Flexibility Inventory for Western Resource Planners

Andrew Mills and Joachim Seel

Lawrence Berkeley National Laboratory

Report Briefing

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Introduction

- Flexibility Inventory:
  - Quantitative estimate of flexibility supply and flexibility demand for a portfolio of resources
  - Estimates based on modified version of existing methodology from the International Energy Agency (IEA)
- Flexibility Supply:
  - Capability of generation or demand to change in response to system conditions over various time scales relevant to power system operations.
- Flexibility Demand:
  - Amount that the net demand will change over those different time scales, the degree to which those changes can be predicted ahead of time, and the contingency reserves.

Why Focus on the Western U.S.?

- Flexibility Inventory is based on a database of planned resources identified in utility IRPs
- The database is called the Resource Planning Portal (RPP: resourceplanning.lbl.gov)
- The Flexibility Inventory was designed to estimate the flexibility of any portfolio or collection of portfolios in the RPP

Motivation

- Deploying more variable resources, such as wind and solar, will increase the need for power-system flexibility, but, historically, flexibility has not been systematically evaluated in utility planning studies
- Flexibility Inventory provides a screening-level assessment of flexibility over the planning horizon
- Shows trends in the balance between flexibility supply and demand with growing demand or increasing shares of variable renewables
- Allows a comparison of flexibility across utilities to identify potential opportunities for collaboration

Limitations and Scope

What does the Flexibility Inventory do?	What does it not do?
Quantifies flexibility supply and demand based on planned generation	Does not identify which sources of flexibility should be added (no economic considerations)
Evaluates needs on various time intervals (15 min to 36 h) to find most constrained interval	Does not identify the cost of providing flexibility
Estimates contributions of different resources to flexibility supply based on simple parameters	Does not provide detailed determination of how much new flexibility should be added (if any), only tracks trends from year to year
Estimates flexibility demand based on summary statistics of load and variable generation	Does not conduct hourly or sub-hourly simulations of generation commitment and dispatch

Summary of Methodology

- Flexibility Supply:
  - Thermal and Hydropower
    - Ramp-rates, minimum generation, startup times, typical dispatch
  - Demand response
  - Energy Storage
  - Transmission Interconnection
- Flexibility Demand:
  - Variability of net load
    - Correlation of load, wind, and solar variability
  - Uncertainty of net load
    - Assume near zero correlation in forecast errors
  - Contingency reserves

- Evaluate over four flexibility intervals relevant to power system operations: 15 min, 1 h, 6 h, 36 h in both up and down direction
- Most constraining is called the **"binding flexibility interval"**
- Ratio of flexibility supply to flexibility demand is **"binding ratio"**
  - Binding ratio greater than 1 indicates surplus flexibility

Case Studies

- Selected two utility IRPs from the RPP database (PSE and NV Energy) and a collection of IRPs from the Pacific Northwest (PNW) and Desert Southwest (DSW)
- Create a Flexibility Inventory with base assumptions
- Parameter sensitivity:
  - Change one key parameter at a time, measure the change in the binding ratio
- Capacity sensitivity:
  - Increase or decrease the capacity of one resource at a time by 1% of peak demand

Resources in RPP

Utility/Region	Load/Resource	2012 (GW)	2020 (GW)	2027 (GW)
PSE	Peak Demand	5.0	5.1	5.5
	Wind	0.82	1.12	1.22
	Solar	0.00	0.00	0.00
PNW	Peak Demand	18.7	21.8	22.9
	Wind	1.74	2.09	2.05
	Solar	0.00	0.01	0.06
NV Energy	Peak Demand	5.5	5.7	6.3
	Wind	0.15	0.16	0.20
	Solar	0.18	0.34	0.27
DSW	Peak Demand	18.7	20.5	23.8
	Wind	0.50	0.71	1.11
	Solar	0.46	1.31	1.44

