WECC

Western Assessment of Resource Adequacy: Planning Reserve Margin Analysis

March 12, 2025

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Planning Reserve Margin Analysis

Historically, resource adequacy planning has focused on the annual peak demand hour. The traditional approach assumes that, if a system is resource adequate when demand is the greatest, it will be resource adequate year-round. For instance, if a 15% planning reserve margin (PRM) during the peak hour is considered adequate, then a 15% PRM is assumed to be sufficient for every hour of the year. When portfolios were predictable baseload generating sources, this method worked. However, extreme weather, changing climate patterns, and resource portfolios shifting toward variable energy resources (VER) have increased demand and resource output variability. Hours of high uncertainty can carry more risk than the peak demand hour. Most resources tend to be made available for peak demand; so, when demand is highest, the system is also best prepared. During times of high uncertainty, often during non-peak hours, the system may not be prepared to respond.

Traditional methods of calculating the PRM do not account for increasing variability in expected energy, as VERs are constructed in place of baseload resources. Without utilities applying energy-based probabilistic analyses to determine appropriate PRMs for their system, the West will continue to see hours in which the 99.98% reliability threshold cannot be maintained[1]. An examination of the hours at risk under different PRMs shows how traditional methods of calculating the PRM do not account for variability. It is important to note that this analysis does not reflect the actual reserve margin carried by each subregion, as PRMs are determined by individual load serving entities. Rather, an estimate of the PRM required to mitigate all demand at risk hours (DARH) and two alternative scenarios are examined for the interconnection and each subregion. The PRMs examined are:

- **Fixed PRM:** A 15% PRM applied to all hours, represents a default PRM.
- **Peak Demand PRM:** The PRM derived in MAVRIC[2] to ensure the peak hour is 99.98% reliable.
- **Total Reliability PRM:** The PRM derived in MAVRIC to ensure all hours of the year are 99.98% reliable.

PRMs are calculated in the following manner consistent with industry standards:

$$Planning\ Reserve\ Margin\ (PRM, \%) = \frac{(Available\ Capacity - Peak\ Load)}{Peak\ Load} \times 100$$

[1] The 99.98% reliability threshold is equal to the one-day-in-ten-years (ODITY) threshold. The ODITY threshold represents the maximum acceptable amount of time electricity generation can be at risk of being short of demand and still be considered adequately reliable.

[2]MAVRIC is WECC's internally developed modeling tool that performs energy-based probabilistic assessments by applying the convolution method. See Appendix A of the 2024 Western Assessment of Resource Adequacy for additional information.

Figures 1 through 18 explore how varying PRMs affect the DARHs in the 2028 assessment year. All time-of-day figures are in hour-beginning format and in Pacific Time. Summer is defined as June through September, winter is defined as December through February, and the shoulder season is defined as March through May and October through November. This analysis incorporates all proposed resources from WECC's Loads and Resources Data Request (tiers 1 through 3). The 2028 assessment year is the focal point for this assessment as it provides a mid-term outlook that balances certainty and speculation regarding anticipated resource plans.

Western Interconnection

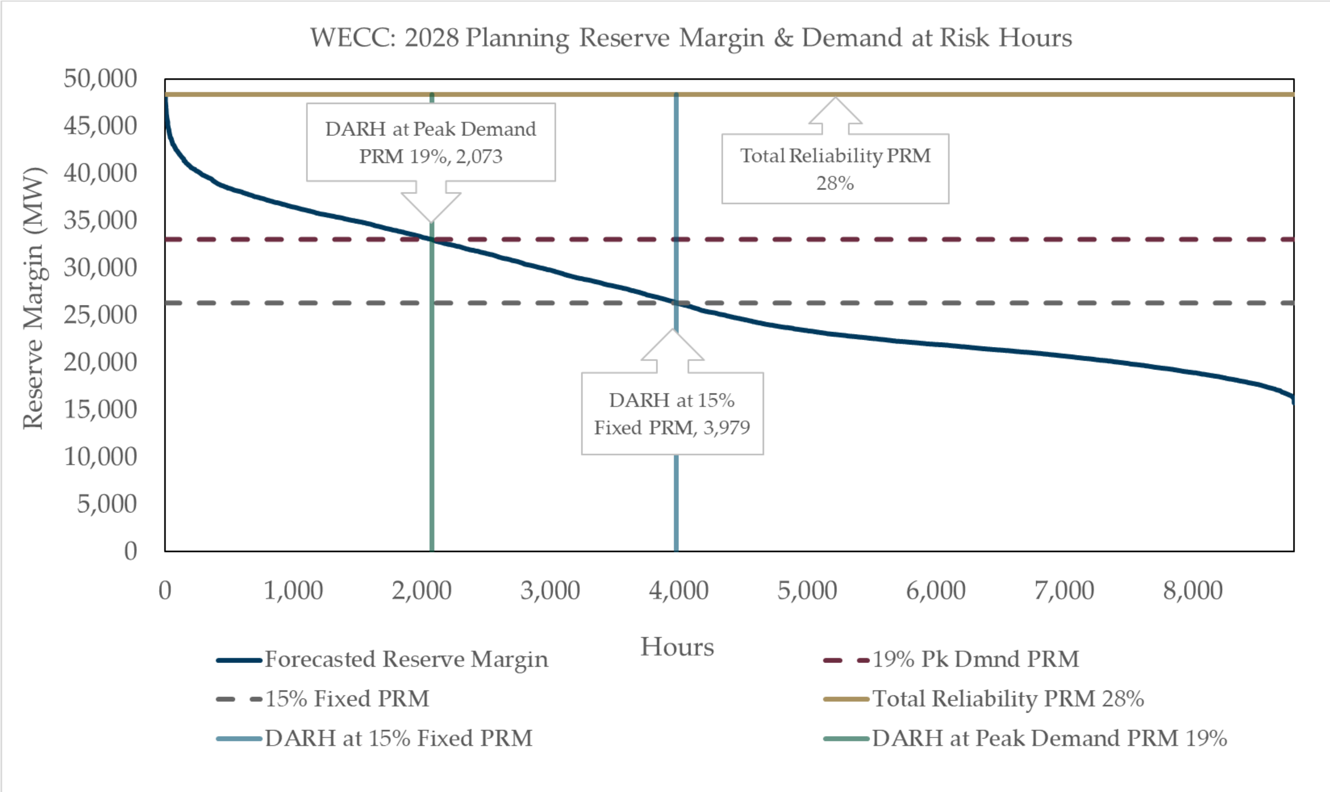
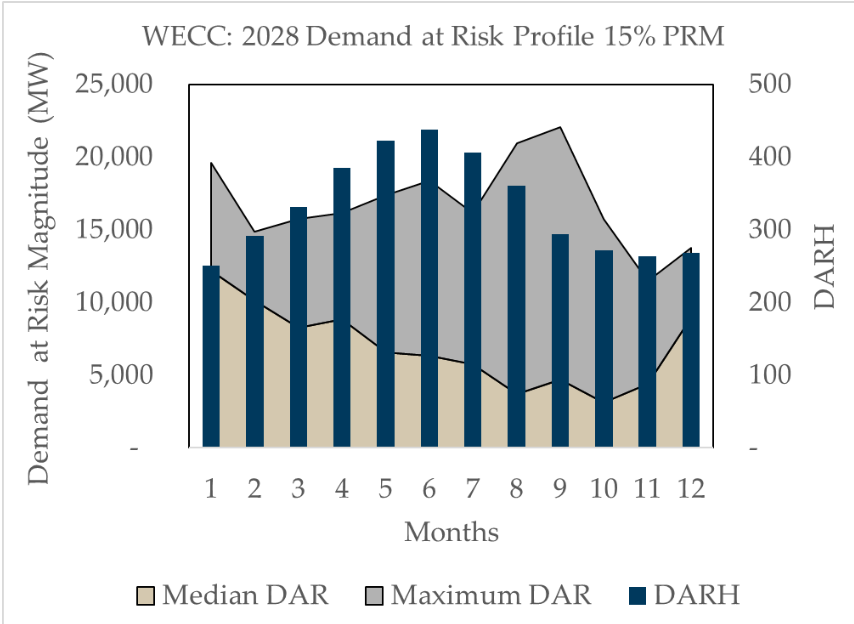


Figure 1: PRMs and their impact on DARHs for the Western Interconnection.

Table 1: Total Reliability, Peak, and Fixed PRMs by year for the Western Interconnection.

Planning Reserve Margins		2025	2028	2031	2034
WECC	Peak Demand	164,353	175,375	183,552	192,637
	Total Reliability PRM	23.1%	27.6%	30.7%	31.5%
		38,022	48,374	56,295	60,690
	Peak PRM	18.2%	18.8%	21.6%	22.1%
		29,904	33,031	39,700	42,547
	Fixed PRM	15.0%	15.0%	15.0%	15.0%
		24,653	26,306	27,533	28,896



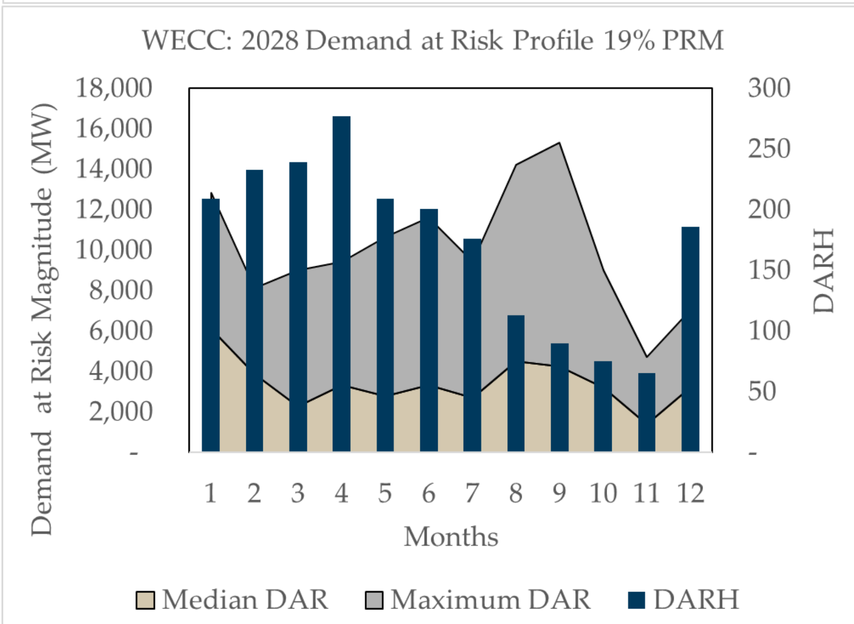


Figure 2: DARHs and corresponding magnitude by month for the 15% Fixed PRM and 19% Peak PRM.

