Energy Storage Applications and Benefits

What will drive the market? Capturing and monetizing benefit!

Janice Lin
Co-Founder & Executive Director, CESA
Managing Partner, Strategen Consulting

March 27, 2014

Strategen

Strategic thinking and industry expertise creates profitable clean energy businesses

A sampling of our clients:

BOSCH Invented for life

CESA CALIFORNIA ENERGY STORAGE ALLIANCE

CalCEF

Chevron Energy Solutions

FLUIDICENERGY™

FMC

GAF GAF MATERIALS CORPORATION

DMB A Passion for Great Places

HUDSON CLEAN ENERGY

RECURRENT ENERGY

ROCKPORT CAPITAL

SHARP solar electricity

SUNPOWER

U.S. Department of Energy

Walmart

3M

© 2014 California Energy Storage Alliance

CESA CALIFORNIA ENERGY STORAGE ALLIANCE

CESA

CALIFORNIA ENERGY STORAGE ALLIANCE

CESA STEERING COMMITTEE MEMBERS

EAST PENN manufacturing co., inc.

ecoult energy storage solutions

GE Energy Storage

POWERTREE

res AMERICAS powering change

SolarCity

Invenergy

NEXTera ENERGY RESOURCES

SUMITOMO ELECTRIC

UET

Xtreme Power The Power to Control.

CESA 2014 MEMBERSHIP (NOW 80+ STRONG!)

1 Energy Systems, A123 Energy Solutions, AES Energy Storage, Alton Energy, American Vanadium, Aquion Energy, AU Optronics, Beacon Power, Bosch Energy Storage Solutions, Bright Energy Storage, BrightSource Energy, CALMAC, ChargePoint, Christenson Electric Inc., Clean Energy Systems Inc., CODA Energy, Customized Energy Solutions, Deeya Energy, DN Tanks, Duke Energy, Eagle Crest Energy, EaglePicher, East Penn Manufacturing Co., Ecoult, EDF Renewable Energy, Energy Cache, EnerSys, EnerVault, EVGrid, FAFCO Thermal Storage Systems, FIAMM Group, FIAMM Energy Storage Solutions, Flextronics, Foresight Renewable Systems, GE Energy Storage, Green Charge Networks, Greensmith Energy Management Systems, Gridtential Energy, Halotechnics, Hecate Energy LLC, Hitachi Chemical, Hydrogenics, Ice Energy, ImMODO Energy Services, Innovation Core SEI, Invenergy, K&L Gates LLP, KYOCERA Solar, LightSail Energy, LG Chem Ltd., NextEra Energy Resources, NRG Energy, OCI Company Ltd., OutBack Power Technologies, Panasonic, Parker Hannifin, PDE Total Energy Solutions, Powertree Services, Primus Power, RedFlow Technologies, RES Americas, Rosendin Electric, S&C Electric Co., Saft America, Samsung SDI, SeaWave Battery Inc.,Sharp Labs of America, Silent Power, SolarCity, Sovereign Energy Storage LLC, Stem, Stoel Rives LLP, Sumitomo Corporation of America, ---TAS Energy, Tri-Technic, UniEnergy Technologies, Xtreme Power, and Wellhead Electric Co.

Successful Launch in September 2013

ENERGY® STORAGE NORTH AMERICA

"I've been to a lot of conferences, yet I've learned more at Energy Storage North America in the first four hours than I've learned at any other conference I've attended"

Phil Undercuffler, Director, Product Management and Strategy at OutBack Power Technologies

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Join us in San Jose on September 30 – October 2, 2014

JOIN THE INDUSTRY LEADERS

Mike Florio
Commissioner –
California Public Utilities Commission

Peter Rives
Co-Founder & CTO
Solar City

John Norris
Commissioner
Federal Energy Regulatory Commission

Carla Peterman
Commissioner –
California Public Utilities Commission

Eric Schmitt
Vice President, Operations
California ISO

Fong Wan
Senior Vice President, Energy Procurement
Pacific Gas & Electric

Mateo Jaramillo
Director of Powertrain Business Development
Tesla Motors

HIGHLIGHTS

- ❑ 3 Days
- ❑ 80 Speakers
- ❑ 6 Tracks
- ❑ Workshops
- ❑ Site Visits
- ❑ Awards

3 FOCUS AREAS

INTEGRATION

MARKETS

POLICY

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Global Energy Storage Alliance – New Global Non Profit

GESA
Global Energy Storage Alliance

GESA Mission

"Advance education, collaboration, knowledge and proven frameworks about the benefits of energy storage and how it can be used to achieve a more efficient, cleaner, reliable, affordable and secure electric power system globally"

ALLIANCE FOR RENEWABLE ENERGY
BVES GERMAN ENERGY STORAGE ASSOCIATION
CESA CALIFORNIA ENERGY STORAGE ALLIANCE
CHINA ENERGY STORAGE ALLIANCE CNESA
IESA India Energy Storage Alliance

DOE Global Energy Storage Database

Sandia National Laboratories

Home

PROJECTS

Basic Search

Advanced Search

US POLICIES

Basic Search

Advanced Search

UPLOAD INFORMATION

New Project

New Policy

Upload Project

Contact Us

Projects

Search Filters

- Technology Type
- Country
- State/Province
- Rated Power
- Duration
- Service/Use Case
- Ownership Model
- Status
- Grid Interconnection

☑ Show Unverified Entries

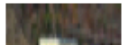
Reset Filters

Google Map Export

Export to Excel | Export to PDF

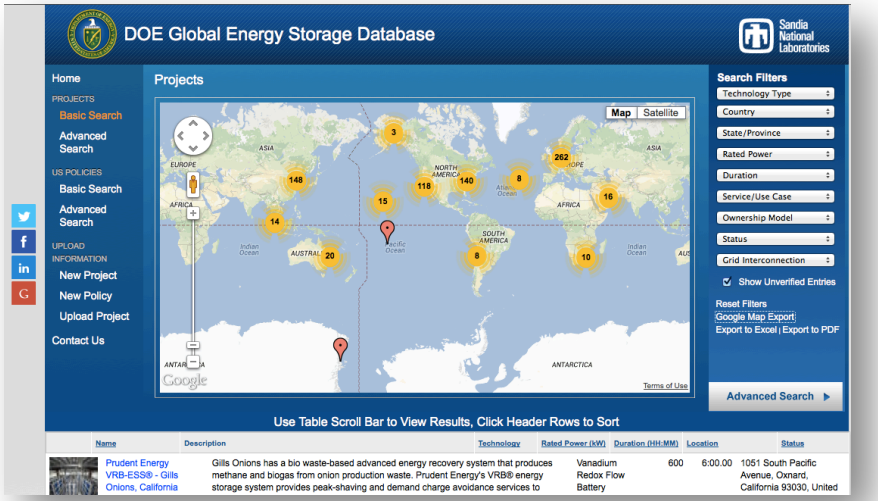
Advanced Search ▶

Use Table Scroll Bar to View Results, Click Header Rows to Sort

	Name	Description	Technology	Rated Power (kW)	Duration (HH:MM)	Location	Status
	Prudent Energy VRB-ESS® - Gills Onions, California	Gills Onions has a bio waste-based advanced energy recovery system that produces methane and biogas from onion production waste. Prudent Energy's VRB® energy storage system provides peak-shaving and demand charge avoidance services to reduce Gills Onions' monthly electric utility bill.	Vanadium Redox Flow Battery	600	6:00.00	1051 South Pacific Avenue, Oxnard, California 93030, United States	
	Kahuku Wind Farm	Xtreme Power installed a 15 MW fully integrated energy storage and power management system designed to provide load firming for a 30 MW wind farm in Hawaii, as well as provide critical grid integration services. The project is supported by a U.S. DOE Office of Electricity loan guarantee. This is one of at least 3 other wind farm projects either planned or operational in Hawaii.	Advanced Lead Acid Battery	15,000	0:15.00	56-1101 Kamehameha Hwy, , Kahuku, Hawaii 96731, United States	
	Bath County Pumped Storage Station	This project consists of a 3GW Pumped Hydro storage plant in Virginia that pumps water to an elevated reservoir at night and lets it run back down to generate electricity during	Open Loop Pumped	3,030,000	10:18.00	State Route 705, George Washington National	

US DOE Global Energy Storage Database

DOE Global Energy Storage Database (GESDB)
Market Development Through Access To Quality Information
www.sandia.gov/ess/database



Overview & Mission Statement

- Provides free, up-to-date information on grid-connected energy storage projects and relevant state and federal policies
- Database went live in May 2012
- 60+ data fields for each project, 50+ energy storage technologies, 3rd party verification process, data is exportable to MS Excel or PDF

Milestones & Progress to Date

- 145 GW of energy storage , 850+ projects, 57 countries, 18 federal and state policies
- Over 450K page views from 161 countries

2014 Plans

- International partnerships
- Grow policy coverage internationally
- Include codes & standards
- Increase publicity and visibility
- Improve usability

Special thanks to

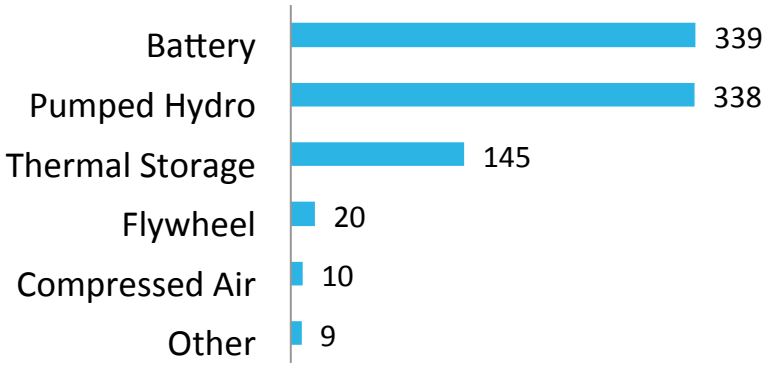
- Dr. Imre Gyuk, US Department of Energy, Office of Electricity Deliverability and Energy Reliability
- Georgianne Huff, PE, PMP, Sandia National Laboratories

© 2014 Strategen

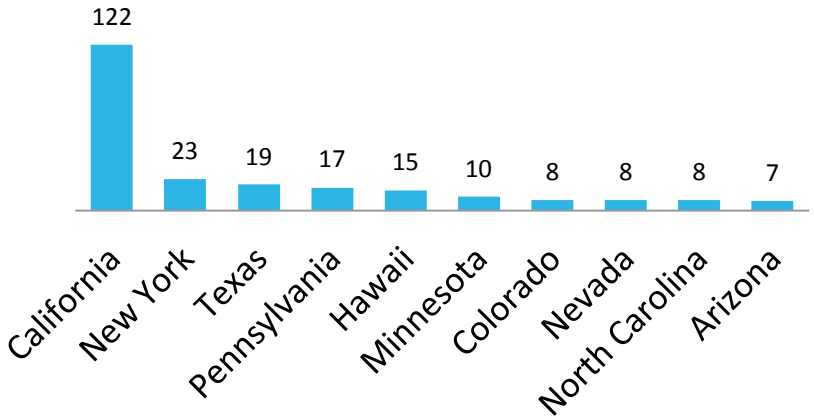
STRATEGEN
STRATEGIES FOR CLEAN ENERGY

March 2014: 861 Projects Worldwide, 185 GW

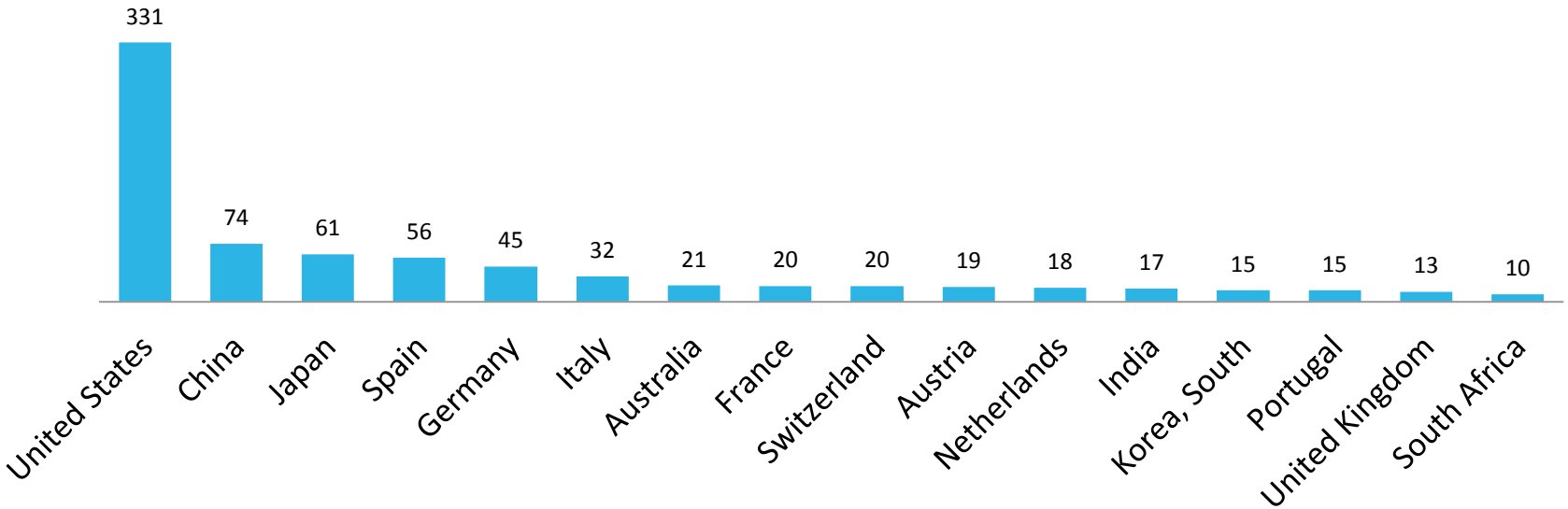
TECHNOLOGY TYPE



LEADING US STATES



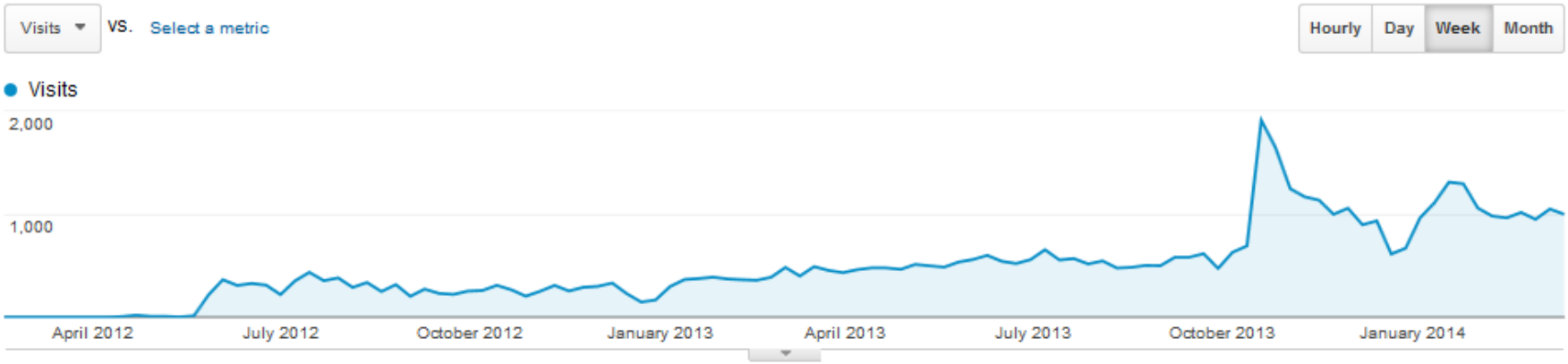
PROJECTS BY COUNTRY (Top 16)



