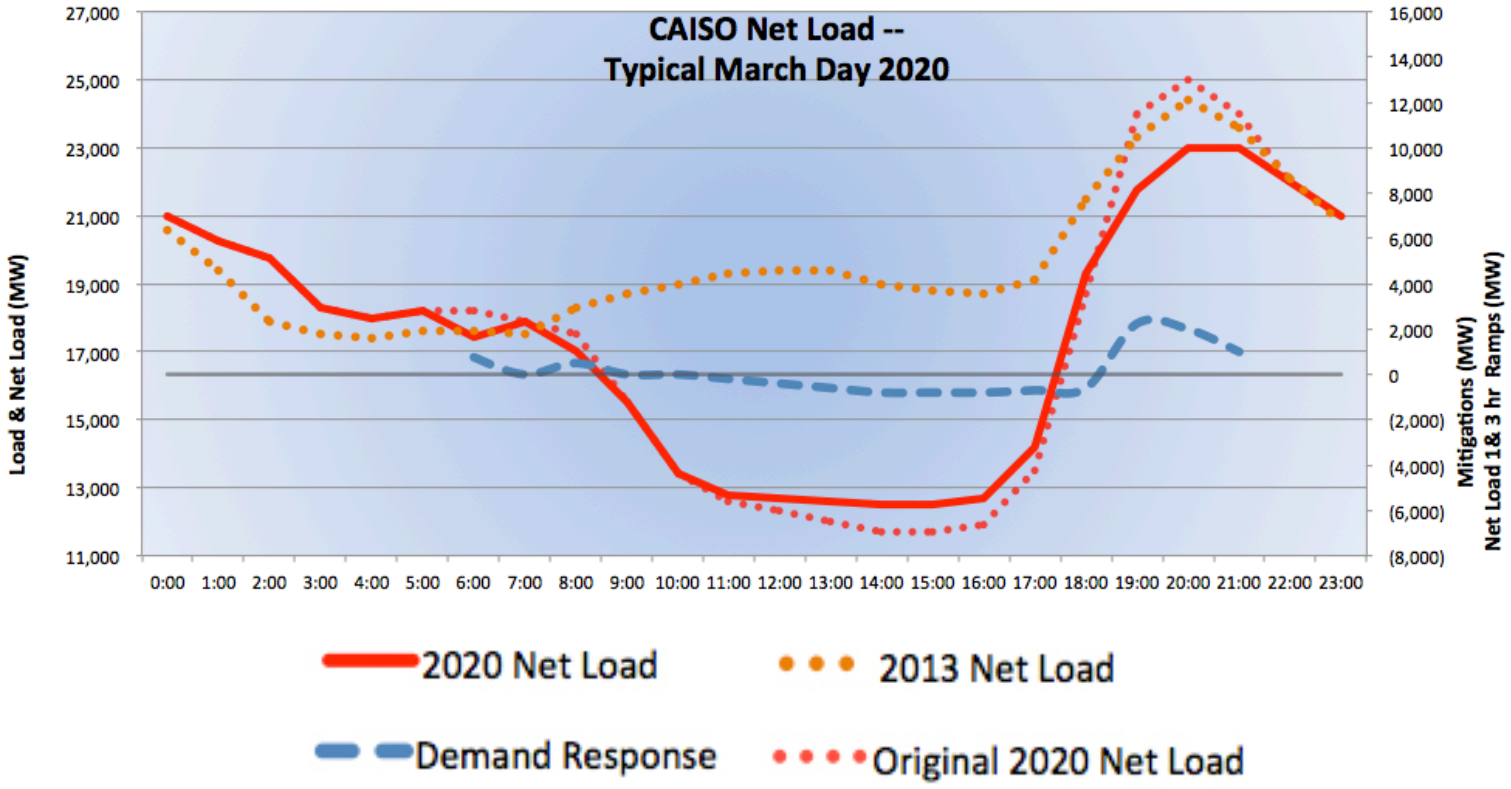
Source: CAISO/NERC variable resources integration report (Nov 2013)

