Clean Coalition

Making Clean Local Energy Accessible Now

Community Microgrids

Maximizing Local Renewables, Energy Storage, and other Distributed Energy Resources

Craig Lewis
Executive Director
Clean Coalition
650-796-2353 mobile
craig@clean-coalition.org

Community Microgrid = Pathway to DER Future

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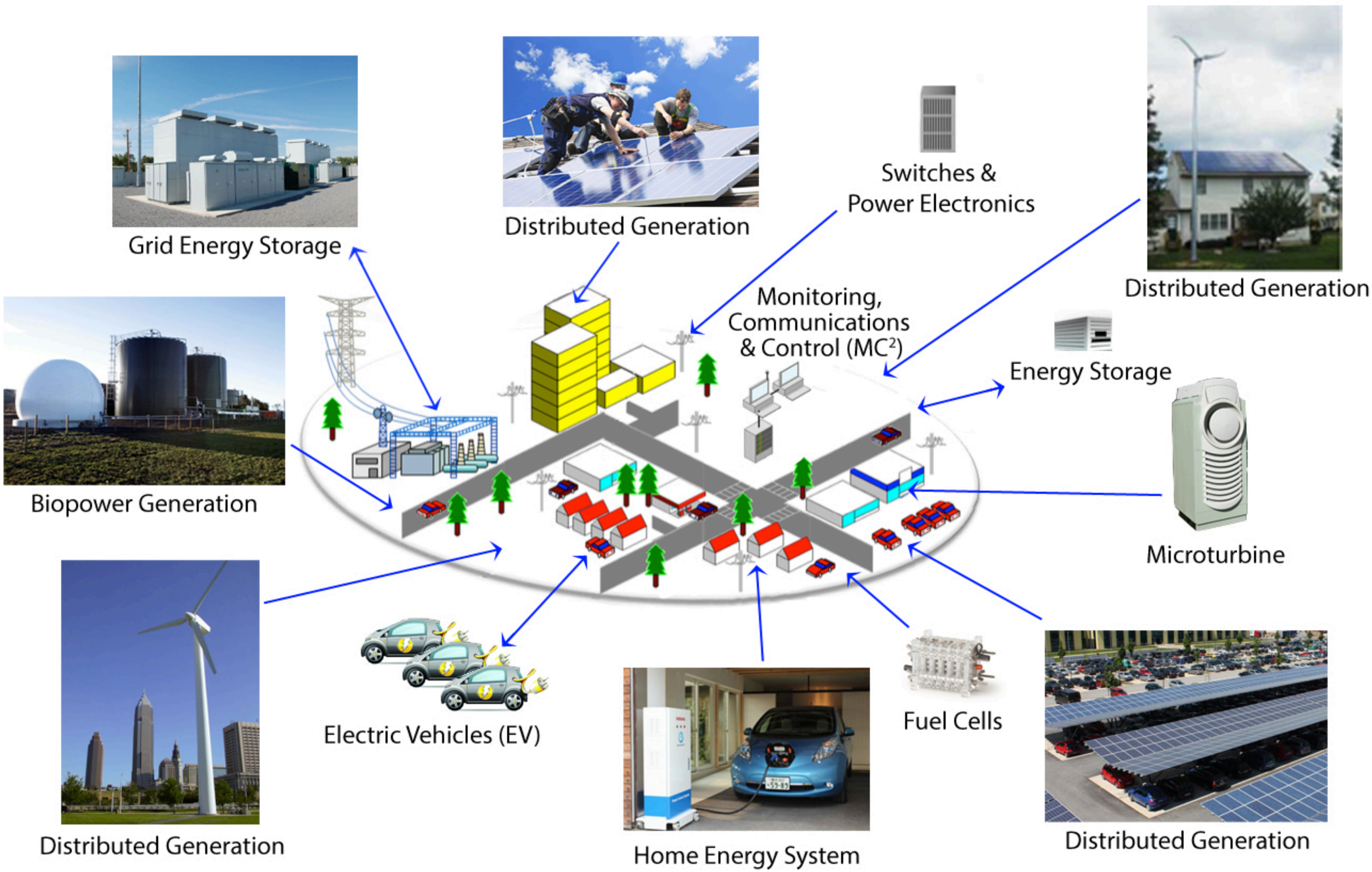
Community Microgrid definition

A coordinated local grid area served by one or more distribution substations and supported by high penetrations of local renewables and other Distributed Energy Resources (DER). Community Microgrids reflect a new approach for grid operations that achieve a more sustainable, secure, and cost-effective energy system while generally providing long-term power backup for prioritized loads. The substation-level foundation of a Community Microgrid facilitates cost-effective replication for optimizing grid operations and customer satisfaction across utility service territories.

Community Microgrid in a Visual

Clean Coalition



Clean Coalition Mission and Advisors

Clean Coalition

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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Expertise Supporting Utilities & Communities

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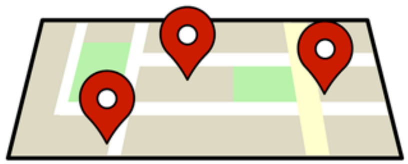
Analysis & Planning

DG siting surveys; full DER cost and value analysis

- PG&E
- PSEG
- SCE



Grid Modeling & Optimization

Powerflow modeling; DER optimization

- PG&E
- PSEG

Program Design

Procurement and interconnection

- LADWP, Fort Collins, PSEG
- City of Palo Alto (FIT and solar canopy RFP)
- RAM, ReMAT
- Rule 21 & FERC

Community Microgrid Projects

Design and implementation

- San Francisco, CA
- Long Island, NY
- U.S. Virgin Islands

Dynamic Grid Council

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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

Wholesale DG is the Critical & Missing Segment

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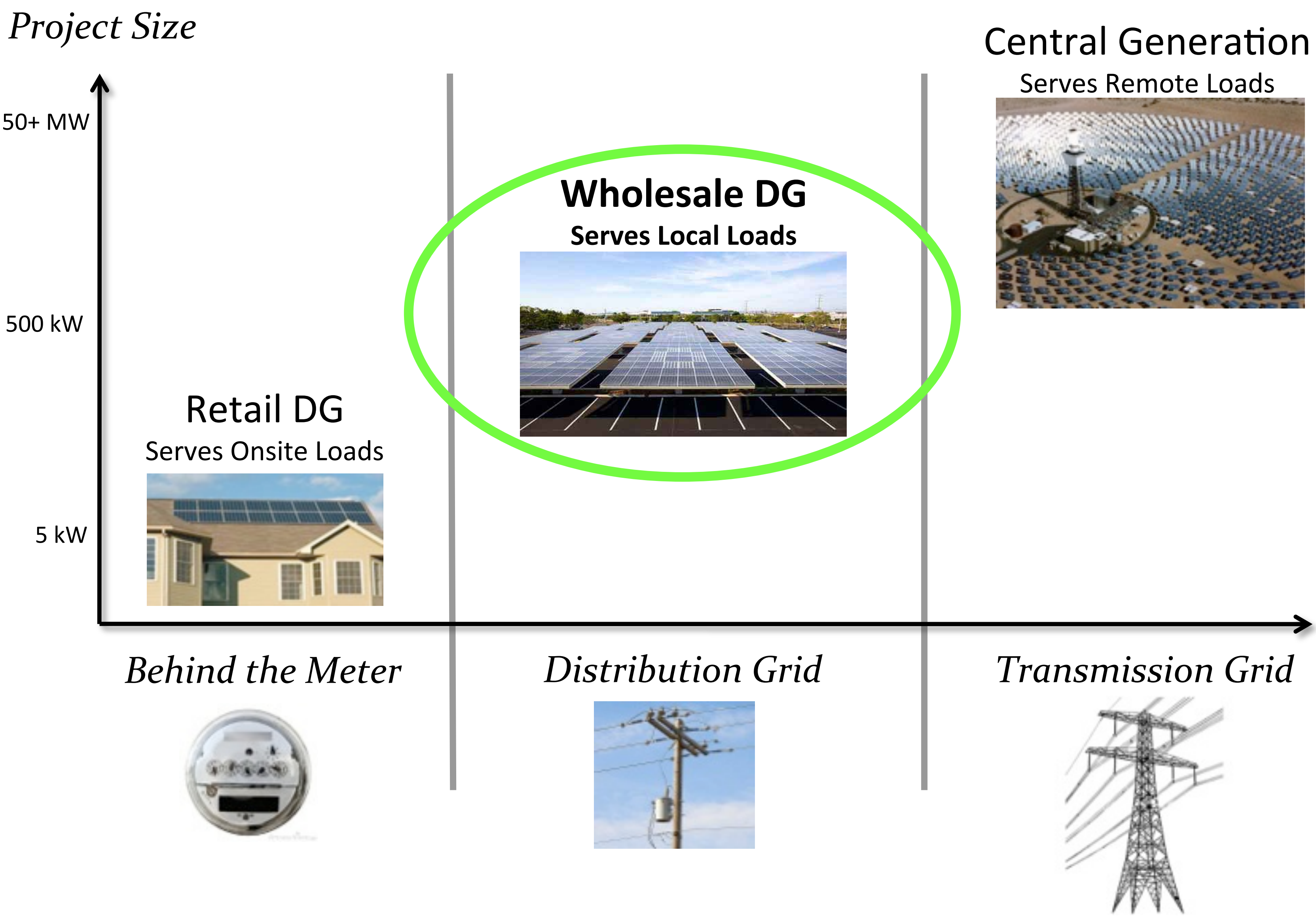

WDG Delivers Scale & Cost-Effectiveness Fast

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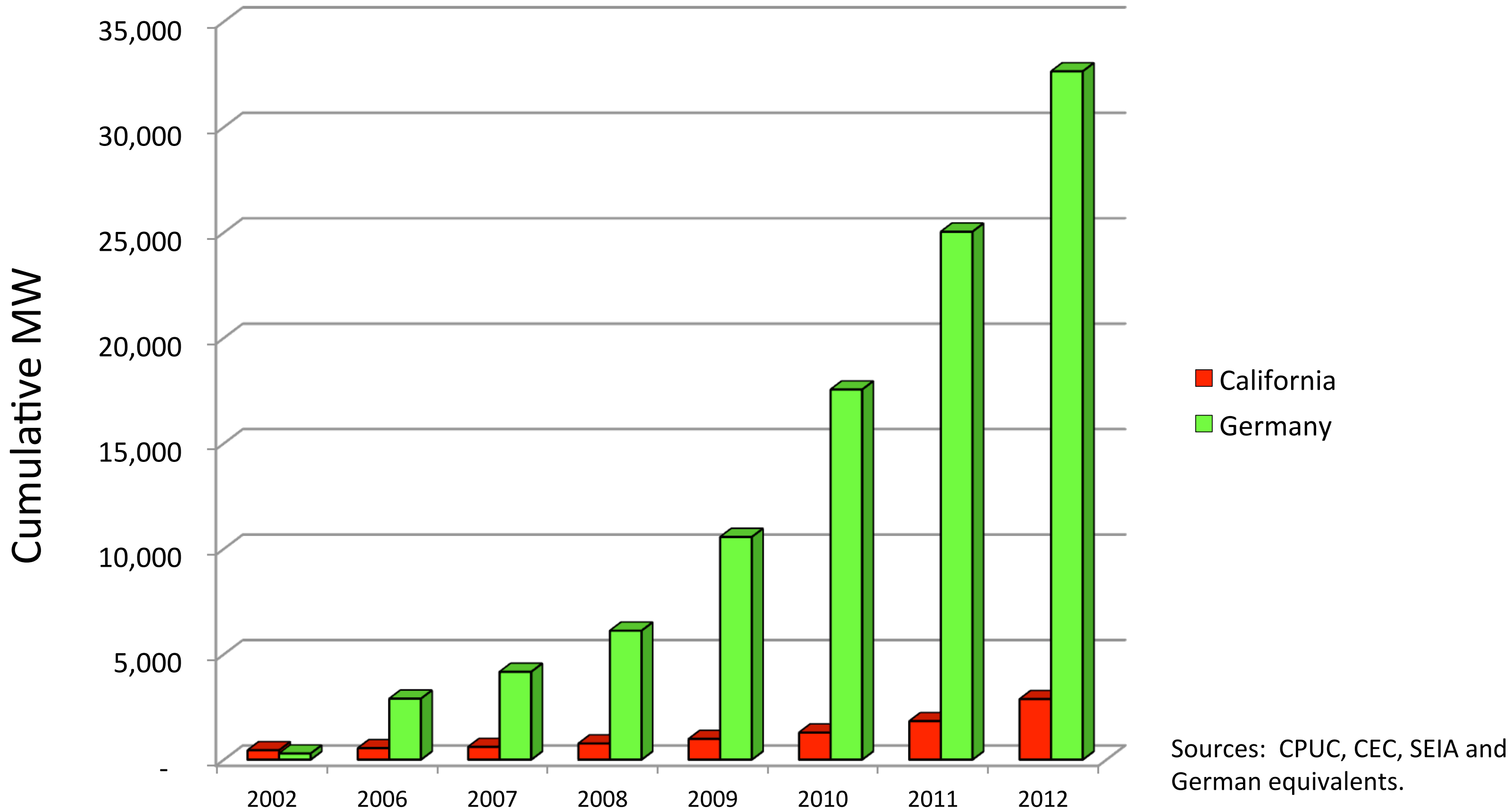
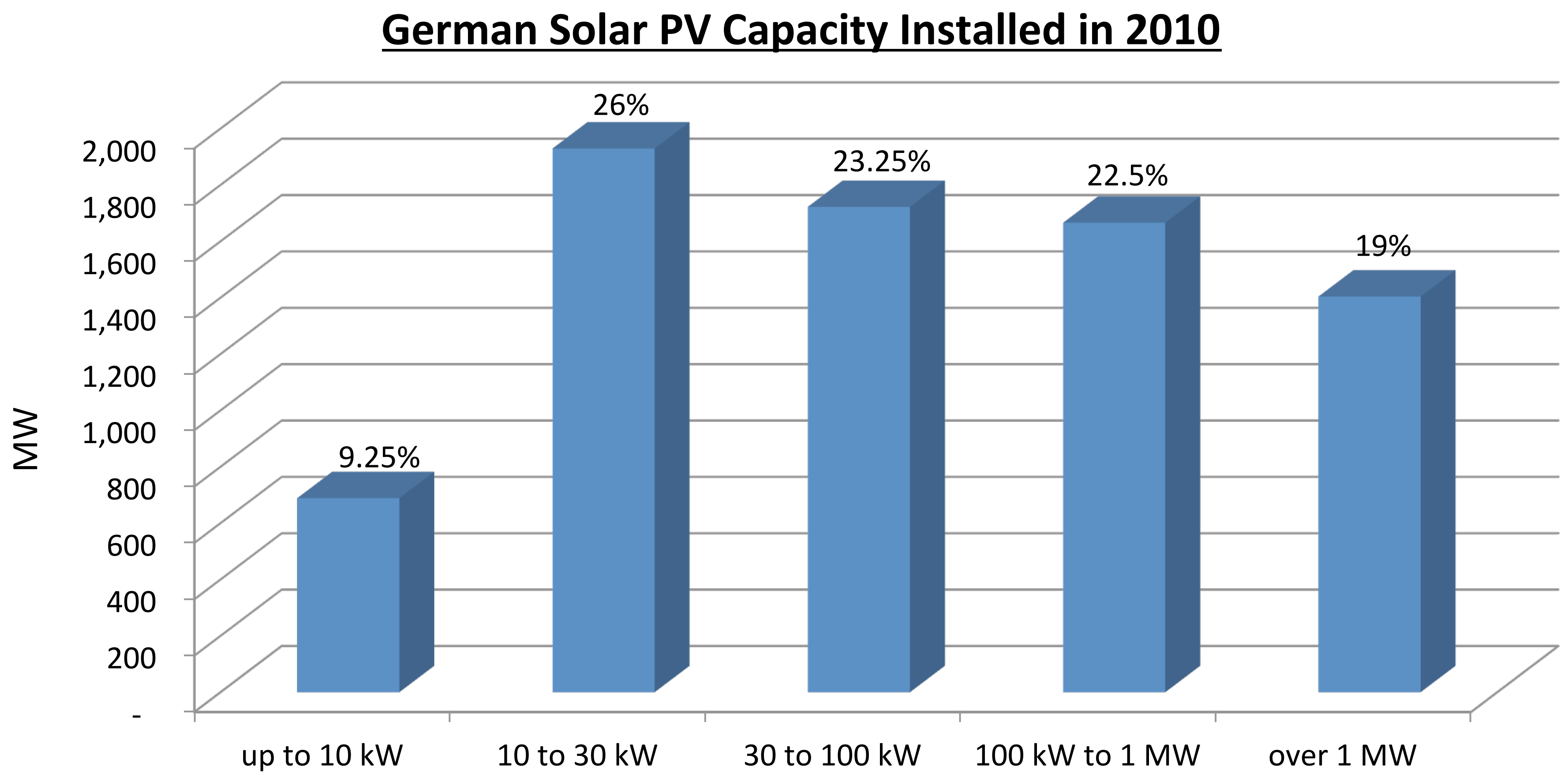
Solar Markets: Germany vs California (RPS + CSI + other)



Germany has deployed over 10 times more solar than California in the last decade despite California's 70% better solar resource!!!

German Solar Capacity is Small WDG (Rooftops)



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)

German WDG Solar is 5 to 7 cents/kWh today

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 today at only between 5 and 7 cents/kWh to California ratepayers

Community Microgrids in Six Steps

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1. Goals:

Desired goals and performance metrics of the target grid area based on local resources and known or anticipated grid issues.

Includes renewables penetration goals, grid reliability & power quality performance targets, and power backup requirements.

2. Baseline Grid Analysis:

Inventory of the existing grid assets including load profiles, voltage regulation, feeder and transformer capacities, and existing generation.

Includes identifying prioritized services that require backup power during outages.

3. Renewable Siting Survey:

Comprehensive survey of the renewable energy potential in the target grid area specific to local resources & site characteristics.

Informs other requirements such as energy storage capacity needs and control system functionality.

4. DER Optimization:

Design of optimal DER portfolios combining renewables, energy storage, and demand response.

Incorporates Baseline Grid Analysis and Renewables Survey to achieve optimal outcomes based on local resources and grid assets.

5. Economic Analysis:

Full analysis of the cost-benefits and net value including reductions in T&D investments, ratepayer benefits, and local job creation.

Includes bulk procurement & interconnection that achieve a “plug-and-play” model, further reducing costs.

6. Deployment Plan:

Final system design, financial model and operational plan for the Community Microgrid.

Includes vendor analysis (e.g. RFIs, RFPs) appropriate to the final design criteria, financial model, and operational requirements.

Result: Distributed Energy Resources can deploy at scale in months rather than years.
A massive acceleration of “one rooftop at a time…”

Community Microgrids start with Goals

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Typical Community Microgrid Goals

- Achieve high penetrations of local renewables (generally at least 25% of total electric energy consumed within the grid area served by the Community Microgrid)
- Defer substantial investments in traditional Transmission & Distribtution (T&D) infrastructure through load shifting and peak shaving etc
- Save ratepayers money
- Provide an efficient pathway to Distribution Services Operator (DSO) grid operations and the Distributed Energy Resources (DER) future
- Enhance grid performance (grid power quality, reliability, and resilience), including by combining local renewables and Energy Storage for indefinitely ongoing power backup to prioritized loads (critical loads and premium services)

Grid Analysis & DER Optimization

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Inputs

Data, existing grid:

- Loads, load forecasting
- Network model & circuit map
- Equipment list, upgrade plan, O&M schedule
- Transmission constraints

Data, DER solutions:

- DG survey
- Solar insolation
- Weather forecasting
- DER specs: advanced inverters, storage, DR, etc.

