Northwest **Power** and
Conservation Council

March 4, 2014

MEMORANDUM

TO: Council Members

FROM: Ben Kujala

SUBJECT: LBNL Studies on Renewable Integration

Andrew D. Mills is a Principal Research Associate in the Electricity Markets and Policy Group at Lawrence Berkeley National Laboratory. At the Council meeting on Tuesday March 11, 2014, Andrew will present some of his recent research on the economic challenges of integrating high penetrations of renewable generating resources in the Western Interconnection. His research indicates that under certain development schemes, as the penetration of variable generation increases, the marginal economic value of the resources decreases. His work also looks at mitigation measures to maintain the value of variable generation.

851 S.W. Sixth Avenue, Suite 1100
Portland, Oregon 97204-1348
www.nwcouncil.org

Steve Crow
Executive Director

503-222-5161
800-452-5161
Fax: 503-820-2370

Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

Economic Challenges to Achieving High Renewables Penetration

Andrew Mills
Electricity Markets and Policy

Northwest Power and conservation Council
March 12, 2014

Planning for Renewables

- How much renewable energy should be added to the system?

Social Planner Perspective:

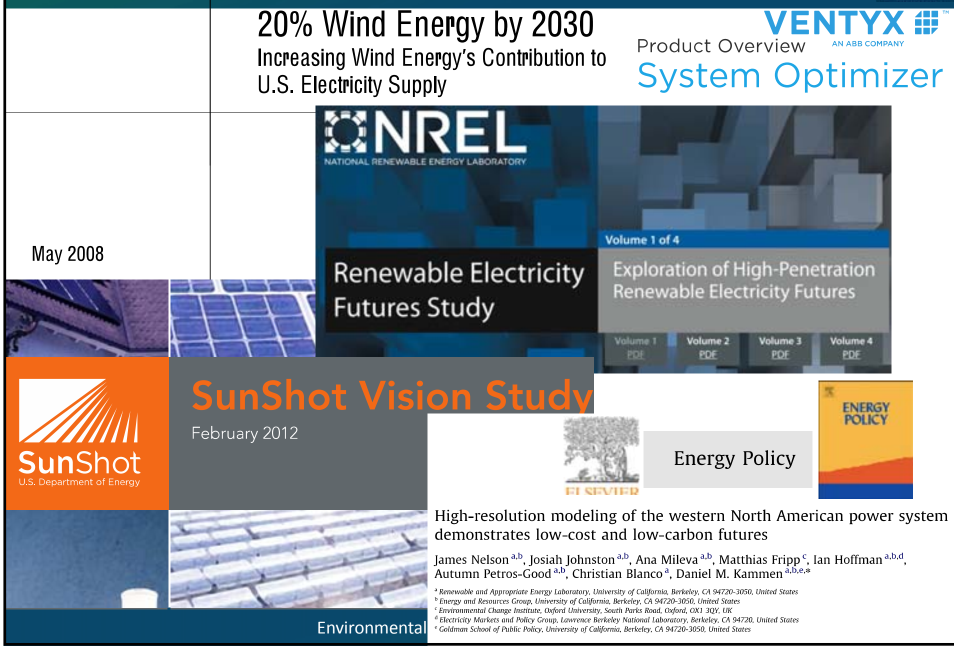
Find the right mix of resources, such that they minimize cost while meeting needs:

minimize: Total Cost = Investment + Operation Cost

subject to:

supply = demand
generator output < generator capacity
etc.

