

LSE Plan Filing Requirements RESOLVE Modeling Results

June 15, 2022



California Public
Utilities Commission

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Purpose

- CPUC staff used the RESOLVE capacity expansion model to create resource portfolios for use in developing LSE filing templates for the 2022-23 IRP cycle
- These portfolios are based on the Preferred System Plan Portfolio and sensitivity portfolio adopted in Decision 22-02-004, with limited modeling updates
- LSEs should refer to the inputs and assumptions described in this presentation when developing their IRPs
 - For any inputs and assumptions not updated here, LSEs should refer to the inputs and assumptions used to create the 2021 Preferred System Plan
 - Please note that the resource baseline used in these filing requirement modeling runs is the same as the baseline used to create the 2021 Preferred System Plan
- LSEs may also refer to the resources selected in these portfolios as an informational guide and point of reference when developing their own IRPs

Summary of RESOLVE Model Updates since February PSP Decision Release

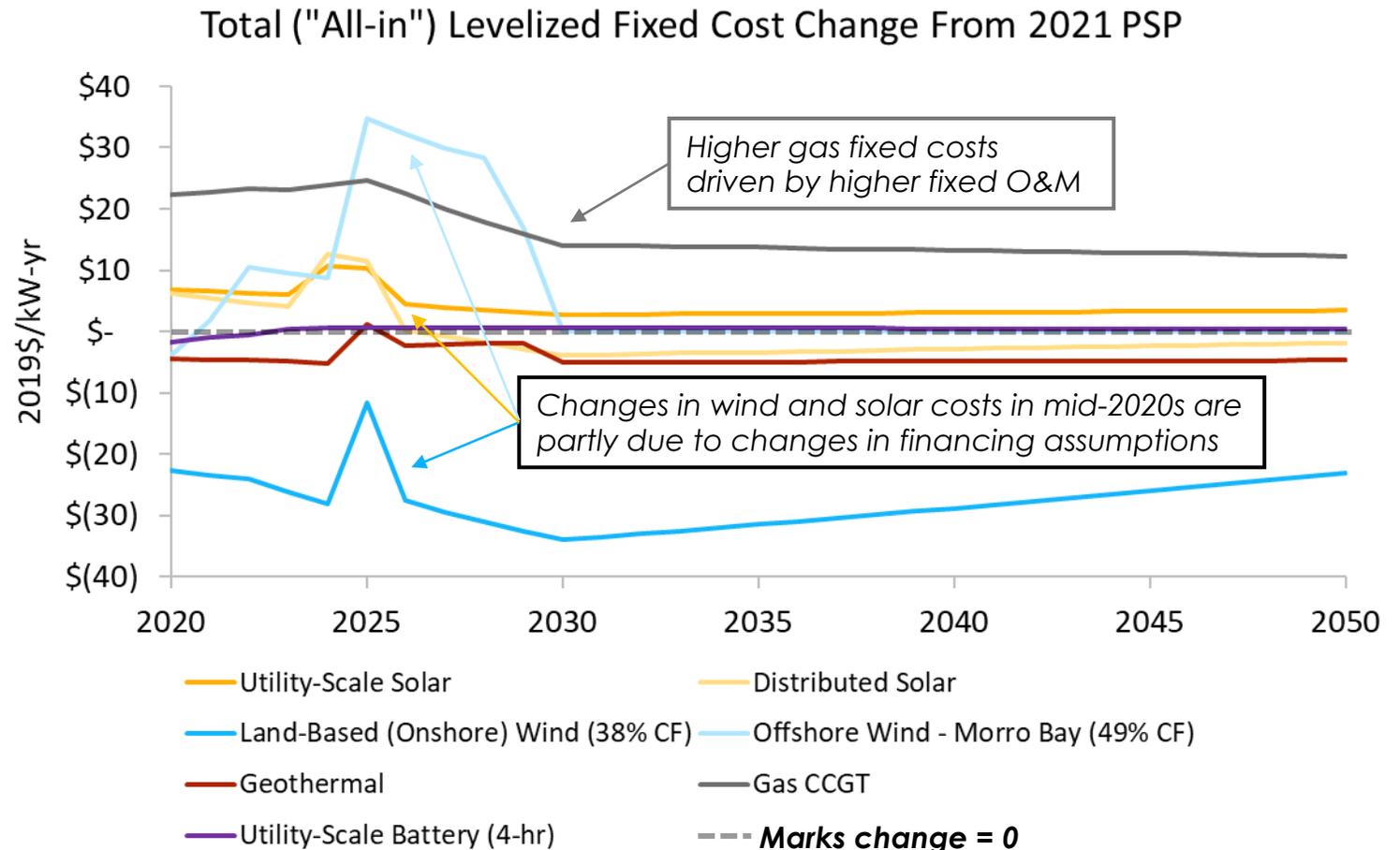
Update Category	Key Changes
Resource Costs and Potential	<ul style="list-style-type: none">Updated resource costs to NREL 2021 ATB and Lazard LCOS v7.0
Load Forecast	<ul style="list-style-type: none">Updated the load forecast to the CEC 2021 IEPR
Transmission Deliverability	<ul style="list-style-type: none">Updates to the transmission deliverability – resource mappings, existing transmission deliverability capacity, transmission upgrades using the updated 2021 CAISO transmission whitepaper and the draft results of the CAISO analysis of the 2021-2022 TPP

Resource Cost Comparison

LSE Filing Requirements vs. 2021 PSP

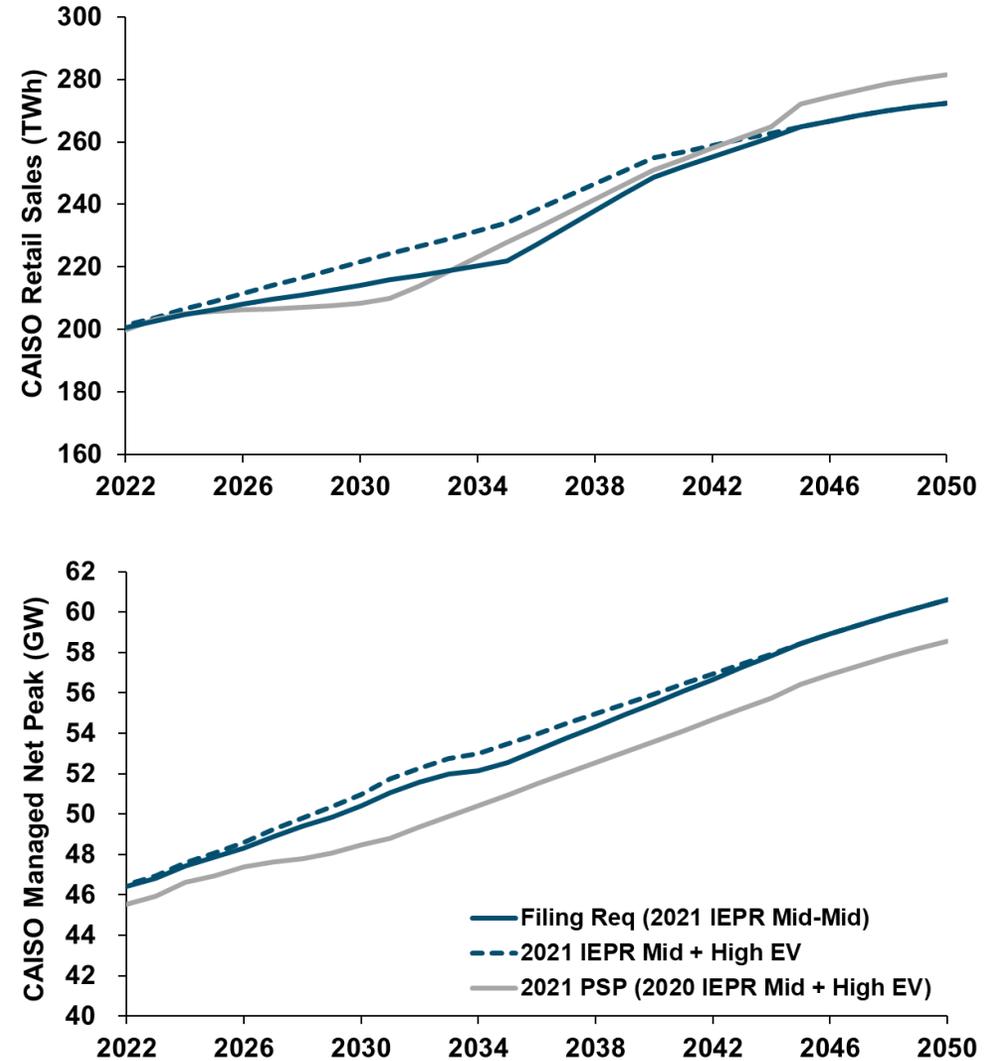
- Total levelized fixed costs are cost inputs into RESOLVE for candidate resources and impact resource build decisions
- Changes in total levelized fixed costs are within about \$20/kW-yr for most technologies
- More details available in Appendix

Note: The 38% capacity factor land-based (onshore) wind technology is representative of California wind resources in RESOLVE.



