Utility Energy Forum

Electric Power in California: The Future Looks Intermittent

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RPS Historic March in California

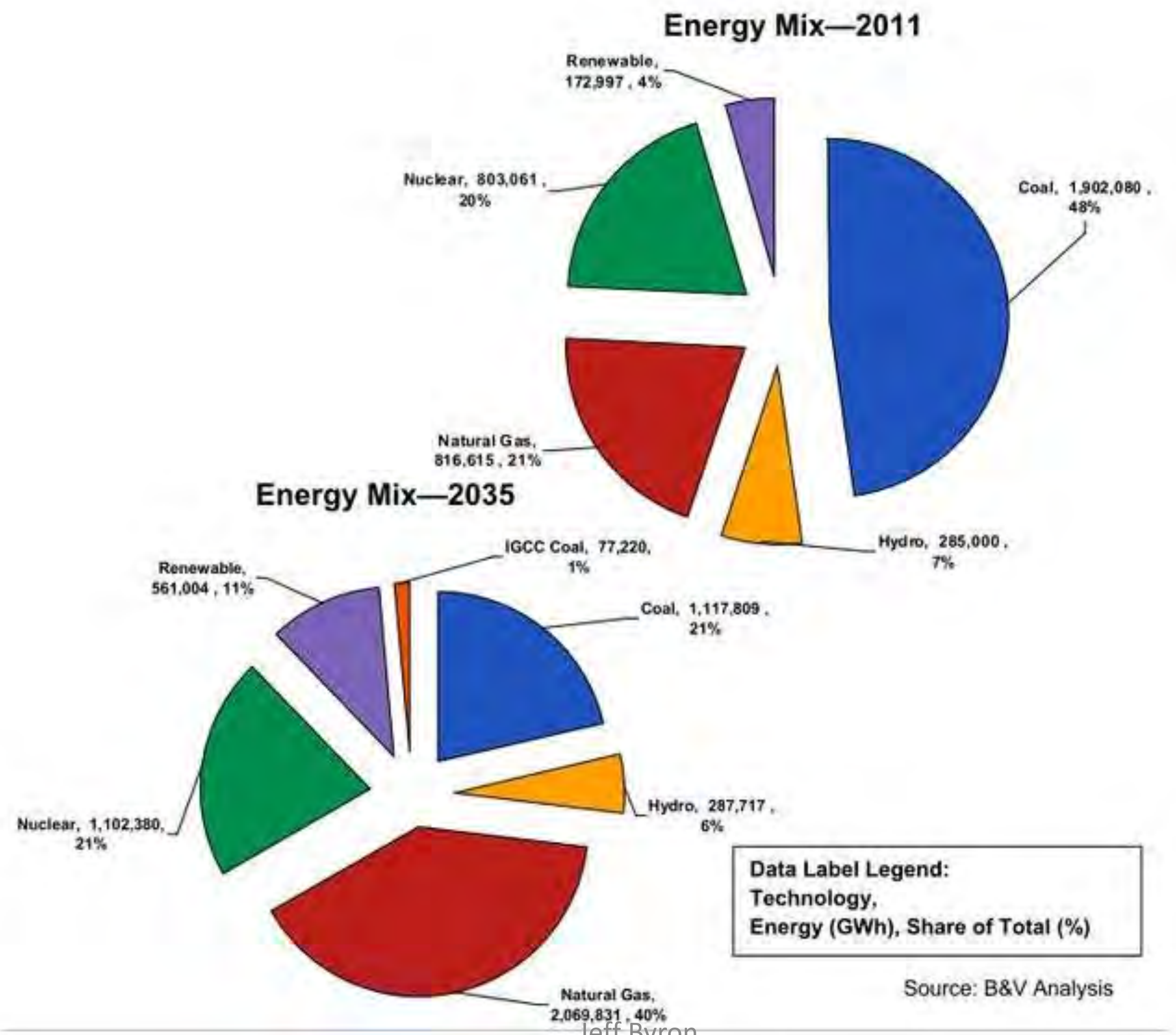
- 2002: SB 1078 establishes the RPS program, requiring 20% of retail sales from renewable energy by 2017
- 2003: Energy Action Plan I accelerated 20% deadline to 2010
- 2005: Energy Action Plan II recommends goal of 33% by 2020
- 2006: SB 107 codified 20% by 2010 deadline into law
- 2008: Governor Schwarzenegger issues Executive Order S-14-08 requiring 33% renewables by 2020
- 2009: Governor Schwarzenegger issues Executive Order S-21-09 directing the California Air Resources Board to adopt regulations by July 31, 2010, consistent with the 33% renewable energy target
- 2011: Senate Bill X1-2, signed by Gov. Edmund G. Brown, Jr., codifies 33% by 2020

RPS in Western States

State	%	By Year
Arizona	15	2025
California*	33	2020
Colorado	30	2020
Hawaii	40	2030
Montana	15	2015
Nevada	25	2025
New Mexico	20	2020
Oregon	25	2025
Utah	20	2025
Washington	15	2020

* Represents approximately 35% of electric load in West

US Electricity Future Prediction



Provisions of SB1X-2 RPS

- Extends requirements to POUs
- Three compliance periods; 2013 (20%), 2016 (25%), and 2020 (33%)
- Eligible energy resources
  - PPAs < 6/1/10
  - PPAs > 6/1/10; 1st point of interconnection or dynamic transfer agreement in BA
  - Limits on unbundled renewable energy credits (RECs)
- IOU provisions
  - Abolishes MPR for IOUs
  - Adds procurement cap
  - Can own up to 8.25% by 2020
  - Can waive 33% requirement under three conditions
    - Inadequate transmission capacity
    - Permitting, interconnection, or other circumstances that delay renewable projects already procured, or an insufficient supply of renewable projects
    - Unanticipated curtailment of eligible renewable energy resources necessary to address the needs of a balancing authority

How Are California Utilities Doing?

