



Update on Trends Affecting the Southwest Power Market

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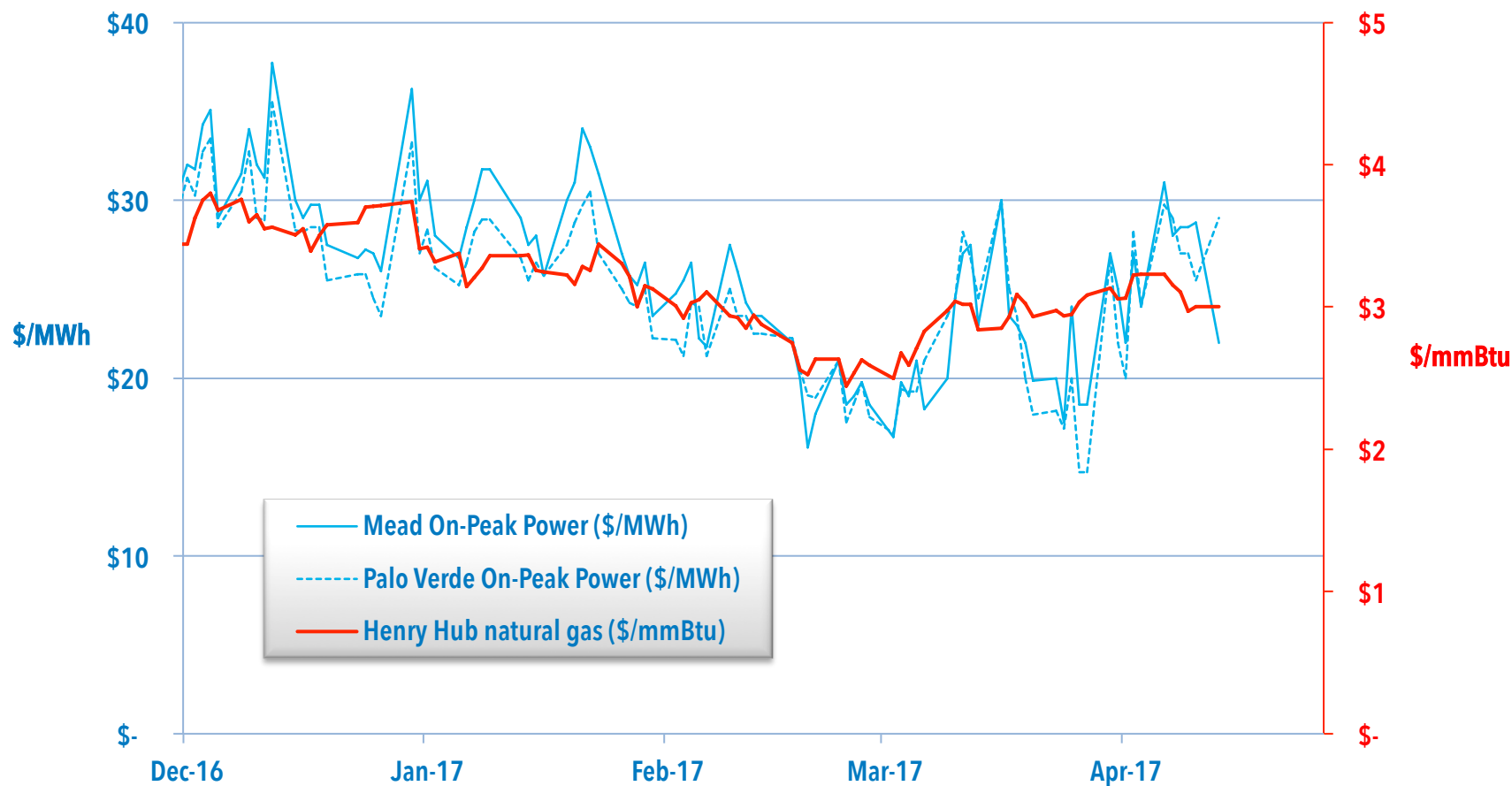
Central Arizona Water Conservation District, Power Committee Meeting

