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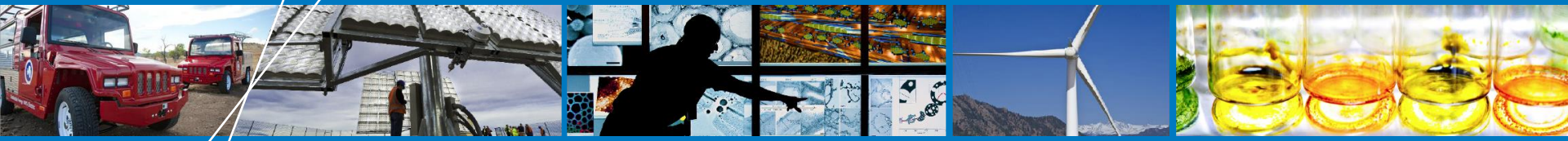
Some random work on solar and storage capacity credit



Paul Denholm

LOLE Working group

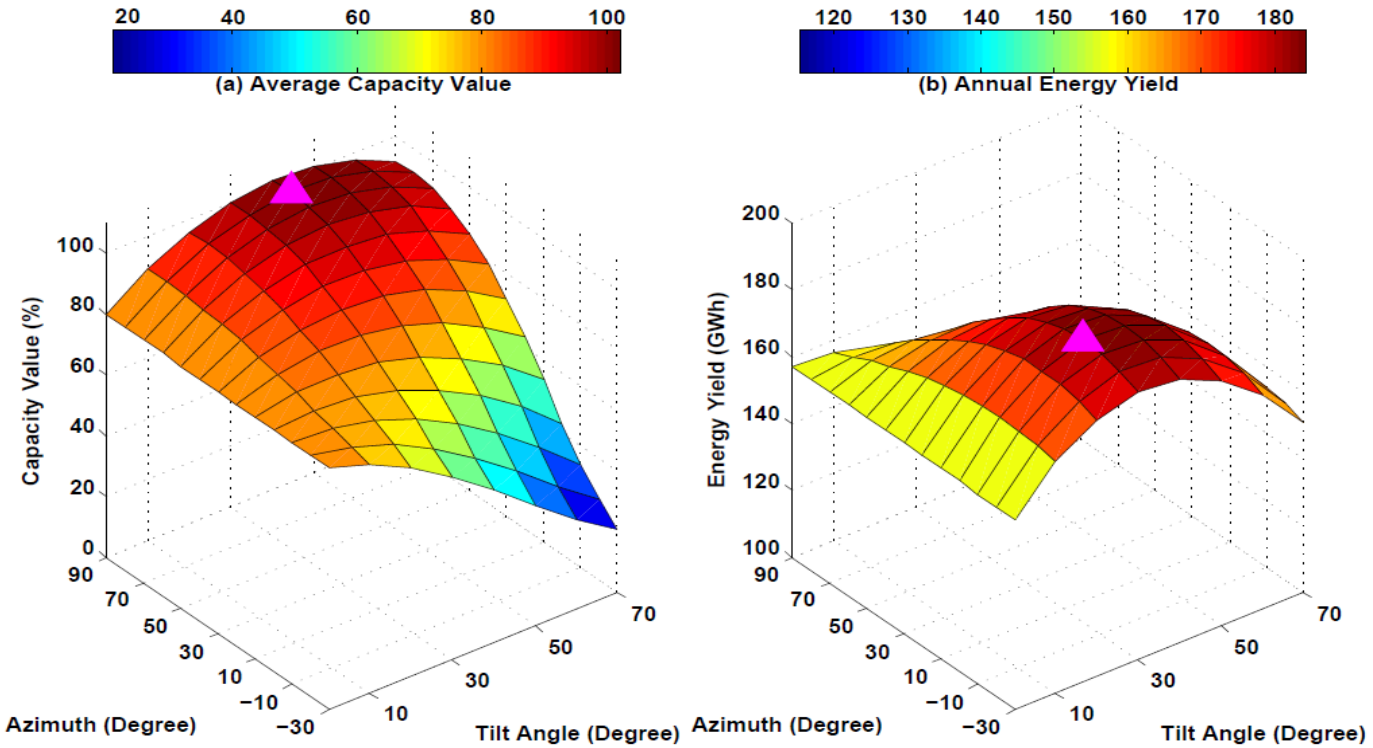
July 31, 2015

Things I am interested in

- Capacity credit of PV and CSP w/TES
- Capacity value of storage
- Impact of PV on load shape and impact on reliability

PV Work

- Much of this effort led by Ramteen Sioshansi at Ohio State University
- Standard ELCC analysis, methods comparison etc.



PV Work

- **Next steps**
  - Eastern U.S. (very little work to date)
  - Decline in capacity credit
  - Is hourly data good enough?