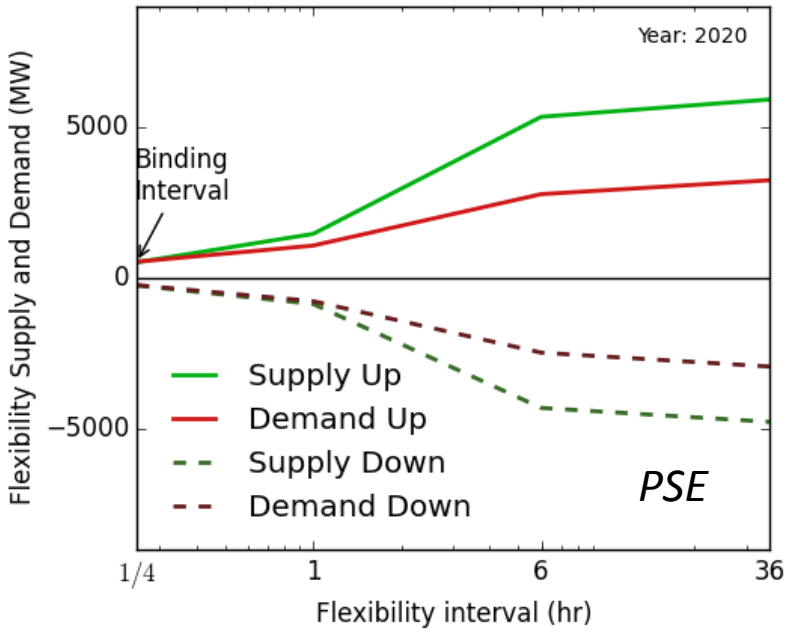
- Note: The variable renewable capacity in these particular IRPs is proportionally much lower than in some states with high renewables targets and limited supply of non-variable renewables (e.g., California).
- We also examine cases where we greatly increased wind or solar penetration beyond the level identified in the IRP in order to understand the degree to which results may change in situations with higher shares of variable renewables.

