



# How PV and CSP with Thermal Storage Can Work Together



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Presentation to the Clean Energy  
Regulatory Forum

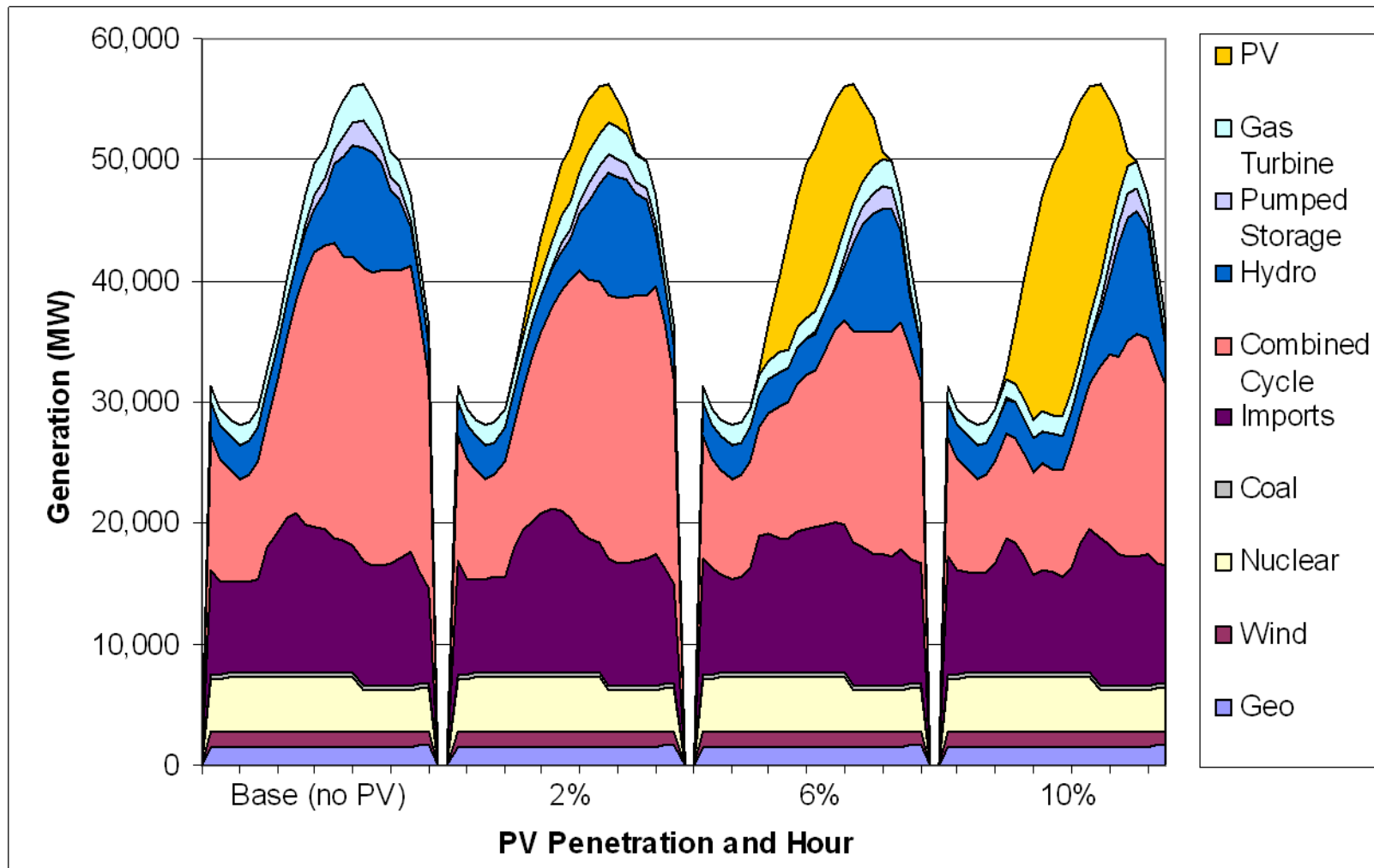
April 19, 2012

# Solar Integration Challenges

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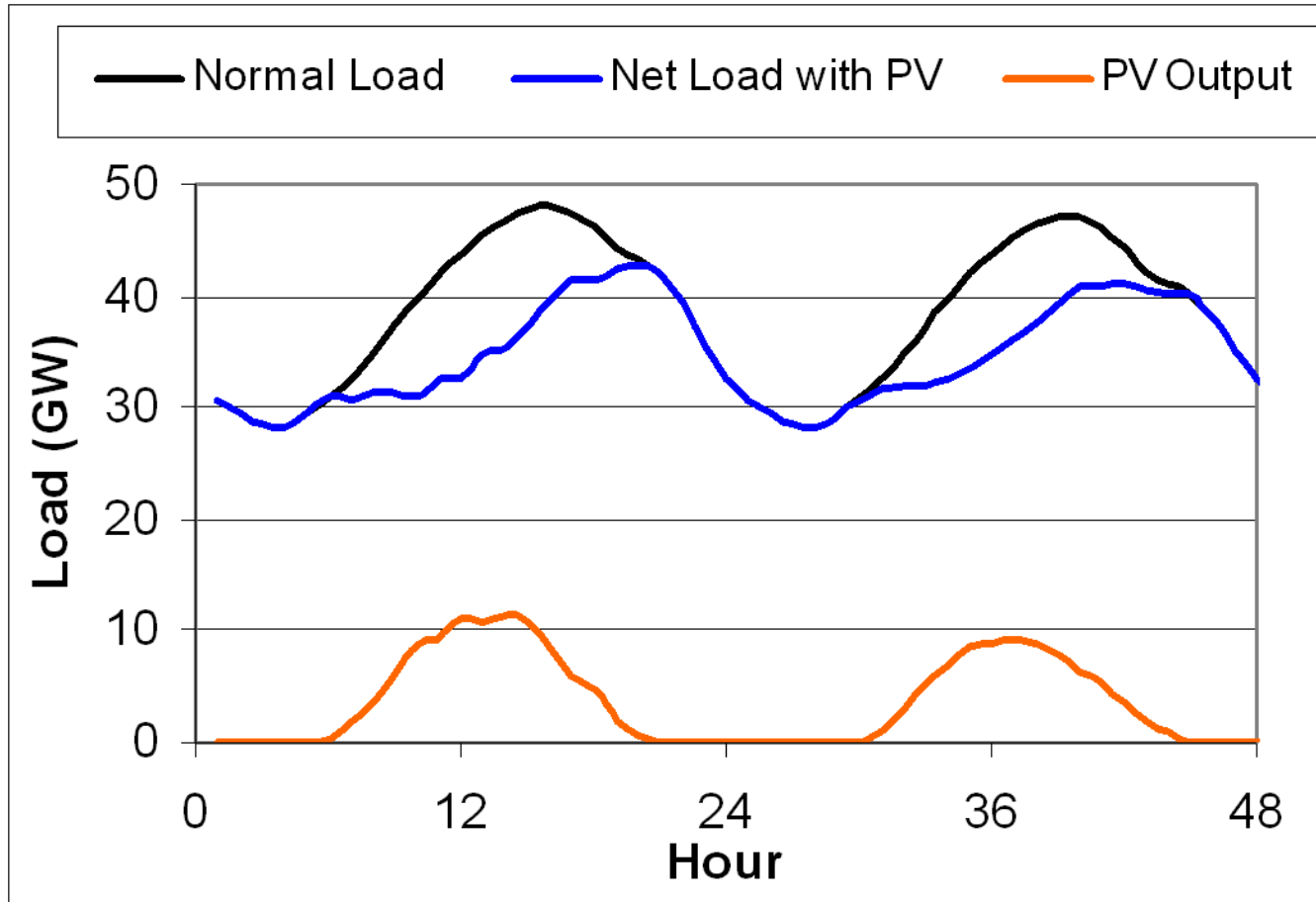
- What are the technical and economic limits of solar in the grid?
- How does solar penetration affect the value proposition?
- How does energy storage and other enabling technologies affect all of this?