Initial points of clarification on the NREL study

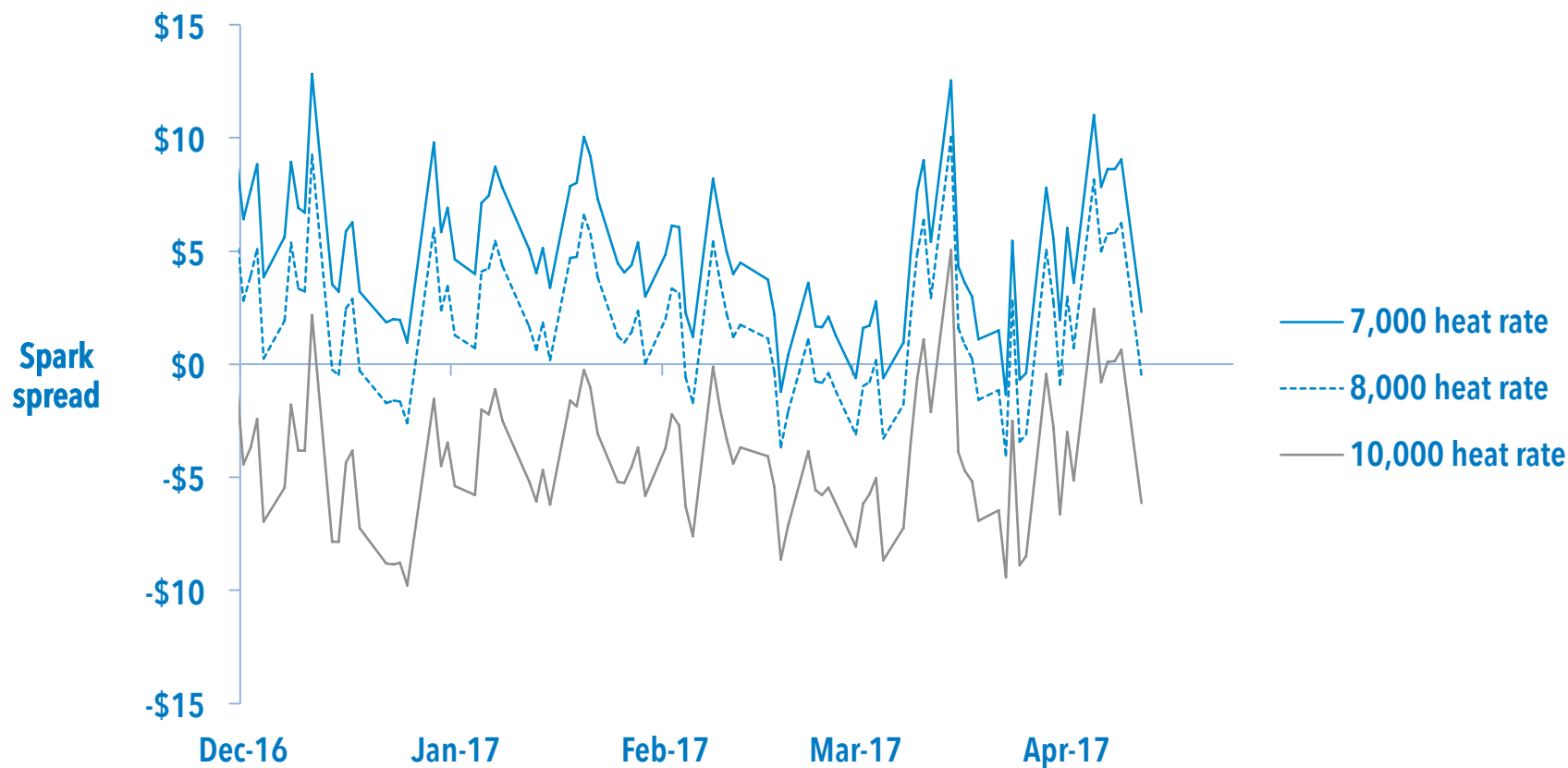
- Was not conducted as an analysis of NGS viability
 - At the time of publication, the assumption was that post-2019 operation would be consistent with TWG Agreement and final FIP (reduction to two-unit operation)
- Did not focus on issues that were utility concerns outside the federal interests
 - Co-tenants' action was a utility business decision
 - Assumed utility business issues would be analyzed by the utilities themselves through their respective IRPs
 - Presentations since the announcement have in fact relied on their own analyses