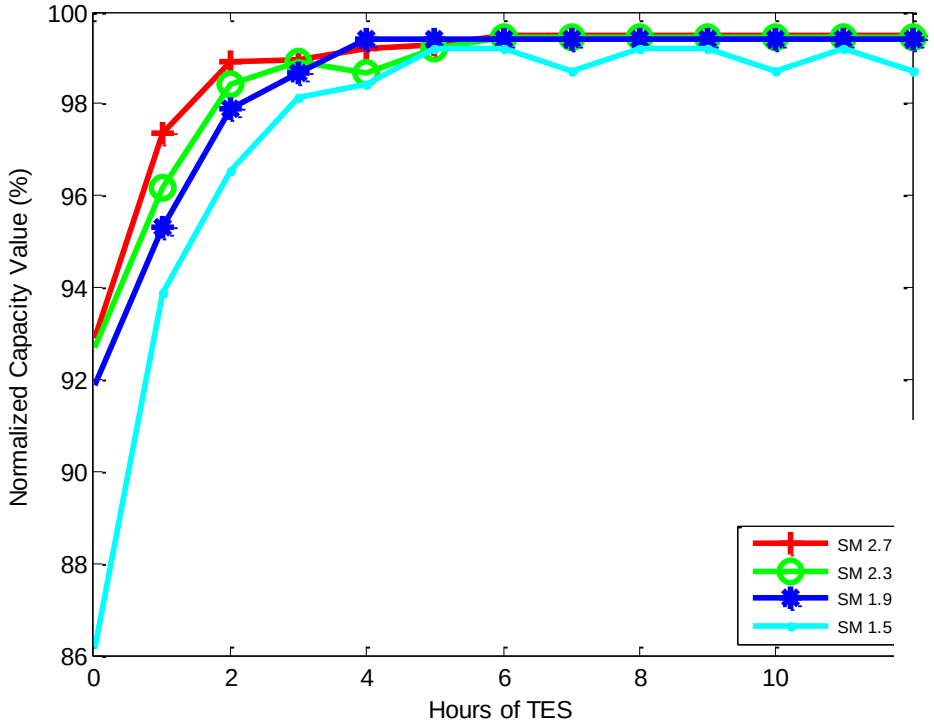
Capacity Credit of CSP with TES

- **No well defined market rules or methods for establishing capacity credit of stored energy devices**
- **We have used two methods**
  - Price taker simulations (Ramteen Sioshansi)
  - Production Simulations

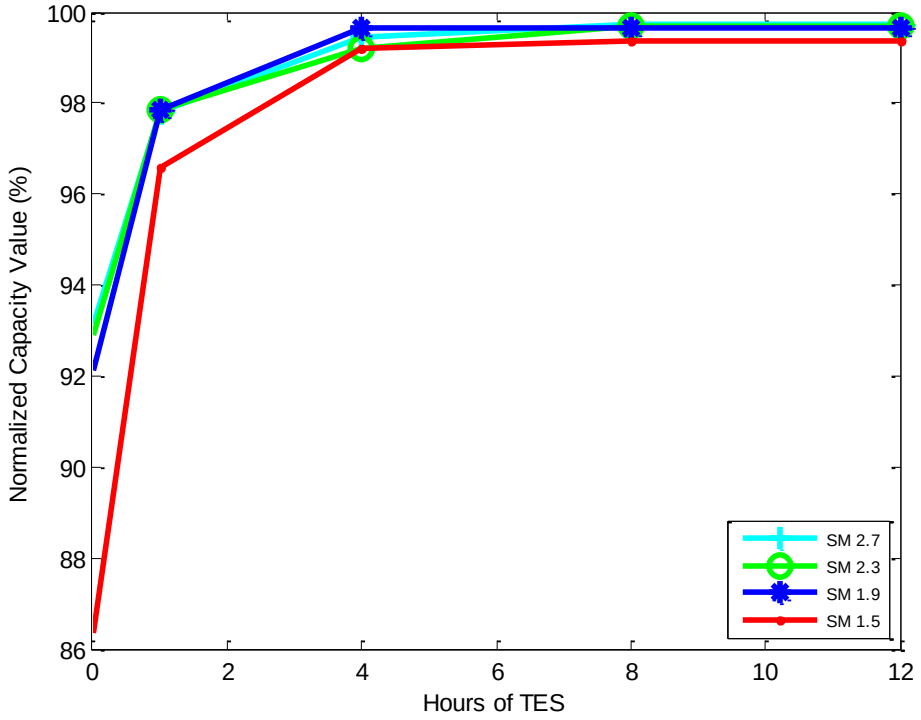
Price-Taker Simulations

- **Two methods:**
  - Capacity credit of a device maximizing energy profits without consideration of capacity. (Energy only markets)
  - Capacity credit of a device co-optimizing energy and capacity. (Used NE-ISO as a proxy market)