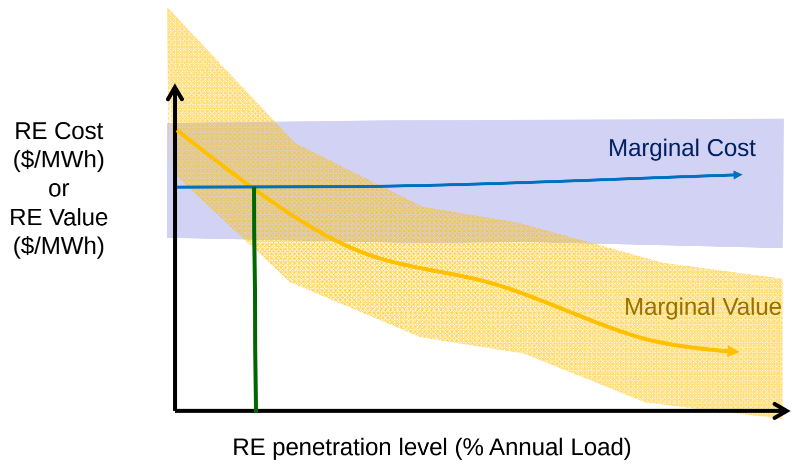
Planning models help answer these questions



How much do total costs change with RE?

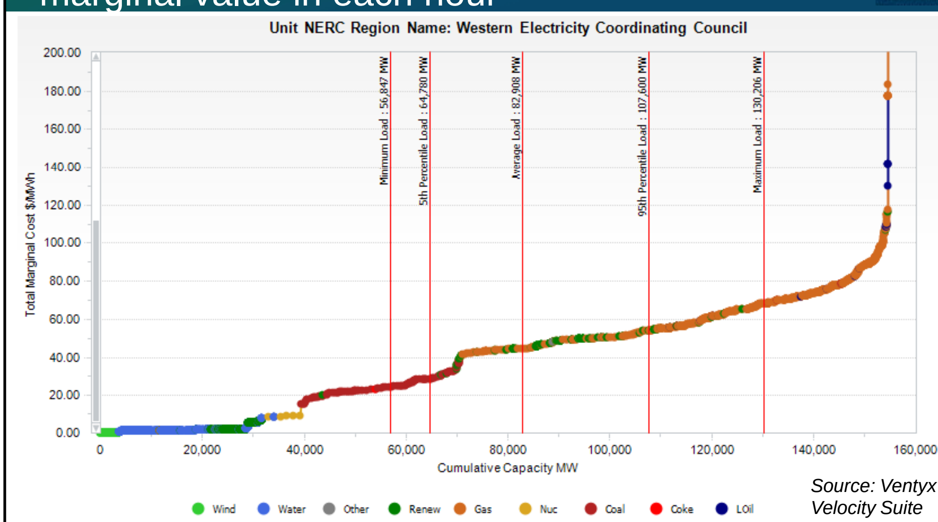
- Objective of social planning models are to minimize costs: how do costs change with RE?
  - Savings: reduction in costs from not needing to burn fuel in other power plants and from not needing to build some power plants
  - Costs: Cost of building a new RE plant
- If Savings of RE are greater than Costs of RE, then adding more RE will, on net, bring down costs and help meet objective

Minimize Total Costs by adding RE until Savings no longer exceed Costs



Illustrative

Wholesale power prices can be used to estimate marginal value in each hour



Source: Ventyx Velocity Suite

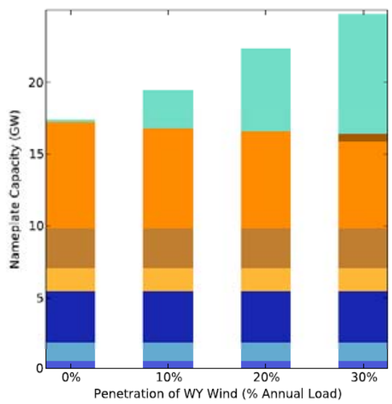
We estimate marginal value based on simulated wholesale prices for a power market in long-run equilibrium

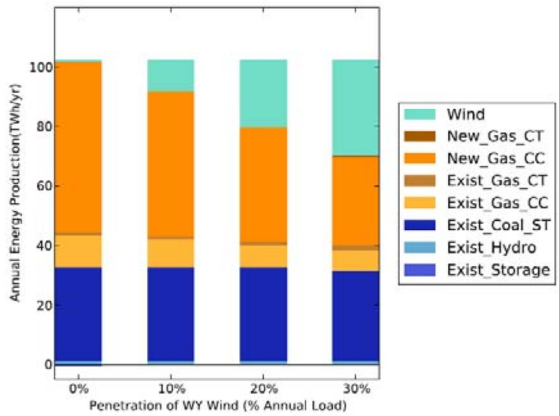
Estimating the value of variable renewables (VG) is challenging due to uncertainty and variability

- Savings: What costs would be avoided by adding VG?
- Challenging to estimate due to variability and uncertainty
- Focus of our recent research is to
  - quantify economic value of VG, examine how it changes with increasing penetration,
  - understand what causes those changes,
  - and how those changes can be mitigated

W... Ca...