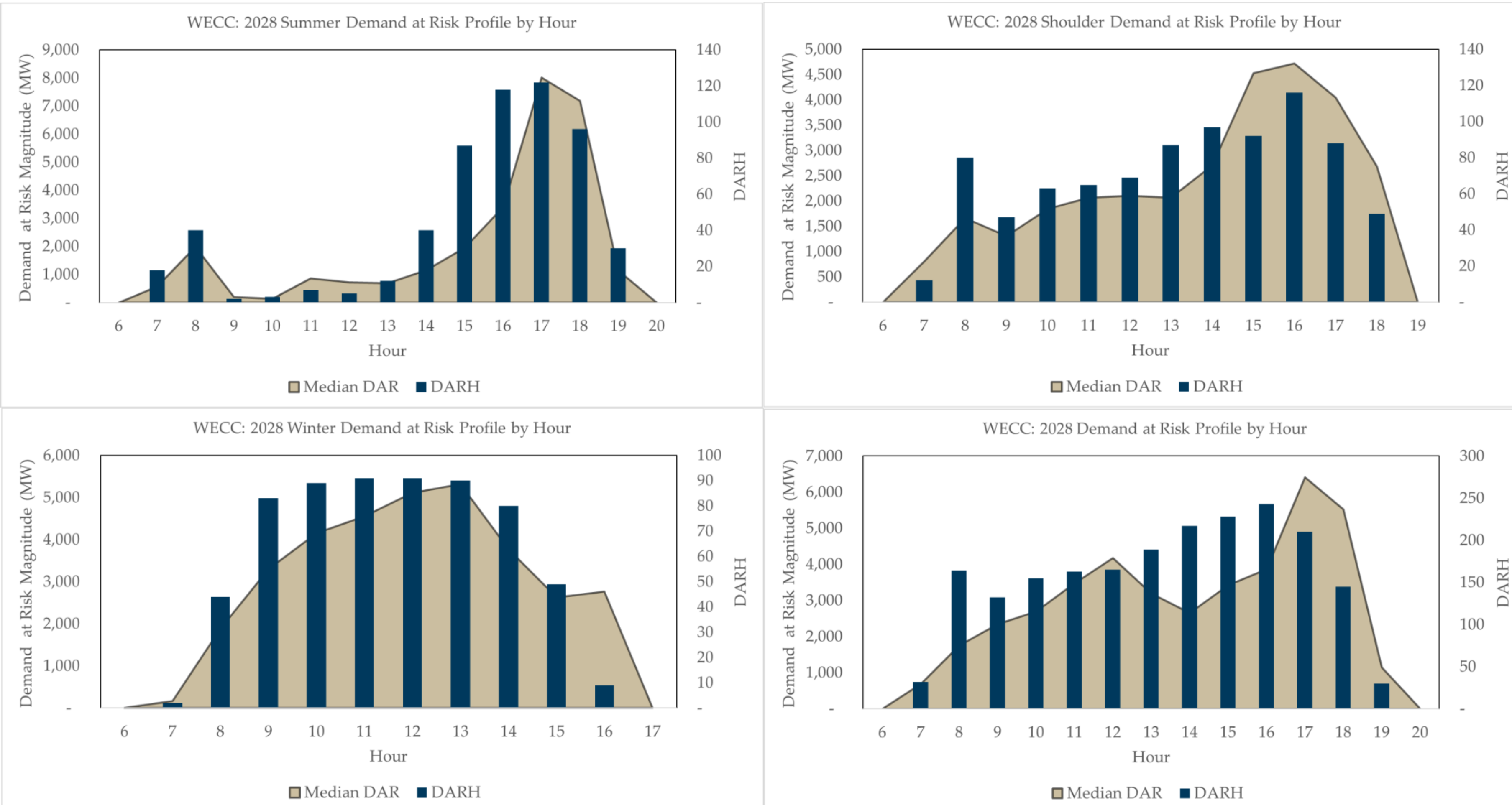


Figure 3: DARHs and corresponding magnitude by hour of day for 19% Peak PRM by season. The bottom-right chart shows the year-round perspective.

The Total Reliability PRM projected for the Western Interconnection in 2028 is 28%. The PRM needed to ensure the peak demand hour for 2028 meets the ODITY threshold is 19%. If the Peak Demand PRM is applied to the entire year, 2,073 hours are projected to fall short of the ODITY threshold. If a 15% PRM was applied to all hours of the year, 3,979 hours are shown to fall short of the ODITY threshold. As shown in Table 1, both the Total Reliability PRM and the Peak PRM increase throughout the 10-year assessment period. This corresponds to an increasing share of VERs within the Western Interconnection's resource portfolio. VER additions with corresponding retirements of baseload generation add uncertainty to a generating portfolio, which corresponds to an increase in reserve margin required to maintain resource adequacy[3].

Figure 2 shows the frequency and magnitude of DARHs at both the Fixed PRM and Peak PRM scenarios. At the 19% Peak PRM, the shoulder and winter months tend to have a higher frequency of DARHs, whereas the summer season shows the greatest magnitude of demand at risk. This is reflective of winter and shoulder seasons in the Western Interconnection having a greater propensity for resource availability risk, whereas summer risk is more associated with extreme demand[4]. However, if one continues to increase the PRM toward the Total Reliability PRM, a point is reached where the winter and shoulder season DARHs are mitigated. This occurs at a PRM of 26%. Since the magnitude of demand at risk in the winter and shoulder seasons are lower than that of the summer, they dissipate at lower PRMs. At a PRM of 26%, only 12 DARHs during the summer remain.

The significant amount of DARHs observed at the Peak PRM for the Western Interconnection indicates the peak hour is not always where the system will experience difficulty in maintaining the ODITY threshold. Figure 3 shows a risk profile by time of day for the Peak PRM for each season. During the summer and shoulder seasons, hours 16:00 through 18:00 show the highest frequency and magnitude of demand at risk. Hour beginning 16:00 is the peak hour for the Western Interconnection, but demand remains elevated through 18:00. This elevated demand, coupled with declining solar output, accounts for much of the demand at risk. During the winter, solar capacity factors are reduced significantly compared to other times of the year. This accounts for the shape of the winter DARHs resembling that of an hourly profile for solar output.

[3] Additional information on the relationship between VERs and uncertainty may be found in Appendix A of the 2024 Western Assessment of Resource Adequacy.

[4] Demand and supply volatility by subregion and season may be found in Appendix D of the 2024 Western Assessment of Resource Adequacy.

California & Mexico (CAMX)

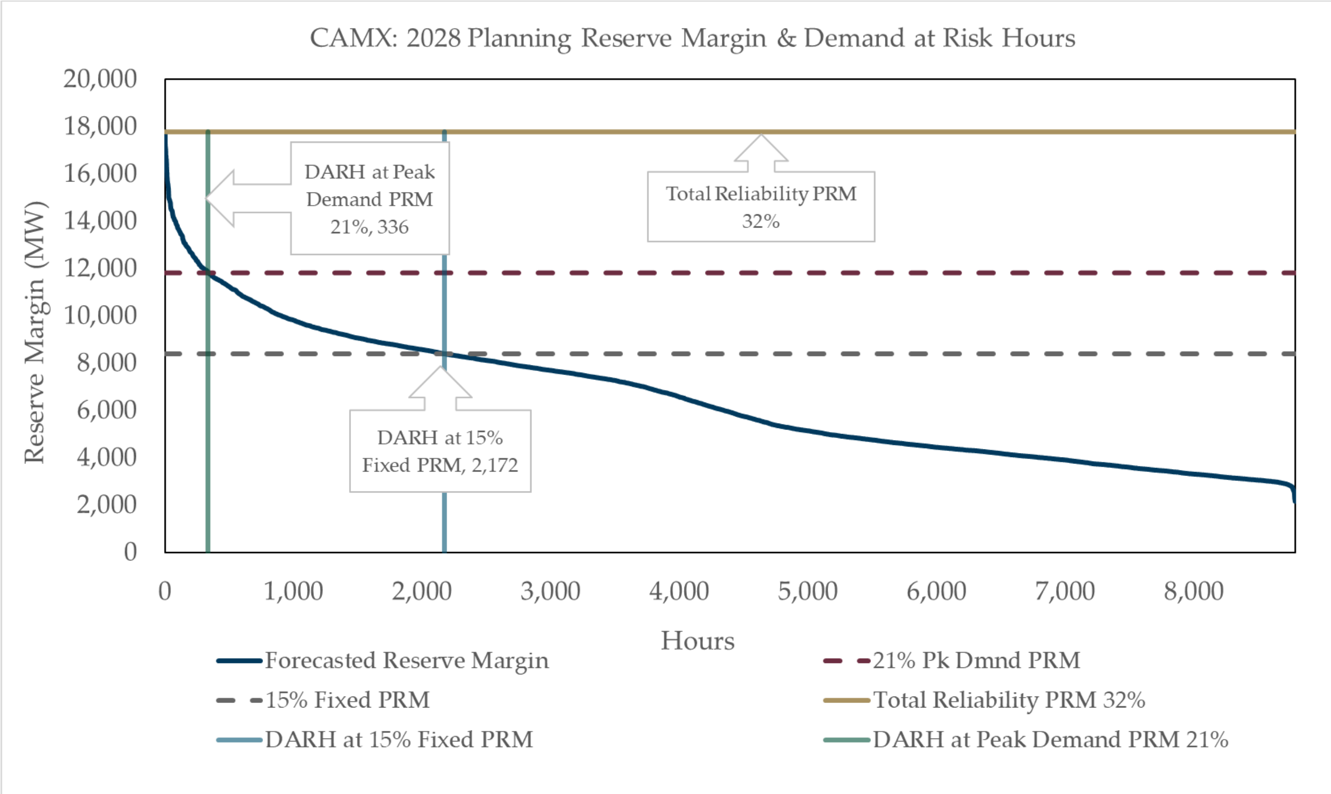


Figure 4: PRMs and their impact on DARHs for CAMX.

Table 2: Total Reliability, Peak, and Fixed PRMs by year for the CAMX subregion.