- California IOUs collectively served 18% of their 2010 retail electricity sales with renewable power:
  - Pacific Gas and Electric (PG&E) 17.7%
  - Southern California Edison (SCE) 19.4%
  - San Diego Gas & Electric (SDG&E) 11.9%
- California POUs (next slide)

Renewable Energy

Publically Owned Utility	% Retail Sales 2009
LADWP	12.4
SMUD	18.7
Anaheim	9.2
Burbank	3.9
Glendale	17.0
IID	6.7
MID	10.4
Palo Alto	16.5
Pasadena	8.3
Redding	2.7
Riverside	14.2
Roseville	7.1
San Francisco	0.3
SVP	25.7
TID	18.0
Others	0 to 61.0

electrotropophobia

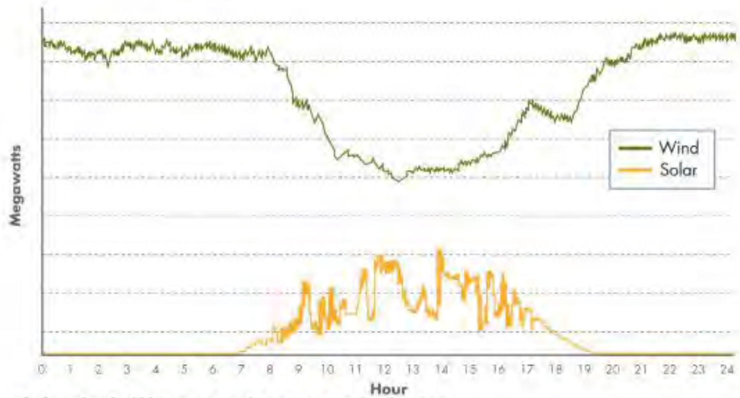
-noun

from Greek, electro electricity *+ -tropos* pertaining to a turn *+ -phobia* fear

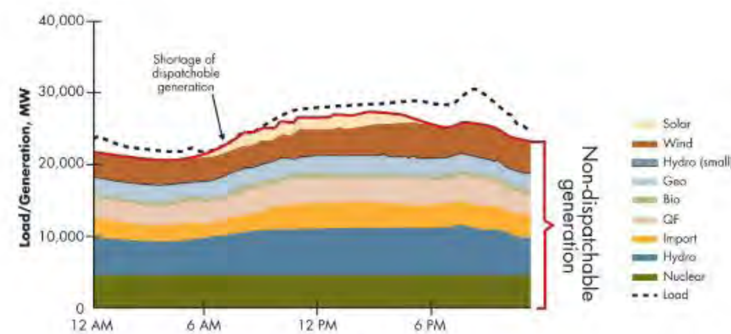
Def. 1. Fear of change in the electric power industry.

2. Abject fear of grid operations that must comply with a 33% intermittent renewable energy resource requirement.

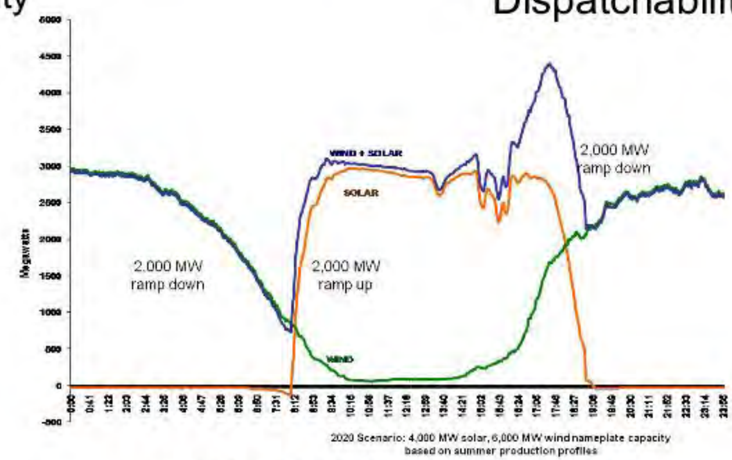
Challenges Integrating Renewable Resources on the Grid



Variability and uncertainty



Dispatchability and Overgeneration



Increased ramping needs

Source: CAISO

Energy Storage

- Many technologies offering variety of characteristics

- **Compressed Air Energy Storage** – will be utilized for "centralized" applications
- **Above Ground CAES →** Gen II, projected as 5MW, above ground (SustainX)
- **Sodium Sulfur (NaS) battery →** Long duration, Transmission back-up, but expensive

- **Vanadium Redox Battery** – Long duration, flow battery, used for back-up applications
- **Advanced Lead Acid Batteries** – 1 to 4 hours, used for renewable integration
- **Sodium Nickel Chloride Battery –** Targeting vehicles and small backup (Telecom)
- **Li-ion – High Energy** – Used for CES, renewable integration, maybe regulation

- **Li-ion – High Power** – used for frequency regulation, renewable integration
- **Flywheels** – 15 minute, many cycles, used for frequency regulation

- Each application is finding its niche, but for one device that can serve all applications – not there yet?
  - Need fast response, 2-4 hour duration, efficiency > 90%, cost competitive
  - Generation II technologies are trying to fill 2-5 hours gap

Bulk Storage Options for Renewable Integration

Technology Option/ Characteristics	CAES Above Ground	NAS	A-Pb Adv. Lead Acid	Zn/Br Redox	Vanadium Redox	Fe/Cr Redox	Zn/Air Redox
Unit Capacity MW MWH	50 250	50 300	50 250	50 250	50 250	50 250	50 250
Ac-Ac Efficiency,% (heat rate)* Energy Ratio**	-------- (4000) 1.0	75-80	85-90	60-65	75-78	70-75	70-75
Foot print Ft2/kW	1.6	2.0	1.9 - 5.1	0.9	2.0	1.1	1.3
Total Capital Costs ($/kW)	1700-1950	3060-3200	1750-4900	1660-1800	3500-3700	1800	1400-1700
Technical Maturity and readiness	Demo	Commercial	Commercial-Demo	Demo	Demo	R&D Lab	R&D Lab