# Solar PV On a Good Day



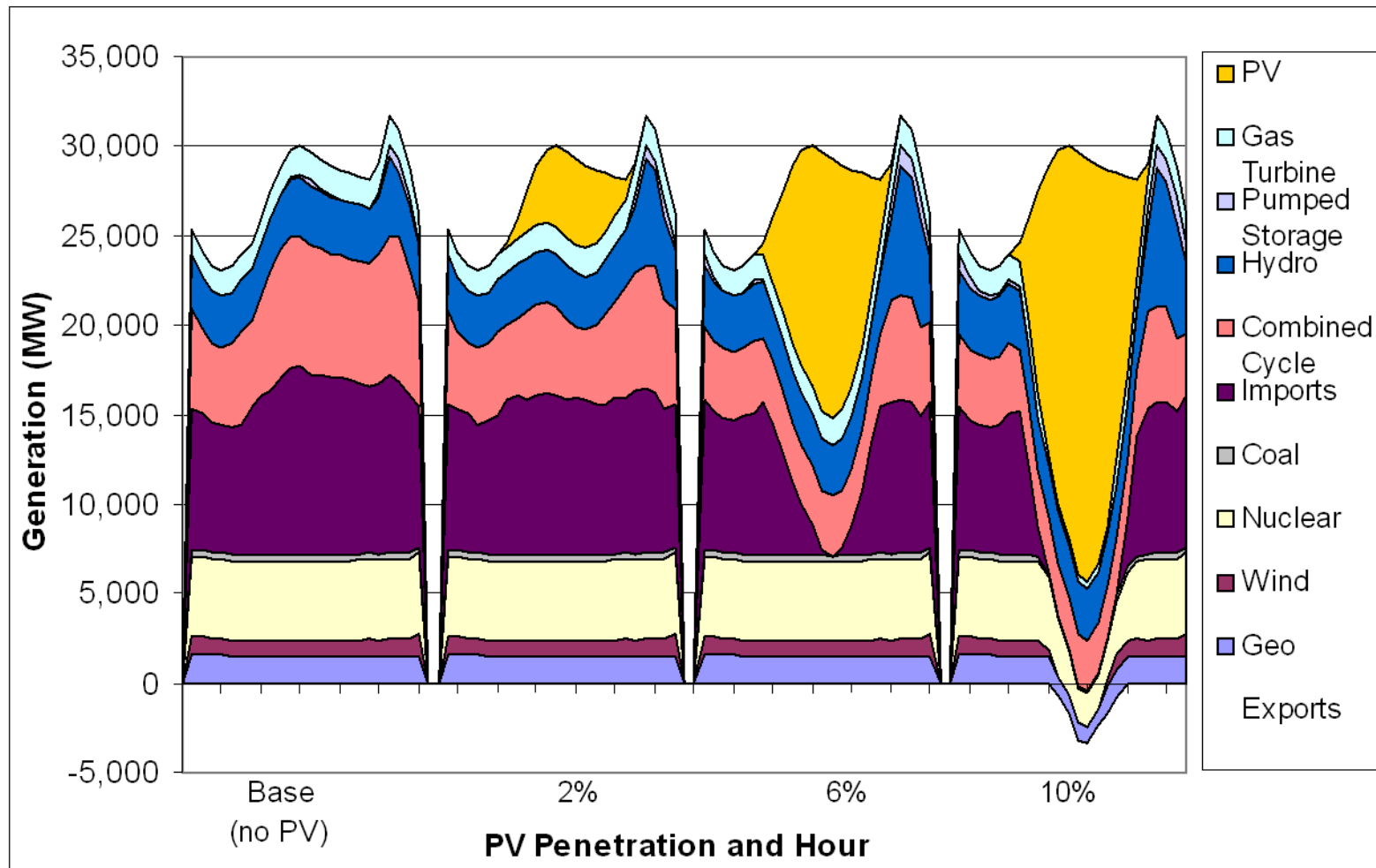
Simulated Dispatch in California for a Summer Day with PV Penetration from 0-10%

# PV Coincidence With Load - Summer



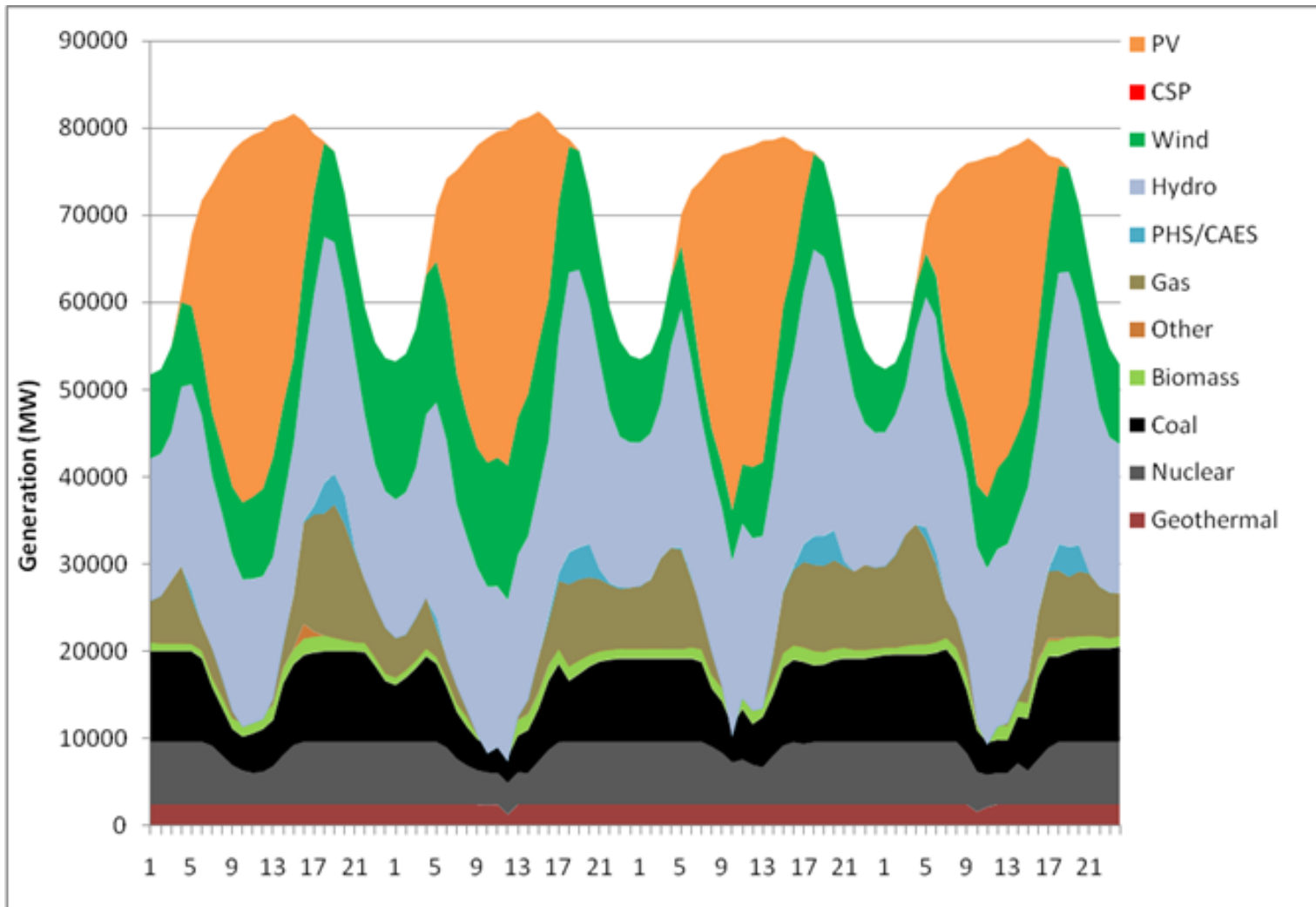
16 GW simulated PV system providing 11% of system's energy