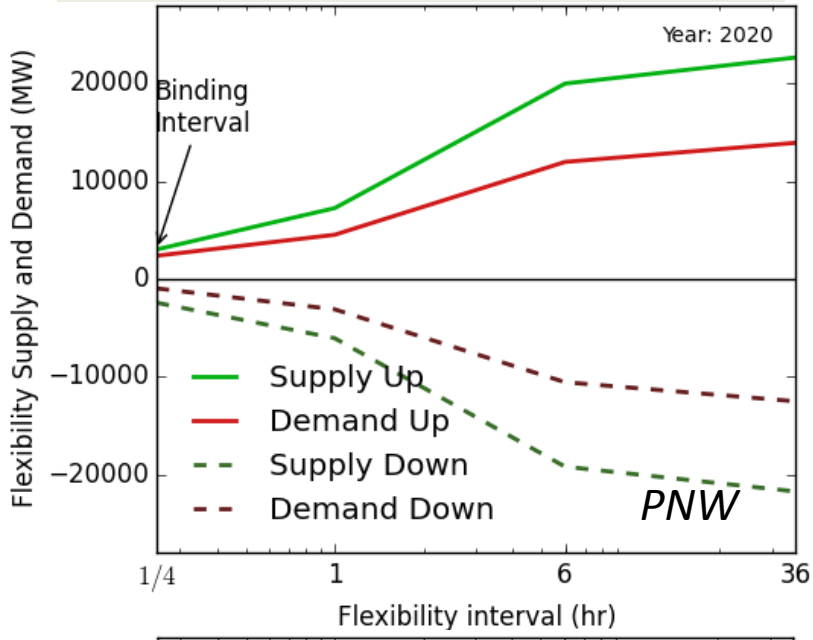
Flexibility Inventory in 2020

Individual Utility

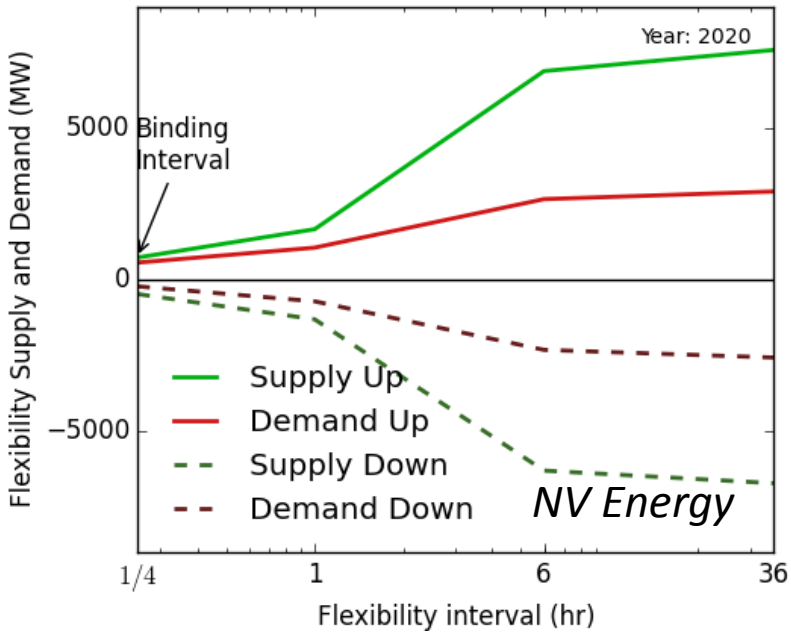
Regional Inventory