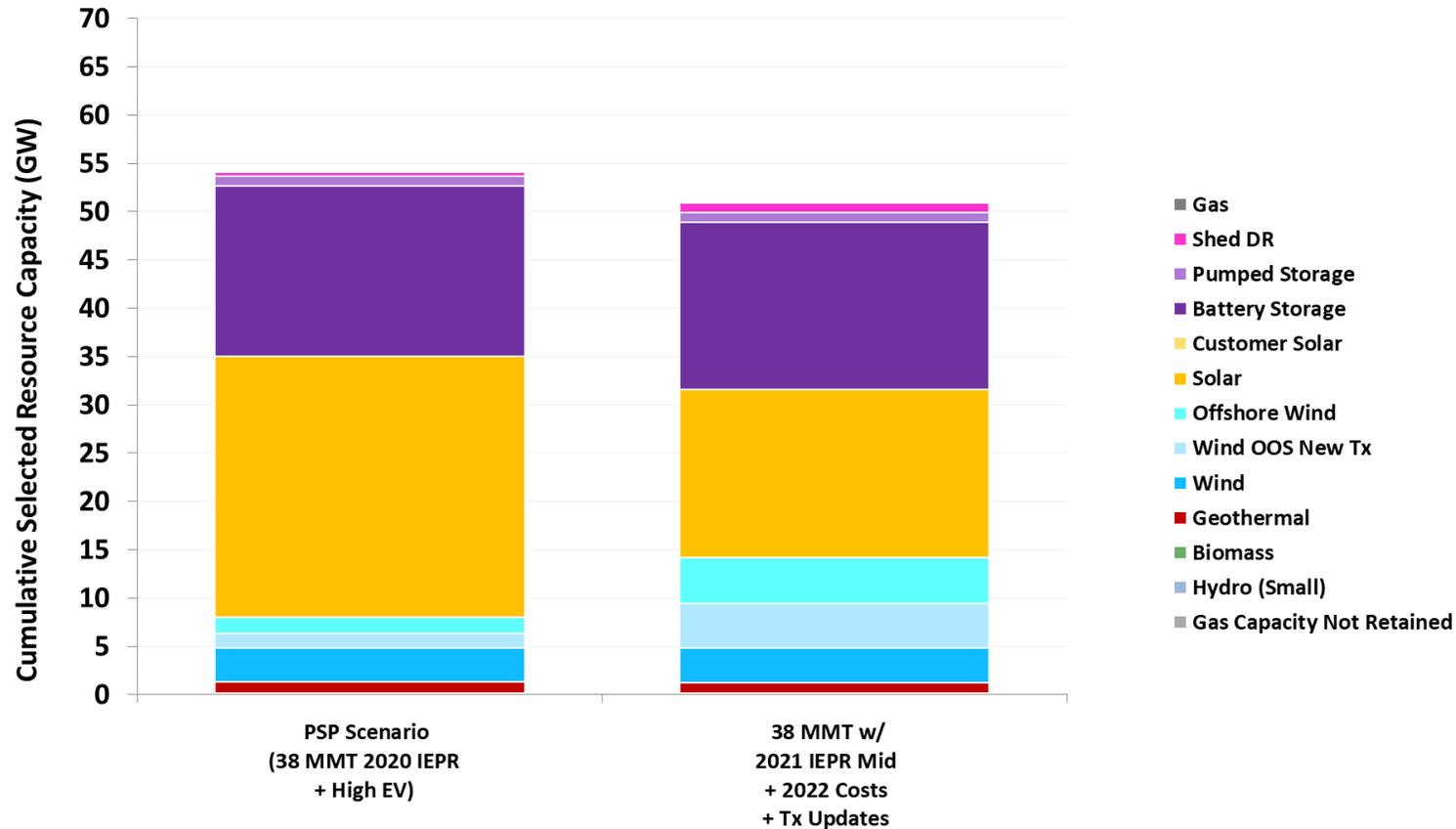
Comparison of IEPR Forecast Vintages

- By 2032 the 2021 IEPR vintages have both higher retail sales and higher managed peaks than the 2020 IEPR vintage
- By 2045 the 2021 IEPR vintages have lower retail sales value because the BTM PV forecast is higher than in the 2020 IEPR vintage
- In all the vintages, the 2045-2050 load components use the 2018 PATHWAYS High Biofuels scenario as the benchmark