4. Higher-Cost DER Capacity

- **Higher DER level incl. storage & local generation (e.g. Fuel Cells, CHP) that further mitigate variability & peaks while islanding critical services**
- **Optimize via locations, sizes, types, costs, system deferrals**

3. Medium-Cost DER Capacity

- **Target DER level in context of net grid value that adds cost-effective storage & DR. May require moderate grid upgrades.**
- **Optimize via locations, sizes, types, costs, system deferrals**

2. Lower-Cost DG Capacity

- **Initial DG level that requires negligible grid upgrades and manages voltage w/existing equipment & advanced inverters**
- **Optimize via locations, sizes, types, costs, system deferrals**

1. Baseline Powerflow

- **Acquire all data sets, validate data accuracy**
- **Model existing grid area, including existing DG**

Outputs

- Scalable, cost-effective, operationally viable DER Optimization plan
- Results validated with utility & tech vendors
- Grid reliability & power quality maintained or improved

DER Optimization with Advanced Inverters

Clean Coalition

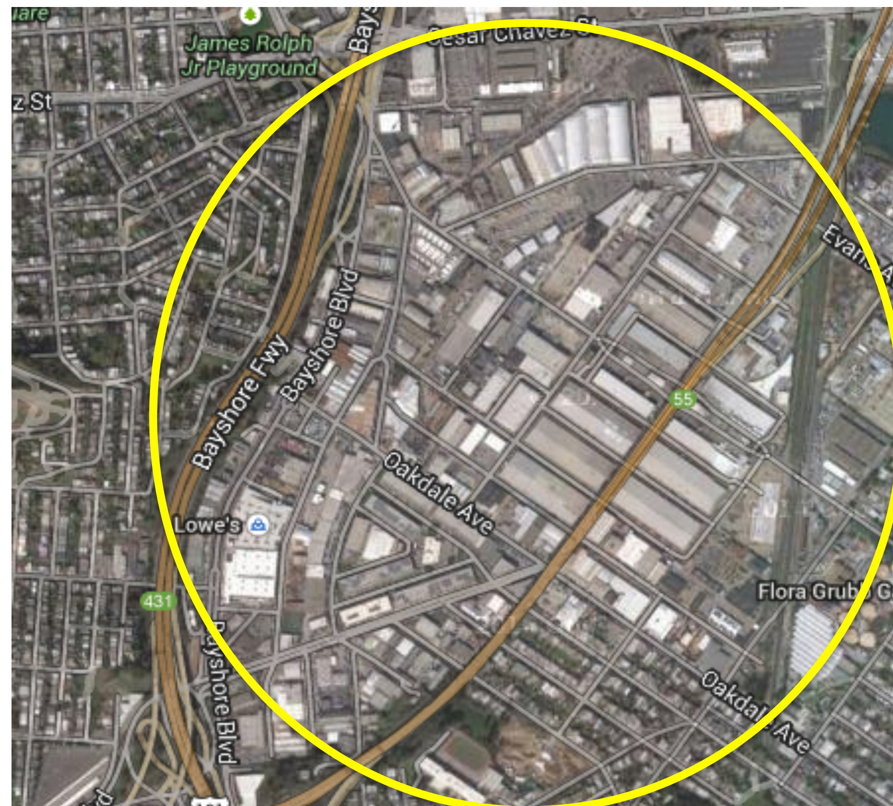
1. 6AM:
   - No PV impact
2. Noon:
   - 20MW PV causes overvoltage
3. Noon:
   - 20MW PV with advanced inverters set at 0.9 power factor stabilizes voltage

C&I Customers: Great Match with Solar

Clean Coalition

C&I Match with Solar:

1. **Most Generation**
   Larger rooftop spaces generate more energy
2. **Lowest System Costs**
   Larger systems reduce overall costs
3. **Best Grid Locations**
   Large loads served by robust feeder segments
4. **Matching Load Profiles**
   Larger daytime loads match solar generation
5. **Financially Motivating**
   Rooftop lease income is large enough to be compelling to property owners



Solar Siting Survey for SCE

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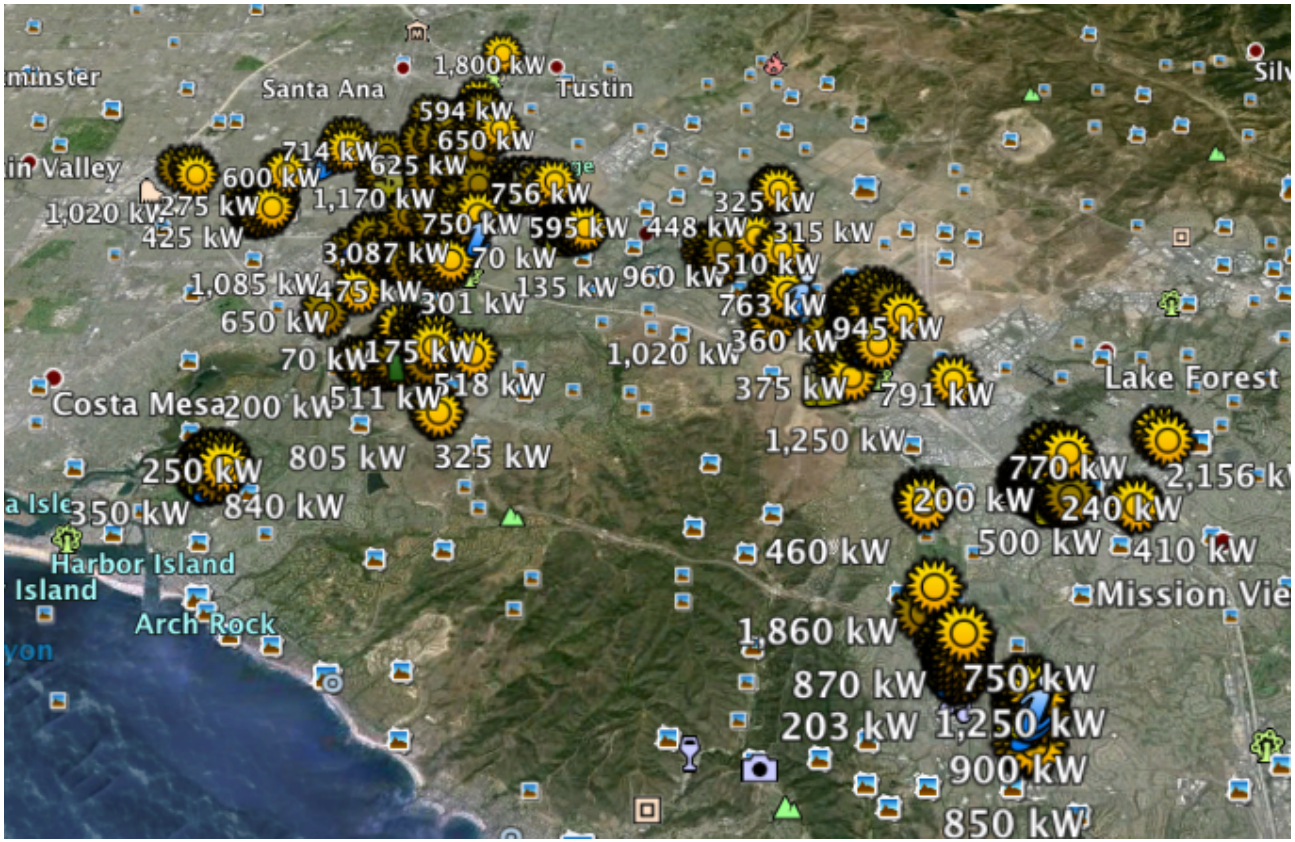
Objective: Conduct a Solar Siting Survey across Southern California Edison's Preferred Resources Pilot (PRP) area for sites 500 kW or greater

The PRP area is approximately 120 square miles in Orange County, CA, bordered roughly by Santa Ana in the north and Laguna Niguel in the south.



SCE PRP Solar Siting Survey summary

Clean Coalition

Summary: over 160 MW of new solar PV technical potential exists in the PRP on very large rooftops, parking lots, and parking garages (500kW+ project sizes)

PRP Solar Potential by PV size: totals per sites greater than 1 MW, sites greater then 500 kW but less than 1 MW, and sites less than 500 kW. The sites that are less than 500 kW are included as part of logical groupings such as office parks or shopping centers.

		Summary by PV Size							
		Num_Sites	kW_Total	PV W_AC >	1,000 kW	> PV W_AC >	500 kW	Less than	500 kW
PRP Area:	24	110	69,964 kW	26	36,599 kW	34	22,118 kW	50	11,246 kW
PRP Area:	59	221	105,437 kW	16	26,371 kW	68	48,031 kW	137	31,035 kW
PRP Area Overlap:		22	11,023 kW	4	6,673 kW	4	2,564 kW	14	1,786 kW
Totals:		309	164,378 kW	38	56,297 kW	98	67,585 kW	173	40,495 kW

PRP Solar Potential by site type: totals for rooftops, parking garages (multi-story parking structures that would enable rooftop-style mounting), parking lots (e.g. ground mount), and brown fields

		Summary by Site Type							
		Roof_Flat	kW_Total	Pkg_Garage	kW_Total	Pkg_Lot	kW_Total	Brown_Fld	kW_Total
PRP Area:	24	48	40,728 kW	18	12,831 kW	43	14,605 kW	1	1,800 kW
PRP Area:	59	113	58,125 kW	15	11,081 kW	93	36,232 kW	-	- kW
PRP Area Overlap:		15	9,599 kW	1	504 kW	6	920 kW	-	- kW
Totals:		146	89,253 kW	32	23,408 kW	130	49,917 kW	1	1,800 kW

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

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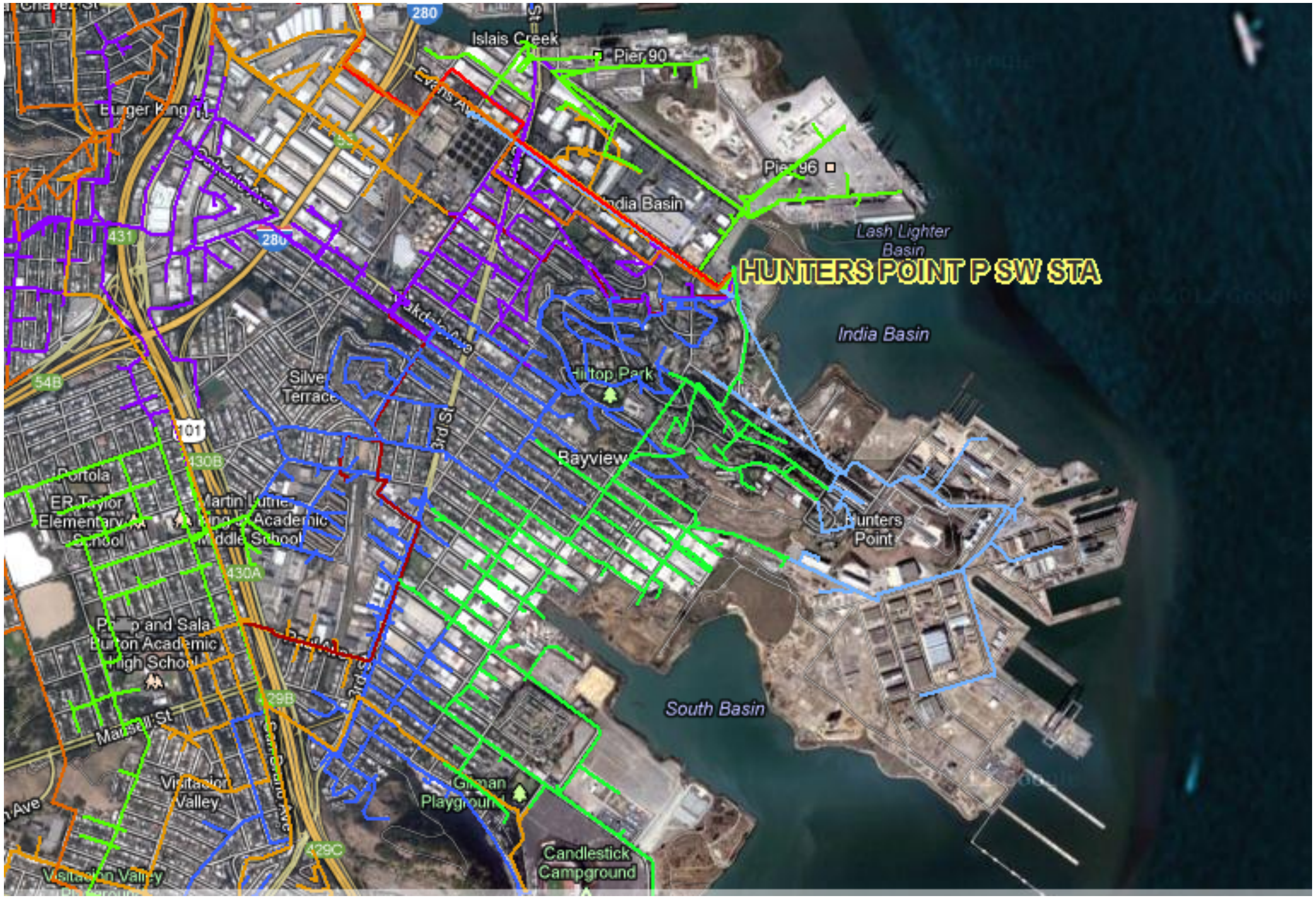
Get 25% of electric energy consumed within Hunters Point substation (Bayview and Hunters Point neighborhoods) from local renewables while at least maintaining grid reliability and power quality



Hunters Point DG Benefits: 50 MW New PV = 25% Total Energy

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50 MW Total = Existing Structures @ 30 MW + Redev Zone @ 20 MW

Example: 180 Napolean St.
- PV Sq. Ft = 47,600
- System size = 714 kW

Commercial: 18 MW

Example: 1485 Bay Shore
- PV Sq. Ft = 37,800
- System size = 567 kW

Parking Lots: 2 MW

Example: 50 avg. rooftops
- Avg. PV Sq. Ft = 343
- Avg. system size = 5 kW

Residential & MDU: 10 MW

Benefits from 50 MW New PV Over 20 Years

Energy

Cost Parity: Solar vs. NG, LCOE

$260M: Spent locally vs. remote

$80M: Avoided transmission costs

$30M: Avoided power interruptions

Economic

$200M: New regional impact

$100M: Added local wages

1,700 Job-Years: New near-term and ongoing employment

$10M: Site leasing income

Environmental

78M lbs.: Annual reductions in GHG emissions

15M Gallons: Annual water savings

375: Acres of land preserved

Long Island Community Microgrid Project

Clean Coalition

Overview

- Collaboration with PSEG Long Island, Long Island Power Authority (LIPA), and NYSERDA covering a substation in East Hampton, NY that serves thousands of customers
- 15 MW of local solar (via Feed-In Tariff) combined with a 5 MW / 25 MWh battery system
- 50% of total annual energy from local renewables while minimizing use of existing fossil generators, including local diesel peakers and backup facilities
- Indefinite and ongoing power backup to multiple critical facilities, including a fire station and two water pumping/filtration facilities
- Sets the stage to preempt hundreds of millions of dollars in transmission and fossil generation investments

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

PSEG LONG ISLAND
We make things work for you.

Configuration Options

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Option 1: Dedicated Feeder

- Energy Storage: single large ES facility connected to substation via dedicated feeder
- PV: all connected via the dedicated feeder, regardless of whether from a single solar facility or distributed at critical load sites and/or other sites
- Critical loads: in backup mode, served by the dedicated feeder and its ES & PV facilities

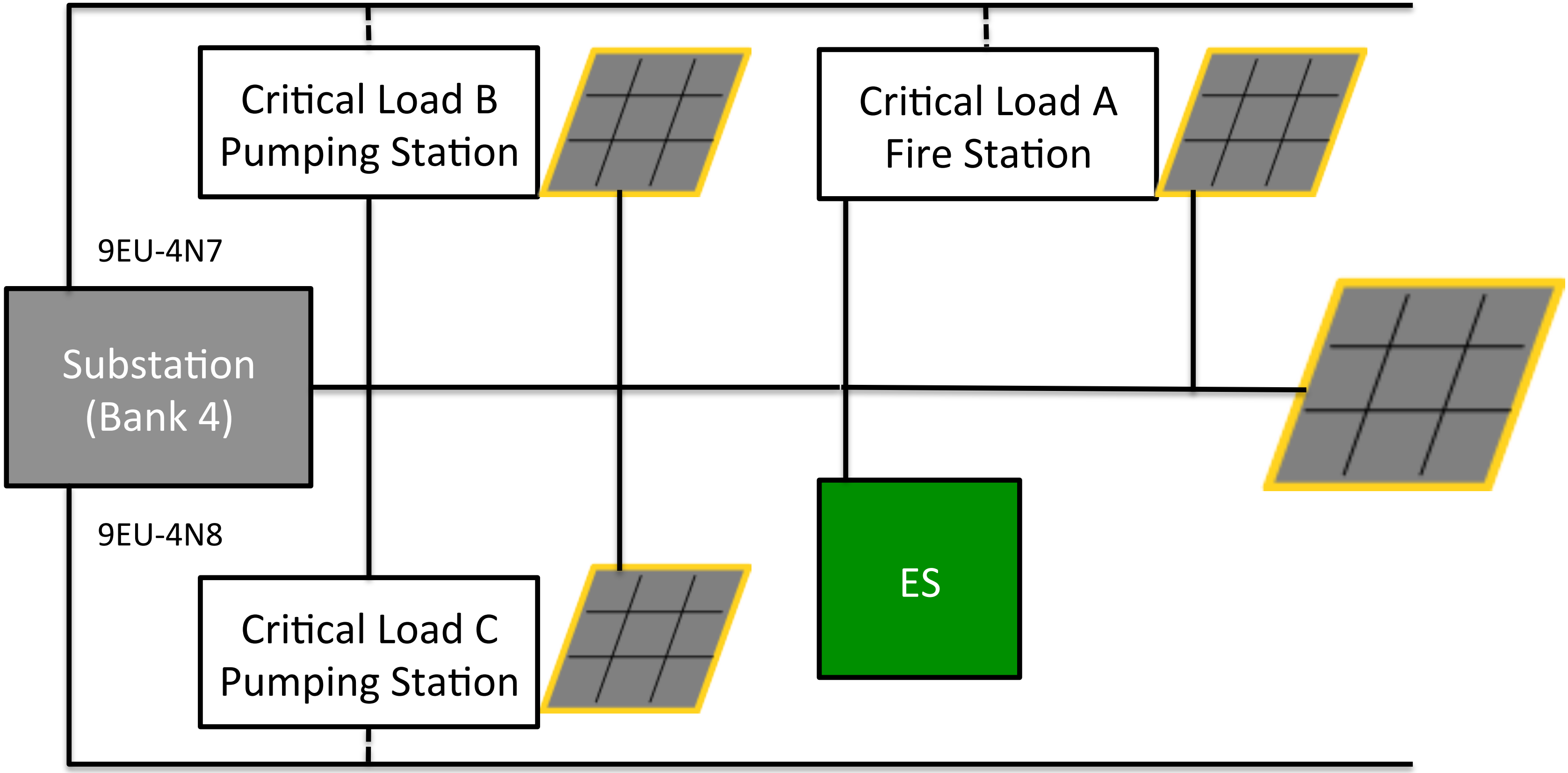
Option 2: Distributed

- Energy Storage: large ES facility connected to substation via dedicated feeder, plus distributed ES facilities located at critical load sites
- PV: at critical load sites and/or other sites, connected via normal feeders
- Critical Loads: in backup mode, served locally by distributed solar + ES. Relevant solar facilities will be shunted to power critical loads and distributed ES facilities directly.

