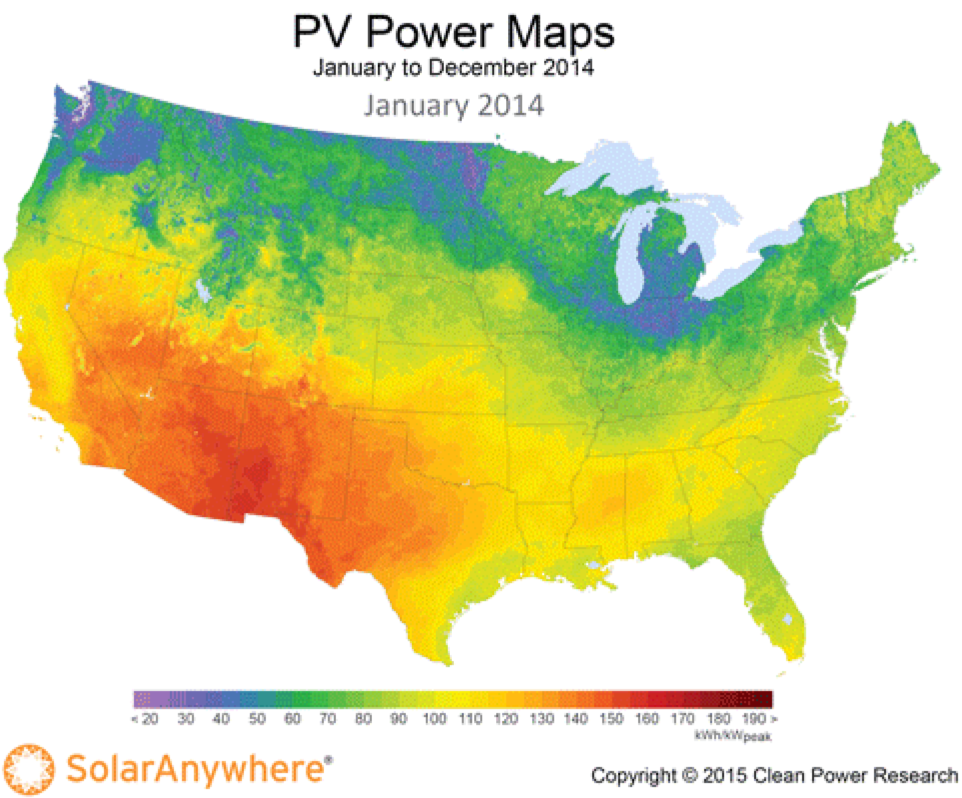
Net Metering Workgroup Session I

Docket No. 14-035-114

April 27, 2015

Prepared for

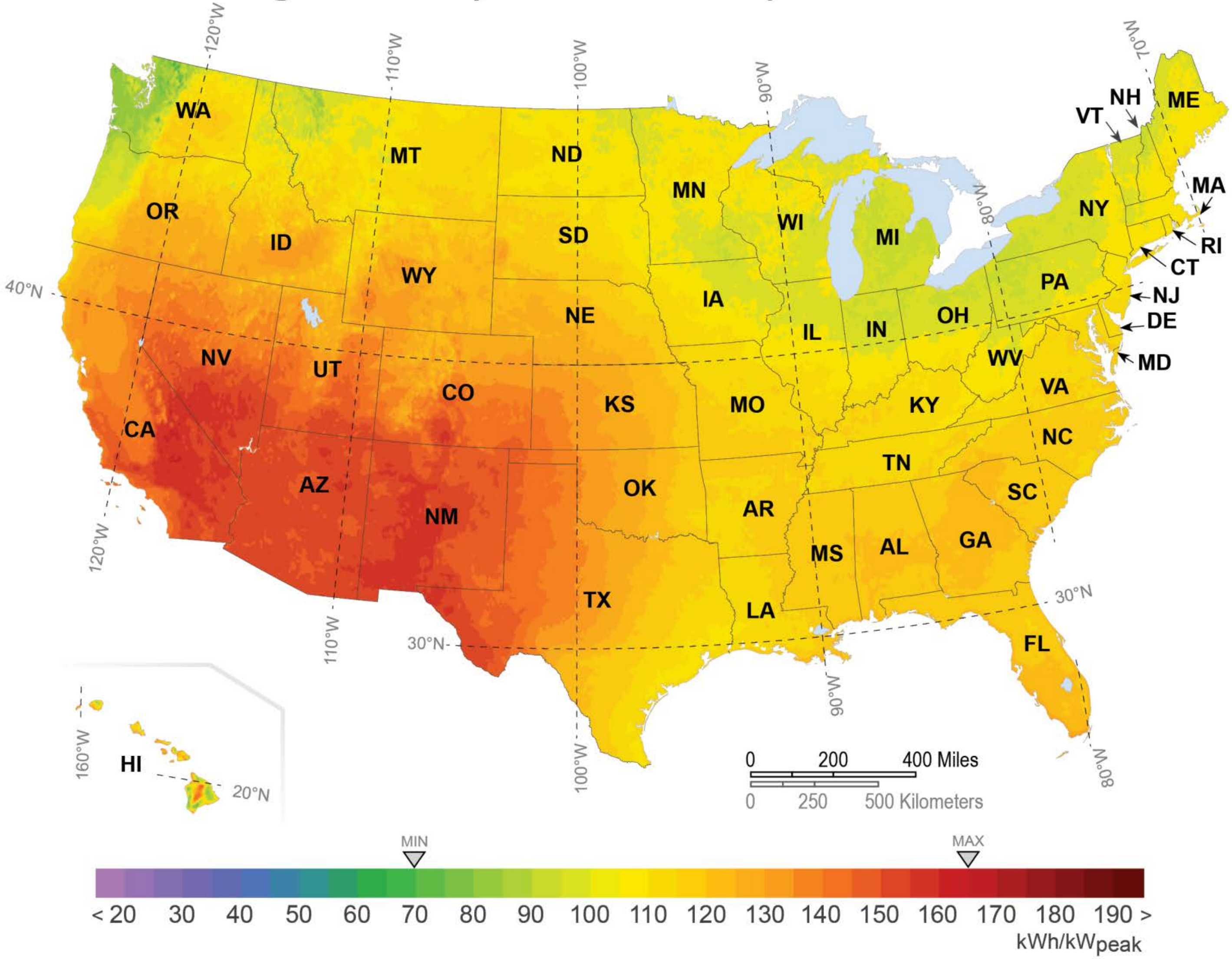
Utah Department of Commerce
Division of Public Utilities



