Revisiting the Long-Term Hedge Value of Wind Power in an Era of Low Natural Gas Prices

Mark Bolinger
Lawrence Berkeley National Laboratory

March 2013

The work described in this presentation was funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (Wind Power Program) under Contract No. DE-AC02-05CH11231

Introduction

- Shale gas production has put downward pressure on natural gas and wholesale power prices across the U.S., making it harder for wind and other renewable power technologies to compete on price alone (despite recent improvements in their cost and performance).
- As wind power finds it harder to compete with gas-fired generation on price, it will increasingly need to rely on other attributes, such as its "portfolio" or "hedge" value, as justification for future deployment.
- This work investigates whether wind power can still serve as a cost-effective hedge against rising natural gas prices, given the significant reduction in gas prices in recent years, coupled with expectations that gas prices will remain low for years to come.
- It does so by comparing prices from a sizable sample of long-term wind power purchase agreements (PPAs) to a range of long-term natural gas price projections.

Roadmap

I. Overview and Analysis of the LBNL Wind PPA Sample

II. Natural Gas Prices: Low By Historical Standards, But Difficult to Lock In Over Longer Terms

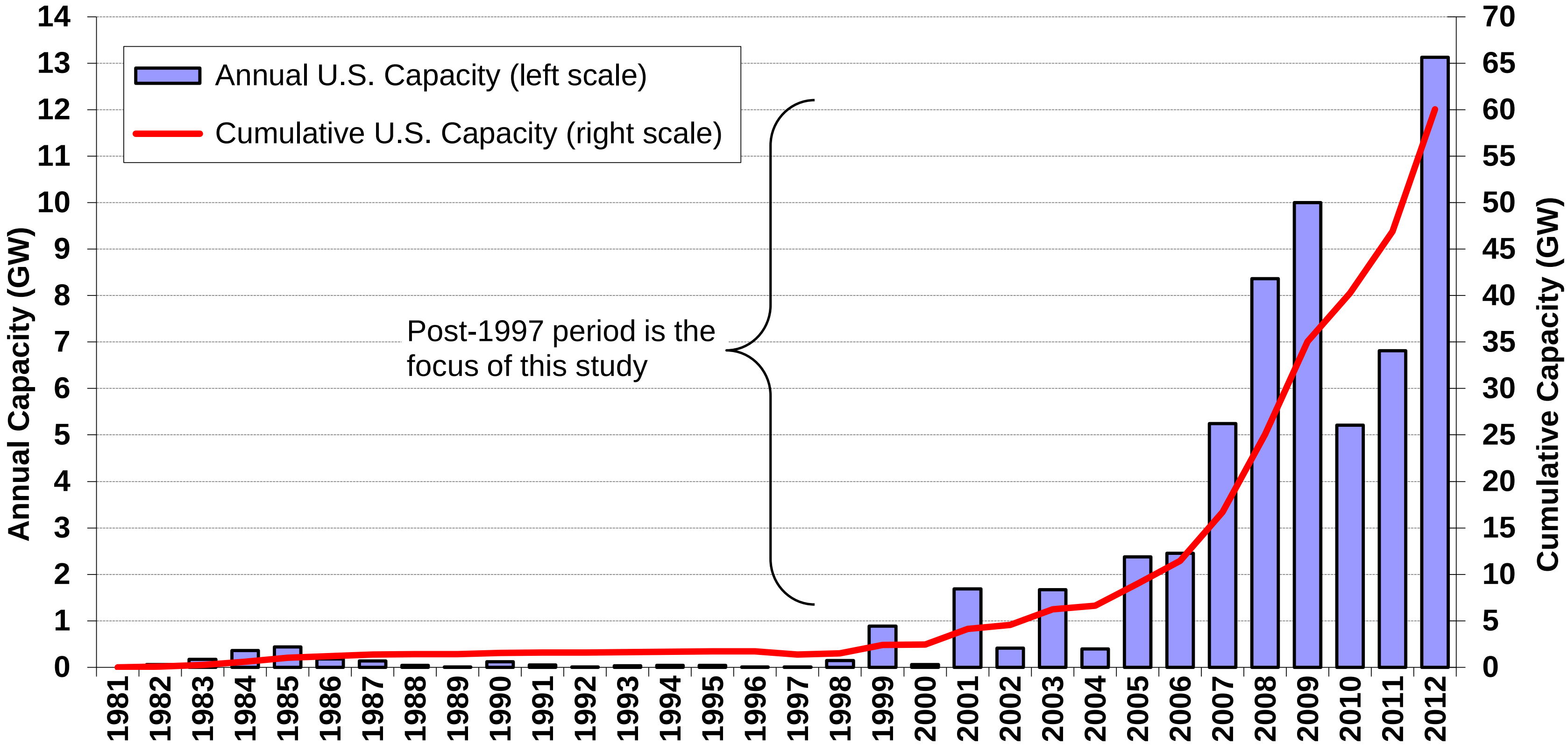
III. Comparison of Wind PPA Prices to Natural Gas Price Projections

IV. In Their Own Words: Wind Buyers on Wind's Long-Term Hedge Value

Why Collect and Analyze Wind PPAs?

- The “bundled” price of energy, capacity, and RECs sold through a long-term PPA can serve as an empirical proxy for (post-incentive) LCOE
- Bundled PPA prices:
  - Allow us to observe total revenue requirements empirically, rather than through financial modeling exercises (and thereby allow us to validate our financial models)
  - Provide an indication of how wind stacks up relative to other generation sources
  - Enable us to empirically observe time trends and regional differences in the LCOE of wind
  - Help to facilitate policy and market analysis
  - Demonstrate the long-term value of wind as a price hedge
- Data sources include FERC filings, SEC filings, state PUC filings, credit rating agency research

Post-1997 Period is the Focus of This Study



- 60 GW of wind in the US, 98% of which has been built since 1997
- This study focuses on PPA prices from a subset of projects built from 1998 through 2012

Certain Types of Wind Projects Are Excluded From the LBNL PPA Sample

- **Merchant projects** (i.e., those that sell their power on the spot market, without a contract) are excluded, because their future revenue is unknowable by definition
- **Projects that sell RECs separately from energy** are generally excluded (unless the separate REC sale price is known) for the same reason
- **Projects built in Alaska, Hawaii, and Puerto Rico** are excluded, because challenging construction environments and isolated power markets can result in PPA prices that are anomalous
- **Utility-owned projects** are excluded because there is no sale of power on the wholesale market (no PPA)
- **Behind-the-meter projects** are excluded because there is generally no sale of power involved (no PPA)

LBNL Sample MW = 67% of Possible Universe *(post-1997 build)*

Possible Sample = 35,370 MW

\+ 58,851 MW were built in the U.S. from 1998-2012

– 389 MW built in Alaska, Hawaii, and Puerto Rico (assumed outliers)

– 13,750 MW are merchant or semi-merchant (with no PPA)

– 9,083 MW are utility-owned (therefore no PPA)

– 259 MW are on-site (behind the meter, with no PPA)

= 35,370 MW possible sample of PPAs through 2012

Actual LBNL Sample = 23,529 MW (287 contracts)

Missing = 11,841 MW (35,370 – 23,529)