# Solar PV On a Bad Day



Simulated Dispatch in California for a Spring Day with PV Penetration from 0-10%

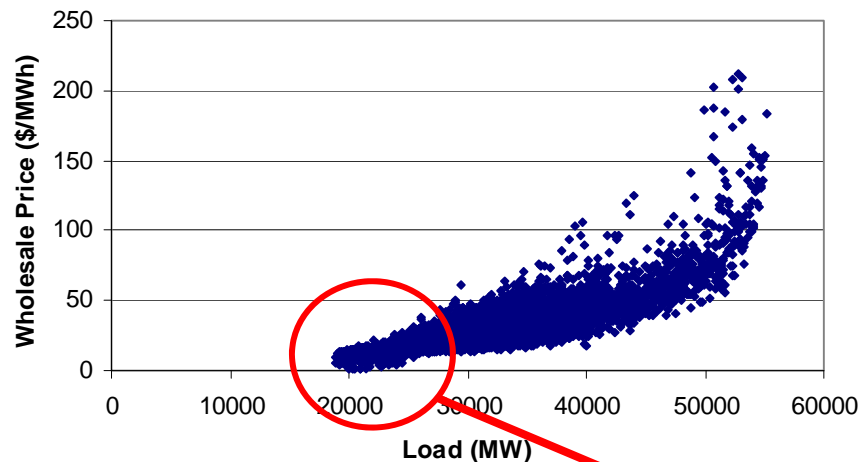
# WECC-Wide Dispatch – 15% Wind/15% Solar



