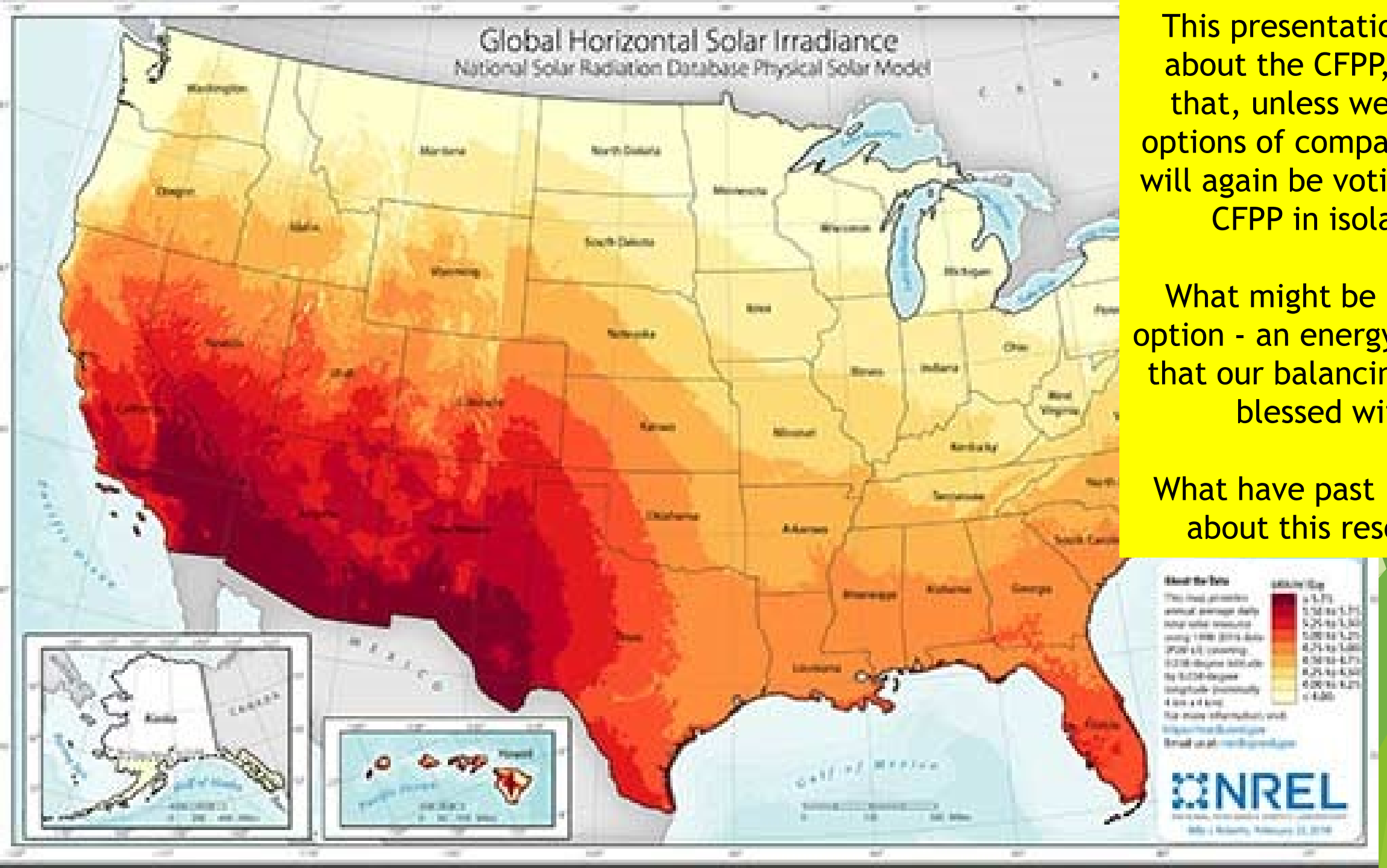
Discussion of Advancing to a Request for Proposal for Solar + Storage

Steve Tobin

- If we keep voting in isolation on power generation contracts – we have only ourselves to credit/blame
  - Who among us makes a “big purchase” …buys a house or a car … without comparing among options?
  - My goal is to make our power purchasing choices more competitive?



This presentation is not about the CFPP, except that, unless we create options of comparison, we will again be voting on the CFPP in isolation

What might be another option - an energy resource that our balancing area is blessed with?

What have past IRPs said about this resource?

