The path for offshore wind in California

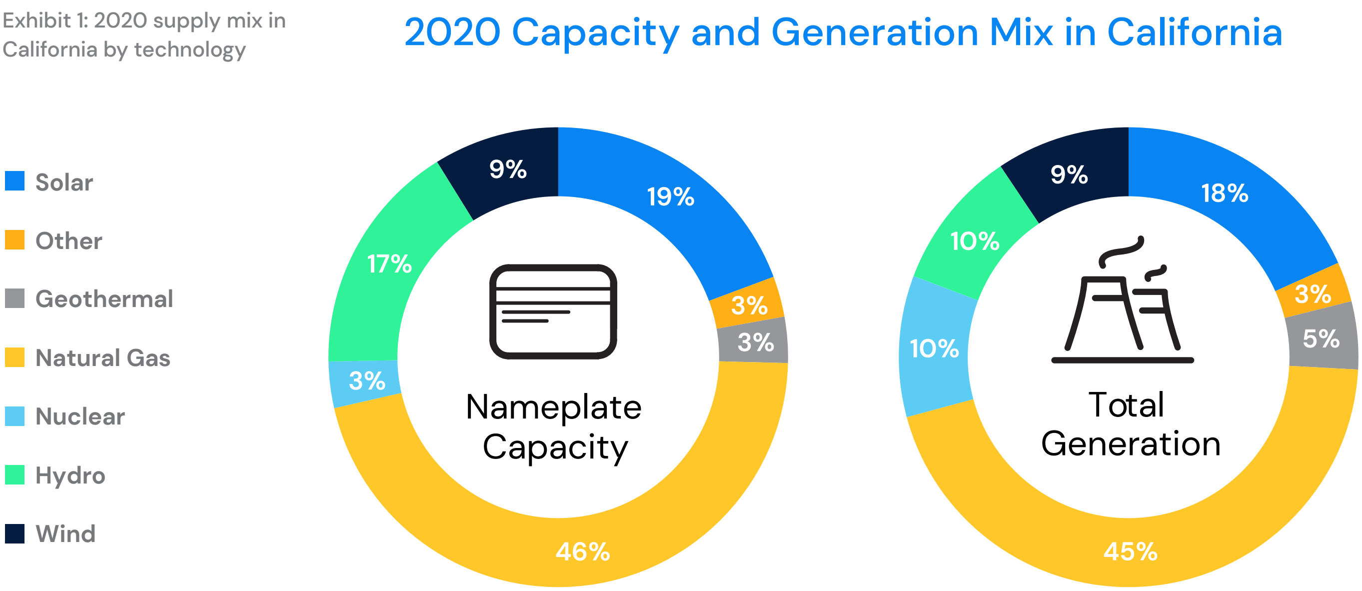
By Himali Parmar, Biwan Zhou, ICF

Introduction

Offshore wind is moving westward and is expected to play a crucial role in the overall power generation supply mix in the Western U.S. in the coming decades. When superimposed over the East Coast, the California coastline extends from Maine to North Carolina. The harnessing of its offshore wind resources will be necessary for California to achieve its zero-carbon energy resources supply goal by 2045.

As of November 2021, just a few offshore wind projects—with a modest combined capacity of 6.5 GW—were active in the California Independent System Operator (CAISO) interconnection queue versus 76 GW of solar and 11.5 GW of onshore wind. However, there is strong momentum from a policy and planning standpoint to expand the renewable base to other technologies including offshore wind.

Exhibit 1: 2020 supply mix in California by technology



Source: ABB Energy Velocity Suite; ICF Research

Even though the Preferred System Portfolio adopted by California Public Utilities Commission (CPUC) in the 2019 Integrated Resource Plan[1] did not include any offshore wind projections, CPUC[2] has requested a sensitivity case in the CAISO's 2021-2022 transmission planning process to assess the cost of upgrading transmission to accommodate 8.3 GW of offshore wind by 2031, with the potential to increase this offshore wind capacity up to 21.1 GW. The Biden administration proposal for a U.S.-wide deployment of 30 GW of offshore wind by 2030 will serve as an impetus to offshore wind development as will the agreement between the Departments of Interior and Defense to "advance areas for offshore wind off the northern and central coasts of California," which they anticipate could bring up to 4.6 GW of new capacity to the grid.