## Simulated Dispatch in WECC

# Current System Flexibility

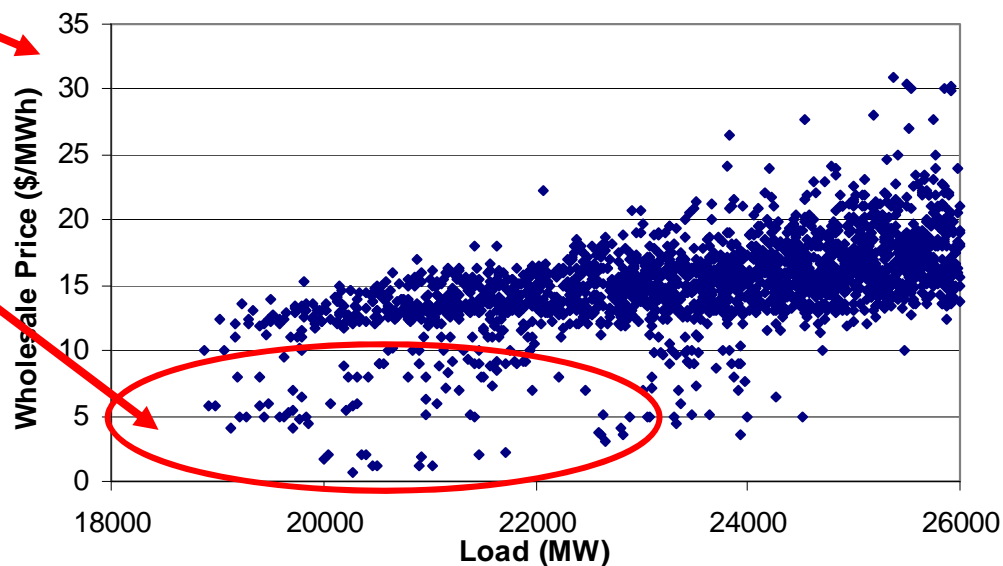
## Limited by Baseload Capacity



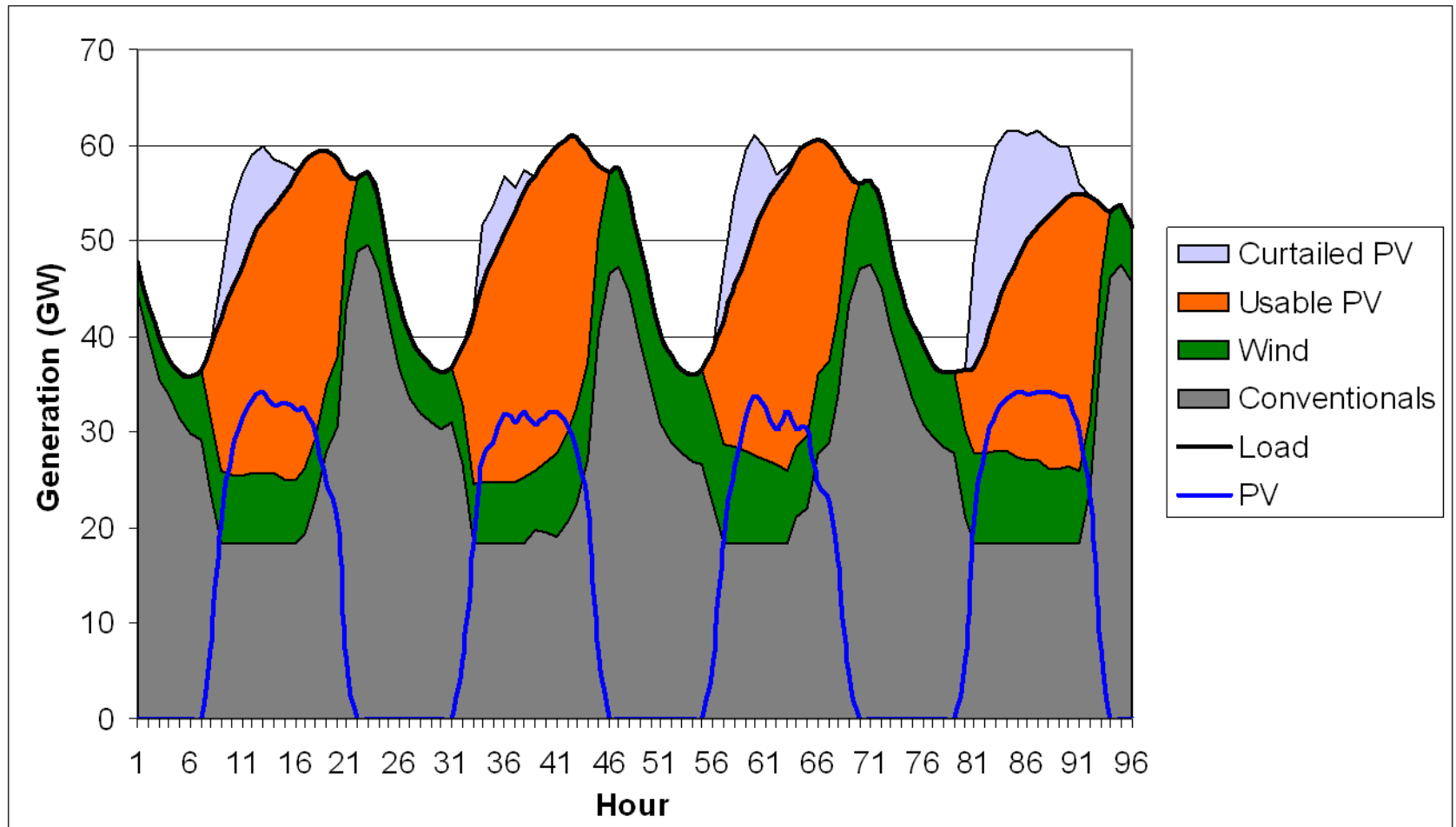
Price/Load Relationship in PJM

## Below Cost Bids

Plant operators would rather sell energy at a loss than incur a costly shutdown. Wind may be curtailed under these conditions



