Slice of Day Workshops (D.21-07-014)

October 6, 2021

Together, Building a Better California

Desired Outcomes for Workshop #2

- **Introduce metric to determine seasons and slices**
- **Introduce straw proposals for slice-of-day framework**

Principles and Summary

Principles / Evaluation Criteria

- Balance a Reliable Electrical Grid with Minimizing Costs to Customers
- Balance Addressing Hourly Energy Sufficiency with Advancing Environmental Goals
- Balance Granularity in Meeting Hourly Needs with Simplicity and Transactability
- Implementable in the Near-Term (2024)
- To be durable and adaptable to a changing electric grid

Evaluation Against Principles

- **Reliable**
  - Use of maximum forecast value and setting requirements at the maximum values for the season and slice ensures reliability
- **Cost-Effective**
  - Requirements match load better than existing framework; some potential for excess procurement depending on final framework
- **Hourly Sufficiency**
  - Requirement for storage charging capacity ensures energy sufficiency
- **Enables Environmental Goals**
  - Better use of solar and wind than under today's framework and rewards the most effective resources for the greatest hours of need
- **Granularity**
  - Significantly more hourly granularity than under today's program
- **Simplicity and Transactability**
  - TBD depending final structure
- **Implementable**
  - Yes, but more development and discussion is needed on administrative details
- **Durable and Adaptable**
  - Yes, if setting seasons and slices with future forecast data

Key Elements

1. Forecast
2. Net or gross
3. Metric: variation metric as a tool to select seasons and slices
4. Evaluation of seasonal options
5. Evaluation of slice options
6. Straw proposals
7. Resource counting
8. Discussion

Key Elements

1. Forecast

- PG&E proposes using the maximum hourly values (in a month or season) from the IEPR CAISO-level hourly load forecast as the basis for establishing requirements in a future framework.
  - This is similar to how requirements are currently established, but on a more granular level
  - It avoids potential issues in future years when the grid has evolved and more times of the day are at risk of insufficient capacity

- Still need to coordinate with IRP in terms of what they use / assume

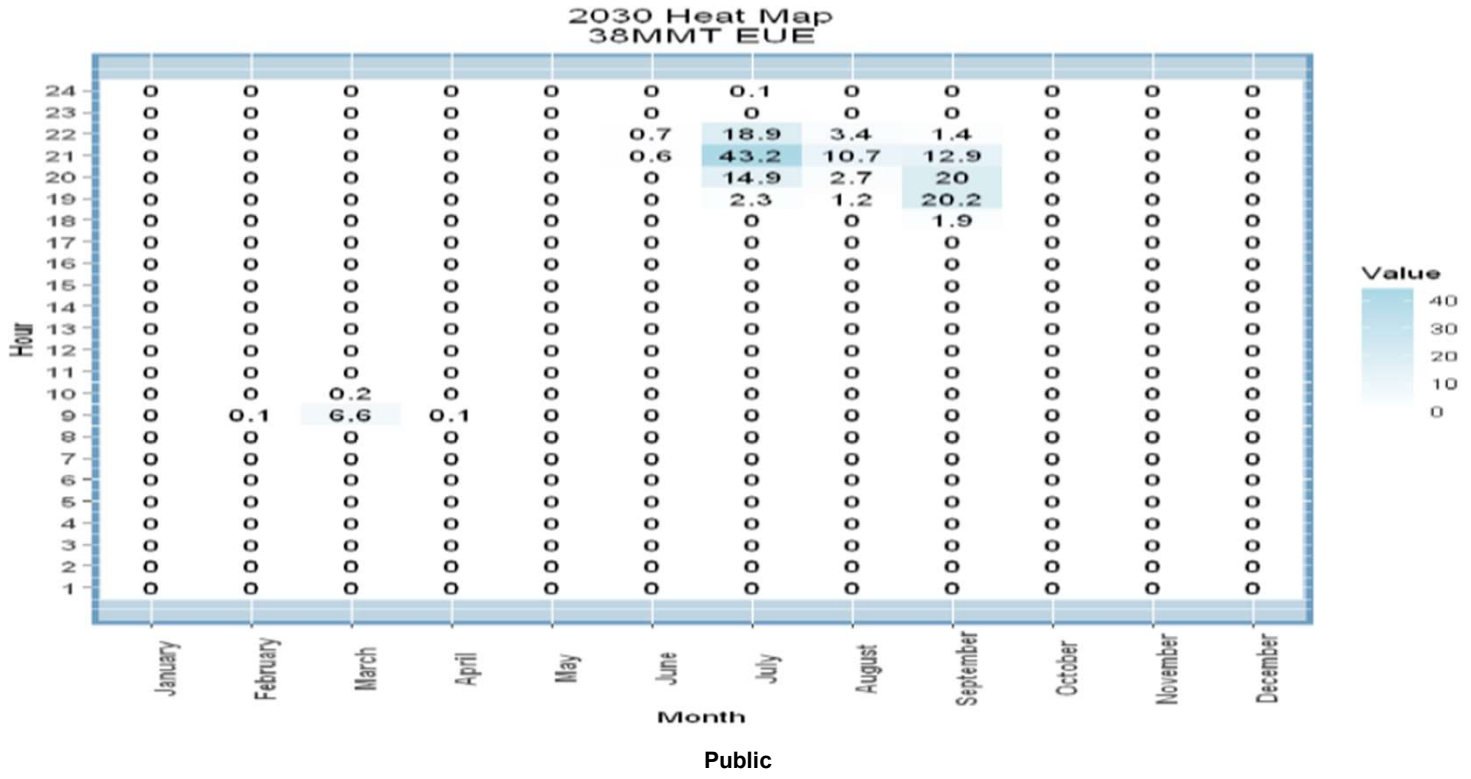
1. Forecast

- The following shows the difference between the max value approach and the worst day approach for 2030.
- We presented this graph in workshop #1.
- The variation in December, January, and March is large enough to be concerning should a worst day approach be used and that load is unaccounted for.
- **Given these potential issues we've used the max approach in setting requirements**

HE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0%	0%	3%	0%	0%	0%	0%	1%	1%	0%	1%	0%
2	0%	1%	3%	0%	0%	0%	0%	1%	1%	0%	0%	0%
3	0%	1%	2%	0%	0%	0%	0%	1%	1%	0%	0%	0%
4	0%	0%	2%	0%	0%	0%	0%	1%	0%	0%	0%	0%
5	1%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
6	0%	0%	1%	0%	0%	0%	0%	2%	0%	0%	1%	0%
7	0%	0%	1%	2%	1%	0%	0%	1%	0%	0%	1%	0%
8	0%	0%	2%	0%	0%	0%	0%	1%	0%	0%	5%	1%
9	1%	0%	6%	0%	0%	0%	0%	1%	0%	0%	7%	3%
10	4%	0%	10%	0%	0%	0%	0%	1%	0%	0%	6%	5%
11	5%	0%	13%	0%	0%	0%	0%	2%	0%	0%	5%	6%
12	4%	0%	13%	0%	0%	0%	0%	1%	0%	0%	3%	6%
13	5%	1%	11%	0%	0%	0%	0%	1%	0%	0%	1%	5%
14	4%	1%	10%	0%	0%	0%	0%	1%	0%	0%	0%	4%
15	2%	2%	7%	0%	0%	0%	0%	0%	0%	0%	0%	3%
16	0%	1%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%
17	0%	1%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%
18	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
19	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
21	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
22	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
23	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%
24	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%

1. Forecast

- IRP analysis shows that hours of concern extend beyond peak hours in 2030
- The following is from the IRP PSP SERVM analysis for the 38 MMT core case for 2030, showing expected unserved energy (EUE) by hour and month
- While most of the potential problem times are summer evening / night-time hours, a significant risk shows up in March mornings, highlighting the need to account for all hours



2. Gross or Net Load

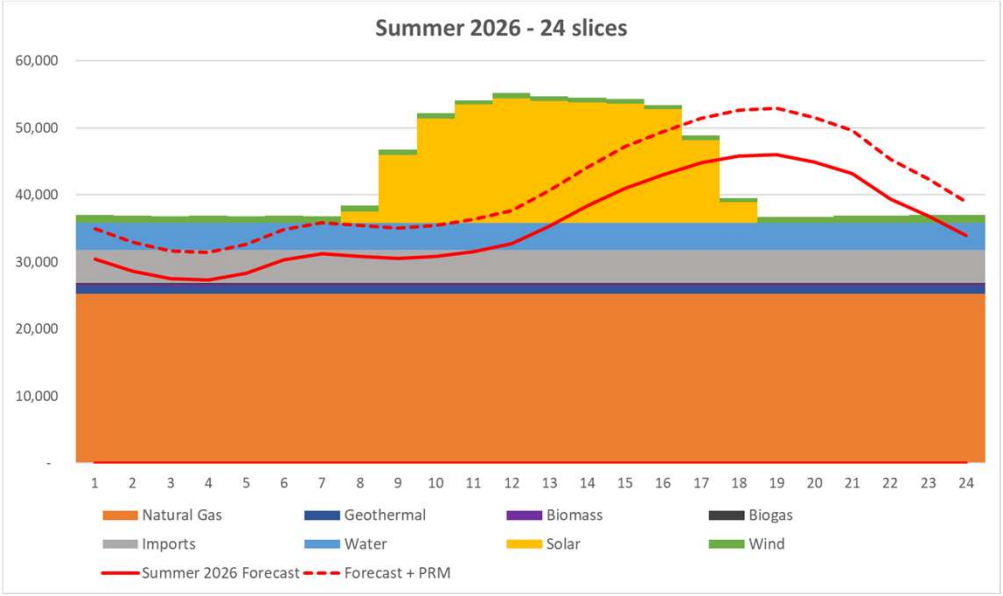
Should the load curve be on gross or net basis?

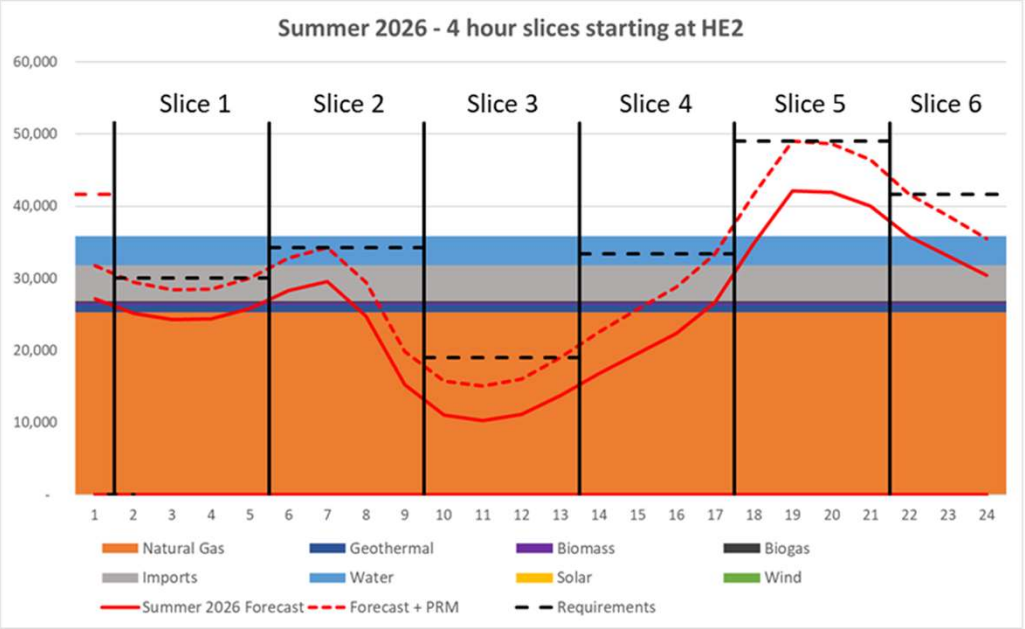
- Net would remove wind / solar from the load curve on an hourly basis
- Net matches variable resource contributions in each hour of production, thereby recognizing the contribution of those resources on an hourly basis
- Some issues to consider with net include:
  - The future mix of standalone renewables relative to hybrid or co-located, as a future that's predominately hybrid / co-located could provide less rationale to use net
  - A more complicated requirement-setting process, as wind / solar would need to be removed from load
  - Transactability impacts of solar / wind during the compliance period, as trading a solar or wind product would impact an LSE's load curve and requirements

2. Gross or Net Load

Incorporation of solar and wind data into the net load curve

- The top graph shows hourly solar and wind estimates relative to load
- The bottom graph shows the impact to the load curve of removing the solar and wind impacts from load





Details:

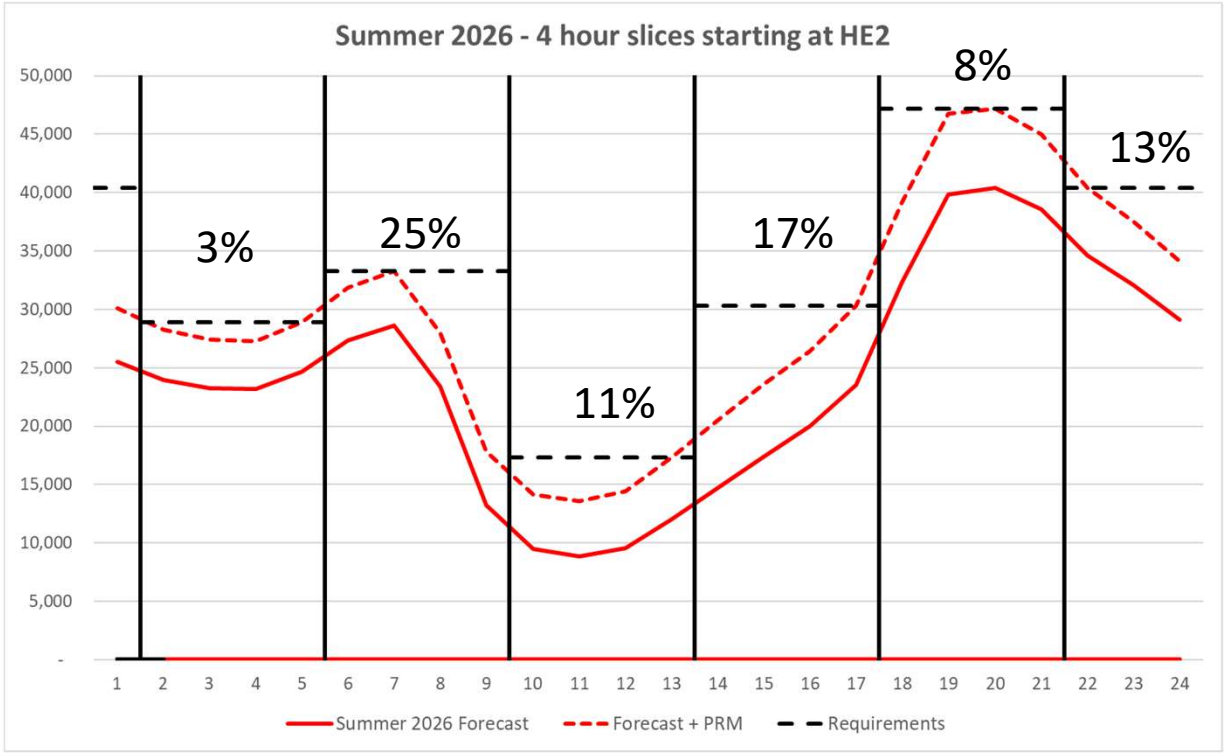
- 2026 CEC forecast data
- 2021 NQC list data adjusted for known retirements
- Solar and wind data has been grossed up to match IRP PSP core scenario resource data for 2026

3. Metrics

- To select season and slice designs, PG&E has focused on identifying a metric that can balance the CPUC's principles
- We focused on a metric that can capture the variation within a season or slice and that informs a durable design
- We chose the coefficient of variation:
  - It's a standard statistical metric based on the mean and standard deviation that can be calculated easily based on the different loads across months (for seasons) and hours (for slices)
- There are other calculations that could be done, but the more important issue is the directional nature of the result

3. Metrics

- Coefficient of variation = standard deviation / mean
- The data used is the set of values that would be grouped together within a season or slice
  - E.g. How much variation is there between the loads in a slice?
  - A slice with a large difference between the load values will have a larger variance than a slice with small differences
  - A slice design with a smaller variance would be preferable, as it would minimize the difference between requirements and load



13% Avg

4. Seasons

Reminder on seasonal trade-offs

- 12 seasons (monthly): Provides the greatest level of precision in terms of matching requirements with load; also comes with a larger showing burden
- Fewer than 12 seasons: Potentially administratively simpler; could help address generator cost recovery issues; potentially presents problems with planned outages and could result in excess procurement

Metrics

- Since monthly is the lowest level of granularity we think reasonable, the metrics are based on an increase in variation from monthly showings
- The data could still be run to explore the level of variation within a month, but we think this is a better exercise for IEPR forecasting discussions
  - Essentially, we are taking the IEPR forecast as a given

4. Seasons

For seasons, the variation metric looks at the loads in each month in each hour

- For instance, a summer season that includes Jun-Oct would group the loads for those months by each hour

HE	JUN	JUL	AUG	SEP	OCT	Mean	StDev	Variation
1	24,424	25,553	25,892	27,186	24,278	25,467	1,188	5%
2	22,831	23,917	24,371	25,171	22,920	23,842	990	4%
3	21,500	23,333	23,361	24,234	22,269	22,939	1,064	5%
4	21,657	23,499	23,408	24,376	22,352	23,058	1,062	5%
5	23,071	24,749	24,876	25,784	23,767	24,450	1,051	4%
6	24,521	26,535	27,046	28,306	26,277	26,537	1,371	5%
7	22,544	26,757	27,955	29,544	27,612	26,882	2,627	10%
8	14,609	20,851	21,977	24,709	24,791	21,388	4,159	19%
9	8,670	14,794	14,344	15,300	15,122	13,646	2,805	21%
10	6,382	11,013	10,517	11,080	8,848	9,568	1,996	21%
11	5,437	10,136	9,260	10,324	6,889	8,409	2,151	26%
12	5,542	9,904	9,380	11,131	6,443	8,480	2,380	28%
13	7,034	12,339	11,744	13,742	9,023	10,776	2,704	25%
14	8,990	14,494	14,159	16,808	11,427	13,176	3,020	23%
15	11,515	17,419	16,872	19,609	14,356	15,954	3,107	19%
16	14,074	20,115	19,789	22,320	17,632	18,786	3,114	17%
17	17,395	23,291	23,177	26,690	24,438	22,998	3,436	15%
18	21,481	26,991	28,021	34,494	34,794	29,156	5,594	19%
19	28,236	32,367	34,884	42,128	37,924	35,108	5,291	15%
20	34,812	37,455	38,612	41,952	36,100	37,786	2,731	7%
21	36,353	38,357	37,209	39,964	33,719	37,120	2,334	6%
22	32,765	34,482	33,414	35,765	30,801	33,445	1,865	6%
23	30,324	32,071	31,132	33,143	28,738	31,082	1,680	5%
24	27,406	29,134	28,542	30,389	26,619	28,418	1,472	5%

HE8 would have an average load of 21 GWs, a standard deviation of 4 GWs, and a coefficient of variation of 19%

HE23 would have an average load of 31 GWs, a standard deviation of 1.6 GWs, and a coefficient of variation of 5%

13% Average Across All Hours

Net load 2026 (using PSP solar / wind data)

4. Seasons

So, what does the data shows across a number of examples?

- Below are two seasonal configurations – a 4 and 2 season option
- Forecasted penetrations of wind and solar drive increased variation in future years

		4 Seasons	2 Seasons
		Spring: Apr-Jun **Summer**: Jul-Sep **Fall**: Oct-Dec **Winter**: Jan-Mar	**Summer**: Jun-Oct **Winter**: Nov-May
2021	**Winter**	7%	8%
	Spring	11%	
	Summer	3%	8%
	Fall	7%	
	Average	**7.0%**	**8.0%**
2026	**Winter**	17%	23%
	Spring	19%	
	Summer	6%	13%
	Fall	13%	
	Average	**13.5%**	**17.9%**
2030	**Winter**	32%	45%
	Spring	-10%	
	Summer	8%	20%
	Fall	20%	
	Average	**12.4%**	**32.6%**

13% Average from previous slide

Net load (using PSP solar / wind data)

5. Slices

Overview:

- PG&E proposed slices in the 3B2 proposal to account for capacity needs in all hours, but also limit the increase to the showing requirements in a revised framework
- Two parameters for selecting slices:
  1. Size of the slice
  2. Start of the slice

Metrics:

- Since hourly is the lowest level of granularity we think is reasonable, the metrics are calculated based on the increase in variation from an hourly showing
- The variation could be calculated based on monthly or seasonal showings; we've used two months (Sep and Jan) representative of a summer and winter

5. Slices

6-hour slices v. 4-hour slices

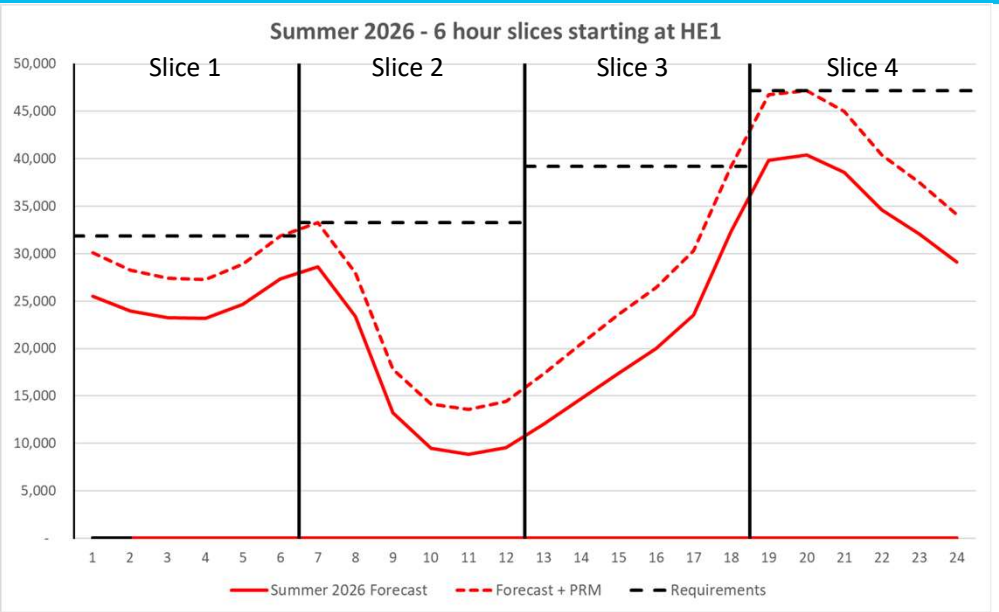
- Variance increases with slice size, particularly under a net framework

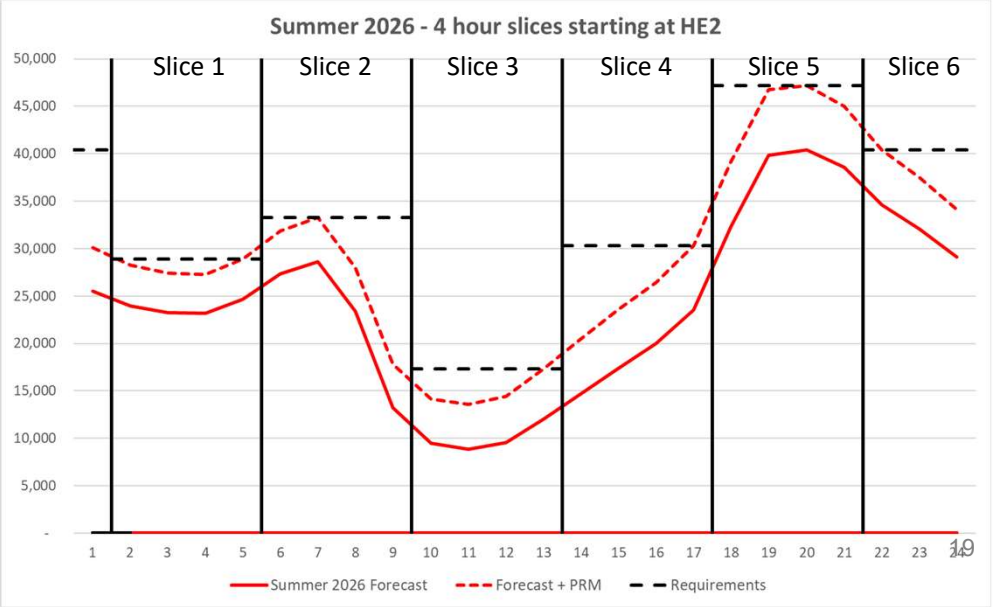
Gross

		6 Hour Slices	4 Hour Slices
		HE 1 Start	HE 2 Start
2021	Jan	8%	6%
	Sep	8%	5%
2026	Jan	10%	7%
	Sep	8%	5%
2030	Jan	11%	7%
	Sep	8%	5%

Net

		6 Hour Slices	4 Hour Slices
		HE 1 Start	HE 2 Start
2021	Jan	8%	6%
	Sep	8%	5%
2026	Jan	24%	14%
	Sep	22%	12%
2030	Jan	28%	17%
	Sep	29%	15%





5. Slices

Impact of slice start times

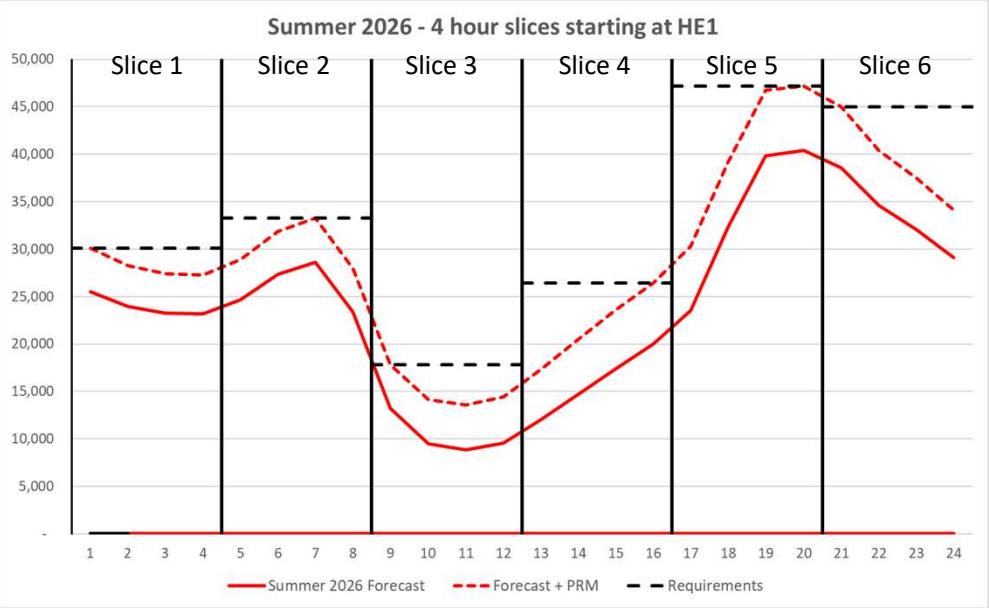
- Under 4-hour slice, HE2 most optimal

Gross

		4 Hour Slices			
		HE 1 Start	HE 2 Start	HE 3 Start	HE 4 Start
2021	Jan	7%	6%	6%	7%
	Sep	6%	5%	6%	6%
2026	Jan	8%	7%	7%	8%
	Sep	6%	5%	7%	7%
2030	Jan	8%	7%	7%	8%
	Sep	6%	5%	7%	7%

Net

		4 Hour Slices			
		HE 1 Start	HE 2 Start	HE 3 Start	HE 4 Start
2021	Jan	7%	6%	6%	7%
	Sep	6%	5%	6%	6%
2026	Jan	15%	14%	14%	15%
	Sep	12%	12%	17%	18%
2030	Jan	12%	12%	17%	18%
	Sep	17%	15%	22%	23%



6. Straw Proposals
Combination of season / slice variation

- Any combination of seasons (fewer than 12) and slices (fewer than 24) should assess the combined variance

- We've selected two straw proposals based on the data reviewed so far to assess the combined variance

- The straw proposals are not intended as PG&E's suggestion on the best slice-of-day design, but are included as options to consider and further develop in future workshops

6. Straw Proposals

Option 1: Net load, 2 seasons, 4-hour slices

showings: 12

Seasons:

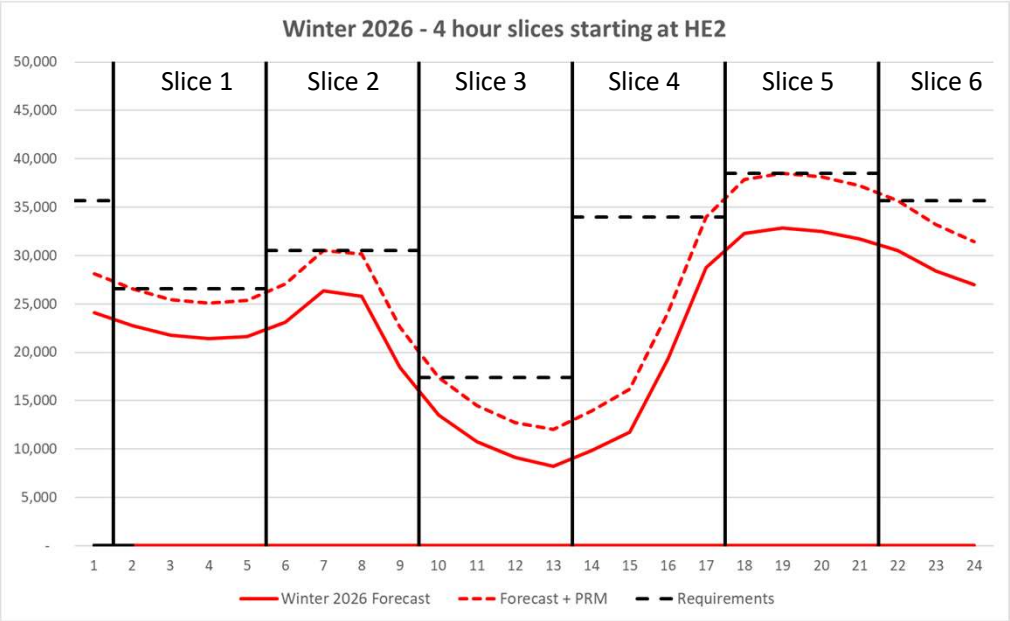
- Summer: Jun-Oct
- Winter: Nov-May

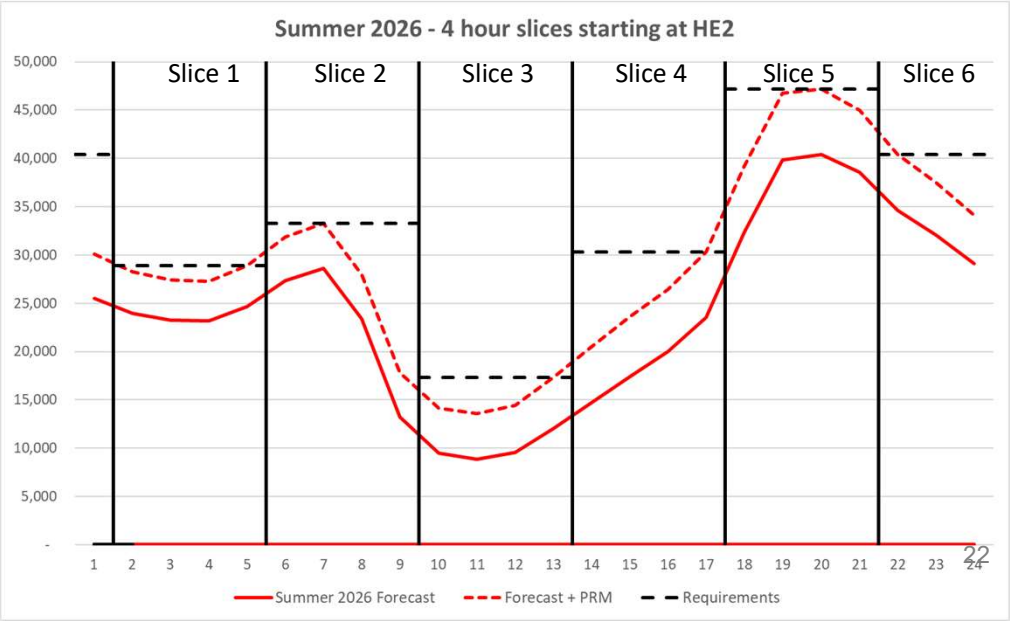
Slices: Six 4-hour slices starting HE2

Winter season, uses highest loads from each winter month to form load curve

Summer season, also uses highest loads from each summer month to form load curve

Net load 2026 (using PSP solar / wind data)





6. Straw Proposals

Option 1: 2 seasons; 4-hour slices

showings: 12

Seasons: Jun-Oct Summer, Nov-May Winter

Slices: Six 4-hour slices starting HE2

Requirement for season / slice

HE	JUN	JUL	AUG	SEP	OCT	Mean	StDev	Variation	Max
1	24,424	25,553	25,892	27,186	24,278				
2	22,831	23,917	24,371	25,171	22,920	23,572	1,145	5%	25,784
3	21,500	23,333	23,361	24,234	22,269				
4	21,657	23,499	23,408	24,376	22,352				
5	23,071	24,749	24,876	**25,784**	23,767				
6	24,521	26,535	27,046	28,306	26,277	22,113	6,107	28%	29,544
7	22,544	26,757	27,955	**29,544**	27,612				
8	14,609	20,851	21,977	24,709	24,791				
9	8,670	14,794	14,344	15,300	15,122				
10	6,382	11,013	10,517	11,080	8,848	9,308	2,350	25%	13,742
11	5,437	10,136	9,260	10,324	6,889				
12	5,542	9,904	9,380	11,131	6,443				
13	7,034	12,339	11,744	**13,742**	9,023				
14	8,990	14,494	14,159	16,808	11,427	17,728	4,729	27%	26,690
15	11,515	17,419	16,872	19,609	14,356				
16	14,074	20,115	19,789	22,320	17,632				
17	17,395	23,291	23,177	**26,690**	24,438				
18	21,481	26,991	28,021	34,494	34,794	34,793	5,231	15%	42,128
19	28,236	32,367	34,884	**42,128**	37,924				
20	34,812	37,455	38,612	41,952	36,100				
21	36,353	38,357	37,209	39,964	33,719				
22	32,765	34,482	33,414	**35,765**	30,801	29,603	3,378	11%	35,765
23	30,324	32,071	31,132	33,143	28,738				
24	27,406	29,134	28,542	30,389	26,619				
								18%	**Average Across All Slices**

Mean, standard deviation and coefficient of variation are now calculated across not only the months, but also the hours within that slice

Net load 2026 (using PSP solar / wind data)

6. Straw Proposals

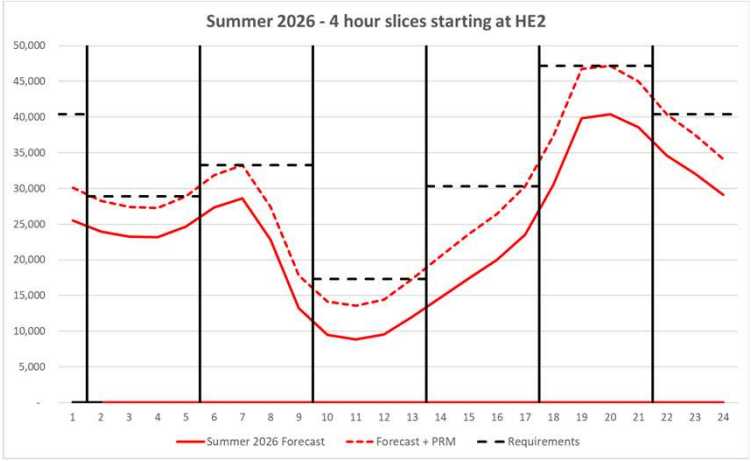
Option 2: Net Load, 4 seasons, 4-hour slices

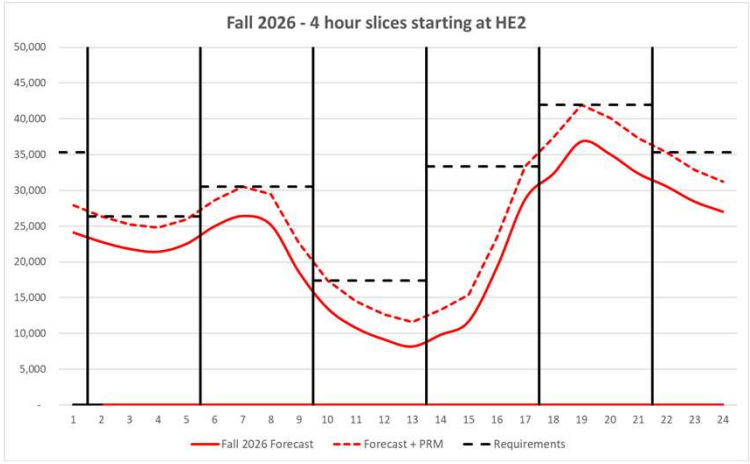
showings: 24

Seasons: See below

Slices: Six 4-hour slices starting HE2

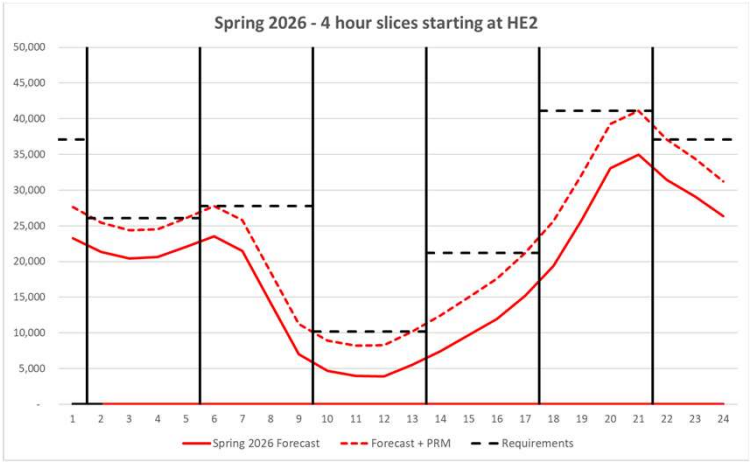
Summer: Jul-Sep

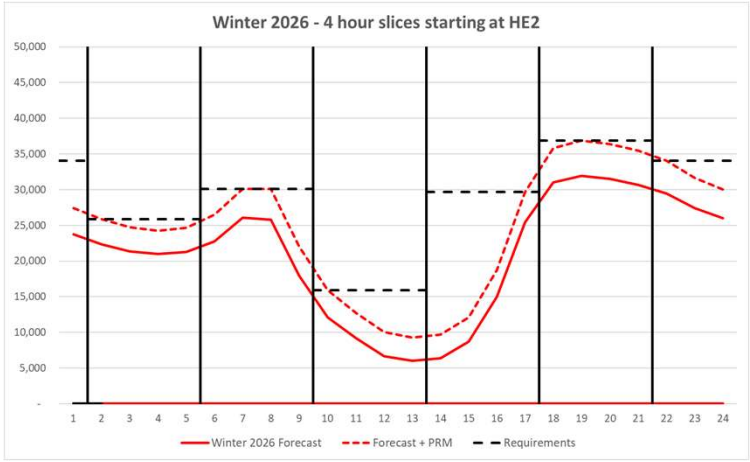




Fall: Oct-Dec

Spring: Apr-Jun





Winter: Jan-Mar

Net load 2026 (using PSP solar / wind data)

6. Straw Proposals

Option 2: Net Load, 4 seasons, 4-hour slices

showings: 24

Seasons: Spring: Apr-Jun Summer: Jul-Sep Fall: Oct-Dec Winter: Jan-Mar

Slices: Six 4-hour slices starting HE2

HE	JAN	FEB	MAR	Variation	APR	MAY	JUN	Variation	JUL	AUG	SEP	Variation	OCT	NOV	DEC	Variation
1	24,257	22,904	22,517		19,819	22,231	24,424		25,553	25,892	27,186		24,278	23,891	24,680	
2	**22,797**	21,618	21,360		18,512	20,946	22,831		23,917	24,371	25,171		22,920	22,441	23,253	
3	21,746	20,466	20,438	4%	18,230	20,127	21,500	8%	23,333	23,361	24,234	3%	22,269	21,418	22,342	4%
4	21,283	20,073	20,304		18,521	20,291	21,657		23,499	23,408	24,376		22,352	20,985	21,892	
5	21,665	20,611	21,198		19,742	21,190	**23,071**		24,749	24,876	**25,784**		**23,767**	21,446	22,152	
6	23,133	22,305	23,721		22,122	22,666	**24,521**		26,535	27,046	28,306		26,277	22,813	23,729	
7	26,448	25,491	25,846	19%	23,514	21,974	22,544	36%	26,757	27,955	**29,544**	24%	**27,612**	25,249	26,936	19%
8	**26,693**	23,389	23,304		17,397	14,219	14,609		20,851	21,977	24,709		24,791	22,074	26,494	
9	20,028	14,278	14,280		8,338	8,345	8,670		14,794	14,344	15,300		15,122	14,530	21,040	
10	**14,688**	9,316	8,193		4,207	5,232	6,382		11,013	10,517	11,080		8,848	9,008	**17,356**	
11	11,375	6,219	4,740	48%	1,716	3,390	5,437	48%	10,136	9,260	10,324	12%	6,889	6,727	14,963	39%
12	9,336	4,655	3,554		793	3,258	5,542		9,904	9,380	11,131		6,443	5,676	12,423	
13	8,914	4,602	3,090		1,714	4,423	**7,034**		12,339	11,744	**13,742**		9,023	6,597	11,584	
14	9,525	6,010	4,162		3,497	6,765	8,990		14,494	14,159	16,808		11,427	8,812	12,946	
15	12,873	7,823	6,346	54%	5,726	8,753	11,515	40%	17,419	16,872	19,609	19%	14,356	13,240	16,172	37%
16	19,157	12,902	10,743		8,803	11,693	14,074		20,115	19,789	22,320		17,632	21,307	22,145	
17	**26,793**	21,617	16,861		12,483	15,873	**17,395**		23,291	23,177	**26,690**		24,438	**29,528**	29,091	
18	31,508	28,541	25,785		18,758	20,439	21,481		26,991	28,021	34,494		34,794	32,440	32,924	
19	**32,403**	30,810	29,661	6%	26,659	27,453	28,236	20%	32,367	34,884	**42,128**	14%	**37,924**	32,306	33,459	6%
20	31,963	30,138	29,854		30,716	32,660	34,812		37,455	38,612	41,952		36,100	31,502	33,111	
21	31,091	29,514	28,878		29,017	31,944	**36,353**		38,357	37,209	39,964		33,719	30,460	32,236	
22	**29,837**	28,156	26,777		26,239	28,813	**32,765**		34,482	33,414	**35,765**		30,801	28,926	**31,073**	
23	27,723	26,059	25,588	7%	24,808	26,927	30,324	11%	32,071	31,132	33,143	8%	28,738	26,731	28,918	7%
24	26,363	24,673	24,325		22,647	24,739	27,406		29,134	28,542	30,389		26,619	25,524	27,459	
				23%				27%				13%				18%

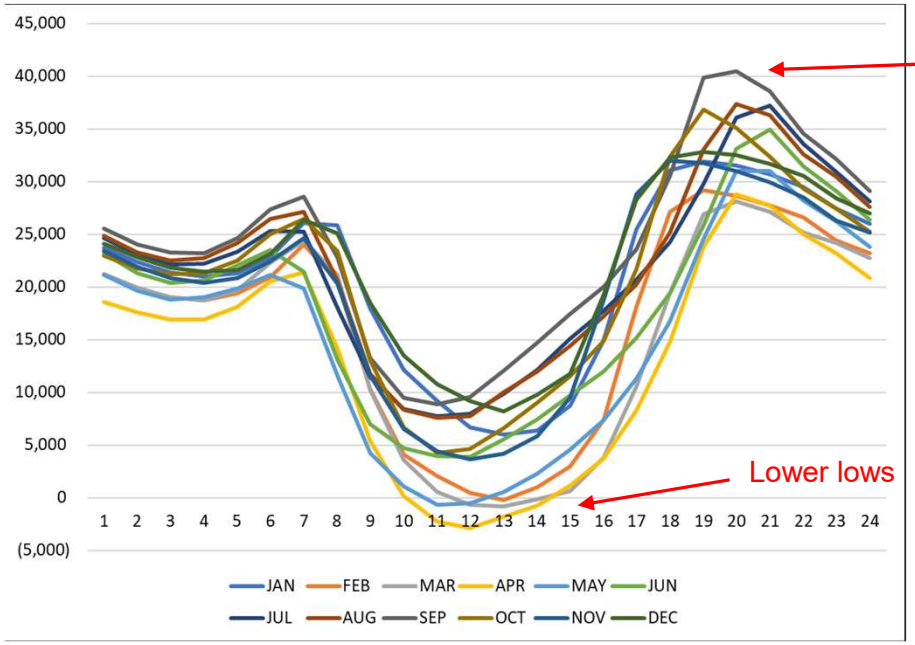
Requirements in bold

Net load 2026 (using PSP solar / wind data)

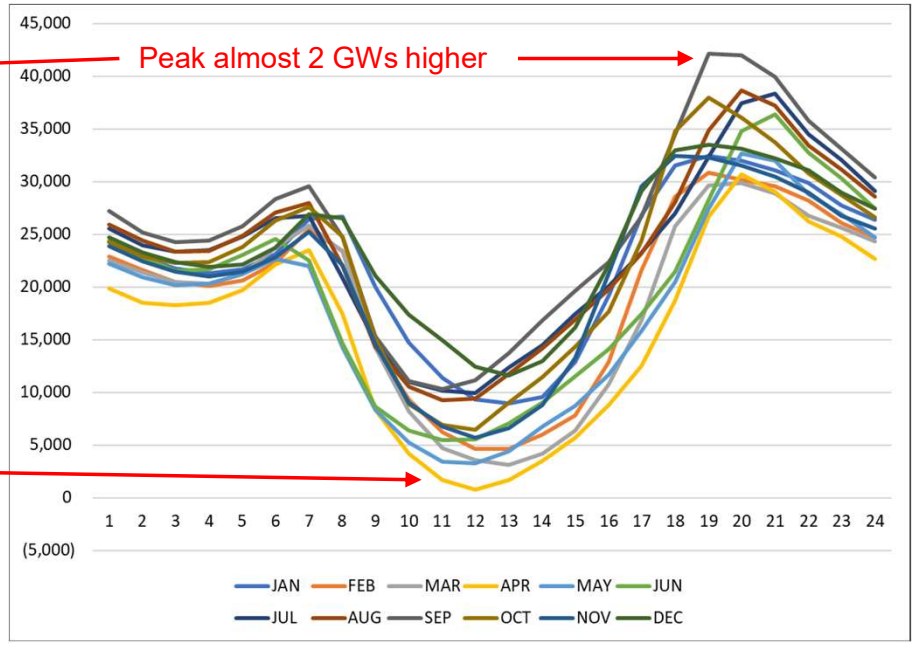
7. Resource Counting

- Exceedance level has a large impact
- The following compare net load forecasts using a 50% and 75% exceedance

2019 CEC Load Forecast, CAISO-Level, Mid-Mid, Hourly for 2026
(maximum values net of solar and wind – 50% exceedance)



2019 CEC Load Forecast, CAISO-Level, Mid-Mid, Hourly for 2026
(maximum values net of solar and wind – 75% exceedance)



Notes:

- Solar and wind resources include projected build in IRP PSP
- Assumes new resource build has same profile as 2018-19 production per CAISO OASIS

8. Discussion

- Straw proposals have been designed to balance and trade-off accuracy with transactability and administrative burden
- Need input from parties on what the greatest pain points are
  - Number / timing of showings
  - Transactions
  - Procurement costs
- Resource counting has an impact on the desirability of number of seasons and slices