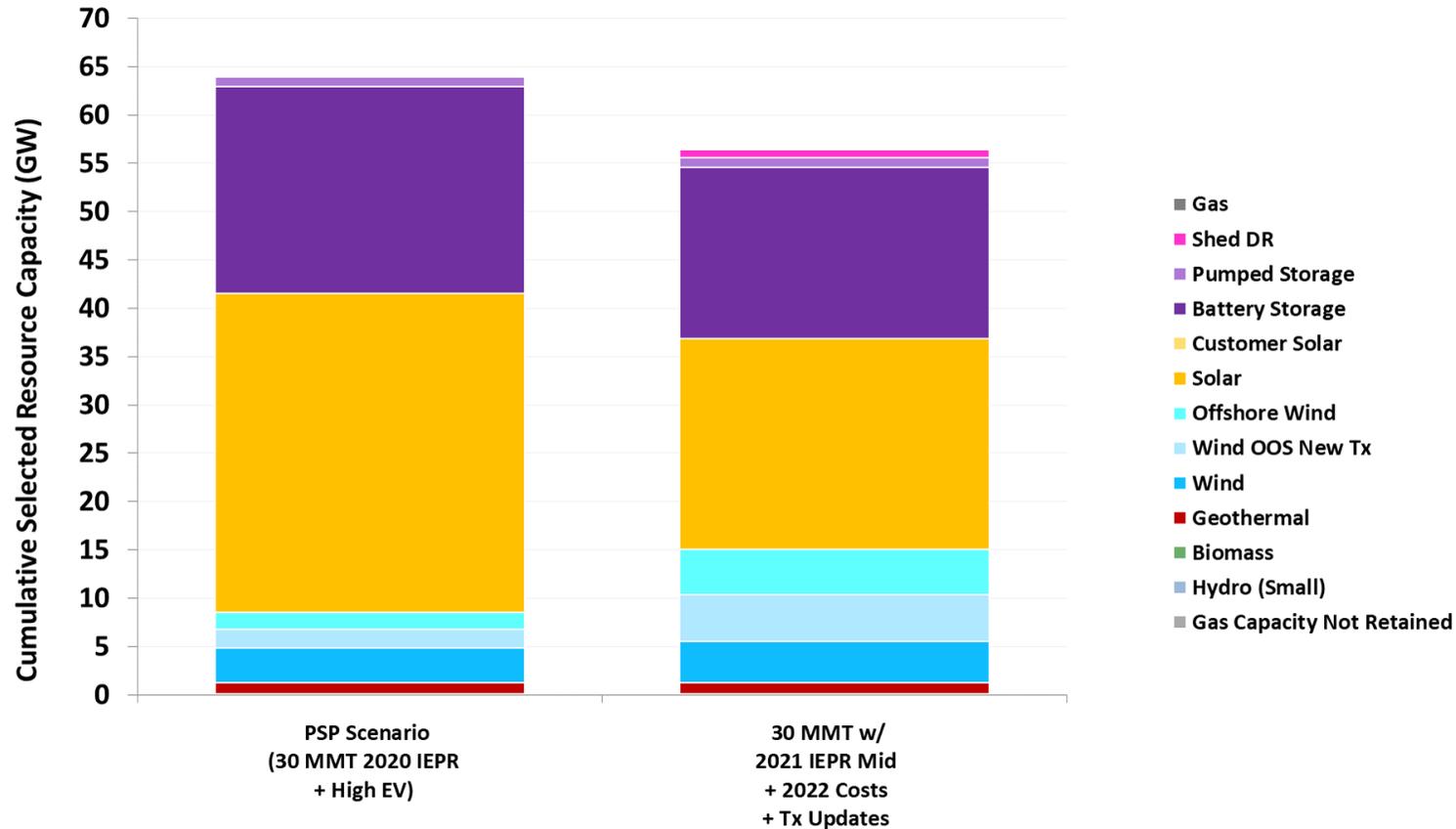


Scenario Results

Summary of 38 MMT Scenarios 2035 Snapshot Year



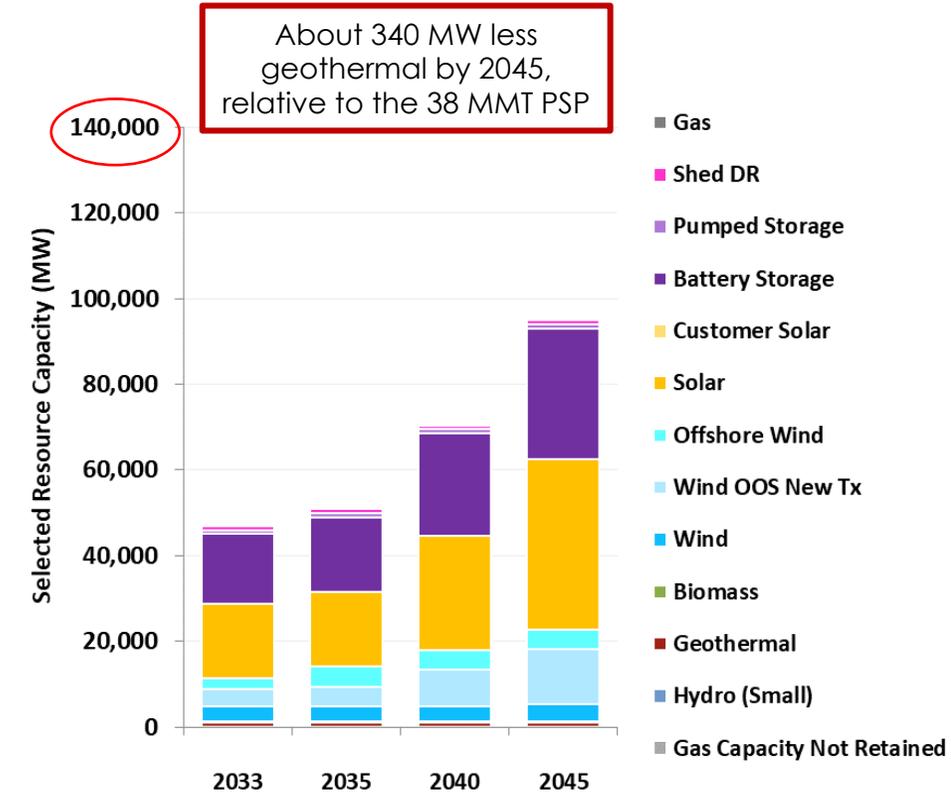
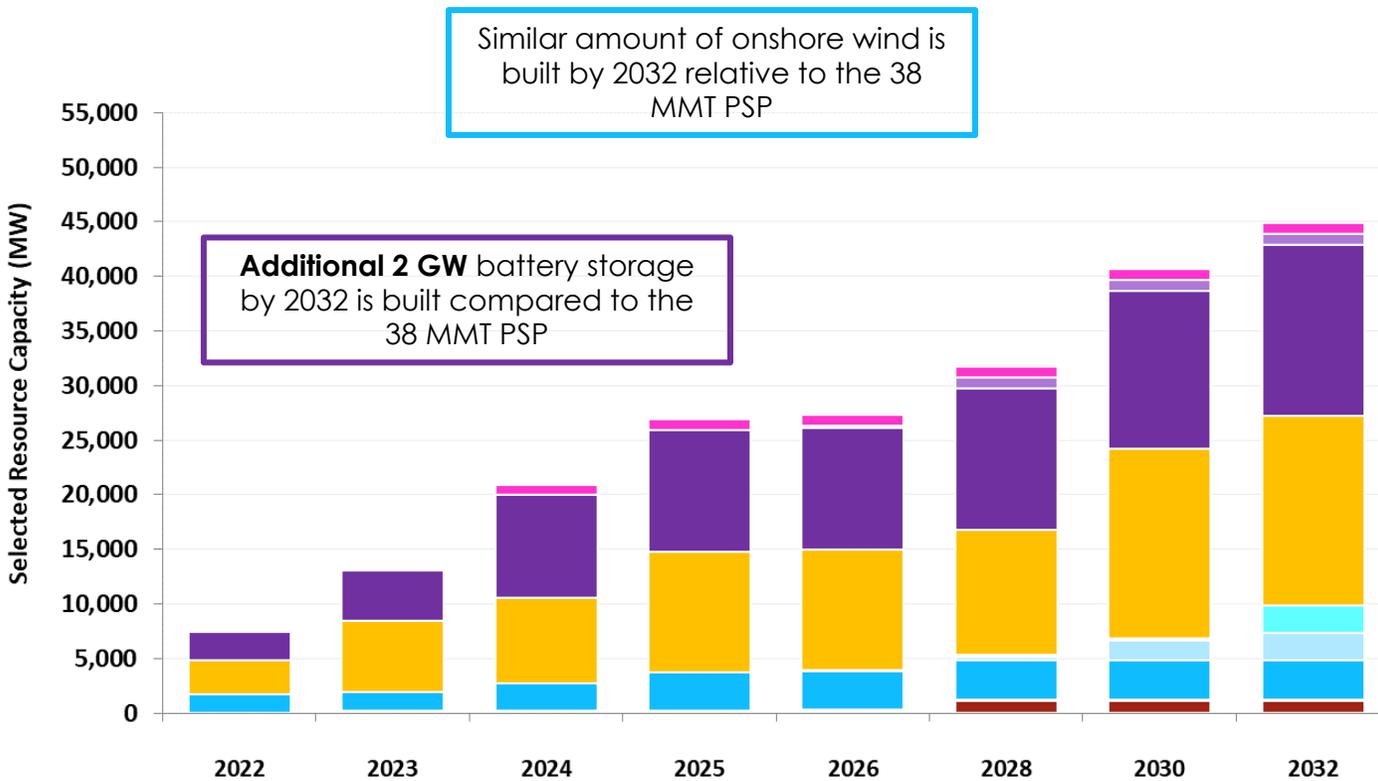
Summary of 30 MMT Scenarios 2035 Snapshot Year



38 MMT With 2021 IEPR Mid + 2022 Costs

With Transmission Updates

Selected resources – 38 MMT with 2021 IEPR Mid + 2022 Costs + Tx Updates



Similar amount of solar is built by 2032 compared to the 38 MMT PSP

1 GW more out-of-state wind on new transmission and 800 MW more offshore wind selected by 2032 relative to the 38 MMT PSP

Like the 38 MMT PSP all gas capacity was retained, but no additional capacity is selected by 2045

About 31 GW less resources relative to the 38 MMT PSP

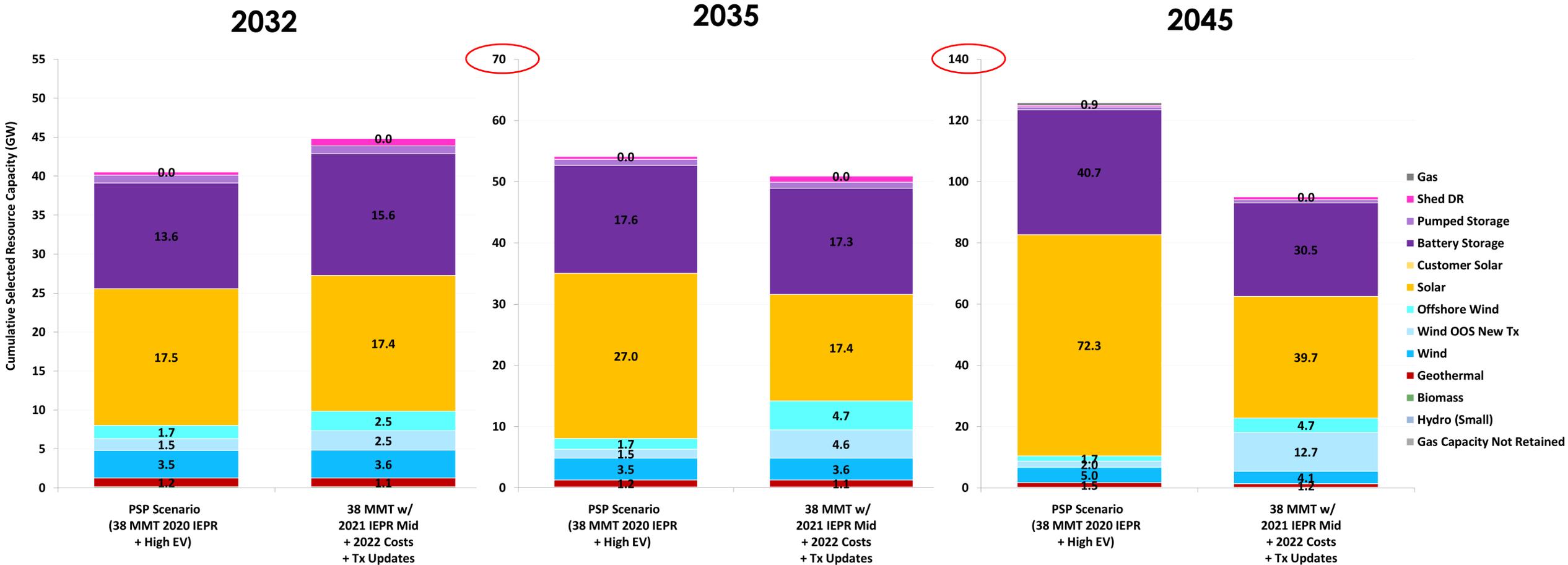
Selected resources – 38 MMT with 2021 IEPR Mid + 2022 Costs + Tx Updates

	Unit	2022	2023	2024	2025	2026	2028	2030	2032	2033	2035	2040	2045
Gas	MW	-	-	-	-	-	-	-	-	-	-	-	-
Biomass	MW	34	65	83	95	107	134	134	134	134	134	134	134
Geothermal	MW	14	114	114	114	184	1,135	1,135	1,135	1,135	1,135	1,135	1,173
Hydro (Small)	MW	-	-	-	-	-	-	-	-	-	-	-	-
Wind	MW	1,697	1,719	2,582	3,562	3,562	3,562	3,562	3,562	3,562	3,562	3,562	4,135
Wind OOS New Tx	MW	-	-	-	-	-	312	1,801	2,500	3,957	4,636	8,452	12,675
Offshore Wind	MW	-	-	-	-	120	195	195	2,502	2,502	4,707	4,707	4,707
Solar	MW	3,094	6,549	7,750	11,000	11,000	11,397	17,418	17,418	17,418	17,418	26,554	39,697
Customer Solar	MW	-	-	-	-	-	-	-	-	-	-	-	-
Battery Storage	MW	2,565	4,603	9,461	11,149	11,149	12,999	14,448	15,619	16,308	17,350	23,899	30,525
Pumped Storage	MW	-	-	-	-	196	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Shed DR	MW	151	151	889	977	977	977	977	977	977	977	977	977
Gas Capacity Not Retained	MW	-	-	-	-	-	-	-	-	-	-	-	-
Storage + DR	MW	2,716	4,755	10,350	12,126	12,322	14,976	16,425	17,596	18,285	19,327	25,876	32,502
Total Resources (Renewables + Storage + DR)	MW	7,554	13,202	20,880	26,898	27,296	31,712	40,672	44,848	46,993	50,920	70,421	95,024

Relative to the 38 MMT PSP we find the following:

- By 2032 there is a similar amount of solar PV resources, about 2 GW more battery storage resources, about 0.5 GW more DR, about 1 GW more out-of-state wind, and about 0.8 GW more offshore wind
- By 2035 there is about 9.6 GW less solar PV, about 0.3 GW less battery storage, about 3.1 GW more out-of-state wind, and 3 GW more offshore wind
- By 2045 there is about 32.6 GW less solar PV, 10.2 GW less battery storage, about 0.9 GW less onshore wind, about 10.7 GW more out-of-state wind, and no new gas.