Prepared by

Ben Norris,
Clean Power Research
on behalf of Utah Clean Energy

2014 Average Monthly PV Power Map



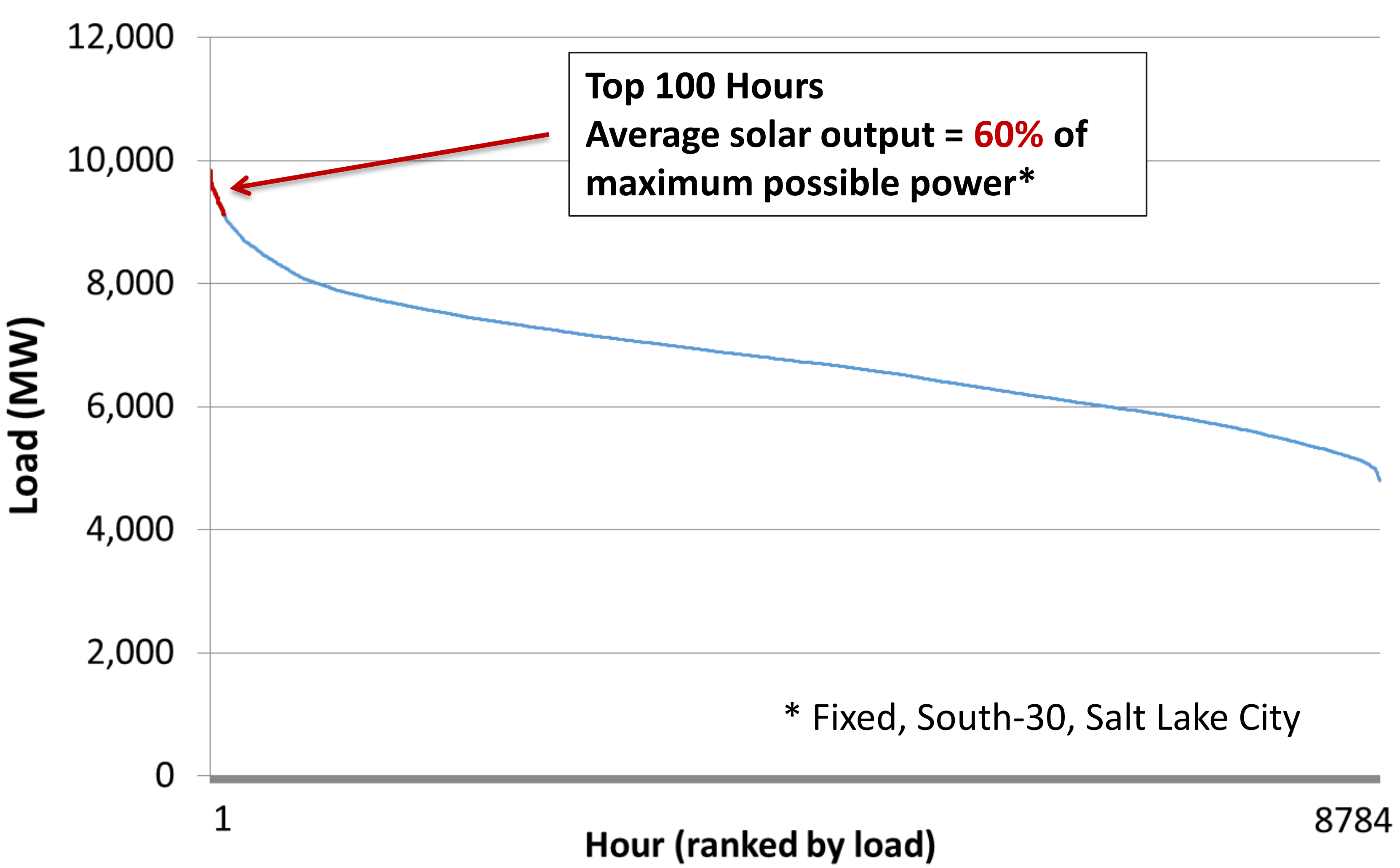
Agenda

- Solar characteristics in Utah
- Impacts of solar in the distribution system
- Differences between utility-scale and distributed solar