Update on Current Market Conditions

Power prices continue to track natural gas prices

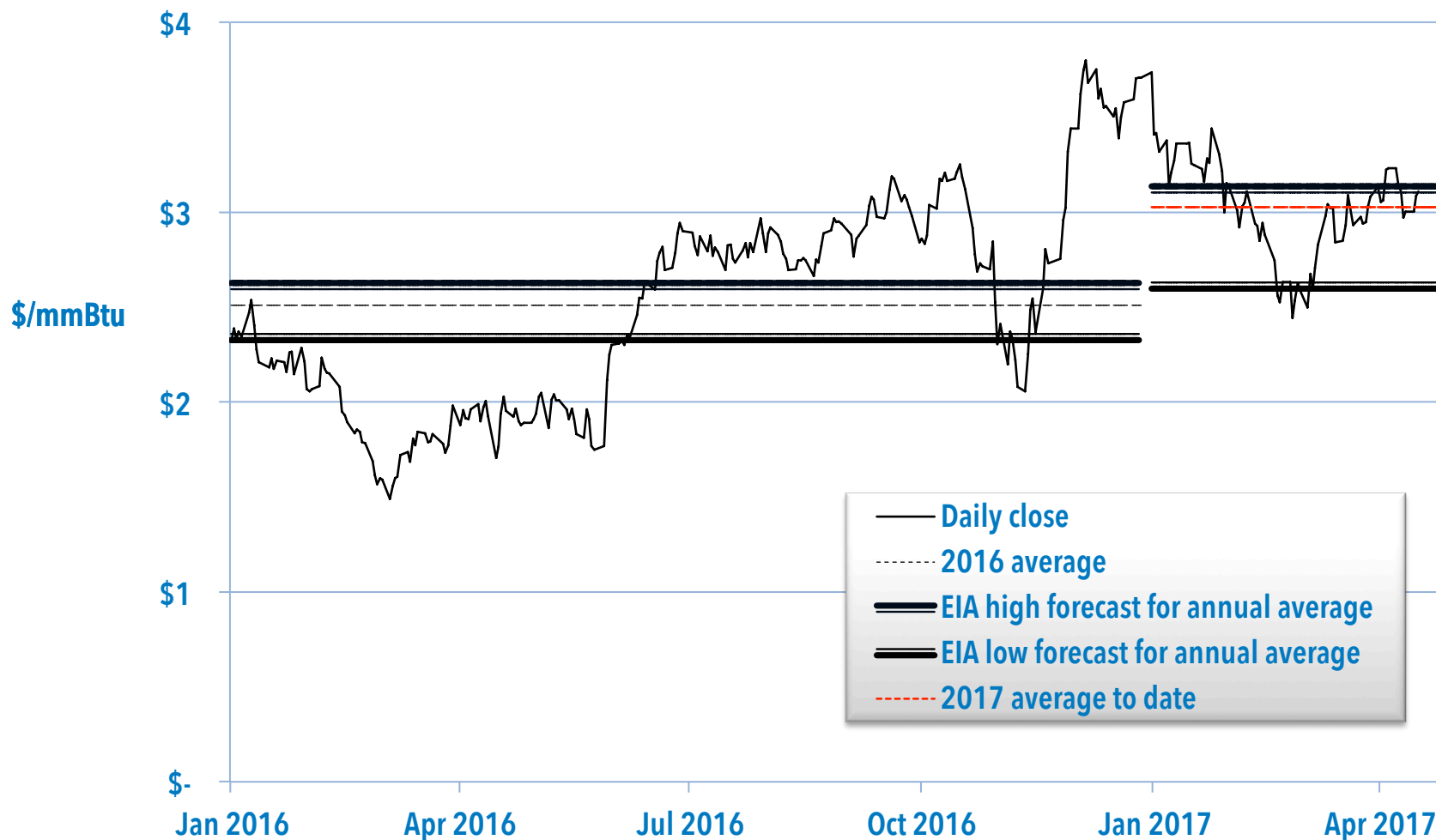


Prices good for existing combined cycles, but not new



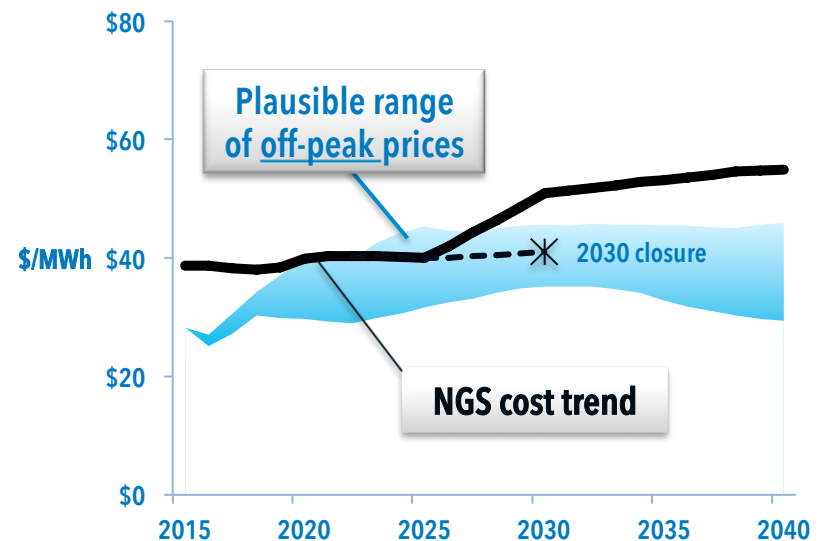
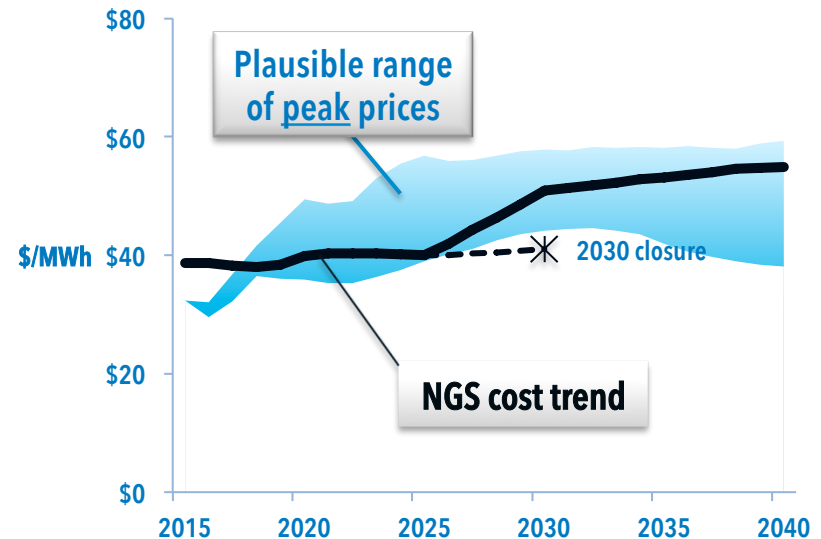
Spark spread calculated on Mead on-peak prices and SoCal Border natural gas prices.
Estimated spread needed to cover capital cost of a new combined cycle: \$24/MWh.