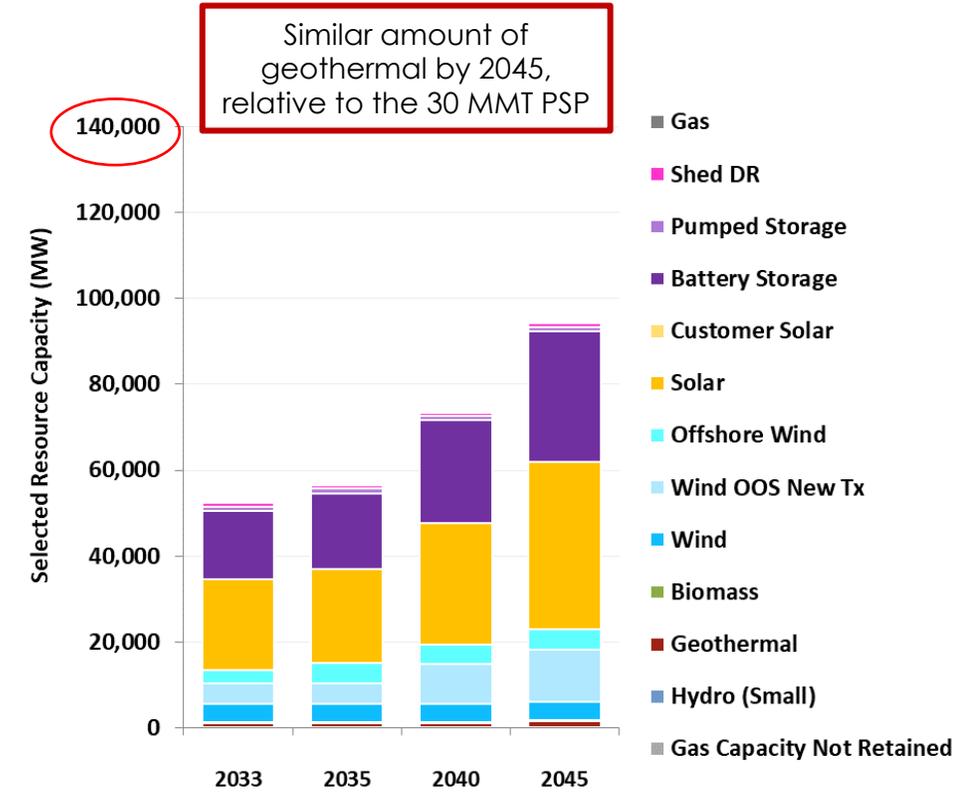
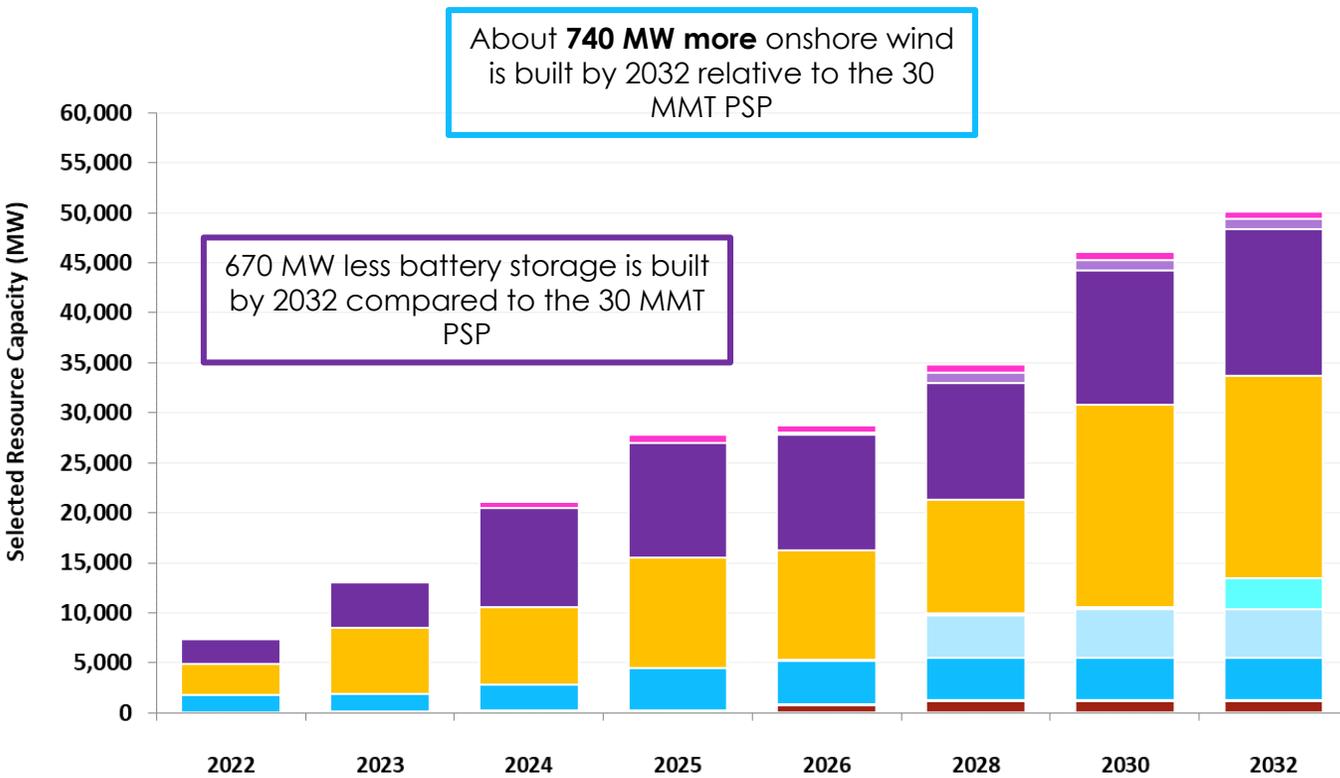
PSP (38 MMT) vs 38 MMT with 2021 IEPR Mid + 2022 Costs + Tx Updates



30 MMT With 2021 IEPR Mid + 2022 Costs

With Transmission Updates

Selected resources – 30 MMT with 2021 IEPR Mid + 2022 Costs + Tx Updates



3.8 GW less solar is built by 2032 compared to the 30 MMT PSP

2.9 GW more out-of-state wind on new transmission and **1.4 GW more** offshore wind selected relative to the 30 MMT PSP

Like the 30 MMT PSP all gas capacity was retained, but **no additional** gas capacity is selected by 2045

About 32 GW less resources relative to the 30 MMT PSP

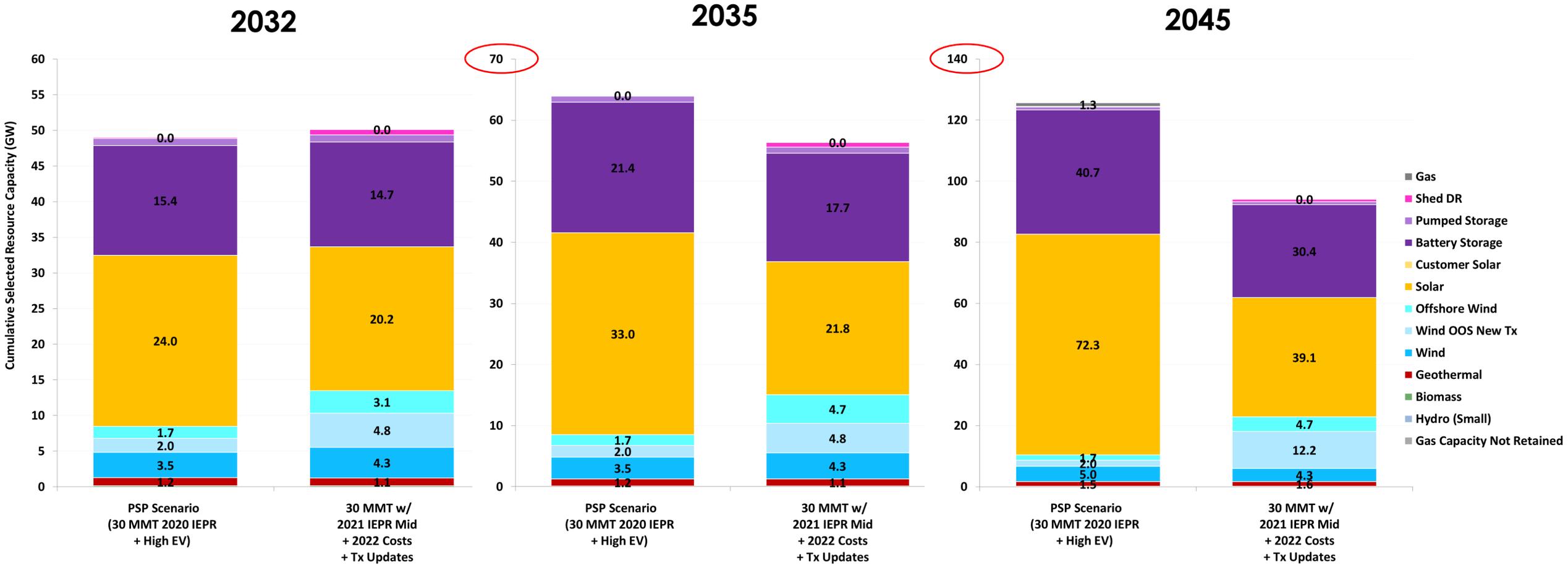
Selected resources – 30 MMT with 2021 IEPR Mid + 2022 Costs + Tx Updates