Solar Characteristics in Utah

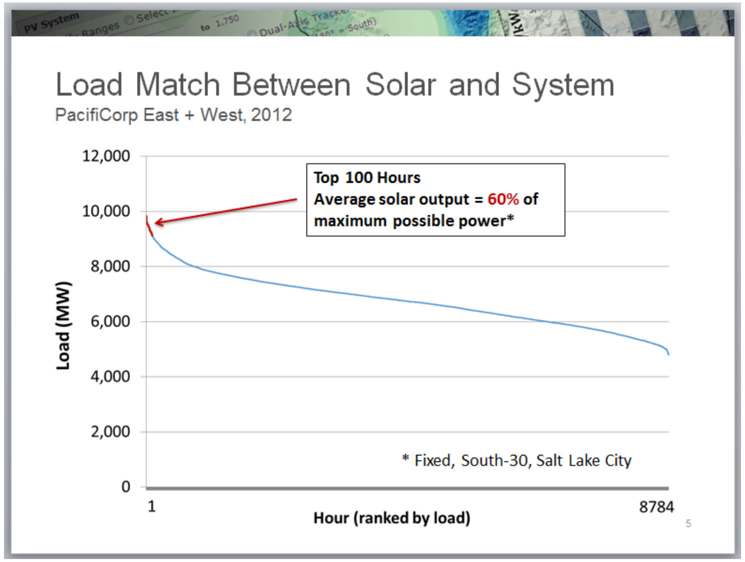
Load Match Between Solar and System

PacifiCorp East + West, 2012



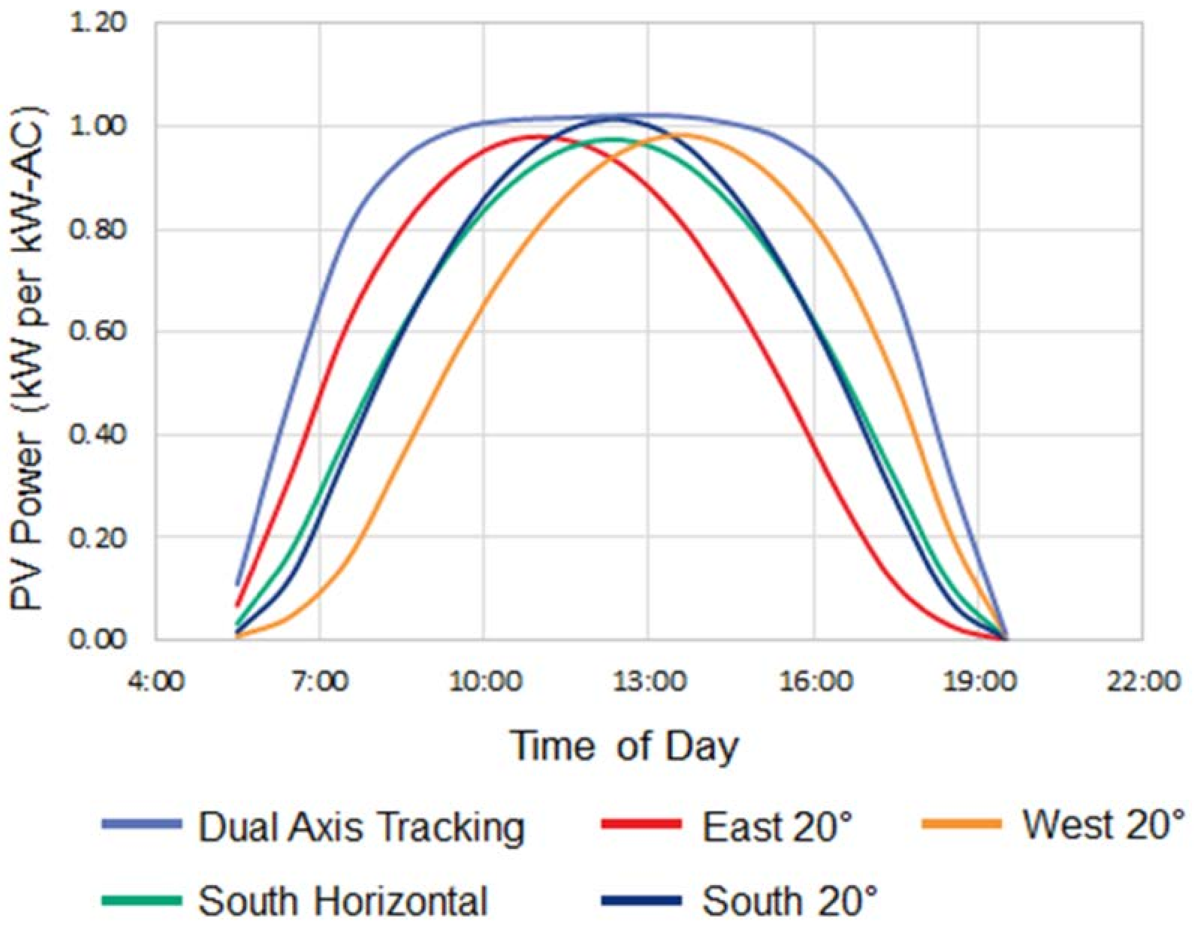
How to Improve Load Match Analysis

- For generation coincidence, should use load data from PacifiCorp East load balancing area (not available to public)
- For distribution coincidence, should use load data from RMP Utah (not available to public)
- Solar modeling should be based on fleet data, rather than a single system



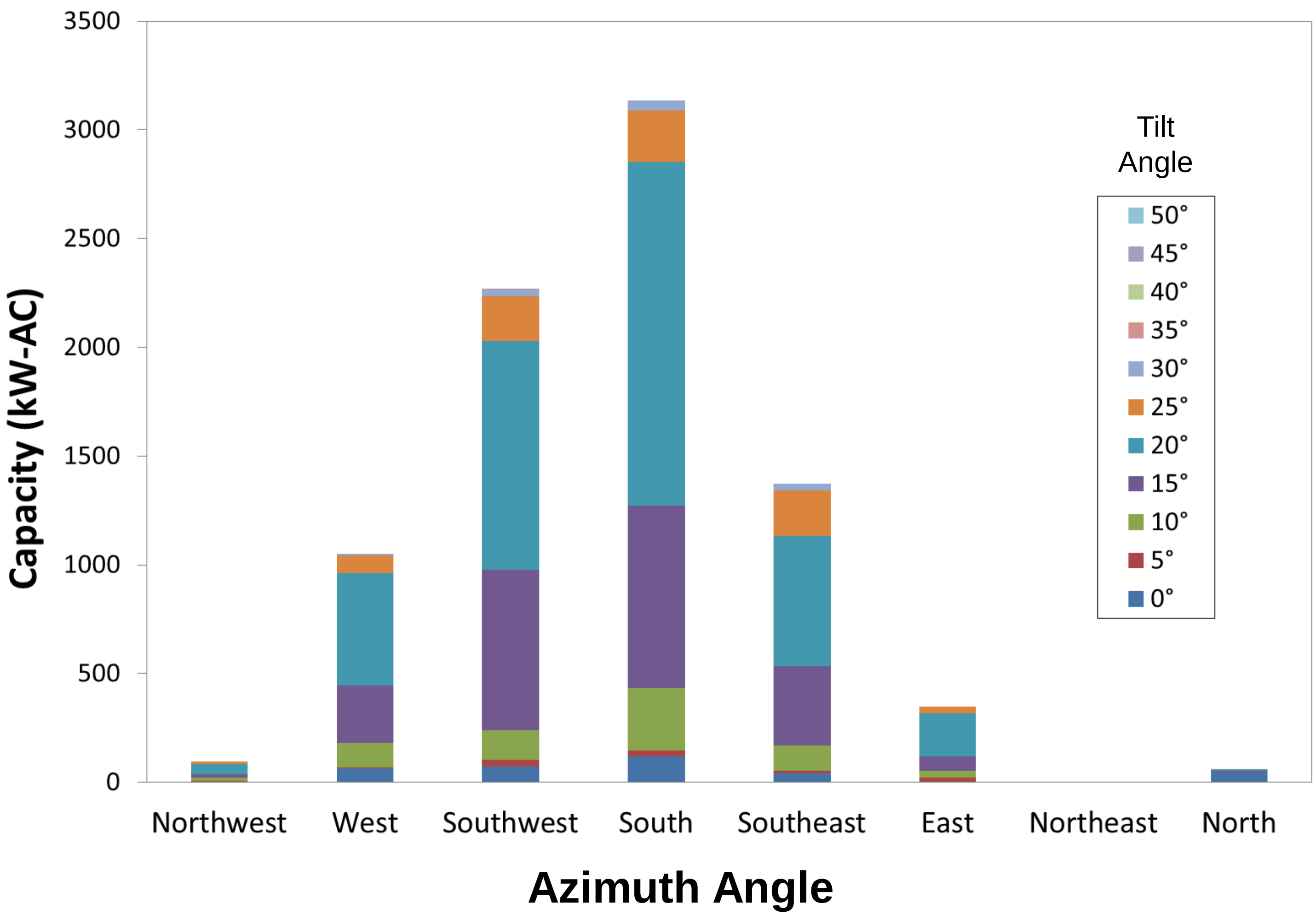
Production Profiles by Orientation

(For illustration)