In line with these findings, the U.S. Bureau of Ocean Energy Management (BOEM) has identified five proposed locations or "Call Areas" along the California coastline, considered to have superior wind resource potential: Diablo Canyon Call Area, Morro Bay Call Area, Morro Bay Call Area East Extension, and Morro Bay Call Area West Extension—all in central California—plus Humboldt Call Area in Northern California.

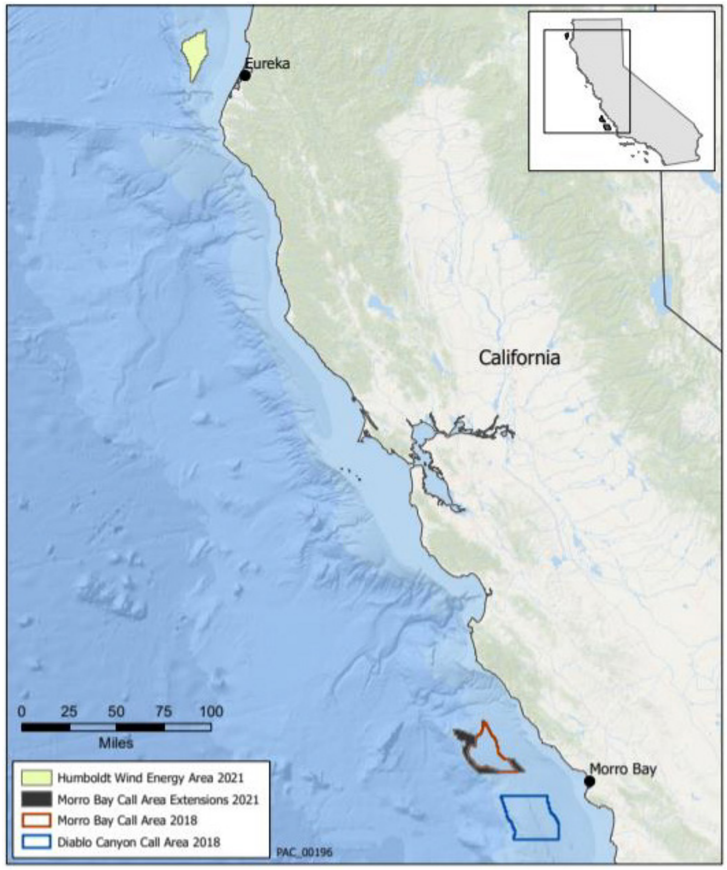
[1] The California Energy Commission adopts an Integrated Energy Policy Report (IEPR) every two years and an update every other year.
[2] The CAISO plans to incorporate the results of this study work into its 2021-2022 transmission plan scheduled for release in March 2022.

Flatten the California duck curve

While solar is expected to continue to dominate the future supply mix, increasing levels of solar penetration will intensify the duck curve effect (i.e., low net peak demand in solar peak output hours, and rapidly increasing demand for non-solar power in the late afternoon/early evening). Another challenge of a solar-dominated grid comes when extreme weather conditions restrict solar radiation over consecutive days.

To address these grid reliability issues, CAISO, CPUC, and other stakeholders have recently put into motion several significant changes and reforms[3] including a major reduction in reliance on solar for meeting reserve requirements by decreasing its effective load carrying capacity (ELCC). This has been accompanied by the adoption of new resource adequacy methodologies, specifically placing more emphasis on evening peaks and the examination of multiple hours instead of just the peak load hour. ICF's assessment[4] of the renewable generation and demand profiles shows that offshore wind has a stronger diurnal coincidence with California load profile compared to solar, especially in the evening hours. By shaving the peak demand in the early evening, offshore wind can potentially reduce the slope of the duck curve by providing a gradual ramp in the early evening when solar generation declines.