- Quote from the Executive Summary of the 2017 IRP, "*The most balanced portfolio that meets renewable goals and carbon reduction targets is a portfolio that relies heavily on solar and storage (based on current indicative bids).*"
  - Since 2017, the price of utility scale solar has fallen ~1/3 [Lazard]
  - Since 2017, the price of utility scale storage has fallen ~1/2 [NREL]
  - Statistically robust polling of LAC residents indicated ~2/3 support for BPU's Net Carbon Neutron Goal [BPU funded survey]

- From my perspective, it is inconceivable that the 2022 IRP will not include a similar recommendation. There is no reason to wait for it.

Xcel Energy data published by Vox, "In Colorado, a glimpse of renewable energy's insanely cheap future," Jan. 16, 2018. Online

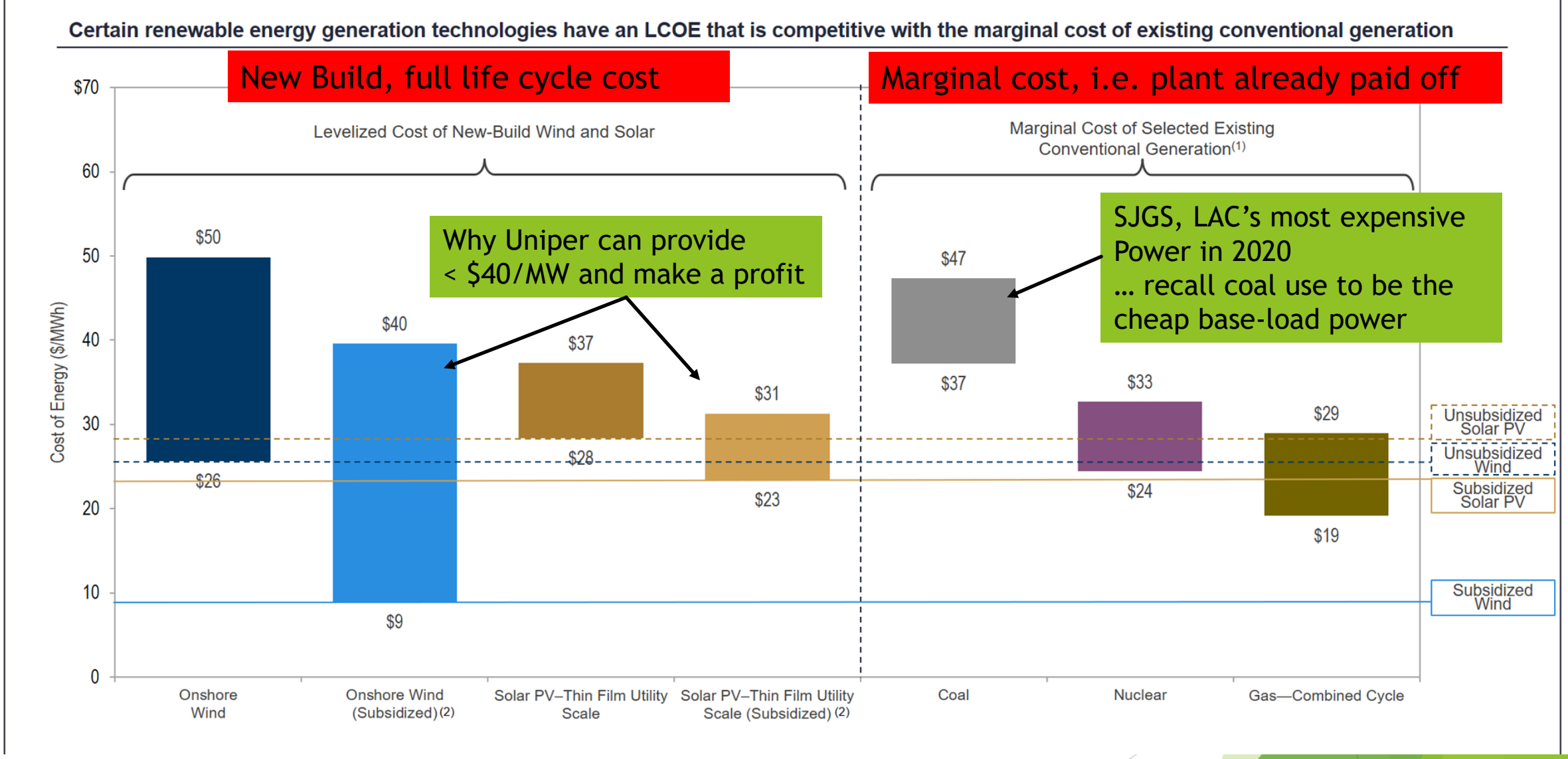
RFP Responses by Technology

Generation Technology	# of Bids	Bid MW	# of Projects	Project MW	Median Bid Price or Equivalent	Pricing Units
Combustion Turbine/IC Engines	30	7,141	13	2,466	$ 4.80	$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.20	$/kW-mo
Gas-Fired Combined Cycles	2	451	2	451		$/kW-mo
Stand-alone Battery Storage	28	2,143	21	1,614	11.30	$/kW-mo
Compressed Air Energy Storage	1	317	1	317		$/kW-mo
Wind	96	42,278	42	17,380	$ 18.10	$/MWh
Wind and Solar	5	2,612	4	2,162	19.90	$/MWh
Wind with Battery Storage	11	5,700	8	5,097	21.00	$/MWh
Solar (PV)	152	29,710	75	13,435	29.50	$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.60	$/MWh
Solar (PV) with Battery Storage	87	16,725	59	10,813	36.00	$/MWh
IC Engine with Solar	1	5	1	5		$/MWh
Waste Heat	2	21	1	11		$/MWh
Biomass	1	9	1	9		$/MWh
Total	430	111,963	238	58,283		

Main point – the low prices are (a) real, (b) local and (c) enduring

The price of electricity in LAC (power, transmission, distribution, etc.) is $115/MWh with our average wholesale power costing between 50/MWh and 60/MWh.

Levelized Cost of Energy Comparison—Renewable Energy versus Marginal Cost of Selected Existing Conventional Generation



Some of the details used in this analysis are listed on the next page

Lazard 2021 Data
LCOE Version 15.0

Assumptions with the previous page

- Note (1) of previous page:
  - Fully depreciated coal, gas and nuclear, inclusive of decommissioning cost for nuclear
  - Salvage value = decommissioning costs for gas and coal … hmm? SJGS exit?