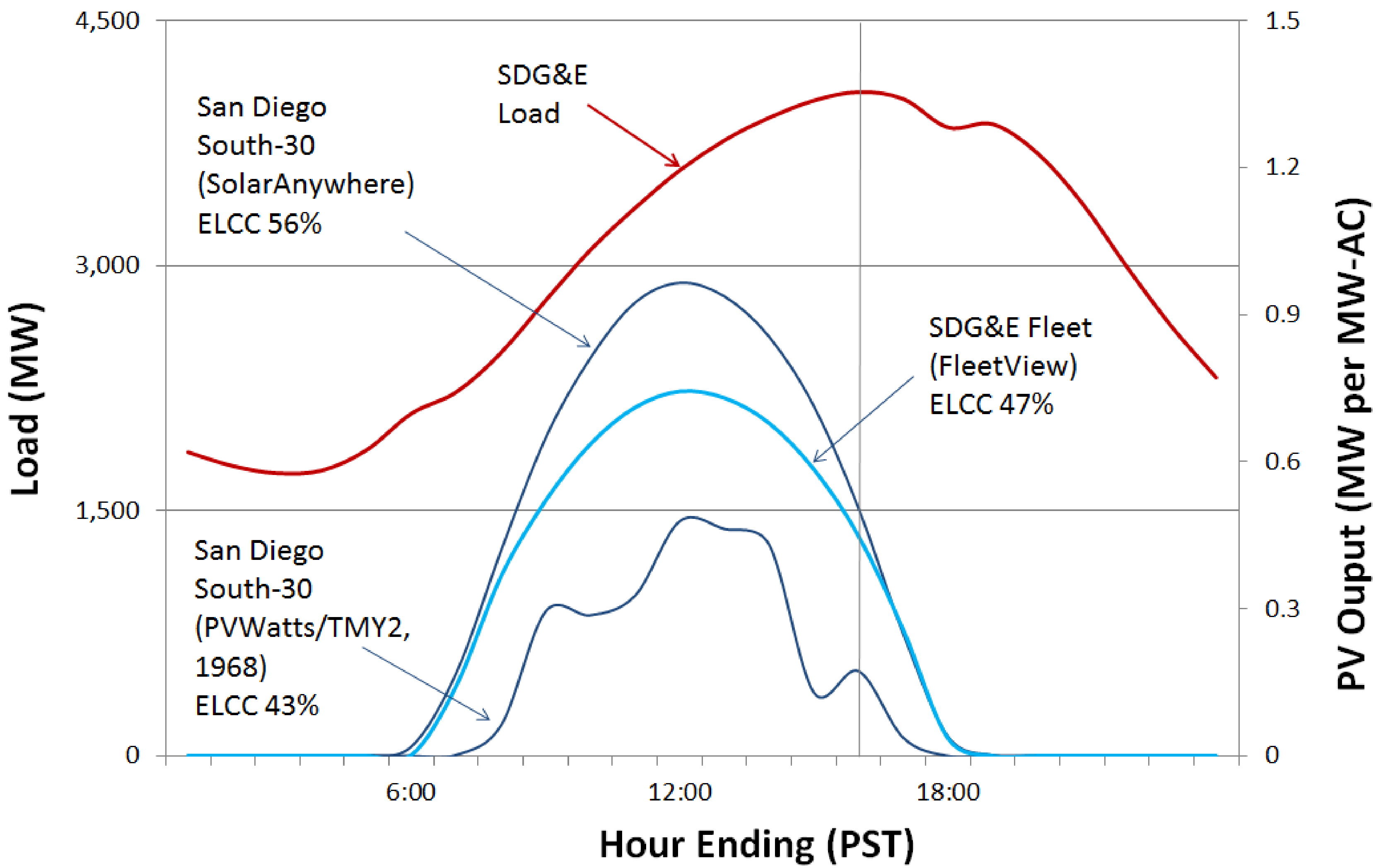
Capacity "Buckets" by Orientation (and location)

(Austin Energy – used for illustration)



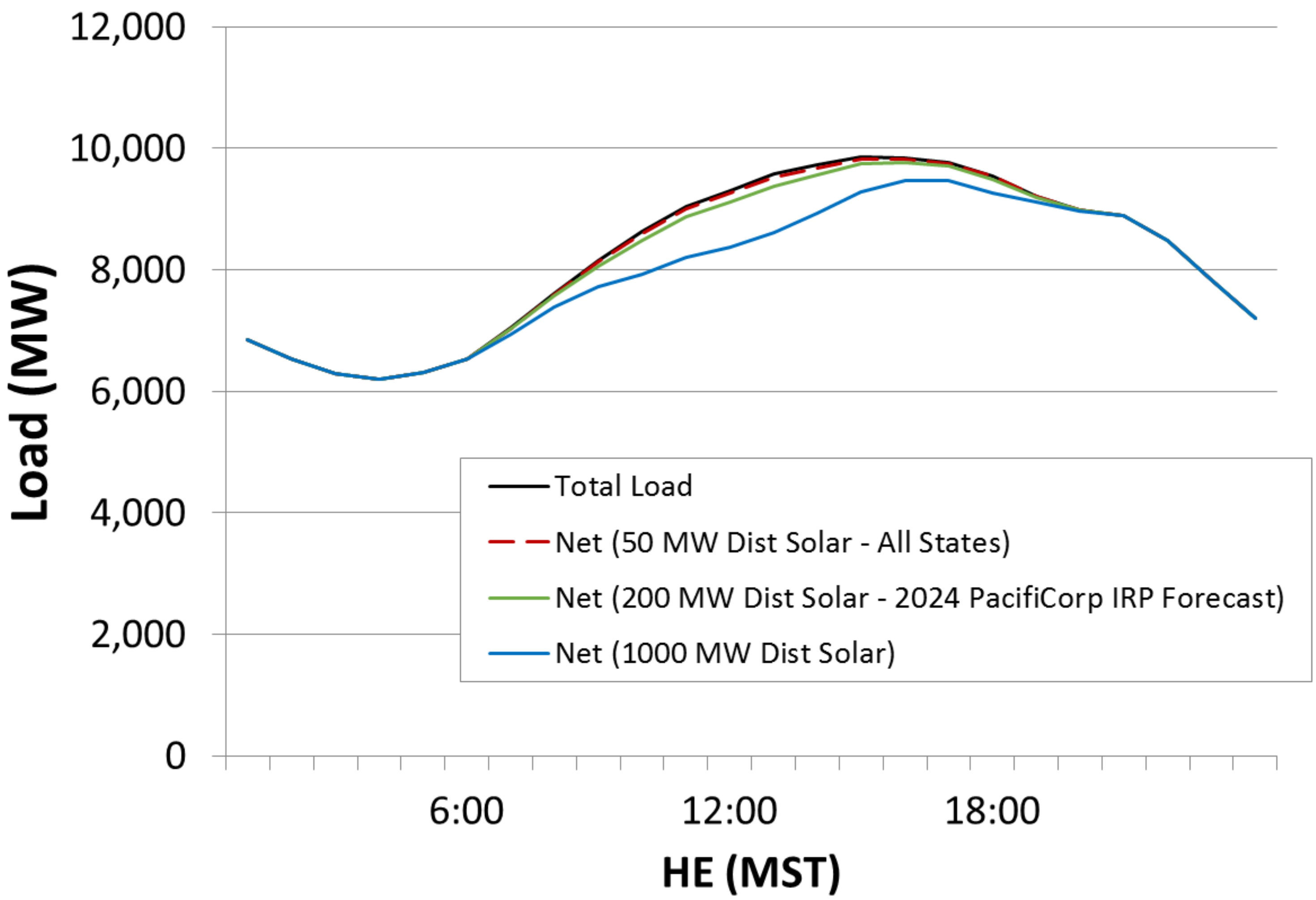
Why do Fleet Modeling?