*Heat rate is Btu/ kWh, LHV

**Energy ratio is kWh - in / kWh-out

Other Emerging Storage Systems Also Need Consideration

Source: EPRI

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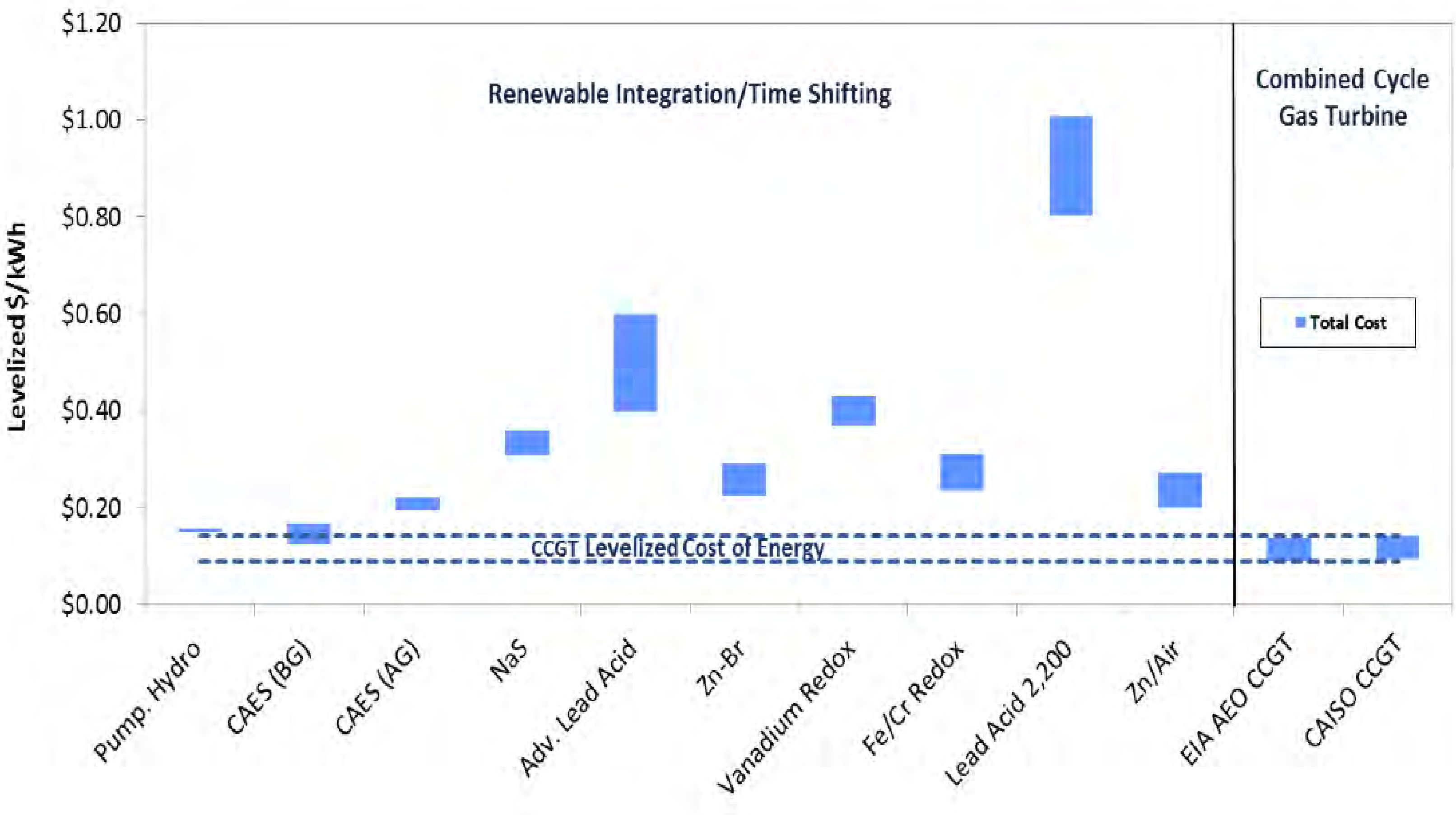
Estimated Range of Benefits for Energy Storage Across 5 ISO Regions

			PV $/kW-h		PV $/kW	
Value Chain	Benefit		Target	High	Target	High
End User	1	Power Quality	19	96	571	2,854
	2	Power Reliability	47	234	537	2,686
	3	Retail TOU Energy Charges	377	1,887	543	2,714
	4	Retail Demand Charges	142	708	459	2,297
Distribution	5	Voltage Support	9	45	24	119
	6	Defer Distribution Investment	157	783	298	1,491
	7	Distribution Losses	3	15	5	23
Transmission	8	VAR Support	4	22	17	83
	9	Transmission Congestion	38	191	368	1,838
	10	Transmission Access Charges	134	670	229	1,145
	11	Defer Transmission Investment	414	2,068	1,074	5,372
System	12	Local Capacity	350	1,750	670	3,350
	13	System Capacity	44	220	121	605
	14	Renewable Energy Integration	104	520	311	1,555
ISO Markets	15	Fast Regulation (1 hr)	1,152	1,705	1,152	1,705
	16	Regulation (1 hr)	514	761	514	761
	17	Regulation (15 min)	4,084	6,845	1,021	1,711
	18	Spinning Reserves	80	400	110	550
	19	Non-Spinning Reserves	6	30	16	80
	20	Black Start	28	140	54	270
	21	Price Arbitrage	67	335	100	500

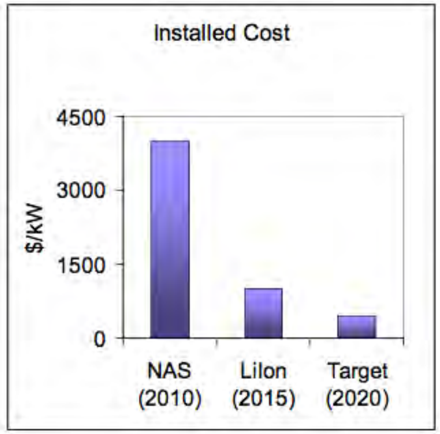
Source: EPRI

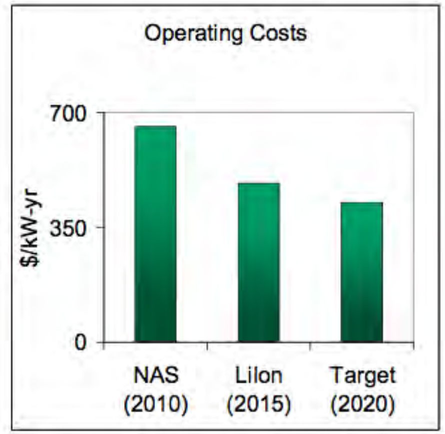
Levelized Cost of Delivered Energy for Energy Storage Technologies