	Unit	2022	2023	2024	2025	2026	2028	2030	2032	2033	2035	2040	2045
Gas	MW	-	-	-	-	-	-	-	-	-	-	-	-
Biomass	MW	34	65	83	107	107	134	134	134	134	134	134	134
Geothermal	MW	14	114	114	114	793	1,135	1,135	1,135	1,135	1,135	1,135	1,584
Hydro (Small)	MW	-	-	-	-	-	-	-	-	-	-	-	-
Wind	MW	1,697	1,719	2,582	4,270	4,270	4,270	4,270	4,270	4,270	4,270	4,270	4,270
Wind OOS New Tx	MW	-	-	-	-	-	4,204	4,828	4,828	4,828	4,828	9,199	12,153
Offshore Wind	MW	-	-	-	-	120	195	200	3,100	3,100	4,707	4,707	4,707
Solar	MW	3,094	6,549	7,750	11,000	11,000	11,397	20,222	20,222	21,106	21,794	28,095	39,063
Customer Solar	MW	-	-	-	-	-	-	-	-	-	-	-	-
Battery Storage	MW	2,565	4,603	9,937	11,512	11,512	11,689	13,490	14,687	15,976	17,742	24,114	30,415
Pumped Storage	MW	-	-	-	-	196	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Shed DR	MW	151	151	679	767	767	767	767	767	767	767	767	800
Gas Capacity Not Retained	MW	-	-	-	-	-	-	-	-	-	-	-	-
Storage + DR	MW	2,716	4,755	10,615	12,279	12,475	13,455	15,256	16,453	17,743	19,509	25,881	32,215
Total Resources (Renewables + Storage + DR)	MW	7,554	13,202	21,145	27,770	28,765	34,791	46,047	50,143	52,317	56,378	73,421	94,126

Relative to the 30 MMT PSP we find the following:

- By 2032 there is about 3.8 GW less solar PV resources, about 0.7 GW less battery storage resources, about 0.6 GW more DR, about 0.7 GW more onshore wind, about 2.9 GW more out-of-state wind, and about 1.4 GW more offshore wind
- By 2035 there is about 11.2 GW less solar PV, about 3.6 GW less battery storage, about 2.9 GW more out-of-state wind, and 3 GW more offshore wind
- By 2045 there is about 33.2 GW less solar PV, 10.2 GW less battery storage, about 0.6 GW more DR, about 0.8 GW less onshore wind, about 10.2 GW more out-of-state wind, and no new gas.

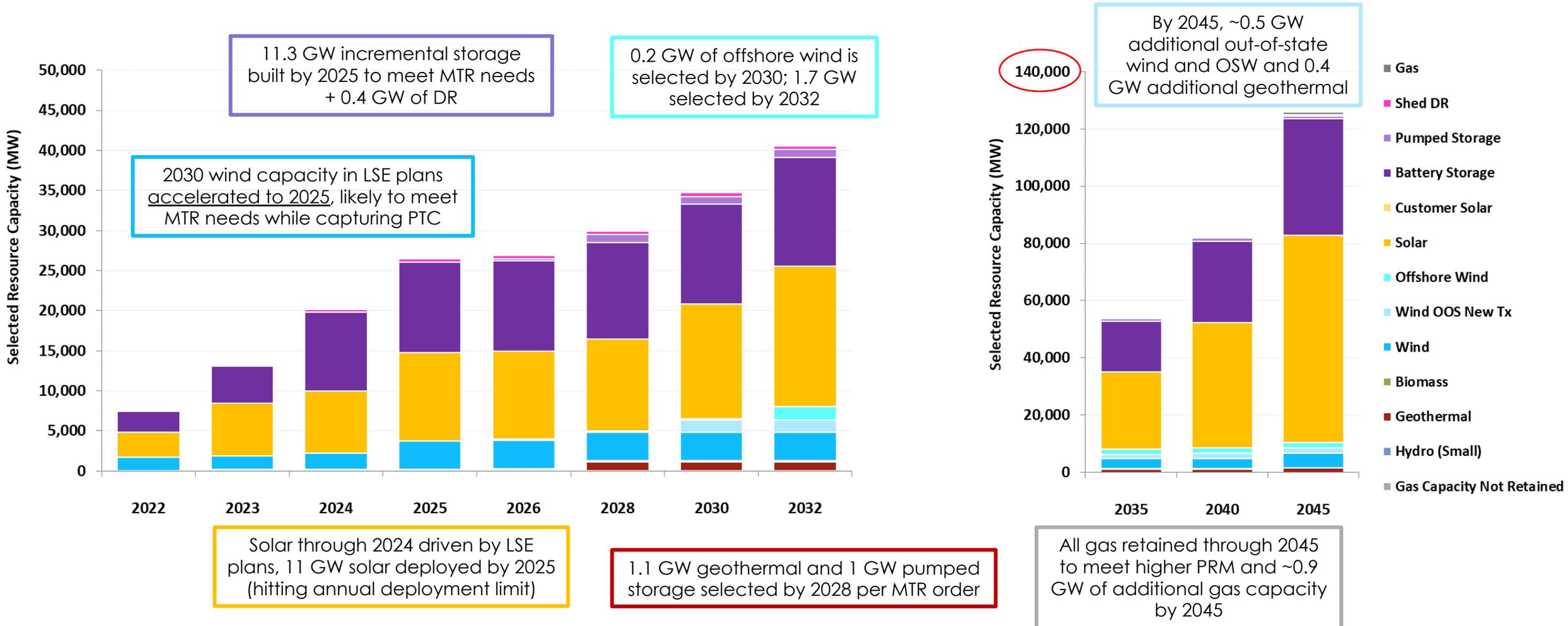
PSP (30 MMT) vs 30 MMT with 2021 IEPR Mid + 2022 Costs + Tx Updates



38 MMT PSP Scenario – 38 MMT with 2020 IEPR + 2020 IEPR High EV

Voted in February

Selected resources – 38 MMT with 2020 IEPR + 2020 IEPR High EV



Selected resources – 38 MMT with 2020 IEPR + 2020 IEPR High EV

	Unit	2022	2023	2024	2025	2026	2028	2030	2032	2035	2040	2045
Gas	MW	-	-	-	-	-	0	0	0	0	0	926
Biomass	MW	34	65	83	107	107	134	134	134	134	134	134
Geothermal	MW	14	114	114	114	184	1,160	1,160	1,160	1,160	1,160	1,521
Hydro (Small)	MW	-	-	-	-	-	-	-	-	-	-	-
Wind	MW	1,697	1,719	2,049	3,531	3,531	3,531	3,531	3,531	3,531	3,531	5,031
Wind OOS New Tx	MW	-	-	-	-	0	0	1,500	1,500	1,500	1,970	1,970
Offshore Wind	MW	-	-	-	-	120	195	195	1,708	1,728	1,728	1,728
Solar	MW	3,094	6,549	7,750	11,000	11,000	11,397	14,342	17,506	26,977	43,716	72,340
Customer Solar	MW	-	-	-	-	-	-	-	-	-	-	-
Battery Storage	MW	2,565	4,604	9,811	11,317	11,317	12,078	12,395	13,571	17,648	28,528	40,706
Pumped Storage	MW	-	-	-	-	196	1,000	1,000	1,000	1,000	1,000	1,000
Shed DR	MW	151	151	353	441	441	441	441	441	441	441	441
Gas Capacity Not Retained	MW	-	-	-	-	-	-	-	-	-	-	-
Storage + DR	MW	2,716	4,755	10,164	11,758	11,954	13,519	13,835	15,012	19,089	29,969	42,147
Total Resources (Renewables + Storage + DR)	MW	7,555	13,202	20,161	26,511	26,897	29,937	34,698	40,551	54,120	82,210	125,799

- Resources selected by RESOLVE between 2030 and 2032, i.e., beyond the planning horizon of the current LSE plans:
 - ~3.2 GW solar PV, ~1.2 GW battery storage, ~1.5 GW offshore wind