SDG&E peak day, 2012 (September 14)



Impact on 2012 Peak Load Day (Preliminary)

PacificCorp East+West, July 12, 2012



Impacts of solar in the distribution system

Hawaiian Electric Experience

Hawaiian Electric has the highest DG penetration in the nation. A company filing to the state PUC on DER Policies, Jan 20, 2015, Docket No. 2014-0192:

- Proposes to raise circuit penetration threshold for transient overvoltage from 120% of "gross minimum daily load" to 250% based on inverter testing (load rejection overvoltage, "LRO") with NREL, EPRI, and Solar City.
- Proposes to monitor impacts on safety and reliability (circuit and system).
- Proposes requiring advanced inverters.
- Proposes to make strategic and cost-effective capital investments to upgrade circuits to support increased thresholds. Seeks collaboration with stakeholders to identify high demand / high benefit circuits.
- Proposes that costs be treated as grid improvements that benefit all customers (paid by all, not just those installing DG).

Utah PV Penetration

	Utah (2014) 9 – 15 ¢/kWh	Utah, 10-yr forecast (2024)	California ISO (2014) 16-33 ¢/kWh	Hawaiian Electric (Oahu, 2014) 25-28 ¢/kWh
[A] Installed BTM Solar	14 MW	175 MW [2]	5,655 MW [4]	283 MW [6]
[B] Peak Load	5,024 MW [1]	5,935 MW [3]	45,089 MW [5]	1,200 MW [7]
Penetration = [A] / [B]	0.3%	2.9%	13%	24% (85 x Utah)

[1] Non-coincident Jurisdictional Peak for Utah, 2014, from PacifiCorp 2015 IRP, Table A.6.
[2] PacifiCorp 2015 IRP (Utah only), developed by Navigant.
[3] Assumes 10-year forecasted average coincident peak load growth rate for Utah (1.68% per year), 2015-24, from PacifiCorp 2015 IRP, Table A.2.
[4] Compiled by Clean Power Research (MW-DC) for PG&E, SCE and SDG&E.
[5] California ISO.
[6] HECO, filing to PUC 1/20/2015.
[7] HECO 2013 IRP.

Technical Interconnection Issues

- Voltage fluctuations
  - Fluctuations in voltage may be caused by cloud transients, requiring additional voltage regulation
  - Aggregations of systems can smooth output
  - Advanced inverters can mitigate
- Circuit protection not designed for backfeed
  - With DG, power can flow in both directions
  - May require upgrades to protective devices and new coordination (protection designs were based on one-way flow only)
- Distribution transformer sizing
  - Output of solar may exceed the rated capacity of the existing transformer
  - May require upgrade to accept higher power

Advanced Inverters

- Advanced inverters can:
  - Act like variable capacitors (source or sink reactive power) - mitigate voltage swings
  - Provide voltage and frequency ride through – improve system reliability
  - If used, would not only mitigate PV impacts, but potentially improve stability and reliability
- "Advanced" inverters use <u>old</u> technology, but <u>new</u> interconnection standards.
  - Rules do not currently allow inverters to control voltage. New standards are being developed by IEEE P1547 Working Group. Utah may wish to keep abreast of this.

Cost impacts

- Upgrades to voltage regulation, distribution transformers, protective devices
- Highly site specific
  - Requirements are specific to circuit, location and proposed installation
  - Some installations require significant upgrade, some require nothing (e.g., small PV system on heavily loaded circuit will not have significant impact)
  - Depends on other DG already installed (“hot potato”)

Difference between utility-scale and distributed solar

Design Differences: Utility Scale vs DG

- Orientation
  - DG often conforms to roof slopes
  - Commercial vs residential fleet shapes
- Tracking
  - Utility scale often designed to track the path of the sun
- Aggregation
  - Distributed systems:
    - Are more widely dispersed (more smoothing)
    - Are higher in redundancy (more reliability)

Valuation Differences: Utility Scale vs Distributed

(Illustrative - categories may not apply to Utah)

Distributed Solar

		Gross Value A ($/kWh)	×	Load Match Factor B (%)	×	Loss Savings Factor (1+C) (%)	=	Distributed PV Value D ($/kWh)
Energy Supply	Avoided Fuel Cost	C1				LSF-Energy		V1
	Avoided Variable O&M Cost	C2				LSF-Energy		V2
	Avoided Fixed O&M Cost	C3		EC		LSF-EC		V3
	Avoided Gen. Capacity Cost	C4		EC		LSF-EC		V4
Transmission and Distribution	Avoided Trans. Capacity Cost	C5		EC		LSF-EC		V5
	Avoided Dist. Capacity Cost	C6		PLR		LSF-Dist		V6
Environmental	Avoided Environmental Compliance	C7				LSF-Energy		V7
	Avoided SO_2 Emissions	C8				LSF-Energy		V8
Customer	Avoided Fuel Price Uncertainty	C9				LSF-Energy		V9
								Total