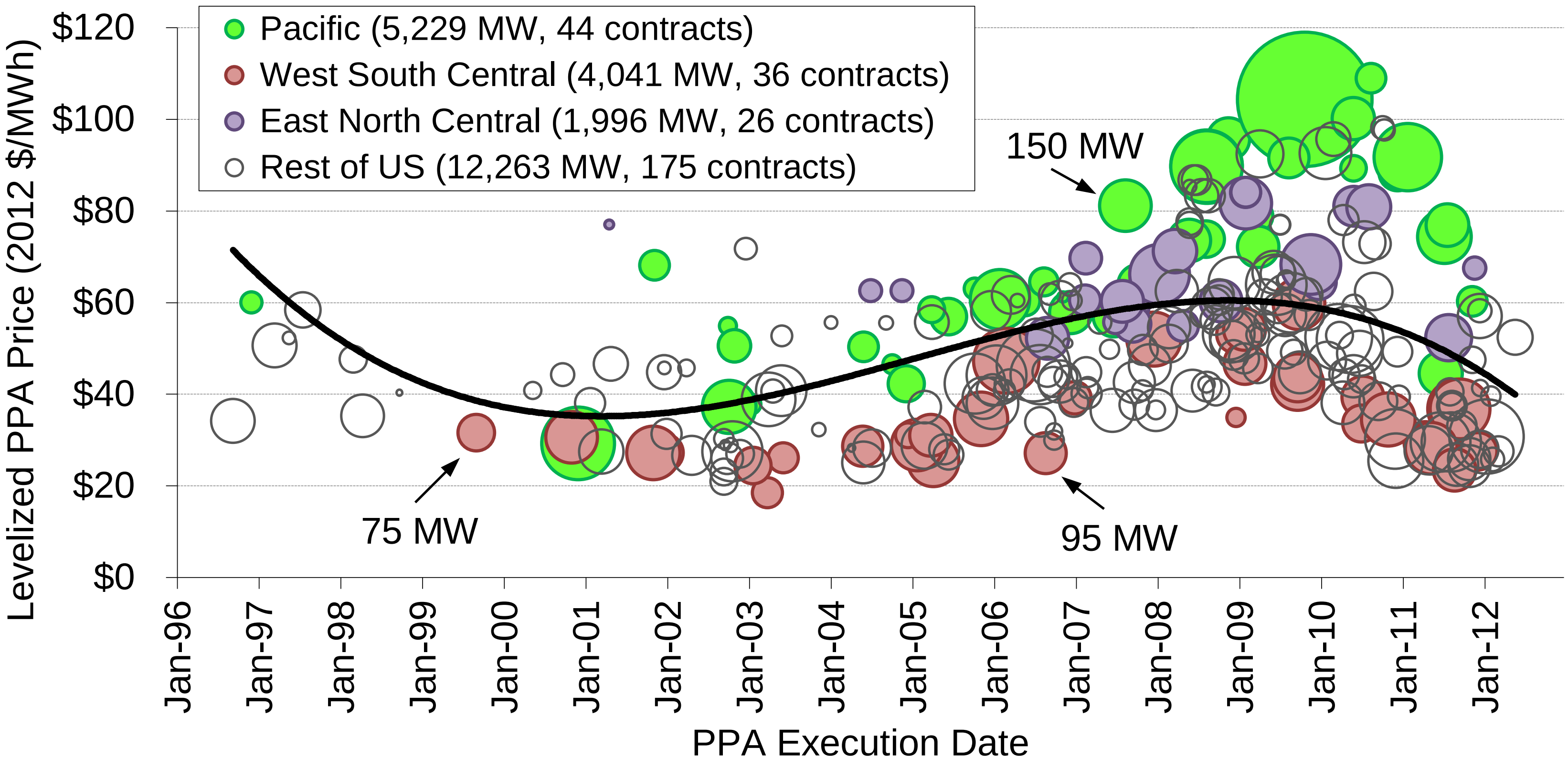
- Texas projects heavily under-represented (ERCOT not subject to FERC)
- Historical (but not future) prices are available for some of this 11.8 GW
- Sample will grow as more information about existing projects comes to light via future filings (and as new projects come online)

Regional Analysis of Contract Sample

Census Division	Possible PPA Universe (MW)	LBNL PPA Sample (MW)	Capacity Missing (%)	Capacity Missing (MW)
New England	417	59	86%	358
Middle Atlantic	908	769	15%	139
East North Central	4,309	1,996	54%	2,313
West North Central	8,244	6,820	17%	1,424
South Atlantic	342	241	30%	101
East South Central	27	27	0%	0
West South Central	8,012	4,041	50%	3,971
Mountain	5,777	4,347	25%	1,430
Pacific	7,334	5,229	29%	2,105
Total U.S.	**35,370**	**23,529**	**33%**	**11,841**

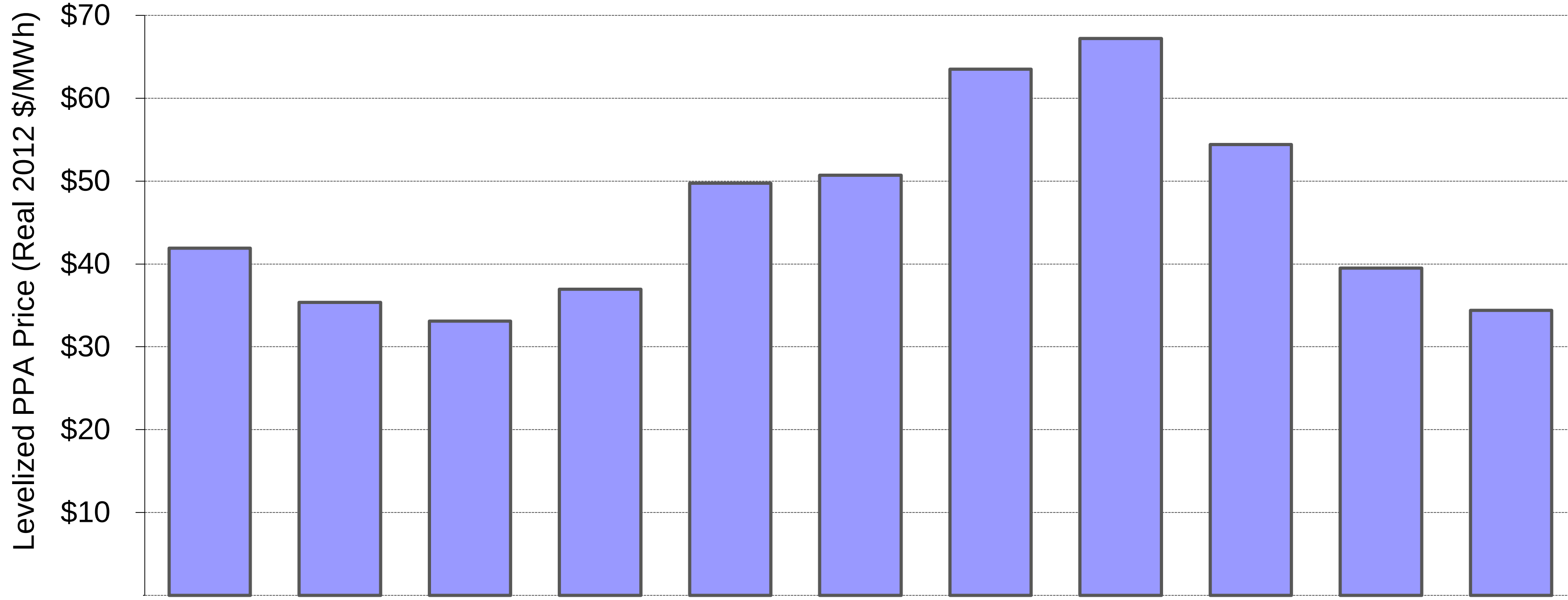
- 70% of the missing sample (in MW terms) falls within three regions: West South Central (TX and OK), East North Central (WI, MI, IL, IN, OH), and Pacific (CA, OR, WA)
- The impact of under-representation within these 3 regions on a national average PPA price is unclear, but may be minimal/offsetting (next slide)