Exhibit 2: Offshore wind call areas

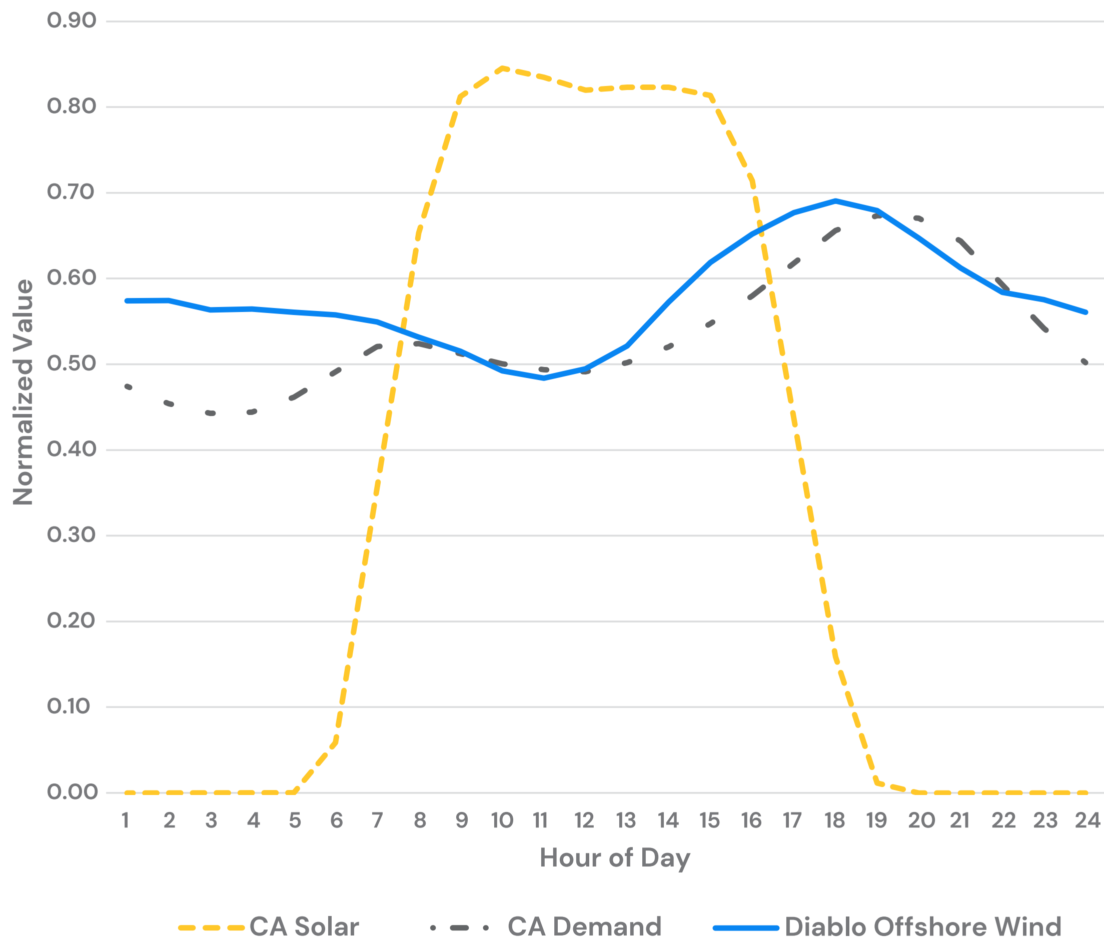


Source: BOEM California Off-Shore Wind Call Areas | Maps | CA Offshore Wind Energy (databasin.org)

[3] CAISO has also been rethinking the role of natural gas-fired plants and long-duration battery energy storage systems (BESS). Namely, fast ramp gas plants will be needed in response to intermittency issues, and long-duration BESS will be needed to shift the utilization of solar generation from mid-day to nighttime hours. Another change has been California's diminished reliance on uncontracted energy imports.

[4] ICF relied on NREL's Wind Toolkit Data for historical wind speed in 2013 and modeled the power output using a power curve similar to that of GE's Haliade-X Turbine.