Planning Reserve Margins		2025	2028	2031	2034
CAMX	Peak Demand	54,543	55,965	60,675	65,812
	Total Reliability PRM	28.9%	31.8%	33.1%	34.2%
		15,790	17,782	20,094	22,483
	Peak PRM	19.5%	21.1%	21.5%	22.1%
		10,634	11,817	13,019	14,552
	Fixed PRM	15.0%	15.0%	15.0%	15.0%
		8,181	8,395	9,101	9,872

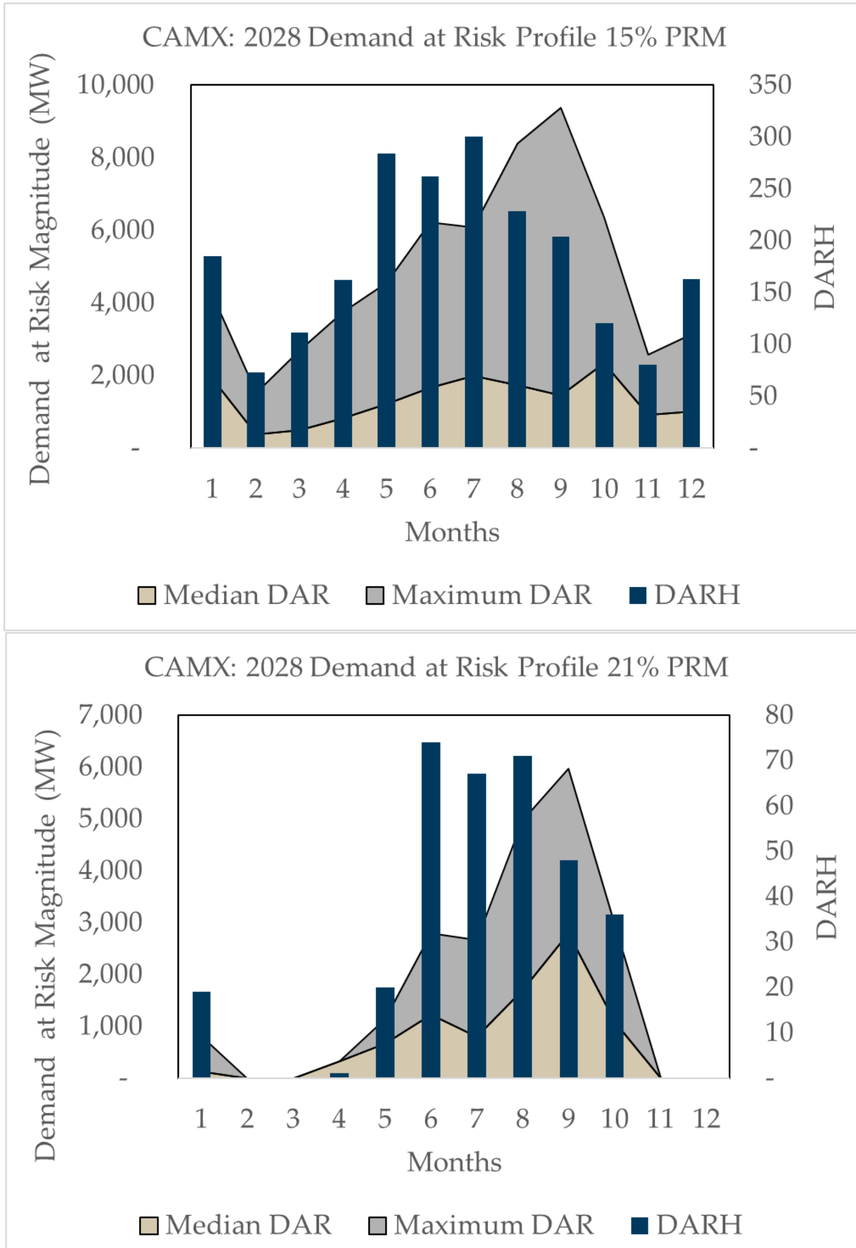


Figure 5: DARH frequency and corresponding magnitude by month for the 15% Fixed and 21% Peak PRM.

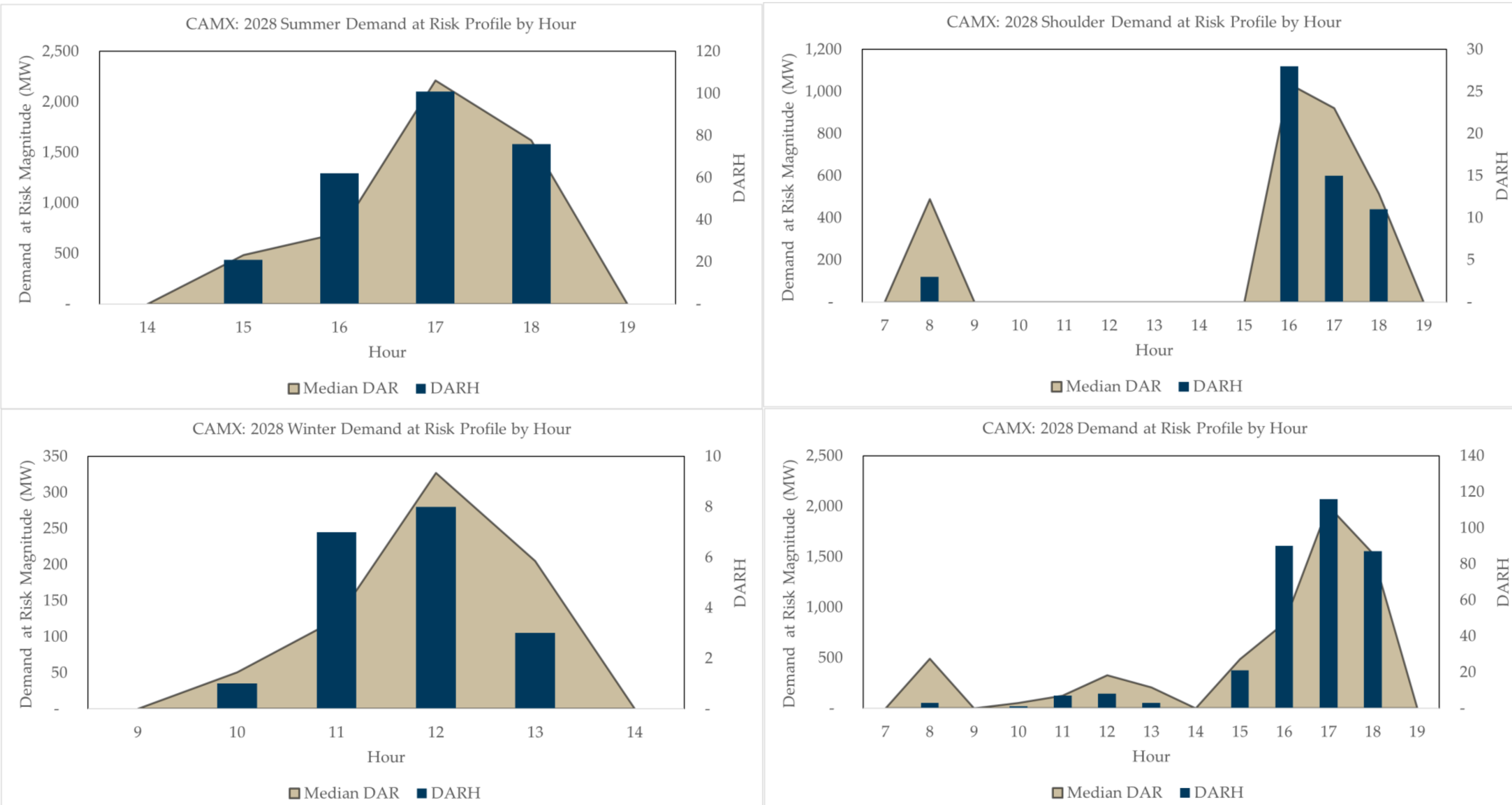


Figure 6: DARHs and corresponding magnitude by hour of day for the 21% peak PRM. The bottom-right chart shows the year-round perspective.

The Total Reliability PRM for the CAMX subregion in 2028 is projected to be just below 32%. The PRM required to ensure the peak demand hour for 2028 meets the ODITY threshold is 21%. If the Peak Demand PRM is applied to the entire year, 336 hours are anticipated to be below the ODITY threshold. If a 15% fixed PRM was applied to all hours of the year, 2,172 hours would be at risk to fall short of the ODITY threshold. As can be seen in Table 2, both the Total Reliability PRM and the Peak PRM increase throughout the 10-year forecast period. This is driven by an influx of solar and wind resources to the CAMX subregion, as well as natural gas and coal retirements, which have the combined impact of increasing uncertainty.

Figure 5 displays the monthly profiles of DARH frequency and magnitude for the Fixed PRM of 15% and the Peak PRM of 21%. The 6% increase in PRM results in winter and shoulder season DARHs dropping off significantly. If the PRM were to be increased to 23%, winter and shoulder season DARHs are mitigated completely. The potential for extreme heat events is highest during the summer, which corresponds with the timeframe of DARHs seen in the Peak PRM scenario.

Figure 6 shows DARHs by time of day at the Peak PRM. CAMX shows the smallest amount of DARHs at the Peak PRM of all subregions. During the summer season, the system is most stressed at the peak hour of 16:00. Most DARHs occur from hours 16:00 through 19:00. CAMX has a high solar contribution that declines in the evening whereas demand remains elevated. CAMX does show a large addition of BESS resources over the next 10 years, which may help mitigate this evening risk. Minimal DARHs are shown during the winter, however, the DARHs that are present correspond with reduced solar output from hours 10:00 through 14:00. No DARHs are observed overnight at the Peak PRM.