Regional Holes in Sample May Offset One Another, Minimizing National Impact



- In general, West South Central is a low-priced region, Pacific is a high-priced region, and East North Central lies somewhere in between
- Strong time trend: recent levelized PPA prices rival lows set a decade ago

A Smoother Look at the Time Trend

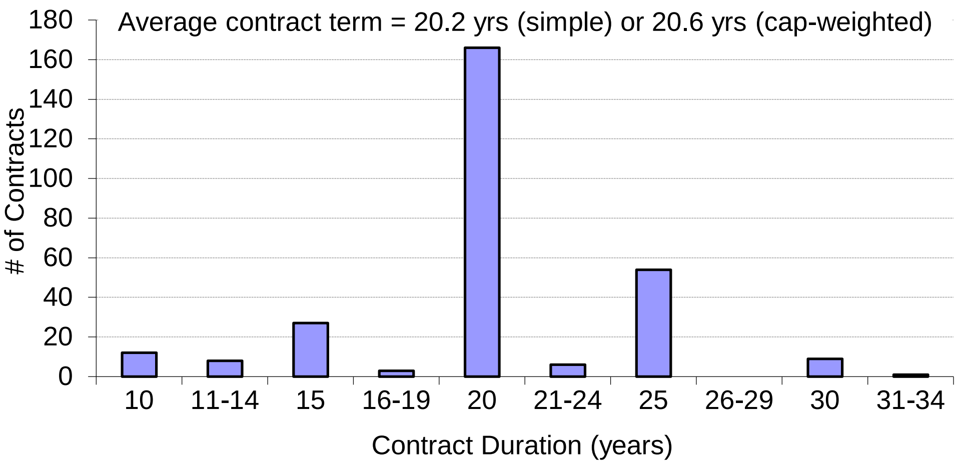


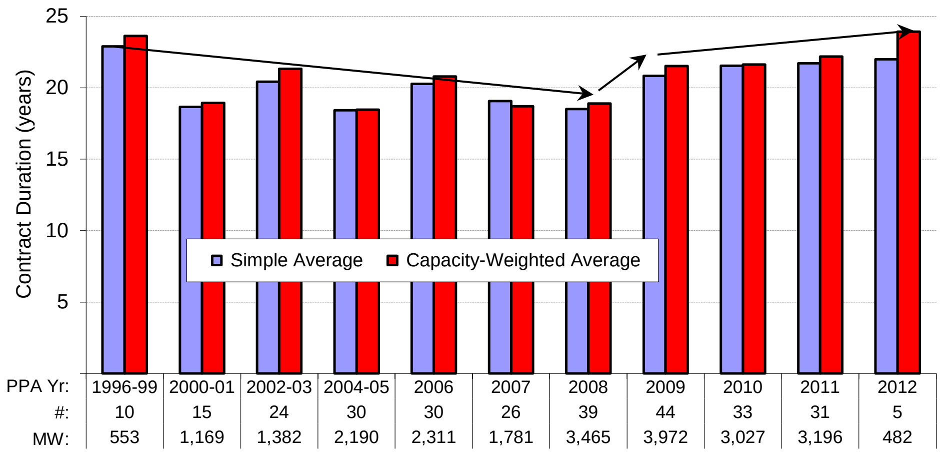
PPA Year:	1996-99	2000-01	2002-03	2004-05	2006	2007	2008	2009	2010	2011	2012
Contracts:	10	15	24	30	30	26	39	44	33	31	5
MW:	553	1,169	1,382	2,190	2,311	1,781	3,465	3,972	3,027	3,196	482

Within each time period (based on PPA execution date), PPA price streams are first generation-weighted, and then the resulting generation-weighted average price stream is levelized over the composite contract period.

Time trend closely follows trends in turbine prices and installed project costs over the past decade: first a sharp increase, followed by a sharp decrease

Analysis of Contract Duration





- 84% of all capacity in LBNL sample have PPAs of 20 years or longer
- Average contract terms declined gradually through 2008, but lengthened again starting in 2009:
  - Initial decline may be indicative of a maturing market or of wind’s ability to compete with higher wholesale power prices
  - The shift to longer contracts post-financial crisis might reflect a more-stringent financing environment (i.e., a need to see contracted cash flow over longer terms), or could simply be one tool that developers are using to offer lower PPA prices in the face of low wholesale power prices