Natural gas prices still trending within forecast range

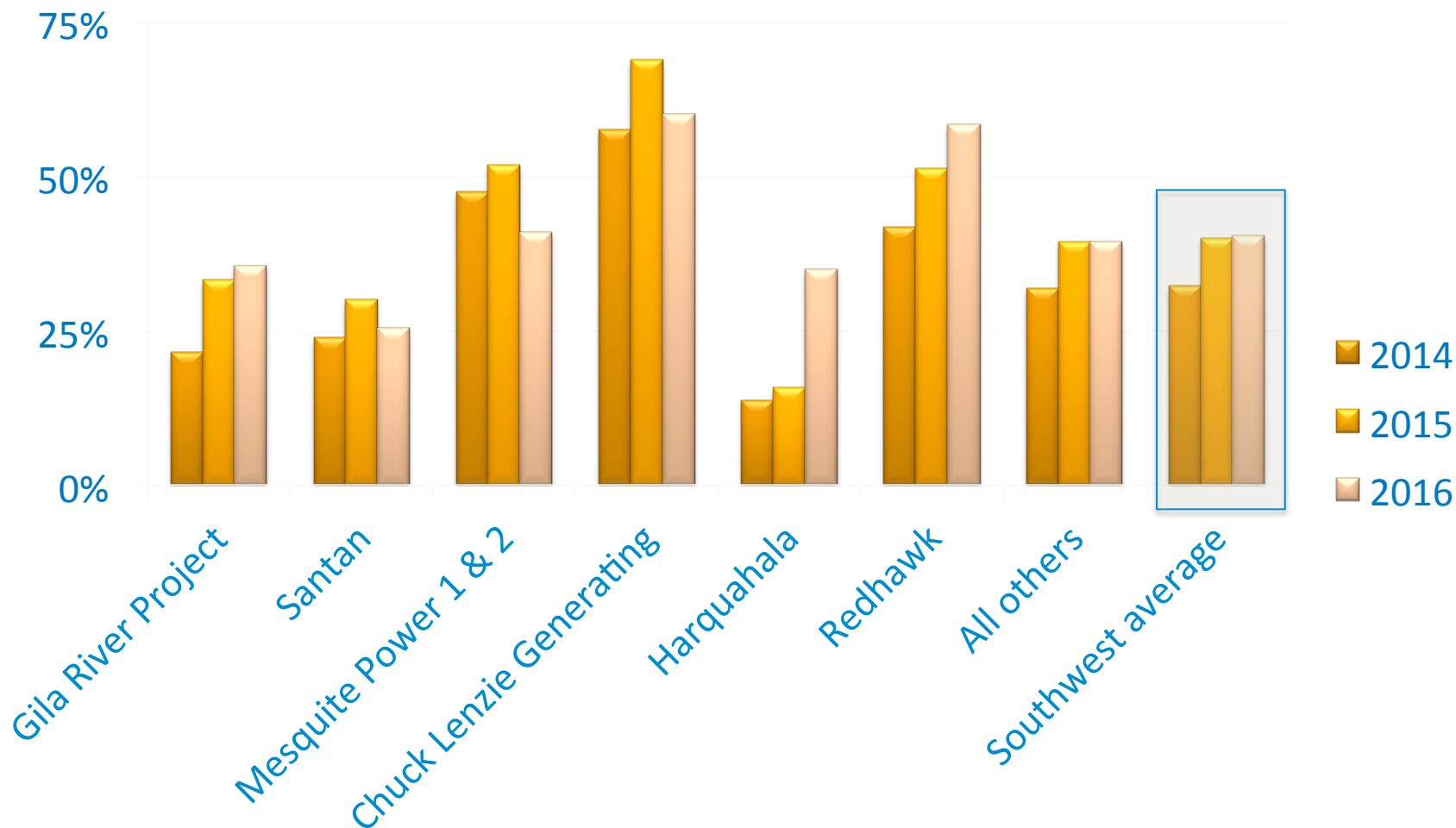


NGS production costs and wholesale prices

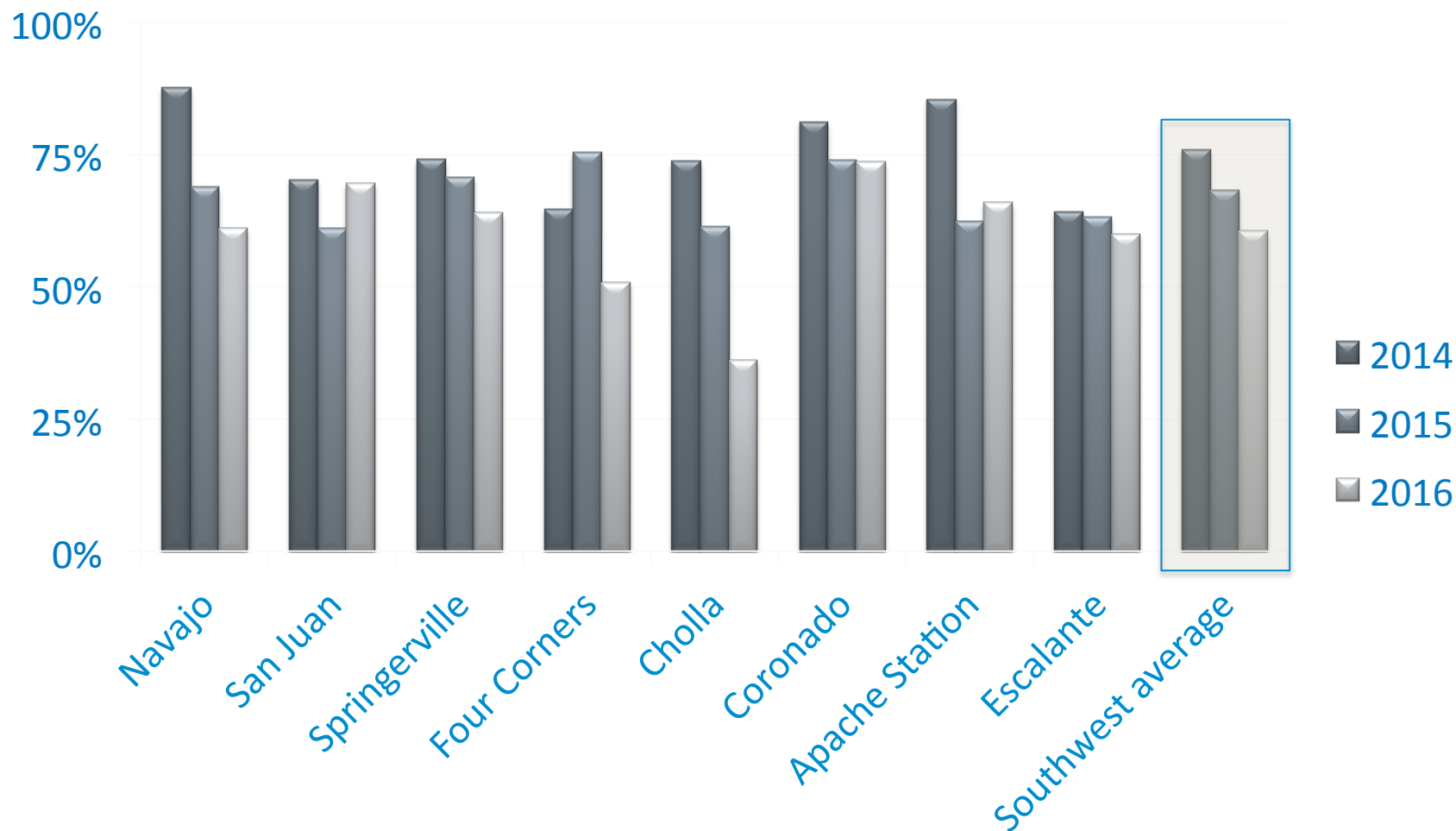
- Plausible range of future wholesale power prices at the Mead Hub estimated by:
 - Statistical analysis of historical Mead prices, Henry Hub natural gas prices, and CAISO load