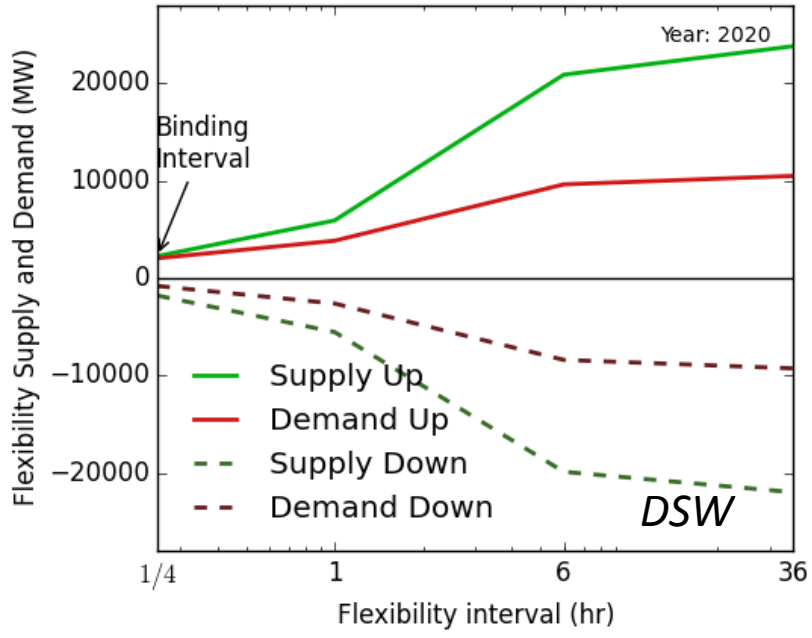
Pacific Northwest



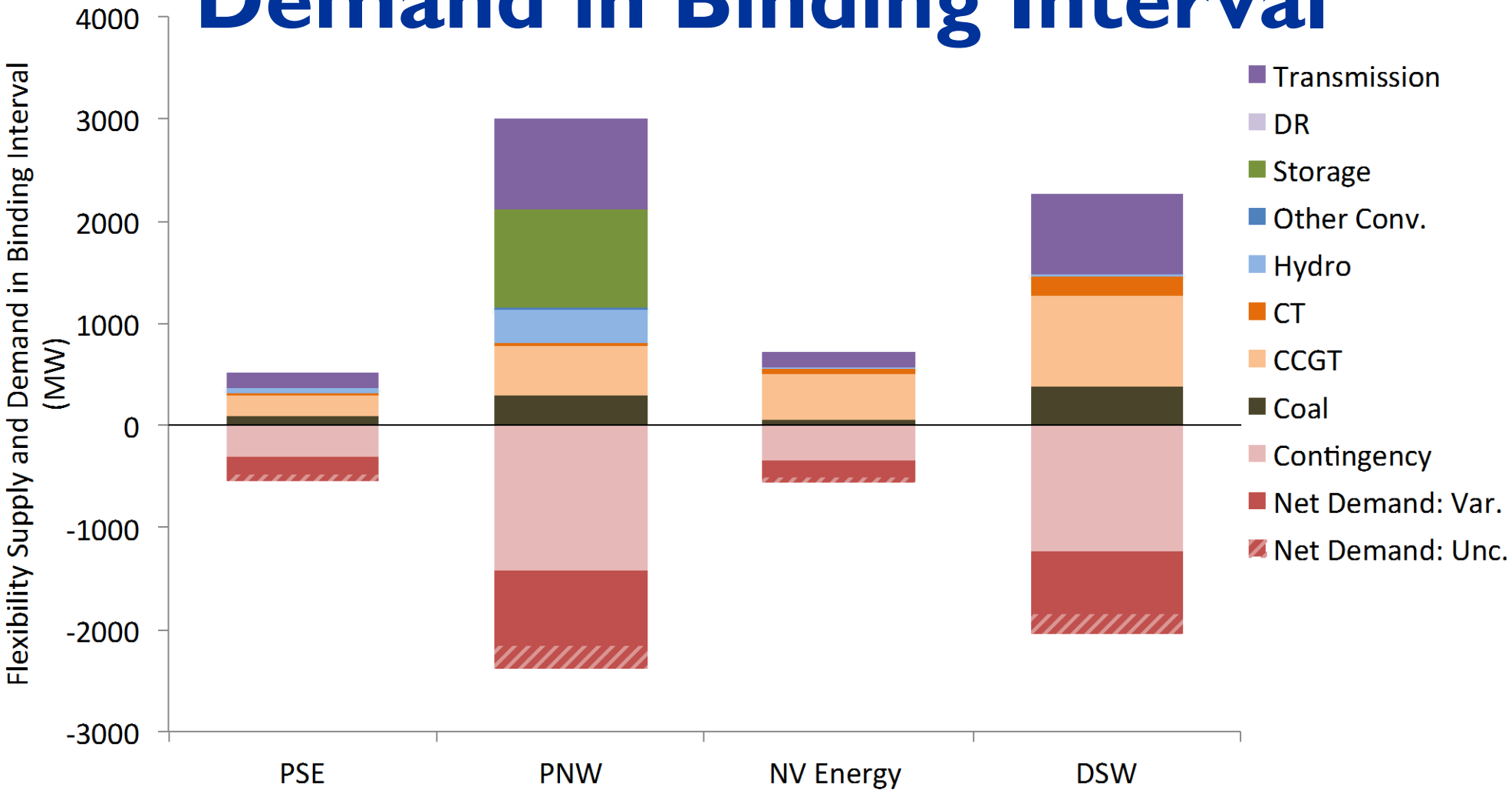


Desert Southwest