Option 3: Balanced

- Energy Storage: single large ES facility connected to substation via dedicated feeder
- PV: at critical load sites and/or other sites, connected via normal feeders
- Critical Loads: in backup mode, Bank 4 and its feeders island from the transmission grid and shed all non-critical loads. Shedding will be performed via utility-controlled DR, by switching off non-critical load customers.

Option 1: Dedicated Feeder



Option 2: Distributed

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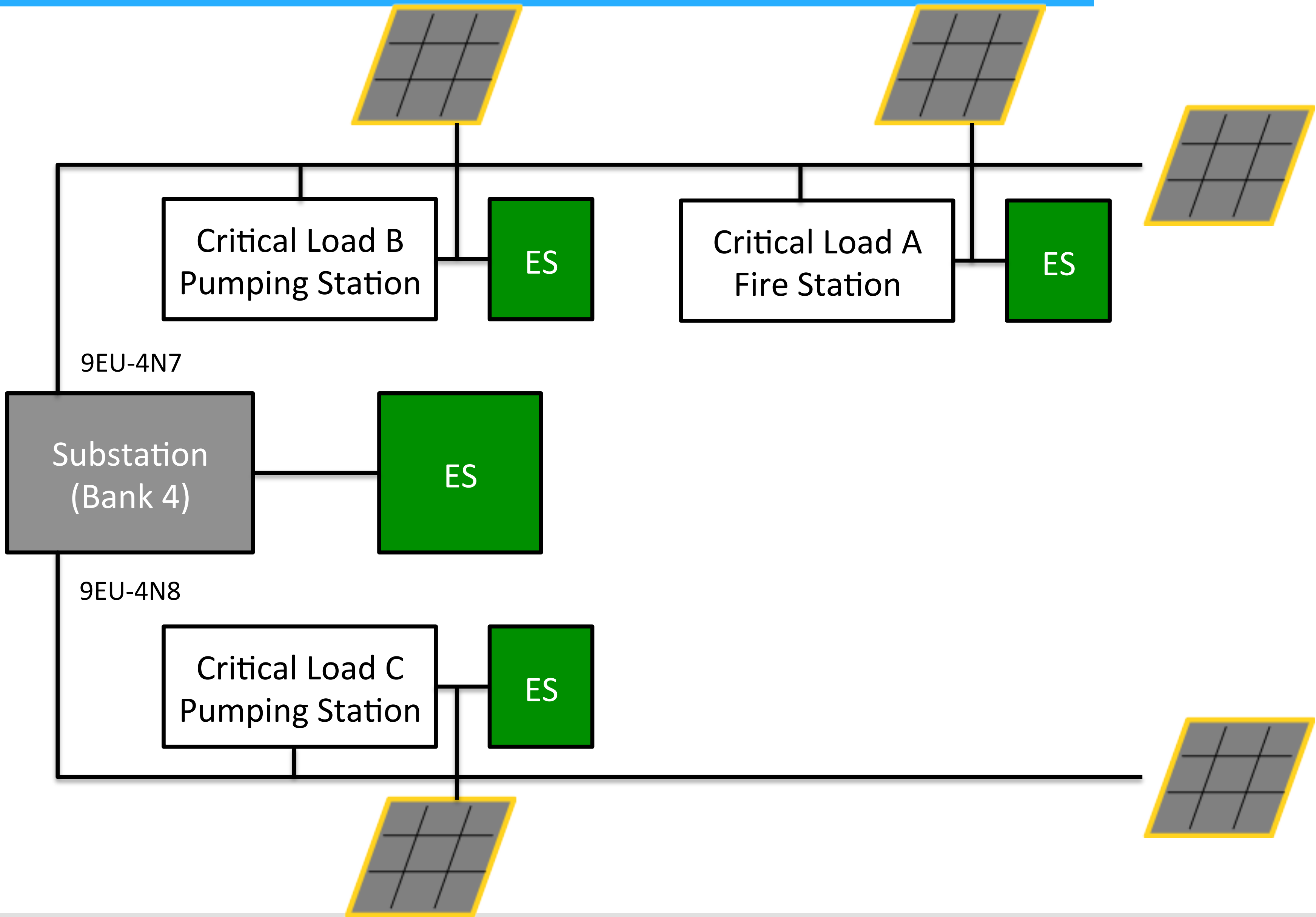

Option 3: Balanced

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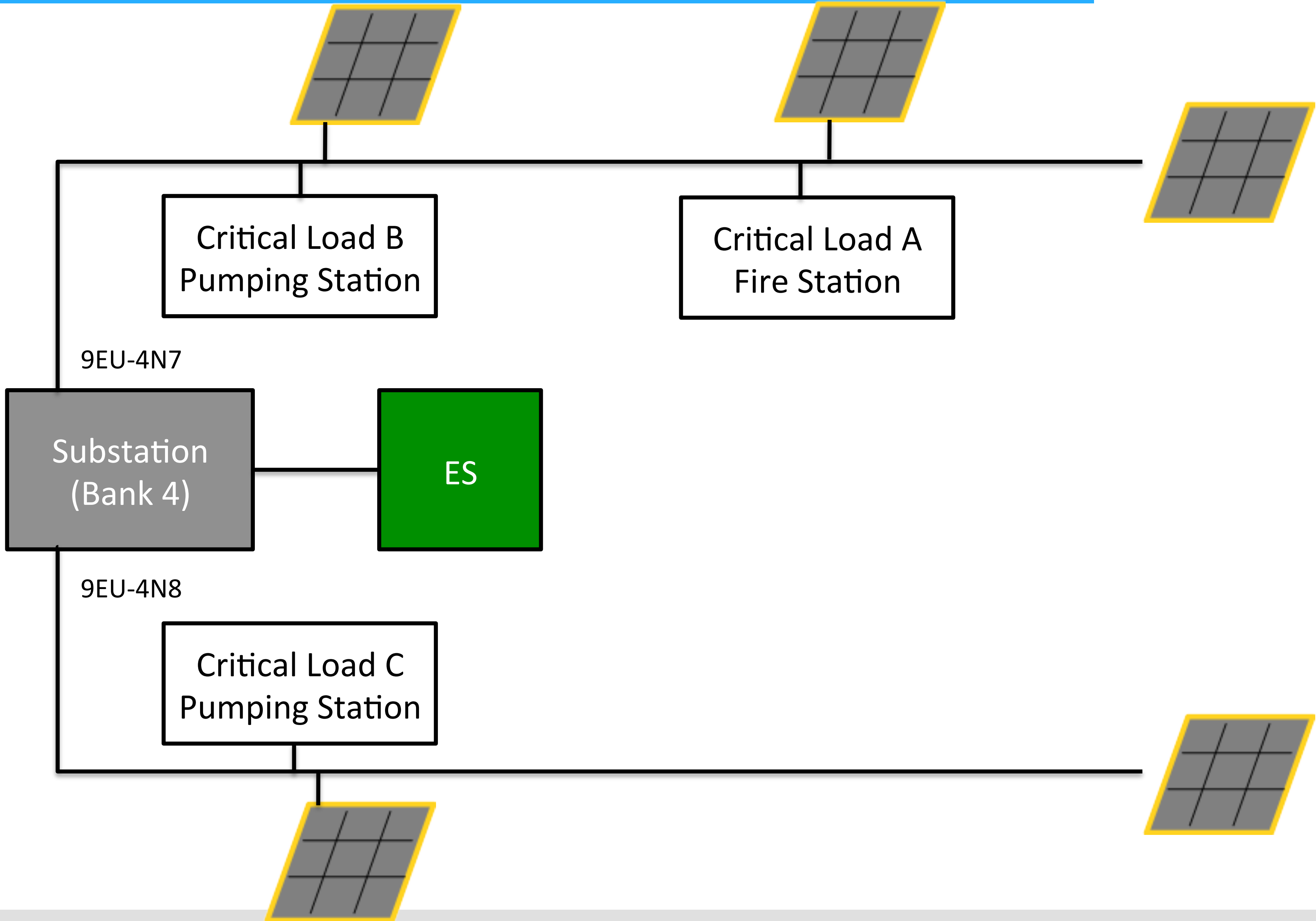

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Making Clean Local Energy Accessible Now

Back-up Slides

LICMP Overview & Goals

The LICMP features 5 MW / 25 MWh energy storage and up to 15 MW of solar serving the two Bank 4 feeders of the East Hampton GT substation. Goals:

1. **Provide local power backup for the identified critical facilities: two SCWA filter/pumping stations, one Fire District facility**
2. **Optimize the 5 MW / 25 MWh energy storage across cost and energy, utilizing both the local solar and import from transmission at night**
3. **Maximize the interconnection and use of local solar generation, integrating up to 15 MW into Bank 4 of the substation**
4. **Optimize other DER such as Demand Response and Energy Efficiency across cost and energy, in context of the local solar and load profiles**
5. **Minimize the use of local diesel generators (e.g. during summer peaks)**
6. **Prove both the economic and operational viability of the LICMP solution while setting the stage for deferring $100s of millions in Transmission costs**
7. **Serve as a model for the State of NY and across the country (and everywhere else that distribution grids exist)**

LICMP Area Map

Clean Coalition

PSEGLI Web Map

March 30, 2015

Ⓐ Fire Department
Ⓑ Water Filter / Pump Station
Ⓒ Water Filter / Pump Station

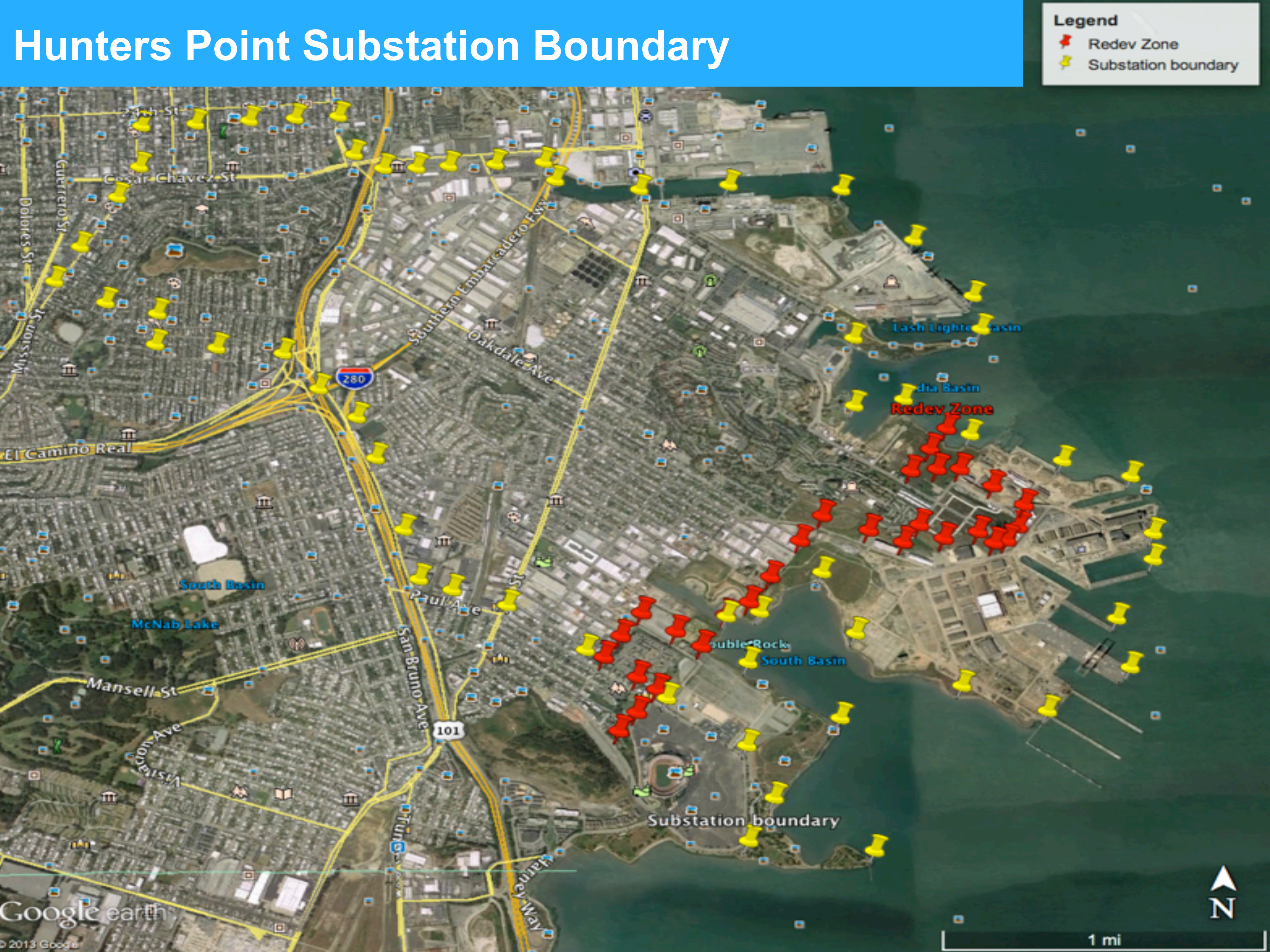
9EU-4N7
9EU-4N8

1:72,224

0 0.75 1.5 3 mi
0 1.25 2.5 5 km

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Hunters Point Substation Boundary



Hunters Point <u>Reasonable</u> DG Potential = 58 MW, Over 25% Total Energy

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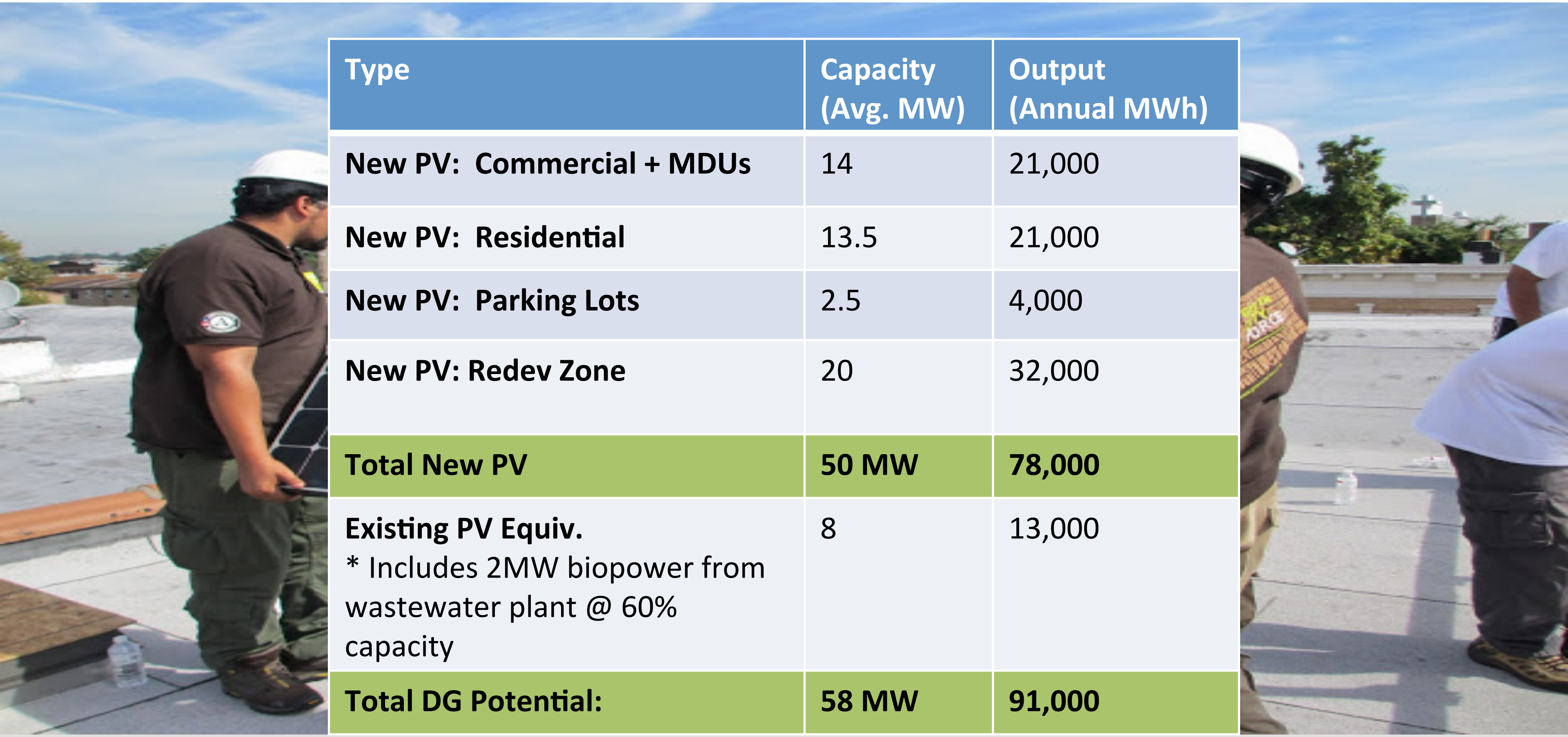
<u>DG Potential</u>: **Over 25% of Total Load (320,000 MWh)**

- **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.