Appendix: Resource Cost Update

Summary of data sources

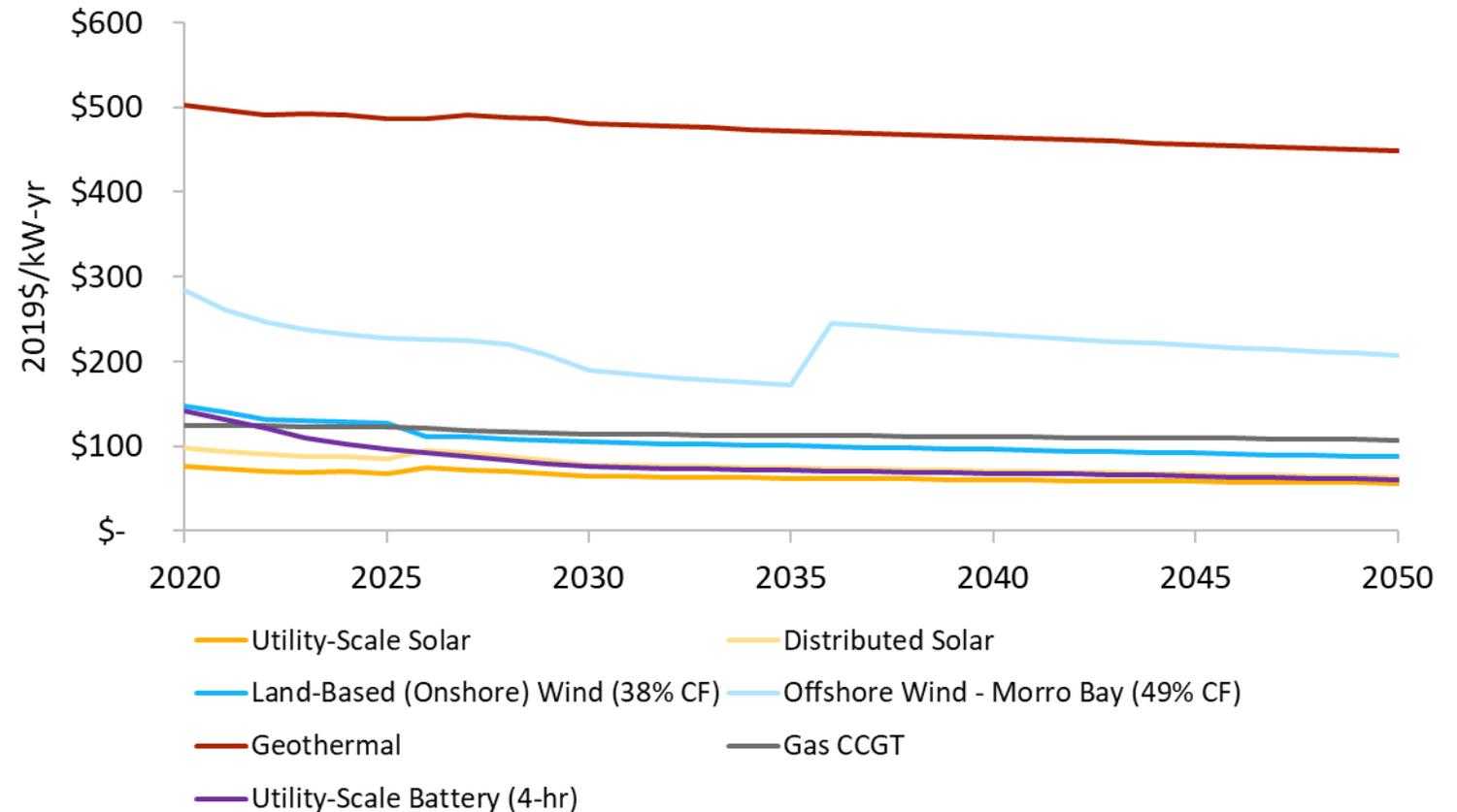
Technology	Data Source – 2021 PSP	Data Source – LSE Filing Requirements
Solar PV (utility-scale, distributed)	NREL 2020 Annual Technology Baseline (ATB)	NREL 2021 ATB
Land-Based (Onshore) Wind	NREL 2020 ATB	NREL 2021 ATB
Offshore Wind	NREL OCS Study BOEM 2020-048 (+ financing from NREL 2020 ATB)	NREL OCS Study BOEM 2020-048 (+ financing from NREL 2021 ATB)
Geothermal	NREL 2020 ATB	NREL 2021 ATB
Small Hydro	NREL 2020 ATB	NREL 2021 ATB
Biomass	NREL 2020 ATB	NREL 2021 ATB
Gas (combined cycle, combustion turbine)	NREL 2020 ATB	NREL 2021 ATB
Li-ion Battery	Lazard Levelized Cost of Storage v6.0 (LCOS 6.0) (+ cost trajectories from NREL battery study)	Lazard LCOS 7.0 (+ cost trajectories from NREL battery study)
Flow Battery	Lazard LCOS 4.0	No update (not available in later LCOS)
Pumped Hydro Storage	Lazard LCOS 2.0	No update (not available in later LCOS)

Note: NREL typically publishes new Annual Technology Baseline (ATB) data around June each year. Lazard typically publishes new Levelized Cost of Storage (LCOS) analysis around November each year.

Summary of total ("all-in") levelized fixed costs LSE Filing Requirements

- Total levelized fixed costs are cost inputs into RESOLVE for candidate resources and impact resource build decisions

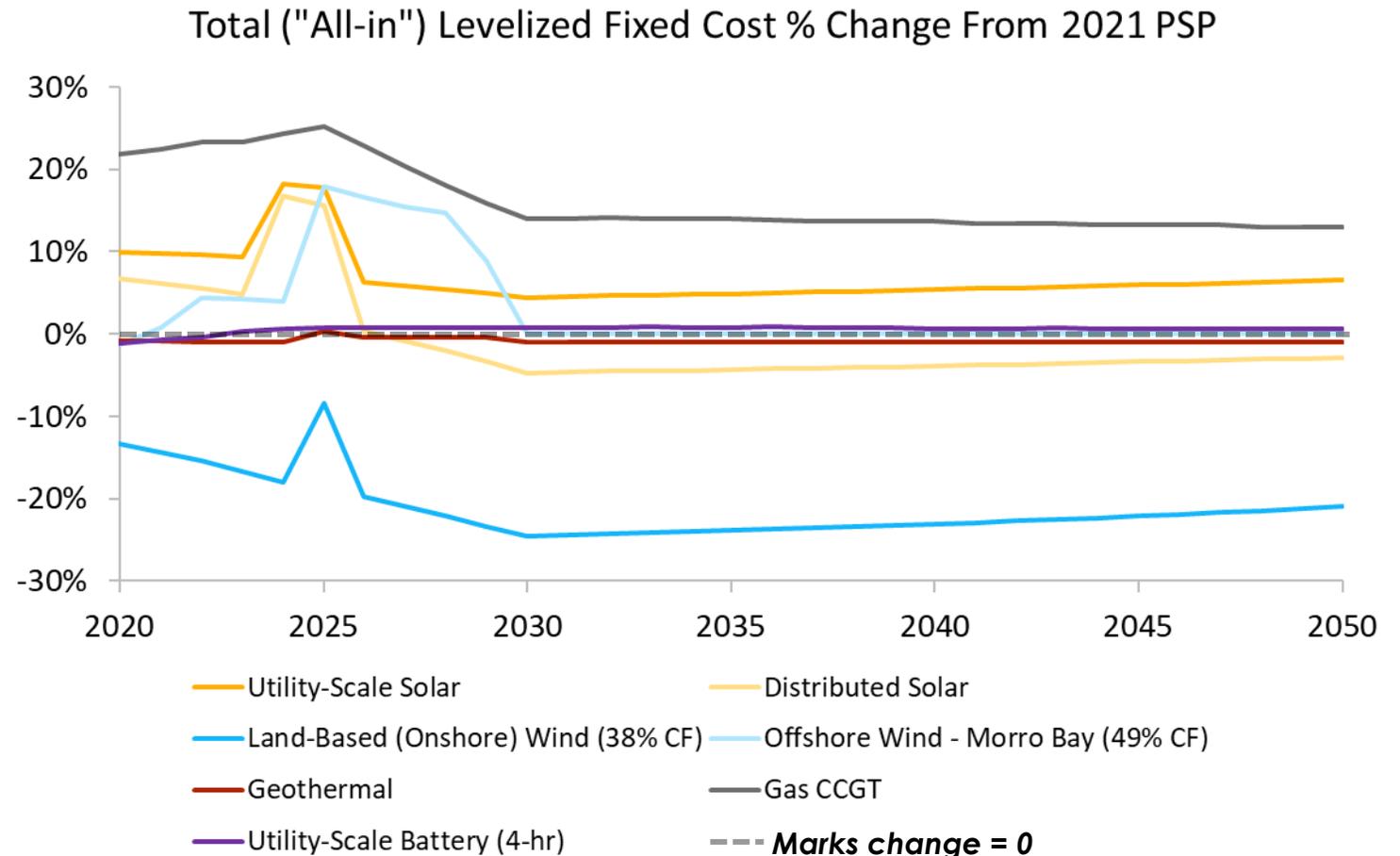
Total ("All-in") Levelized Fixed Cost



Note: The 38% capacity factor land-based (onshore) wind technology is representative of California wind resources in RESOLVE.