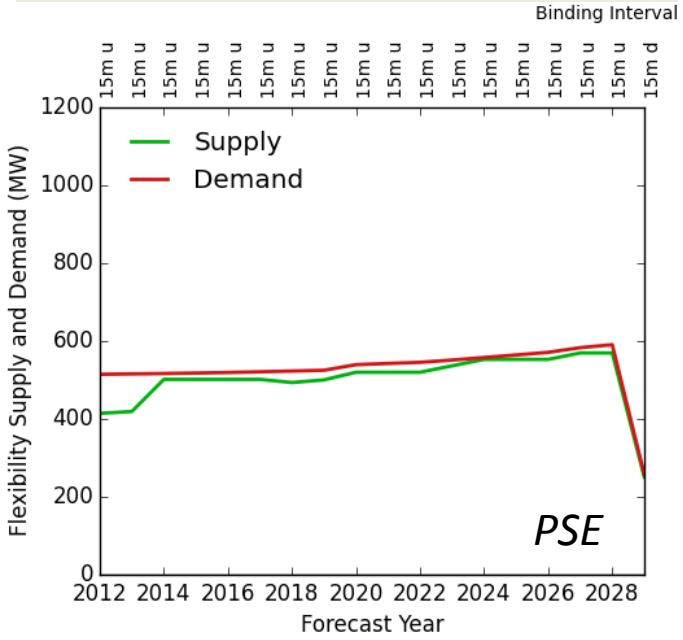
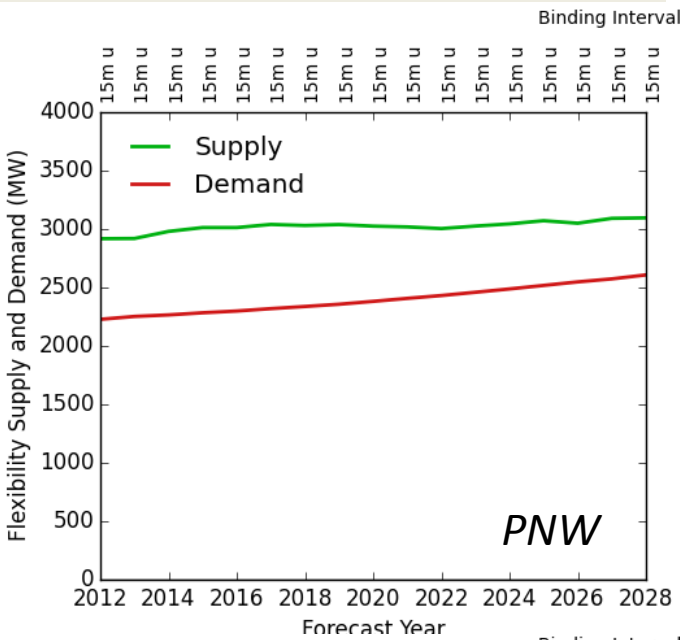
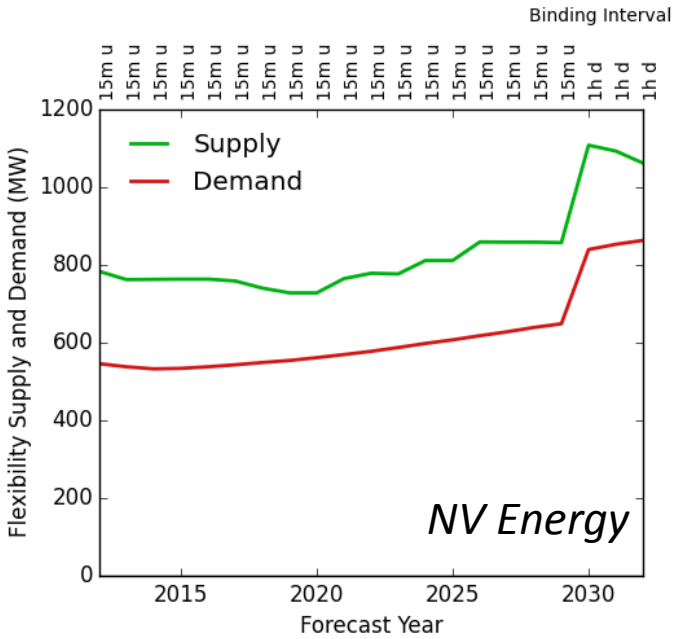
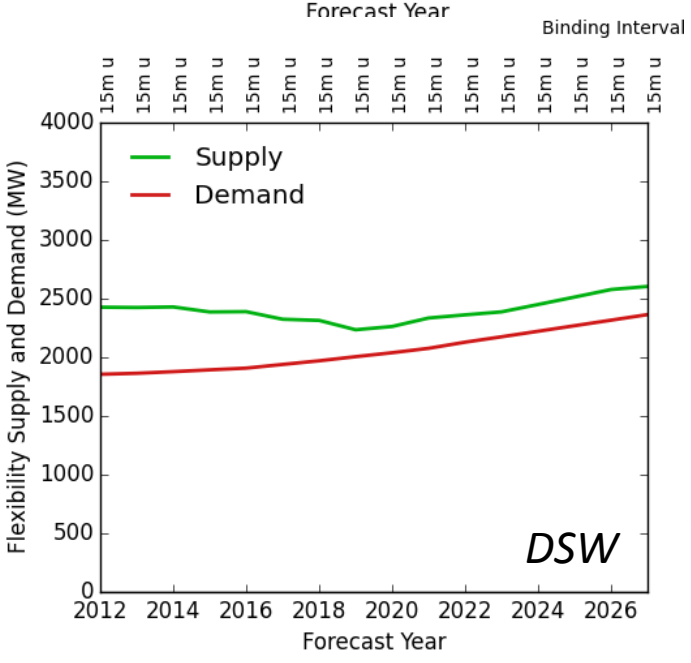