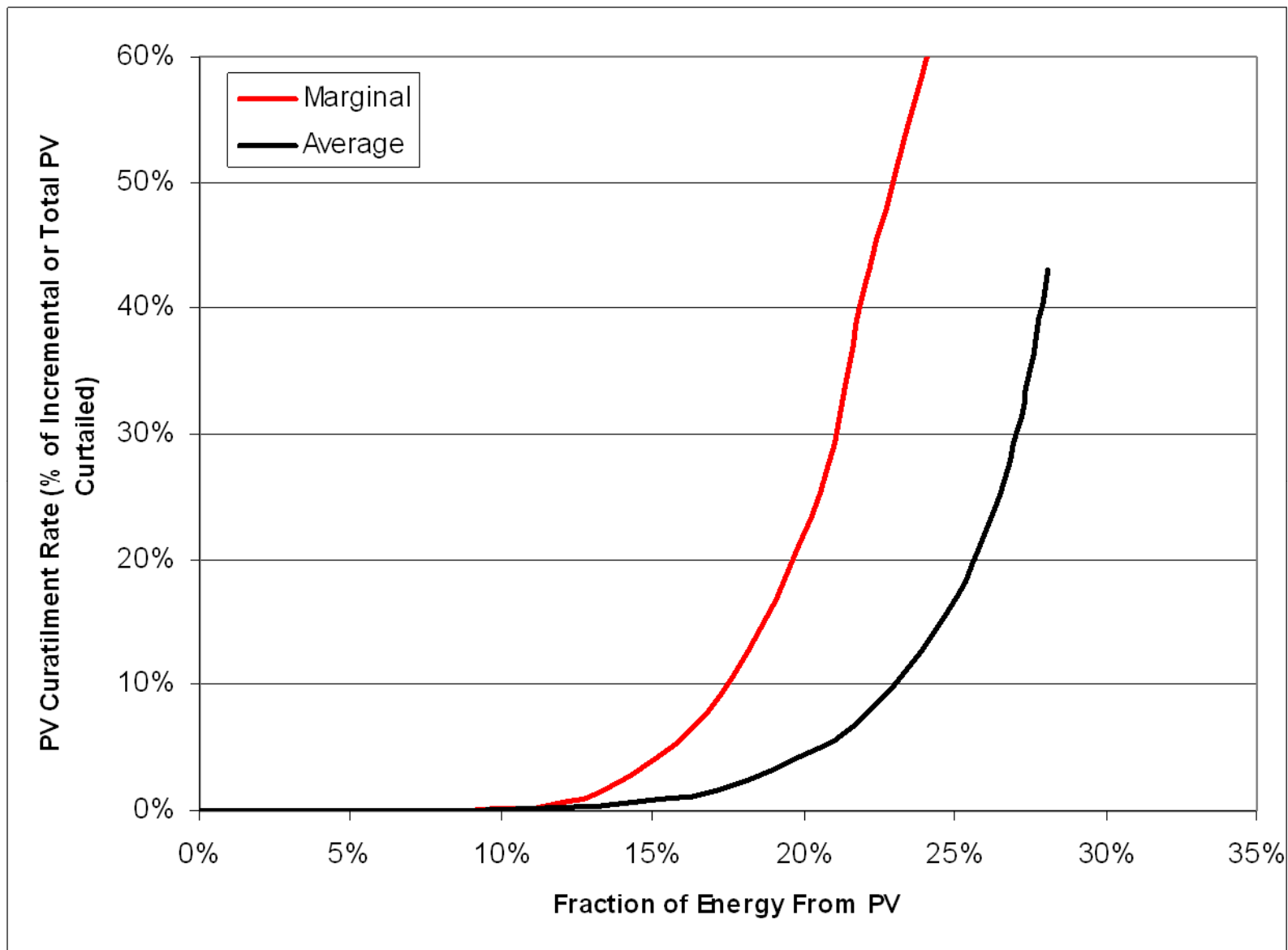
# PV Curtailment



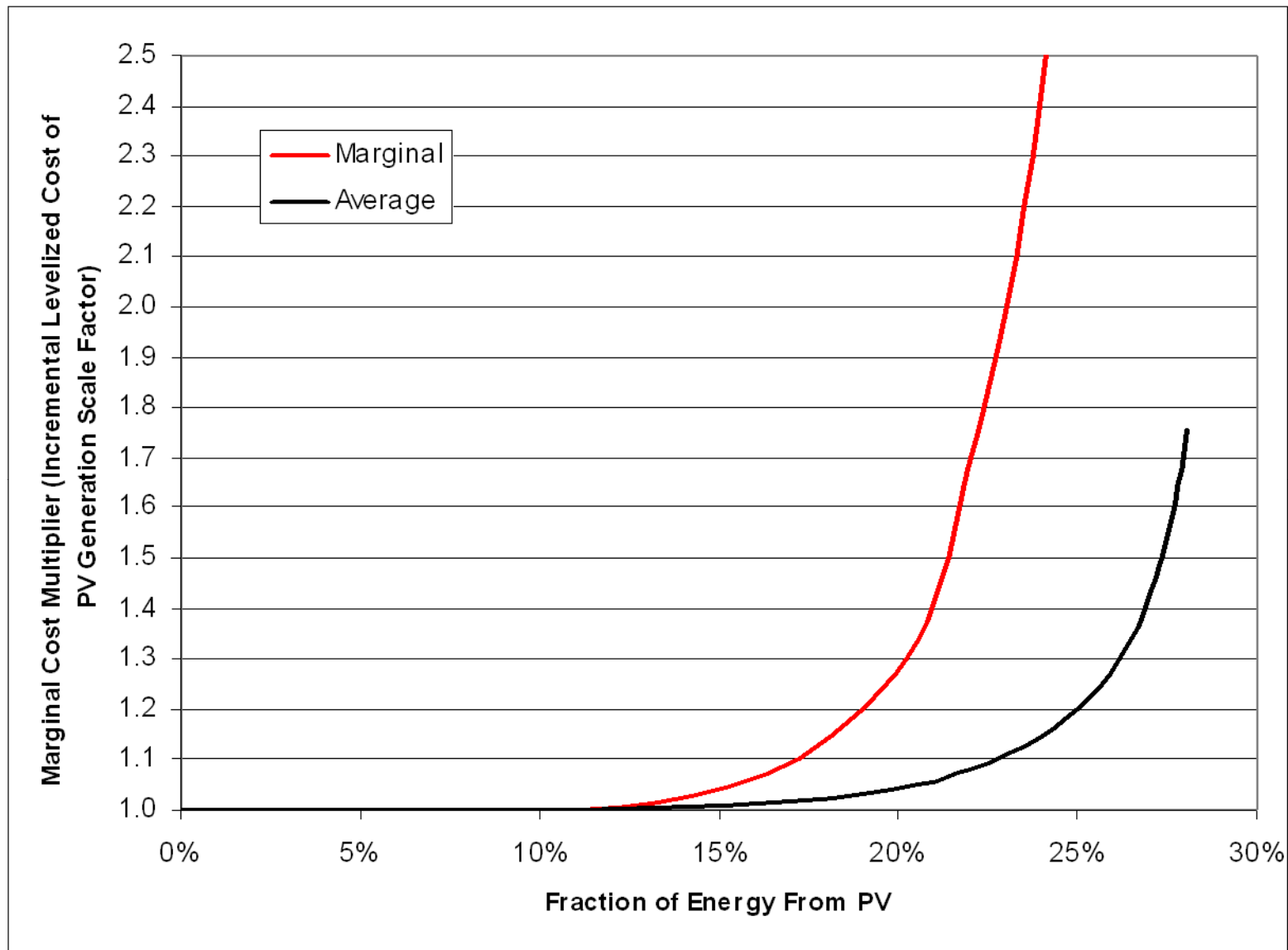
20% Contribution from PV



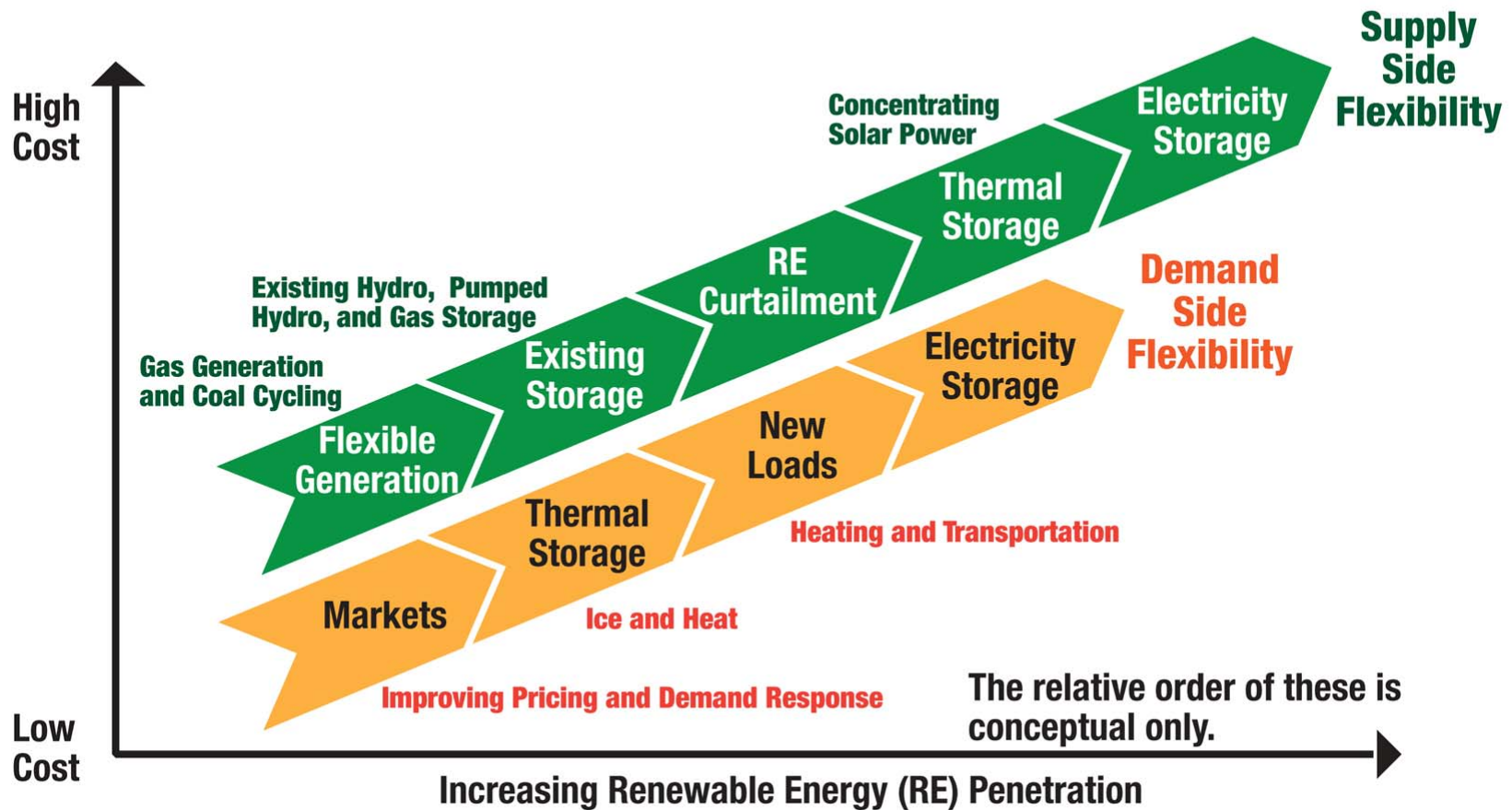