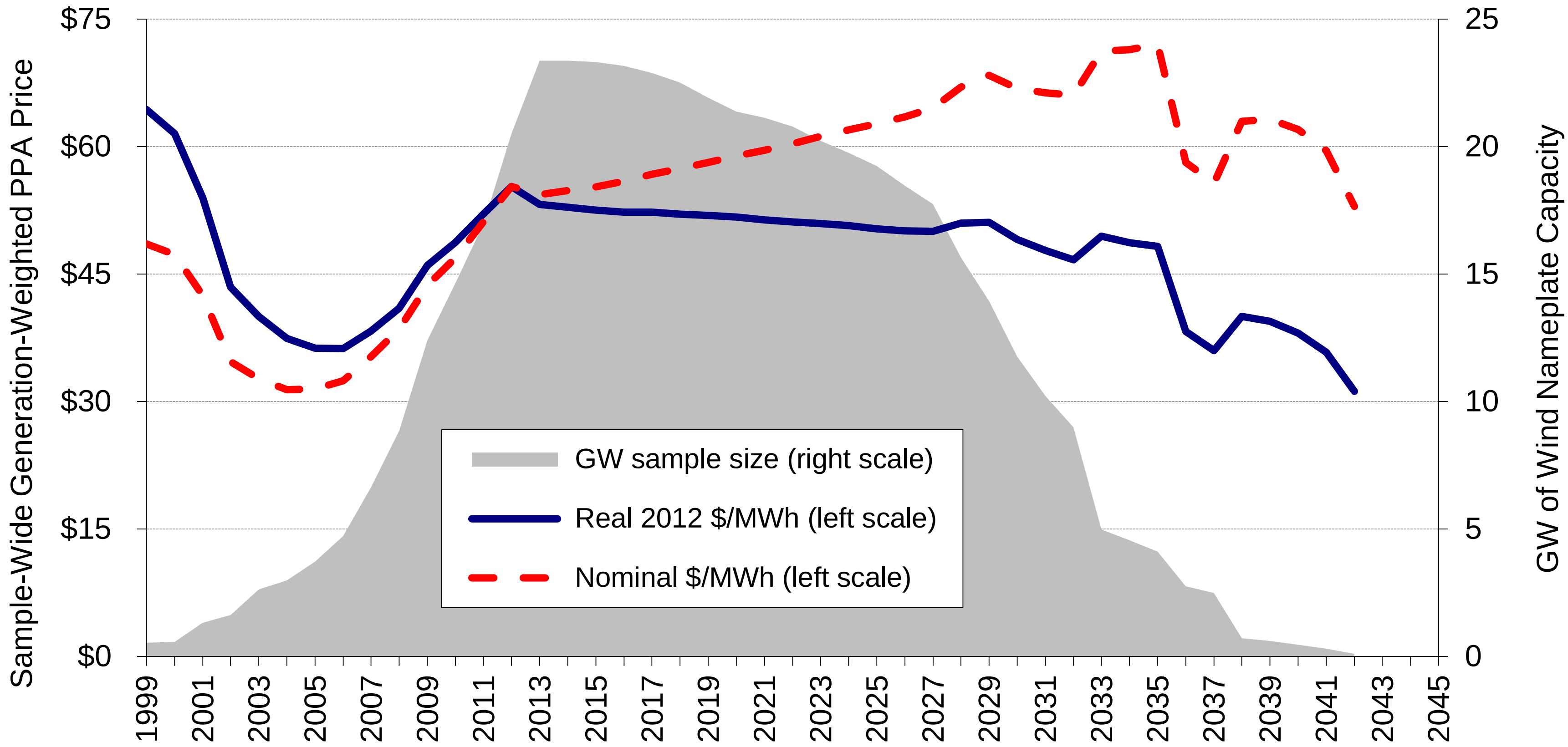
Analysis of Contract Pricing Structure

Contract Price Characteristics*			Contract Sample Characteristics			
Annual	**Seasonal**	**Diurnal**	**# Contracts**	**# MW**	**% Contracts**	**% MW**
Flat	Flat	Flat	127	11,258	44%	48%
Flat	Flat	Variable	12	1,336	4%	6%
Flat	Variable	Flat	1	75	0%	0%
Flat	Variable	Variable	13	999	5%	4%
Escalates	Flat	Flat	97	7,699	34%	33%
Escalates	Flat	Variable	2	55	1%	0%
Escalates	Variable	Flat	9	423	3%	2%
Escalates	Variable	Variable	12	800	4%	3%
De-Escalates	Flat	Flat	2	211	1%	1%
Mix	Flat	Flat	12	673	4%	3%
		Total:	**287**	**23,529**	**100%**	**100%**

**in nominal dollar terms*

- 58% (of MW in the sample) feature flat annual pricing (48% are *totally* flat), while 38% escalate annually (the remaining 4% either de-escalate or are some combination of flat, escalation, and/or de-escalation)
- 15% (of MW) vary prices seasonally and/or diurnally (7% vary both)
- 81% (of MW) feature simple pricing structures: either totally flat (48%) or flat intra-year but with annual escalation (33%)

Generation-Weighted Average Wind PPA Price (real and nominal) Plotted Against Sample Size



- Big drop in 2036 when Alta contracts end (>1 GW in CA)
- Weighted-average prices more volatile at times of low sample size

Takeaways from Part I

- The LBNL PPA sample is sizable (67% of possible MW).
- A majority of PPAs in the sample are long-term (84% ≥ 20 years) and non-escalating (58%). Another 38% do escalate annually, but escalation rates are generally modest (intended to keep pace with expected inflation).
- The locked-in, generation-weighted average PPA price among the full sample is essentially flat over time in real dollar terms, hovering just below $50/MWh (real 2012 dollars).
- Significant time trends are evident in the data – levelized PPA prices bottomed in 2002, peaked in 2009, and have now returned to 2002-era levels.

Roadmap

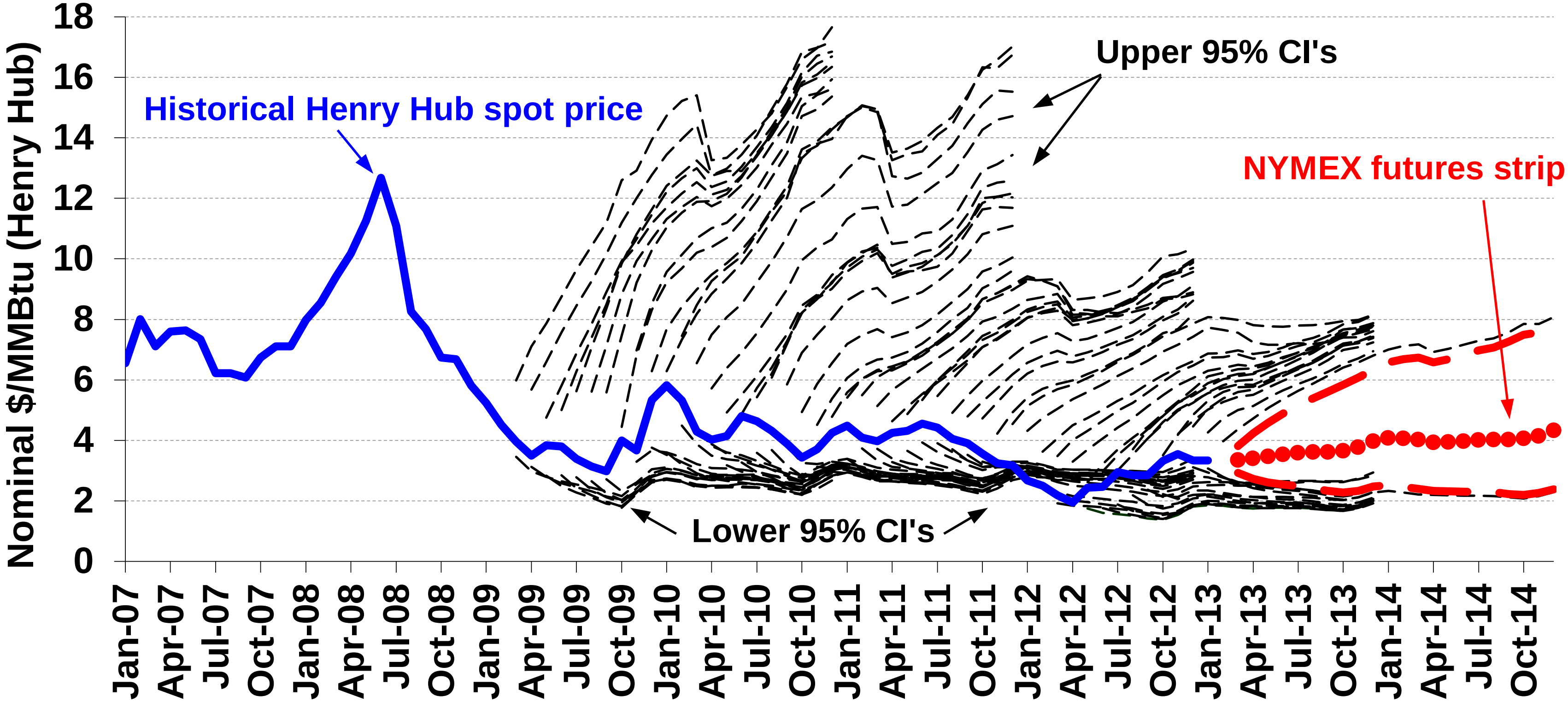
I. Overview and Analysis of the LBNL Wind PPA Sample