Sources of Flexibility Supply and Demand in Binding Interval

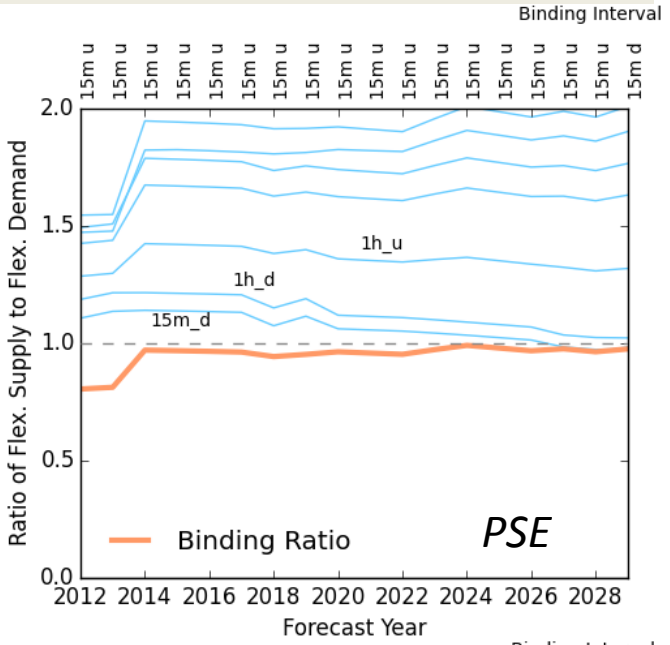
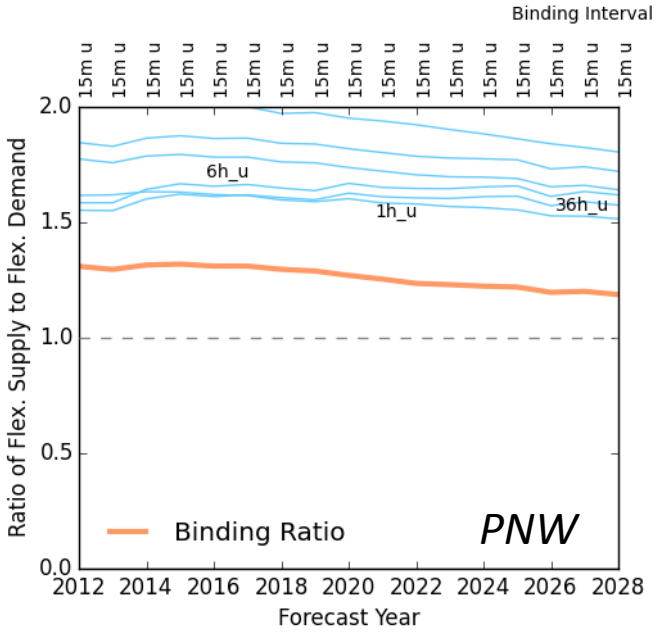
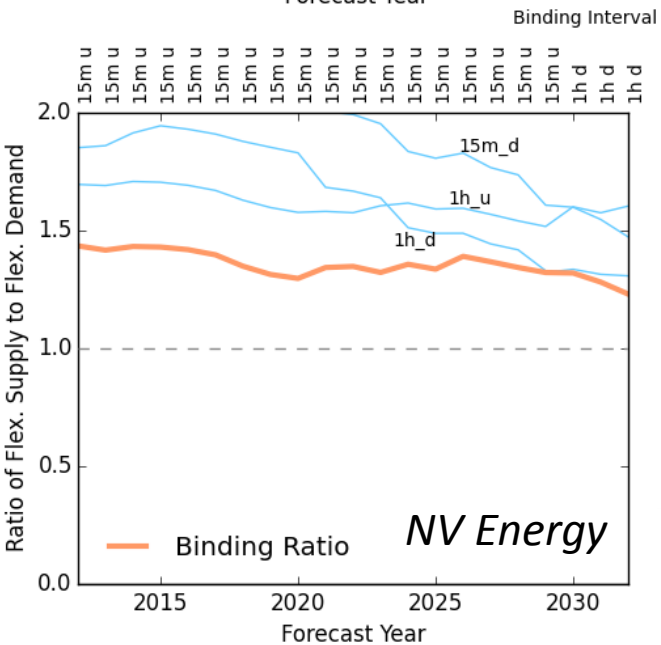
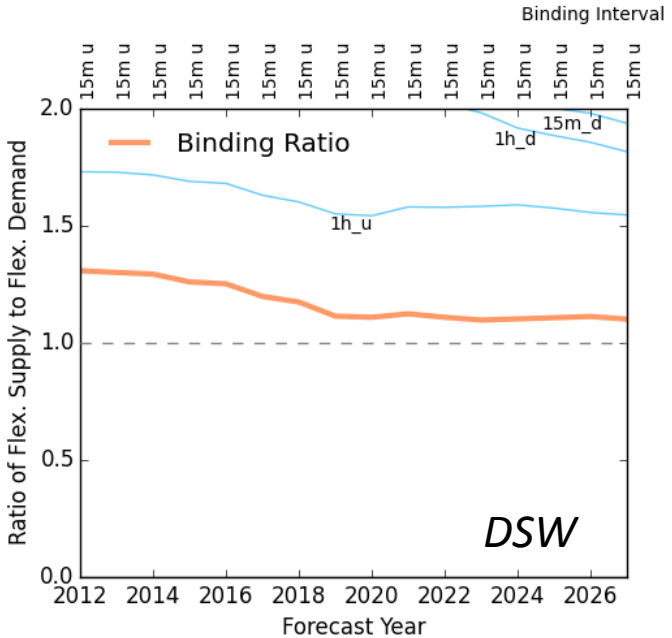


- Contingency reserve is major source of flexibility demand
- Flexibility supply largely from online resources (CCGT, coal)
  - Storage and hydro are important in PNW