© 2014 Strategen

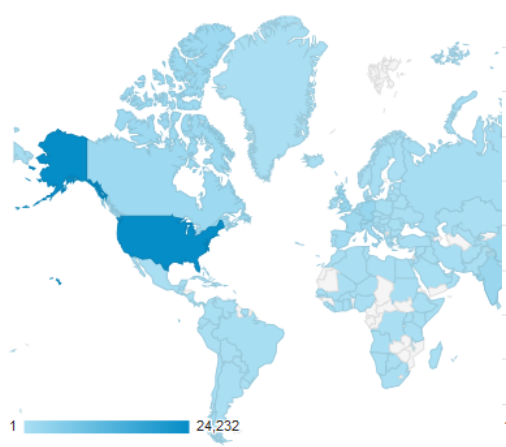
STRATEGEN
STRATEGIES FOR CLEAN ENERGY

Users: 31,000 visitors – 161 Countries – 450,000 page views



Visits	Unique Visitors	Pageviews
53,262	31,493	457,216
Pages / Visit	**Avg. Visit Duration**	**Bounce Rate**
8.58	00:05:04	1.21%
% New Visits		
59.12%		

161 Countries



1. United States
2. Germany
3. United Kingdom
4. India
5. South Korea
6. Canada
7. Italy
8. France
9. China
10. Japan

© 2014 Strategen

STRATEGEN
STRATEGIES FOR CLEAN ENERGY

Energy Storage Is A Very Broad Asset Class

Chemical Storage

(Batteries)

Mechanical Storage

(Flywheel)

Bulk Mechanical Storage

(Compressed Air)

Thermal Storage

(Ice)

(Molten Salt)

Bulk Gravitational Storage

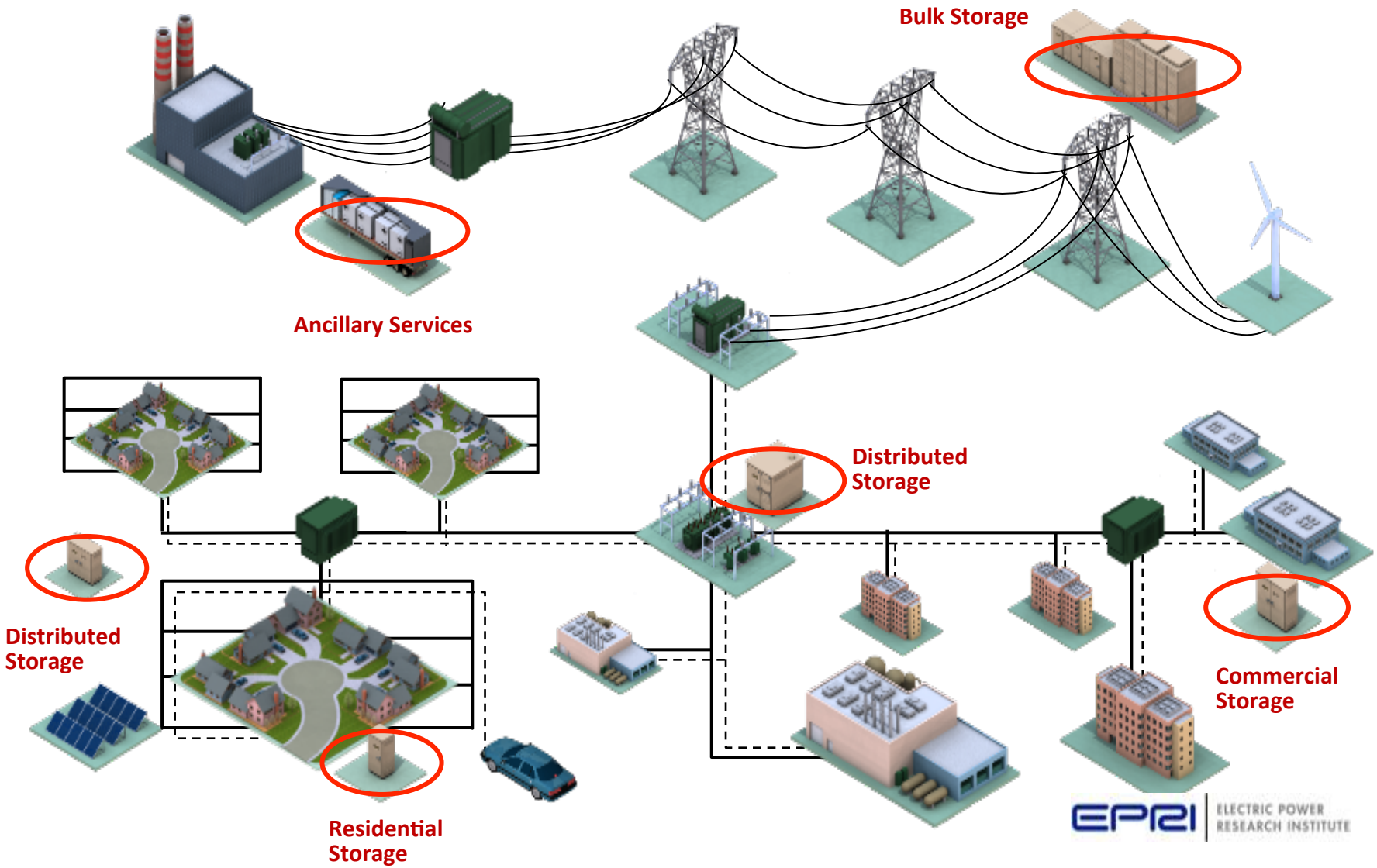
(Pumped Hydro)

(Gravel)

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

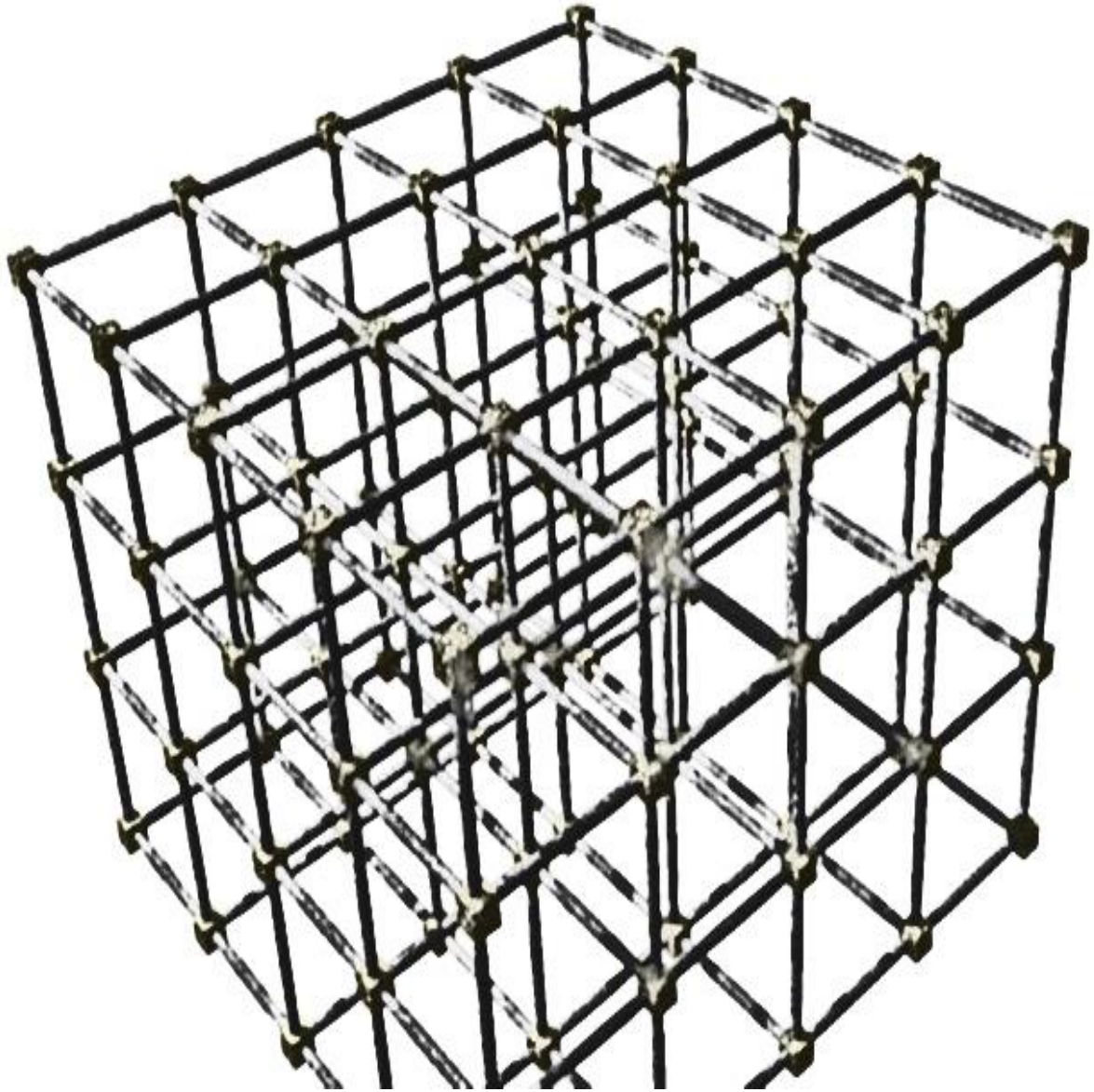
Diversity & Modularity = Broad Electric Power System Applicability



© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

What is the framework for value and cost effectiveness?



© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

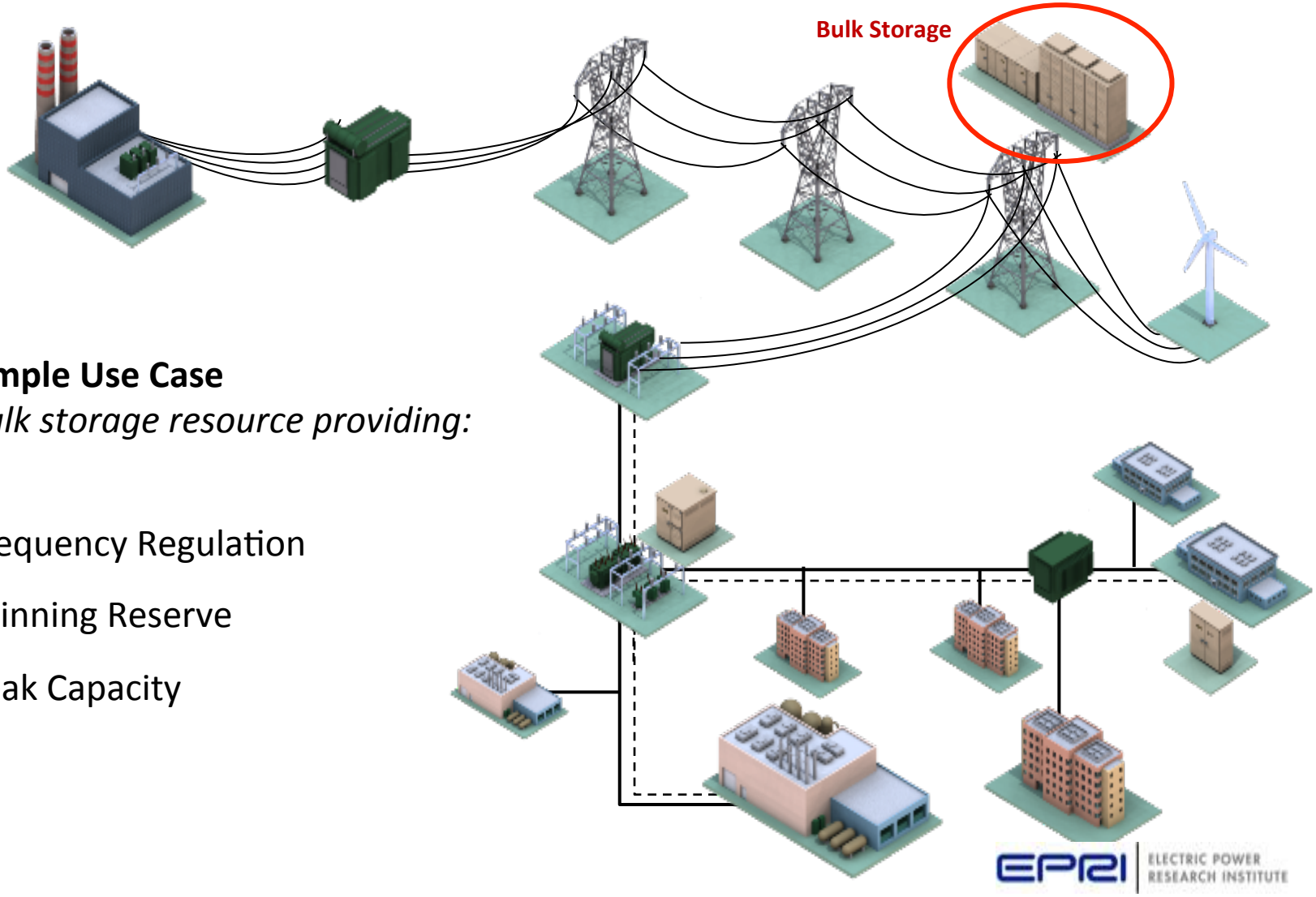
Definition of Energy Storage "application" or "use case"

We followed Southern California Edison's definition of an application/use case as:

"A collection of benefits that can be captured by a single storage device sited in a particular place and used in a particular way"

© 2014 California Energy Storage Alliance

Application Example 1



Example Use Case

A bulk storage resource providing:

» Frequency Regulation

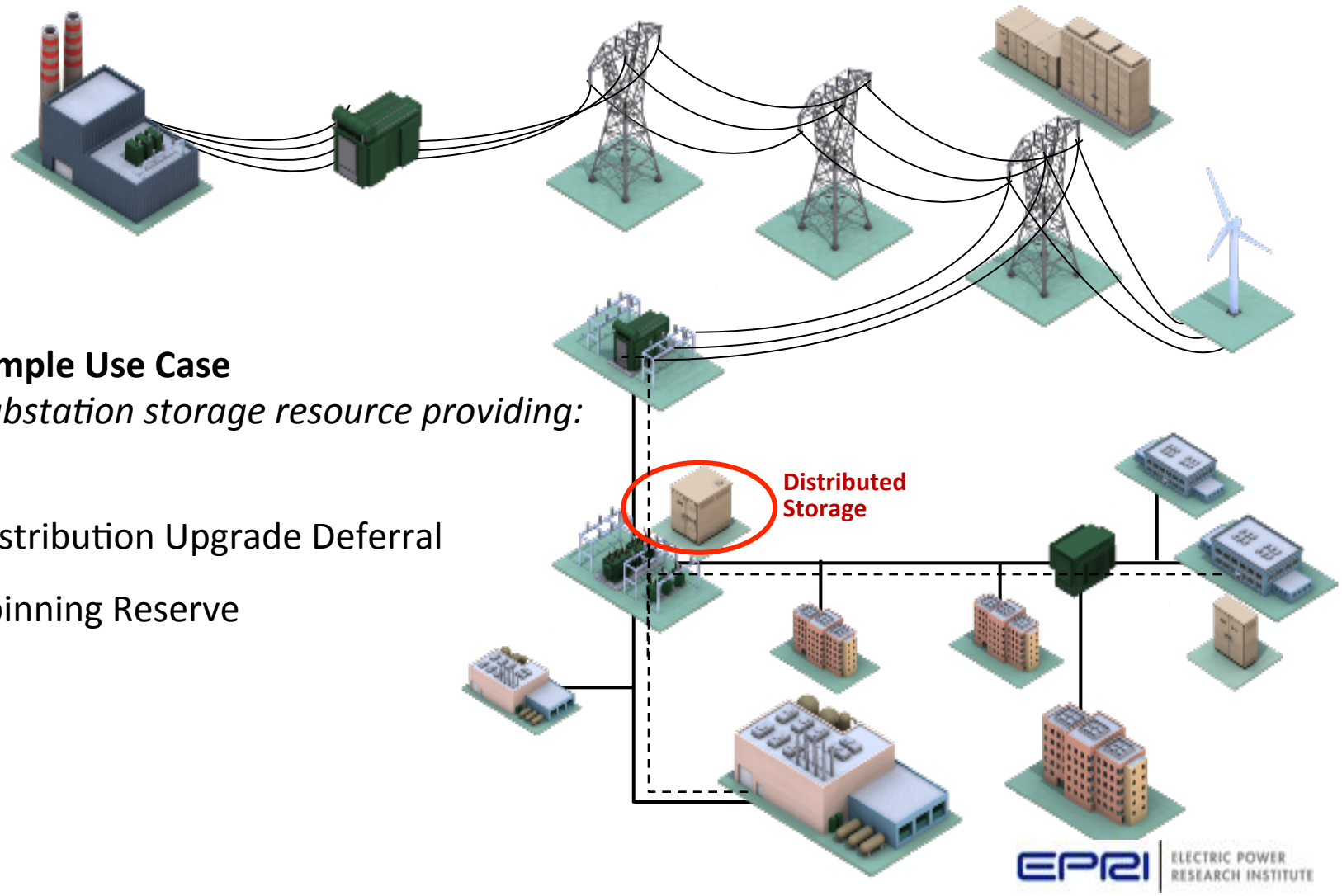
» Spinning Reserve

» Peak Capacity

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Application Example 2



Example Use Case

A substation storage resource providing:

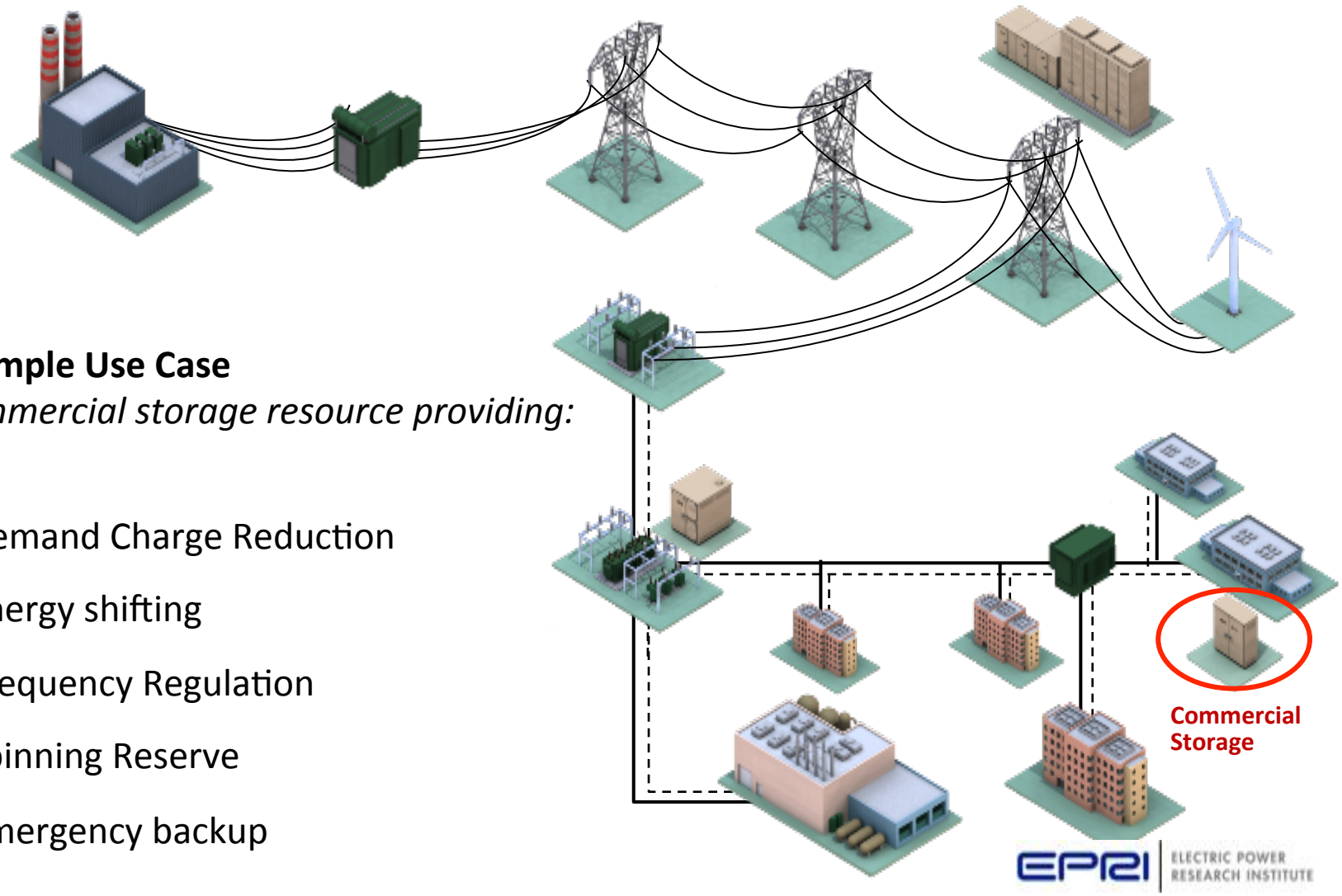
» Distribution Upgrade Deferral

» Spinning Reserve

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Application Example 3



Example Use Case

Commercial storage resource providing:

» Demand Charge Reduction

» Energy shifting

» Frequency Regulation

» Spinning Reserve

» Emergency backup

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

So what are these benefits?

Frequency Regulation

Reliability

Time Shifting

Transmission Upgrade Deferral

Demand Charge Reduction

Voltage Support

Distribution Upgrade Deferral

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

What are the possible benefits of grid storage?

Market Services

Electric Energy Time-Shifting

Frequency Response

Frequency Regulation Up

Frequency Regulation Down

Ramping

Real-Time Energy Balancing

Synchronous Reserve (Spin)

Non-Synchronous Reserve

Black Start

Capacity Products

System Electric Supply Capacity

Local Electric Supply Capacity

Resource Adequacy

Generation Services

Intermittent Resource Integration (Ramping & Voltage Support)

Variable Energy Resource Shifting, Voltage Sag, Rapid Demand Support

Supply Firming

Transmission/Distribution

Peak Shaving: Load Shift

Transmission Peak Capacity Deferral

Transmission Operation

Transmission Congestion Relief

Distribution Peak Capacity Deferral

Distribution Operation (Voltage/VAR Support)

Additional Grid Benefits

Reduced fossil fuel use

Increased renewables

Grid Reliability

Faster build time

Modularity/incremental build

Mobility

Flexibility of purpose

Optionality

Locational flexibility

Multi-site aggregation

32

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Some are compensated under current CA rules

Market Services

- Electric Energy Time-Shifting
- Frequency Response
- Frequency Regulation Up
- Frequency Regulation Down
- Ramping
- Real-Time Energy Balancing
- Synchronous Reserve (Spin)
- Non-Synchronous Reserve
- Black Start

Capacity Products

- System Electric Supply Capacity
- Local Electric Supply Capacity
- Resource Adequacy

Generation Services

- Intermittent Resource Integration (Ramping & Voltage Support)
- Variable Energy Resource Shifting, Voltage Sag, Rapid Demand Support
- Supply Firming

Transmission/Distribution

- Peak Shaving: Load Shift
- Transmission Peak Capacity Deferral
- Transmission Operation
- Transmission Congestion Relief
- Distribution Peak Capacity Deferral
- Distribution Operation (Voltage/VAR Support)

Additional Grid Benefits

- Reduced fossil fuel use
- Increased renewables
- Grid Reliability
- Faster build time
- Modularity/incremental build
- Mobility
- Flexibility of purpose
- Optionality
- Locational flexibility
- Multi-site aggregation

© 2014 California Energy Storage Alliance
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Some may be partially compensated

Market Services

Electric Energy Time-Shifting

Frequency Response

Frequency Regulation Up

Frequency Regulation Down

Ramping

Real-Time Energy Balancing

Synchronous Reserve (Spin)

Non-Synchronous Reserve

Black Start

Capacity Products

System Electric Supply Capacity

Local Electric Supply Capacity

Resource Adequacy

Generation Services

Intermittent Resource Integration (Ramping & Voltage Support)

Variable Energy Resource Shifting, Voltage Sag, Rapid Demand Support

Supply Firming

Transmission/Distribution

Peak Shaving: Load Shift

Transmission Peak Capacity Deferral

Transmission Operation

Transmission Congestion Relief

Distribution Peak Capacity Deferral

Distribution Operation (Voltage/VAR Support)

Additional Grid Benefits

Reduced fossil fuel use

Increased renewables

Grid Reliability

Faster build time

Modularity/incremental build

Mobility

Flexibility of purpose

Optionality

Locational flexibility

Multi-site aggregation

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Other benefits are not yet captured

Market Services

Electric Energy Time-Shifting

Frequency Response

Frequency Regulation Up

Frequency Regulation Down

Ramping

Real-Time Energy Balancing

Synchronous Reserve (Spin)

Non-Synchronous Reserve

Black Start

Capacity Products

System Electric Supply Capacity

Local Electric Supply Capacity

Resource Adequacy

Generation Services

Intermittent Resource Integration (Ramping & Voltage Support)

Variable Energy Resource Shifting, Voltage Sag, Rapid Demand Support

Supply Firming

Transmission/Distribution

Peak Shaving: Load Shift

Transmission Peak Capacity Deferral

Transmission Operation

Transmission Congestion Relief

Distribution Peak Capacity Deferral

Distribution Operation (Voltage/VAR Support)