Exhibit 3: Indicative CA demand, solar and wind shape



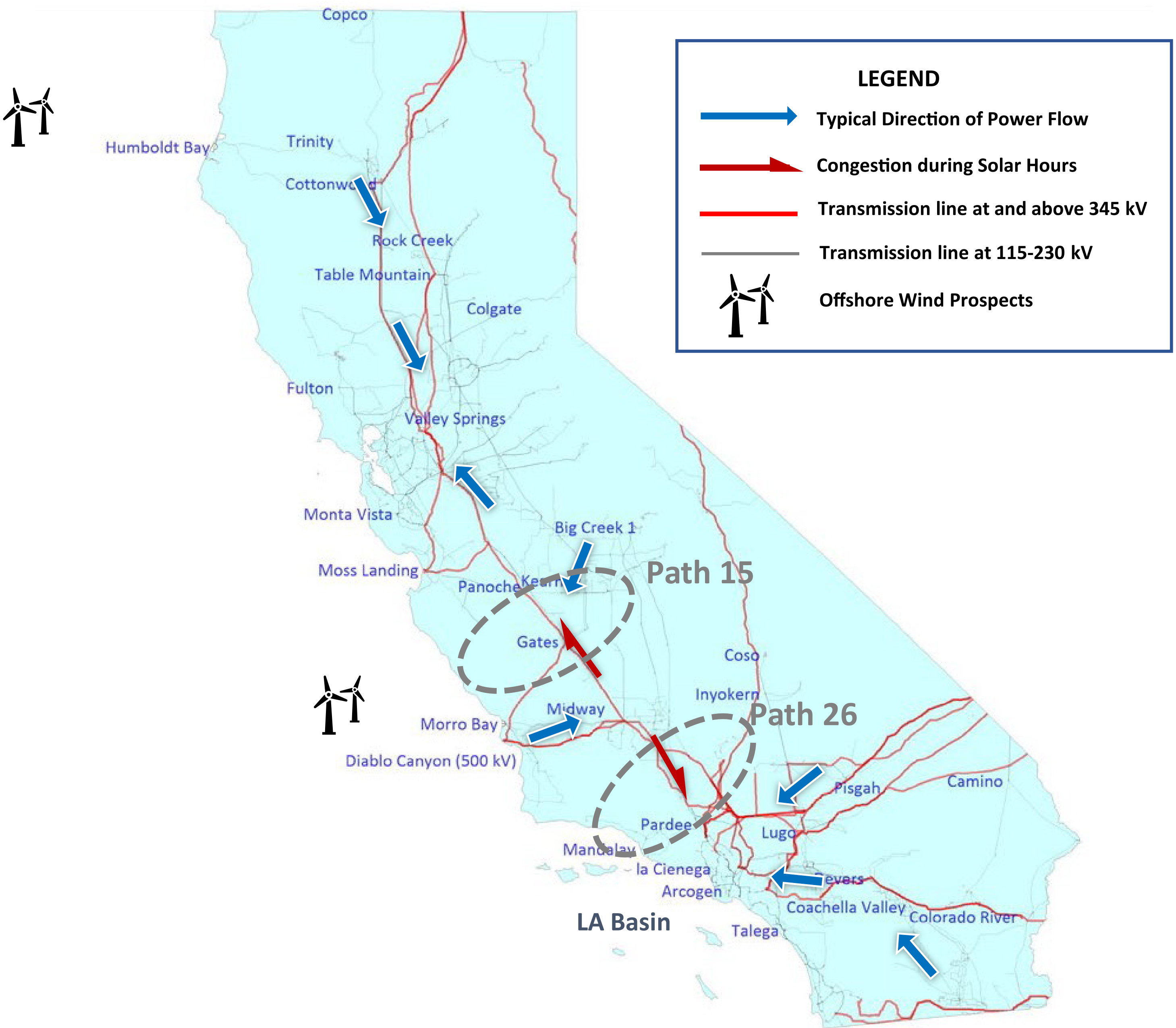
Source: ICF

Moreover, while overall California demand peaks in the summer, northern areas such as Humboldt and the Central Coast in the PG&E service territory experience highest demand in the winter. Offshore wind aligns better with seasonal demand profile as compared to solar.

Power flow dynamics today

The bulk power system in California is connected through a 500-kV transmission system consisting of commercially significant interfaces—most notably Path 15 and Path 26 as shown in Exhibit 4 below. Solar resources are expected to continue to penetrate in Southern California, particularly in the Kern and Big Creek areas that are located between Paths 15 and 26. Due to the location of the solar resources, one would expect significant congestion in the South to North direction on Path 15 and North to South direction on Path 26 during solar hours, creating potential chokepoints for the Morro Bay and Diablo Canyon Call Areas. The most sustained wind output, however, will be injected during non-solar hours (Exhibit 3) muting the effects of these mid-day bottlenecks.