  - Capacity factors, fuel, variable and fixed operating expenses are based on upper and lower quartiles estimates derived from Lazard's research.
- Note (2) of previous page: the subsidized analysis includes sensitivities related to the Tax Cut and Job Act and U.S. federal tax subsidies.
- General assumption of analysis:
  - Financing: 60% debt, 8% interest rate, 40% equity at 12% cost. Sensitivity to these assumptions addressed elsewhere in their research
  - For solar, low cost case is a single axis tracking system and high case represents a fixed axis system
  - $3.45/MMBTU gas cost assumed
  - Inputs are derived from a benchmark of operating gas combined cycle, coal and nuclear assets across the U.S.

Cost Estimate for Solar and Solar Plus Storage

- I give highlights on this page and then – very briefly - point out a few salient points in the next 5 slides from a publication by NREL: "U.S. Solar Photovotaic System and Energy Storage Cost Benchmarks: Q1 2021" – just google it
  - Utility Scale Solar only: $41/MWh
  - Sticker price for 100 MW solar, 60 MW battery storing 240 MWh
    - Total cost: $167 million
    - This system is double or triple what we want
  - "Real LCOE" = $77/MWh
  - Some of the input factors:
    - No investment tax credit,
    - No state or local subsidies,
    - Profits included in the cost of hardware

Table 11. LCOE (Stand-Alone PV) Input Assumptions and Outputs (2020 USD)

	Residential		Commercial Rooftop		One-Axis Tracker	
	2020	**2021**	**2020**	**2021**	**2020**	**2021**
Installed cost ($/W)	2.74	2.65	1.74	1.56	1.02	0.89
Annual degradation (%)	0.70	1.00	0.70	0.70	0.70	0.70
Levelized O&M expenses over life of asset ($/kW-yr)	29	29	19	18	18	16
Preinverter derate (%)	90.5	85.9	90.5	85.9	90.5	85.9
Inverter efficiency (%)	98.0	96.0	98.0	96.0	98.0	96.0
Inverter loading ratio	1.15	1.15	1.15	1.15	1.34	1.28
Inflation rate (%)	2.5	2.5	2.5	2.5	2.5	2.5
Equity discount rate (real) (%)	6.1	10.2	6.1	6.1	5.1	5.1
Debt interest rate (%)	5.0	4.5	5.0	5.0	5.0	5.0
Debt fraction (%)	71.8	100	71.8	71.8	71.8	71.8
Debt term (years)	18	25	18	18	18	18
Entity	Corporation	Homeowner	Corporation	Corporation	Corporation	Corporation
Analysis period (years)	30	25	30	30	30	30
Initial energy yield (kWh/kW_{DC})	1,546	1,445	1,440	1397	1,721	1,694
Real LCOE (2020 US$)	**13.0¢/kWh**	**11.9¢/kWh**	**9.1¢/kWh**	**8.3¢/kWh**	**4.6¢/kWh**	**4.1¢/kWh**