Capacity Value – With TES

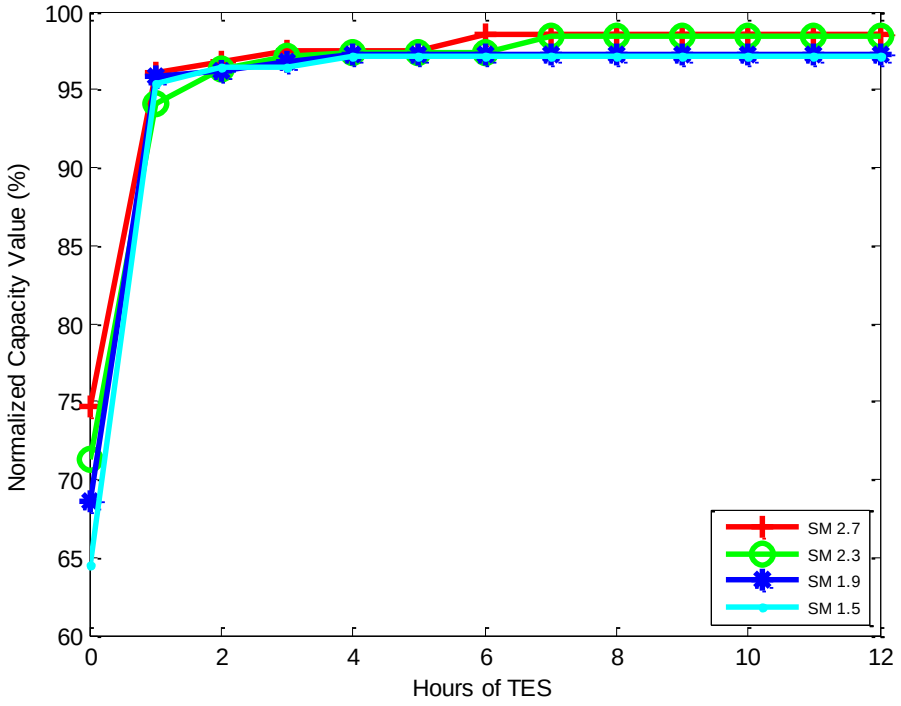


Imperial Valley, CA
Energy Only

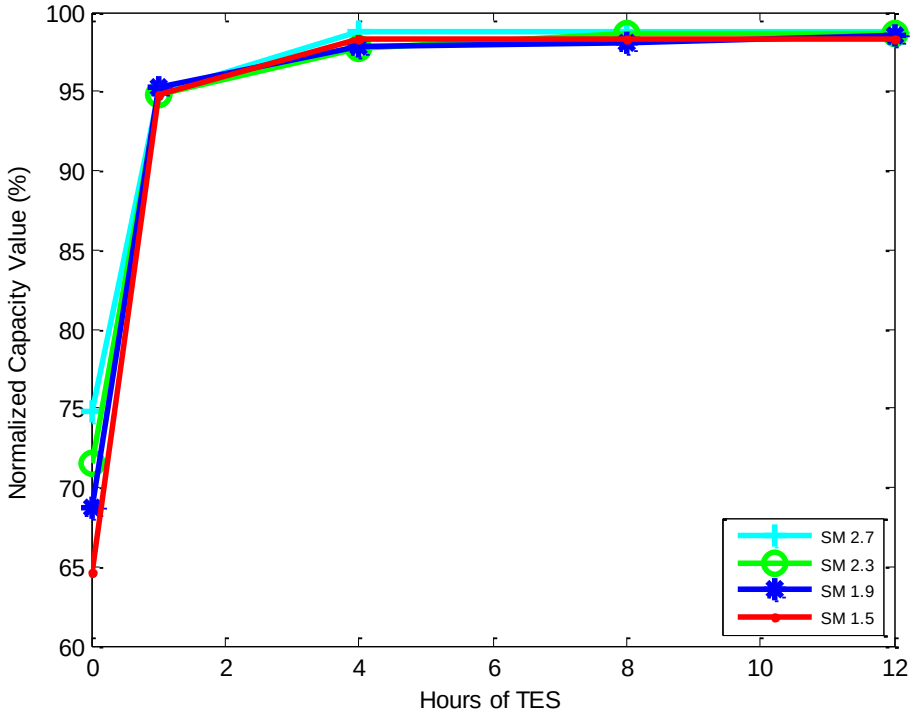


Imperial Valley, CA
Energy + Capacity

Capacity Value – With TES

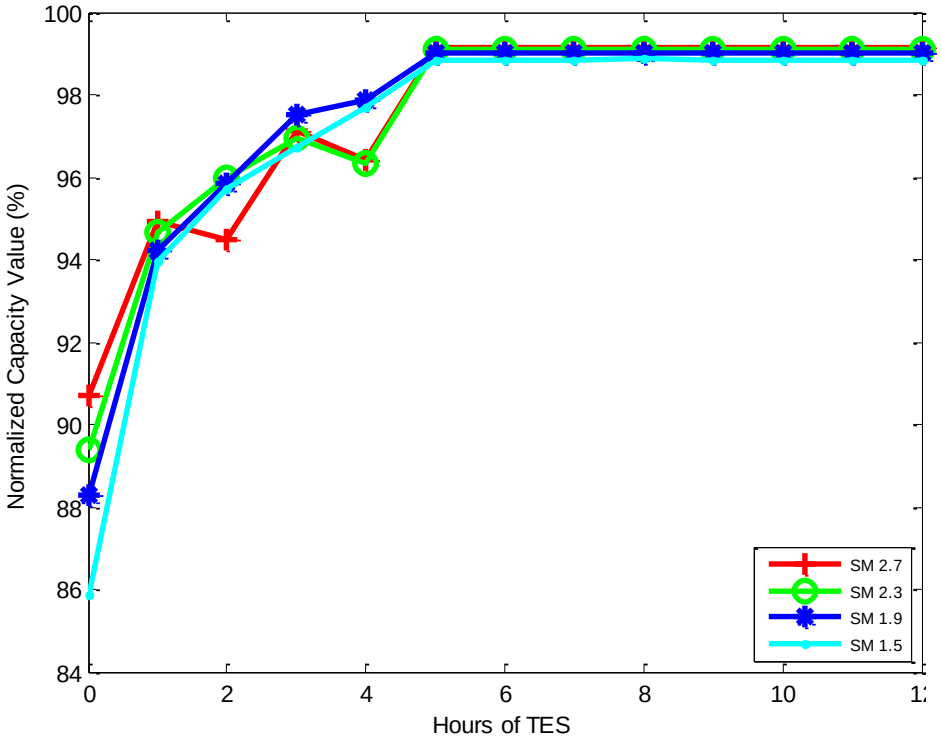


New Mexico
Energy Only

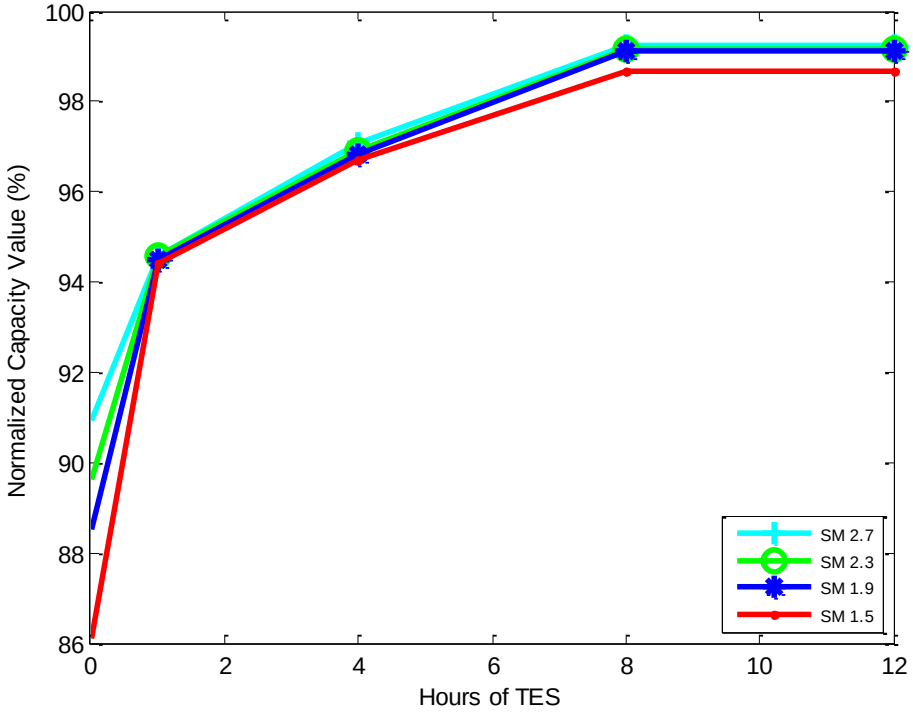


New Mexico
Energy + Capacity