# PV Curtailment



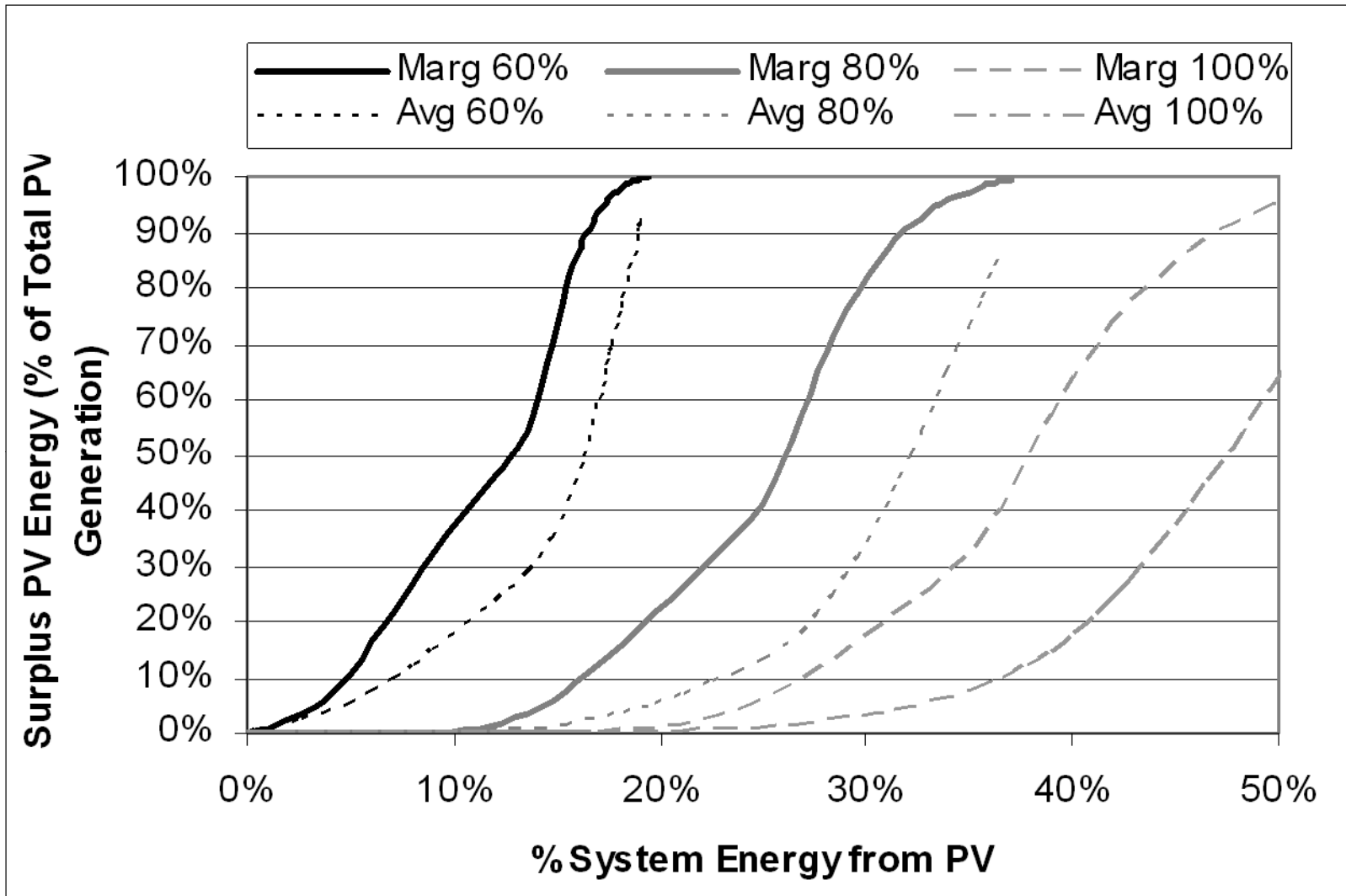
# Curtailment Cost Impact



# Options for Increasing System Flexibility

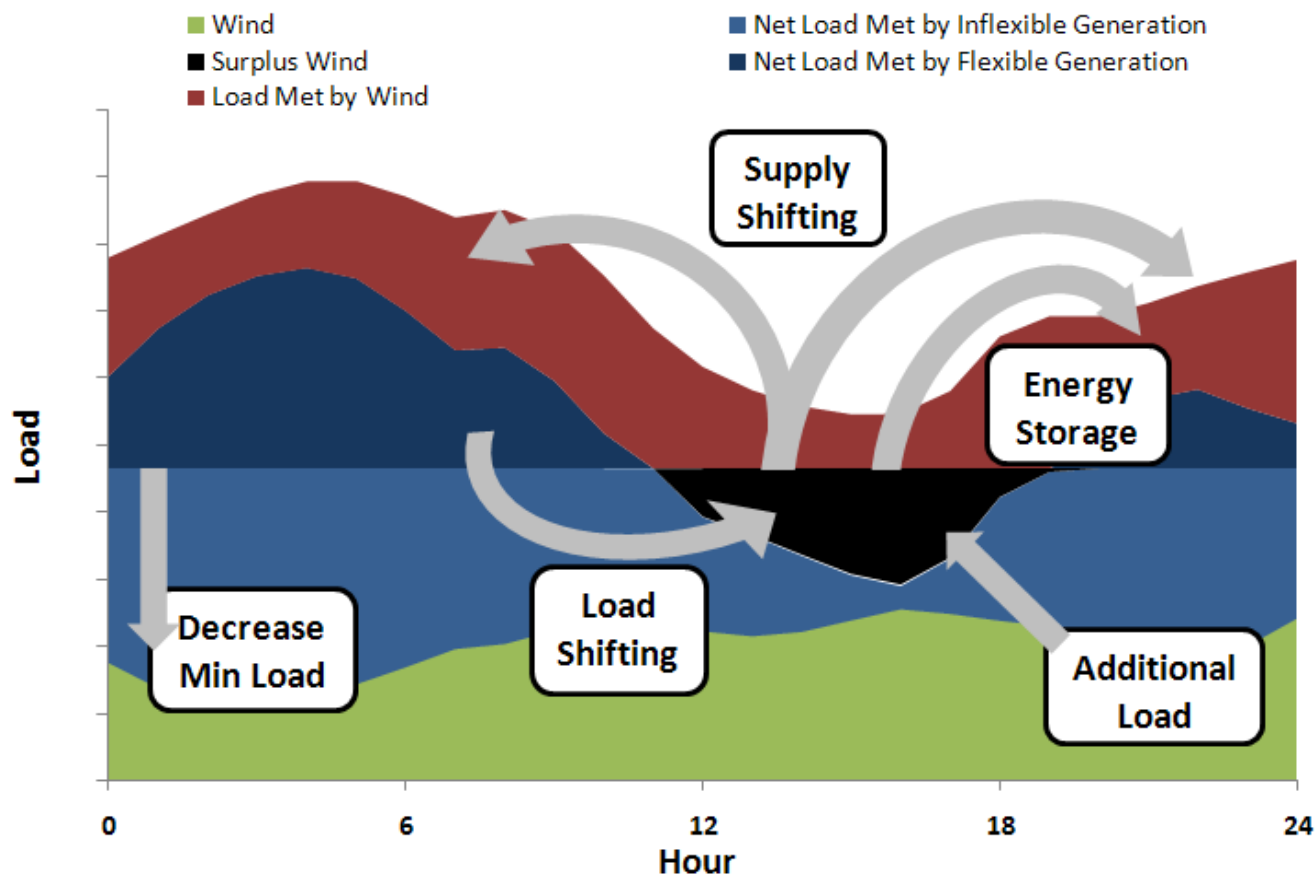