Additional Grid Benefits

Reduced fossil fuel use

Increased renewables

Grid Reliability

Faster build time

Modularity/incremental build

Mobility

Flexibility of purpose

Optionality

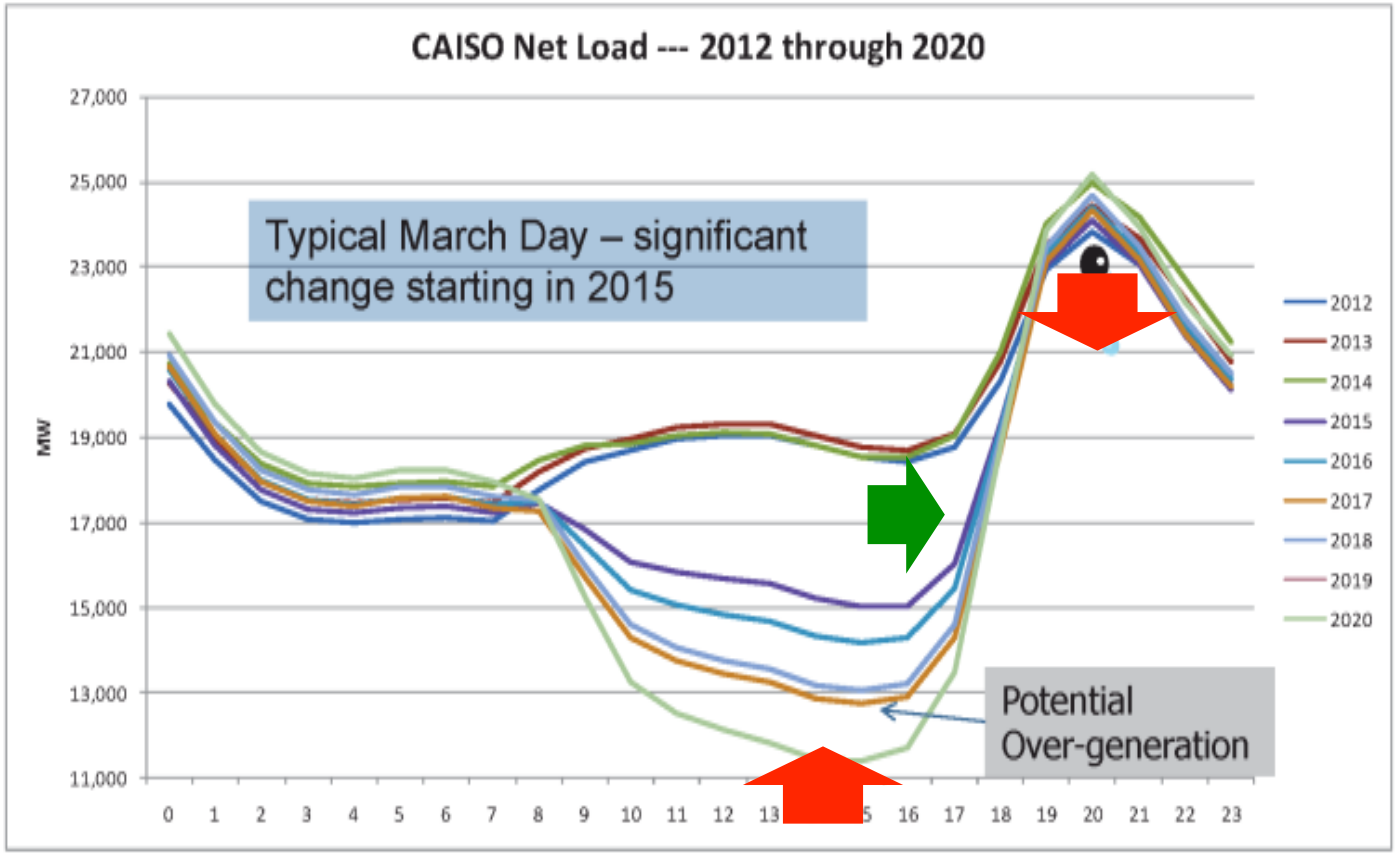
Locational flexibility

Multi-site aggregation

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

New Requirements in California: Flexible Capacity



California ISO

ISO PUBLIC – © 2012 CAISO

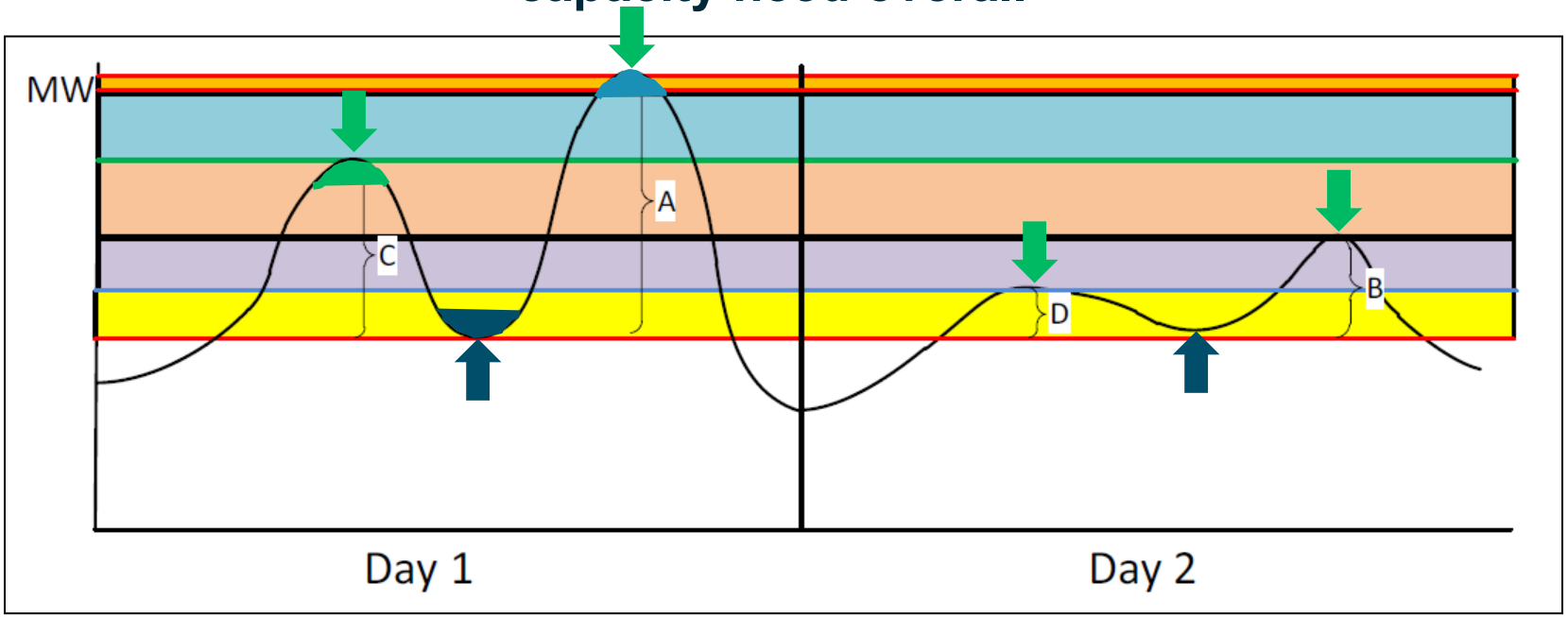
Page 7

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Storage effect on flexible capacity

Longer duration energy storage can shift larger amounts of energy, adding flexible capacity while reducing the flexible capacity need overall[1]



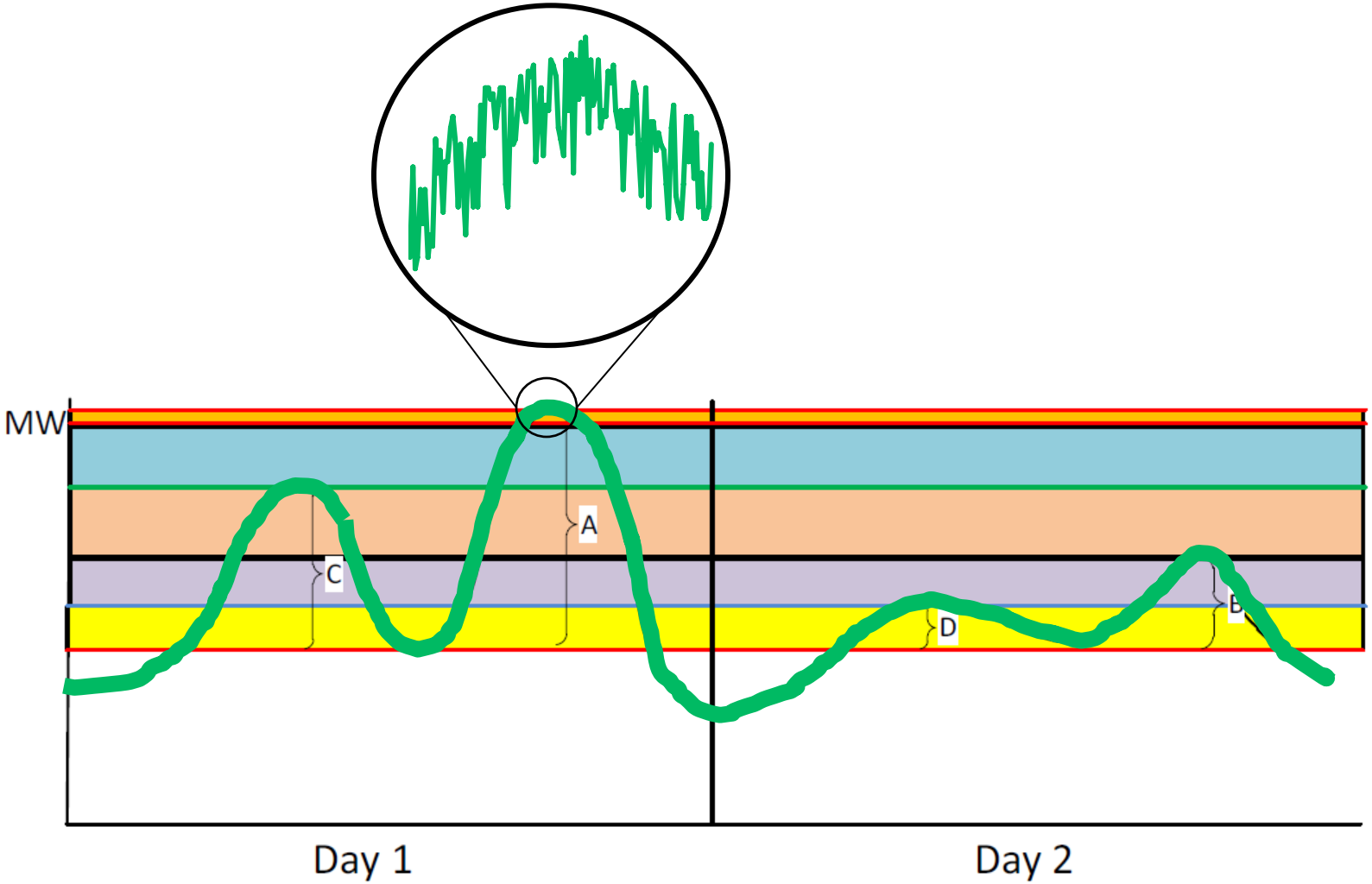
Reducing the need for flexible capacity (raising the red line) will lead to a cleaner grid due to a greater reliance on long-duration energy sources

1. **Using** CAISO's proposed structuring of flexible capacit**y, from the fifth FRAC-MOO straw proposal**

© 2014 California Energy Storage Alliance
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Fast storage contribution to the three hour ramp

Regulation is a key component of flexible capacity, though it only makes up a percentage of the overall flexibility requirement



© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Example Application: Regulation Storage

Grid Service	Primary/ Secondary	Benefits/Comments	Additional Benefits	
			Attribute	Benefits/Comments
1. Frequency regulation	P	Earn revenues in Fast Acting Regulation market	Modularity/ Incremental build	Improve system upgrade efficiencies by purchasing only the capacity needed
			Faster build time	Reduce project logistics and project financing costs
			Locational flexibility / Mobility	Site systems at source of grid challenge
			Multi-site aggregation	Command transmission level capacity from network of locally sited systems
			Optionality	Solve multiple grid challenges with one solution; Adapt services to needs

© 2014 California Energy Storage Alliance

Example Application: Distributed Peaker

End Use	Primary/ Secondary	Benefits/Comments
1. Frequency regulation	S	Earn revenues in Fast Acting Regulation market
2. Spin	S	If it can qualify
3. Ramp	S	Adds flexible supply capacity in milliseconds at nameplate.
4. Black start	S	
5. Real-time energy balancing	S	Discharge energy in the real-time energy markets
6. Energy arbitrage	S	Earn revenues from discharging during periods of peak demand and charging when prices are low
7. Resource Adequacy	S	If it can provide on a firm basis.
8. VER / wind ramp/volt support	S	
9. VER/ PV shifting, Voltage sag, rapid demand support	S	
10.Supply firming	S	
11.Peak shaving: load shift	P	Automatically discharge energy when local distribution lines reach capacity to reduce peak load
15.Distribution peak capacity support (deferral)	P	Defer expensive distribution infrastructure upgrades by increasing efficiency and reducing peak demand of distribution system
16.Distribution operation (volt/VAR support)	P	Instantly improve local power quality by providing reactive power and responding to voltage fluctuations
17.Outage mitigation: micro-grid	S	They are currently doing this now on a micro-grid.
18.TOU energy mgt	S	Ex. Non-utility owned: peak shaving for Industrial / Commercial customers to manage demand charges.
19.Power quality	S	Inject or absorb real or reactive power instantly and accurately to help with local power quality issues
20.Back-up power	P	Immediately discharge to continue supplying energy to loads in the event of an outage

Additional Benefits

Attribute	Benefits/Comments
Modularity/ Incremental build	Improve system upgrade efficiencies by purchasing only the capacity needed
Faster build time	Reduce project logistics and project financing costs
Locational flexibility / Mobility	Site systems at source of grid challenge
Multi-site aggregation	Command transmission level capacity from network of locally sited systems
Optionality	Solve multiple grid challenges with one solution; Adapt services to needs

© 2014 California Energy Storage Alliance
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