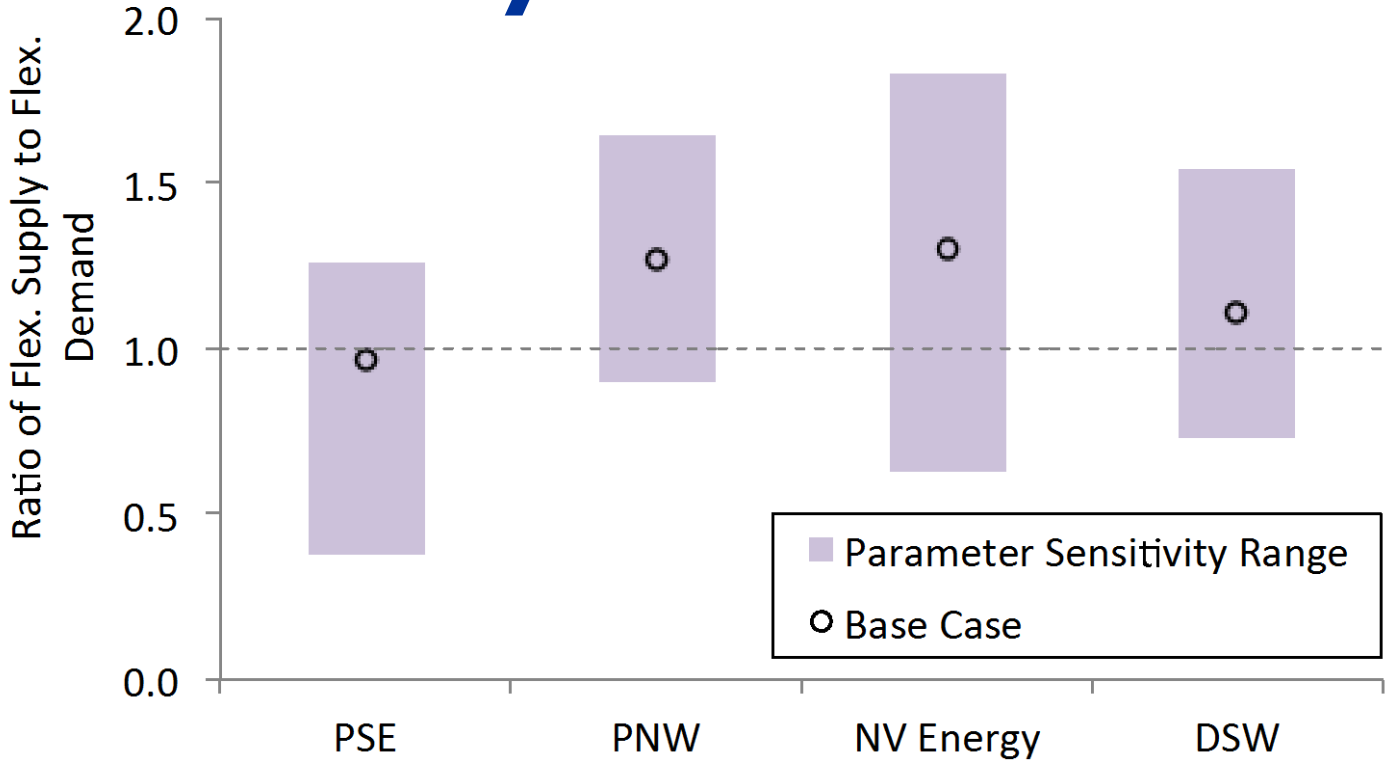
Flexibility Supply and Demand Increase Over the Planning Horizon