Peek at the Future of Bayview-Hunters Point

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

Virgin Islands Example: Island of St John

Clean Coalition

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

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

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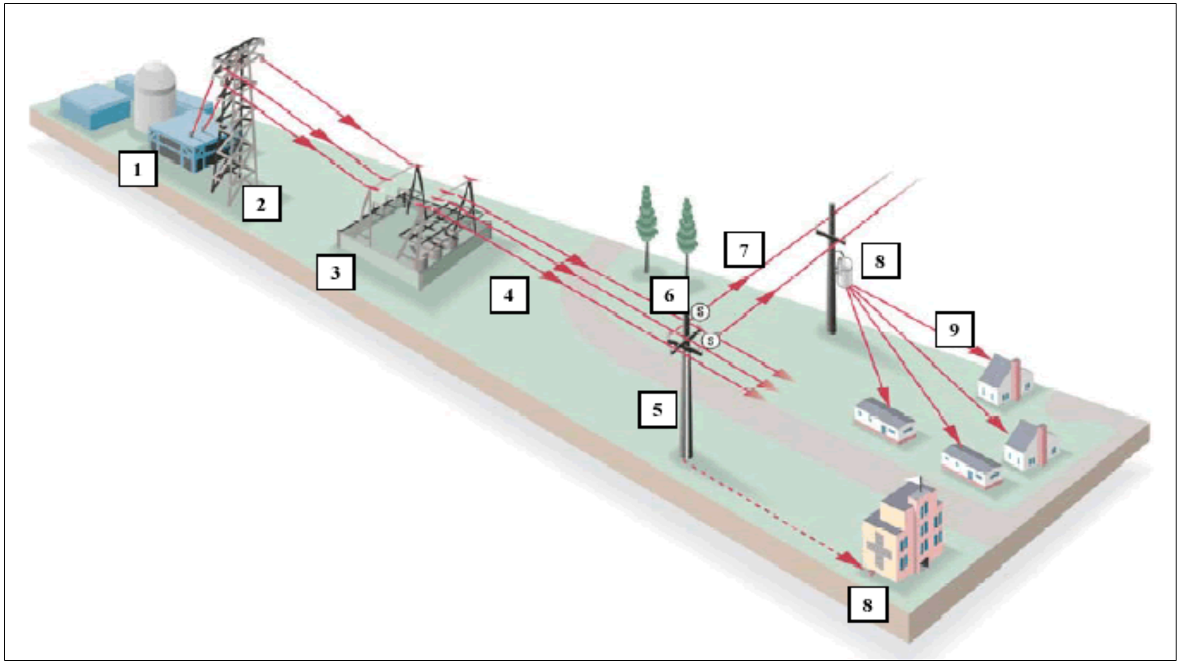
- Work with five utilities across the US to deploy a Community Microgrid demonstration project at each by yearend-2016
- Prove viability of Distributed Generation (DG) providing at least 25% of total electric energy consumed within a single substation grid area



- 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

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

Benefits of Modernizing the Grid

Clean Coalition

- 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

Distributed Voltage Regulation – Location Matters

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

Oak Ridge National Laboratory (2008)

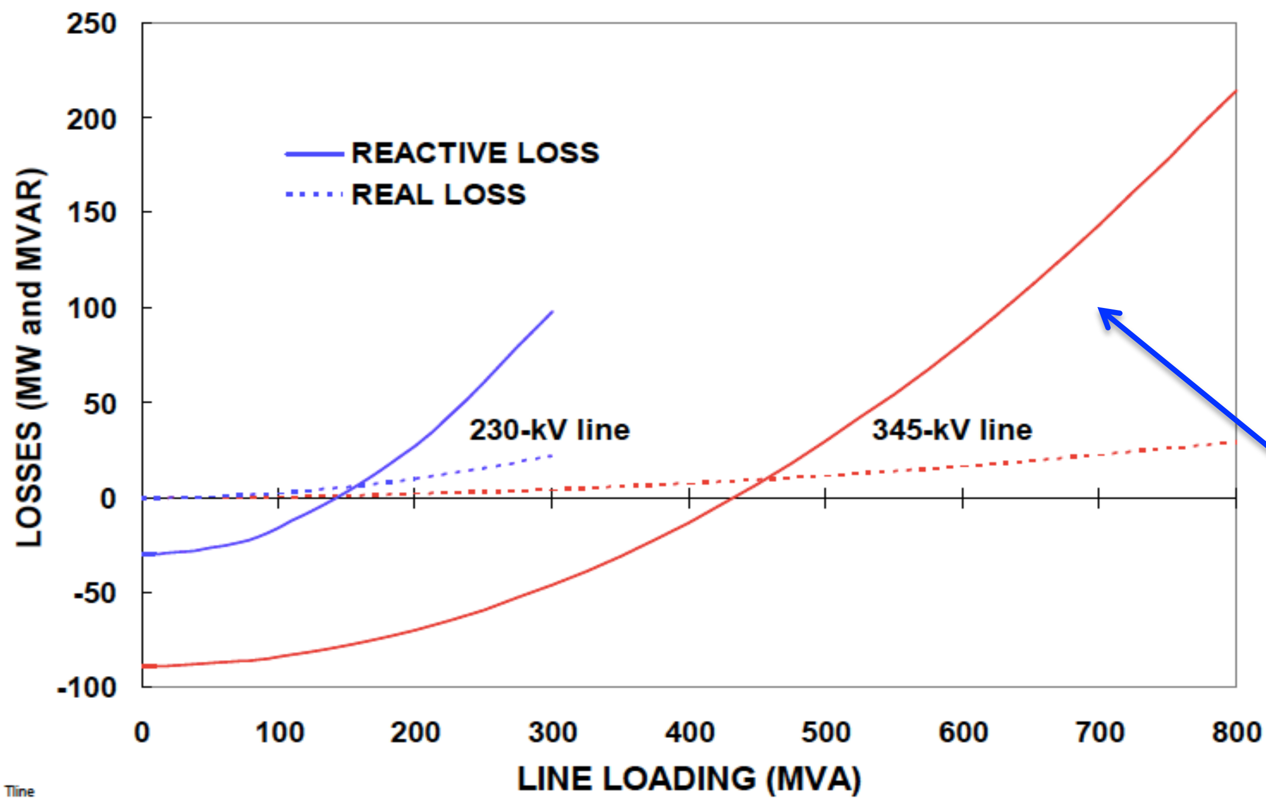


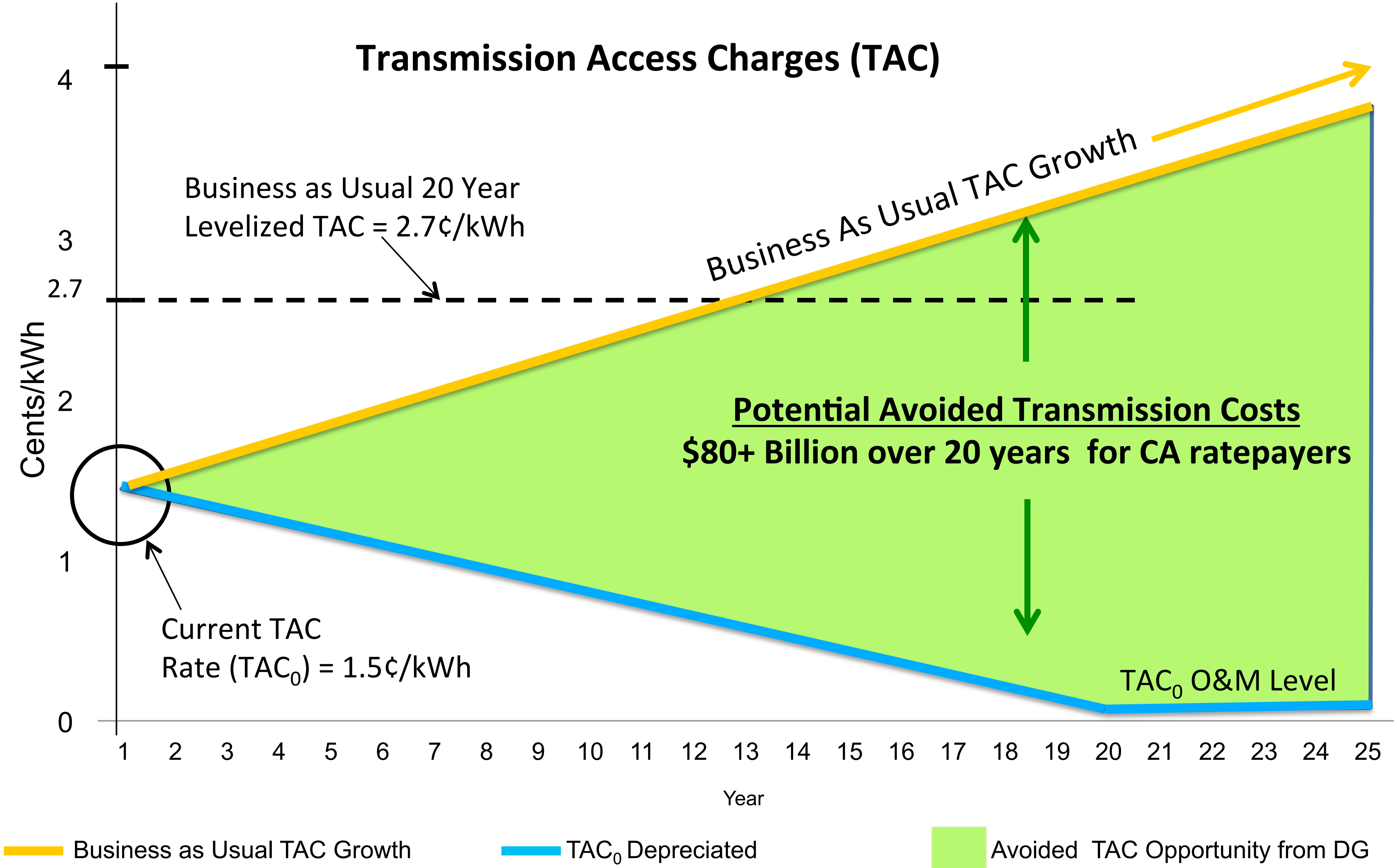
Figure 1-1. Transmission line absorption of reactive power.

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.

Source: Oak Ridge National Laboratory (2008)

Potential Transmission Savings for California



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

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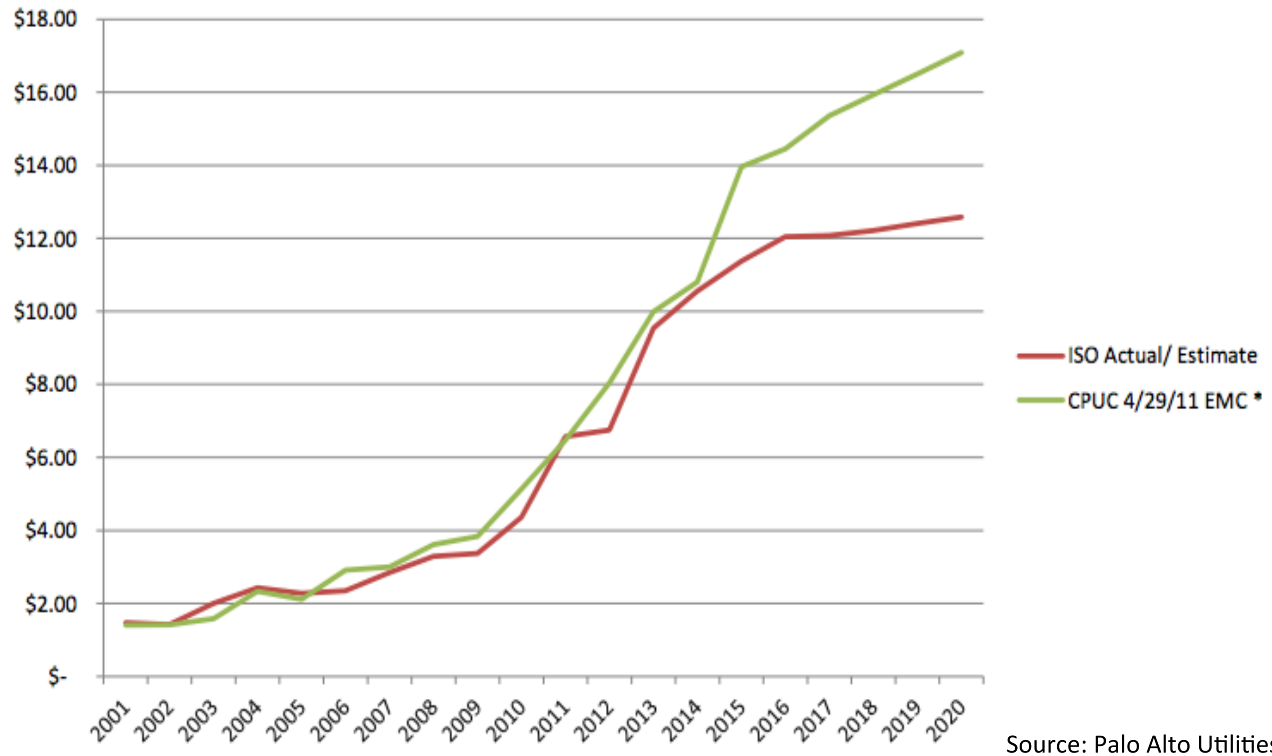
- Under a business as usual scenario, new incremental transmission investments will reach **$80 billion** over the next 20 years, imposed on California ratepayers
- Levelized over 20 years, this approaches **3 cents/kWh** – or roughly 25% of the wholesale cost of electricity, or 33% of the energy price 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

Utility of the Future? "Distribution System Operator"

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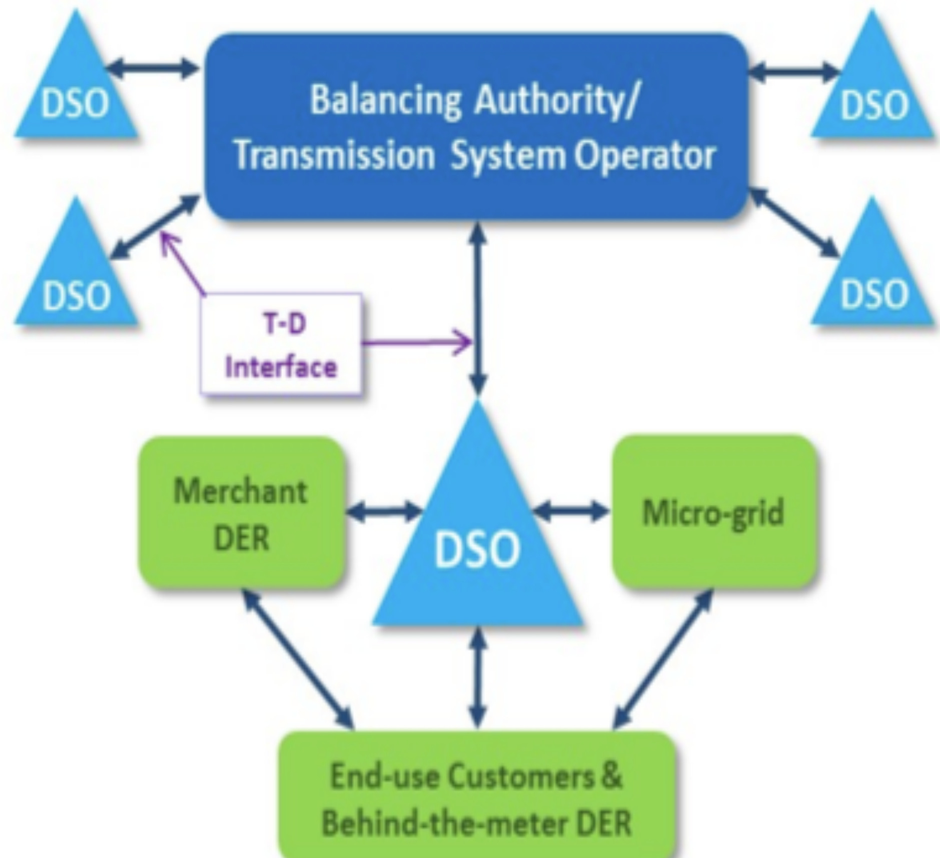
The Distribution System Operator (DSO) will:

- 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

Future "Integrated Distributed" Electricity System
(High-DER, Multi-directional energy flows & Multi-level optimizations)

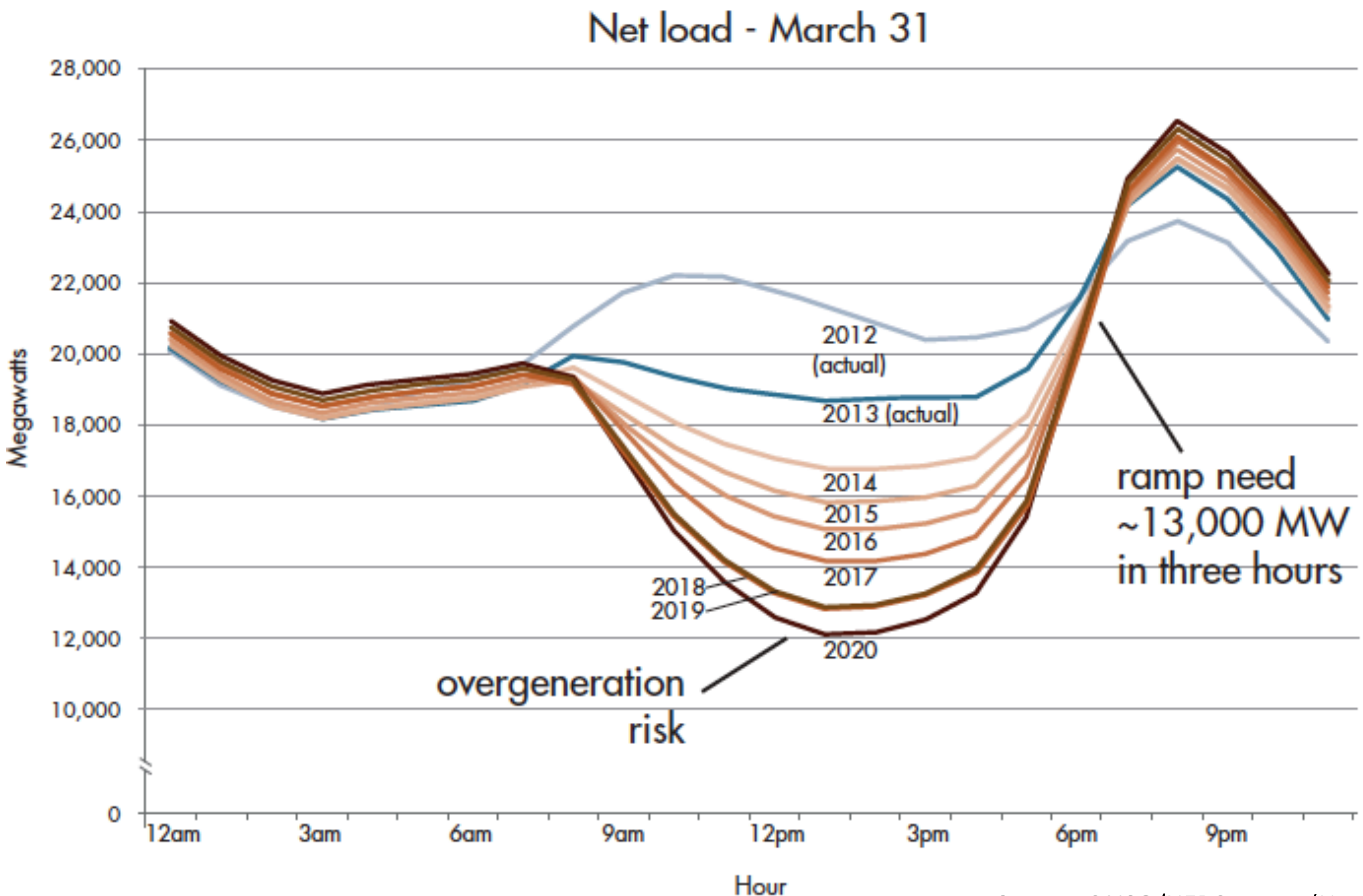


Source: 21st Century Electric Distribution System Operations, May 2014, by Lorenzo Kristov of CAISO and Paul Di Martini of the Caltech Resnick Institute

Is this Duck Real or a Decoy for Natural Gas?