‘Application Framework’ - Define applications by their benefits

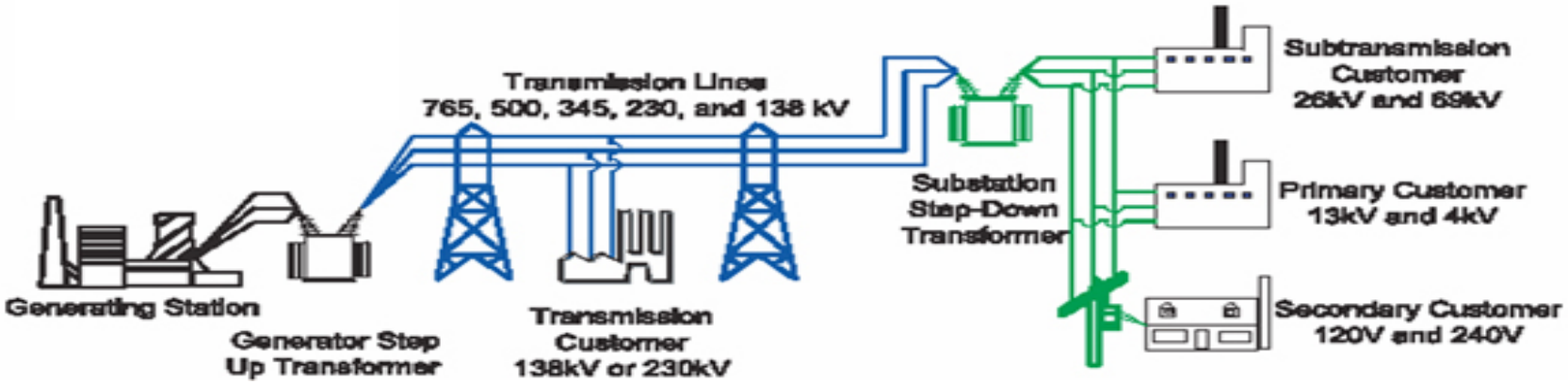
Applications

Benefits	Transmission Connected				Distribution Connected			Demand Side										
	BulkSystem	A/S Only	On-Site Generation	On-site VER	Distributed Peaker	Distributed - Substation Level (SDG&E	Community Energy Storage	Demand Side PLS		EV Charging		Customer Bill Management			Customer Bill Management + Market		Behind the Meter Utility Controlled	
End Use (Primary - P, Secondary - S)								Permanent Load Shifting - Battery Board Batteries, CAES, RFB	Business Customer, Building Thermal Mat. Ice, Thermal Tanks	EV Charging, Aggregated Batteries, CAES, RFB	EV Charging, Non-Aggregated Batteries, CAES, RFB	Business Customer, Peak/Max Demand Mat. Batteries, CAES, ICE, RFB	Residential Customer, Renewable Integration Batteries, CAES,	Multi-family Residential, Solar and Demand Batteries CAES,	Business Customer, Bill - Market Participation Batteries, CAES, Thermal,	Residential Customer, Bill - Market Participation Batteries, Thermal, CAES	Cooperative Ownership, Grid Operation Benefits Batteries, RFB	3rd Party Aggregator, Grid Operation Benefits Batteries, RFB
Utility Control								*Yes*	*Yes*	*Possible*	*Possible*				*Yes*	*Yes*	*Yes*	*Yes*
Frequency Response					S	S		S	S	S	S				S	S	S	S
1. Frequency regulation	P	P	P	S	S	S	S	S		S	S				S	S	P	P
2. Spin	P	P	P	S	S	S		S							S	S	S	S
3. Ramp	P	P	P	S	S	S	S	S							S	S	S	S
4. Black start	S	S		S	S	S	S	S							S	S	S	S
5. Real-time energy balancing	P	S	P	P	S	S		S		P	P				S	S	S	S
6. Energy arbitrage	P		P	P	S	S	S			S	S				S	S	S	S
7. Resource Adequacy	P	S*	P	P	S	S		P	P						S	S	S	S
8. VERMIT				P	S	S	S								S	S	S	S
9. VER/PV shifting, Voltage sag, rapid demand support				P	S	S	P			S	S				S	S	P	P
10. Supply firming				P	S	S	S	S		S	S	P	P	P	P	P	S	S
11. Peak shaving: load shift					P	P	S	P	P	P	P							
12. Transmission peak capacity support (deferral)	S		S	S	N/A	P		S	S									
13. Transmission operation (short duration performance, inertia, system reliability)					N/A	P	S	S										
14. Transmission congestion relief	S		S	S	N/A	P												
15. Distribution peak capacity support (deferral)					P	P	S	P	P	P	P	S	S	S	P	P	S	S
16. Distribution operation (volt/VAR support)					P	P	S					S	S	S	P	P	P	P
17. Voltage mitigation: microgrid					S		S	S	S	S	S	S	S	S	S	S	S	S
18. TOU energy mgt					S			P	P	P	P	P	P	P	P	P		
19. Power quality					S		P			S	S				S	S	S	S
20. Back-up power					P		S	S		S	S	S	S	S	S	S	S	S
11VER - Variable Energy Resource																		
Other Benefits																		
Fossil generation portfolio could operate more efficiently								X	X	X	X	X	X	X	X	X	X	X
Avoid curtailment of renewable energy resources								X	X	X	X	X	X	X	X	X	X	X
Increased renewables on feeder circuits								X	X	X	X	X	X	X	X	X	X	X
Faster build time than some traditional assets - time value of money					X	X	X	X	X	X	X	X	X	X	X	X	X	X
Modularity/Incremental build					X	X	X	X	X	X	X	X	X	X	X	X	X	X
Optionality - offer will better fit what the need is					X	X	X	X	X								X	X
Locational flexibility					X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mobility - Planned Operation					X	X		X		X								

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

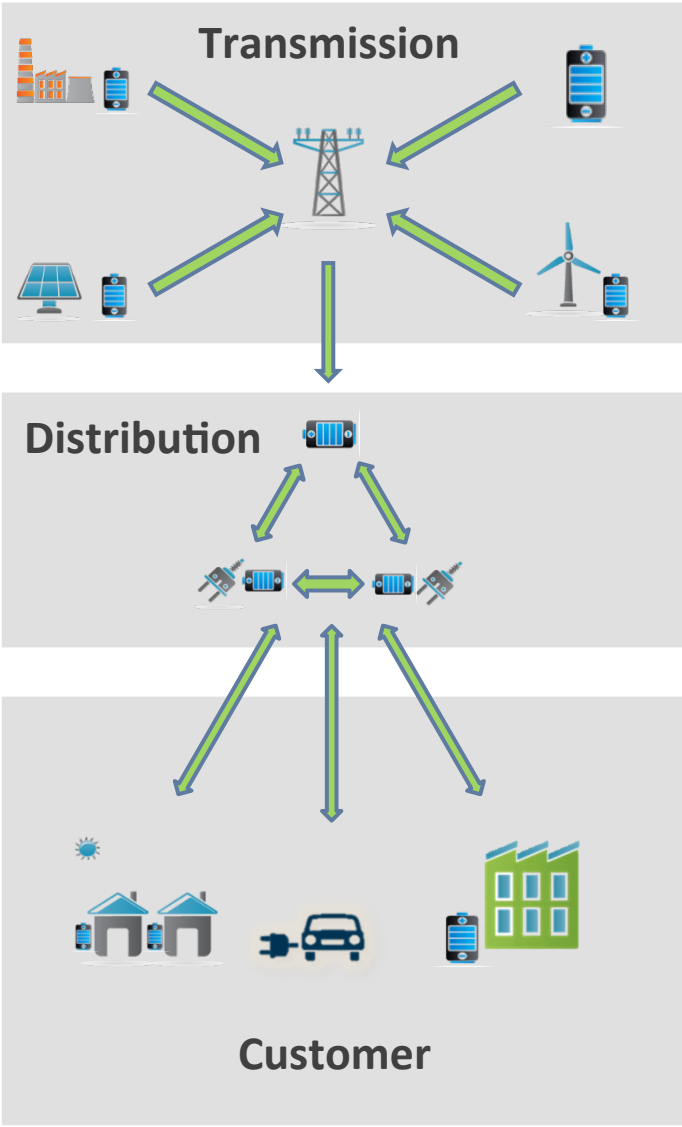
Types of Energy Storage Systems



Bulk Generation		Transmission	Distribution	Behind-the-Meter
Generation –Sited Storage	Transmission Connected Bulk Storage	Transmission Grid Storage	Distribution Grid Storage	Customer-Sited Storage
▪ CSP ▪ Wind + Storage ▪ CCGT+ TES	▪ A/S ▪ Peaker ▪ Load following	***FERC Jurisdiction***	▪ Substation Level Storage ▪ Distributed Peaker ▪ Community ES	▪ Bill mgt / PLS ▪ Power quality ▪ EV
←== Transmission-Connected ==→				

Source: CPUC IOU Solicitation Application Workshop Intro Presentation 3/14/14

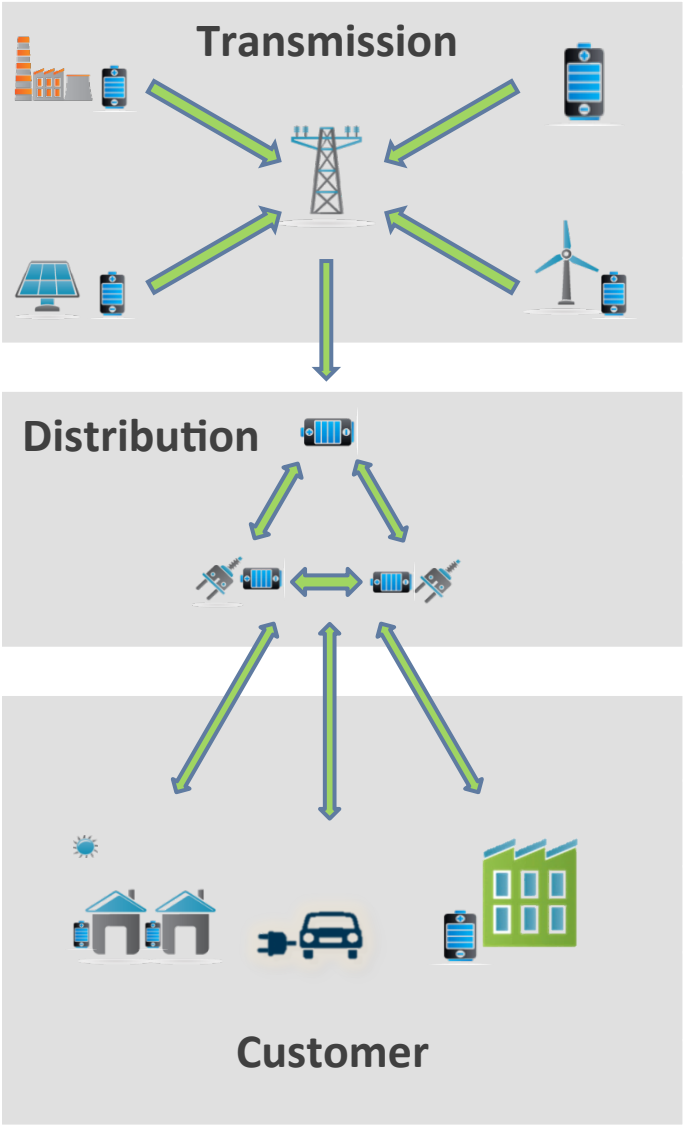
Prioritize applications appropriate to the market



Bulk Peaking Power Plant
Regulation Only
On-Site Generation
On-site Variable Energy Resource
Distributed Peaking Power Plant
Distributed Energy Storage - Substation Level
Community Energy Storage
Demand Side Permanent Load Shifting
EV Charging
Customer Bill Management
Customer Bill Management + Market Participation
Behind the Meter Utility Controlled

© 2014 California Energy Storage Alliance
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Some applications are utility controlled



- Bulk Peaking Power Plant
- Regulation Only
- On-Site Generation
- On-site Variable Energy Resource

- Distributed Peaking Power Plant
- Distributed Energy Storage - Substation Level
- Community Energy Storage

- Demand Side Permanent Load Shifting
- EV Charging
- Customer Bill Management
- Customer Bill Management + Market Participation
- Behind the Meter Utility Controlled

© 2014 California Energy Storage Alliance
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Storage Procurement Targets

Energy Storage Procurement Targets (in MW)[22]

Storage Grid Domain Point of Interconnection	2014	2016	2018	2020	Total
Southern California Edison					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal SCE	**90**	**120**	**160**	**210**	**580**
Pacific Gas and Electric					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal PG&E	**90**	**120**	**160**	**210**	**580**
San Diego Gas & Electric					
Transmission	10	15	22	33	80
Distribution	7	10	15	23	55
Customer	3	5	8	14	30
Subtotal SDG&E	**20**	**30**	**45**	**70**	**165**
Total - all 3 utilities	**200**	**270**	**365**	**490**	**1,325**

ix

Source: CPUC IOU Solicitation Application Workshop Intro Presentation 3/14/14

What about ownership/operation/financing models?

Ownership	Siting	Procurement
Utility	Utility	Rate Based
		Financed
	Third Party	Financed
	Customer	Rate Based
		Financed
Third Party (IPP)	Utility	Financed
	Third Party	Financed
	Customer	Financed
Customer	Customer	Financed
		Purchased

© 2014 California Energy Storage Alliance
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Comparing Energy Storage With The Status Quo

VS.

Key Criteria to Consider

- Siting Constraints
- Installation Speed
- Available Flexible Range
- Capacity Factor (hours of operation/ year)
- Multiple Value Stream Capture
- Ramp/Response Rate
- Total Emissions
- Water Usage

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Summary

Energy storage can provide much greater benefits per MW as a flexible resource!

vs.

100 MW Gas Turbine	Energy Storage Benefits	100 MW Energy Storage
10 minute ramp	>600x the ramp rate	<1 second ramp
50 MW flexible range	>4x the flexible range	200 MW of flexible range
2768 useable hours/year(1)	>3x the operational hours	>8300 useable hours/year
6500 gallons per hour	Less water usage on many sites	Little to no water usage
Status quo GHG emissions	Lower GHG emissions	Reduces GHG emissions by up to 90%(2)

(1)Excluding start-up and shutdown time

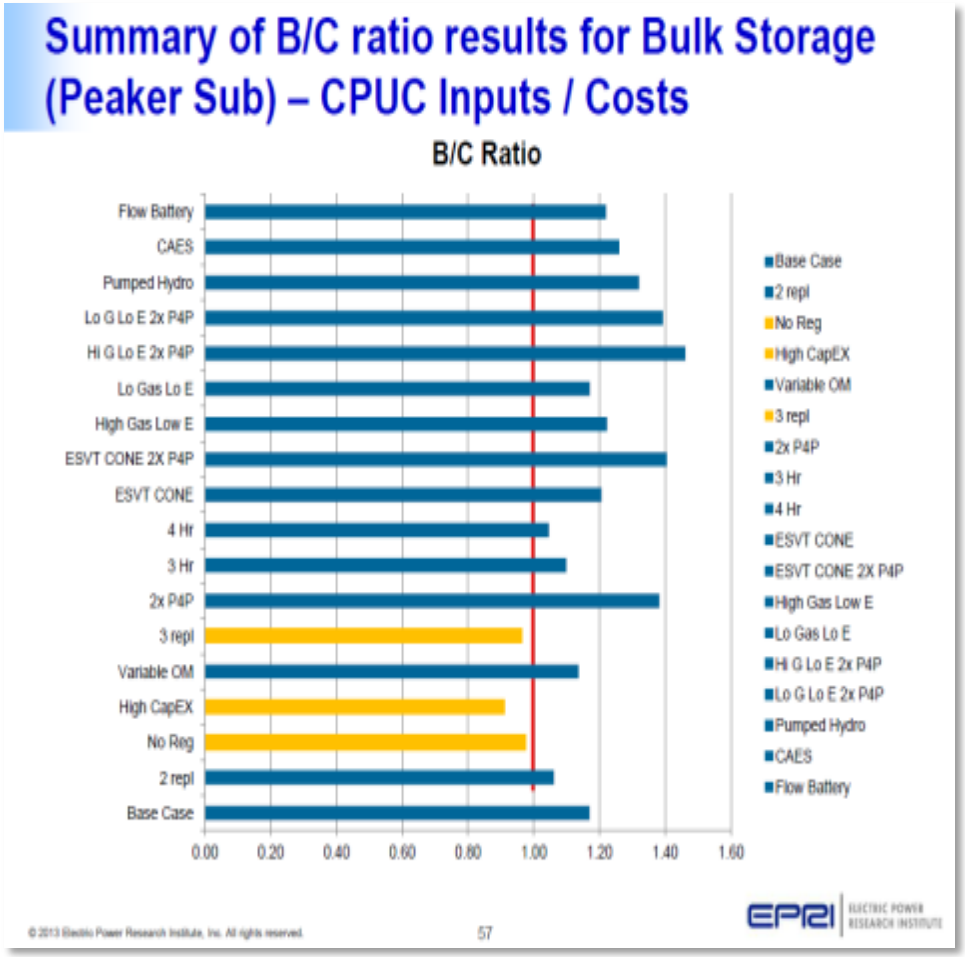
(2)http://www.energy.ca.gov/2011_energypolicy/documents/2011-02-15_workshop/comments/California_Energy_Storage_Alliance_03032011_TN-59863.pdf

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Cost Effectiveness Results: Bulk Peaking Power Plant Use Case

Preliminary results by EPRI using stakeholder input showed a benefit to cost ratio over one for nearly every scenario



- » Projects were assumed to be utility scale projects starting in 2015 and 2020
- » Cost effectiveness results did not include GHG benefits of storage or GHG costs due to AB32 implementation
- » High renewable penetration cases had the highest benefit to cost ratios for storage.
- » GHG benefits for storage are greater the more renewables we have on the grid.