# PV Curtailment

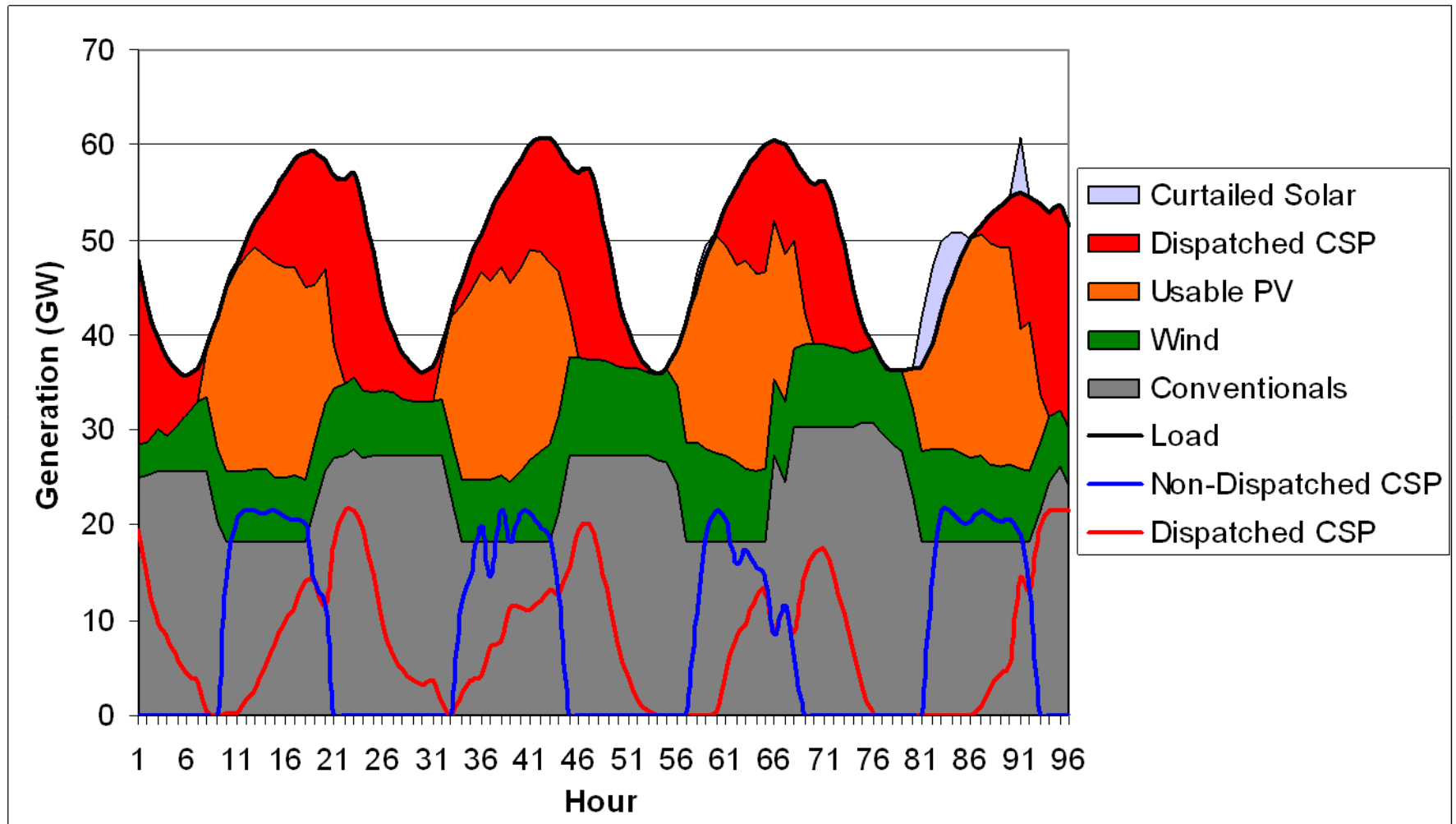


# Increased Renewable Penetration

While storage provides an “obvious” answer to the problem of supply-demand coincidence, there are a number of options