Import/Export Assumptions



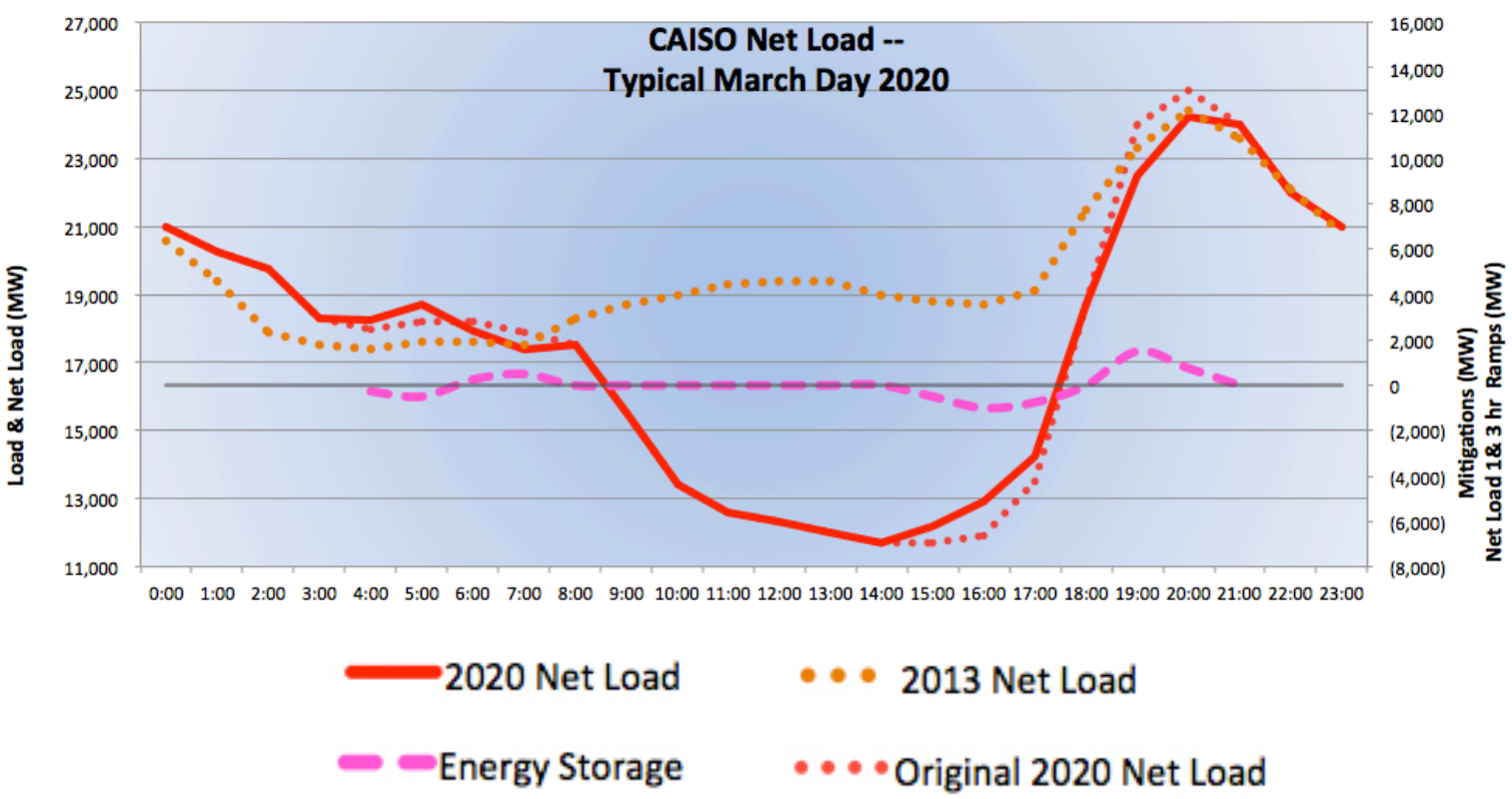
	- = Exp + = Imp
ToD	**Import/Export**
0:00	
1:00	
2:00	
3:00	
4:00	500
5:00	1,000
6:00	500
7:00	-
8:00	500
9:00	-
10:00	(500)
11:00	(1,000)
12:00	(1,000)
13:00	(1,000)
14:00	(1,000)
15:00	(2,000)
16:00	(2,000)
17:00	(2,000)
18:00	500
19:00	-
20:00	500
21:00	1,000
22:00	
23:00	
Total Net:	(6,000)
Max: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