Desert Southwest (DSW)

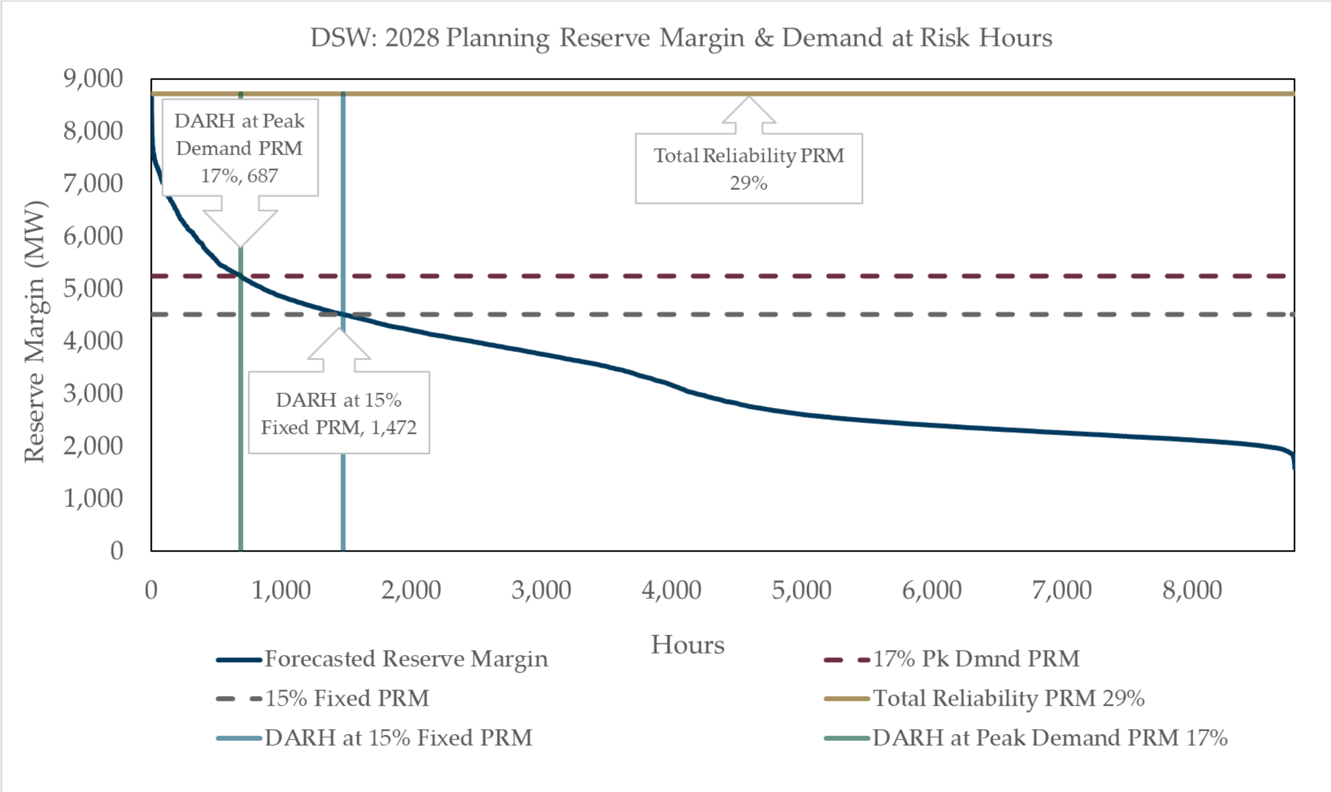
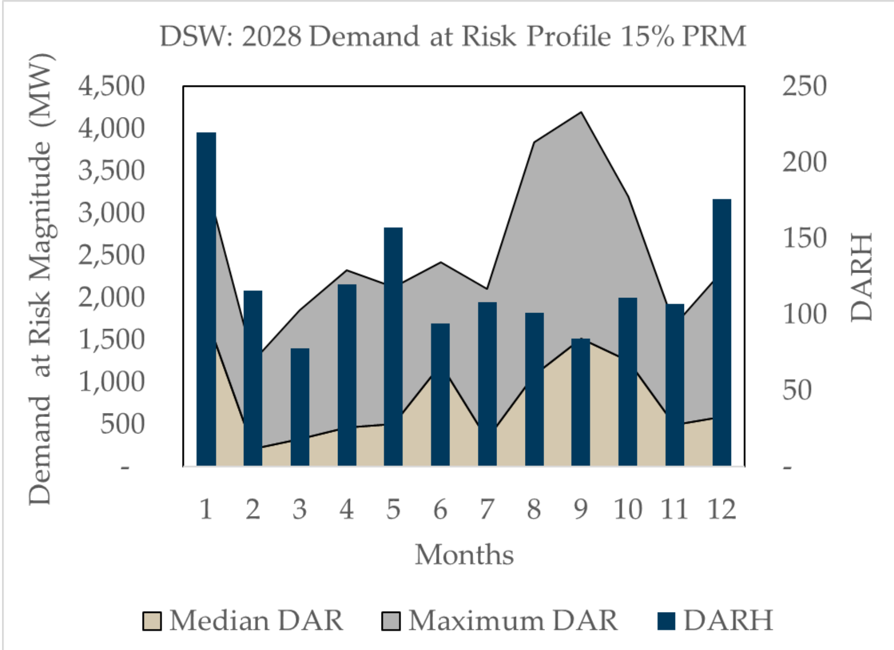


Figure 7: PRMs and their impact on DARHs for the DSW.

Table 3: Total Reliability, Peak, and Fixed PRMs by year for the DSW subregion.

Planning Reserve Margins		2025	2028	2031	2034
DSW	Peak Demand	27,679	30,099	32,171	33,916
	Total Reliability PRM	22.2%	29.0%	31.4%	33.9%
		6,153	8,717	10,111	11,494
	Peak PRM	13.5%	17.4%	16.4%	18.5%
		3,734	5,245	5,272	6,371
	Fixed PRM	15.0%	15.0%	15.0%	15.0%
		4,152	4,515	4,826	5,087



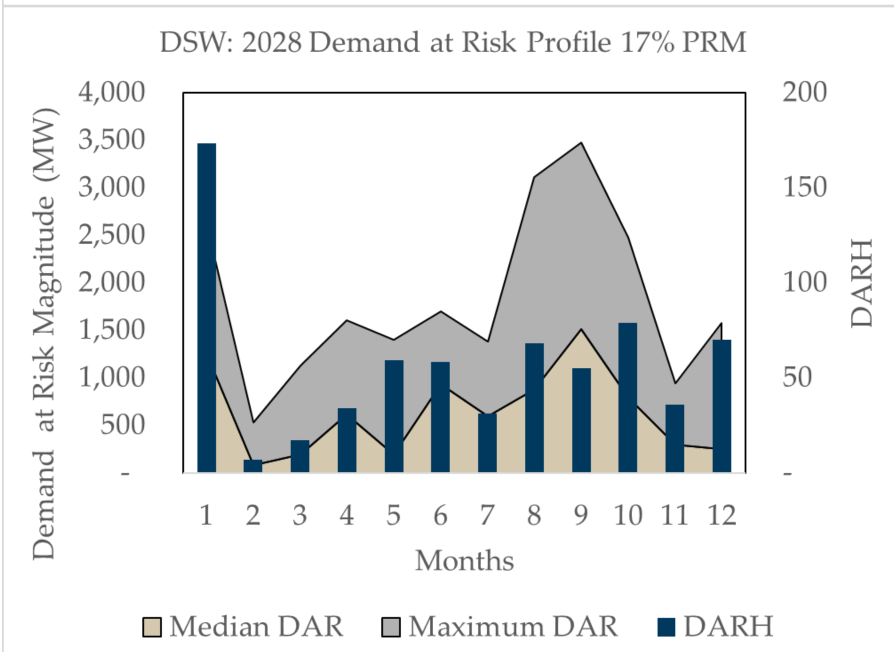


Figure 8: DARH frequency and corresponding magnitude by month for the 15% Fixed and 17% Peak PRM.

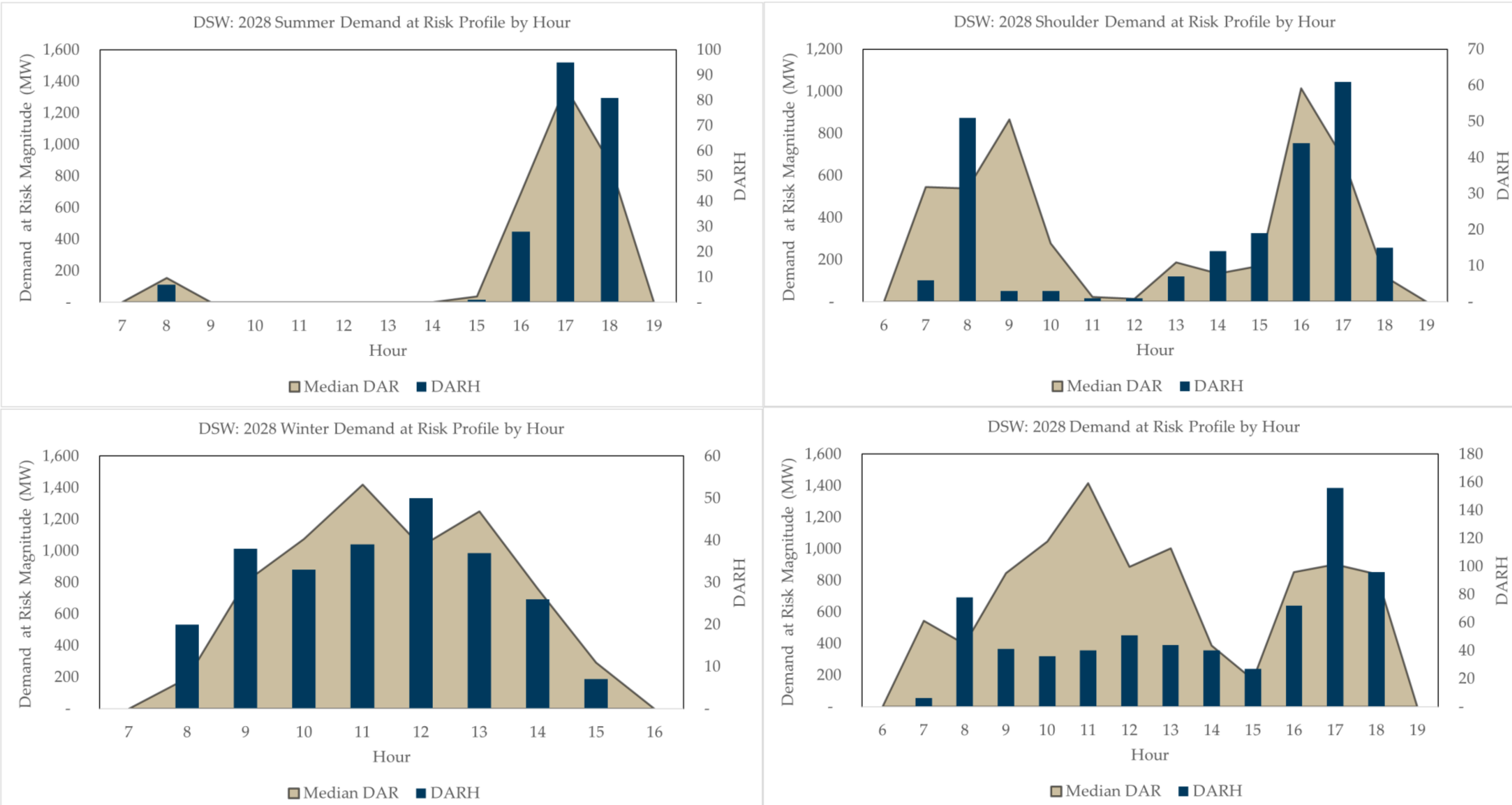


Figure 9: DARHs and corresponding magnitude by hour of day for the 17% Peak PRM. The chart in the bottom right shows the year-round perspective.

The Total Reliability PRM for the DSW in 2028 is forecast at 29%. The PRM required to ensure the peak demand hour for 2028 meets the ODITY threshold is 17%. If the Peak Demand PRM is applied to the entire year, 687 hours would remain below the ODITY threshold. If a 15% PRM was applied to all hours of 2028, 1,472 hours are projected to be at risk to fall short of the ODITY threshold. As shown in Table 3, the Total Reliability PRM and Peak PRM generally increase over the 10-year assessment period. The DSW portfolio will have major additions for solar and wind resources coinciding with natural gas and coal retirements, increasing the uncertainty of its generation portfolio.

Figure 8 displays the DARHs by month for the 15% and 17% PRMs. Spring and early summer DARHs drop off significantly with the 2% increase in PRM, as do the late fall DARHs. December and January DARH frequency remains high at the Peak PRM. The DSW has a large generating contribution from solar resources, and solar capacity factors in the winter months are reduced significantly in comparison to other times of the year. In addition, recent events such as Winter Storm Uri and Winter Storm Elliott reached as far south as New Mexico. Non-winterized natural gas performance and the increased demand during these times increased the DARH frequency and magnitude in the winter[5]. The greatest demand at risk magnitude is concentrated in the summer and early fall seasons. If the PRM were increased to approximately 26%, only summer DARHs would remain. This indicates that shortages of resource availability during extreme heat events would result in the greatest potential shortfall of supply.

Figure 9 displays the seasonal DARH profiles by time of day for the DSW for the Peak PRM. 16:00 is the peak hour for the DSW subregion, and the greatest frequency for DARHs in the summer and shoulder seasons is concentrated from 16:00 through 19:00. This indicates that waning solar output coinciding with elevated demand is a risk. A large addition of BESS resources is anticipated over the next 10 years, which will help mitigate this concern. The DSW hourly winter demand at risk profile mirrors a typical solar output profile, indicating that reduced solar availability is a risk during the winter. The DSW does not display DARHs overnight at the Peak PRM.

[5] See Appendix B of the 2024 Western Assessment of Resource Adequacy for additional information on how historic demand and resource performance influences MAVRIC results.

Northwest-Central (NW-Central)

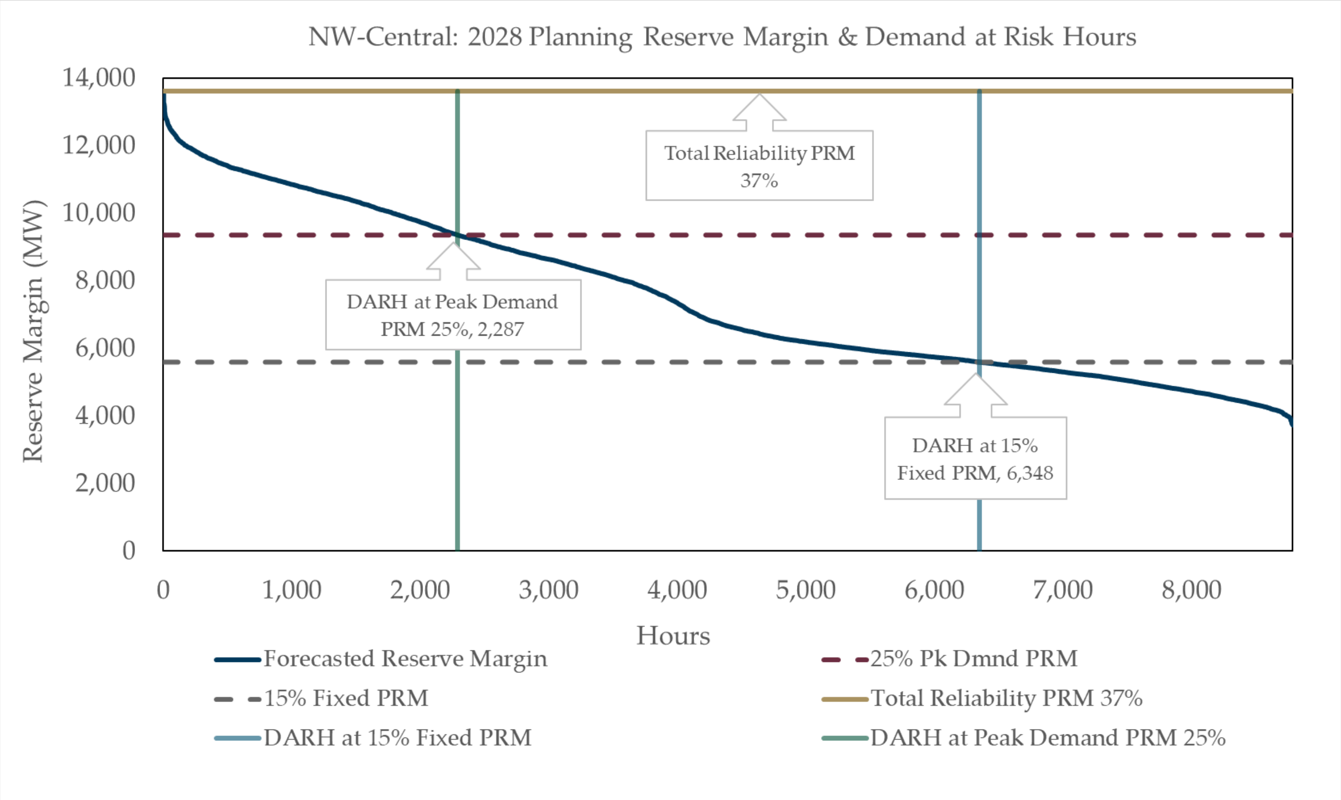
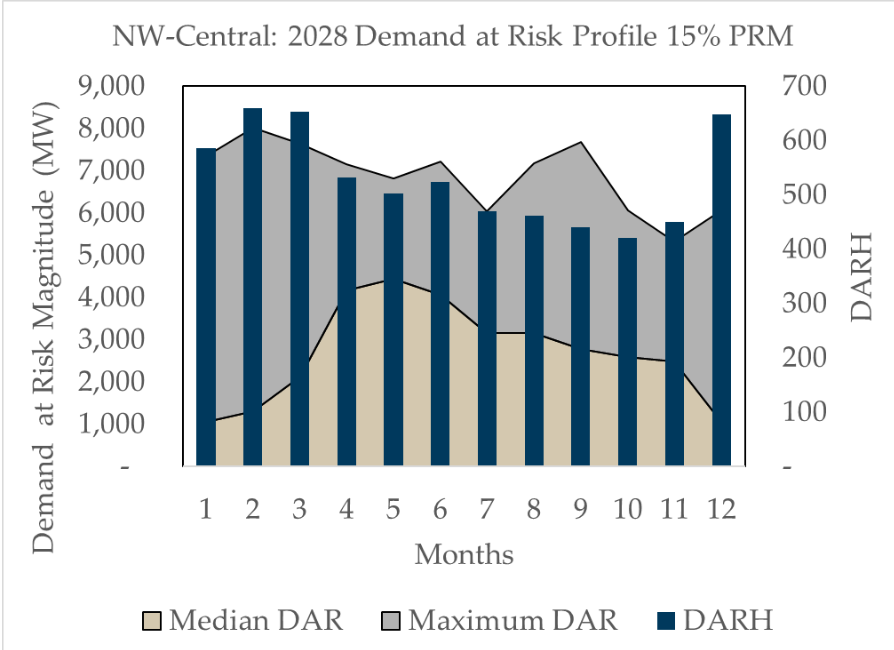


Figure 10: PRMs and their impact on DARHs for NW-Central.

Table 4: Total Reliability, Peak, and Fixed PRMs by year for the NW-Central subregion.

Planning Reserve Margins		2025	2028	2031	2034
NW-Central	Peak Demand	35,967	37,286	38,542	39,551
	Total Reliability PRM	25.4%	36.5%	48.4%	49.2%
		9,142	13,615	18,659	19,472
	Peak PRM	18.3%	25.1%	28.6%	26.9%
		6,594	9,355	11,018	10,648
	Fixed PRM	15.0%	15.0%	15.0%	15.0%
		5,395	5,593	5,781	5,933



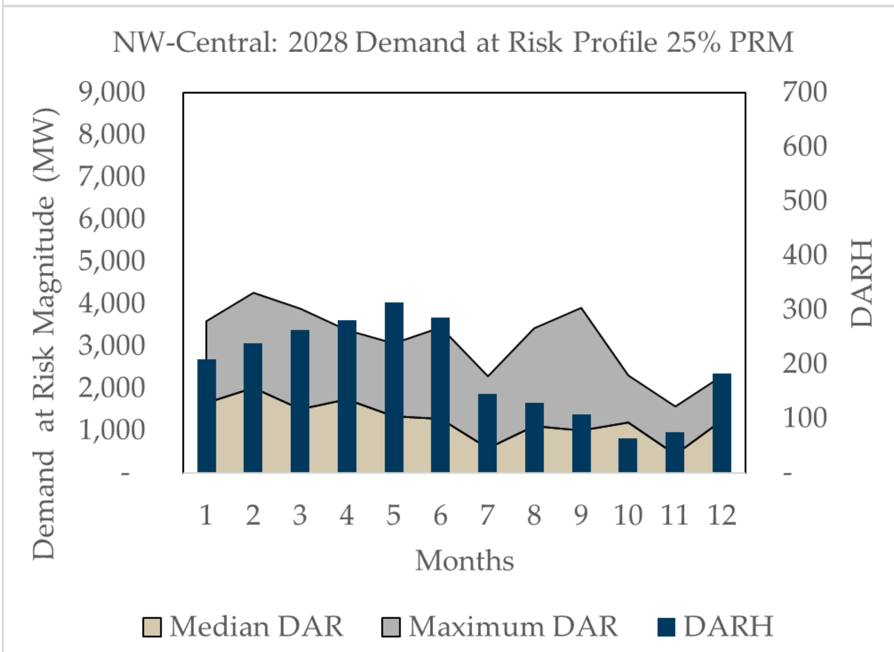


Figure 11: DARH frequency and corresponding magnitude by month for the 15% Fixed and 25% Peak PRM.

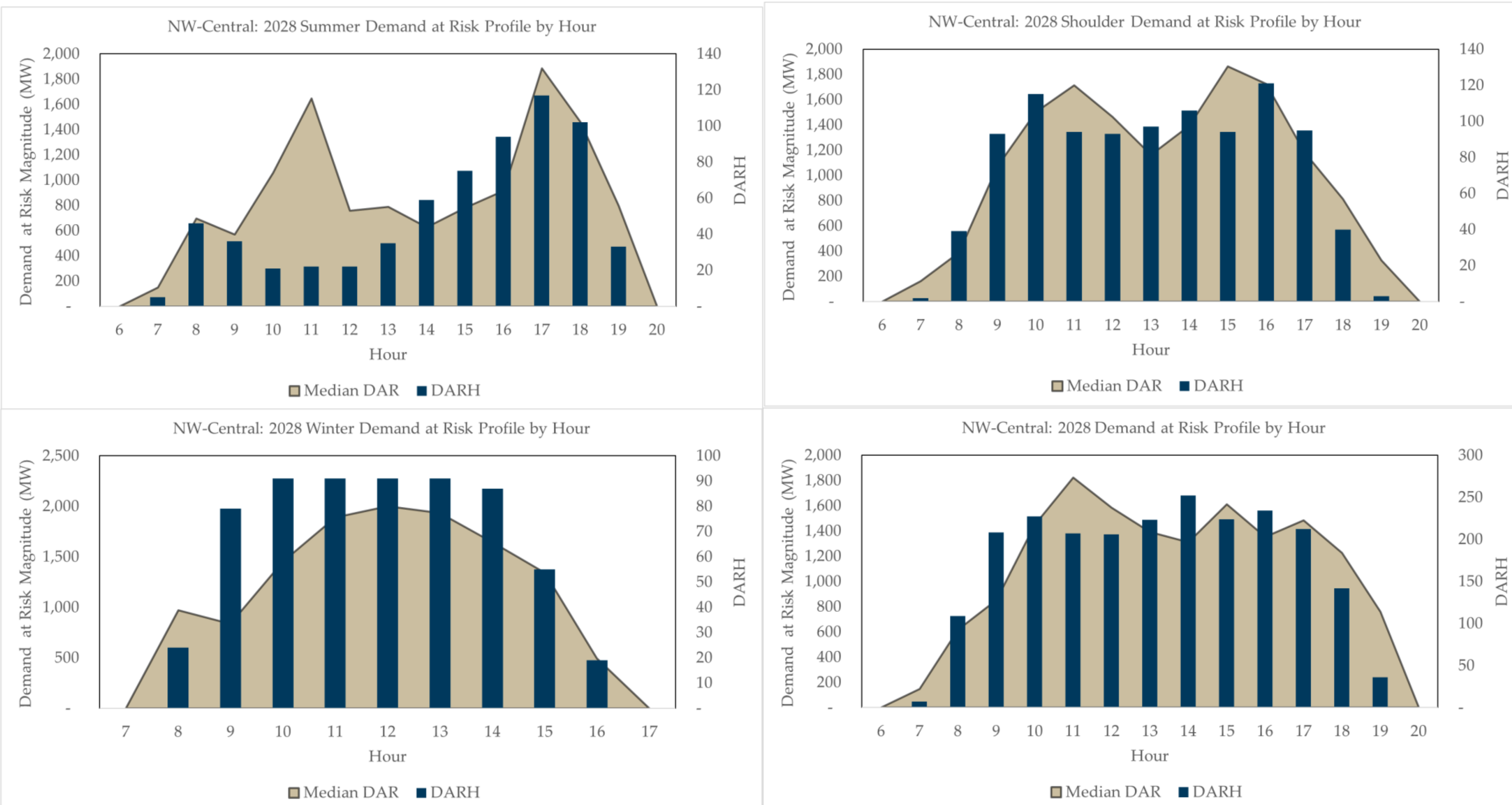


Figure 12: DARHs and corresponding magnitude by hour of day for the 25% peak PRM. The chart in the bottom right shows the year-round perspective.

The Total Reliability PRM for the NW-Central subregion in 2028 is projected to be 37%. The PRM required to ensure the peak demand hour for 2028 meets the ODITY threshold is 25%. If the Peak Demand PRM is applied to the entire year, 2,287 hours are projected to be below the 99.98% reliability threshold. If a 15% PRM was applied to all hours of the year, 6,348 hours would be at risk to fall short of the ODITY threshold. The NW-Central Total Reliability PRM is the highest in the Western Interconnection. The NW-Central subregion is projected to have just under 30% of its portfolio on a capacity basis composed of wind resources, which carry the greatest variability in output of any VER type[6]. Projected solar additions combined with those of the wind would make up just under 50% of the NW-Central's portfolio in 2028. Natural gas and coal retirements, coupled with continued additions of solar and wind resources will further increase uncertainty in energy output. This results in the Total Reliability PRMs and Peak PRMs generally increasing over the next decade.

Figure 11 shows the decrease in DARHs when increasing the PRM from 15% to 25%. In both cases, most DARHs are projected to occur in the winter and spring. This is due to the reduction in solar availability, the potential for extreme cold weather events, and the high variability of wind resources during the winter months. The subregion also includes both summer and winter peaking areas, which accounts for the somewhat evenly spread demand at risk magnitude throughout the year.

Figure 12 shows the DARH profiles by time of day and season for the 25% Peak PRM. The significant amount of DARHs observed at the Peak PRM indicates that the peak hour is not consistently where the system will experience the greatest strain. The DARHs during the summer season correspond with the peak demand hours of the summer-peaking entities, as well as the immediate hours afterward, during which solar output declines in the evening. The winter DARHs correspond with hours during the middle of the day, which indicates risk from reduced solar availability for the winter-peaking areas. It follows that the shoulder DARHs are a blend of the summer and winter DARH profiles. In the shoulder season, maximums of DARH frequency and magnitude occur both in the morning and the evening peak hours, with a somewhat uniform spread of DARHs between these periods. No DARHs are observed overnight.

[6] Appendix D of the 2024 Western Assessment of Resource Adequacy provides resource portfolio data by subregion.

Northwest-Northeast (NW-NE)

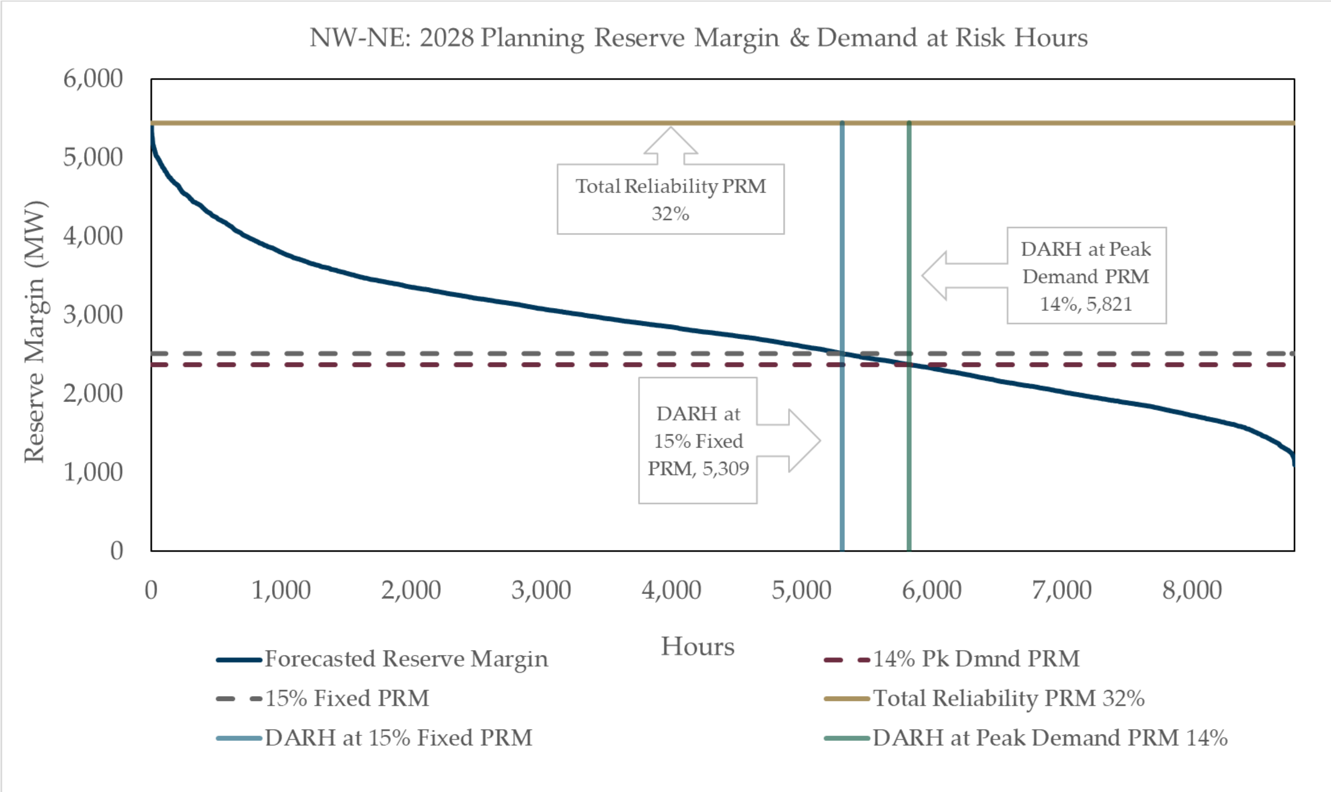


Figure 13: PRMs and their impact on DARHs for the NW-NE.

Table 5: Total Reliability, Peak, and Fixed PRMs by year for the NW-NE subregion.

Planning Reserve Margins		2025	2028	2031	2034
NW-NE	Peak Demand	16,143	16,745	16,667	17,527
	Total Reliability PRM	30.9%	32.5%	35.7%	35.9%
		4,987	5,440	5,943	6,292
	Peak PRM	13.4%	14.2%	15.5%	15.5%
		2,170	2,371	2,590	2,721
	Fixed PRM	15.0%	15.0%	15.0%	15.0%
		2,421	2,512	2,500	2,629

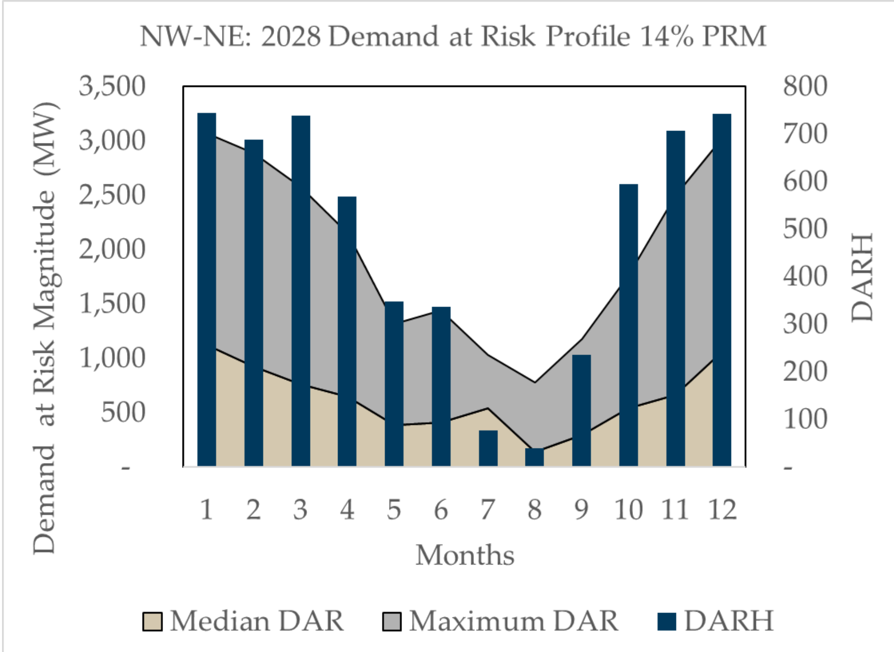


Figure 14: DARH frequency and corresponding magnitude by month for the 14% Peak PRM. The 15% Fixed PRM profile is not shown, as it is similar to the above.

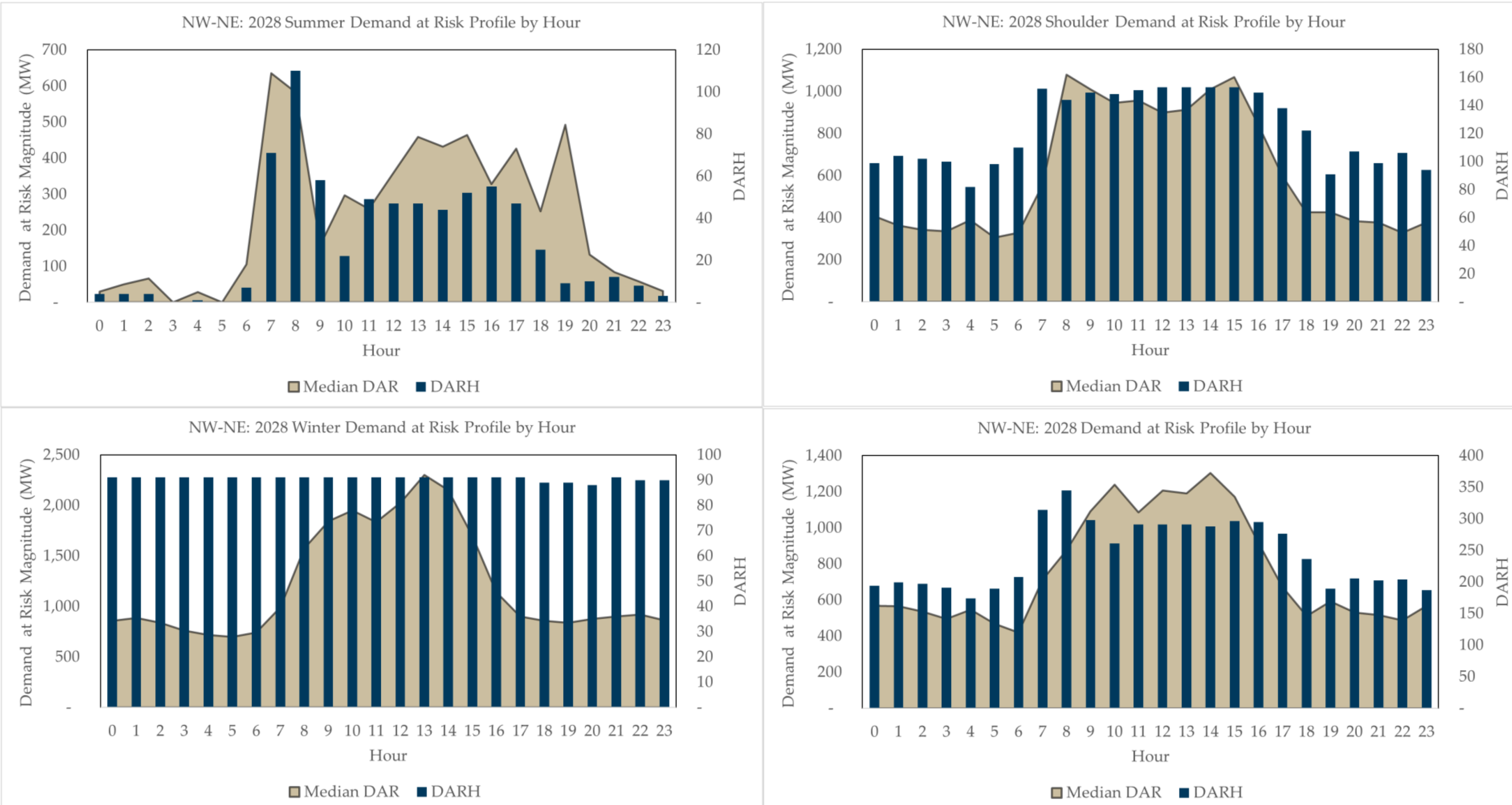


Figure 15: DARHs and corresponding magnitude by hour of day for the 14% Peak PRM. The bottom-right chart shows the year-round perspective.

The Total Reliability PRM for the NW-NE subregion in 2028 is projected to be approximately 32%. The PRM required to ensure the peak demand hour for 2028 meets the ODITY threshold is 14%. If the Peak Demand PRM is applied to the entire year, 5,821 hours would remain below the 99.98% reliability threshold. If the 15% Fixed PRM was applied to all hours of the year, 5,309 hours would be at risk to fall short of the ODITY threshold. Wind makes up a substantial share of the 2028 NW-NE portfolio from a capacity basis, and wind resources carry the greatest variability in output for VER resource types. As such, a high Total Reliability PRM is required to ensure the ODITY threshold can be met for all hours of the year. As shown in Table 5, the Total Reliability PRM and the Peak PRM generally increase throughout the 10-year assessment period. This is driven by coal retirements and the large-scale incorporation of solar and wind resources into this subregion.

Figure 14 displays the DARHs and magnitude by month with the implementation of the 14% Peak PRM for the entire year. At a 14% PRM, the winter and shoulder seasons carry the greatest risk for the subregion. The winter months have the highest uncertainty of demand and supply for this subregion, leading to the increased DARH frequency for these months[7]. Elevated demand during extreme weather events such as Winter Storms Uri, Elliott, and Heather contribute to the high magnitude of DARHs in the winter, and the decrease in solar contribution during these months is a driver of the high frequency of DARHs. Summer DARHs are projected to be completely mitigated in 2028 if a PRM of 23% is applied.

The NW-NE subregion has the greatest amount of DARHs observed at the Peak PRM of all subregions in the Western Interconnection. This indicates that there are many hours outside the peak demand hour in which the system will experience strain. Figure 15 confirms this, as the demand at risk profile for the 14% Peak PRM shows DARHs for almost every hour of the day for all seasons. During the winter, every hour of almost every day shows demand at risk. This is a clear indicator that a 14% PRM would not be sufficient. The NW-NE is a dual-peaking subregion and, for 2028, the peak was in the summer. Despite that, the subregion averages approximately 9% lower PRMs required to maintain the ODITY threshold in the summer than in the winter. If one were to apply the average PRM of the winter required to maintain the ODITY threshold (25%), most DARHs in the winter would be associated with reduced solar output during the middle of the day from 8:00 to 15:00, and summer DARHs would be mitigated.

[7] See Appendix D of the 2024 Western Assessment of Resource Adequacy for information regarding the NW-NE's demand and energy volatility during the winter months.

Northwest-Northwest (NW-NW)

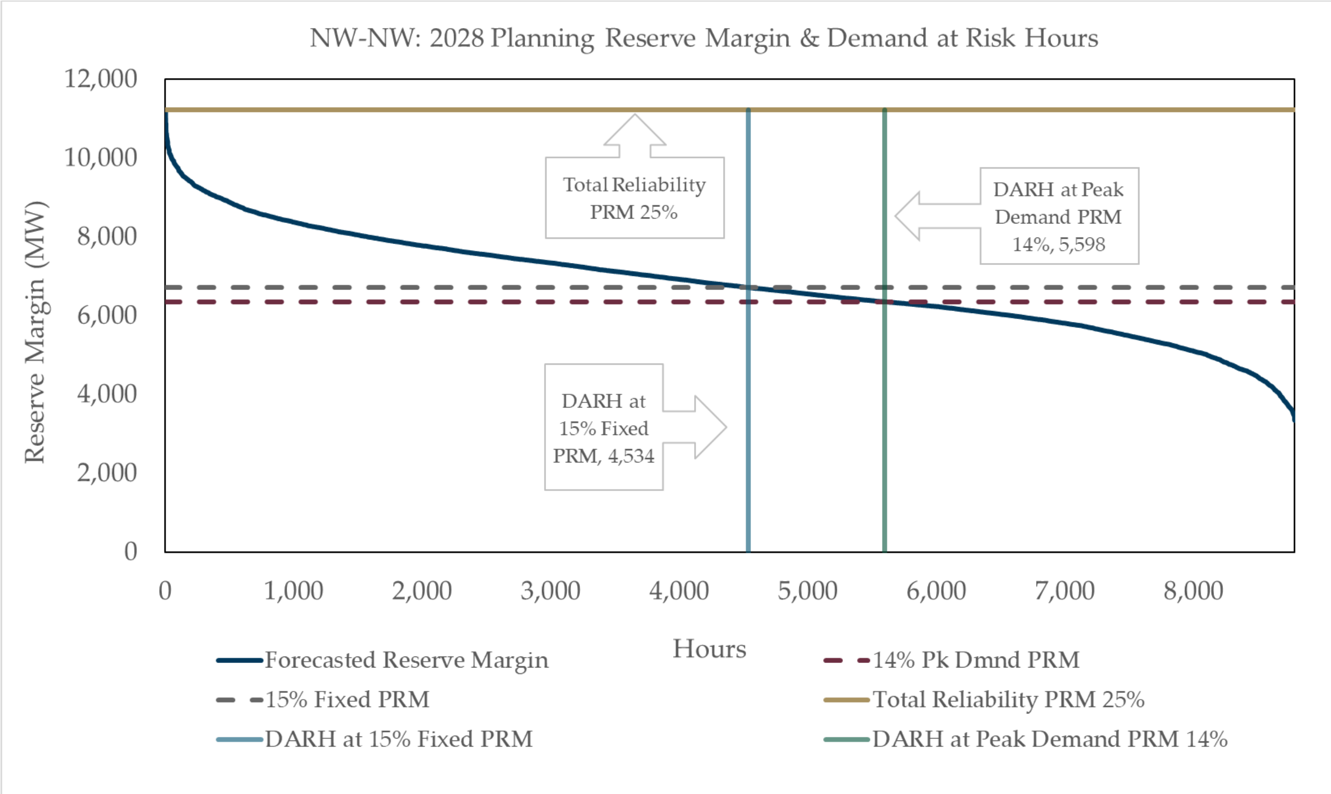


Figure 16: PRMs and their impact on DARHs for the NW-NW.

Table 6: Total Reliability, Peak, and Fixed PRMs by year for the NW-NW subregion.

Planning Reserve Margins		2025	2028	2031	2034
NW-NW	Peak Demand	41,706	44,766	46,333	47,356
	Total Reliability PRM	23.1%	25.1%	24.6%	25.1%
		9,626	11,227	11,388	11,879
	Peak PRM	14.8%	14.2%	16.5%	16.7%
		6,193	6,350	7,635	7,922
	Fixed PRM	15.0%	15.0%	15.0%	15.0%
		6,256	6,715	6,950	7,103

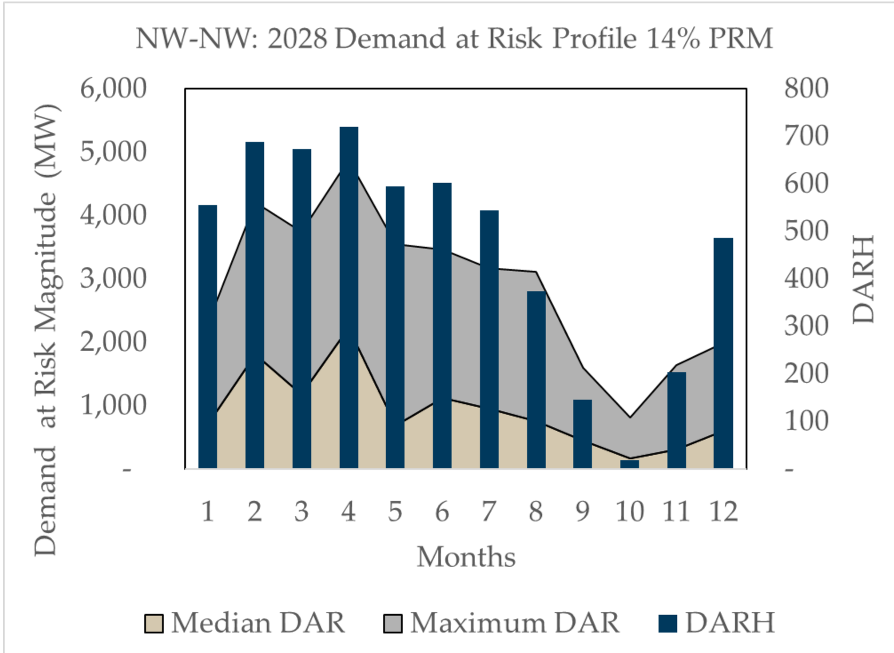


Figure 17: DARH frequency and corresponding magnitude by month for the 14% Peak PRM. The 15% Fixed PRM profile is not shown, as it is similar to the above.

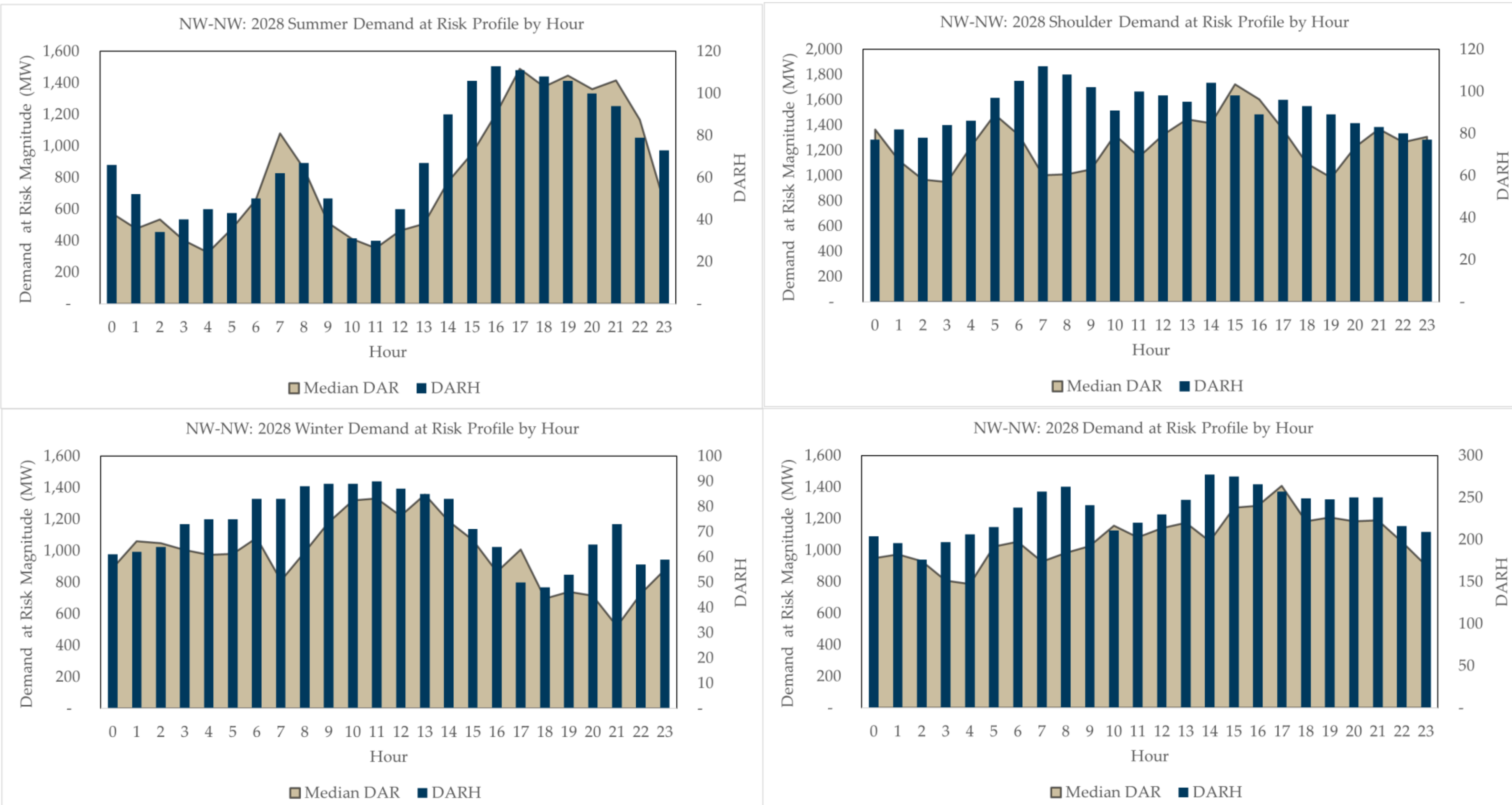


Figure 18: DARHs and corresponding magnitude by hour of day for the 14% Peak PRM. The chart in the bottom right shows the year-round perspective.

The Total Reliability PRM for the NW-NW subregion in 2028 is projected to be approximately 25%. The PRM required to ensure the peak demand hour for 2028 meets the ODITY threshold is 14%. If the Peak Demand PRM is applied to the entire year, 5,598 hours would remain below the 99.98% reliability threshold. If the 15% Fixed PRM was applied to all hours of the year, 4,534 hours would be at risk to fall short of the ODITY threshold. Unlike the other subregions, from a percentage-of-peak-demand standpoint, Table 6 shows a relatively flat profile for the Total Reliability PRM and the Peak PRM. The NW-NW resource portfolio is over 70% hydro generation[8], and this is not anticipated to change much over the next 10 years. Other subregions need to replace baseload resources with a large amount of VERs to meet clean-energy mandates; however, due to the large share of hydro in this subregion, NW-NW does not need to alter its portfolio to the same degree.

Figure 17 displays the DARHs and magnitude by month with the implementation of the 14% Peak PRM for the entire year. NW-NW is a winter-peaking subregion and carries the greatest demand uncertainty during the winter months due to extreme cold weather events. This greater volatility of demand coincides with low hydro output from December through April, resulting in this period having the greatest frequency and magnitude of DARHs.

Figure 18 provides the 2028 demand at risk profile at a 14% PRM by time of day and season in the NW-NW subregion. The NW-NW has a significant amount of DARHs observed at the Peak PRM, indicating that hours besides the peak demand hour will also be stressed. DARHs are present for every hour of all seasons at a 14% PRM, with most occurring in the winter. As such, the 14% Peak PRM would be insufficient to maintain reliability in the NW-NW. The Peak PRM for the NW-NW is 7% below the 2028 projected average PRM for maintaining the ODITY threshold, which is closer to 22%. Applying a 22% PRM would mitigate nearly all DARH in the summer, and leave only winter and shoulder season DARHs, primarily from 12:00 through 18:00.

[8] See Appendix D of the 2024 Western Assessment of Resource Adequacy for further information on the NW-NW's generating portfolio and demand volatility.

Takeaways

1. A 15% PRM will not be sufficient to ensure resource adequacy in the Western Interconnection. The least amount of DARHs in 2028 at a 15% PRM was 1,472 hours in the DSW. This means the subregion with the least risk at a 15% PRM still shows that 17% of the year will fall short of the ODITY threshold.
2. The Peak PRM is also insufficient to ensure resource adequacy in the Western Interconnection. Over 60% of the year would fall short of the ODITY threshold for the Northwest subregions at the Peak PRM. CAMX, which shows the least DARHs at the Peak PRM, still shows 336 DARHs. This is 4% of the year that would fall short of the ODITY threshold. This indicates that there are many hours with greater resource adequacy risk than the peak hour.

- In 2028, all subregions except NW-Central appear to have a PRM that will mitigate risk in the off-peak season. CAMX and the DSW mitigate winter DARHs at a 23% and 26% PRM, respectively. The NW-NE and the NW-NW can mitigate nearly all summer DARHs at PRMs of 25% and 22%, respectively.
- Winter DARHs are primarily associated with a reduction in solar output.
- Summer DARHs primarily coincide with declining solar output after the evening peak.

3. In all subregions except the NW-NW, the PRMs required to maintain the ODITY threshold will increase as VERs are added to the system. Methods to decrease the PRM required to maintain the ODITY threshold include adding dispatchable resources or BESS, increasing energy efficiency efforts, or coordinating via a market structure or resource adequacy program.
4. An increasing frequency of widespread extreme weather events in the West will also increase the PRMs required to maintain the ODITY threshold. Widespread extreme weather events increase demand over a large area, thereby limiting transfer capabilities from neighboring entities.