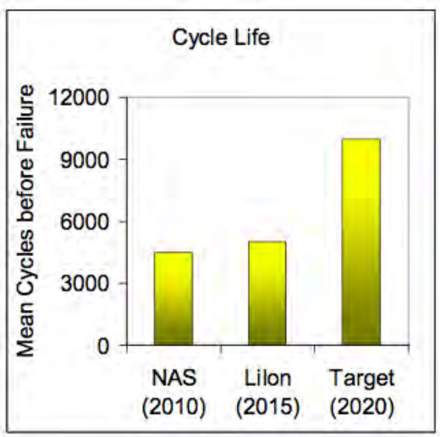


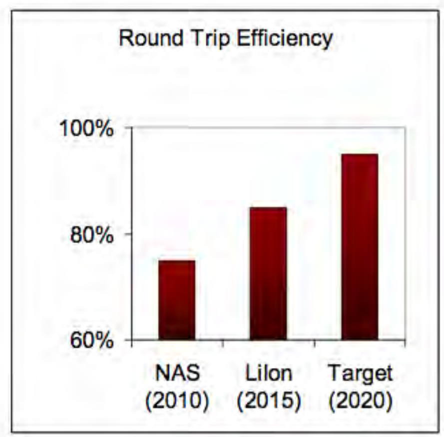
Source: EPRI

Energy Storage Technologies: Not Ready Yet



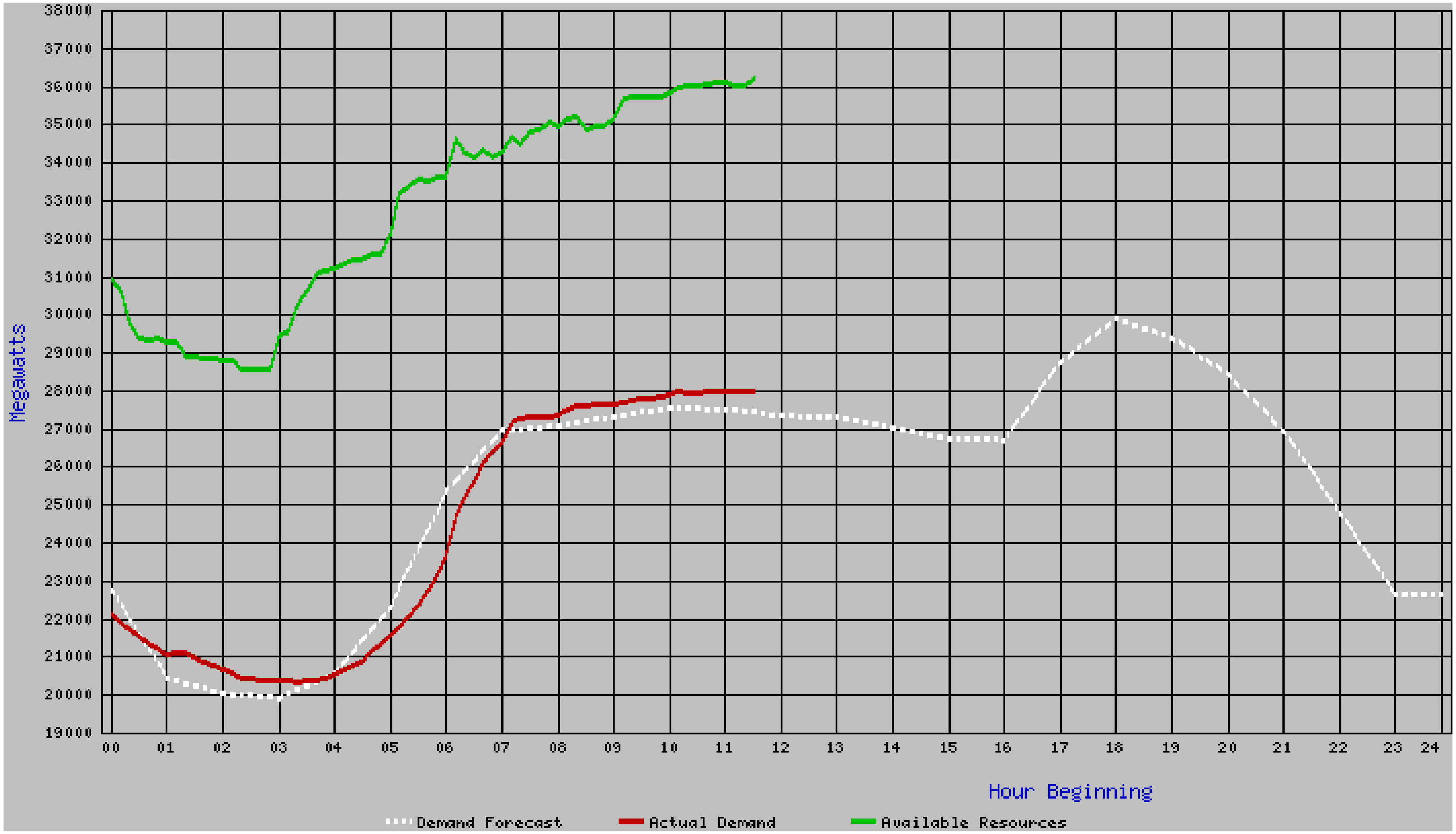