Capacity Value – With TES

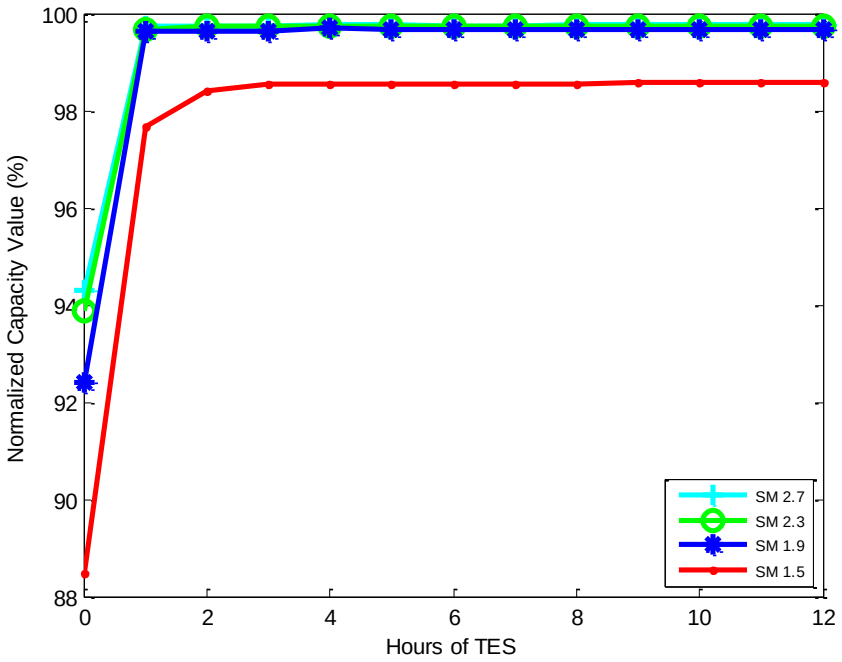


Death Valley, Ca
Energy Only



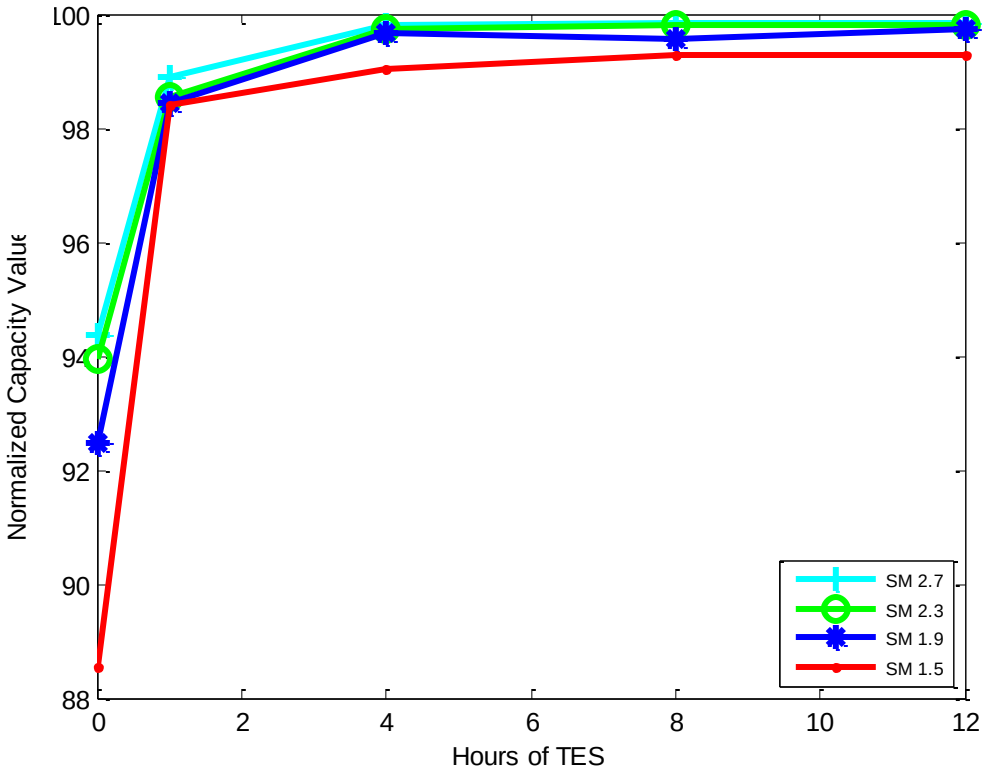
Death Valley, Ca
Energy + Capacity

Capacity Value – With TES



Arizona
Energy Only

Arizona
Energy + Capacity



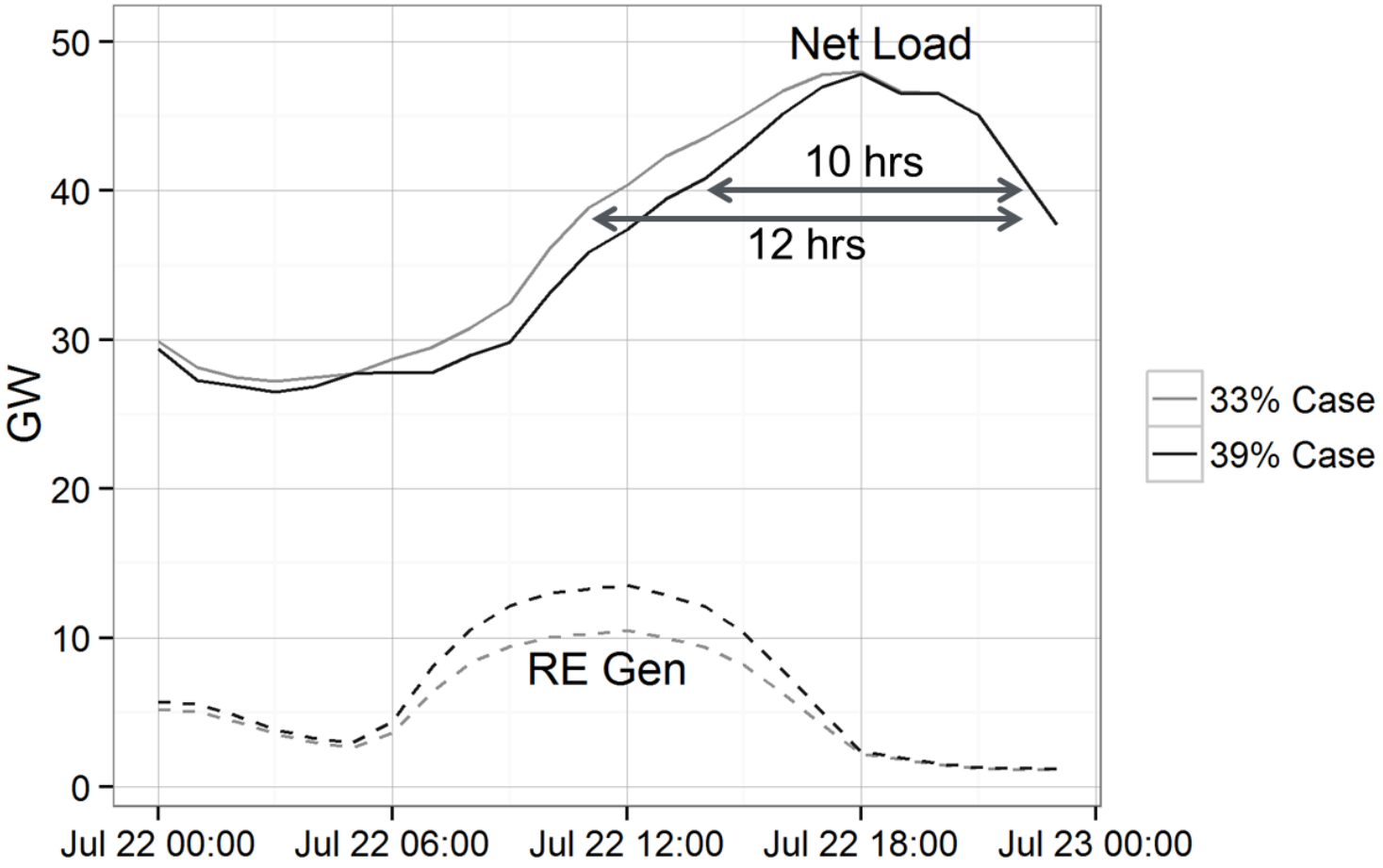
Capacity value using production cost models