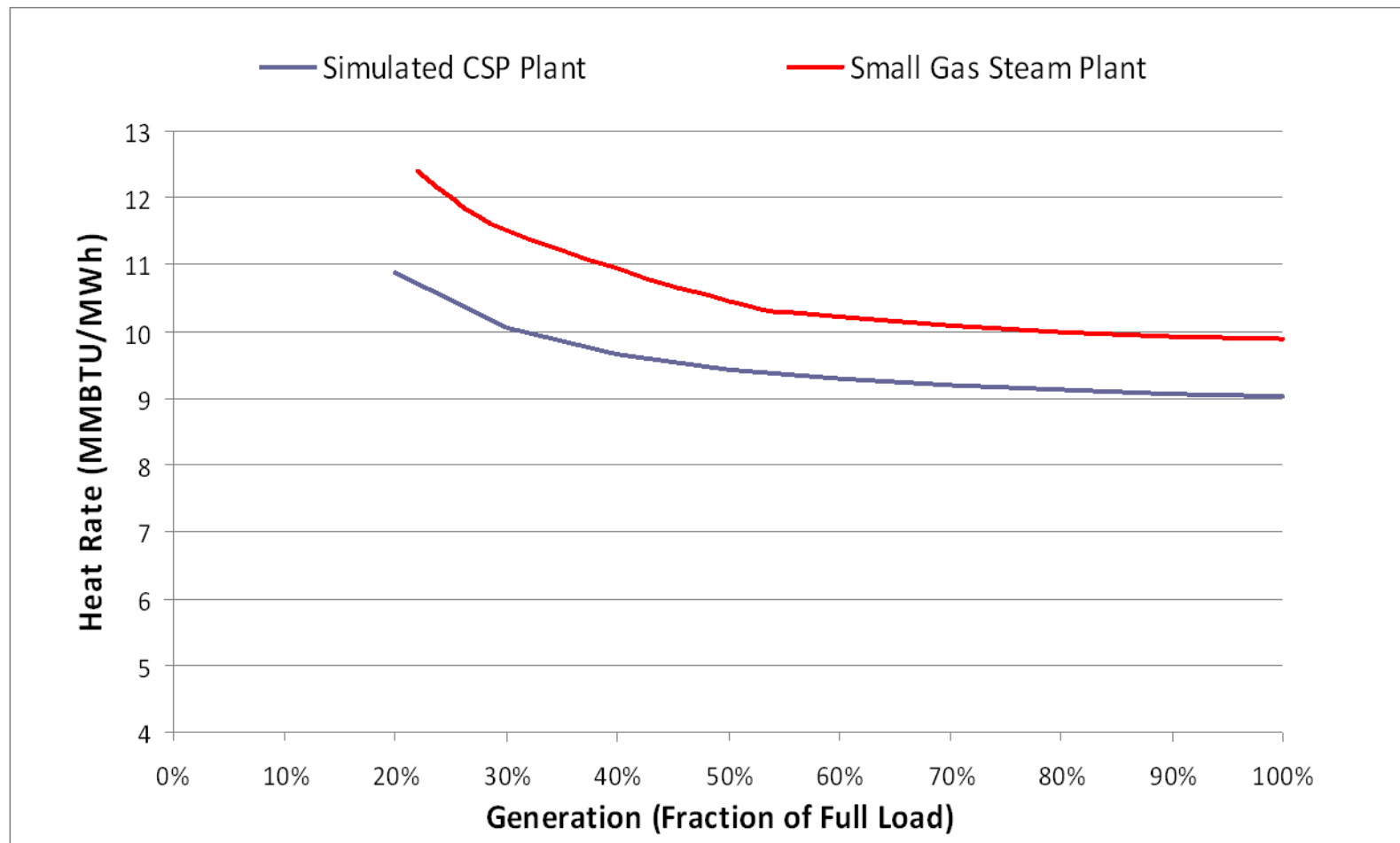


# Add Dispatchable CSP



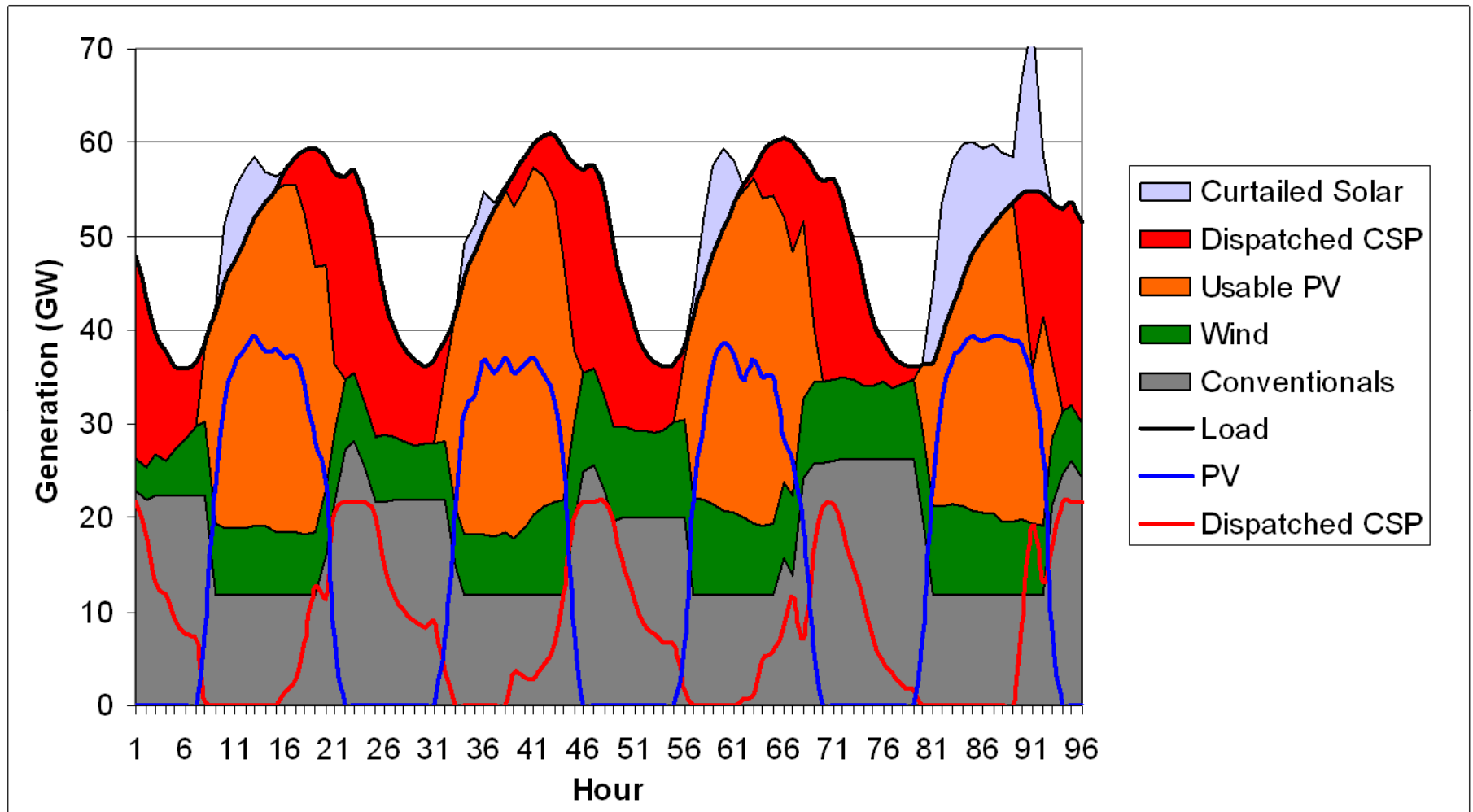
May 10-13 with 15% Contribution from PV and 10% from Dispatchable CSP

# CSP Flexibility



Large operating ranges with small heat range increases are an important component of PV integration.

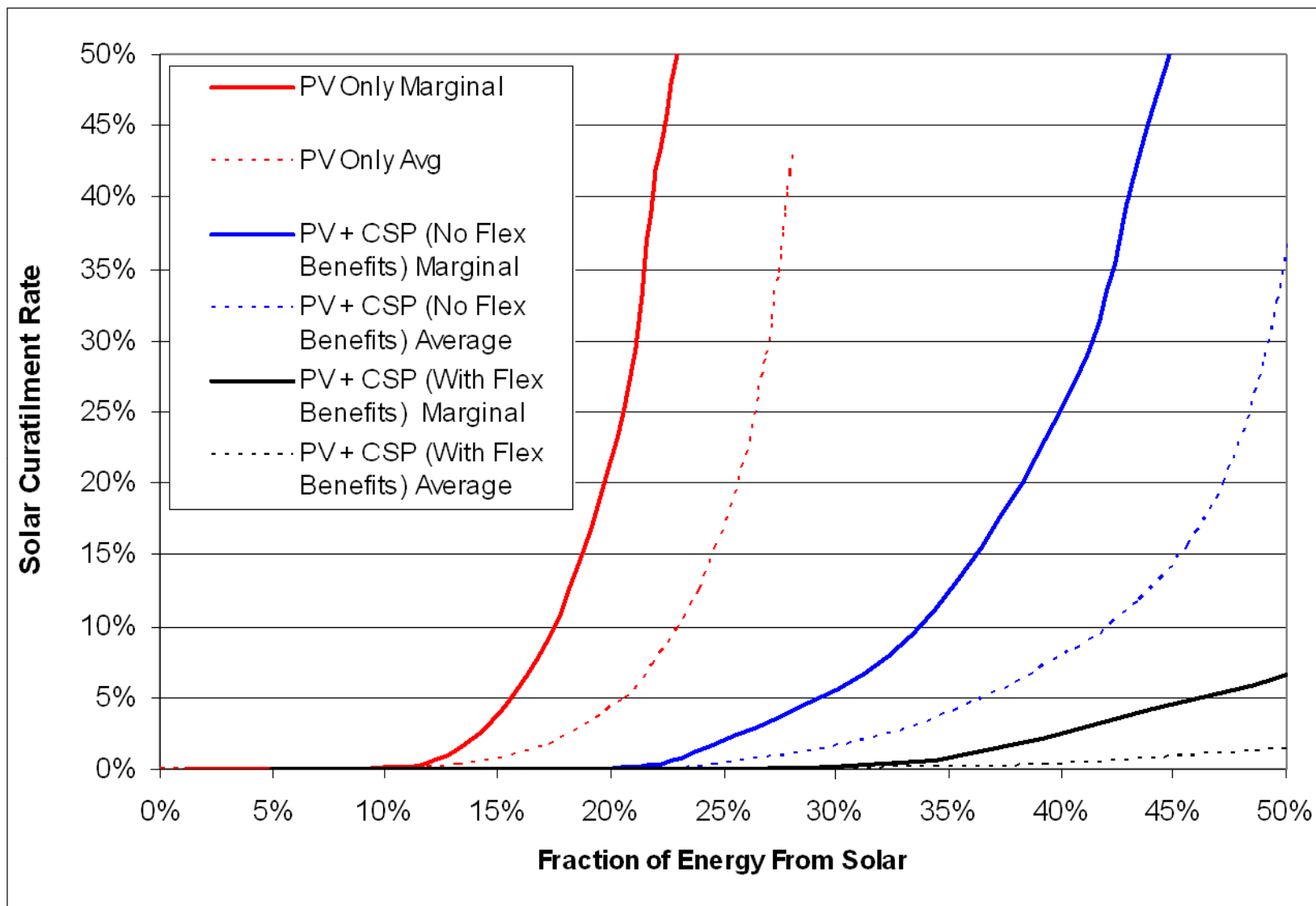
# CSP Flexibility Impact



25% Contribution from PV and 10% from Dispatchable CSP where CSP Reduces the Minimum Generation Constraint



# CSP Flexibility Impact



# Questions

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