Changes in total (“all-in”) levelized fixed costs LSE Filing Requirements vs. 2021 PSP

- Total levelized fixed costs are cost inputs into RESOLVE for candidate resources and impact resource build decisions
- Changes in total levelized fixed costs are within about 10% for most technologies

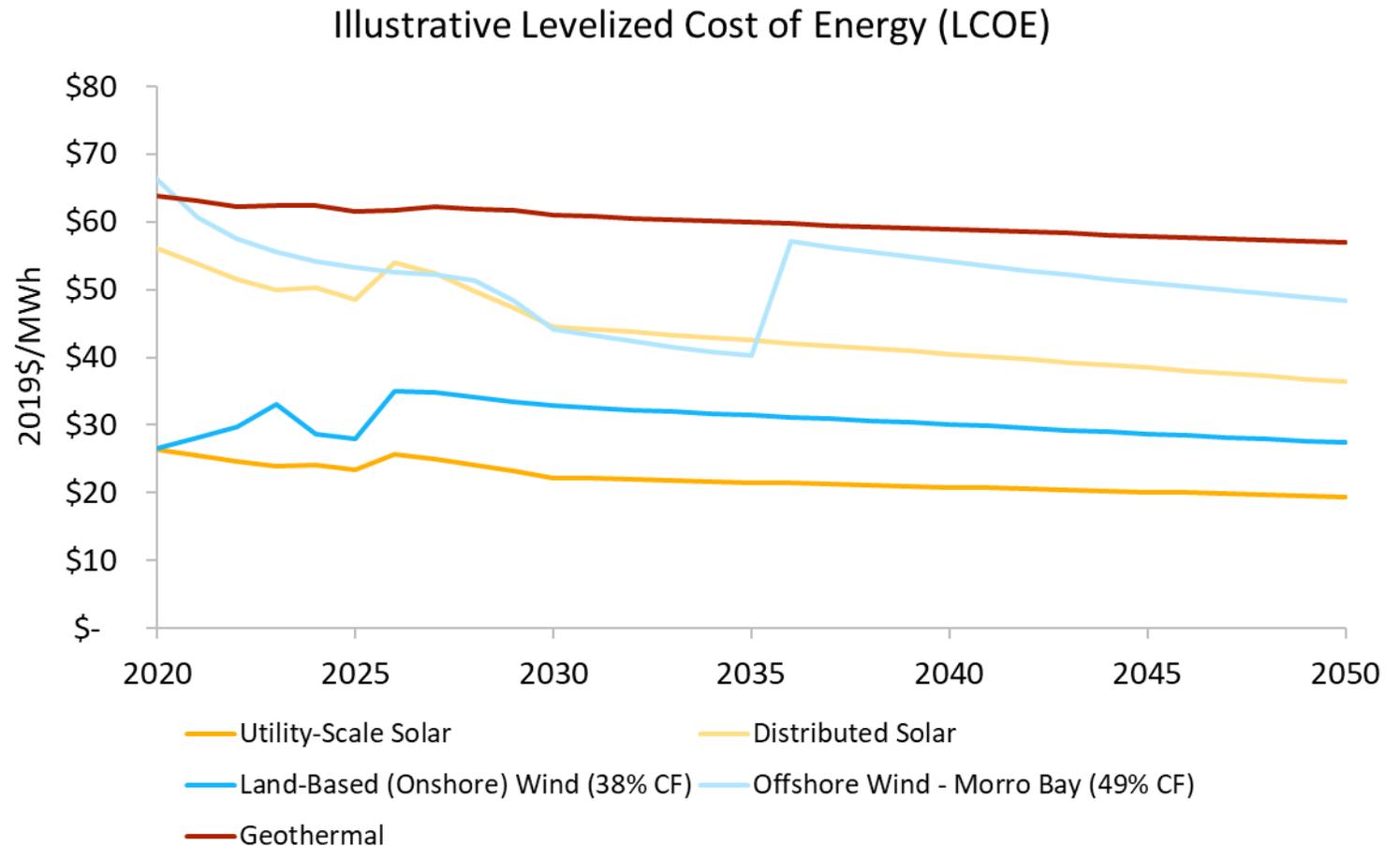


Note: The 38% capacity factor land-based (onshore) wind technology is representative of California wind resources in RESOLVE.

Summary of levelized cost of energy (LCOE) LSE Filing Requirements

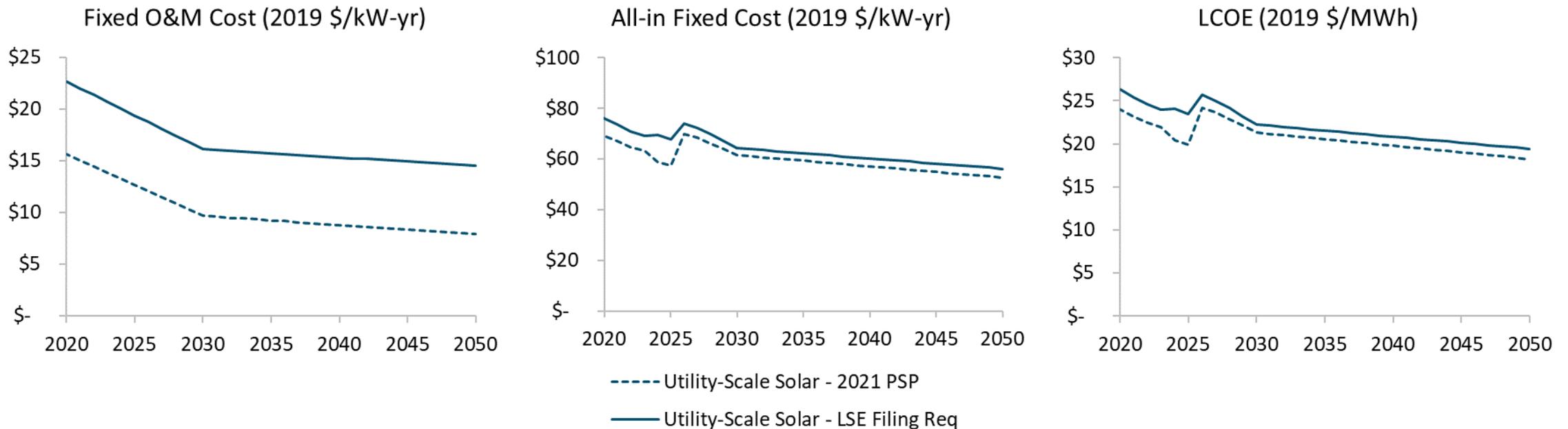
- The LCOEs shown here are illustrative. LCOE is not a RESOLVE input or output but can be inferred from dispatch results. The LCOE of individual resources would vary by factors such as resource location and availability.
- All-in levelized costs are the primary cost inputs for new resources in RESOLVE.

Note: The 38% capacity factor land-based (onshore) wind technology is representative of California wind resources in RESOLVE.



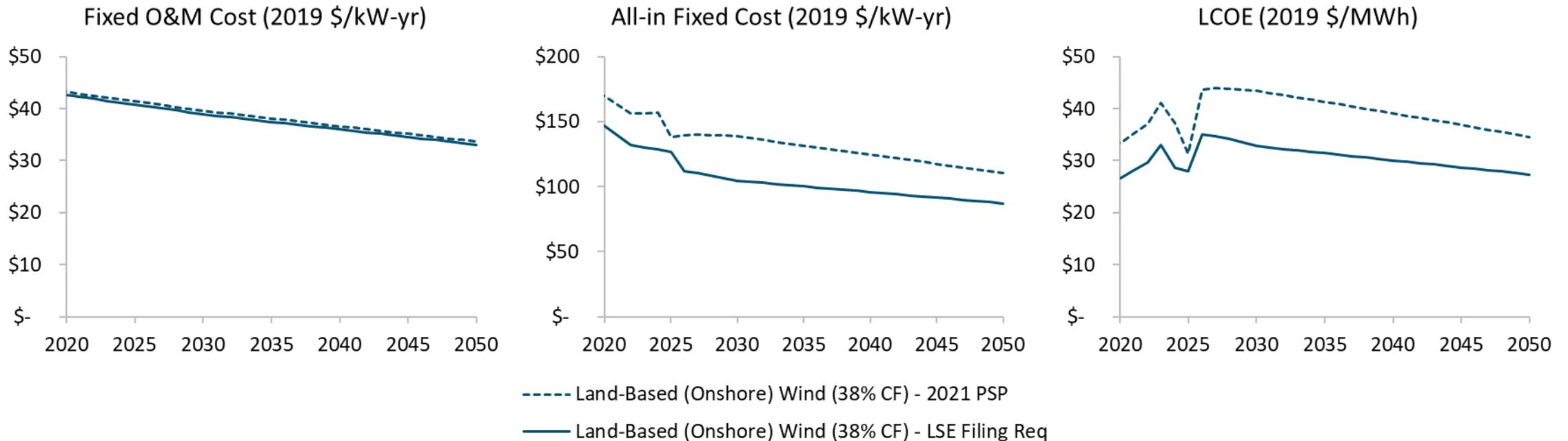
Utility-scale solar PV LSE Filing Requirements vs. 2021 PSP