Other key assumptions:

(1) Corporation has a federal corporate tax rate of 21% and state corporate tax rate of 6%, and uses the Modified Accelerated Cost Recovery System depreciation schedule.
(2) Homeowner uses a mortgage loan that is interest deductible, with a federal personal tax rate of 15% and a personal state tax rate of 6%.
(3) No state or local subsidies
(4) For corporations:

- a working capital and debt service reserve account for six months of operating costs and debt payments (earning an interest rate of 1.75%)
- a six-month construction loan, with an interest rate of 4% and a fee of 1% of the cost of the system
- $1.1 million of upfront financial transaction costs for a $100 million third-party ownership transaction of a pool of commercial projects

(5) 2020 capacity factors are based on Kansas City, Missouri, with a tilt/azimuth of 25/180 (residential), 10/180 (commercial rooftop), and tracking/180 (utility-scale). 2021 capacity factors are based on Fredonia, Kansas (which is near the geographic center of the 48 conterminous states and corresponds with the area-weighted capacity factor of the 48 conterminous states as outlined in the 2021 Annual Technology Baseline), with a tilt/azimuth of 20/214 (residential) (Barbose et al. 2020), 10/190 (commercial rooftop) (Barbose et al. 2020), and tracking/180 (utility-scale).

Table 12. LCOE (PV-plus-storage) Input Assumptions and Outputs (2020 USD)

	Residential 22-panel PV plus 5-kW/12.5-kWh storage system[24]		**Commercial** 1-MW fixed-tilt ground-mounted PV plus 600-kW/2.4-MWh storage system		**Utility-scale** 100-MW one-axis tracker PV plus 60-MW (240-MWh) battery storage, AC-coupled	
	2020	**2021**	**2020**	**2021**	**2020**	**2021**
Installed cost ($)	$34,942	$30,450	$2,170,851	$1,970,000	$190 million	$167 million
Annual degradation (%)	0.70	1.00	0.70	0.70	0.70	0.70
Levelized O&M expenses over life of asset ($/kW-yr)	39	39	29	28	28	26
First follow-on investments (inverter, battery replacements) ($)	$865	$763	$80,439	$63,360	$8.0 million	$6.3 million
Second follow-on investments (inverter, battery replacements) ($)	$648	$572	$60,329	$47,520	$6.0 million	$4.8 million
Preinverter derate (%)	90.5	85.9	90.5	85.9	90.5	85.9
Inverter efficiency (%)	98.0	96.0	98.0	96.0	98.0	96.0
Inverter loading ratio	1.15	1.15	1.15	1.15	1.34	1.28
Inflation rate (%)	2.5	2.5	2.5	2.5	2.5	2.5
Equity discount rate (real) (%)	6.1	10.2	6.1	6.1	5.1	5.1

[24] The current version of our residential PV-plus-storage model assumes a battery size of 5 kW/12.5 kWh; the Q1 2020 benchmark models a battery size of 3 kW(6 kWh) (Feldman et al. 2021). To better distinguish the historical cost trends from the changes to our cost models, we calculate the Q1 2020 residential PV-plus-storage using a battery size of 5 kWh (12.5 kWh). For this reason, CAPEX (2020 USD 28,721) and LCOE (20.1 USD cents/kWh) differ from those reported in Table 12, adjusting for dollar year.