 - Applying EIA natural gas price forecasts under reference scenario and high supply scenario
- Held NGS operating costs constant except for
 - Coal prices (EIA forecast)
 - New lease in 2019
 - NO_x controls by 2030



Combined cycle capacity factors are generally up

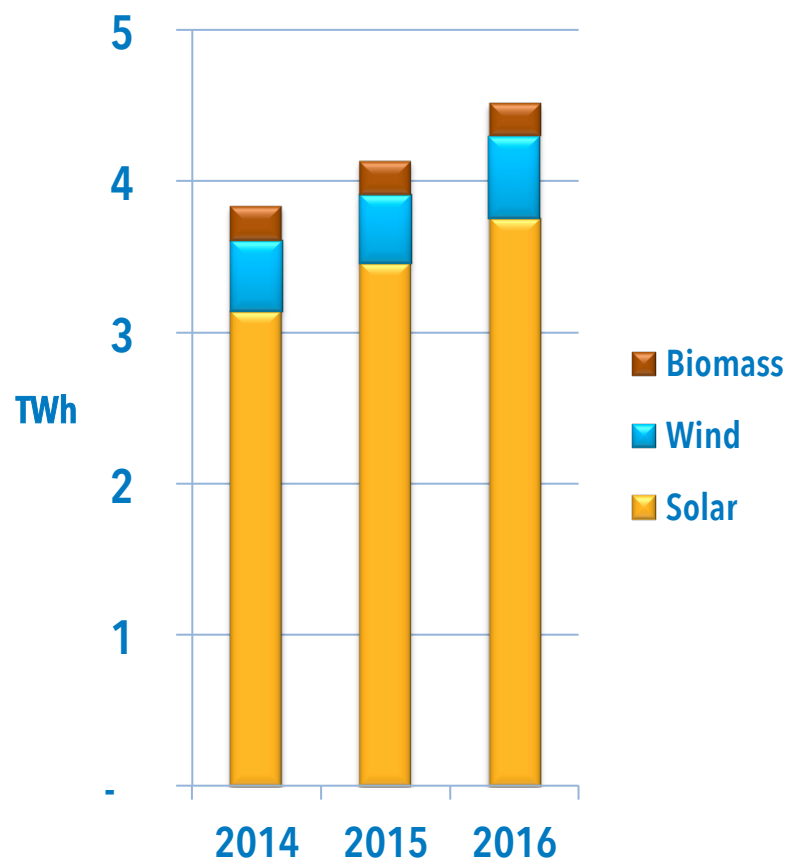


Coal capacity factors are generally down



Renewable generation up; flexibility costs down (APS)