Exhibit 4: CAISO transmission system



Strength of the underlying power grid close to the Call Areas

Central California

Morro Bay and Diablo Canyon Call Areas in Central California are connected to a strong transmission network consisting of 230 kV and 345 kV systems, directly connecting to Path 15 and Path 26. These Call Areas are also in close proximity to two large generating resources, the 2.4 GW Diablo Canyon nuclear power plant proposed to be retired by 2026 and the 1 GW Morro Bay gas plant that ceased dispatching to the grid in 2018. According to CAISO's 2020-2021 Transmission Plan, the transmission in the region can accommodate up to 6 GW of offshore wind, with part of the transfer capacity hinging on Diablo Canyon's retirement in 2025. The owner of the nuclear plant, PG&E, retains deliverability options for repowering that can remain in effect for up to three years following the retirement of the nuclear plant. This may create some uncertainty for offshore wind developers seeking queue positions in anticipation of available transmission capacity associated with future retirements. However, the state is accelerating its resource deployment to plan for this anticipated retirement. And in spite of the near-term uncertainties, the backbone transmission system is capable of accommodating large scale offshore wind injections.

Northern California

Humboldt Call Area in Northern California lacks strong access to the transmission system. The transmission network in close proximity to this Call Area is primarily a weak 115-kV system with a 500-kV Cottonwood substation approximately 100-miles inland. ICF's assessment[6] shows significant limitations in this area both along the 115-kV corridor to transfer the power to the Cottonwood 500 kV substation and exports out of Cottonwood to the rest of PG&E. ICF estimates roughly $600 million[7] of network upgrades will be necessary to accommodate a gigawatt of offshore wind in this area. This translates to network upgrade costs of $600/kW, which is significantly higher than the current area interconnection costs of approximately $100/kW[8] for new builds—especially solar.

It is worth noting CAISO has shown a strong reliance on the remedial action scheme (RAS) to mitigate interconnection-related overloads in lieu of large-scale transmission upgrades. RAS is designed to monitor system conditions and automatically take corrective actions such as tripping a generator to maximize the use of the existing transmission facilities. However, the increased transmission system utilization that is partly made possible with implementation of the RAS can also result in increased risk of not meeting system performance criteria if the RAS fails. This is why RAS is typically not relied upon as a long-term solution for the grid—especially one with significant renewable needs.

Key takeaways

California offshore wind development has sufficient tailwinds with support from both federal and state governments. Offshore wind's profile may help to alleviate California's duck curve issues, and also aligns better with the winter peaking Northern California grid. Hence, we expect it to be a crucial part of the future supply mix. The power grid in Central California may have available injection capacity; however, significant transmission chokepoints are observed for the Humboldt Call Area in Northern California. ICF's assessments shows $500 million-$600 million of network upgrades will be required to integrate 1 GW of offshore wind.

[6] ICF's case study is based on a First Contingency Incremental Transfer Capability (FCITC) approach. ICF relied on CAISO's 2023 summer-peak reliability case and performed a linear-approximation power flow analysis to estimate the maximum injection capacity at each bus in the PG&E system before triggering any incremental overloads. It's noted that ICF's assessment doesn't consider any Remedial Action Schemes or Nomogram mitigations.
[7] ICF estimates do not include direct interconnection costs such as collector system/substations.
[8] Based on average interconnection costs (reliability and local delivery upgrade costs) for select queue positions in the Cluster 13 PG&E interconnection study.

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Himali joined ICF in 2002 and leads the Interconnection and Transmission practice at ICF. Her areas of focus are renewable integration, grid interconnection, production cost modeling, transmission congestion and losses, and their effect on locational power prices and asset valuation. She regularly provides financing and lending agencies with an independent and unbiased view of the future market and grid conditions and the economic viability of individual assets. Himali closely follows interconnection and transmission issues and proposed transmission plans across various power markets and performs independent assessments of reliability issues on the grid.

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