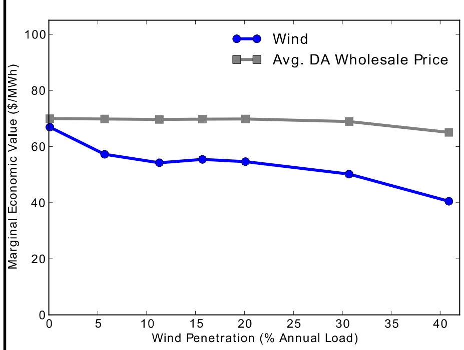
What costs are avoided with increased wind in the Rocky Mountain Power Area (2030)?



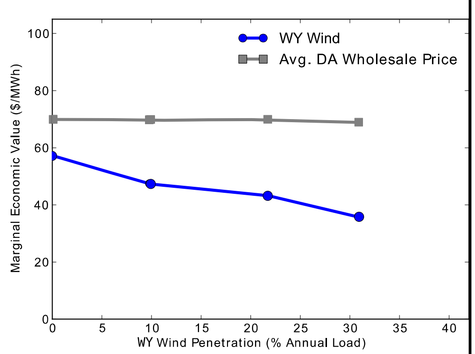


Economic value of wind decreases with increasing penetration levels

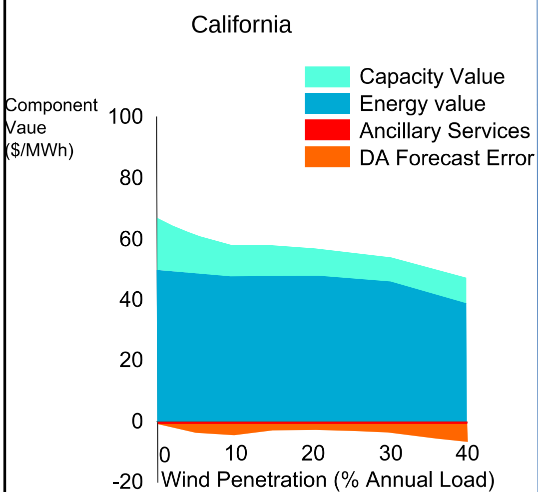
California

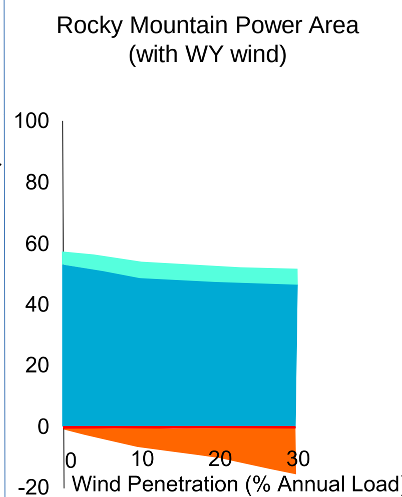


Rocky Mountain Power Area (with WY wind)

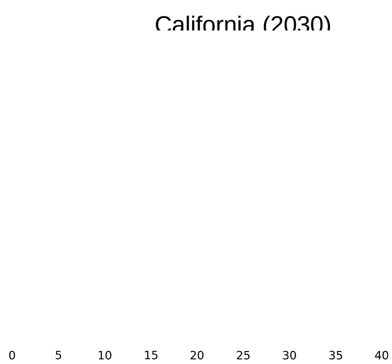


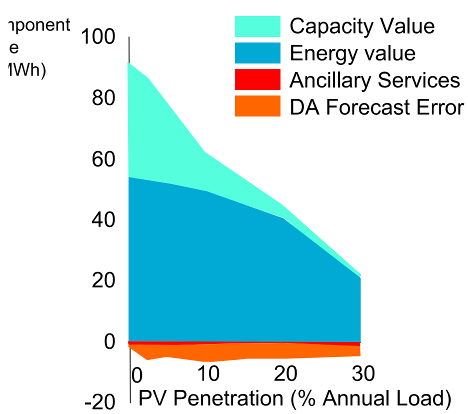
What drives the change in economic value with increased penetration levels?