Net generation from Arizona renewables



Savings from Energy Imbalance Market

	1Q 2016	2Q 2016	3Q 2016	4Q 2016
APS				\$6.0M
EIM total	\$18.9M	\$23.6M	\$26.2M	\$28.3M

APS joined EIM in the 4th quarter 2016.

CAISO reports that the EIM reduced flexibility reserves needed in all participating balancing authority areas. During the each month of the last quarter of 2016,

- Up-ramping requirements were reduced 399 MW to 490 MW (32% to 50%)
- Down-ramping requirements were reduced 474 MW to 482 MW (41%)

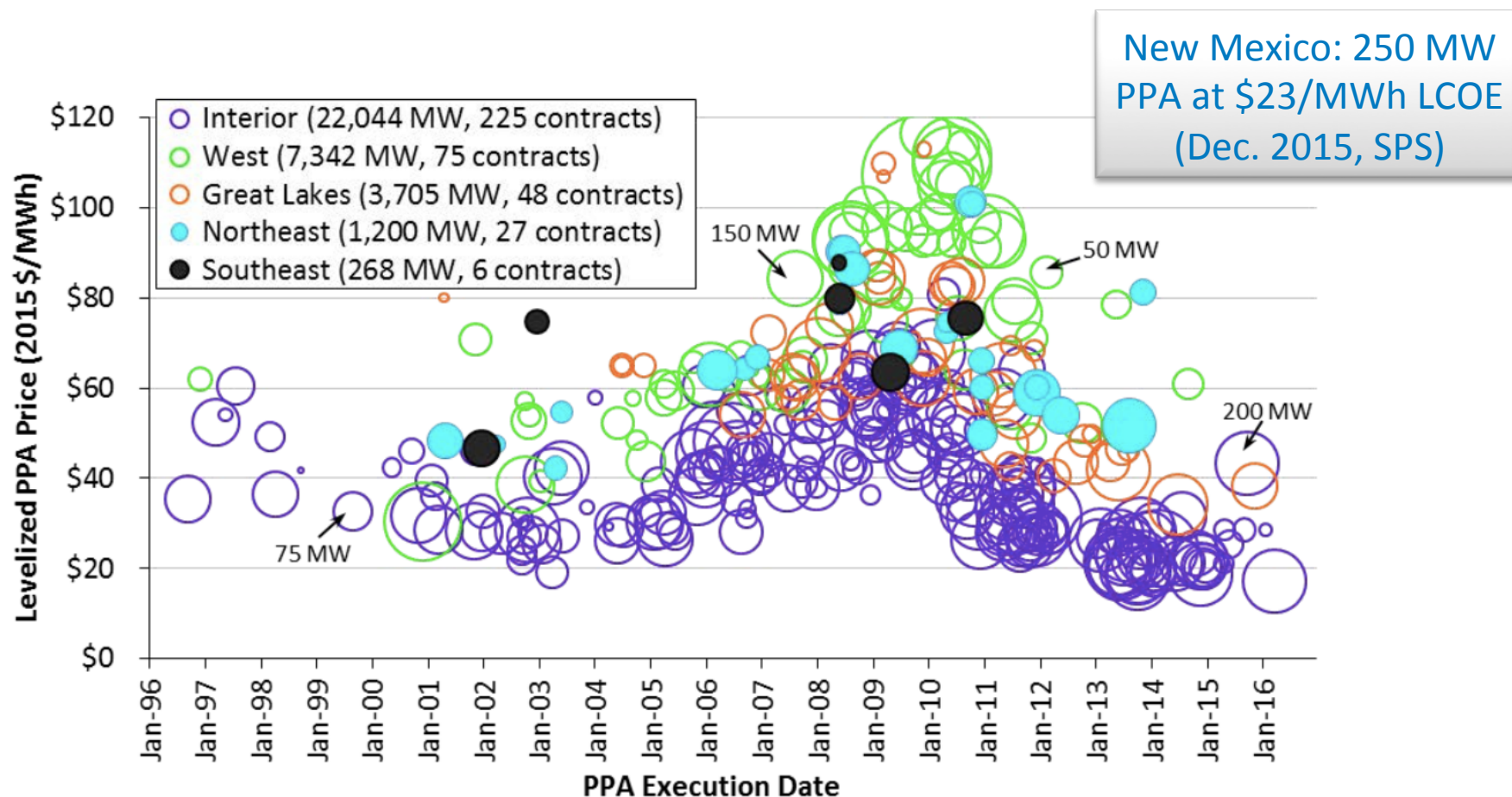
Utility-scale solar cost trends (2015\$ per MWh)

		Year PPA signed		
		2013	2014	2015
Year of energy delivery	2017	\$70.9	\$58.5	\$45.7
	2018	\$69.5	\$57.5	\$45.1
	2019	\$68.1	\$56.4	\$44.4
	2020	\$66.7	\$55.2	\$43.7

- Newer PPAs are lower
- Future deliveries are lower
- Anecdotal reports suggest continued trend for 2016 PPAs
 - ✓ City of Palo Alto, \$37/MWh for delivery in 2021.