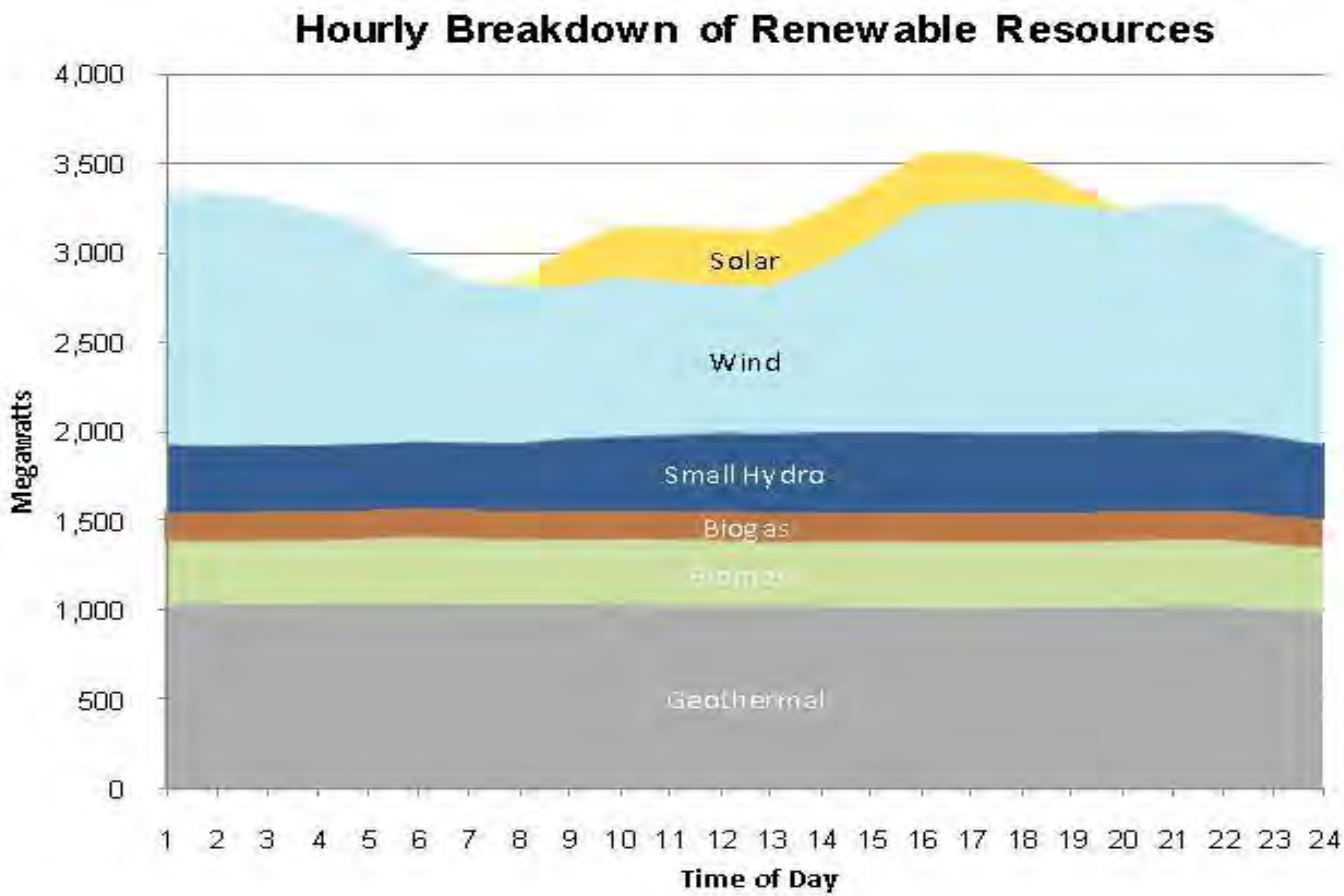


Source: EPRI

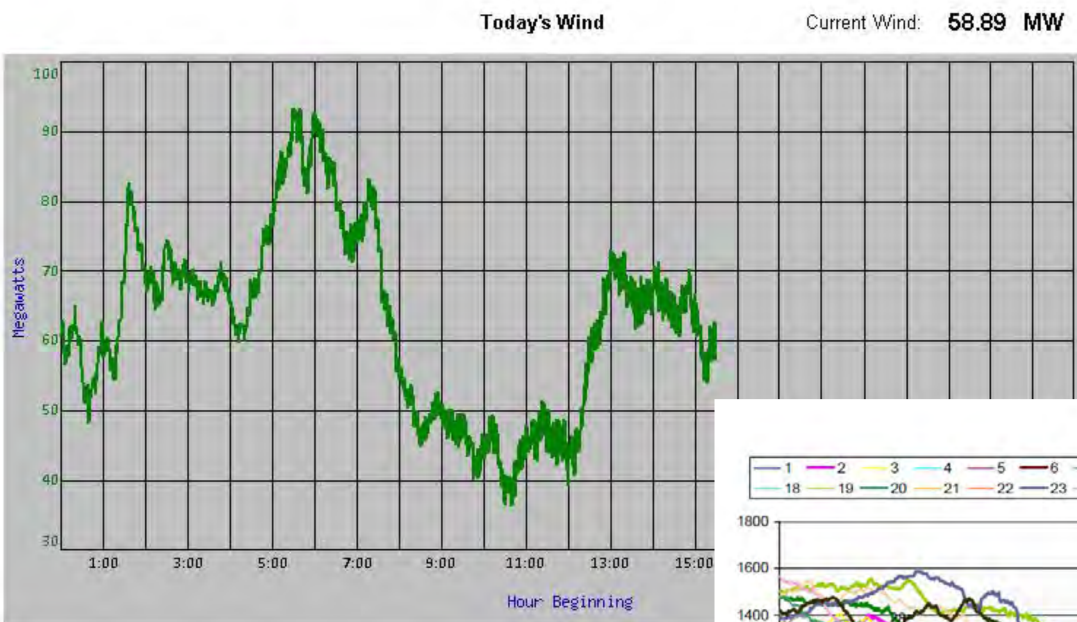
Existing Dispatch at the CAISO

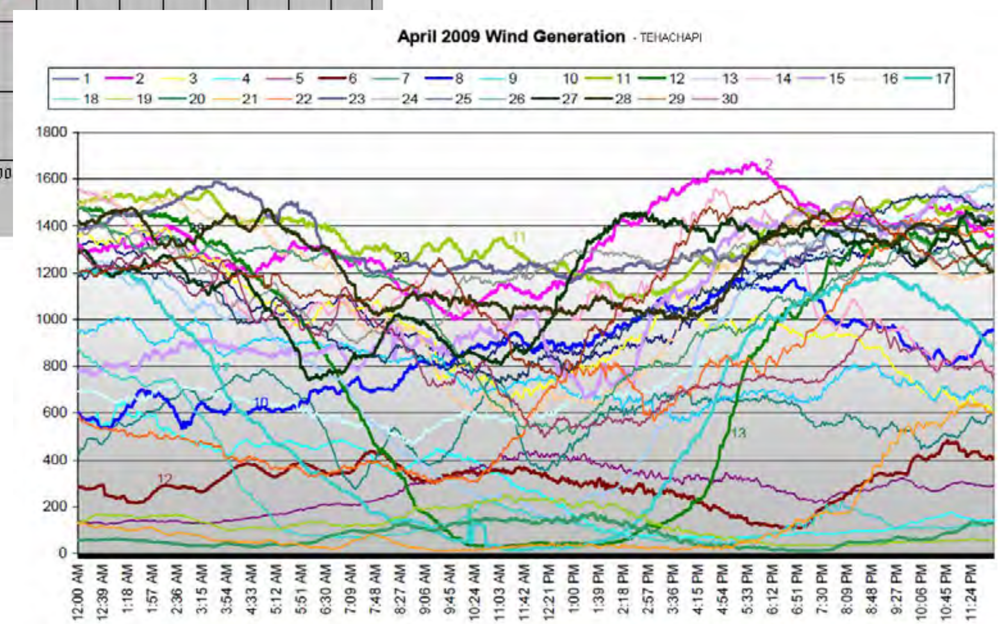


Adding Renewables Is “No Problem”