- An approximation method uses plant output during the highest net load hours and the availability of stored energy during those hours, taking into account consecutive high load hours

	Solar Multiple						
TES	0.7	1	1.3	1.7	2	2.5	3
6	93%	96%	97%	98%	98%	-	-
9	-	-	-	98%	98%	99%	-
12	-	-	-	-	-	99%	-
15	-	-	-	-	-	99%	99%
18	-	-	-	-	-	-	99%

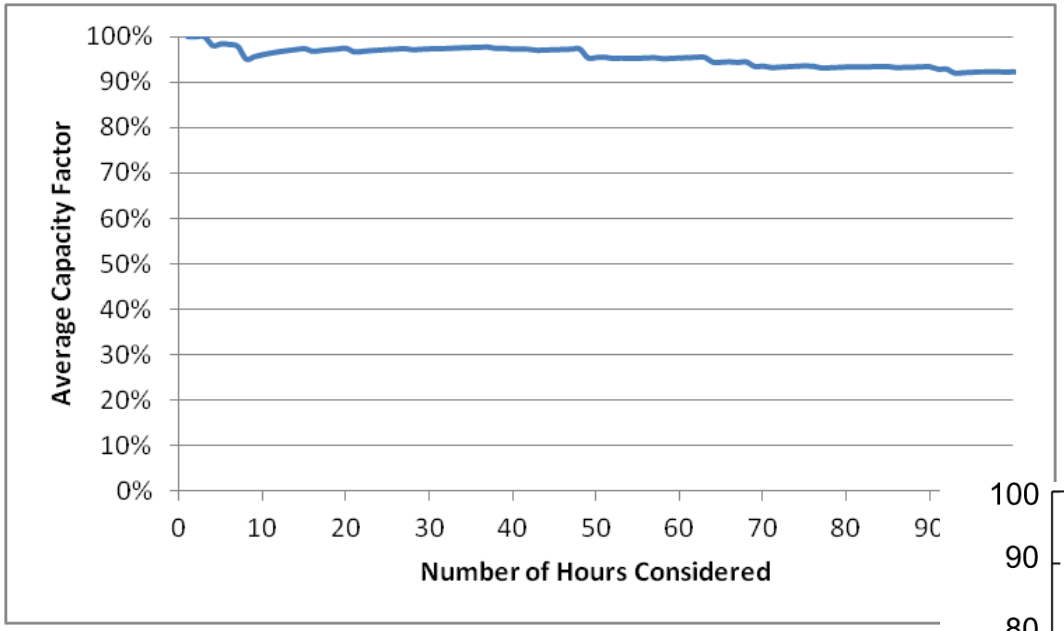
Interaction of solar PV

- With increased PV penetration, the capacity credit of PV decreases while the capacity credit for CSP-TES *increases*



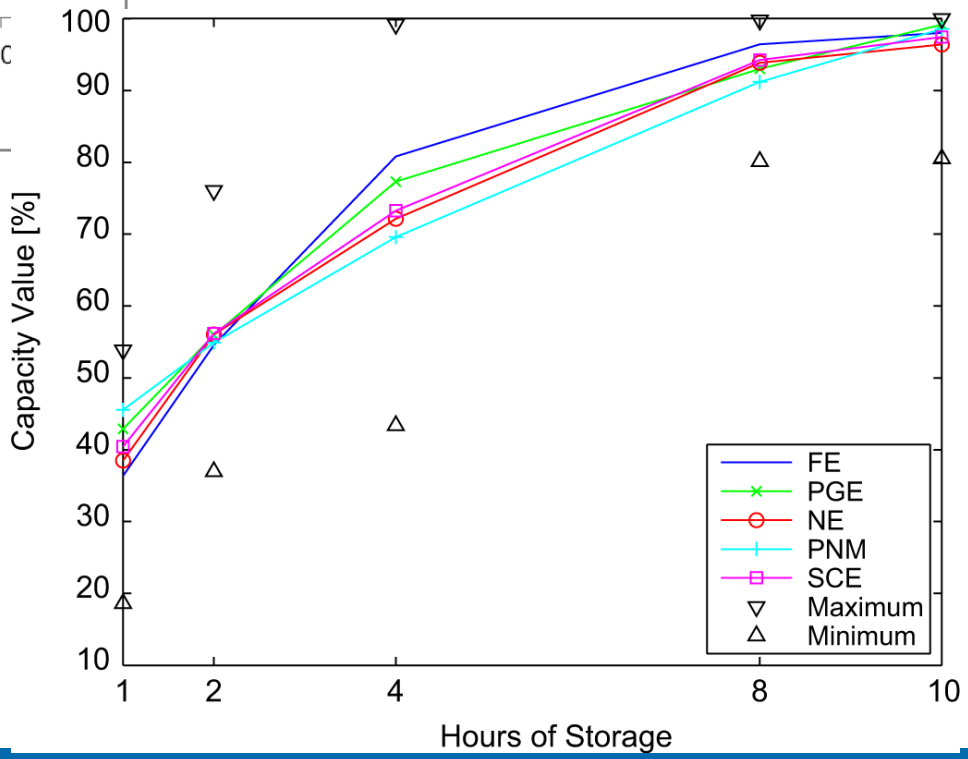
- For CSP-TES (in this configuration):
  - 92.8% capacity credit in the 33% RPS case
  - 96.6% capacity credit in the 40% RPS case