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

More Information

» Contact : Janice Lin
- Email: jlin@strategen.com
- Office: 510 665 7811 extension 101
- Mobile: 415 595 8301

» Strategen – custom consulting advisory
- http://www.strategen.com

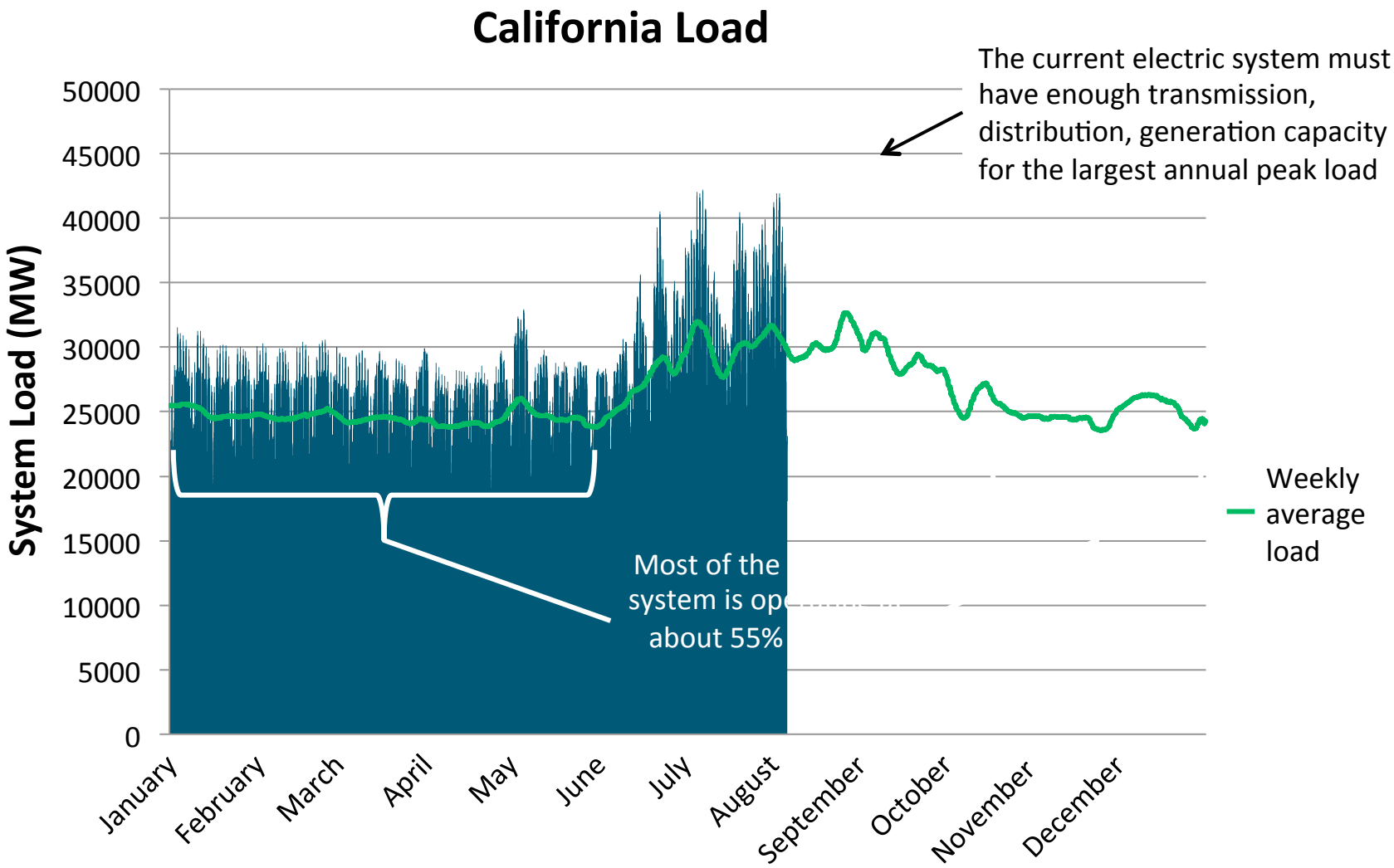
» CESA Membership
- http://www.storagealliance.org/

» GESA information
- http://www.globalesa.org

» Energy Storage North America
- Sep 30-Oct 2, 2014 San Jose Convention Center CA
  http://www.esnaexpo.com/

© 2014 California Energy Storage Alliance

California's Electric System Is Not Being Efficiently Utilized

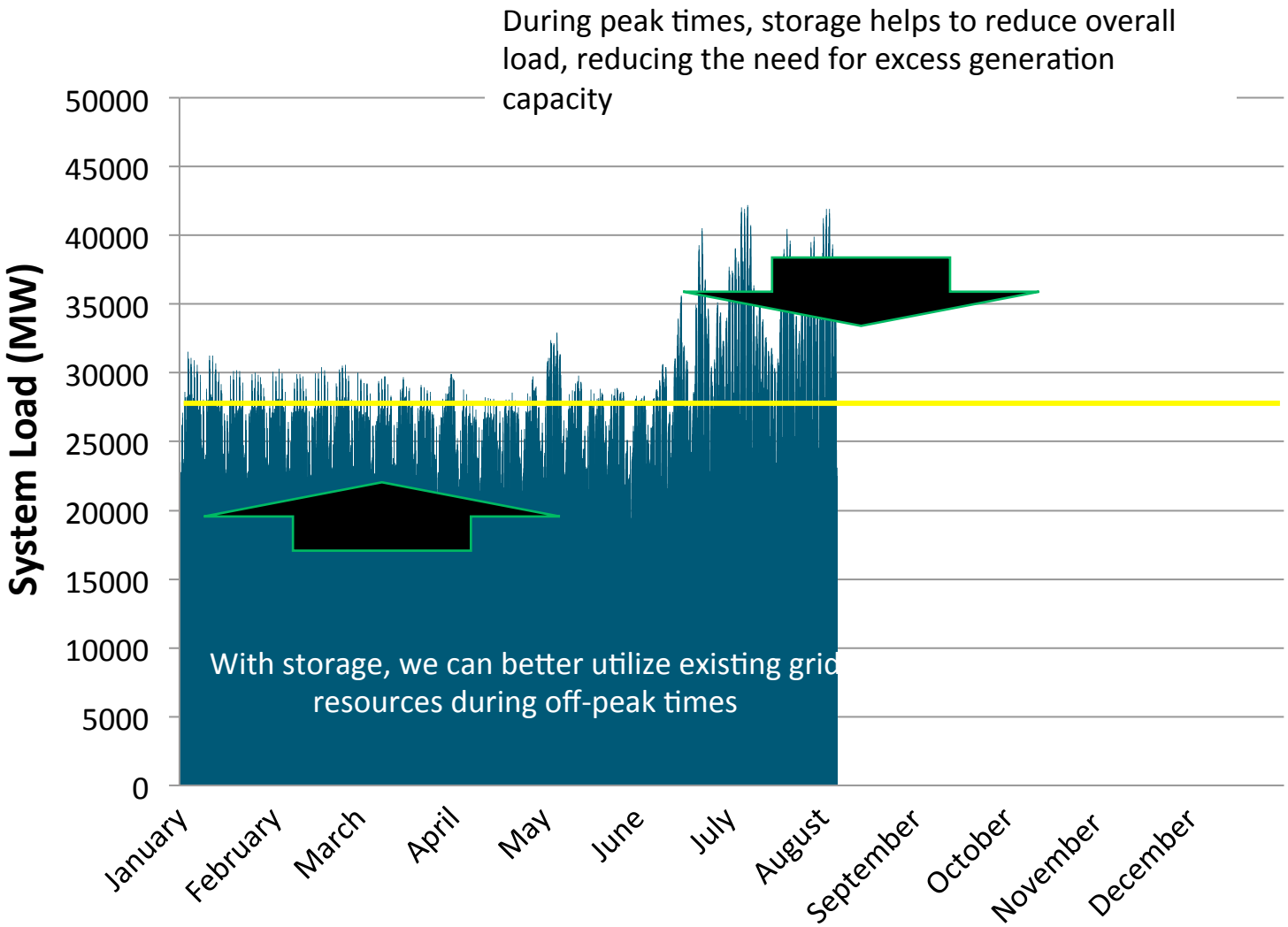


Data Source: CAISO 2011 OASIS Data – Graph is for illustration purposes only.

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Storage lets us utilize the system assets we have more efficiently

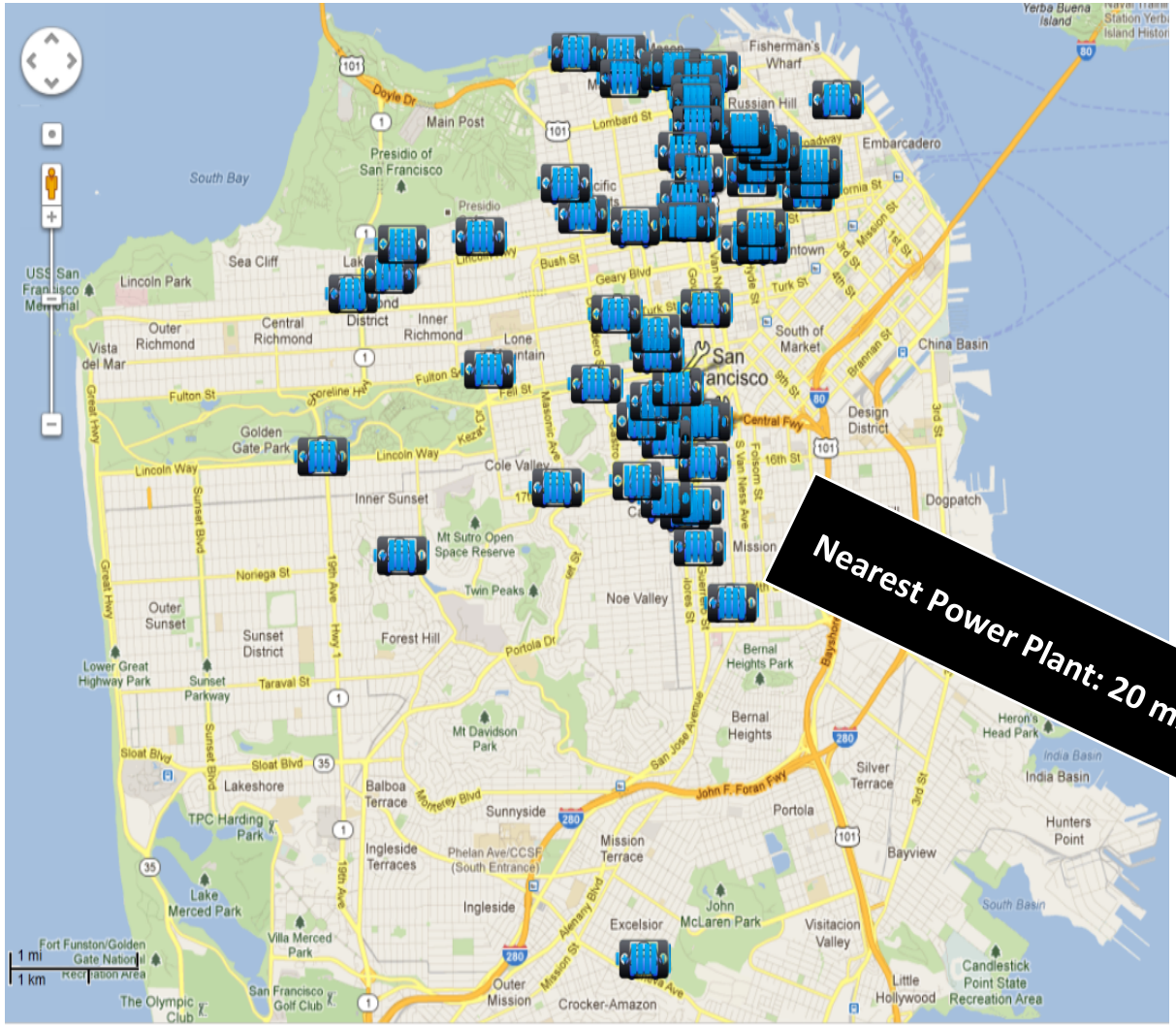


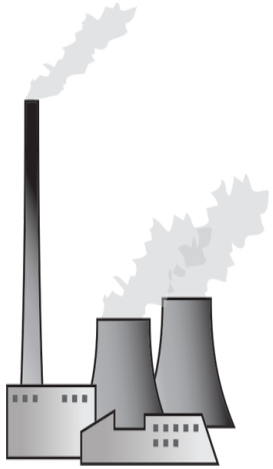
Data Source: CAISO OASIS Data – Graph is for demonstration purposes only.