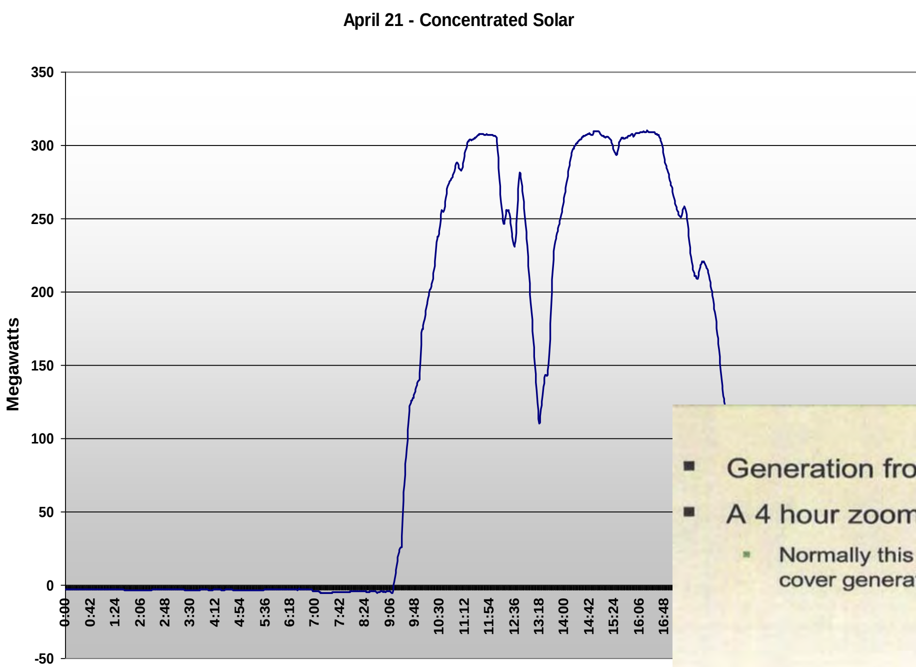


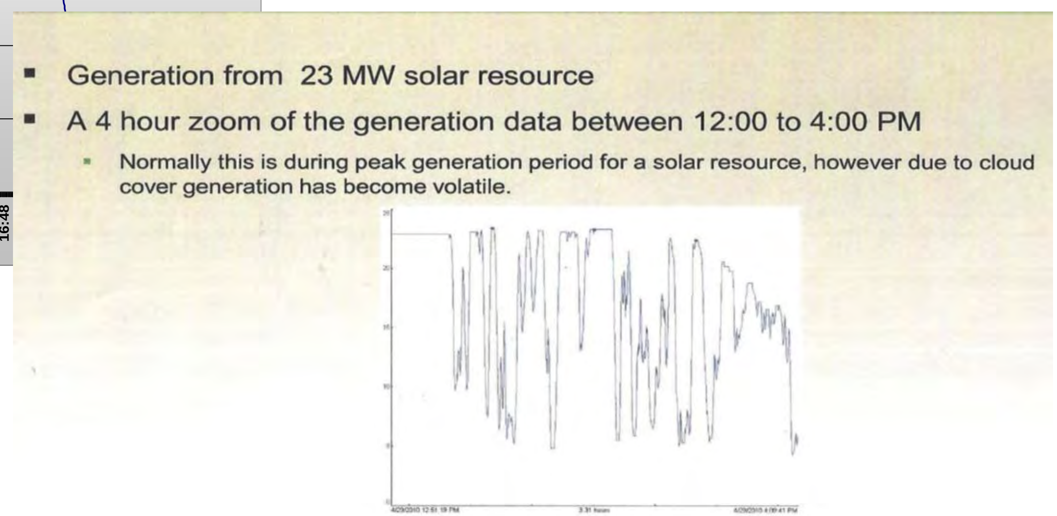
Looking at Wind Power More Closely



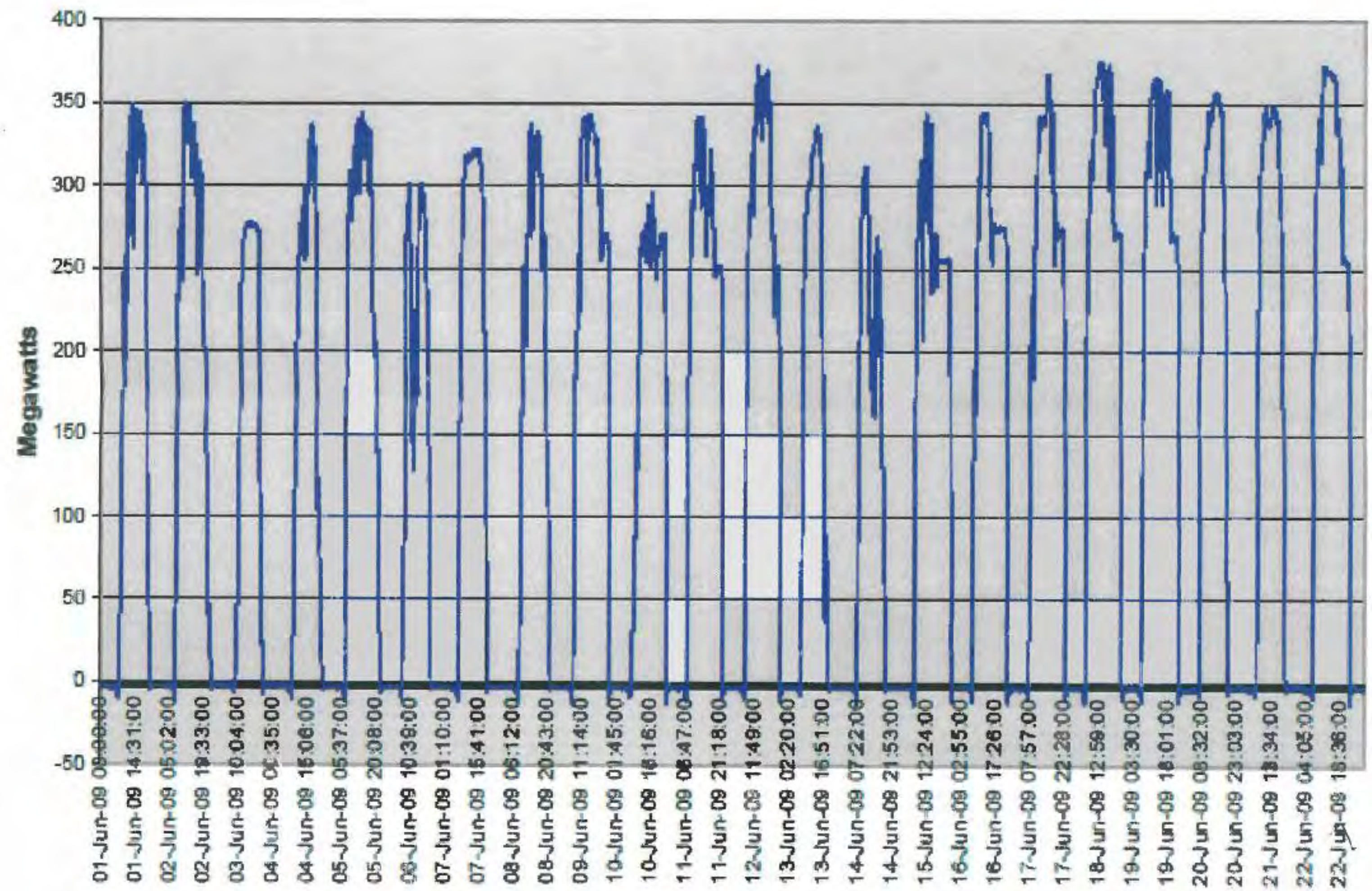


And Solar…

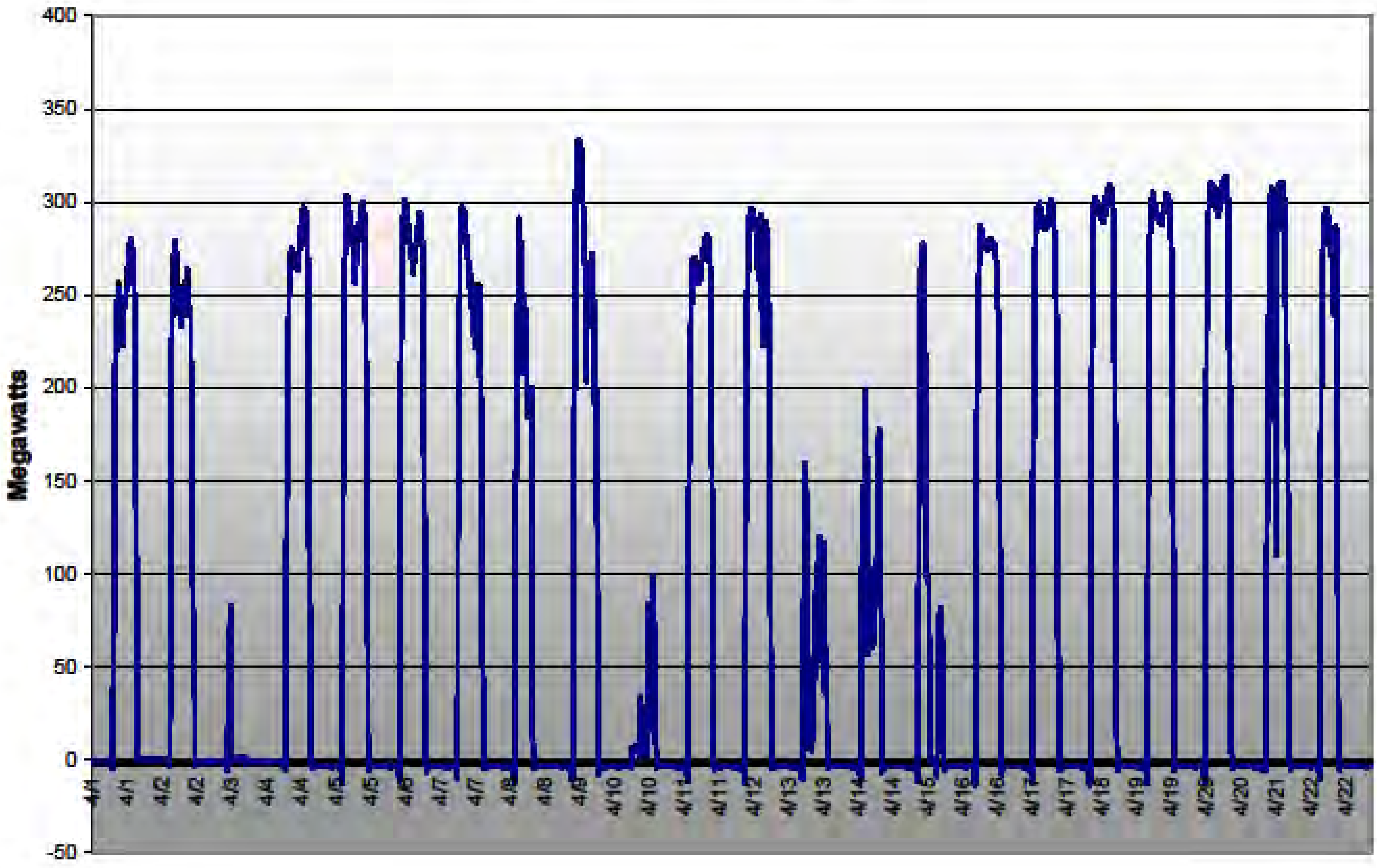

April 21 - Concentrated Solar
Megawatts
350
300
250
200
150
100
50
0
-50
0:00
0:42
1:24
2:06
2:48
3:30
4:12
4:54
5:36
6:18
7:00
7:42
8:24
9:06
9:48
10:30
11:12
11:54
12:36
13:18
14:00
14:42
15:24
16:06
16:48