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	2020	**2021**	**2020**	**2021**	**2020**	**2021**
Debt interest rate (%)	5.0	4.5	5.0	5.0	5.0	5.0
Debt fraction (%)	71.8	100	71.8	71.8	71.8	71.8
Debt term (years)	18	25	18	18	18	18
Entity	Corporation	Homeowner	Corporation	Corporation	Corporation	Corporation
Analysis period (years)	30	25	30	30	30	30
Initial energy yield (kWh/kW_{DC})	**1,546**	**1,445**	**1,440**	**1397**	**1,721**	**1,694**
Real LCOE (2020 US$)	**23.3¢/kWh**	**20.5¢/kWh**	**12.1¢/kWh**	**11.4¢/kWh**	**8.8¢/kWh**	**7.7¢/kWh**

Other key assumptions:

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(6) Round-trip energy losses from PV/battery/grid: 10%; round-trip energy losses from grid/battery/grid (8%)
(7) Battery is charged solely by PV because of investment tax credit considerations.

Solar capacity factor is for Kansa City, Missouri

Figure 26 compares LCOE, by market segment, for the current and previous benchmark analyses. From 2020 to 2021, residential PV-plus-storage LCOE fell 13%,[25] and residential stand-alone-PV LCOE fell 9%; there were 7% and 13% reductions in levelized electricity costs for commercial and utility-scale PV-plus-storage systems. At the same time, LCOE of commercial and utility scale stand-alone PV systems fell by 9% and 12% respectively.The reduction in electricity costs were mostly due to changes in CAPEX and OPEX (operating expenditures), though residential PV LCOE and PV-plus-storage LCOE also fell due to changes in financial model assumptions.[26] The reductions were partially counterbalanced by a change in capacity factor assumptions that reduced system performance to better align with U.S. averages.[27]

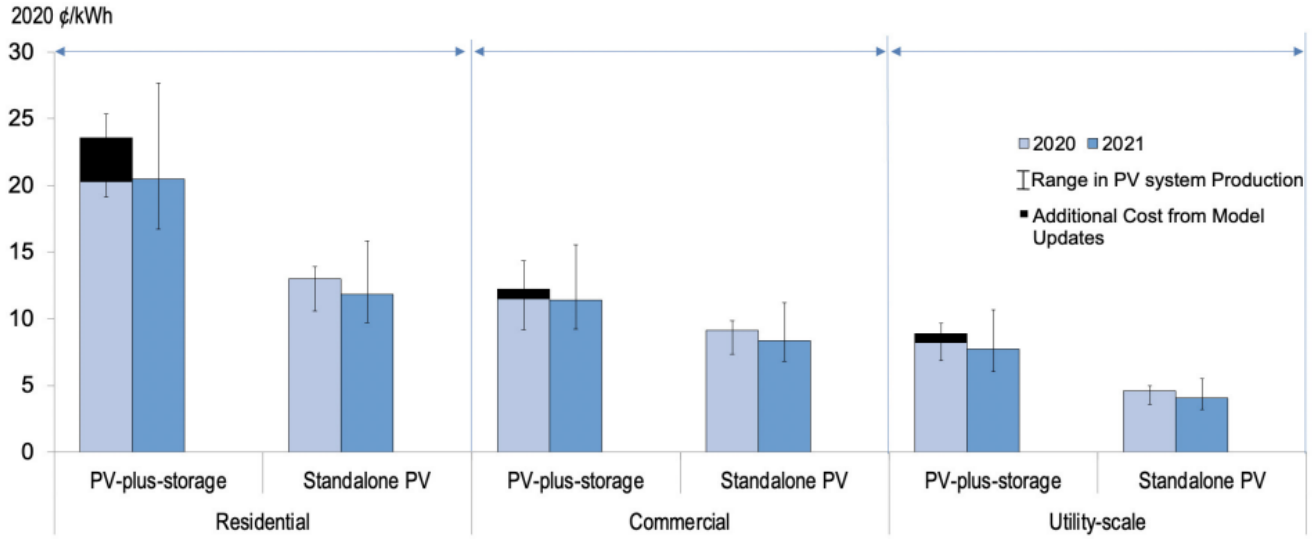


Figure 26. LCOE 2020–2021

2021 Range estimated by using Seattle Washington for the “high cost” location and the desert inland from Los Angeles for the “low cost” location

Recycling of Solar Panels [U.S. EPA]