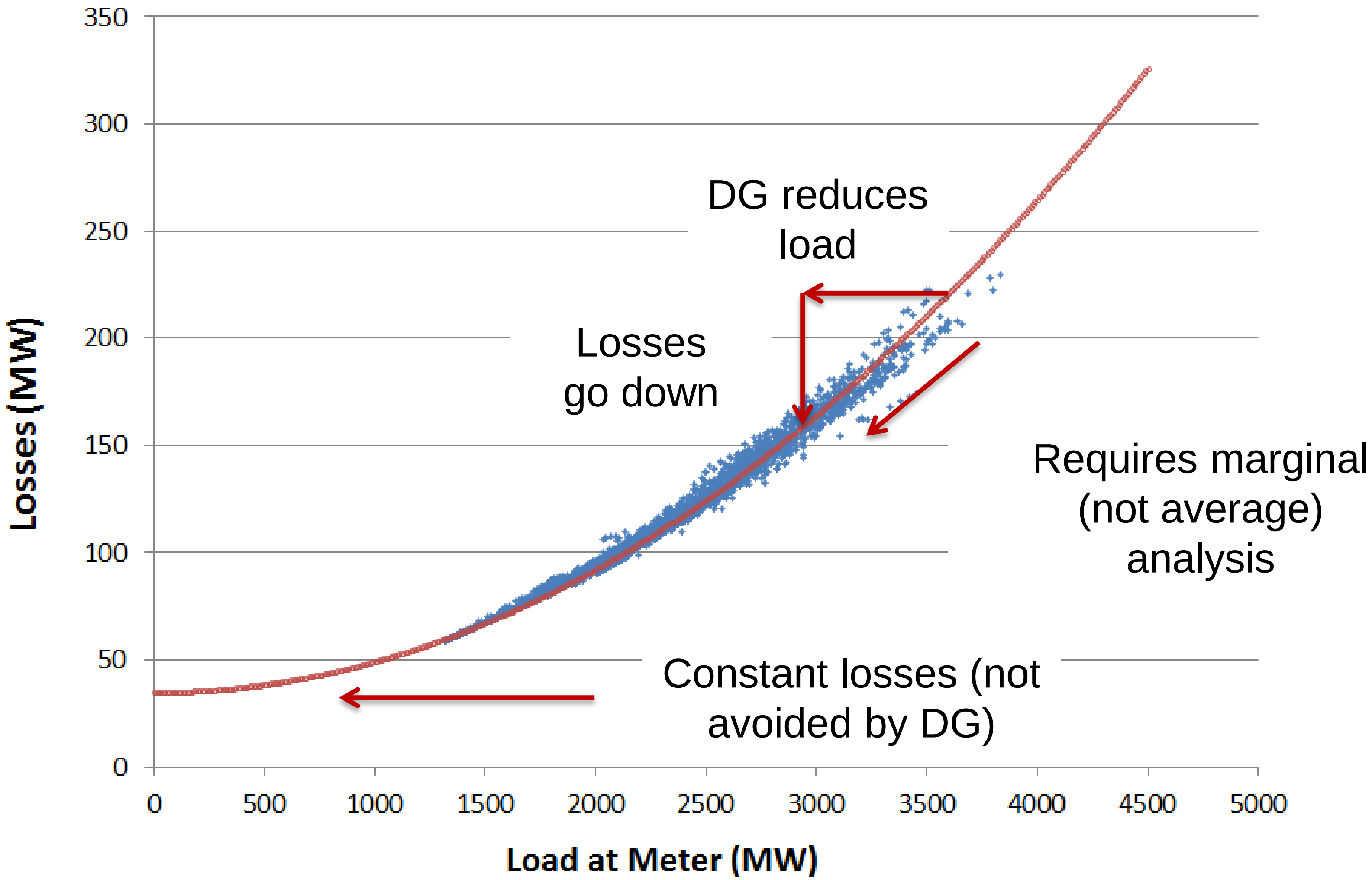
Valuation Differences: Utility Scale vs Distributed

(Illustrative - categories may not apply to Utah)

Utility Scale Solar

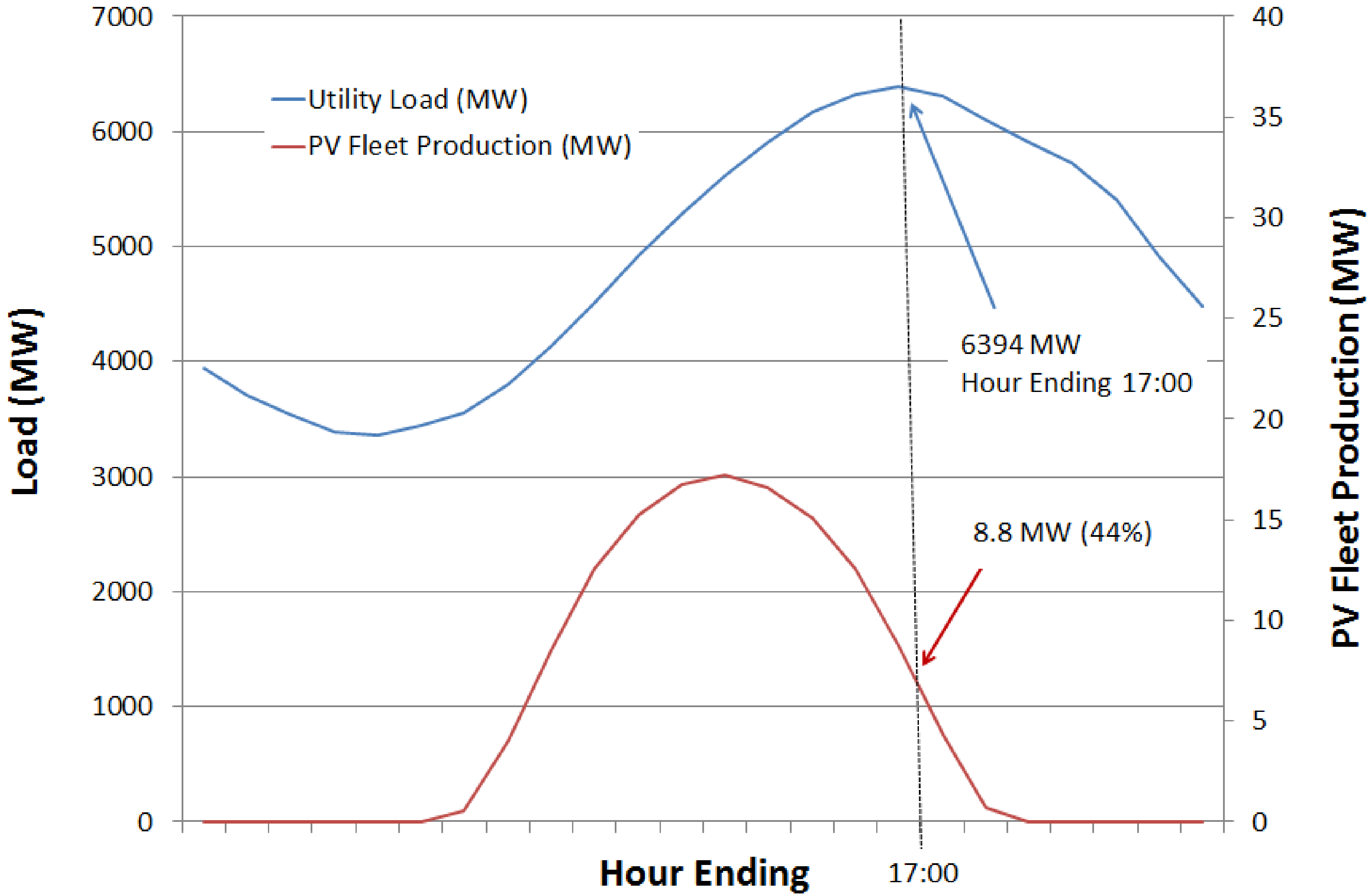
Category	Component	Gross Value A ($/kWh)	×	Load Match Factor B (%)	×	Loss Savings Factor (1+C) (%)	=	Distributed PV Value D ($/kWh)
Energy Supply	Avoided Fuel Cost	C1				~~LSF-Energy~~		V1
	Avoided Variable O&M Cost	C2				~~LSF-Energy~~		V2
	Avoided Fixed O&M Cost	C3		EC		~~LSF-EC~~		V3
	Avoided Gen. Capacity Cost	C4		EC		~~LSF-EC~~		V4
Transmission and Distribution	~~Avoided Trans. Capacity Cost~~	~~C5~~		~~EC~~		~~LSF-EC~~		~~V5~~
	~~Avoided Dist. Capacity Cost~~	~~C6~~		~~PLR~~		~~LSF-Dist~~		~~V6~~
Environmental	Avoided Environmental Compliance	C7				~~LSF-Energy~~		V7
	Avoided SO_2 Emissions	C8				~~LSF-Energy~~		V8
Customer	Avoided Fuel Price Uncertainty	C9				~~LSF-Energy~~		V9
								Total

Avoiding T&D Losses with DG



Avoided Distribution Capacity Costs

Peak Load Reduction – Illustrative (not Utah loads)



What Costs Should Be Included in the Distribution Capacity Value Calculation?