	Individual Utility	Regional Inventory
Pacific Northwest		
Desert Southwest		

Surplus of Flexibility Supply Decreases In Future Years

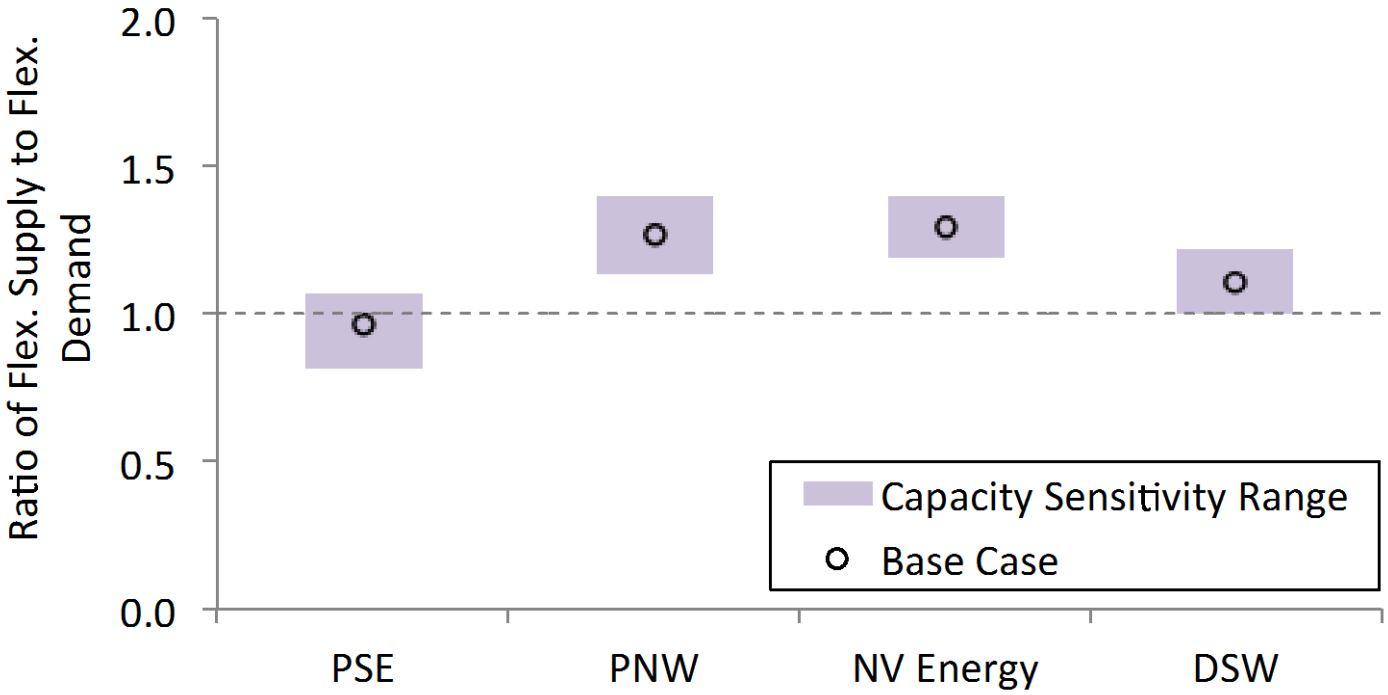
	Individual Utility	Regional Inventory
Pacific Northwest		
Desert Southwest		

Binding Ratio is Highly Sensitive to Key Parameters



- Parameters that greatly increase ratio:
  - Shorter start times for CTs; assumed dispatch of CTs; faster ramp rates for coal, CCGTs, and over interconnections; more control of DR; and more tolerance for risk of extreme changes in net demand
- Parameters that greatly decrease ratio:
  - Slower ramp rates for coal, CCGTs, and over interconnections; assumed dispatch of coal and CCGTs, and lower tolerance for risk

Changing Capacity of Small Set of Resources Markedly Impacts Ratio



- Since binding interval is 15 min, only fast resources can increase flexibility supply
- The two resources that produce the greatest change are energy storage and DR available via direct load control
- Quick start CTs and ICEs are also found to have a substantial impact.

Discussion of Results

- Short flexibility intervals are the most constrained, making fast sources of flexibility more important in determining the degree of surplus flexibility
- Flexibility up is more important in the majority of cases owing to the contingency reserve requirements
- Decrease in ratio of flexibility supply and demand is relatively gradual with time, as flexibility supply grows more slowly than flexibility demand
- Opportunities for collaboration exist where flexibility is much higher in the region than at an individual utility
- If needed, most useful resources for increasing flexibility supply will be DR, energy storage, quick-start CTs or ICEs

Conclusions and Future Work

- Flexibility of a portfolio can be estimated at a high-level, though the results are sensitive to several key parameters
- For portfolios in our case study flexibility is projected to decrease, though the rate of decline is gradual.
- Future work can focus on four main areas:
  - Extending application of the current methodology to other IRPs in the Resource Planning Portal
  - Improving parameters used in the flexibility methodology
  - Validation of the flexibility inventory methodology
  - Use the validation to identify ways to improve the flexibility inventory

For More Information

Download the full report and companion briefing:

http://emp.lbl.gov/publications

Contact the authors:

Andrew D. Mills	ADMills@lbl.gov	510.486.4059
Jo Seel	Jseel@lbl.gov	510.486.5087

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