Clean Coalition

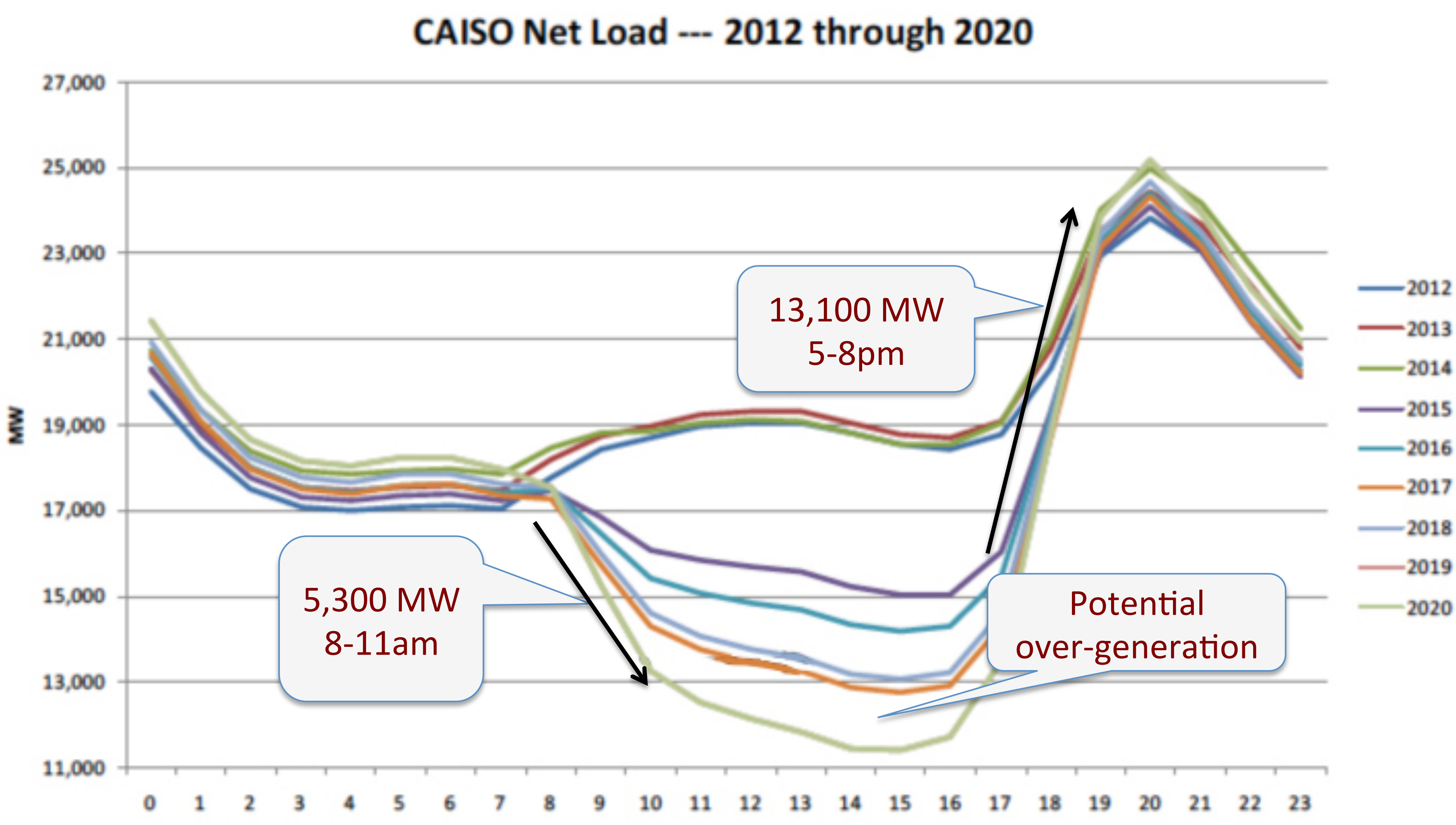
Figure 2: The duck curve shows steep ramping needs and overgeneration risk



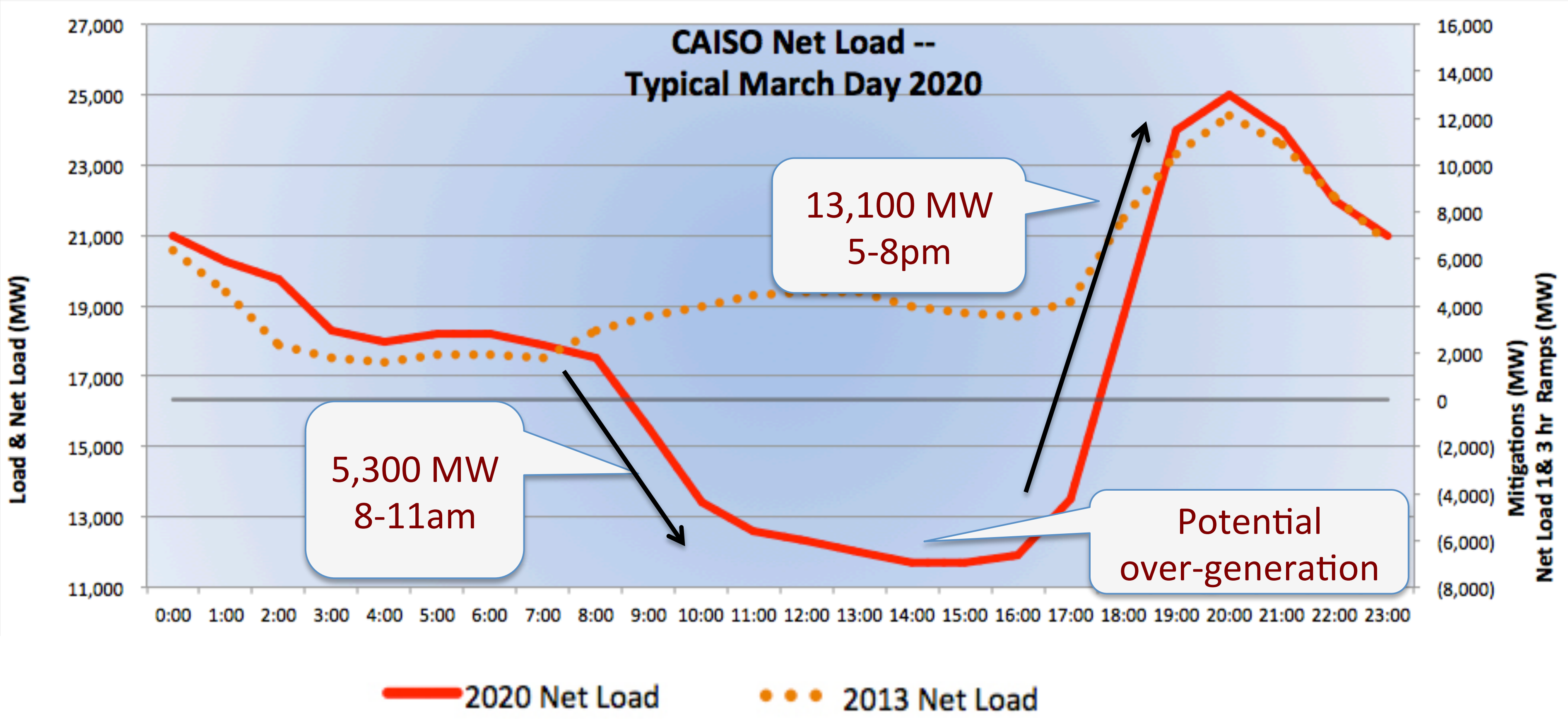
Source: CAISO/NERC report (Nov 2013)

The California ISO Duck Chart (2012 – 2020)

Clean Coalition

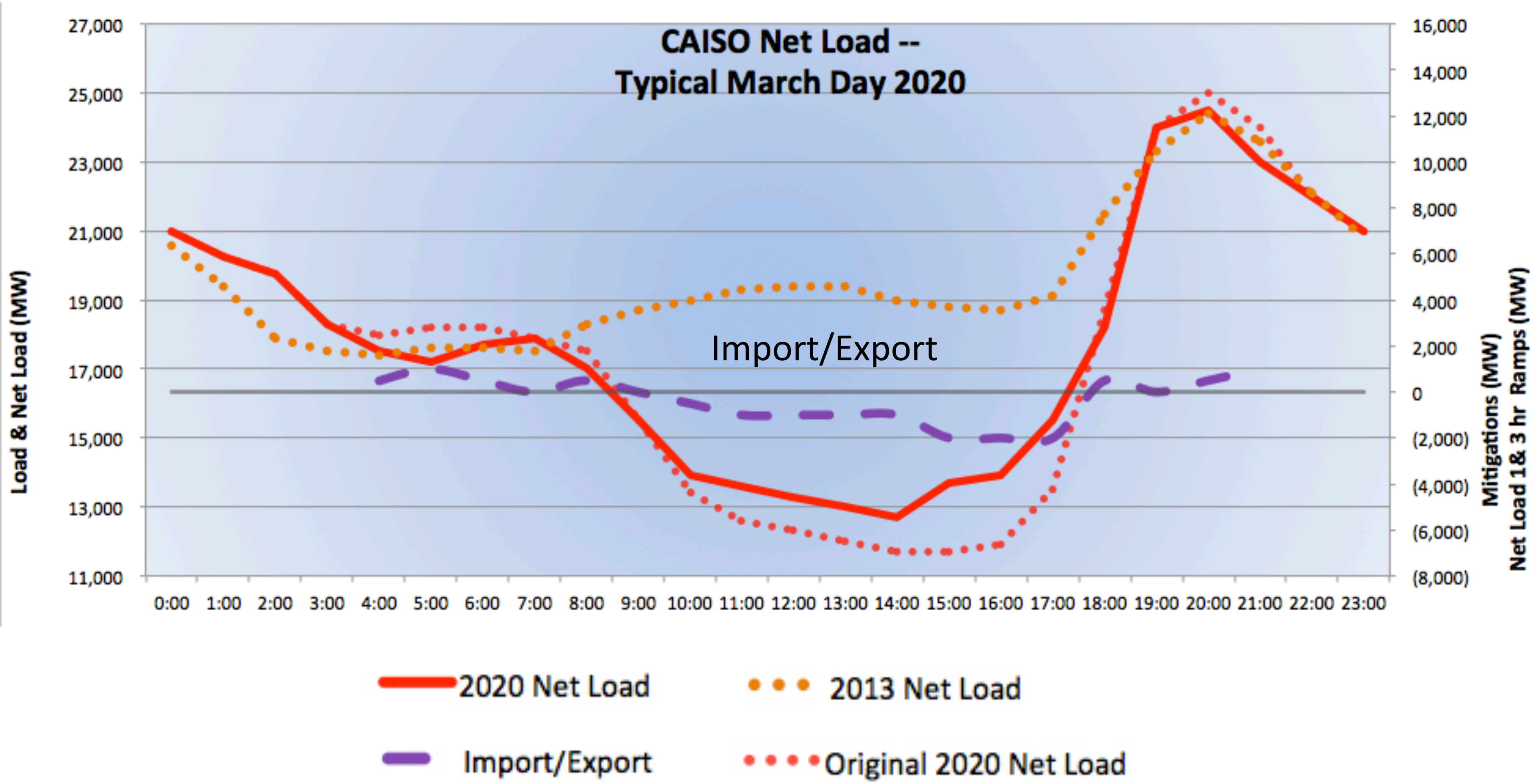


CAISO Duck Chart (2020 Issues)