Source: Bolinger and Seel, *Utility-Scale Solar 2015: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States*, Lawrence Berkeley National Laboratory, 2016

Six-year drop in wind prices tapered in 2015-16



Source: Wiser and Bolinger, *2015 Wind Technologies Market Report*, U.S. Department of Energy, 2016

Potential game changer: solar thermal



- Lowest CSP bid to date: \$63/MWh in Chile's August 2016 auction
 - Chile offers no RE subsidy
 - 240 MW of generating capacity
 - 14 hours of thermal storage
 - Lost out in August auction; winning bids ranged from \$38/MWh (wind) to \$66/MWh (geothermal)
 - Developer plans to re-bid
- How much will capacity value of CSP with storage in the Southwest increase with higher penetrations of solar PV?

Reducing the Impact of Price Variability

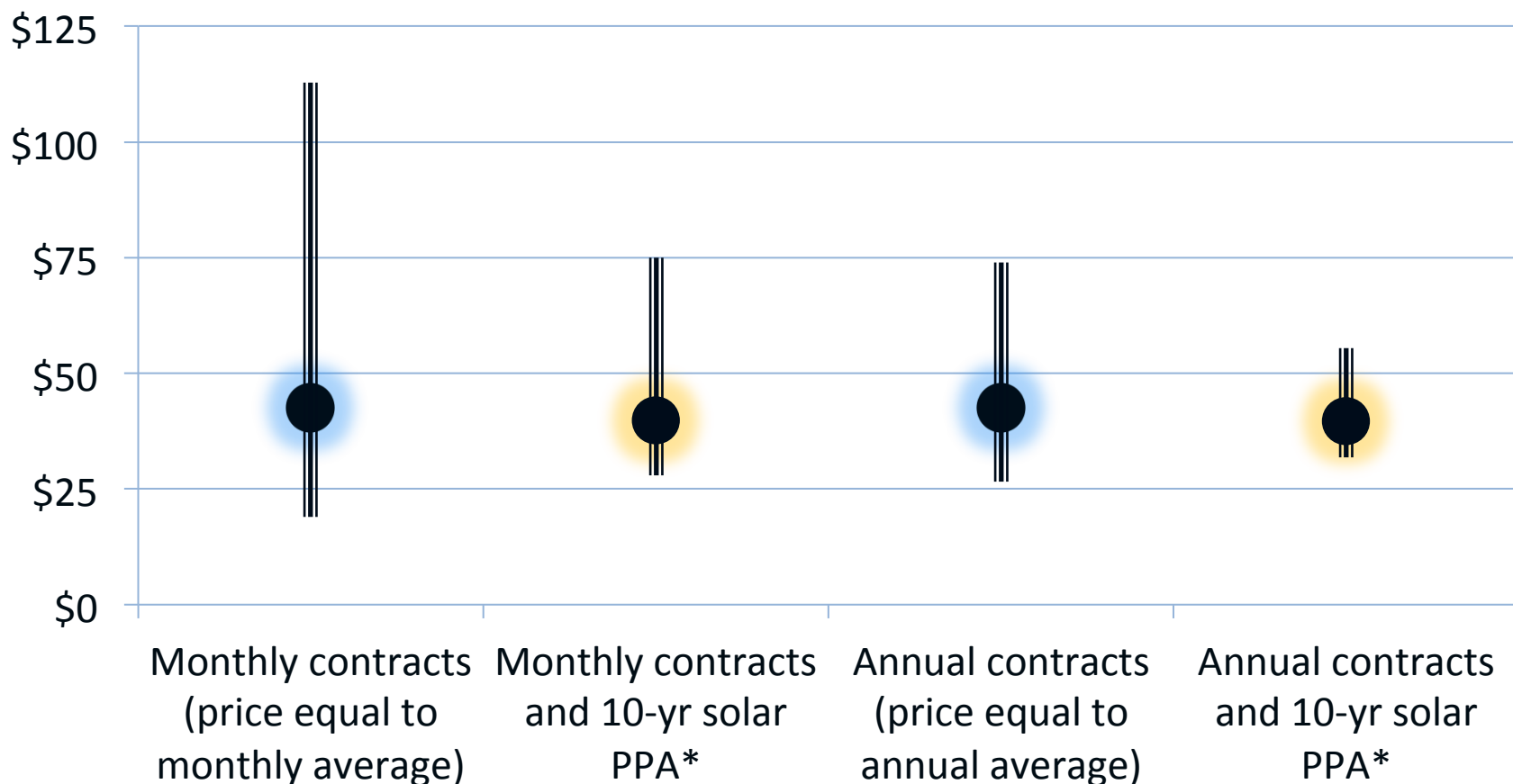
Assembling portfolio for low cost and low variability