- Increase in total fixed costs and LCOE is driven by increase in fixed O&M



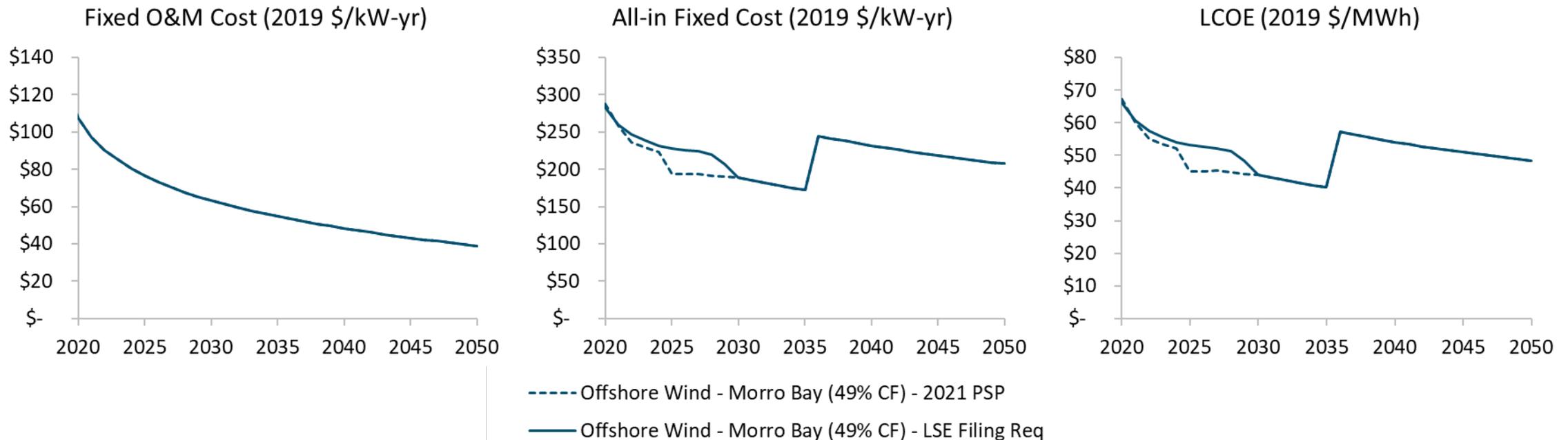
Land-based (onshore) wind LSE Filing Requirements vs. 2021 PSP

- Decrease in total fixed costs is driven by NREL ATB's updated analysis and innovation assumptions
 - “Bottom-up technology analysis and cost modeling”, “with innovations that increase wind turbine size, improve controls, and enhance science-based modeling” (see: [NREL 2021 ATB](#))



Floating offshore wind LSE Filing Requirements vs. 2021 PSP

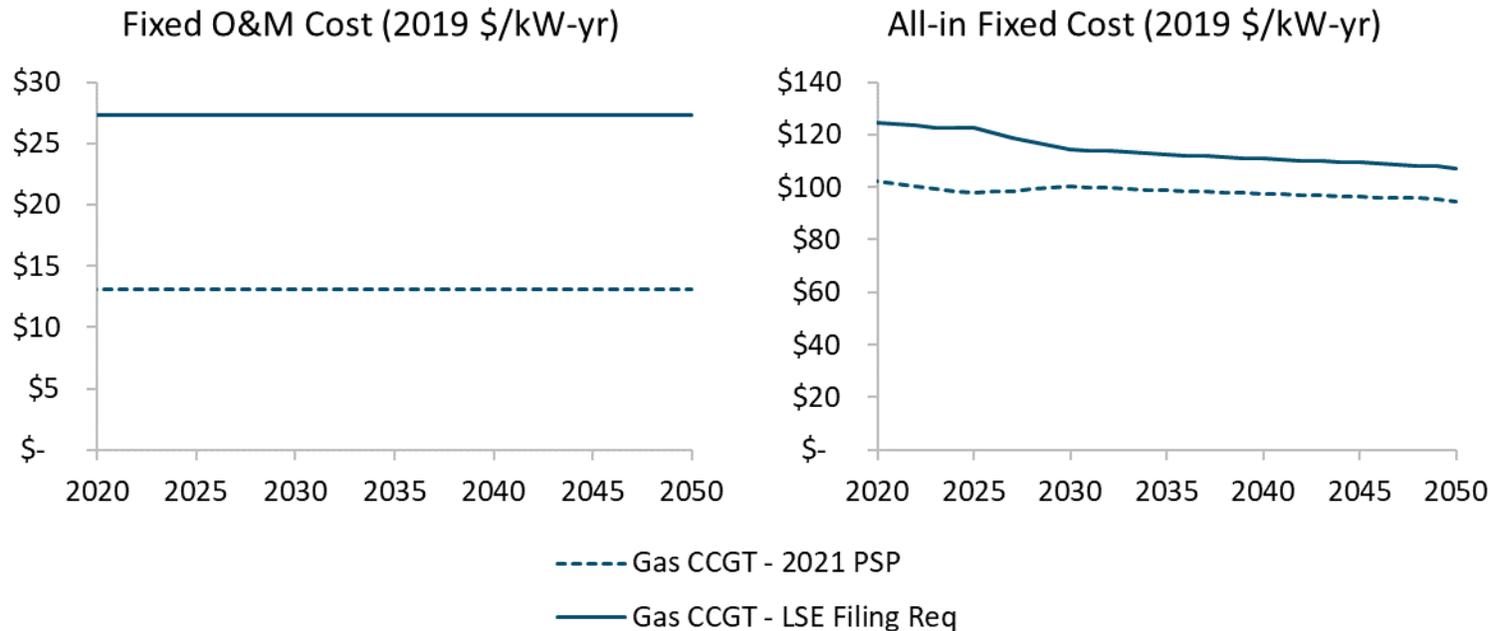
- LSE Filing Requirements cost update uses the same inputs (capex, fixed O&M, etc.) as the PSP, both from NREL [OCS Study BOEM 2020-048](#)
- Differences in levelized fixed costs due to NREL 2020 vs. 2021 ATB financing assumptions



Note: Both LSE Filing Requirements and PSP offshore wind costs assume ITC benefits are accessed through 2035 via the safe harbor exemption.

Natural gas combined cycle (CCGT) LSE Filing Requirements vs. 2021 PSP

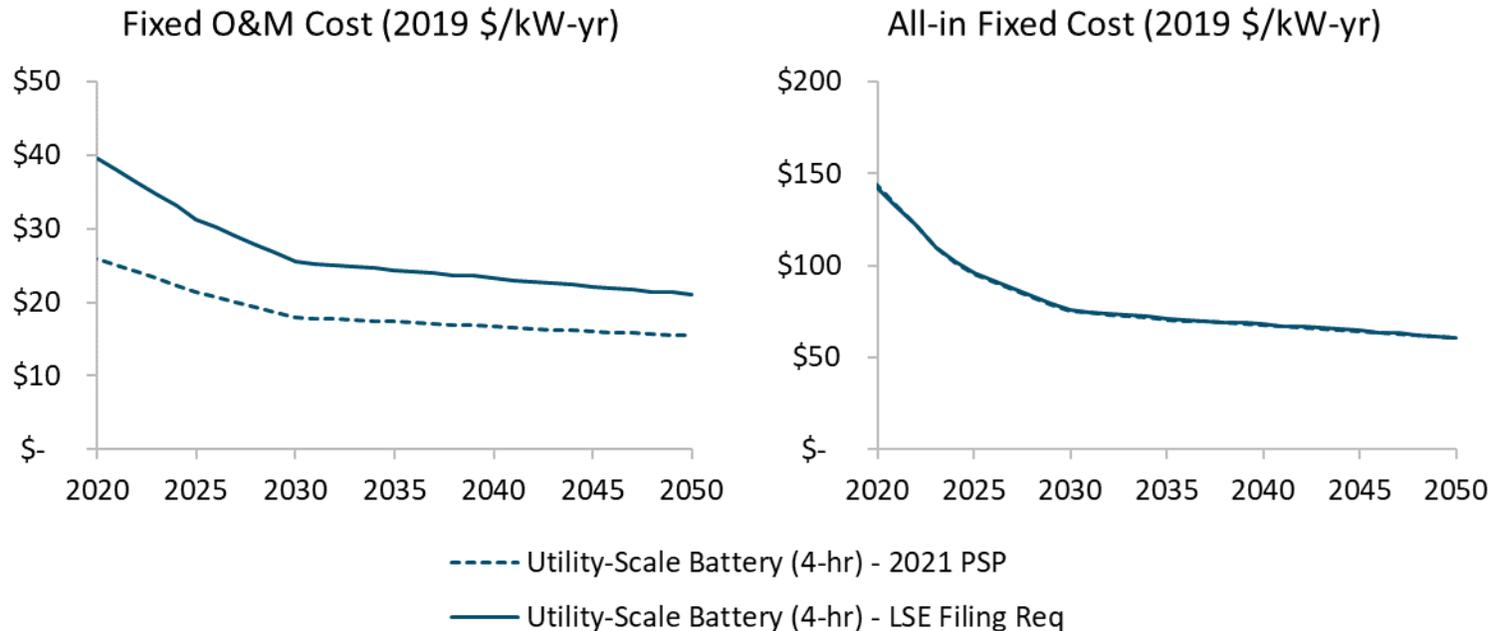
- Natural gas fixed O&M costs in NREL 2021 ATB include property taxes and insurance costs (see: [NREL 2021 ATB](#))
 - These costs are not included in prior NREL ATB cost estimates (matched to EIA's Annual Energy Outlook)



Note: LCOE not shown because the capacity factor of gas resources is a RESOLVE output. The capacity factor can change over time and cannot be predicted prior to each model run.

Utility-scale standalone Li-ion battery LSE Filing Requirements vs. 2021 PSP

- All-in fixed costs are similar between LSE Filing Requirements and PSP
 - Lazard LCOS 7.0 capital costs are ~15% lower than the previous version
 - Fixed O&M costs increased due to higher warranty extension and augmentation costs assumed in LCOS 7.0



Note: Battery fixed O&M cost includes warranty extension, augmentation, and periodic replacement.