Flattening the Duck – Import/Export

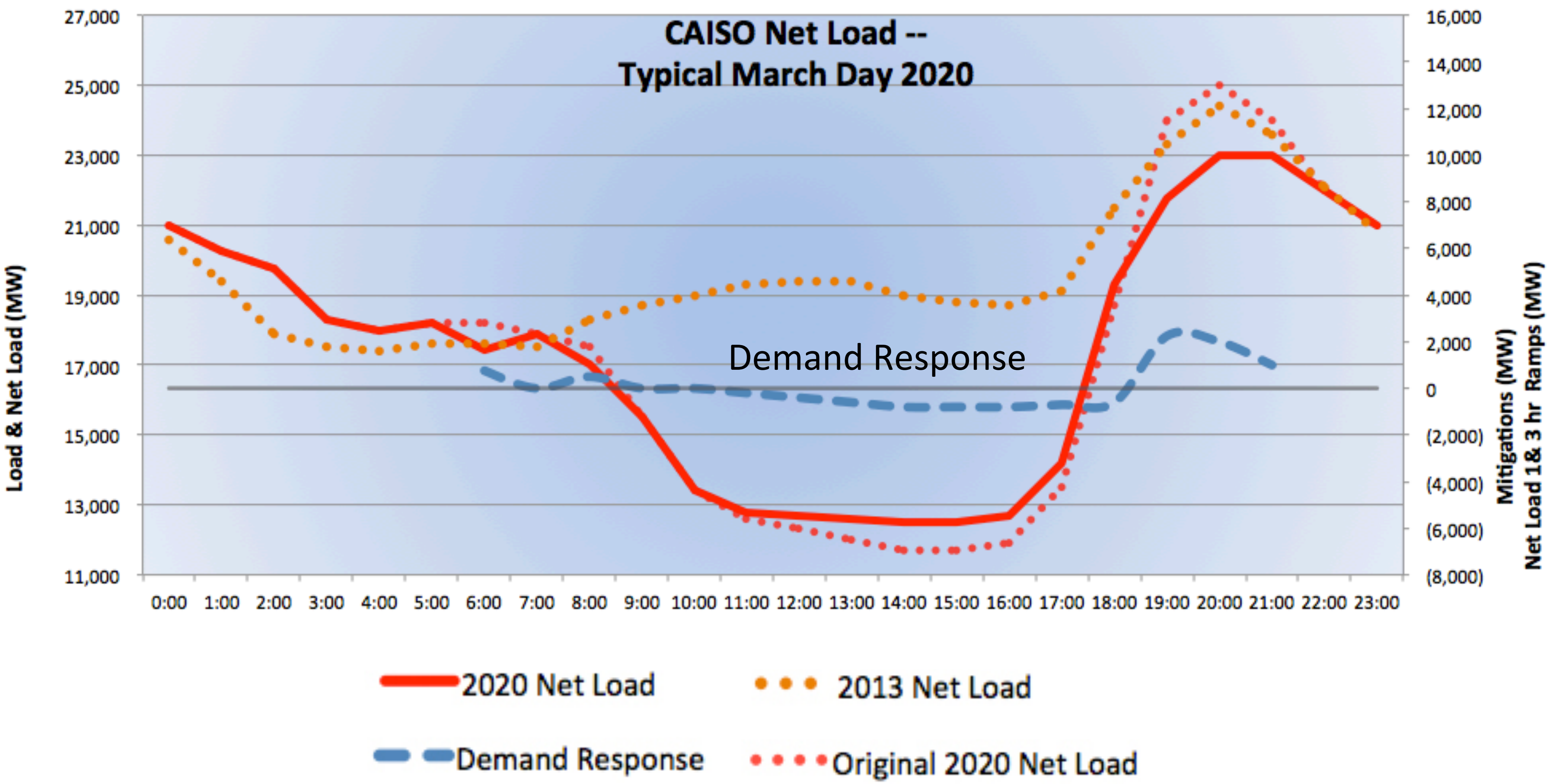
Clean Coalition



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

Flattening the Duck – Demand Response

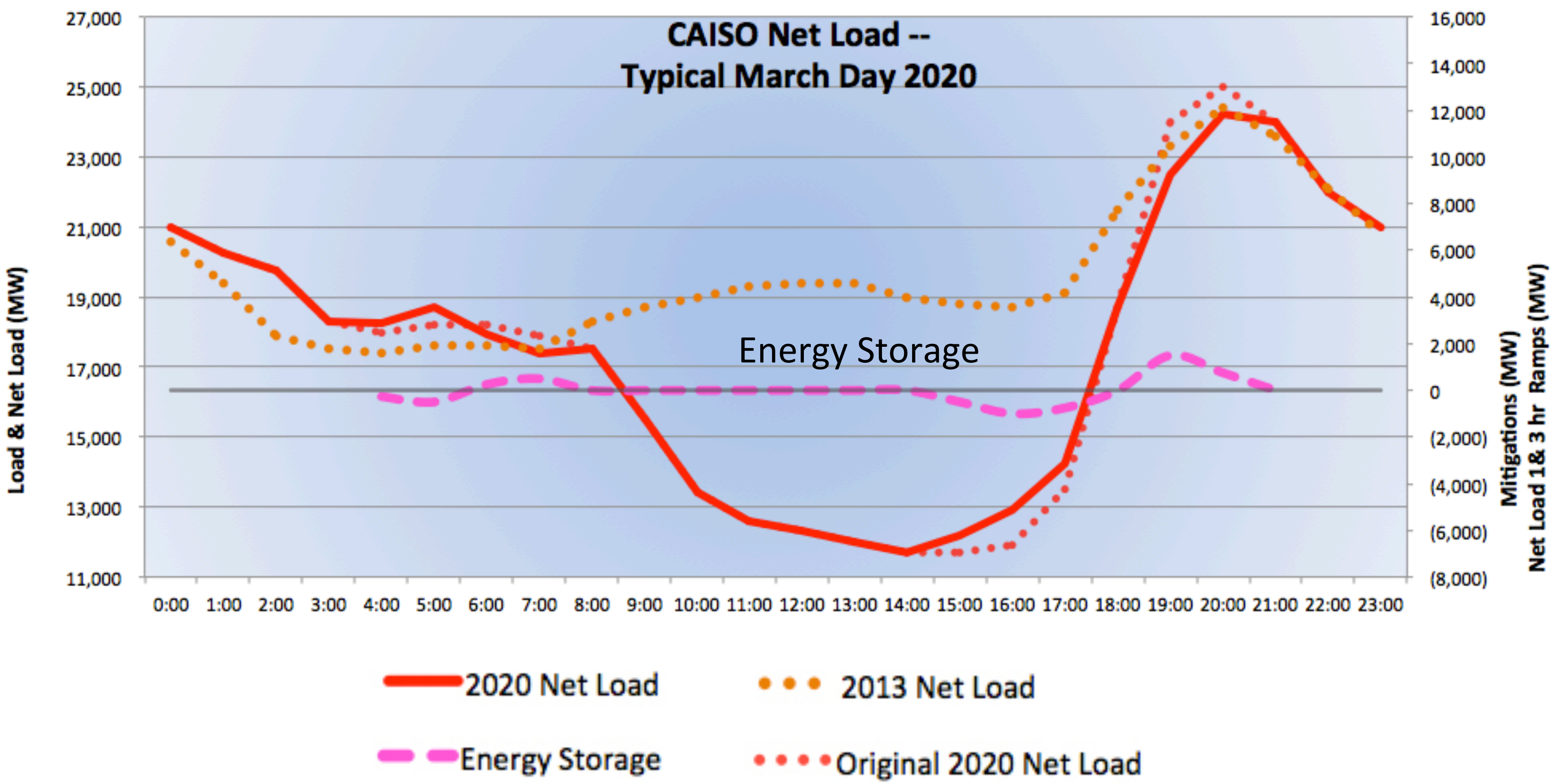
Clean Coalition



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

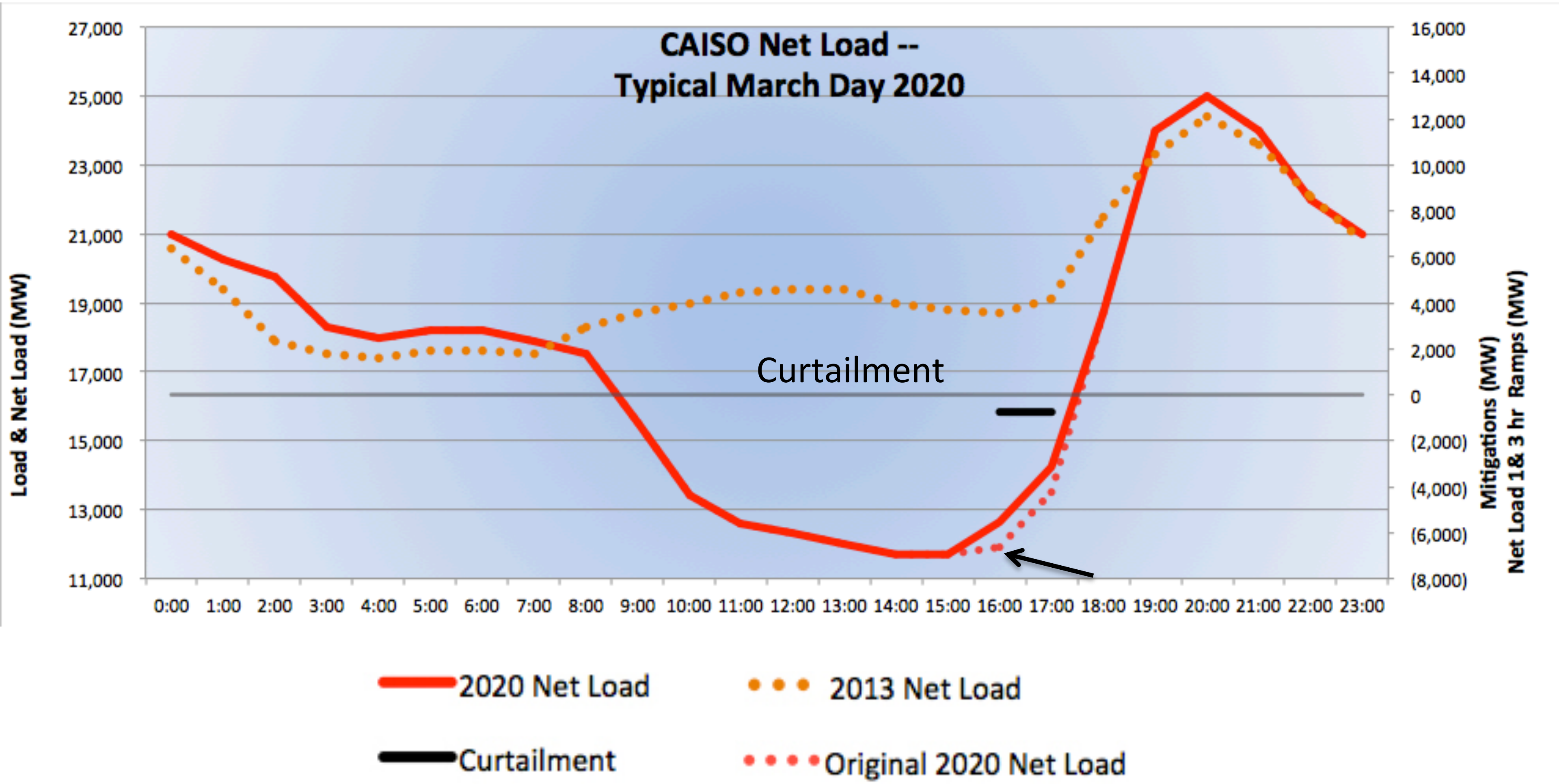
Flattening the Duck – Energy Storage

Clean Coalition



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

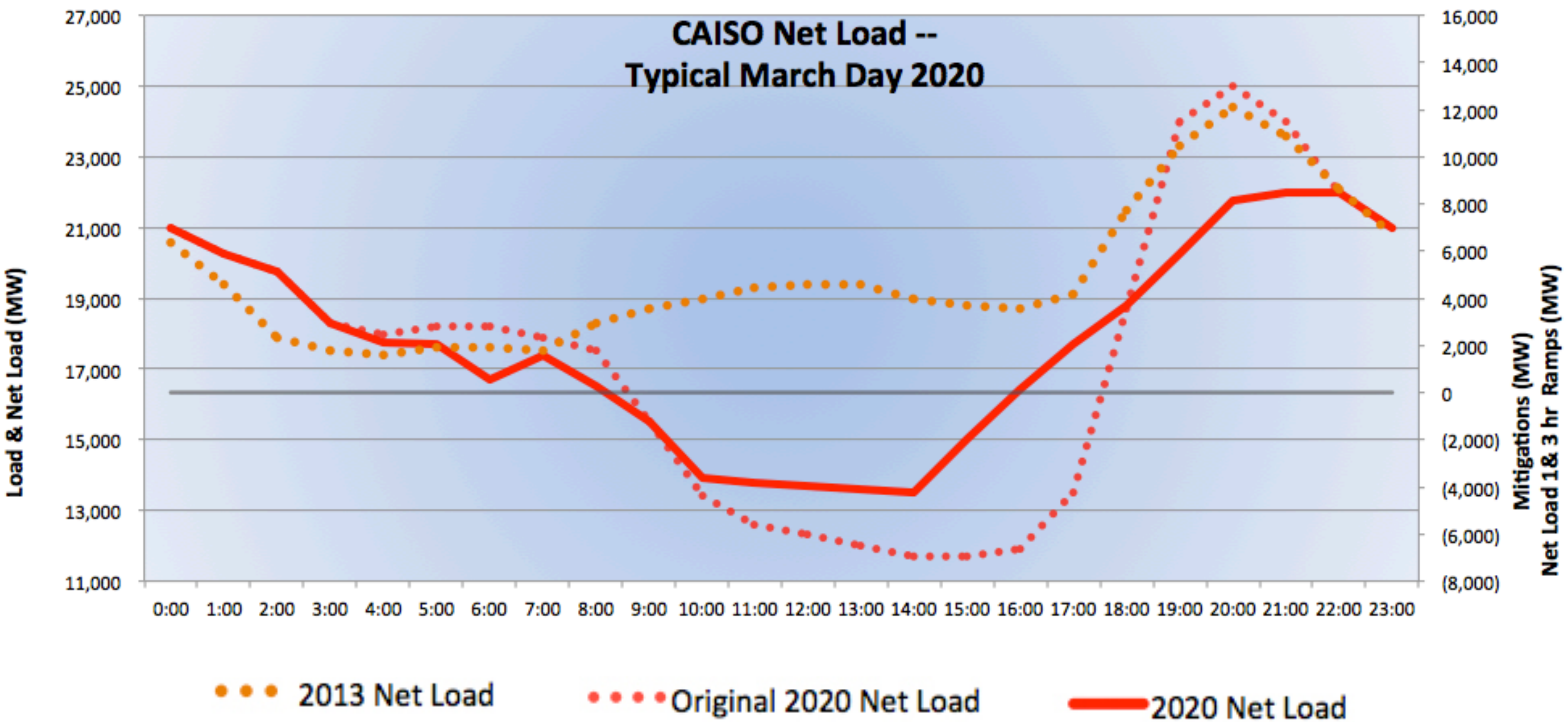
Flattening the Duck – Curtail Solar



Can also curtail baseload by scheduling maintenance during shoulder months

Flattening the Duck – Aggregated Solutions

Clean Coalition



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

Replace SONGS – DG/Storage + Advanced Inverters

Clean Coalition

VS.

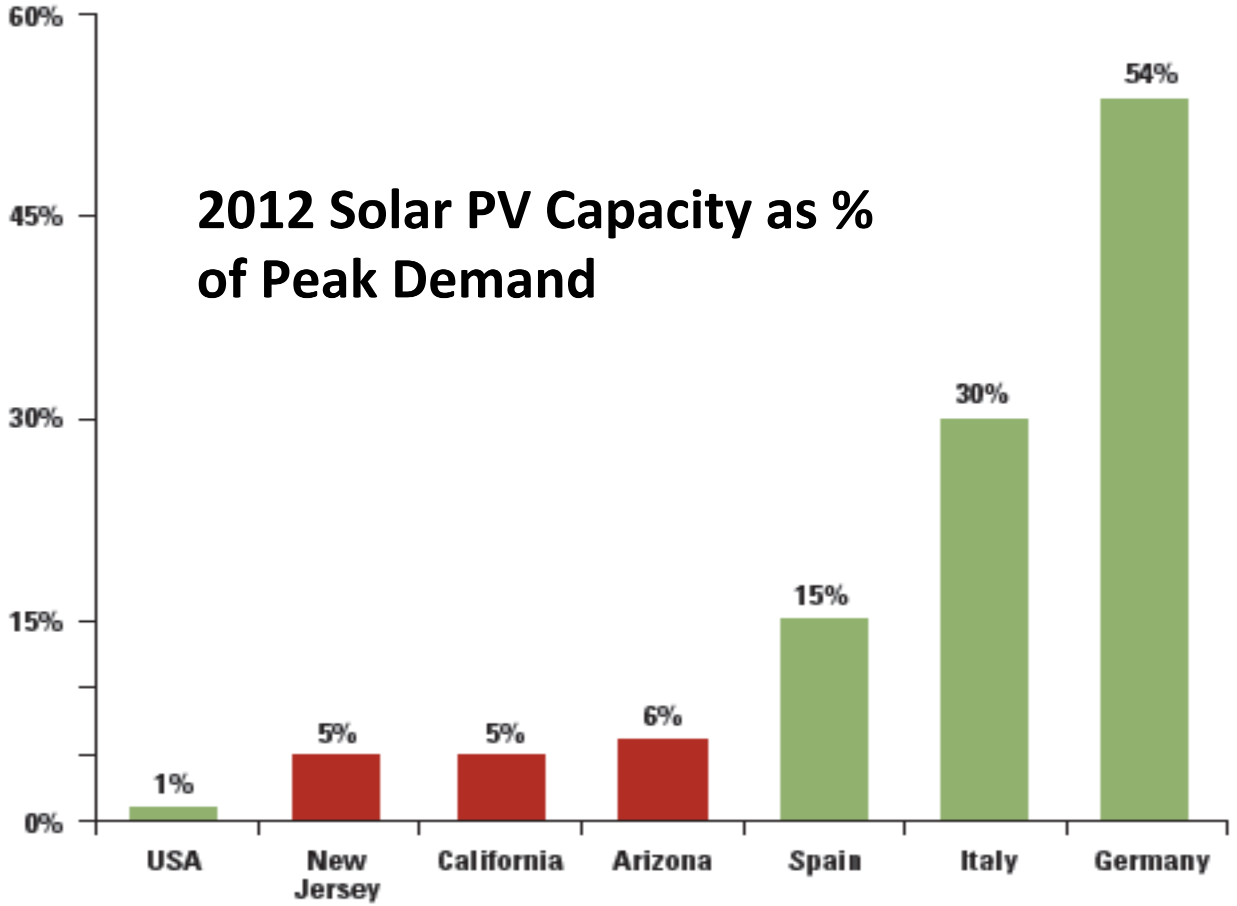
$80 million
2 Synchronous Condensers
San Luis Rey Substation
450 MVAr
(minus line losses = **400 MVAr**)

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)**

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.

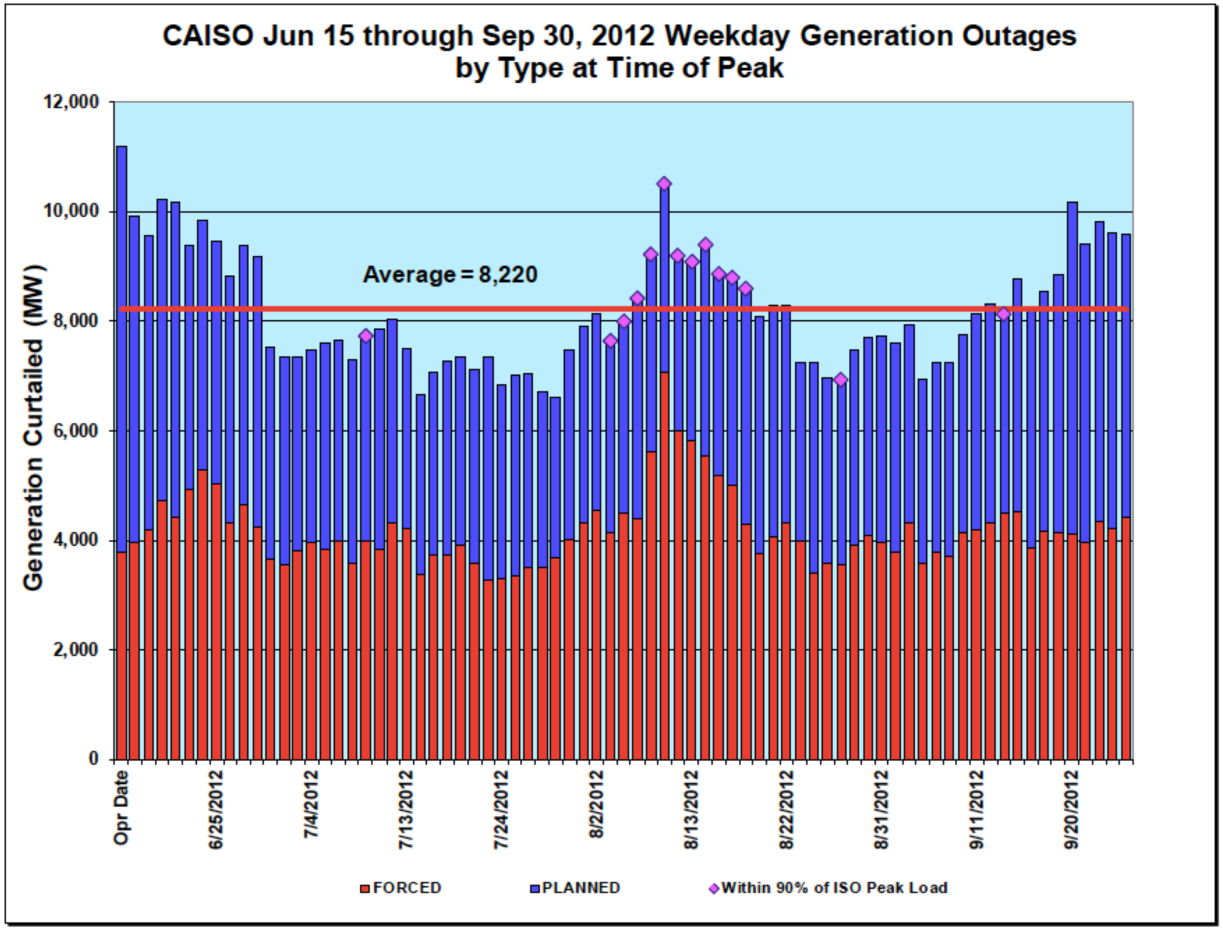


Source: Union of Concerned Scientists, SEIA 2013

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

Clean Coalition

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

FLEX ALERT
FLEXALERT.ORG

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

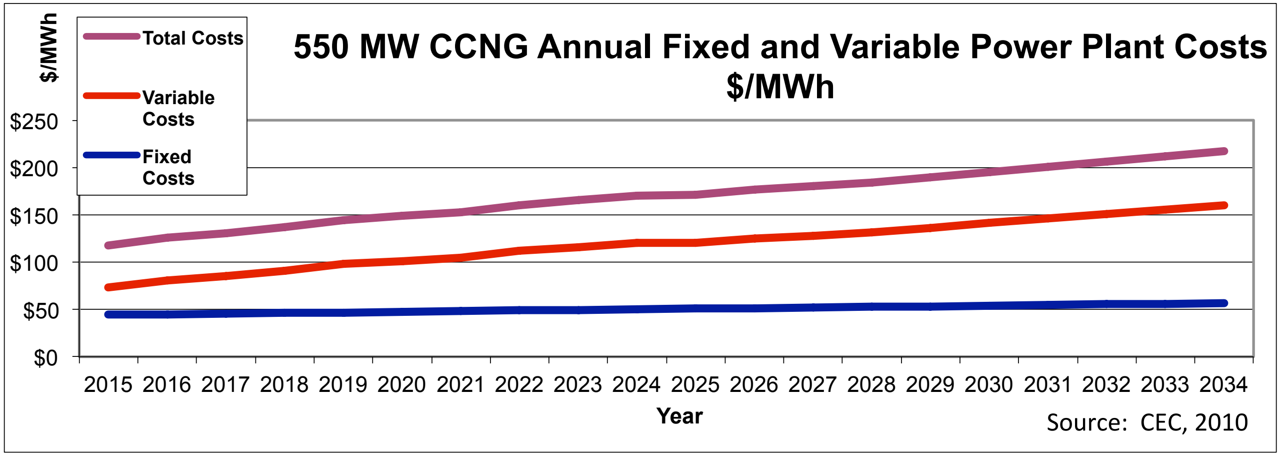
Clean Coalition

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

Clean Coalition

SCE Share of 12,000 MW Goal

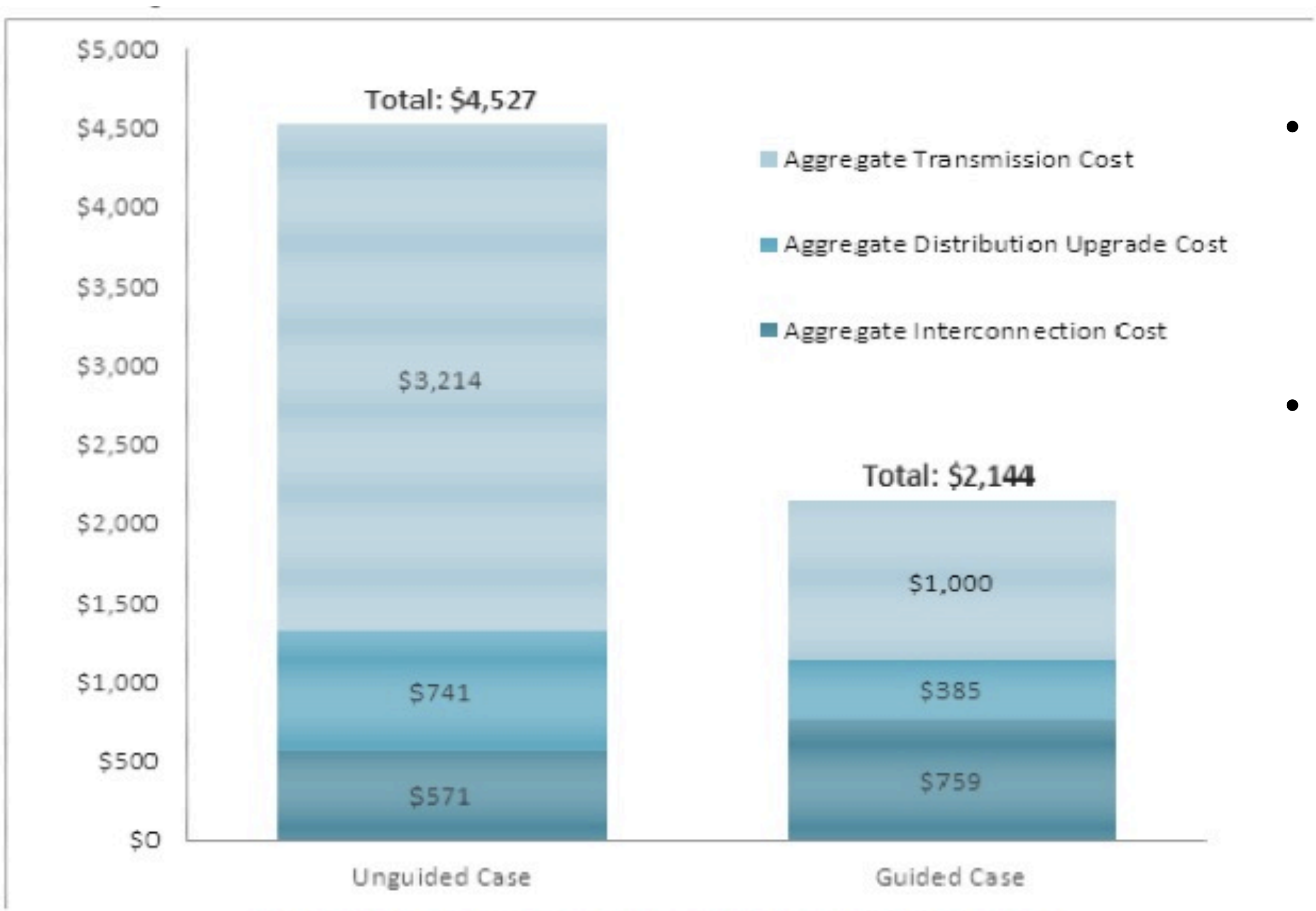


Figure 8: Total SCE System Costs of LER Proposal (Million USD)