II. Natural Gas Prices: Low By Historical Standards, But Difficult to Lock In Over Longer Terms

III. Comparison of Wind PPA Prices to Natural Gas Price Projections

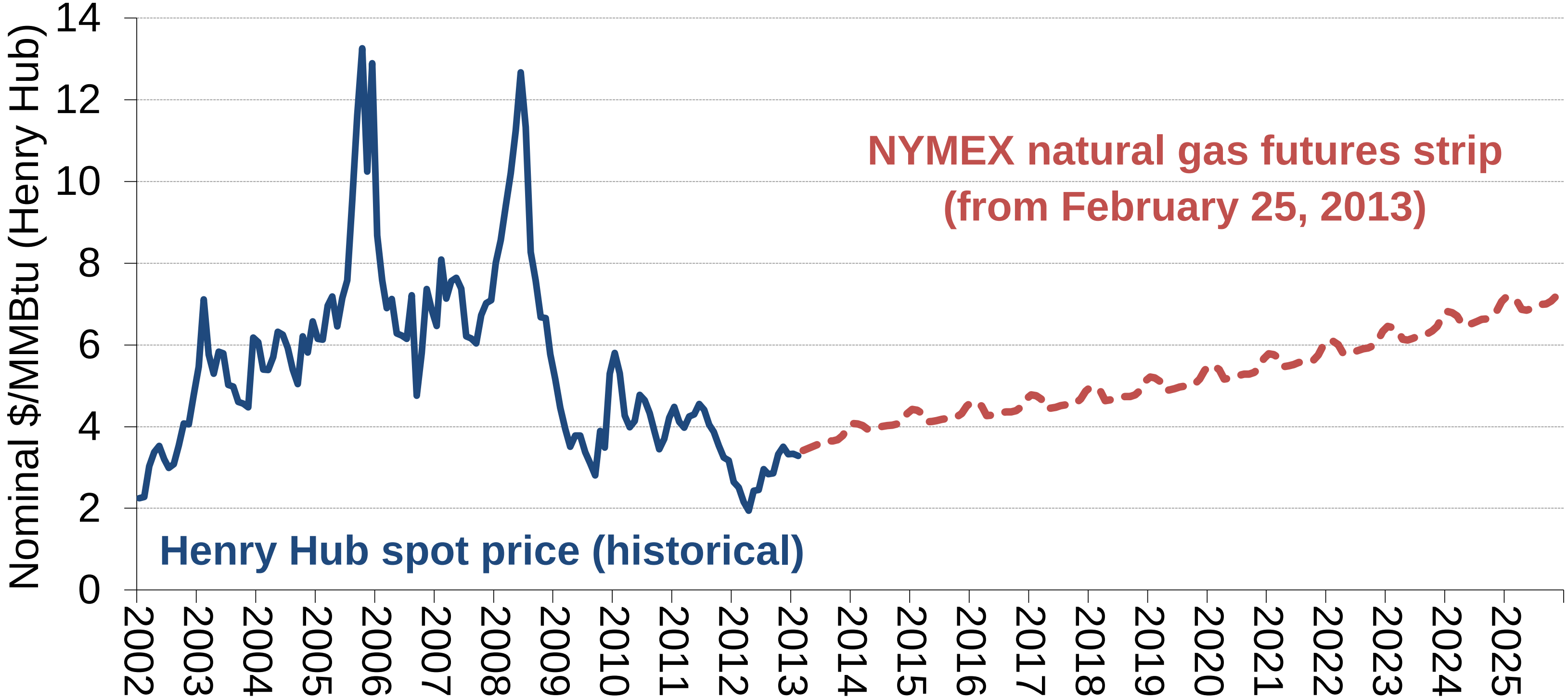
IV. In Their Own Words: Wind Buyers on Wind's Long-Term Hedge Value

Gas Prices Cannot Go Much Lower ($0 Floor) – Risk is Skewed Towards Higher Prices



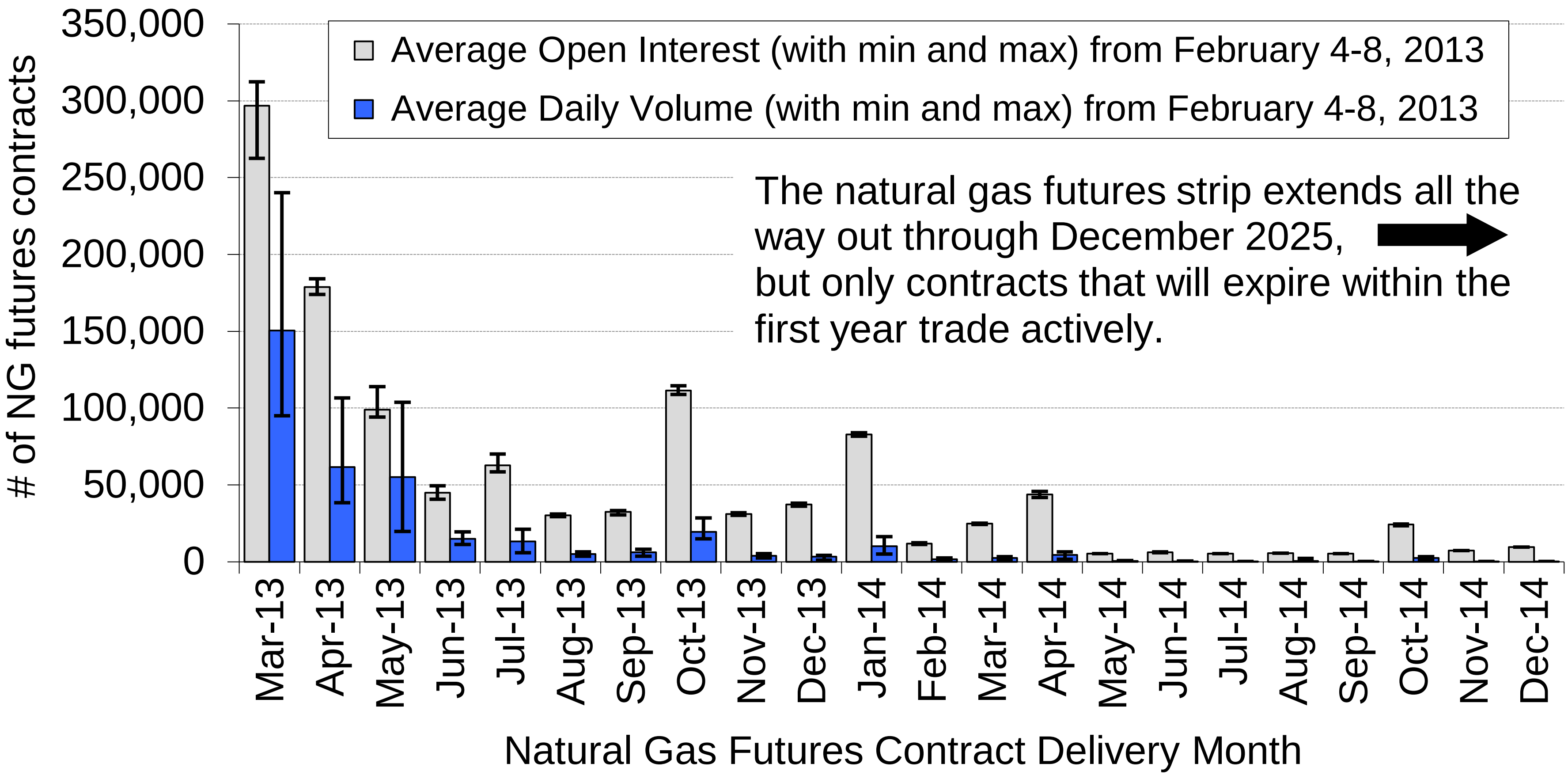
- Dashed lines represent 95% confidence intervals around the futures strip (as derived from the price of options on gas futures) at monthly intervals
- The options market considers the risk that future spot prices will diverge from current futures prices to be skewed upward (but the *degree* of skew has shrunk)

But It's Hard To Lock In Today's Low Prices, Because the Futures Curve is Upward Sloped…



- Because the futures strip is upwards sloping (implying higher expected spot prices in the future), it is difficult to lock in today's low spot gas prices
- One could buy a series of "in the money" call options with strike prices below the futures strip, but the "intrinsic value" embedded in the options premium will negate the lower strike price, leaving you no better off than the futures strip

…And The Futures Market Is Illiquid After Just A Few Years



Trying to lock in any serious amount of volume via the futures strip may be problematic out beyond a year or two.