Generation from 23 MW solar resource
A 4 hour zoom of the generation data between 12:00 to 4:00 PM
Normally this is during peak generation period for a solar resource, however due to cloud cover generation has become volatile.

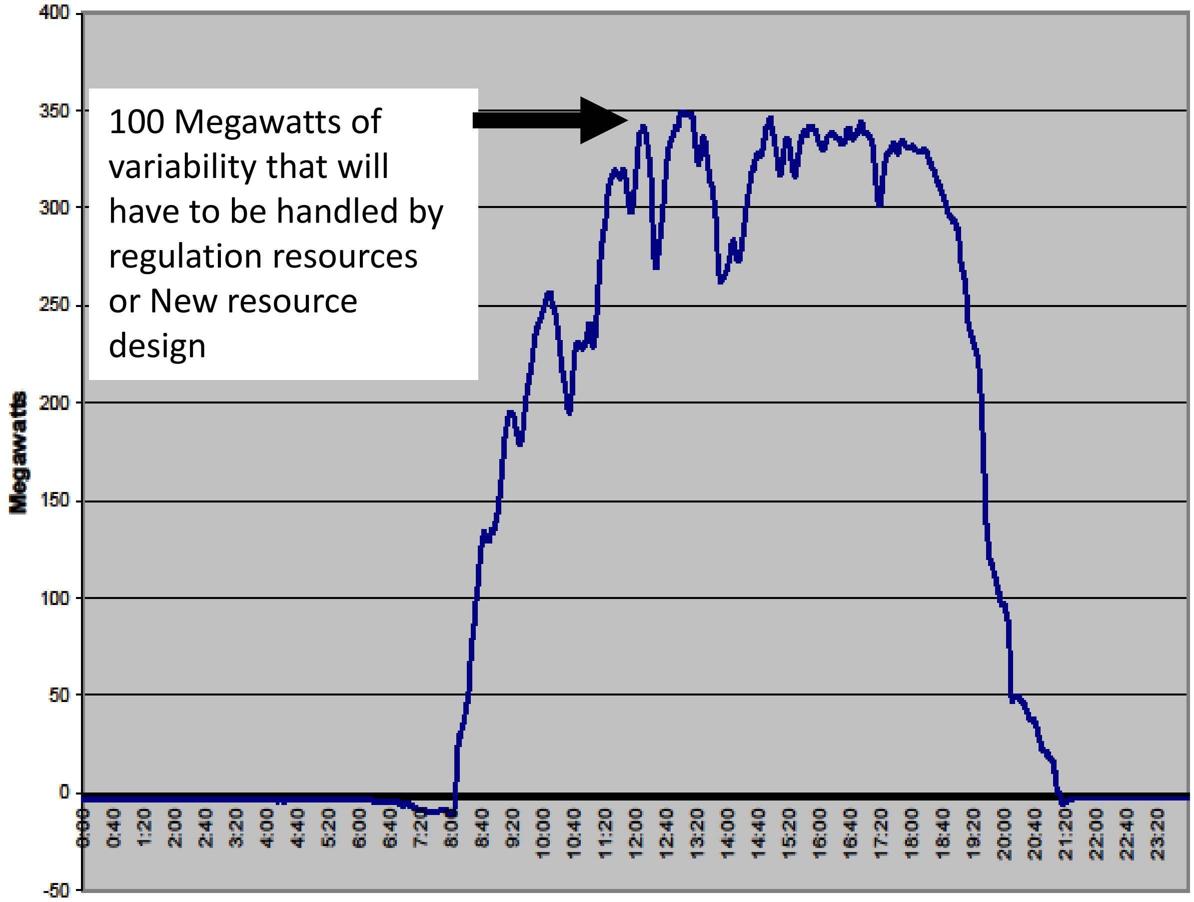
Daily Concentrated Solar Energy Production



Some Months Are Worse Than Others



Concentrated Solar Production Variation



Resources Needed to Meet Challenge

Characteristic Needed	Superior Options
Fast start capability	Internal combustion engines
Fast ramping	Internal combustion engines
Good cycling performance	Internal combustion engines
Output conditioning	Batteries – with the right inverter package
Rotating inertia	Combined cycle
Cost mitigation	Integration at project level
Proper market design	To be decided

This Is a Complex Transformation

- Leg-reg-ulators do not fully appreciate the challenges and adaptive changes are slow and difficult
- All power system effects must be understood and managed by the Balancing Authority or System Operator with existing system resources
- Many effects at different layers of the supply chain are not yet understood or addressed

More Unanswered Questions

- What do these Power System transformation problems look like?
- What are the indicators showing the problem exists and the size of the issue?
- What must be done to correct problems before they develop?
- What must be learned to anticipate the problems of the transformation?
- Can the existing markets solve the problems of the transformation?
- Who will pay for this increase in complexity?

Summary

- Deployment of significant amounts of renewable generation will fundamentally transform operation of grid in unanticipated ways
- The devil is in the second-to-second details for ISO and Balancing Authorities
- Bulk energy storage will not play a significant role in near term
- Need for integrated solutions involving gas-fired recips
- New resources and new ways of doing business (market design) are needed now to meet challenge
- Newly embedded costs will be significant
- Explaining all this to legislators, regulators, and public will be major challenge
- Watch out for *Electrotropophobia*!