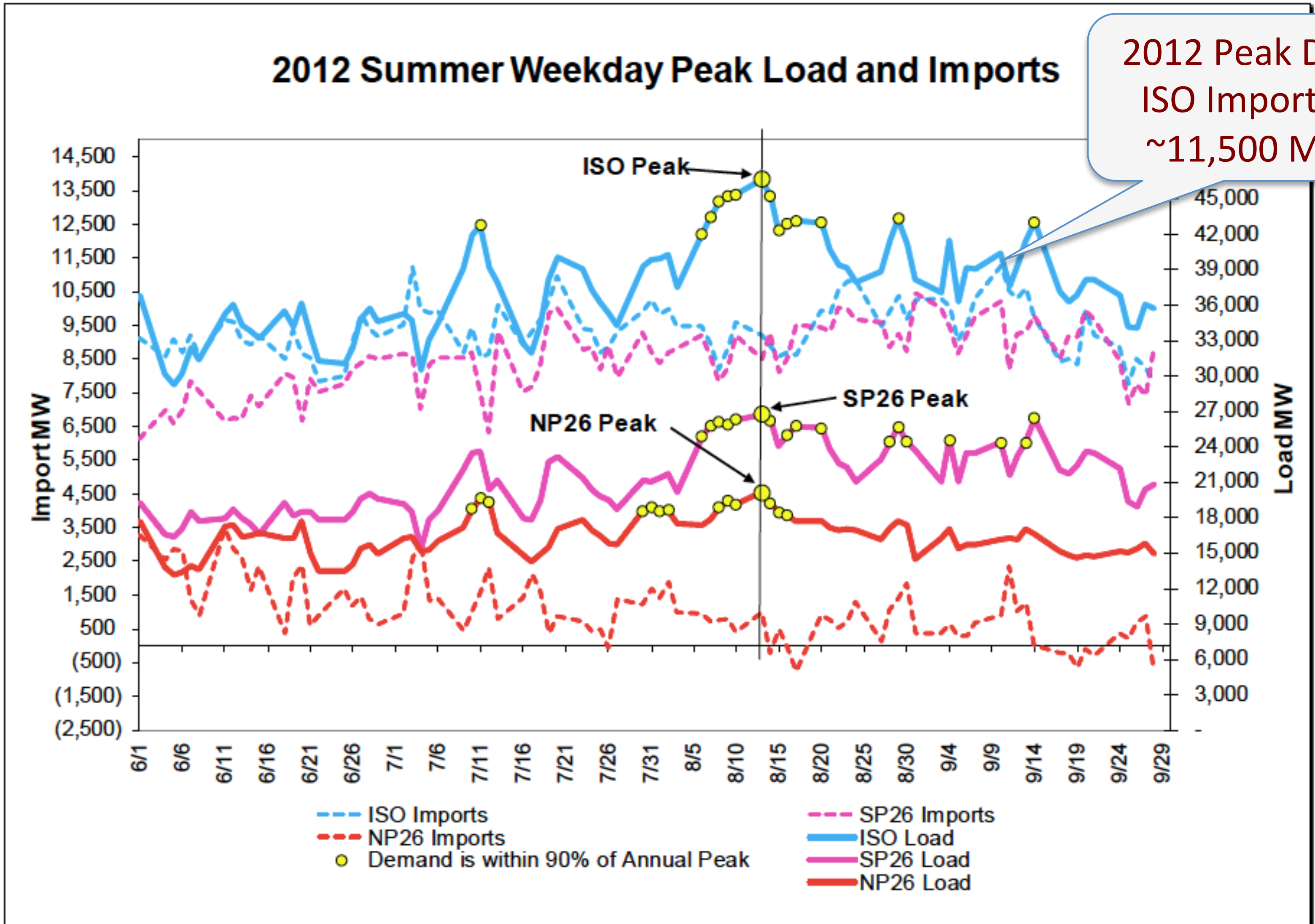
Guided Siting Saves Ratepayers 50%

- **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

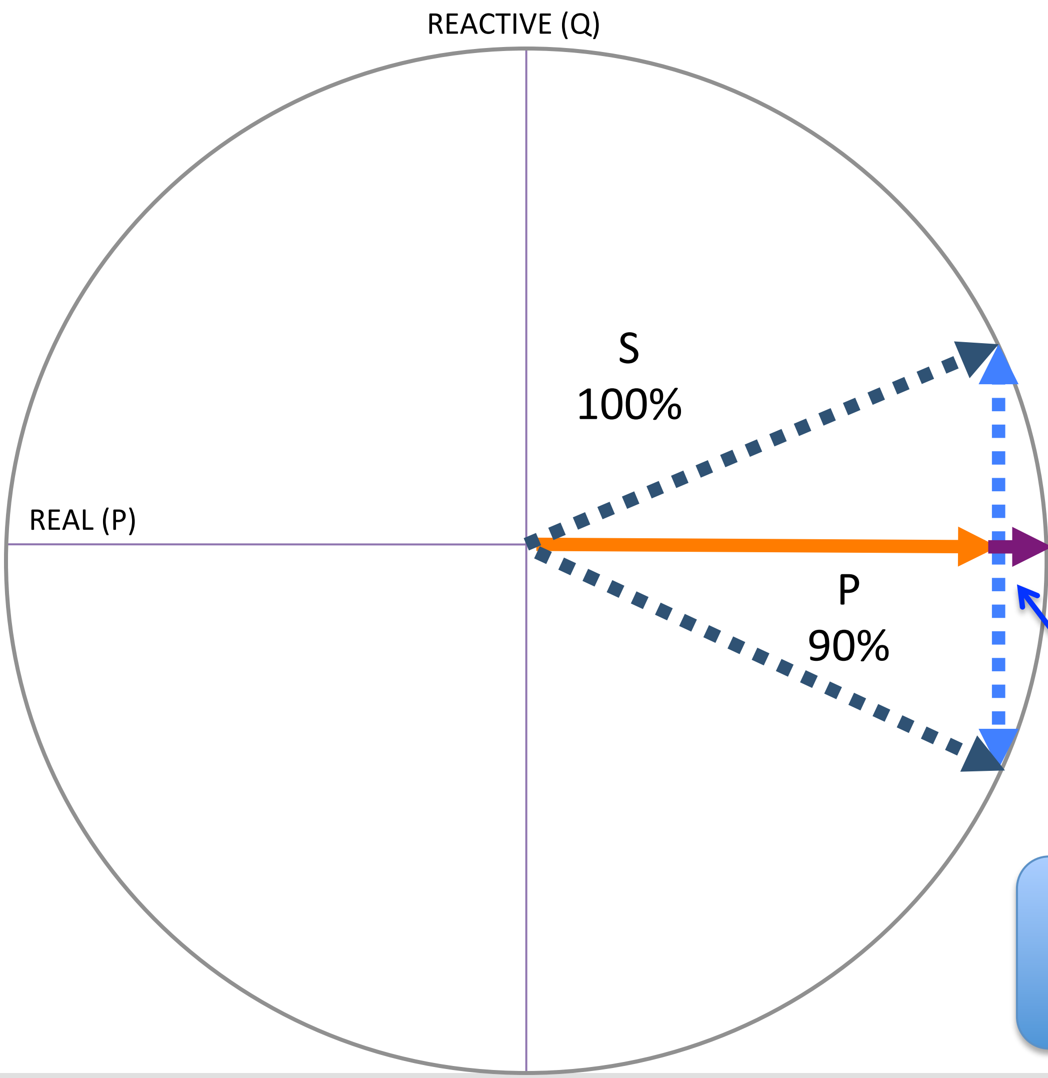
Clean Coalition



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



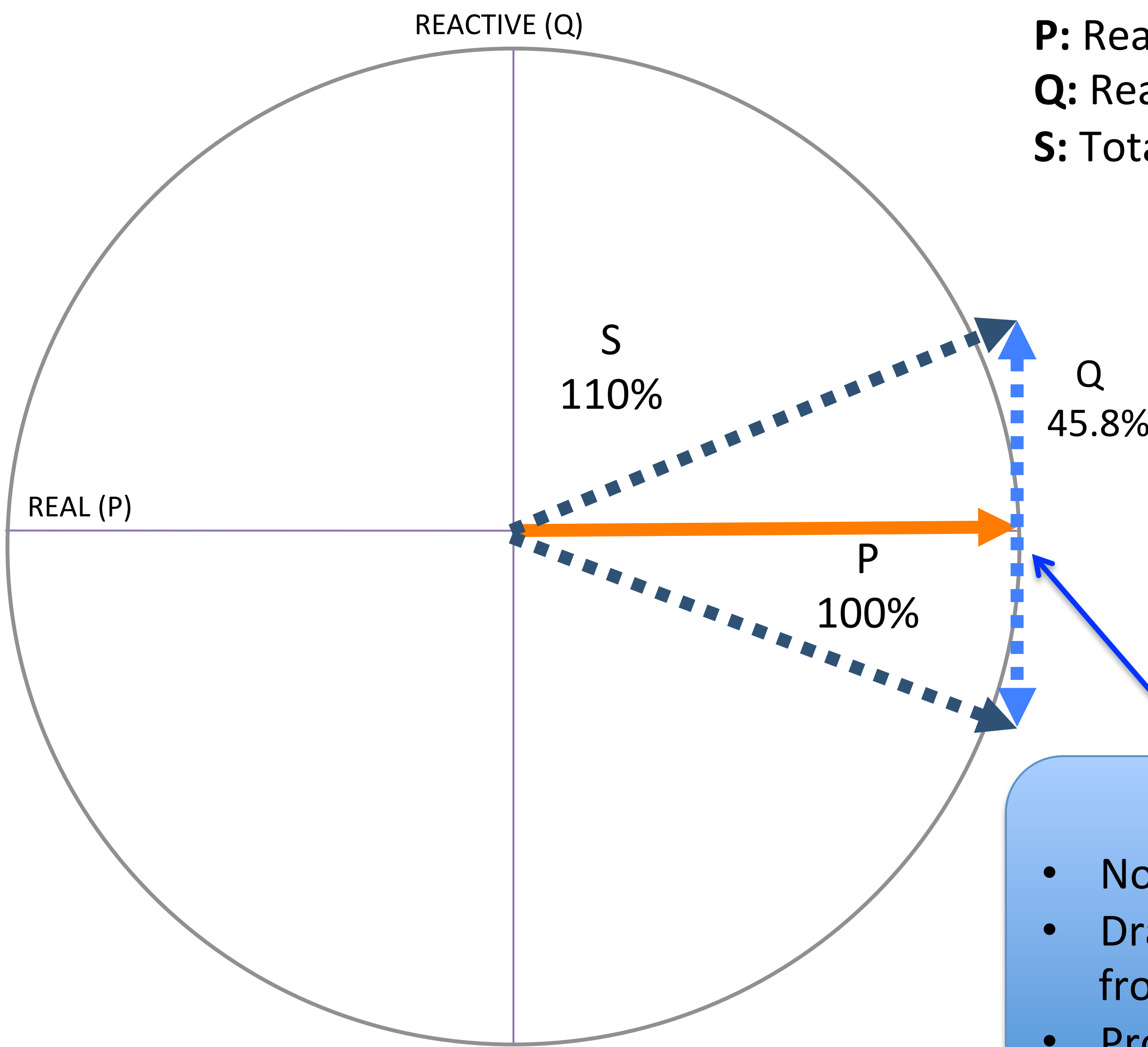
P: Real power (kW)
Q: Reactive power (kVAr)
S: Total power (kVA)

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)

Clean Coalition



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:

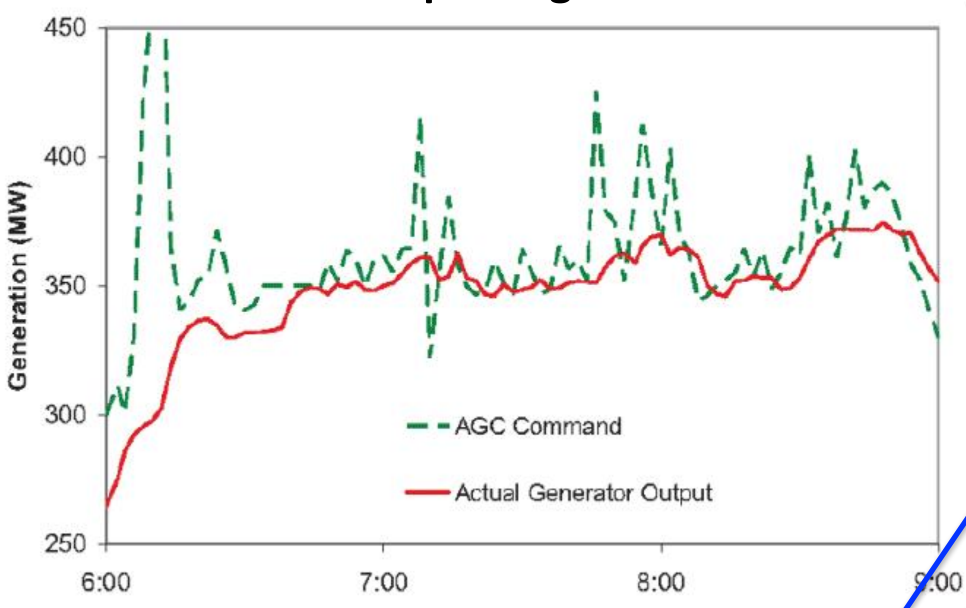
- No reduction of PV real power
- Draws up to 10 kW real power from the grid
- Provides reactive power 24/7/365

Regulation: Faster, More Accurate Solutions

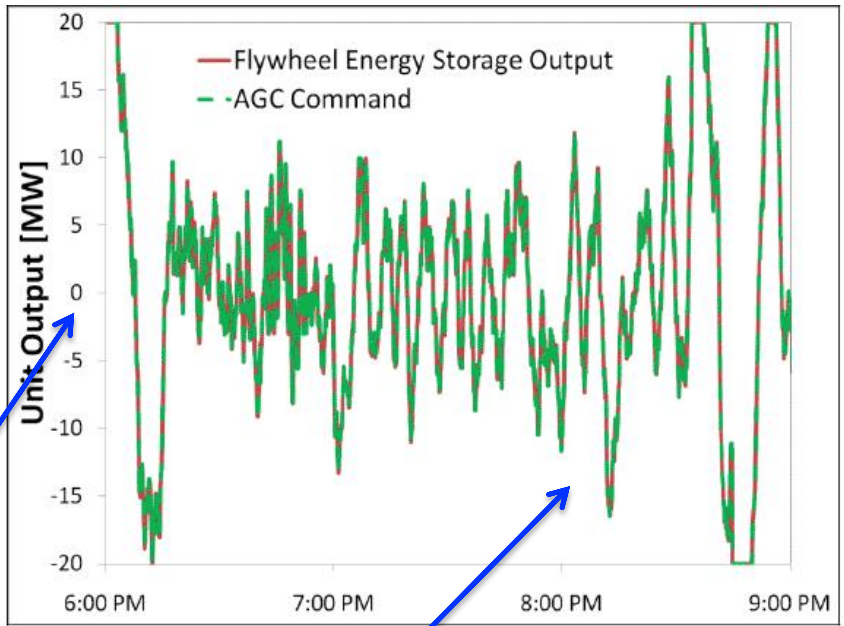
Clean Coalition

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

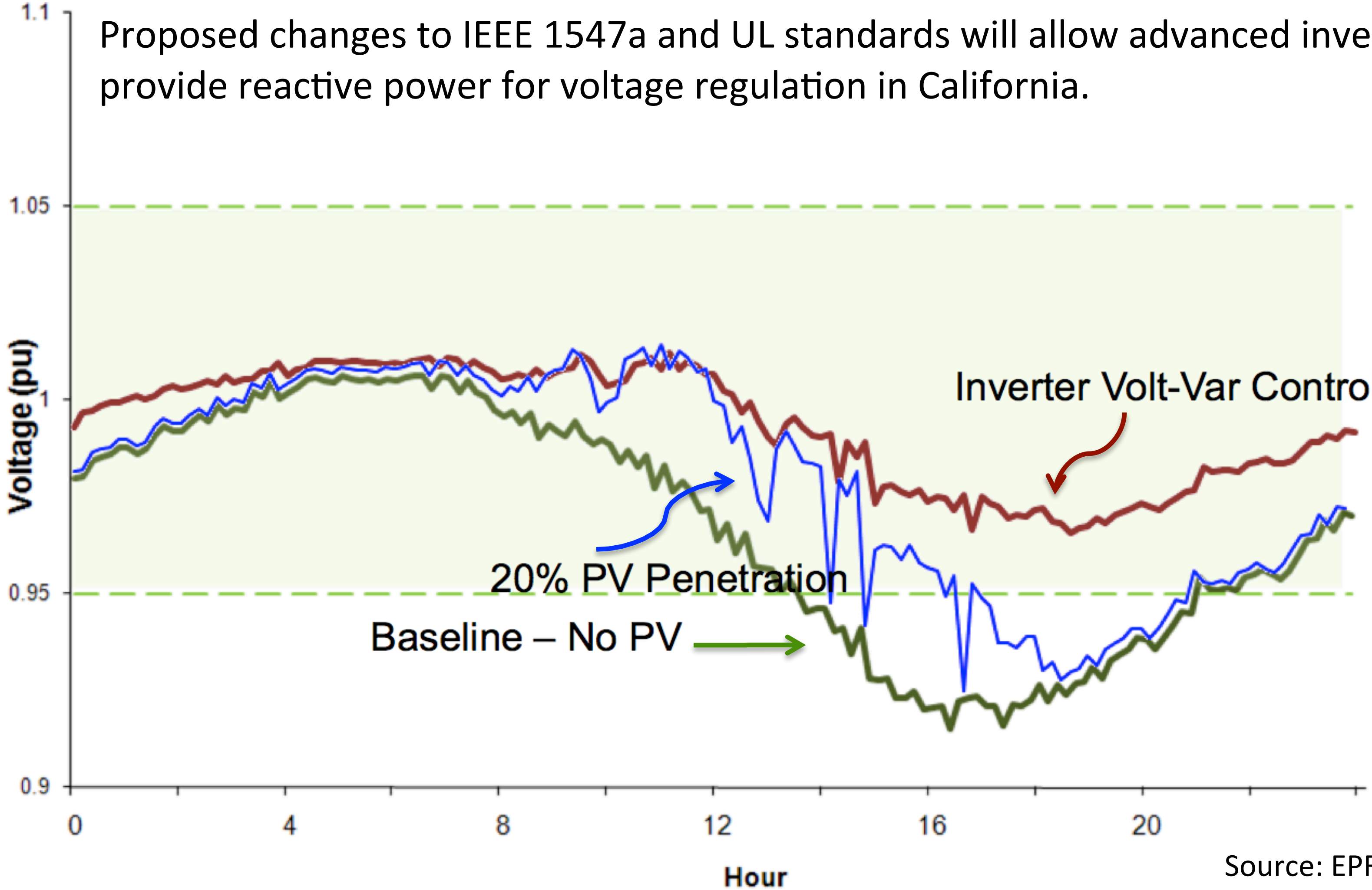
Faster and more accurate regulation = less MW required

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)