- Price trends suggest that by 2019 a transition toward greater use of low-emitting energy sources might not involve significant price tradeoffs
- Natural gas prices have historically been volatile and could continue to be so
 - Fuel price variability affects the wholesale power market, due to the correlation between natural gas prices and power prices
- Renewables combined with natural gas capacity in a mixed resource portfolio could provide a hedge against future price volatility

Simulate contract prices (using 2008-2017 Mead Hub prices)



Average, high, and low costs over the 10-year period



**Simulated as 50% market purchase, 50% solar PPA; utility-scale solar PPA assumed to be fixed at \$37/MWh*

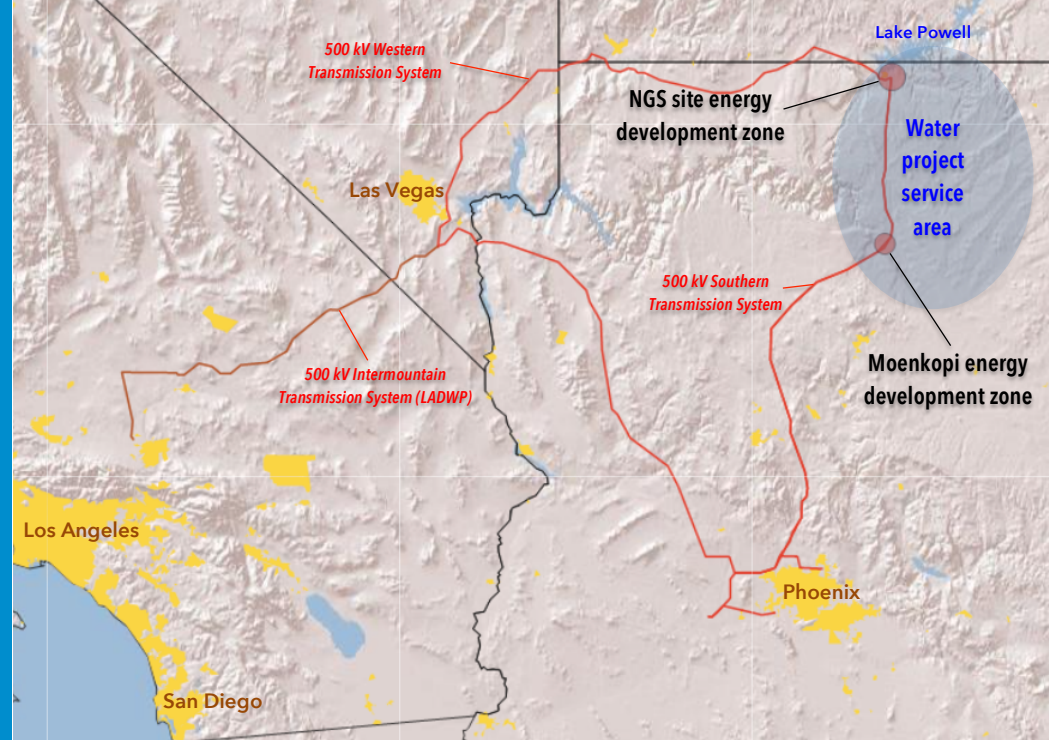
Notes and takeaways

- Mead Hub prices from 2007 through 2016 are used as a non-arbitrary input for the purpose of illustration
 - Comparison of average values is not usefully indicative, and is not the aim of this exercise
 - ✓ Outcomes will change for different periods of actual prices
 - Price deviations, however, will show same trend: Including renewables can moderate the effects of variations in short-term wholesale prices
 - ✓ Reduction in variation will be a function of RE's share of the total portfolio

Current NREL Tasks for Reclamation

Analysis of strategic contingency options

- Energy development zones encompassing 500 kV substations at NGS, Moenkopi Switch
 - NGS: solar
 - Moenkopi Switch: solar, wind, gas CT
- Potential nexus with new water development for Navajo, Hopi tribes



Early technical assessments indicate 100 MW PV project in the NGS zone delivering energy beginning in 2020 could come in at a PPA price comparable to the City of Palo Alto's recent procurement

More detailed site assessment needed; unknowns include allocation of substation upgrade costs, changes in ROW lease terms

Focus on Navajo Nation, Hopi Tribe

- Energy development zones would serve both internal load and market export
 - NGS currently provides no power directly to the tribes
 - Development can be incremental, reducing capital risk
- Potential for additional economic development on the reservations
 - Rather than job-for-job replacement, emphasis is on broad-based economic development that will support diverse job growth
- Tribes are already receiving strategic support from Reclamation (and NREL) to develop tribal energy policies that can reduce current barriers to development
- NREL will be modeling different tribal ownership models

Final note: Funding for CAWCD technical support

- Reclamation's contract with NREL has included a task for direct technical support to CAWCD for NGS-related analysis, as may be requested by CAWCD
- Other tasks are likely to change based on outcomes of stakeholder summits conducted by Department of the Interior
- Aim of contingency scenario analysis is to identify options that are likely to be market-competitive

Questions?

www.nrel.gov