Demand Response Assumptions



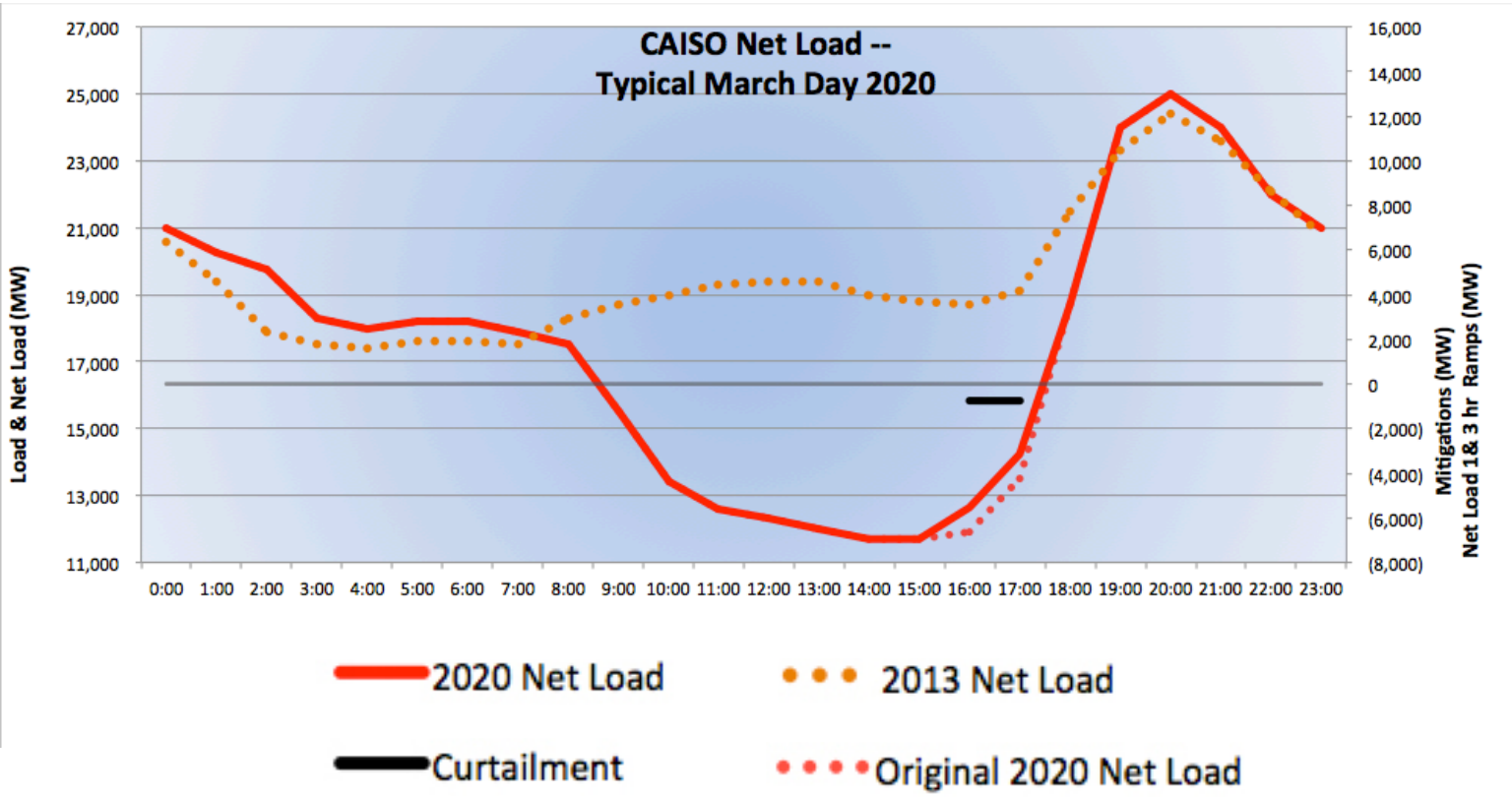
ToD	DR
0:00	
1:00	
2:00	
3:00	
4:00	
5:00	
6:00	750
7:00	-
8:00	500
9:00	-
10:00	-
11:00	(200)
12:00	(400)
13:00	(600)
14:00	(800)
15:00	(800)
16:00	(800)
17:00	(700)
18:00	(600)
19:00	2,250
20:00	2,000
21:00	1,000
22:00	
23:00	
Total Net:	1,600
Max:	2,250
Min:	(800)

Energy Storage Assumptions



	- = Charge + = Gen
ToD	ES
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
ToD	Curtailment
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)

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

The Fossil Free Future is Arriving

Clean Coalition