Capacity Value of storage

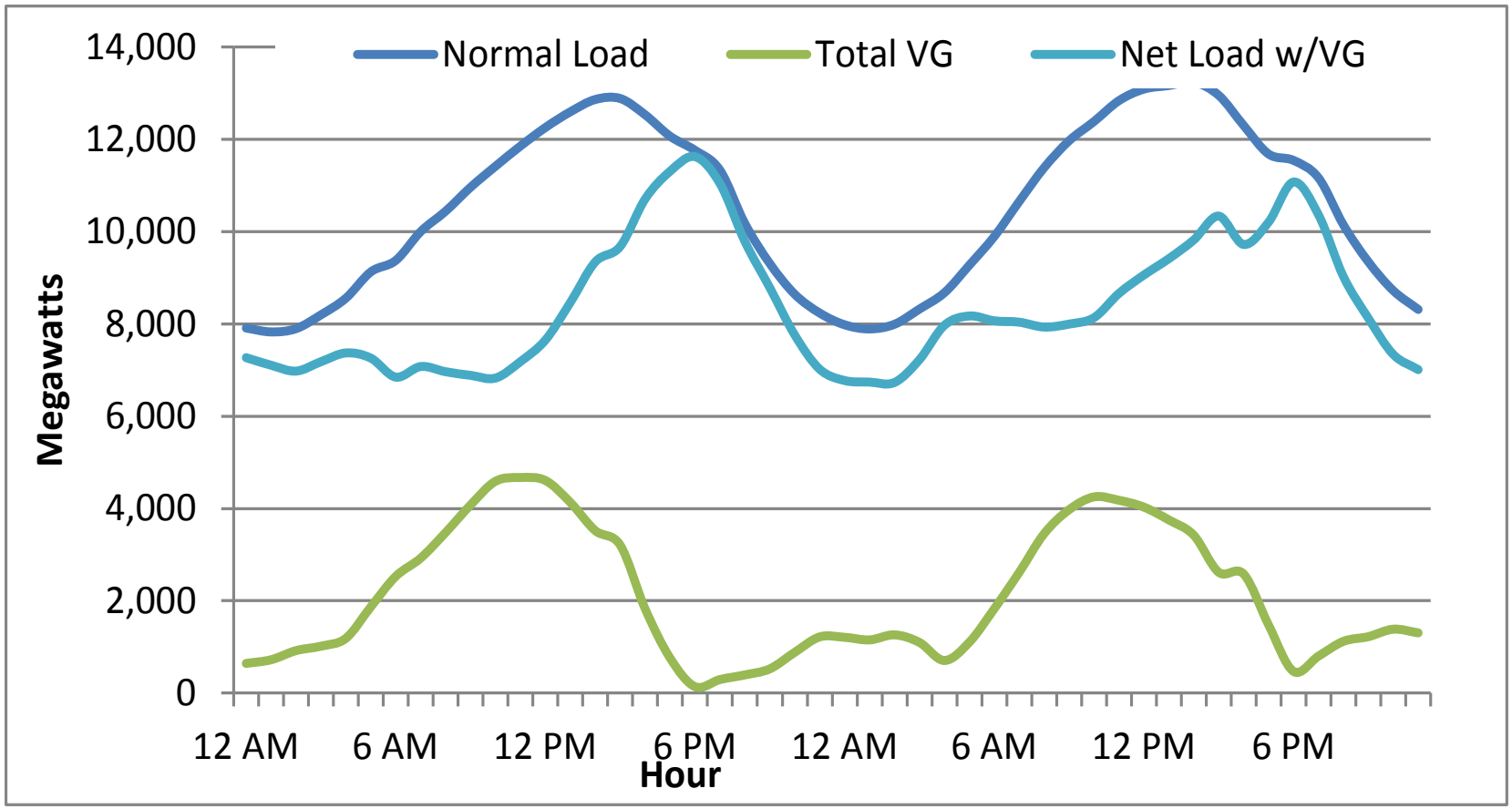


Approximation approach, using PLEXOS simulations

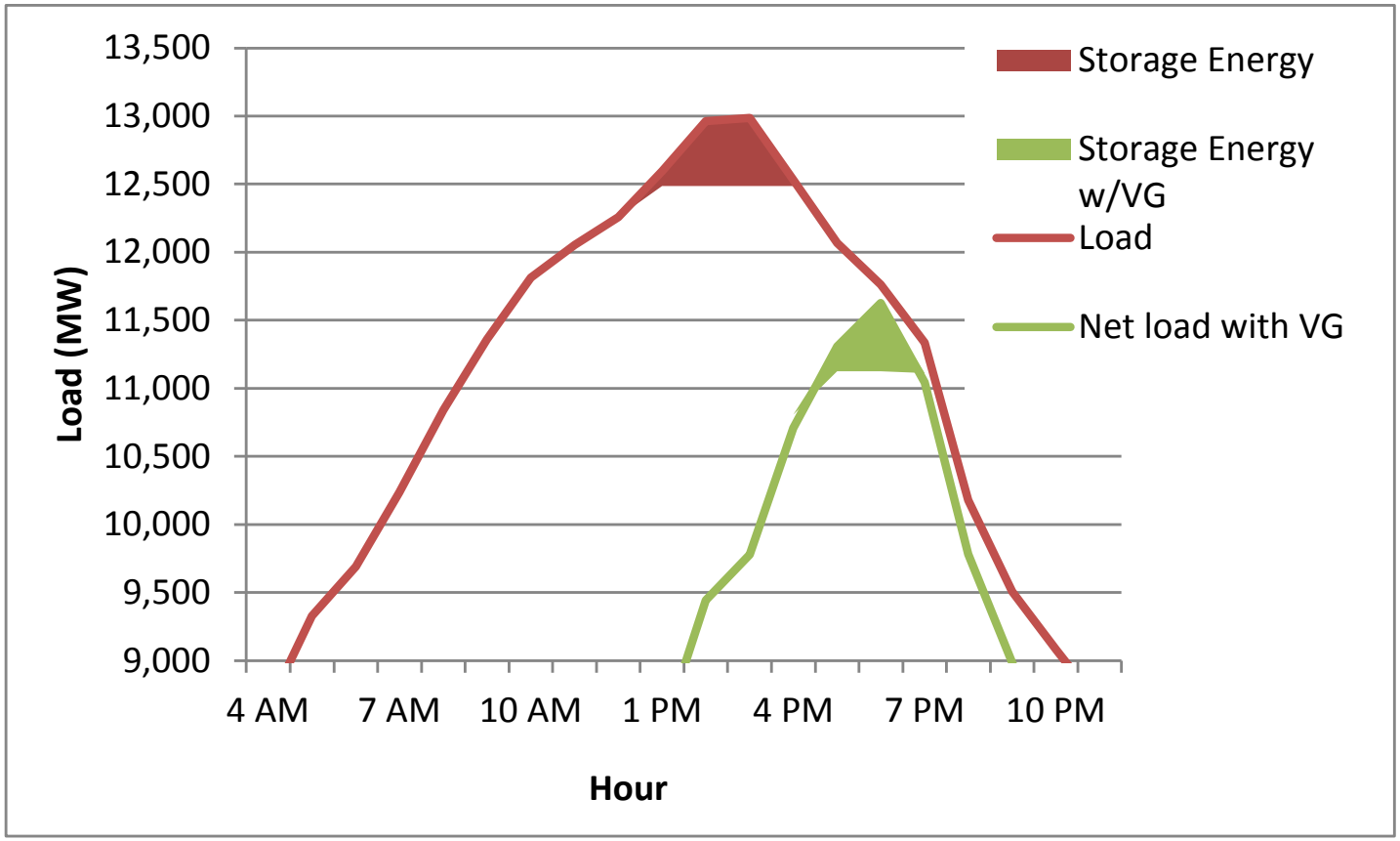
Dynamic programming simulations (using historic prices – Ramteen Sioshansi)