- Glass composes most of the weight of a solar panel, ~75 percent, well-established industry process
- Remaining primary components by mass: aluminum frame, copper wire, and plastic junction box also have well-established industry process
- The more challenging part:
  - Silver, internal copper, lead, tin, tellurium, antimony, gallium and indium may be present in some panels – note the films containing these are generally in the 0.2 to 0.5 mm thickness so the mass is not that high – paper ~0.1 mm. [non-U.S. EPA reference] paper
  - These have been recycled but the recycling costs more than the material is worth – Europe has mandated recycling of these materials for this reason, U.S. has not
  - Note that there are very few panel ready to be recycled – some of the original Bell labs panels are still producing energy and the growth of solar has overwhelmingly been in the past 10 years.
    - A median degradation rate of about 0.5% per year but the rate could be higher in hotter climates and for rooftop systems. [NREL]
    - Modules are typically warrantied for 20–25 years, after which they can still produce electricity, but the level of actual output is no longer guaranteed. [NREL]

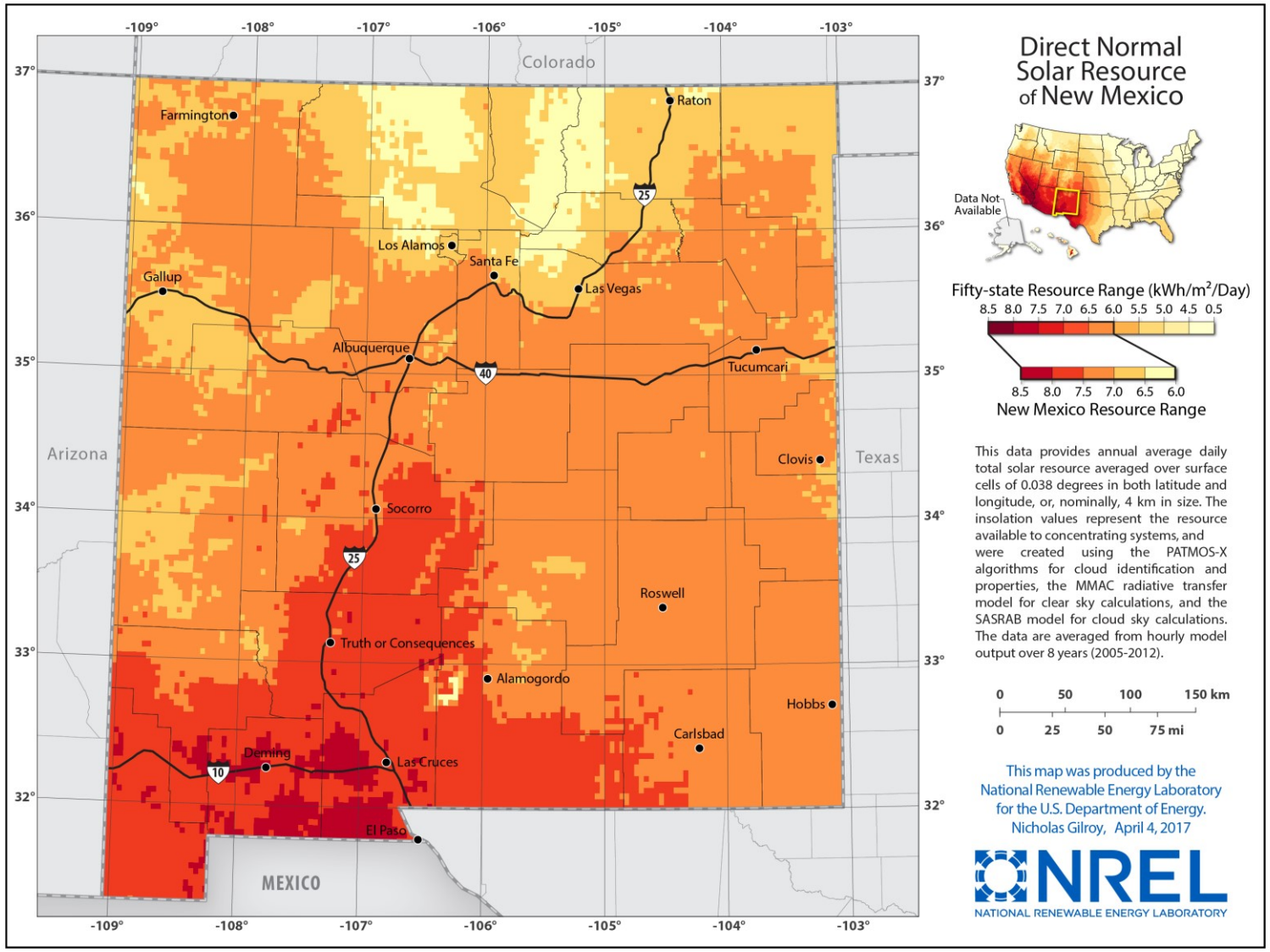
Summary

- We owe it to the residents of LAC to have a competitive energy selection process
- The 2017 IRP recommended Solar + Storage, both of which have experience large cost reductions since 2017, 33% and 50%, respectively
- The NREL study, using data based on deployed equipment, puts the cost of solar plus storage above our average rate, yet with yearly falling prices