Physical Gas Supply Deals Are Possible, But…

1) **Are not very liquid and impose significant counterparty risk (more so than with an exchange, where this risk is spread)**
2) **Generally do not exceed 10 years**
3) **Provide similar pricing to the futures strip (upward slope)**

Example: In Dec. 2010, the CO PUC approved a 10-yr, fixed-price (with escalation) physical gas contract between PSCo and Anadarko

- Afterwards, PSCo said: "The limitations on these types of long-term contracts include negotiating the ***additional collateral requirements triggered by the inherent increase in counter-party risk*** (created by fixing a gas price over an extended contract term) and by the market's appetite for these types of transactions being ***limited to generally a 10-year time horizon***." *[Page 3 of "Report of Public Service Company of Colorado Regarding Long-Term Gas Supply Options" filed December 29, 2011]*
- PSCo/Anadarko contract pricing largely mirrors the basis-adjusted NYMEX futures strip at that time

Takeaways from Part II

Gas prices are near historic lows and price risk is skewed upward – making this a great time to hedge.

But easier said than done:

- Today's low prices ***cannot*** be easily locked in (or at least not without cost) going forward, because the futures strip is upward-sloping
- Even the upward-sloping futures strip is hard to lock in long-term (for significant volume), because trading is illiquid beyond the first few years
- Physical gas deals are rare, mostly short- or mid-term (10 years max), and follow futures pricing (also upward-sloping)
- Regulators are scrutinizing utility gas hedging programs more closely

<u>Key Takeaway</u>: Despite low gas prices (and low gas price expectations), thinking of wind as a long-term fuel price hedge is as appropriate now as it has ever been (and perhaps even more so given skewed risk).

Roadmap

I. Overview and Analysis of the LBNL Wind PPA Sample

II. Natural Gas Prices: Low By Historical Standards, But Difficult to Lock In Over Longer Terms

III. Comparison of Wind PPA Prices to Natural Gas Price Projections

IV. In Their Own Words: Wind Buyers on Wind's Long-Term Hedge Value

<u>Simplifying Assumption</u>: Wind Offsets Only the Fuel Costs of Gas-Fired Generation

Considers wind a source of energy (a "fuel saver"), *not* capacity:

- Eliminates the need to estimate wind's capacity contribution/value
- Seems to be how at least some utilities (e.g., PSCo) think of wind

Ignores wind integration and transmission costs:

- Integration costs are generally low and area-specific – and may not even be readily quantifiable (a growing recognition among analysts)
- Transmission costs can be significant, but are project-specific and may not be borne by the wind buyer or seller, depending on cost allocation

But also ignores some wind benefits:

- Capacity contribution/value and pollution/carbon benefits of wind
- Wind also offsets gas-fired generation's *non-fuel* variable O&M costs

<u>Bottom Line</u>: This is not intended to be a full-blown social analysis – the comparison is simply ***wind PPA prices vs. projected natural gas fuel costs***, in order to focus on hedge value

Overview of Data Needed For Comparison

1. Wind PPA Prices

The LBNL PPA sample that was described and analyzed in Part I

2. Projected Natural Gas Fuel Costs

A range of 20 different fuel price projections, all from the EIA:

- **3 reference case projections: AEO 2011, 2012, and 2013 (early release)**
- **5 shale gas scenarios from AEO 2011 and AEO 2012**
  - High/low “estimated ultimate recovery” (“EUR”) per well from AEO11 & AEO12
  - High “technically recoverable resource” (“TRR”) case from AEO12
- **12 gas export scenarios from Part 1 of DOE LNG export study (using AEO11 model)**
  - 4 scenarios consider both the level of exports and the time to reach that level (low/slow, low/rapid, high/slow, high/rapid)
  - These 4 export scenarios are layered on 3 different base scenarios (reference, low EUR, high EUR)

Characterization of Recent EIA Natural Gas Scenarios

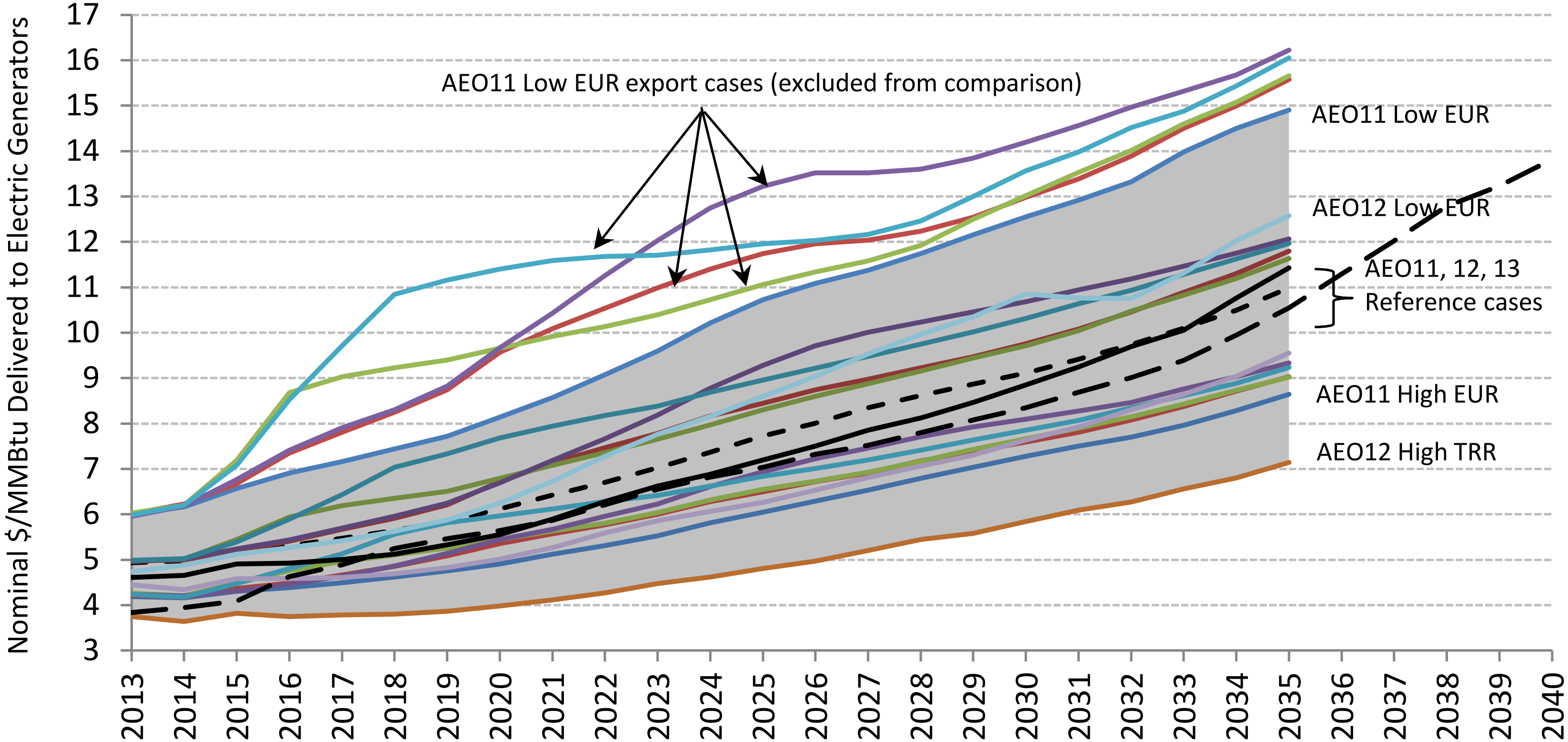
NEMS Modeling Platform	Scenario Name	EUR per shale well (% diff from reference)	Unproved Shale TRR (Tcf)	LNG Export Volume (Bcf/day)	LNG Export Phase-In (Bcf/day/year)
AEO 2013	Reference (early release)	N/A	543	N/A	N/A
AEO 2012	Reference	N/A	482	N/A	N/A
AEO 2012	High EUR	+50%	723	N/A	N/A
AEO 2012	Low EUR	-50%	241	N/A	N/A
AEO 2012	High TRR[A]	+50%	1,091	N/A	N/A
AEO 2011	Reference	N/A	827	N/A	N/A
AEO 2011	Reference, Low/Slow Export	0%	827	6	1
AEO 2011	Reference, Low/Rapid Export	0%	827	6	3
AEO 2011	Reference, High/Slow Export	0%	827	12	1
AEO 2011	Reference, High/Rapid Export	0%	827	12	3
AEO 2011	High EUR	+50%	1,230	N/A	N/A
AEO 2011	High EUR, Low/Slow Export	+50%	1,230	6	1
AEO 2011	High EUR, Low/Rapid Export	+50%	1,230	6	3
AEO 2011	High EUR, High/Slow Export	+50%	1,230	12	1
AEO 2011	High EUR, High/Rapid Export	+50%	1,230	12	3
AEO 2011	Low EUR	-50%	423	N/A	N/A
AEO 2011	Low EUR, Low/Slow Export	-50%	423	6	1
AEO 2011	Low EUR, Low/Rapid Export	-50%	423	6	3
AEO 2011	Low EUR, High/Slow Export	-50%	423	12	1
AEO 2011	Low EUR, High/Rapid Export	-50%	423	12	3