Impact of Solar on Storage Requirements

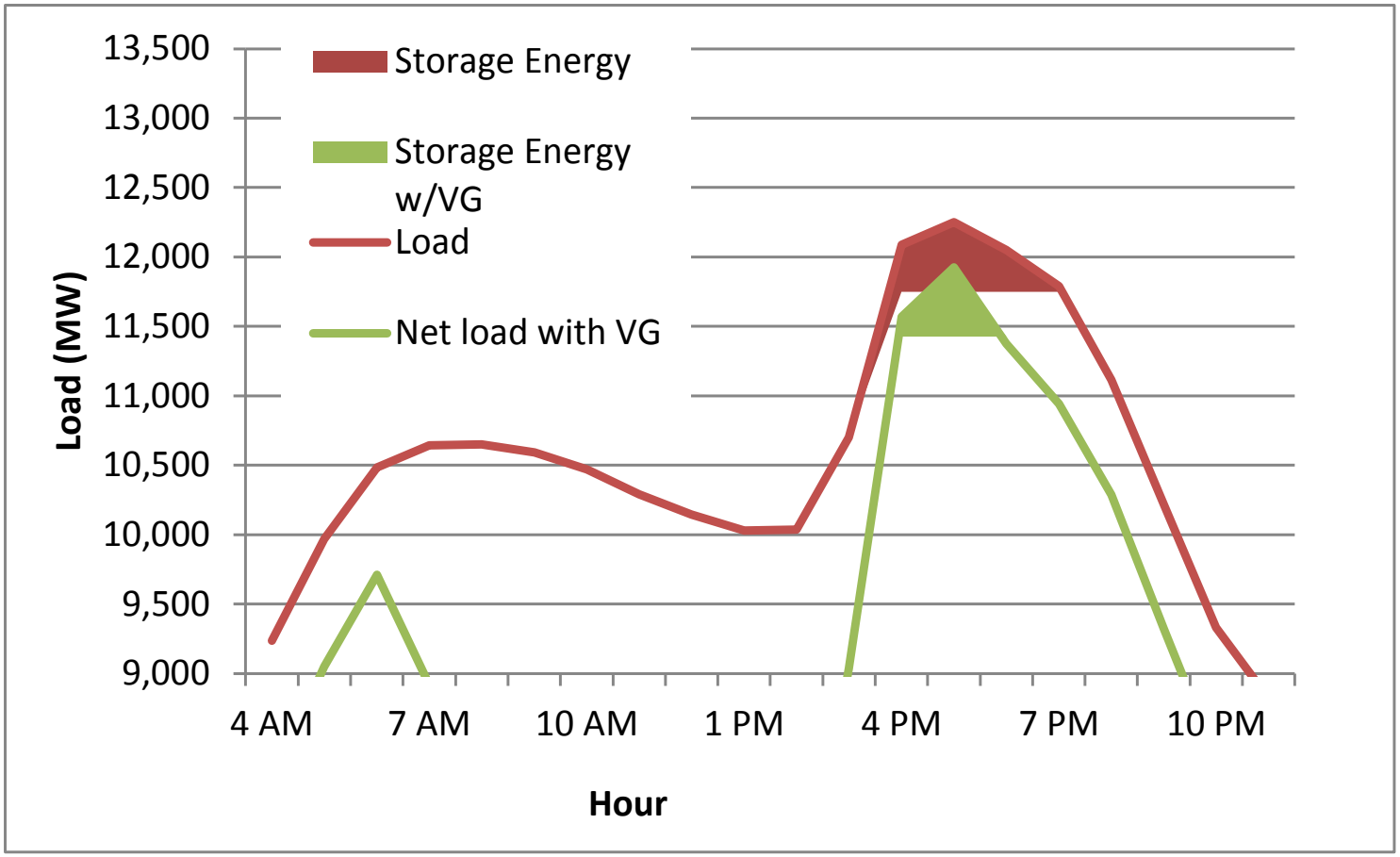


Impact of Solar on Storage Requirements



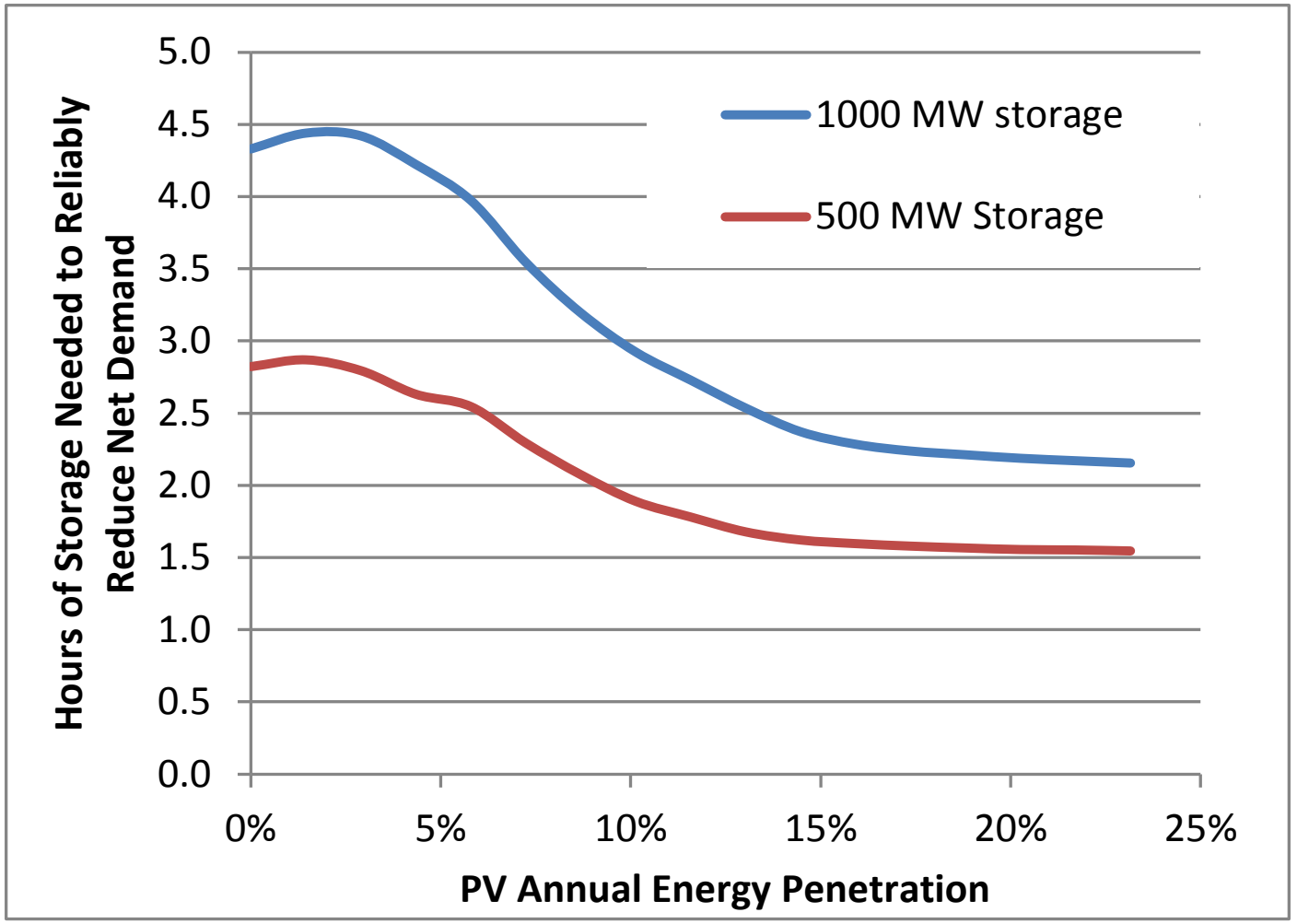
July 30, the normal demand would require about 1336 MWh of stored energy, or 2.7 hours of capacity for a 500 MW battery. This amount is reduced to 684 MWh (1.4 hours) in the case with the added VG.

Impact of Solar on Storage Requirements



December 21, the normal demand would require 2.4 hours of capacity for a 500 MW battery. This amount is reduced to 1.3 hours in the case with the added VG.

Impact of PV Penetration on Storage Capacity Requirements



Hours of Storage needed to reduce peak demand by 500 MW and 1000 MW as a function of PV penetration for top 100 demand days. ****With perfect forecasts**

Next steps/Issues

- **I want a better understanding of high penetration solar on "balance of system" operation**
  - Storage
  - DR
  - Other limited energy resources –hydro etc.

- **Does this mean that we can't calculate the ELCC of individual resources in isolation?**

Questions?

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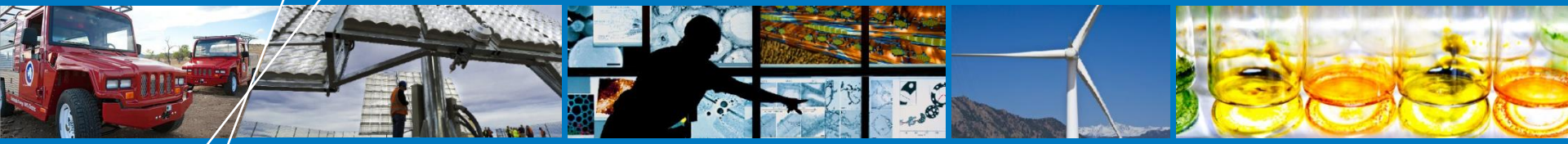

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