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Energy Storage Can Be Sited Closer to the Load





Russell City Energy Center
Hayward, Ca

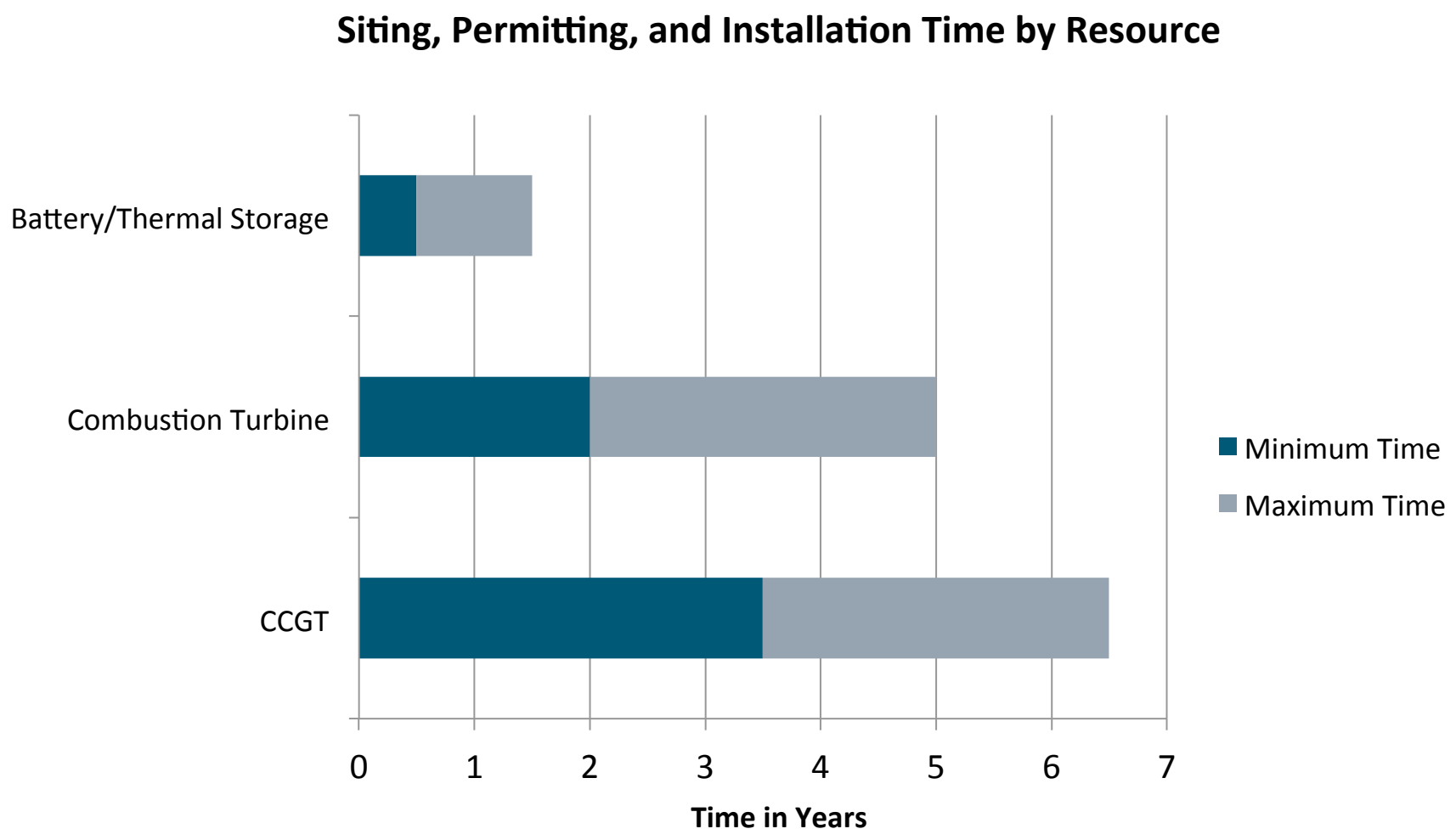
ES Siting Source: Powertree Integrated Energy Services

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Energy Storage: Diverse, Modular, Faster to Install!

Battery and thermal storage resources can be installed much more quickly than traditional resources, reducing risk and increasing technology flexibility

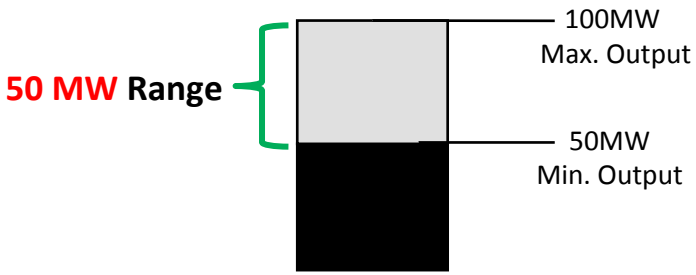


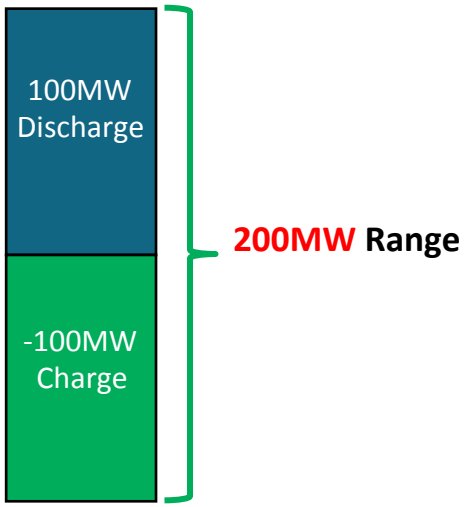
© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

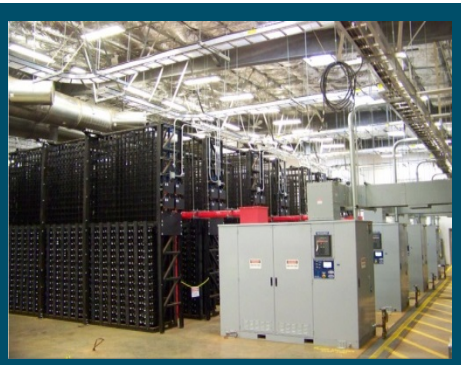
Energy Storage: Four Times the Flexible Range

Important to compare benefits, not megawatts





100MW LMS 100 Gas Peaker Plant[1]



100MW Energy Storage System

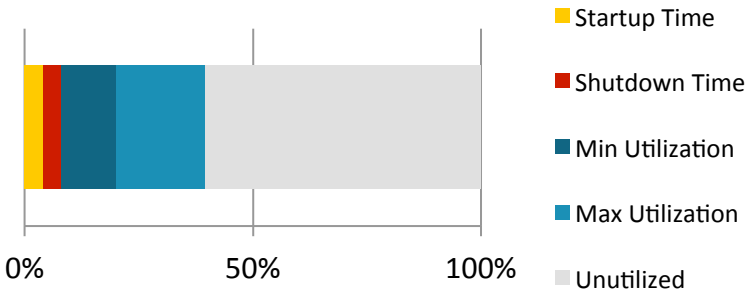
1. Source: http://yosemite.epa.gov/R9/air/EPSS.NSF/e0c49a10c792e06f8825657e007654a3/8a153d8ab24cb6868825723400679b82/$FILE/WCE%20Evaluation.pdf

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Energy Storage: Three Times the Utilization

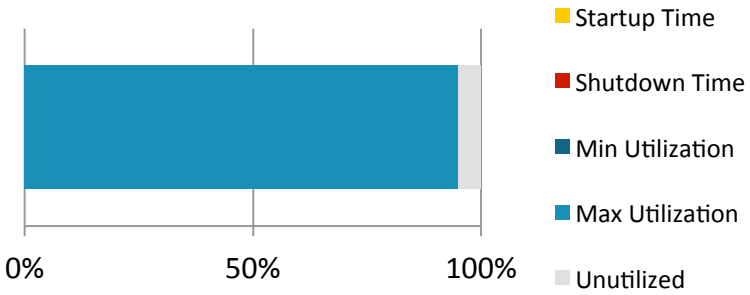
Energy storage can be utilized more fully throughout the year



20%-40%

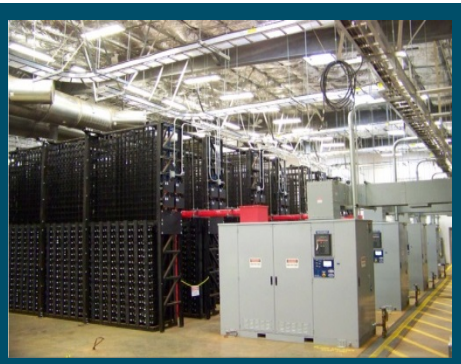
Utilization

100 MW LMS 100 Gas Peaker Plant[1]



>95%

Utilization



100MW Energy Storage System

1. Source: http://yosemite.epa.gov/R9/air/EPSS.NSF/e0c49a10c792e06f8825657e007654a3/8a153d8ab24cb6868825723400679b82/$FILE/WCE%20Evaluation.pdf

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Status Quo: CT Operation at EME Walnut Creek Energy Park

State of the art LMS 100 installations require significant start-up and shutdown operating hours, accounting for at least 20% of operations:

EME Walnut Creek Energy Park SCAQMD Analysis[1]	
Capacity Factor - min	**20%**
Capacity Factor - max	**40%**
Operating Hours - Normal	**2768**
Operating Hours - Start-up	**350**
Operating Hours - Shutdown	**350**
Service Factor - Normal	**32%**
Service Factor - Total	**40%**
Minimum load	**50%**
Average load	**75%**
Starts/year	**350**
Max starts/day	**2**
Max start-ups/year	**350**
Start-up time (minutes)	**35**

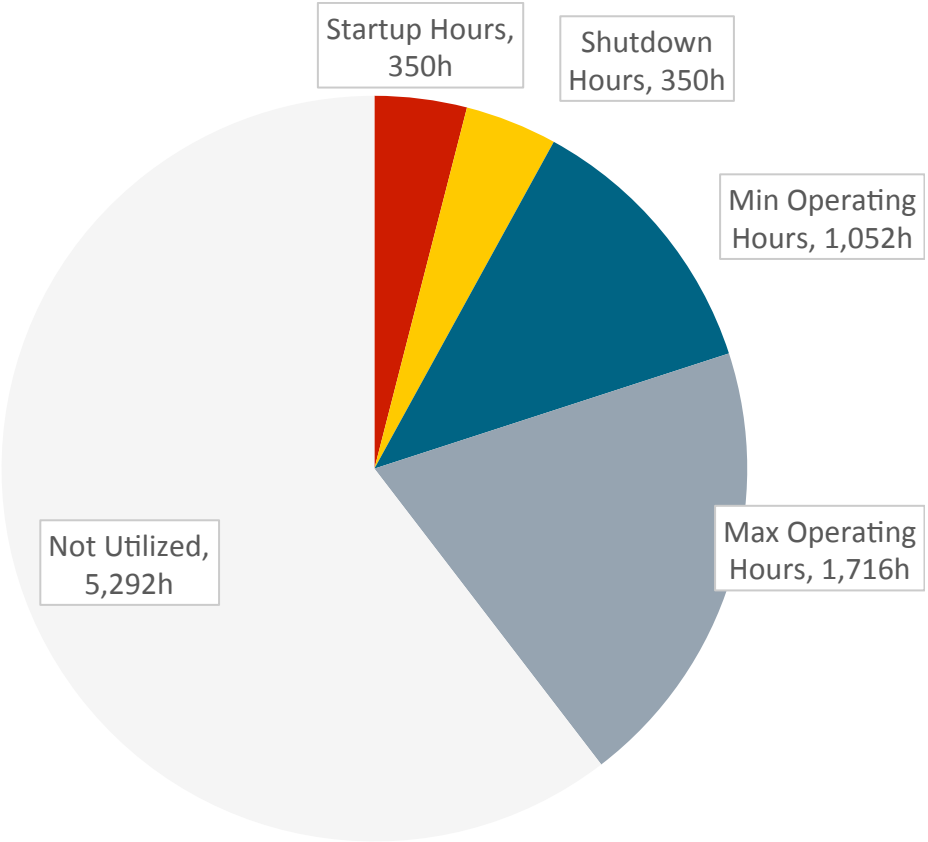


Chart of Annual Plant Operation

1) http://yosemite.epa.gov/R9/air/EPSS.NSF/e0c49a10c792e06f8825657e007654a3/8a153d8ab24cb6868825723400679b82/$FILE/WCE%20Evaluation.pdf

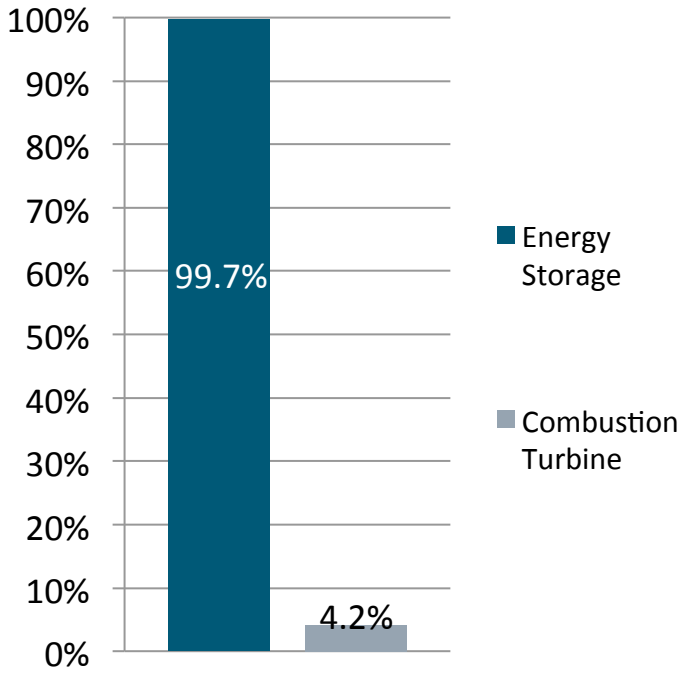
© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

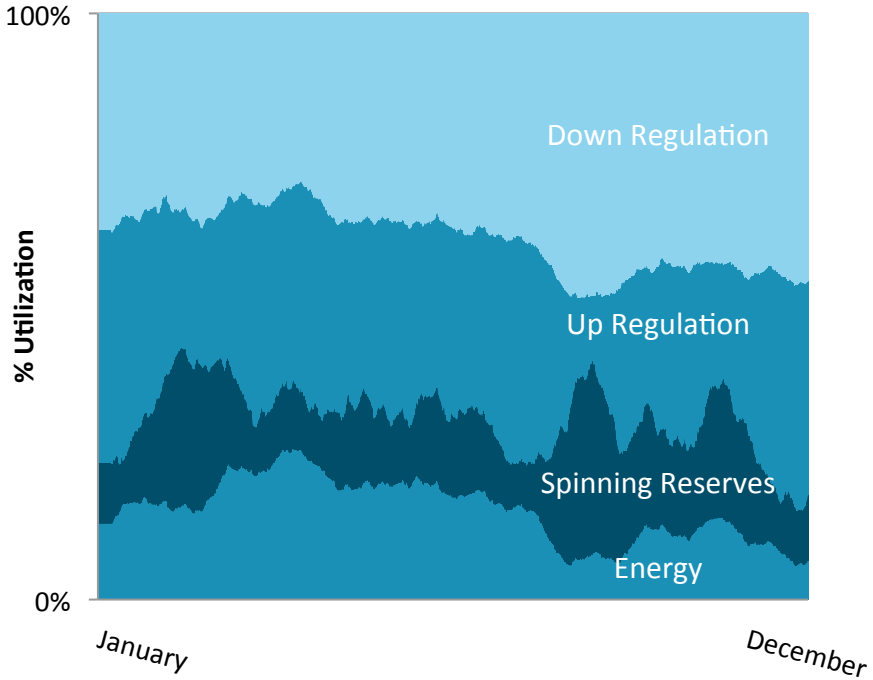
Energy Storage Can Capture Multiple Value Streams

Energy storage can be fully utilized throughout the year, providing multiple services from a single asset

% Total Annual Hourly Asset Utilization



Services Provided by Energy Storage Over the Year*



Energy storage is a cost effective way to provide numerous benefits to many stakeholders, few of which can be monetized today.