[A]The High TRR case assumes tighter well spacing than the other AEO12 scenarios, which is why the unproved TRR increases even though the EUR per well remains 50% above the reference case.

Source: EIA 2012a, EIA 2012b, EIA 2012c, EIA 2011

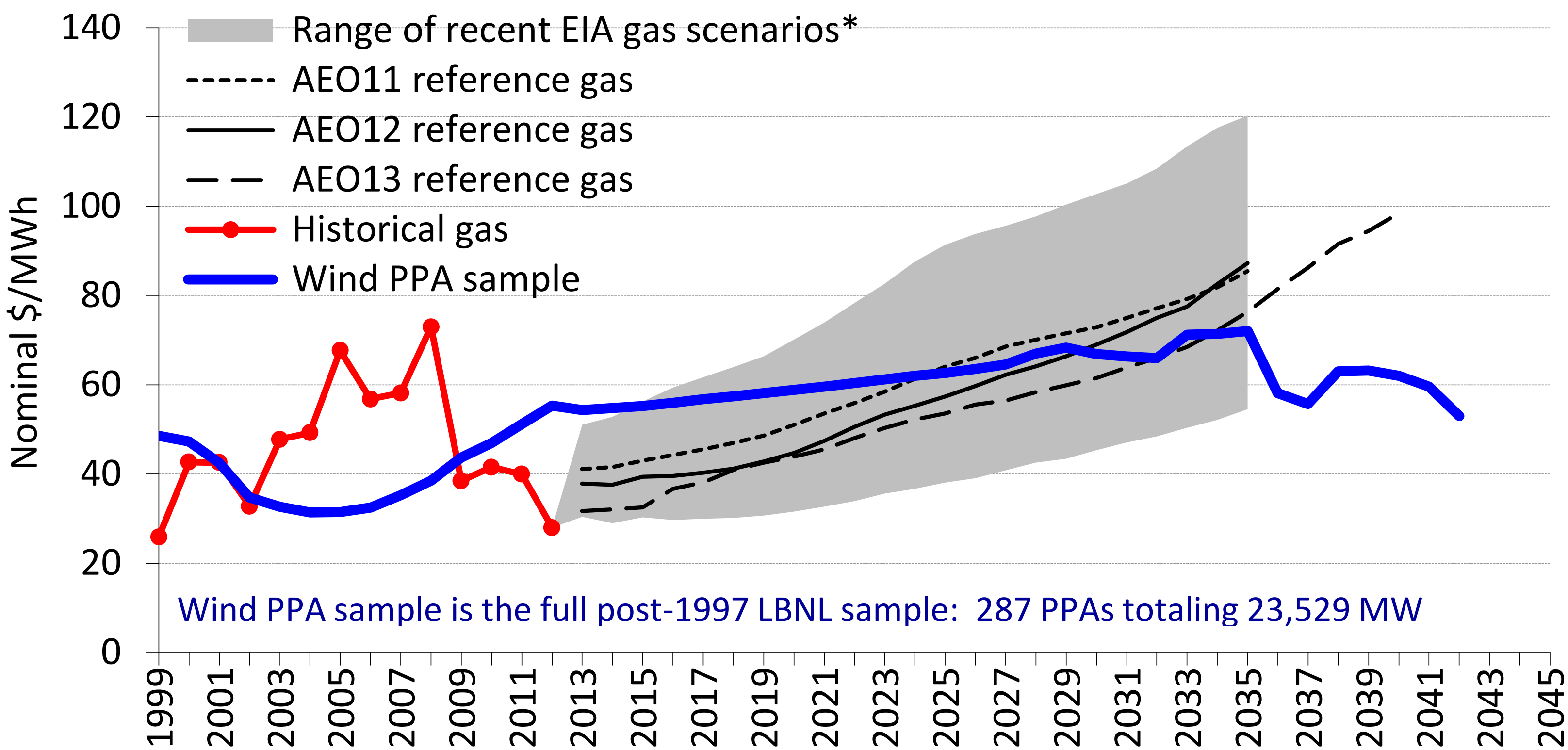
- Later, Part 2 of DOE's LNG export study found that under Low EUR conditions, domestic gas prices are too high to justify LNG exports (there is no world demand at such price levels)
- As a result, the four Low EUR export scenarios are excluded from further consideration in the analysis that follows

Projected Natural Gas Fuel Costs



- To reduce visual clutter, future slides will show only the ***range*** of fuel cost projections (rather than each individual projection), as denoted here by the gray-shaded area (the “cone of uncertainty”)
- In addition, fuel cost projections will be translated from $/MMBtu into $/MWh terms using average heat rates implied in the EIA/NEMS modeling output