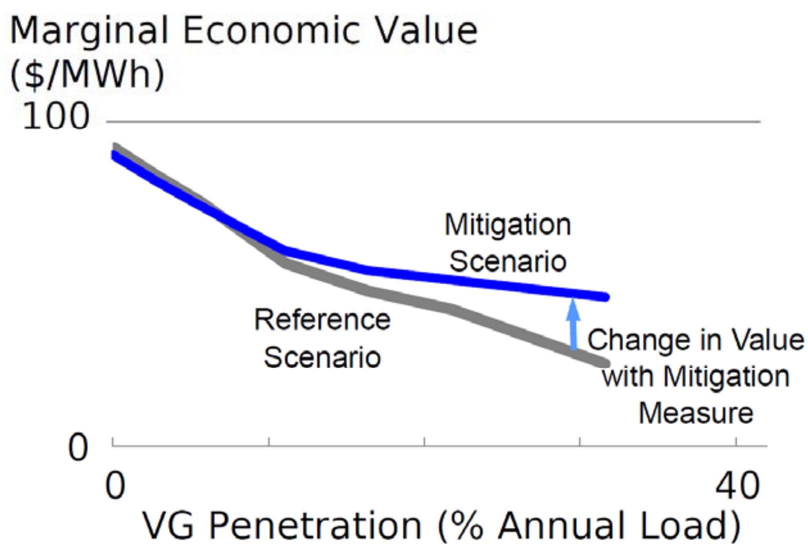


Solar PV has steeper decline with increasing penetration due to decreasing capacity value





What are potential options for mitigating the decline in economic value?



Strategies to mitigate the decline in the economic value in California

WIND

	Wind Penetration		
	20%	30%	40%
Reference Value ($/MWh)	**54**	**50**	**40**
Impact of Mitigation Measure ($/MWh)			
Geographic Diversity	+2.5	+4.9	+10.6
RTP	+3.7	+5.0	+7.9
Low-cost storage	-0.1	+0.4	+4.4
Quick-start CCGT	+0.3	+0.3	-0.6
10% PV	+1.1	-1.1	-5.2
10% CSP6	-0.2	-0.6	-4.4

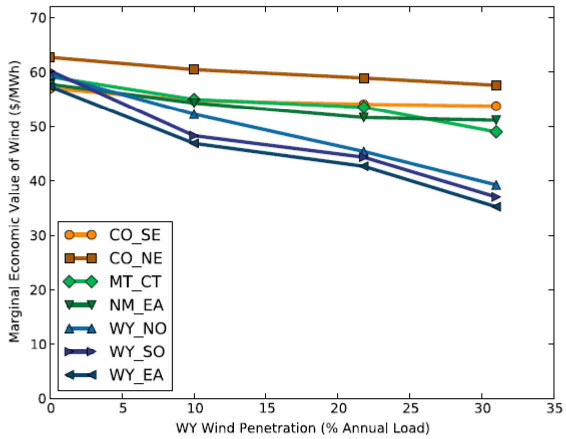
PV

	PV Penetration		
	10%	20%	30%
Reference Value ($/MWh)	**55**	**41**	**25**
Impact of Mitigation Measure ($/MWh)			
Low-cost storage	+3.3	+8.4	+19.7
RTP	+10.4	+7.5	+7.4
Quick-start CCGT	-1.8	-1.0	-0.2
10% Wind	+7.4	-1.1	-6.4

Positive indicates an **increase** in the value of VG relative to the value in the Reference Scenario

Negative indicates a **decrease** in the value of VG relative to the value in the Reference Scenario