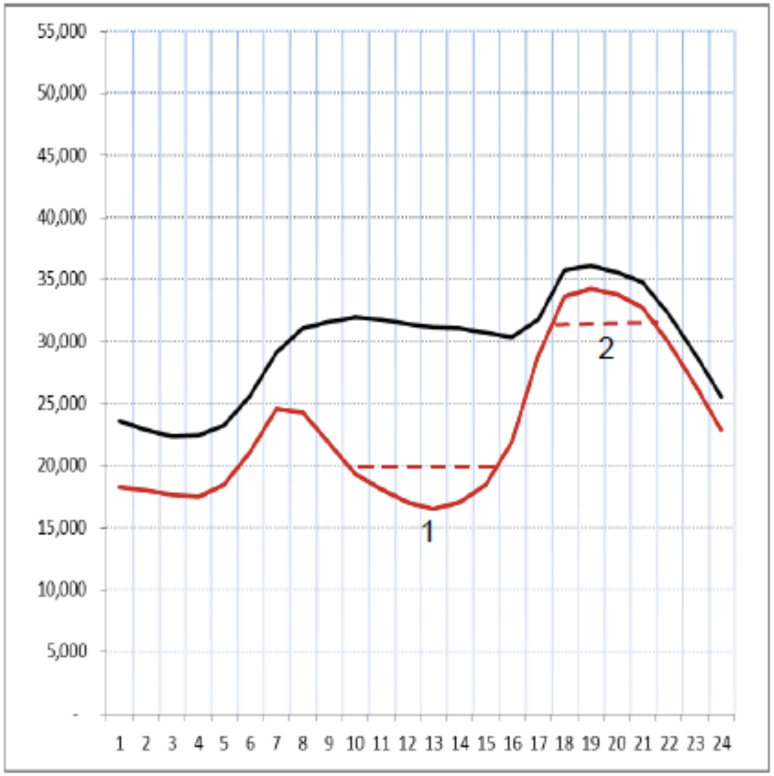
Flattening the Duck – Demand Response

Clean Coalition

PG&E

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

Flattening the Duck – Curtail Baseload

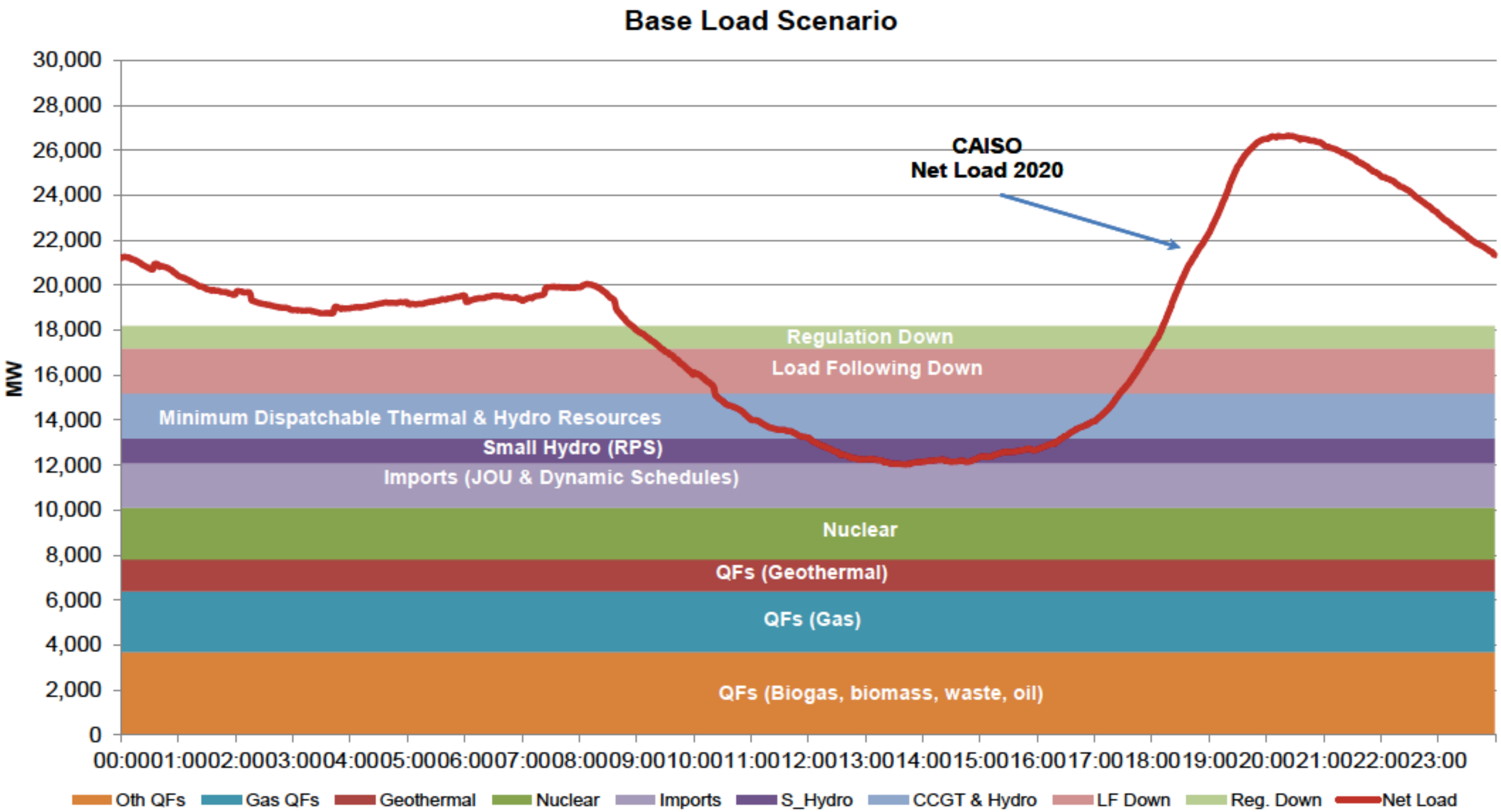
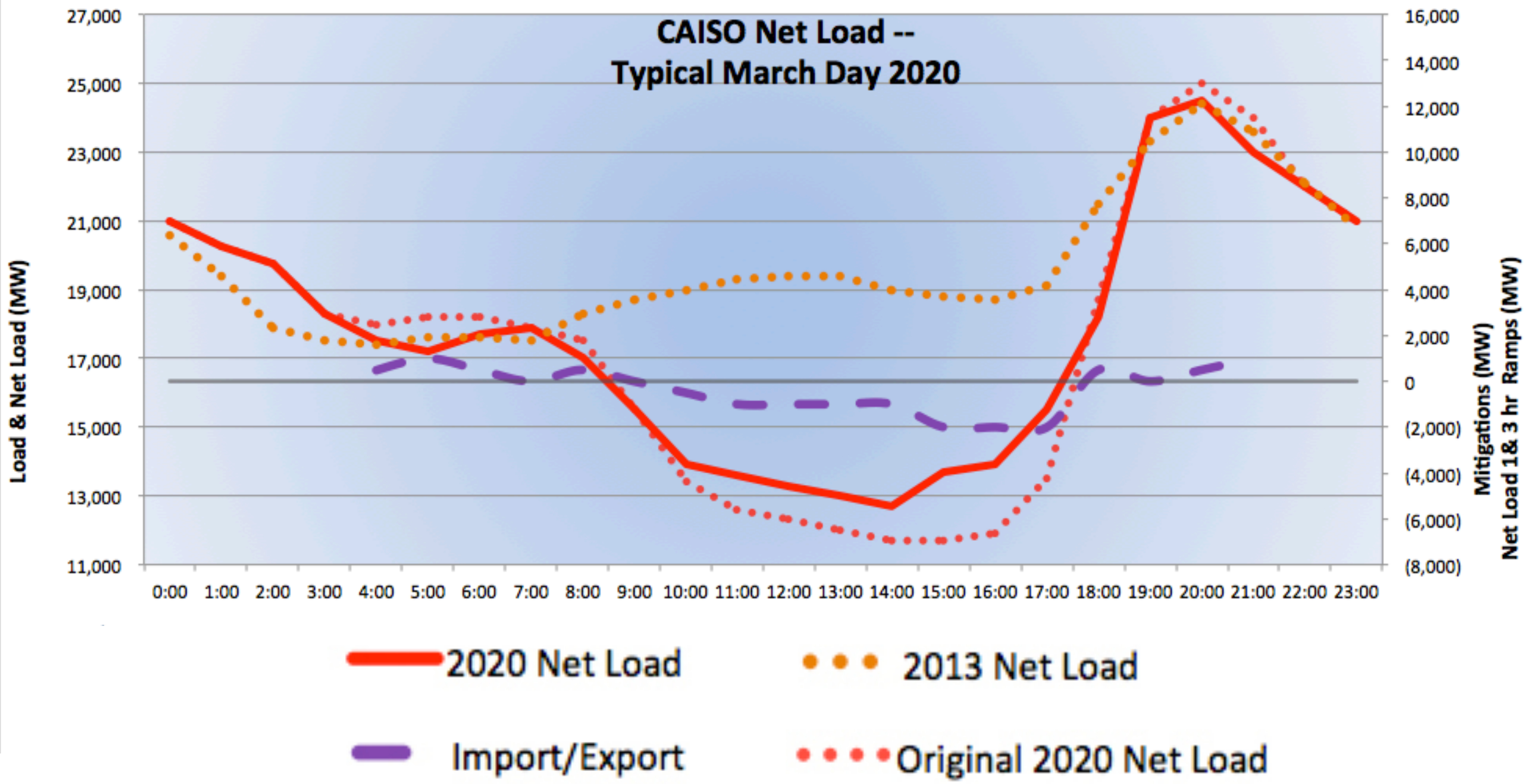


Figure 5: Potential Overgeneration Conditions – March 2020

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

Import/Export Assumptions

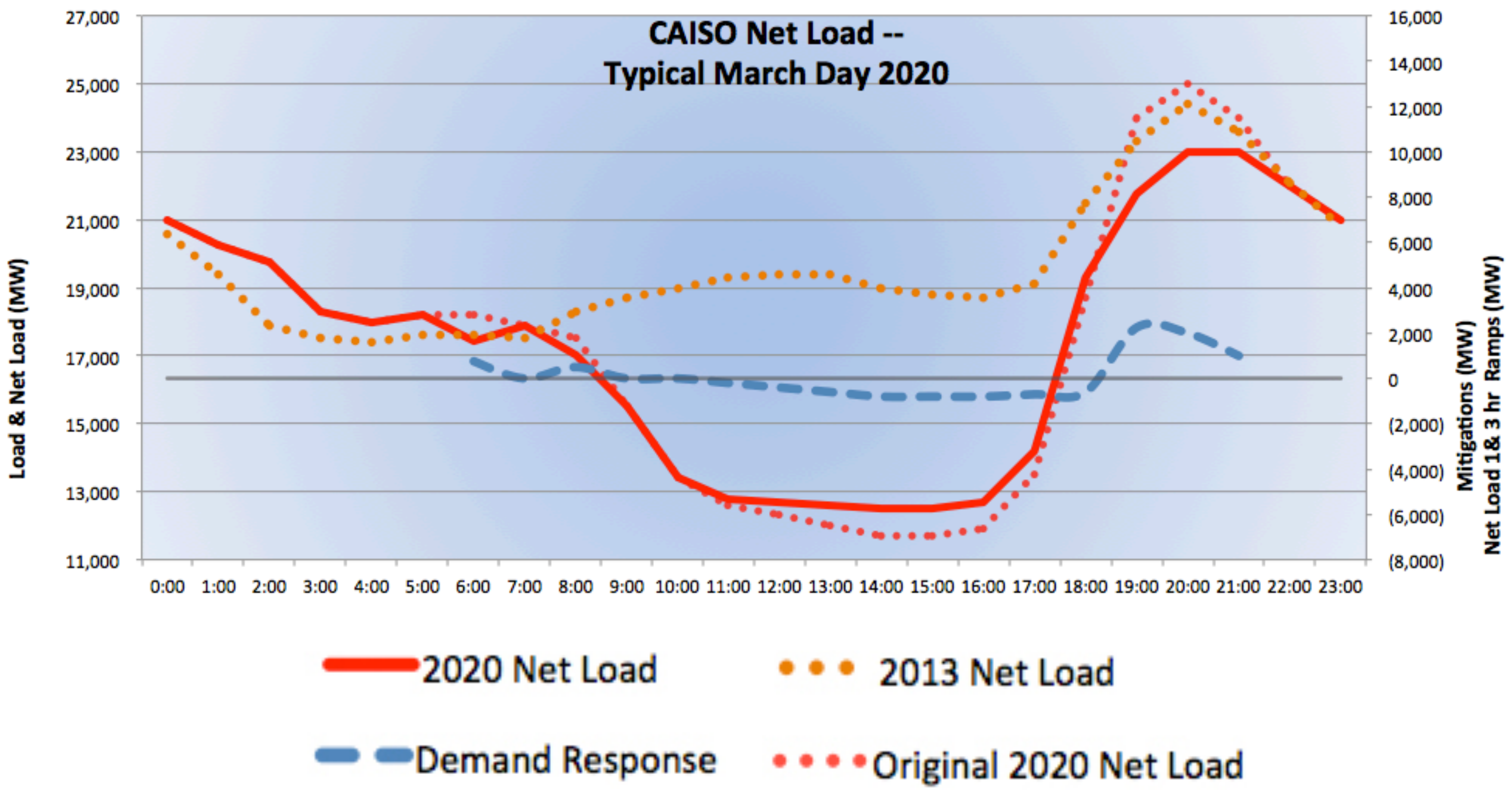
Clean Coalition



	- = 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

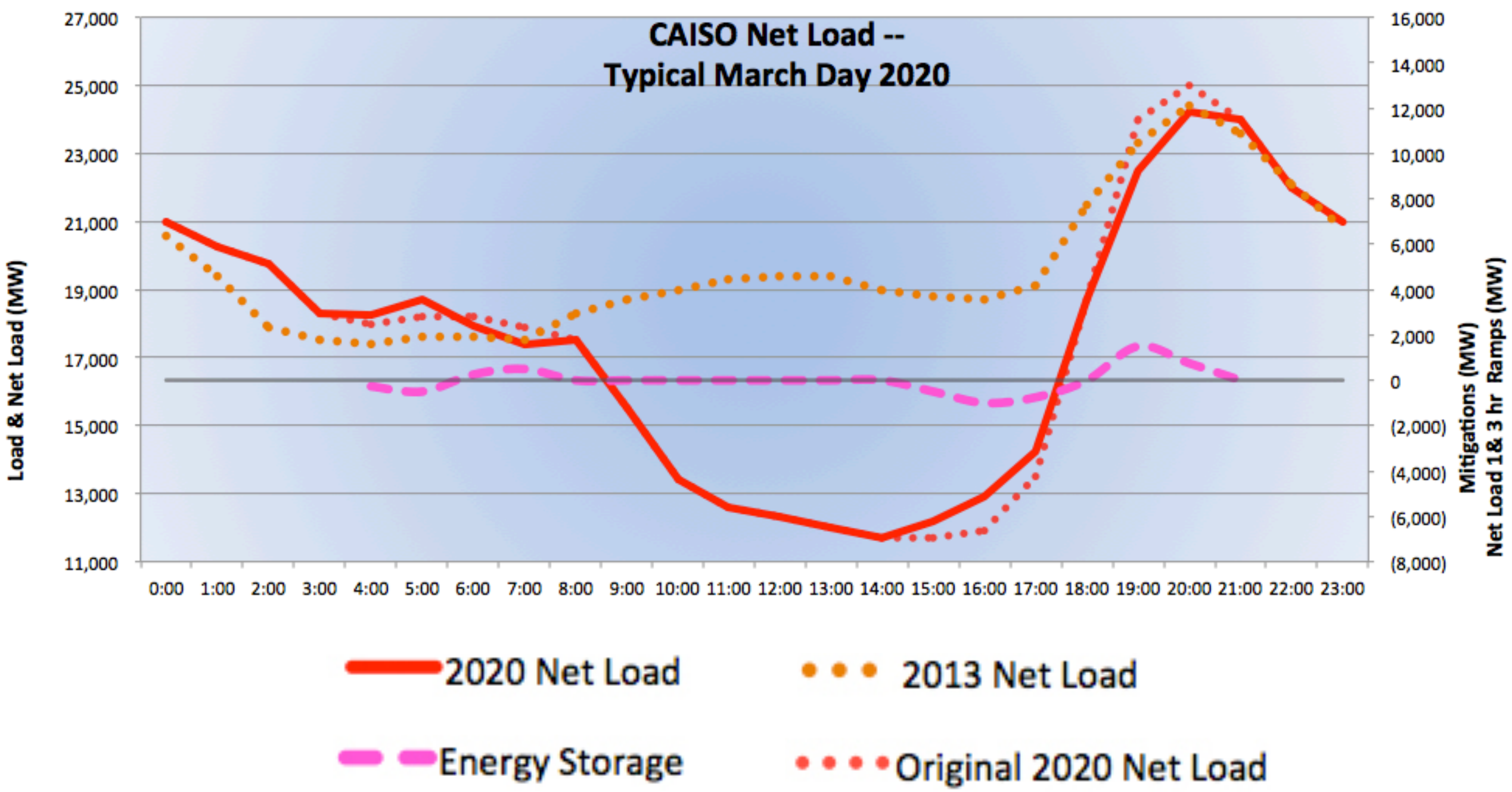
Clean Coalition



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

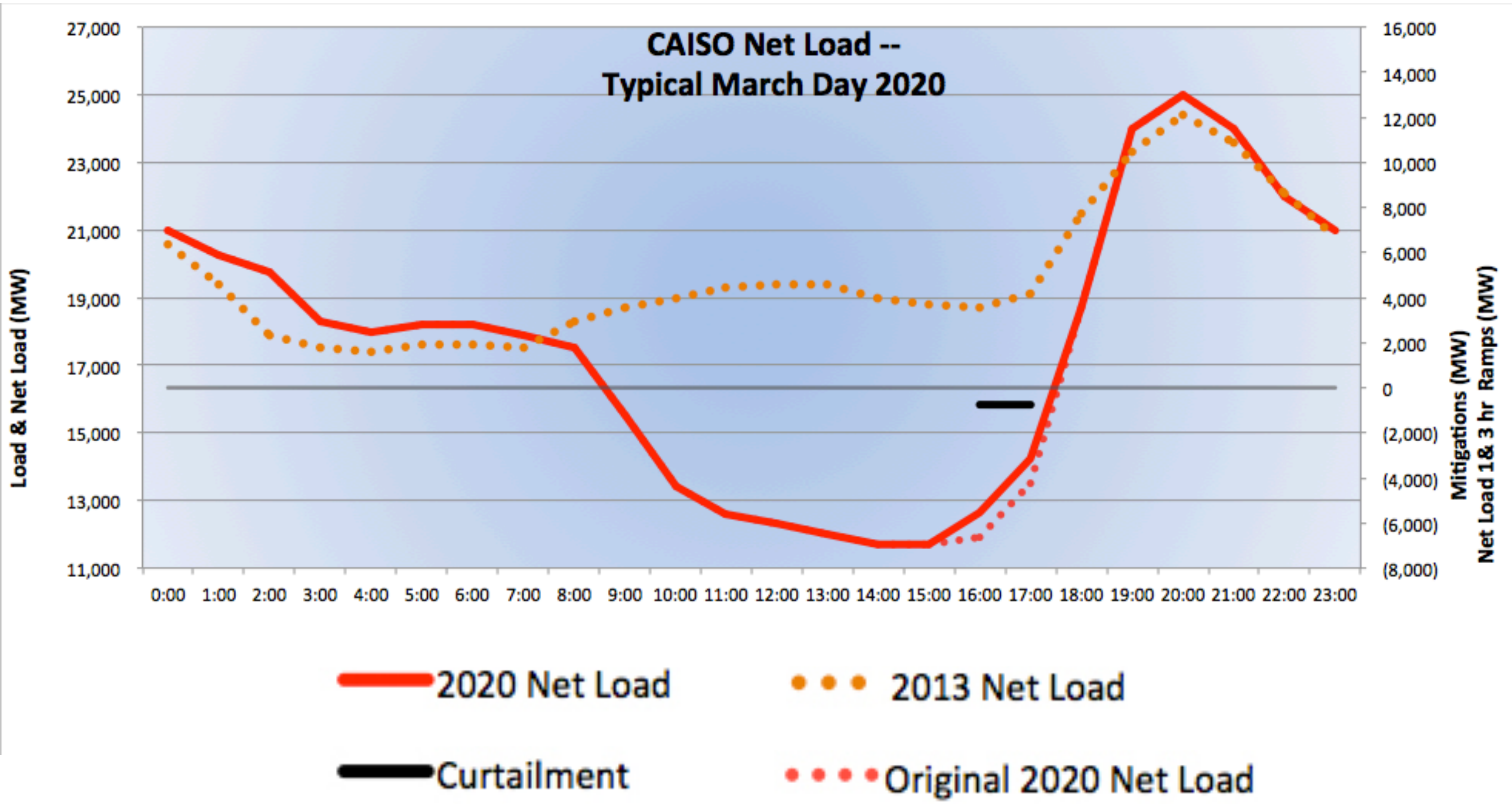
Clean Coalition



	- = 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

Clean Coalition



ToD	+ = Gen 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)

The Fossil Free Future is Arriving

Clean Coalition