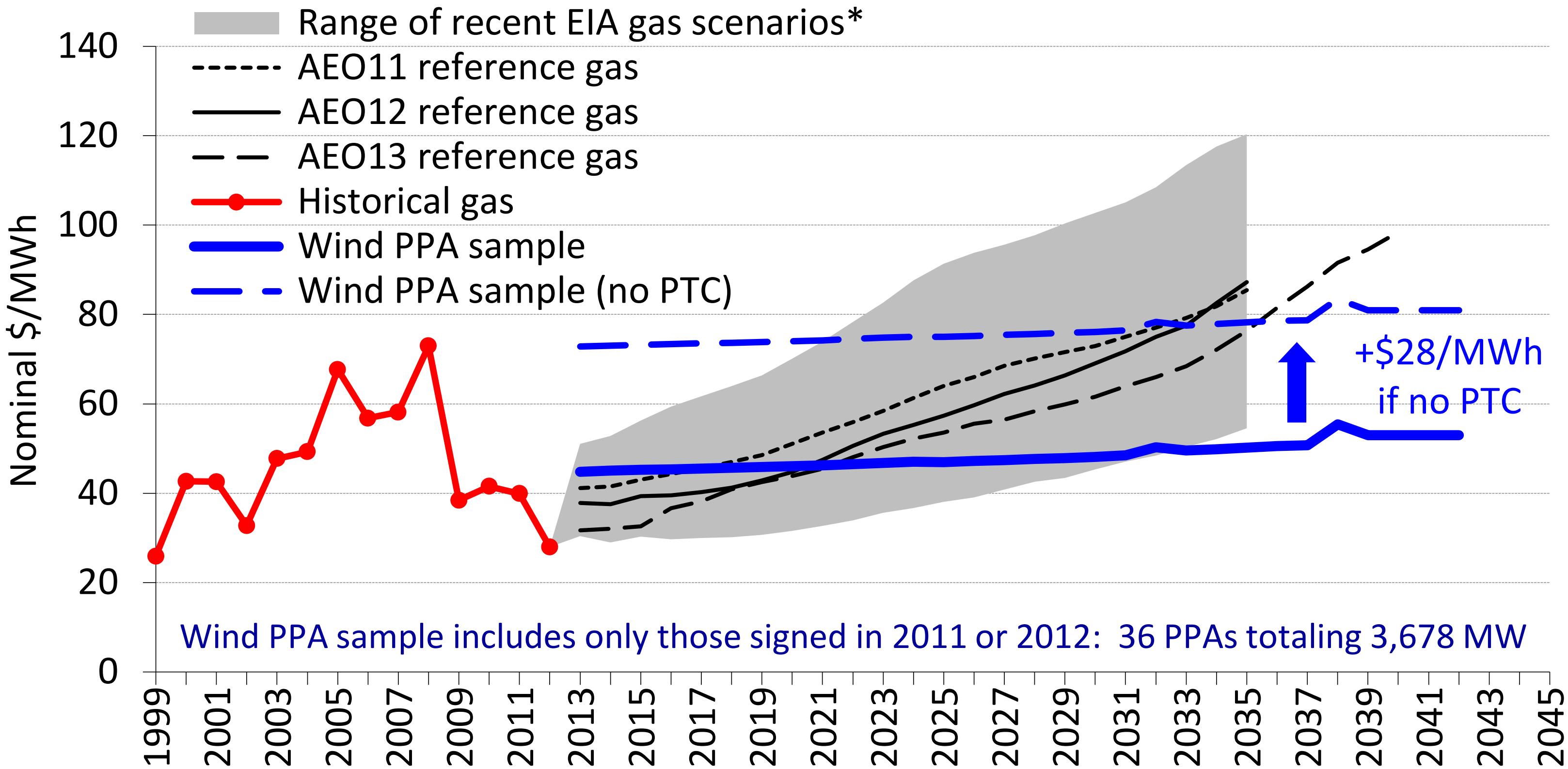
Full-Sample US Wind/Gas Comparison Demonstrates Long-Term Hedge Value



Fuel cost projections are translated from $/MMBtu into $/MWh terms using average heat rates implied in the NEMS modeling output

- Average wind PPA price exceeds reference case gas projections until late-2020's
- ***BUT*** wind enters the "cone of uncertainty" much earlier, and after 2015 serves as an effective hedge against many of the higher-priced gas scenarios

Recent-Sample US Wind/Gas Comparison Shows Wind As More Competitive (with the PTC)



**Fuel cost projections are translated from $/MMBtu into $/MWh terms using average heat rates implied in the NEMS modeling output*

- Focusing only on the most recent contracts, wind (or at least this limited sample) is very competitive with natural gas price projections
- Without the PTC, wind as a "fuel saver" would be less compelling, even at today's low wind prices (though some long-term hedge value would remain)

Takeaways from Part III

- Even in this low gas price environment, wind can be a cost-effective near-term "fuel saver" – particularly among the most recent contracts in our sample – and provider of long-term hedge value.
- Without the PTC, wind would struggle to be a cost-effective "fuel saver" in the near-term, but would still provide long-term hedge value
- From a hedging perspective, long-term hedge value is arguably more important than short-term competitiveness:
  - Short-term gas price risk can already be effectively hedged using conventional hedging instruments (like futures and options)
  - But conventional hedging instruments come up short when trying to lock in prices over longer terms – ***wind holds a rather unique competitive advantage as a long-term fuel price hedge***

Roadmap

I. Overview and Analysis of the LBNL Wind PPA Sample

II. Natural Gas Prices: Low By Historical Standards, But Difficult to Lock In Over Longer Terms

III. Comparison of Wind PPA Prices to Natural Gas Price Projections

IV. In Their Own Words: Wind Buyers on Wind's Long-Term Hedge Value

Wind Buyers In Their Own Words: PSCo on Wind's Long-Term Hedge Value

- "The wind generation is a source of fuel or energy, it's not a source of capacity…When we look at dispatching on the wind, or dispatching on gas, it doesn't matter. It's providing the energy. That's what this [Limon II wind contract] is really a play on, a play on energy."
- "Whenever wind energy is generated from the Limon II [wind] facility, it will displace fossil-fueled energy on the Public Service system, mostly energy generated from natural gas. We think of this wind contract as an alternative fuel, with known contract pricing over 25 years that will displace fuels where the pricing is not yet known. That is the essence of the fuel hedge."
- "We typically don't have a lot of long-term natural gas contracts…especially ones that go out 25 years. So this [the Limon II wind contract] is basically providing a long-term fuel contract or energy contract at known prices."

[Remarks of Kurtis Haeger (Managing Director of Wholesale Planning, PSCo) during Limon II proceeding before the Colorado Public Utilities Commission]

Wind Buyers In Their Own Words: Google on Wind's Long-Term Hedge Value

- "We see value in getting a long-term embedded hedge. We want to lock in the current electricity price for 20 years. We are making capital investment decisions [regarding data centers] on the order of 15 to 20 years. We would like to lock in our costs over the same period. Electricity is our number one operating expense after head count."
- "We are signing [conventional] contracts with three to five years of fixed pricing, but over the life of the data center, those will reset. We are short-term fixed and long-term floating, so it [wind] will not be a perfect hedge in the near term. We are less concerned about hedging our cash flows on a quarter by quarter basis. We are more concerned about the long term."
- "We are losing considerable amounts of money on every [wind] MWh [in the near term]. We just want to ensure the project is there in the later years."

[Remarks of Ken Davies (Google) as recorded in "Battle Over Power Contracts", Project Finance Newswire, November 2011, pp. 57-58]

Thank You!

Mark Bolinger
Lawrence Berkeley National Laboratory
MABolinger@lbl.gov

March 2013

The work described in this presentation was funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (Wind & Water Power Program) under Contract No. DE-AC02-05CH11231

Appendix: Conversion Methods (the fine print)

- Where generation-weighted average prices are presented, the weighting is based on historical capacity factors when available; weightings for recent projects with an insufficient operational track record are based on specified contract quantities or published production estimates
- Where prices are presented by vintage, the PPA execution date is used rather than the commercial operation date, because the former is a better indicator of when pricing was actually locked in
- Nominal prices are converted to real 2012 dollars using the GDP deflator
  - Historical prices (through 2012) use the actual published deflator
  - Future prices (2013-2040) use AEO 2013’s GDP deflator projection
  - Future prices beyond 2040 use an assumption of 2%/year inflation
- Where levelized PPA prices are presented, they are levelized over the full contract term (which varies by contract), using a 7% real discount rate