- Only capital costs
- Only equipment that PV can defer/avoid ("capacity related")

Example 1: SCADA Communications Gear

Analysis: This equipment is needed to provide operators with real-time information about the grid. It is needed whether PV is present or not.

Conclusion: Do not include this as a deferrable cost.

Example 2: Substation Transformer

Analysis: This equipment is needed to serve all load in the area. If the load reaches the transformer capacity limit, it has to be replaced with a larger unit. DG can reduce the load on this equipment and potentially delay the investment of a new unit.

Conclusion: Include this as a potentially deferrable cost (depends on load match).

Thank you

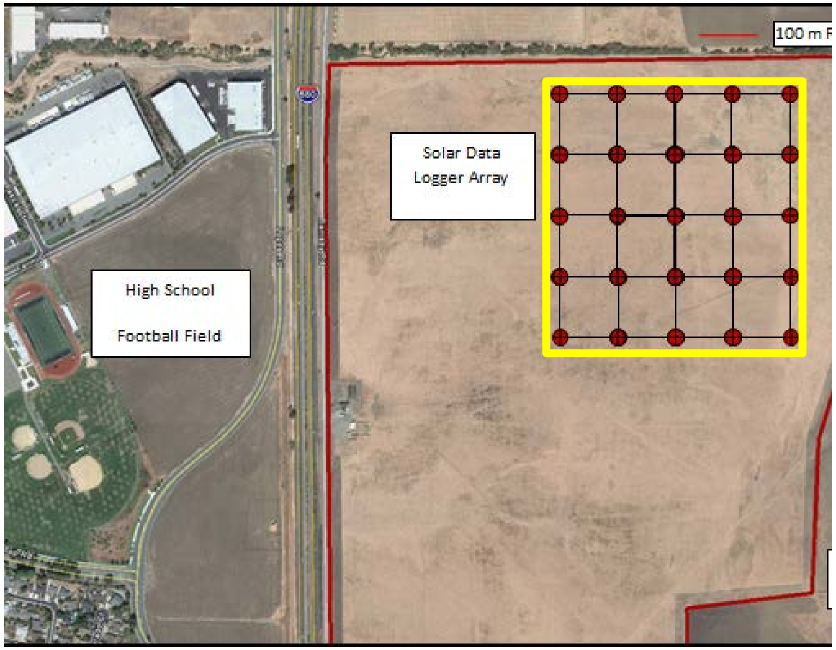
Ben Norris
ben@cleanpower.com

Clean Power Research

Appendix

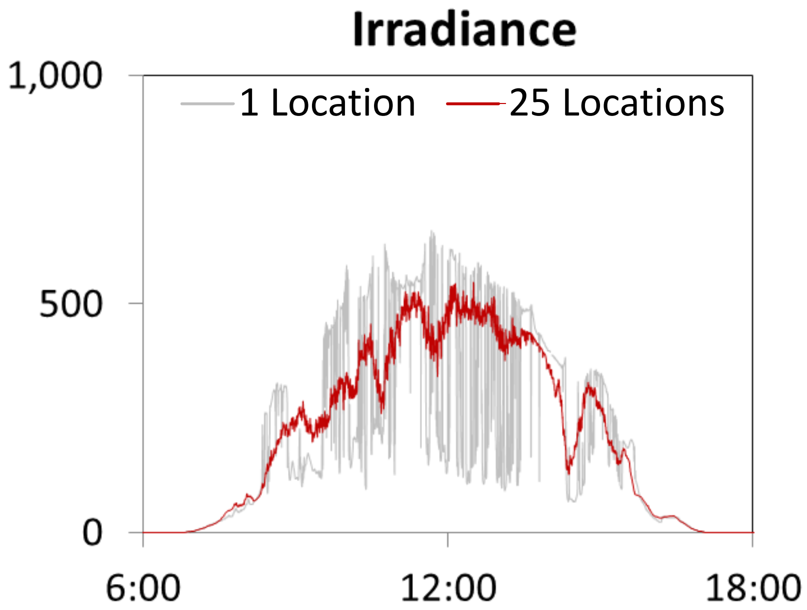
Measured data at two high-density networks

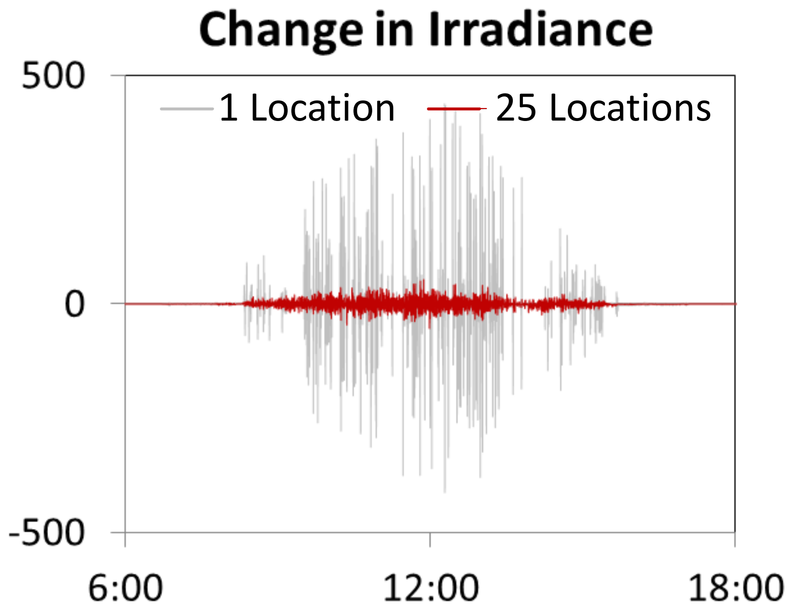
Location	Cordelia Junction, CA	Napa, CA
Grid Size	400 m x 400 m	4 km x 4 km
Representative Capacity	4 MW	400 MW
Data collection rate	10 seconds	10 seconds
Data collection period	11/6/10 to 11/12/10	11/19/10 to 11/23/10



10-second data in 4 km grid (11/21/10)