The marginal value of VG depends on the where VG is installed



Rocky Mountain Power Area:

At low penetration, the marginal value of wind is similar for wind from any state

As penetration of wind from Wyoming increases, the value of additional wind from WY is less than the value of wind from other states

Conclusions

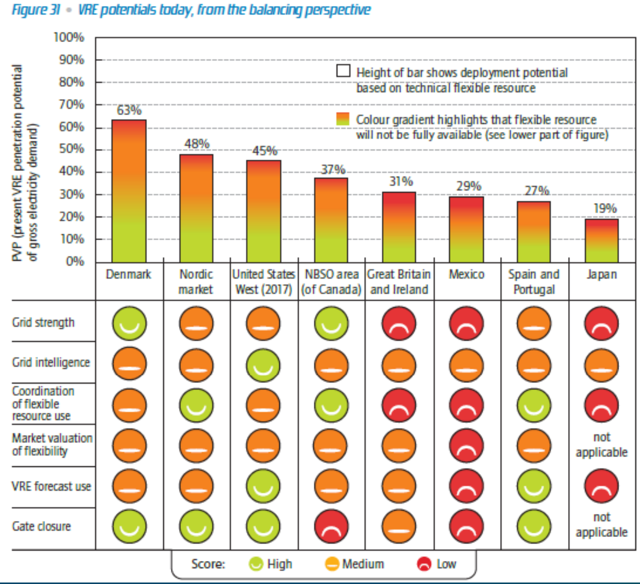
- The marginal economic value of VG decreases as the penetration increases
- Changes in value are driven primarily by changes in capacity value and energy value in California
- With concentrated wind siting and limited flexibility, day-ahead forecast error costs can also contribute to the decline in value
- Several measures can help stem the decline, though the value still decreases with increasing penetration

Related research: Current LBNL work on utility business models

"EE Business Models"	• Analyze impacts of EE goals and alternative utility business models (e.g., performance incentives, decoupling) on utility costs, revenues and customer bills • Technical assistance to state Public Utilities Commissions (PUCs) • Support SEE Action Working Group: Regulatory Policy Exercise for Midwest, Southeast, and Northeast regulators
Quantifying Financial Impact of Distributed Solar on Utilities	• Scoping analysis to characterize the scale of financial impacts of distributed solar, assess impact of key underlying drivers and efficacy of potential mitigation approaches
Tracking Activity of Future Regulatory and Utility Business Models	• LBNL tracking utility industry discussions on incremental and/or fundamental changes to existing cost of service regulation and utility business models • LBNL "framing presentations" given at NARUC, WIEB, NGA, NCSL and other meetings

Related research: Flexibility Inventory Project

Figure 31 • VRE potentials today, from the balancing perspective



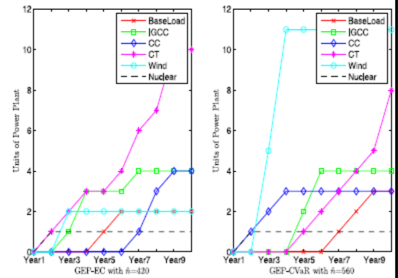
Flexibility Inventory:

Apply existing methodology to quantify flexibility demand and supply of resources identified in Western utility resource plans.

Existing methodology based on IEA Harnessing Variable Renewables report

Incorporating (long-term) uncertainty into capacity expansion models (with Sandia)

- Sandia is developing a capacity expansion model that selects the optimal portfolio given that several parameters (load growth, gas prices) are uncertain
- Minimize expected costs:
  - Minimize: Investment cost + **Expected** Production cost
- Or to avoid bad outcomes:
  - Minimize: Investment cost + Conditional Value at Risk (e.g. 5% tails)
- Compare the advanced stochastic results to existing methods
  - Case study of a utility that recently completed an IRP with that included solar



Source: Jin et al 2011

For More Information

Download reports:

http://emp.lbl.gov/reports/re

Contact info:

Andrew Mills, ADMills@lbl.gov, (510) 486-4059

Ryan Wiser, RHWiser@lbl.gov, (510) 486-5474

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