Extra slides

Solar Data in NM

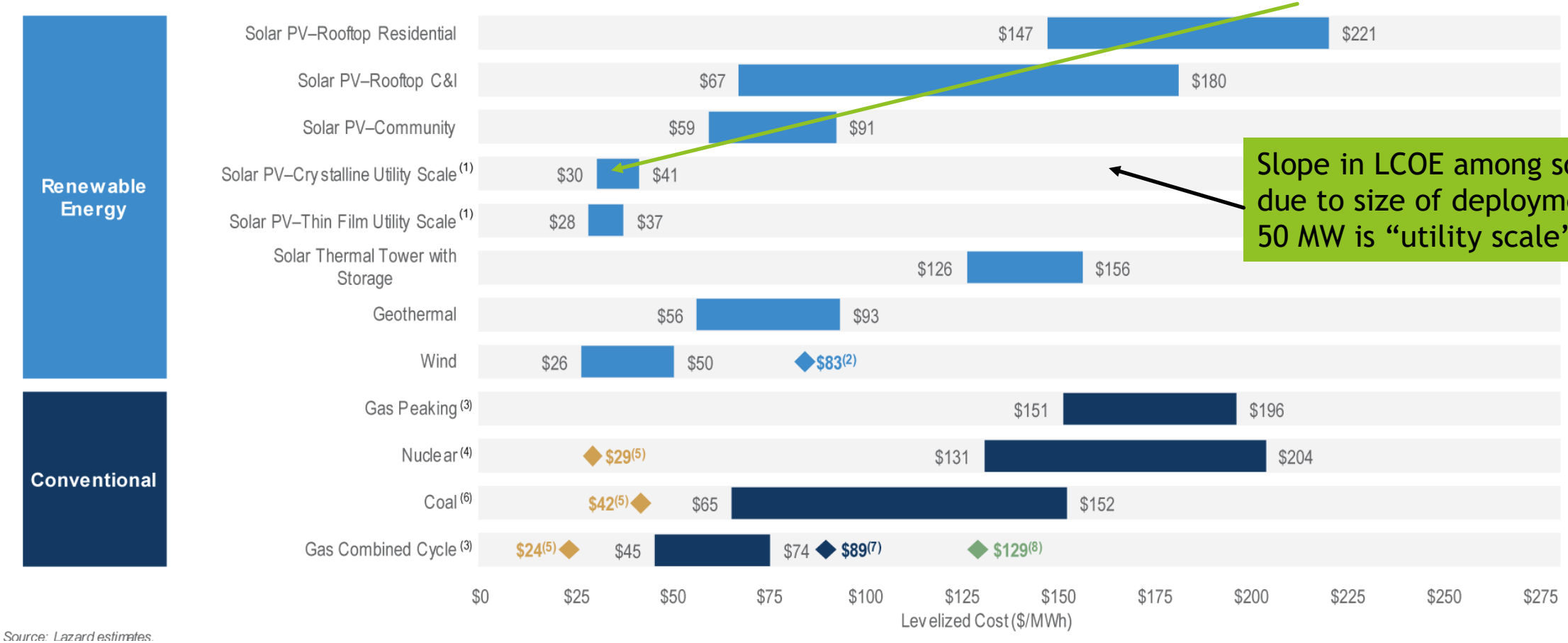
- What is optimal for LAC?
  - Southern NM is part of LAC's "balancing area"
  - Solar panel from LAC will generate ~20% more power near Las Cruces – and we pay the same transmission fee if we connect directly to PNM
  - The bigger economic issue is that solar farm need to be large for optimal economics
    - 50 MW average power requires ~1.4 miles by ~1.4 miles (10 W/m^2 by D. MacKay)
    - Note: less than 1% of state surface area needed to meet entire states electric power needs



Levelized Cost of Energy Comparison—Unsubsidized Analysis

Emphasis: UNSUBSIDIZED Prices

Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances



Slope in LCOE among solar due to size of deployment, 50 MW is “utility scale”

Source: Lazard estimates.

Lazard 2021 Data
LCOE Version 15.0