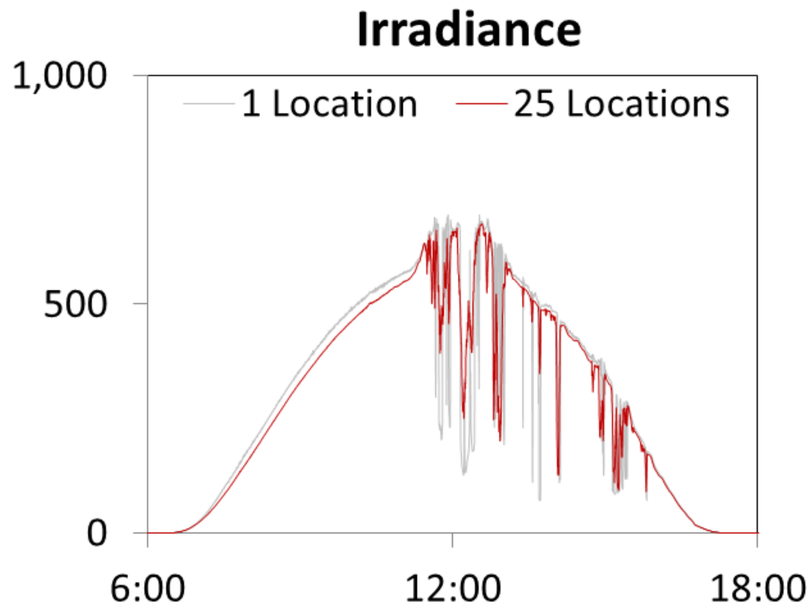
Combining output from multiple locations reduces variability

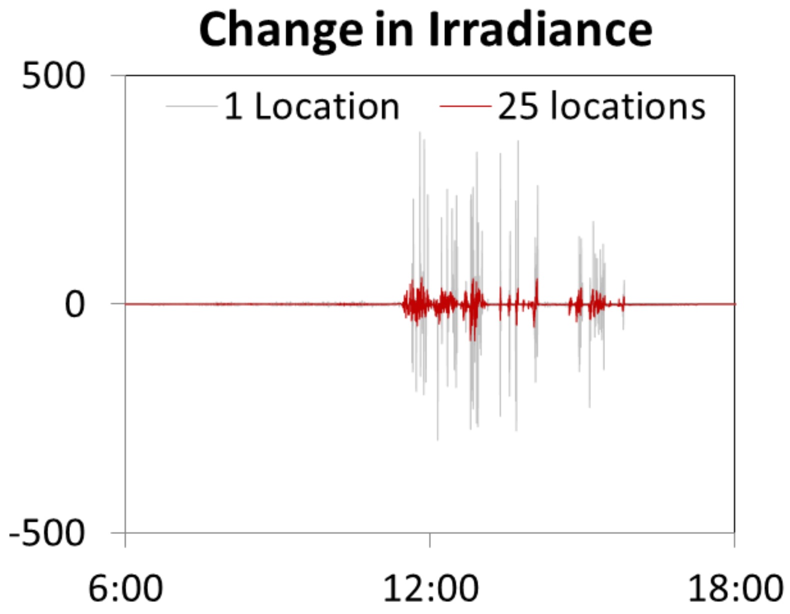




10-second data in 400 meter grid (11/10/10)

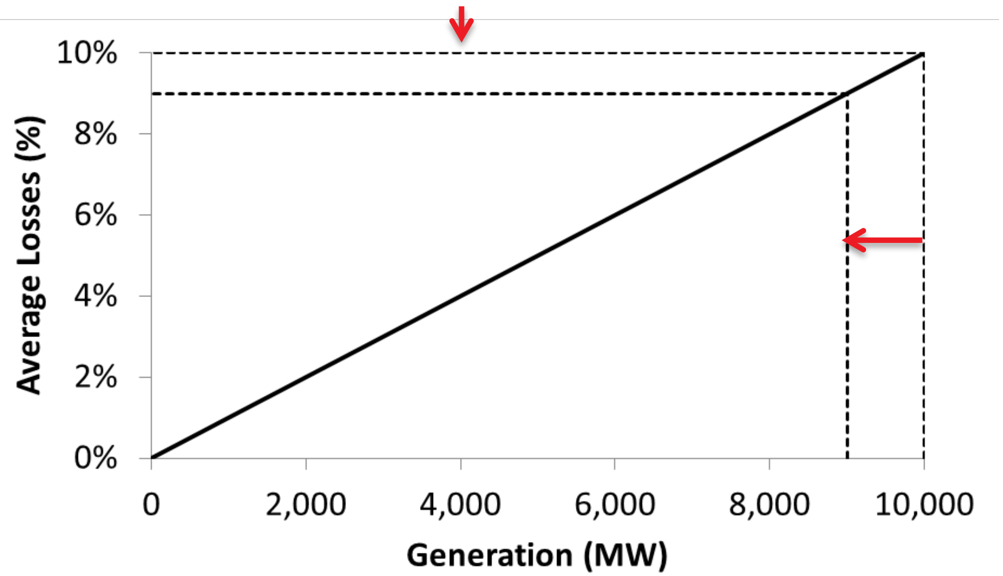
Combining output from multiple locations reduces variability





Generation Relates Linearly to Avg. Losses

Example of marginal loss savings calculation for a given hour



	Without PV	With PV	Change
Generation	10,000 MW	9,000 MW	1,000 MW
Avg. Losses	**10%**	9%	
Losses	1,000 MW	810 MW	190 MW
Loss Savings			**19%**

Example Account Evaluation

Account	Account Name	Additions ($) [A]	Retirements ($) [R]	Net Additions ($) = [A] - [R]	Capacity Related?	Deferable ($)
	DISTRIBUTION PLANT					
360	Land and Land Rights	13,931,928	233,588	13,698,340	**100%**	13,698,340
361	Structures and Improvements	35,910,551	279,744	35,630,807	**100%**	35,630,807
362	Station Equipment	478,389,052	20,808,913	457,580,139	**100%**	457,580,139
363	Storage Battery Equipment					
364	Poles, Towers, and Fixtures	310,476,864	9,489,470	300,987,394		
365	Overhead Conductors and Devices	349,818,997	22,090,380	327,728,617	**25%**	81,932,154
366	Underground Conduit	210,115,953	10,512,018	199,603,935	**25%**	49,900,984
367	Underground Conductors and Devices	902,527,963	32,232,966	870,294,997	**25%**	217,573,749
368	Line Transformers	389,984,149	19,941,075	370,043,074	**10%**	37,004,307
369	Services	267,451,206	5,014,559	262,436,647		
370	Meters	118,461,196	4,371,827	114,089,369		
371	Installations on Customer Premises	22,705,193		22,705,193		
372	Leased Property on Customer Premises					
373	Street Lighting and Signal Systems	53,413,993	3,022,447	50,391,546		
374	Asset Retirement Costs for Distribution Plant	15,474,098	2,432,400	13,041,698		
TOTAL		3,168,661,143	130,429,387	3,038,231,756		**$ 893,320,481**

Est. 28% of distribution 2012 capital investments were potentially deferrable by DG