Graphs based on EPRI cost effectiveness model data, "Bulk Peaker substitution application" CPUC Workshop March 25, 2013

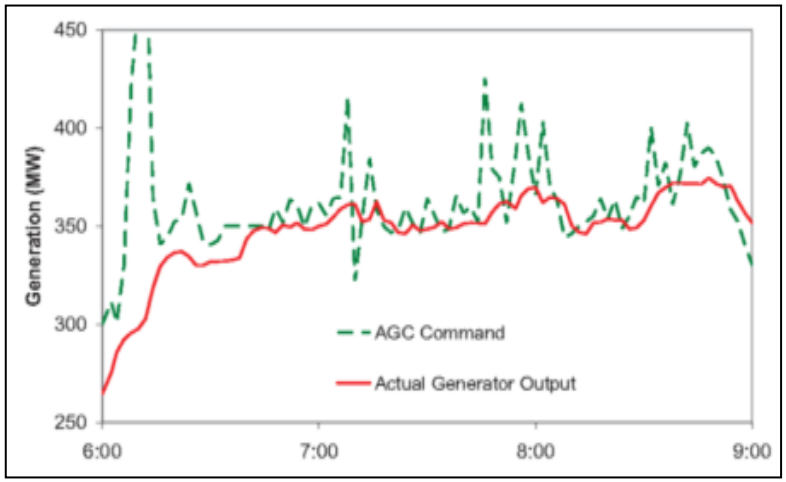
*All services include charging and discharging bids

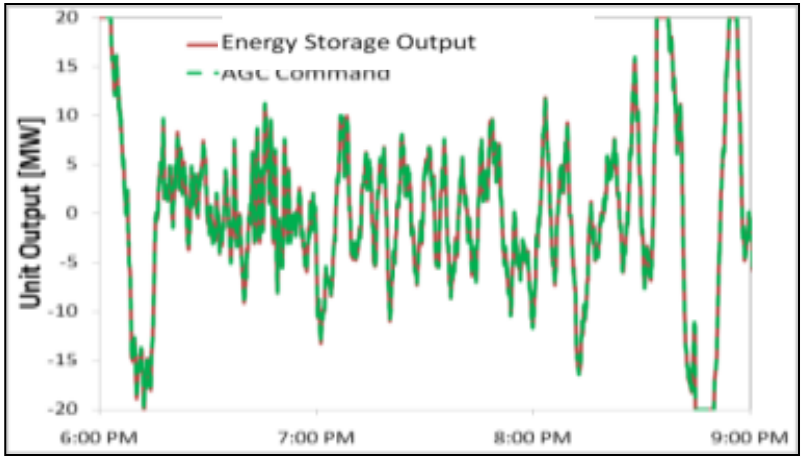
© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Energy Storage Can Respond Faster and is More Effective

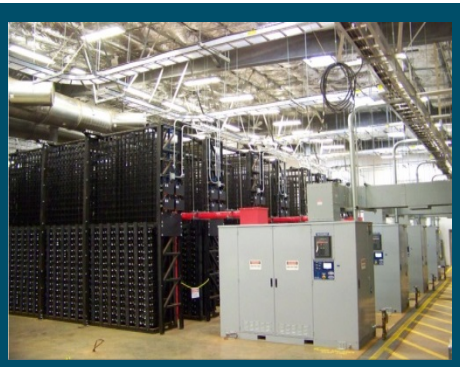
Energy storage responds far more quickly and is more effective





LMS 100 Gas Peaker Plant

Full Power Ramp
10 Minutes



Energy Storage System

Full Power Ramp
<1 second

Graph Source: Kirby, B. "Ancillary Services: Technical and Commercial Insights." Wartsilla, July, 2007. pg. 13
1. http://www.cpvsentinel.com/about.html

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Conventional Peakers are Expensive and Use Tons of Water

J-Power Orange Grove Peaking Plant

- 100 MW (2 x LM6000)
- $174/kW-year in capacity revenue (Source: FERC EQR)
- 25 year tolling agreement with SDG&E

"Water delivery will require approximately one [6500 gallon] truck per hour for fresh water and one truck per hour for reclaimed water during times when the plant is operational."[1]

1) Source: CEC http://www.energy.ca.gov/2009publications/CEC-800-2009-003/CEC-800-2009-003-CMF.PDF

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Even Repowered Peakers are Expensive

Repower: Building a new power plant on the same site as an old, decommissioned plant

LADWP Haynes Repower
6 x LMS100
$782M / 577.8 net MW

Cost: **$1353/kW**[1]

Due to repower, cost excludes:

- Land aquisition & permitting
- New transmission infrastructure
- Site access construction

1) Source: http://www.powermag.com/ladwp-harnesses-lms100-to-solve-once-through-cooling-dilemma/

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Emission Impacts Due to Cycling CCGTs & CTs

NREL concluded that cycling conventional power plants has significant impacts on emissions

CO_2 Emissions Penalties[1]			
Power Plant Type	**Part-Load[2]**	**Ramping[3]**	**Start/Stop**
Gas Combined Cycle (CCGT)	15%	1%	30%
Gas Combustion Turbine (CT)	17%	1%	40%

NO_X Emissions Penalties[1]			
Power Plant Type	**Part-Load[2]**	**Ramping[3]**	**Start/Stop**
Gas Combined Cycle (CC)	29%	8%	610%
Gas Combustion Turbine (CT)	16%	1%	180%

1) Listed as percentage penalty over the equivalent full-load operation for one hour
2) Assumes operation at 50% of capacity
3) Ramping leads to far less emissions compared to startups, but occurs more often

Source: National Renewable Energy Laboratory (NREL/PR-6A20-55828): *Impacts of Renewable Generation on Fossil Fuel Unit Cycling: Costs and Emissions* (May 20, 2012)

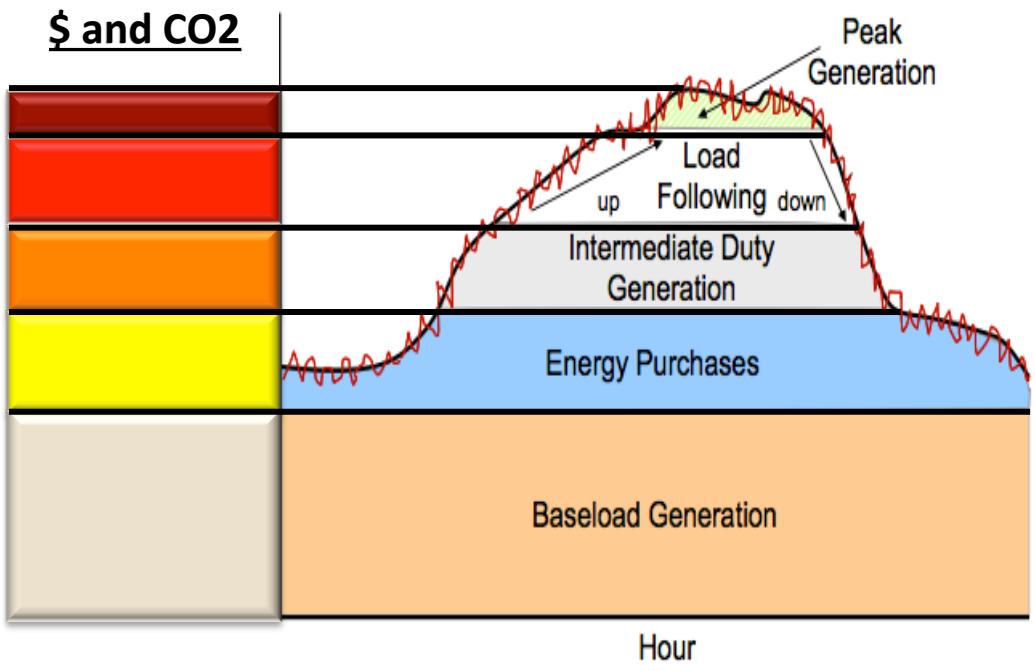
© 2014 California Energy Storage Alliance

Storage Can Help Optimize Existing Fossil Assets

Build cleaner CCGT's, let them run at max efficiency

- » Generation comes on "in order"
- » Cheaper & cleaner "baseload" is always on
- » More expensive, dirtier "peakers" turn on in succession.
- » Let storage be load following
- » Energy Storage can even cut costs & reduce emissions!

Daily System Energy Demand



© 2014 California Energy Storage Alliance

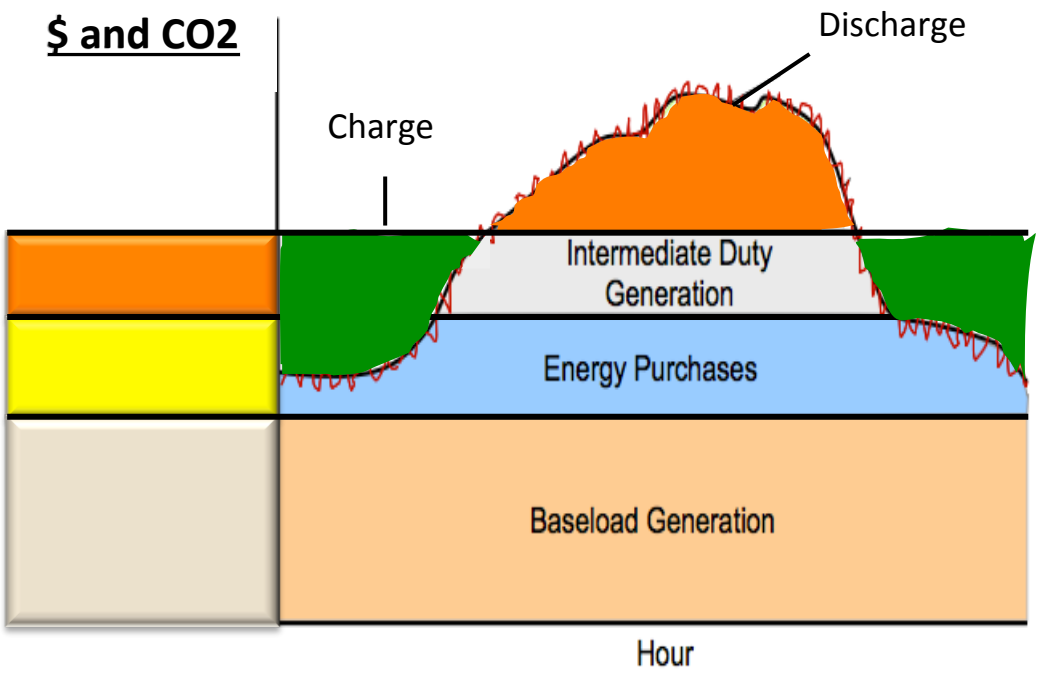
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Storage Can Help Optimize Existing Fossil Assets

Build cleaner CCGT's, let them run at max efficiency

- » Generation comes on "in order"
- » Cheaper & cleaner "baseload" is always on
- » More expensive, dirtier "peakers" turn on in succession.
- » Let storage be load following
- » Energy Storage can even cut costs & reduce emissions!

Daily System Energy Demand

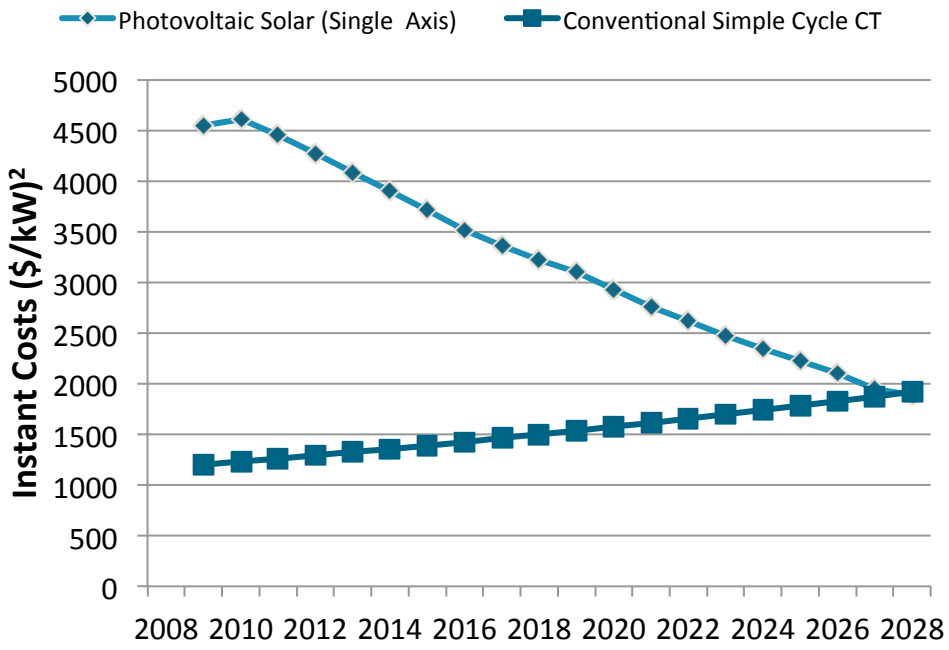


© 2014 California Energy Storage Alliance

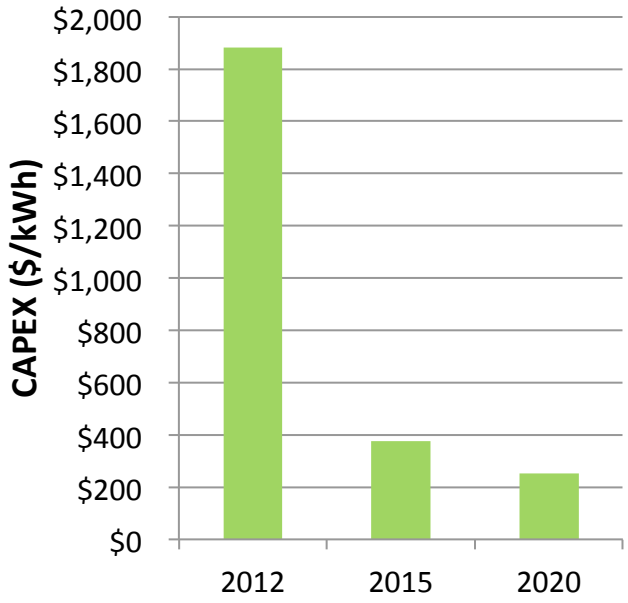
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Why Renewable Energy + Energy Storage Is the Future

Upfront Cost of Solar vs. Traditional Generators[1]



NEDO/DOE 2010 Li Ion Cost Projections



Key Trends

- » **Industry is tracking DOE & NEDO cost reductions for Li-ion (10X improvement in ten years)**
- » **Upfront costs for traditional generators are increasing**
- » **Renewable costs are decreasing, reducing the charging costs for energy storage**

1. Source: California Energy Commission
2. 2009 starting dollars, escalated at 2.5% per year

© 2014 California Energy Storage Alliance

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE