Peak Load Shift Analysis

Preliminary Results Presented to
Demand Analysis Working Group (DAWG)

Energy Resources Modeling Section
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Energy Division, CPUC
November 3, 2015, Sacramento, CA

Purpose of This Presentation

- How is load shape changing?
  - Consumption is becoming counterfactual
- Compare grid behavior at forecast **consumption peak** versus **sales peak** (2016 – 2026)
- '*Kick the Tires*' of the new CPUC modeling platform
  - Compare to CEC analysis
- Analysis based on:
  - 35 synthetic / historical hourly profiles (1980 – 2014)
  - 2015 CEC IEPR Forecast (2017 – 2026)
    - Peak and Annual Average Consumption
    - Installed BTM PV capacity
    - Hourly AAEE Profiles

Starting Point

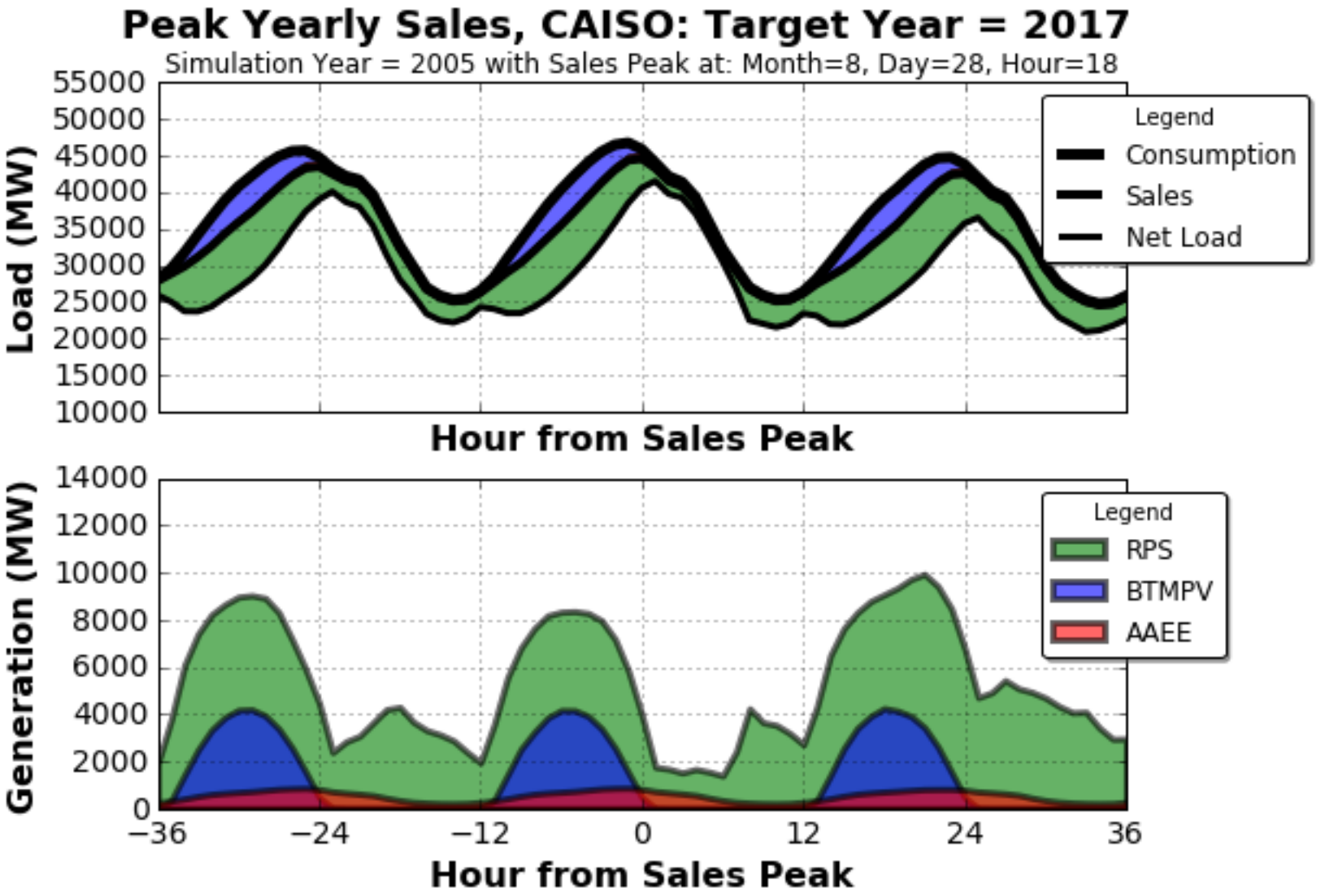
Load Type	Definition
Consumption	Sum of electrical energy used to operate end-use devices excluding charge/discharge of storage
Sales	Consumption load less BTM onsite generation plus charge/discharge of storage
System Load	Sales load plus T&D losses plus theft and unaccounted for
Net Load	System load less system intermittent renewable generation (currently wind and solar)

Note: For our modeling purposes, we treat all quantities at system level

Acronyms
BTM: Behind The Meter
PV: Photo Voltaic
AAEE: Additional Achievable Energy Efficiency
T&D: Transmission and Distribution

What Follows Are Two Animations

- Each animation corresponds to best guess forecast
- Each consists of 10 slides (2017 – 2026)
- There are 35 such 10 year animations available
- These animations are for CAISO using:
  1. 2005 synthetic hourly profiles
  2. 2009 synthetic hourly profiles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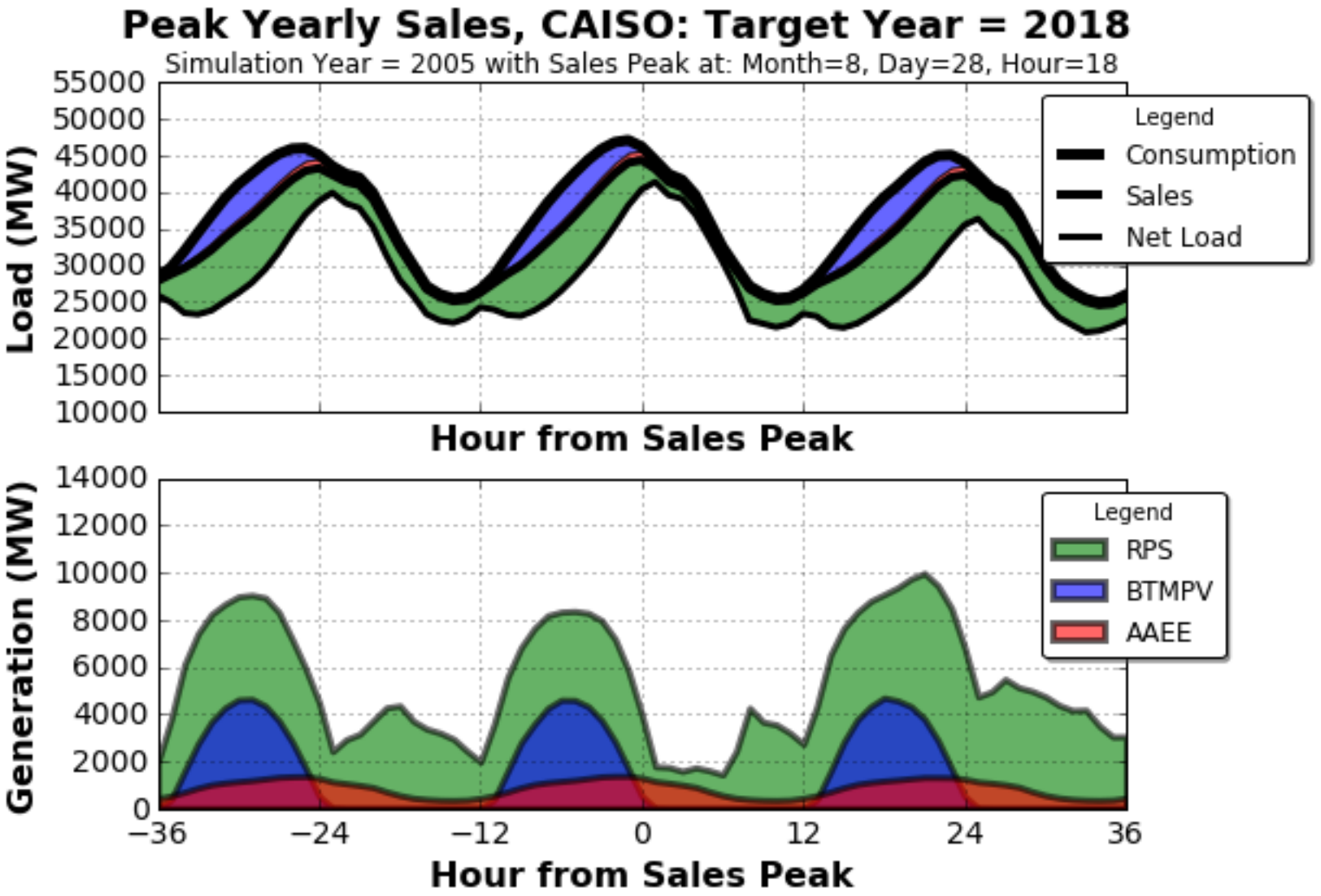
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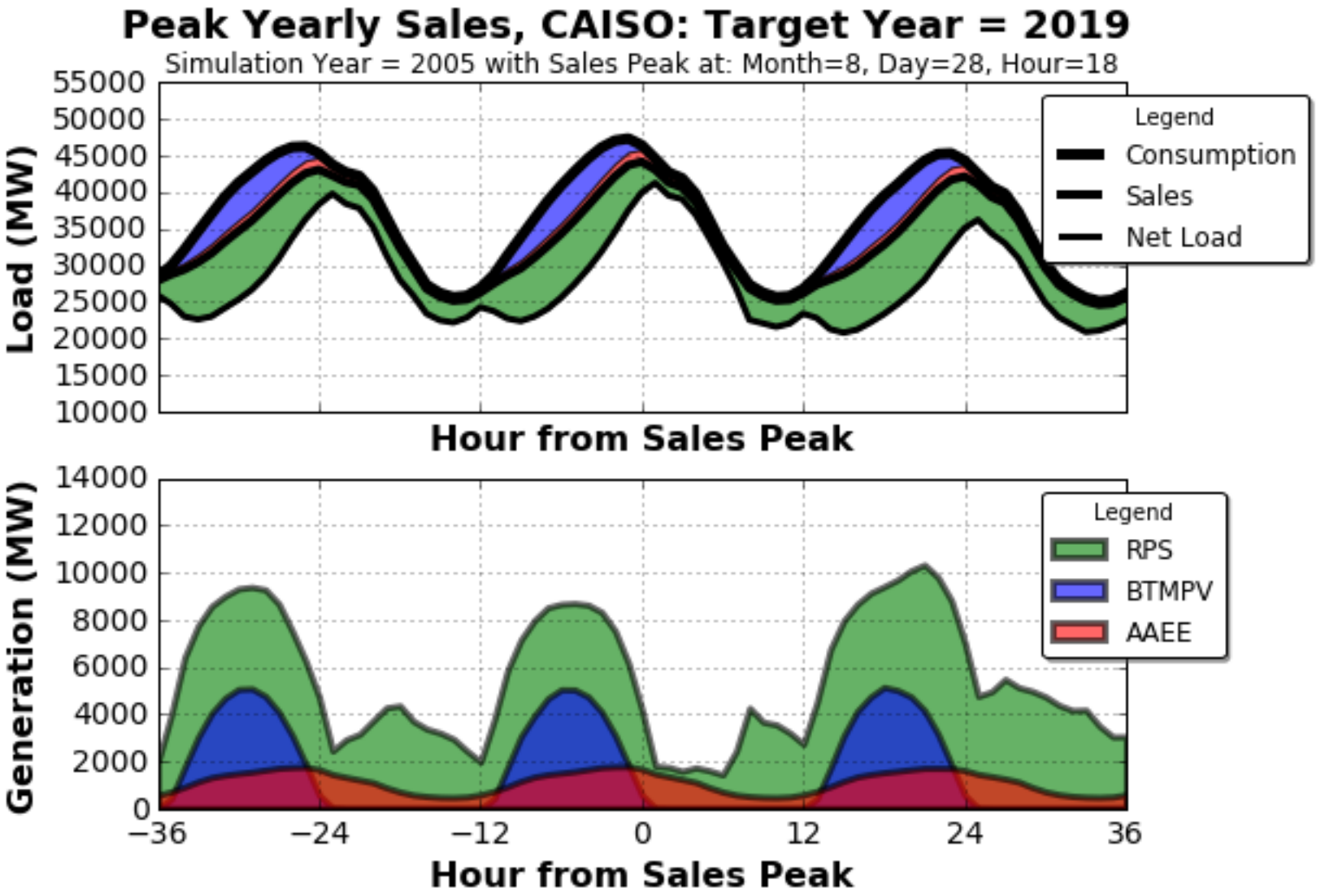
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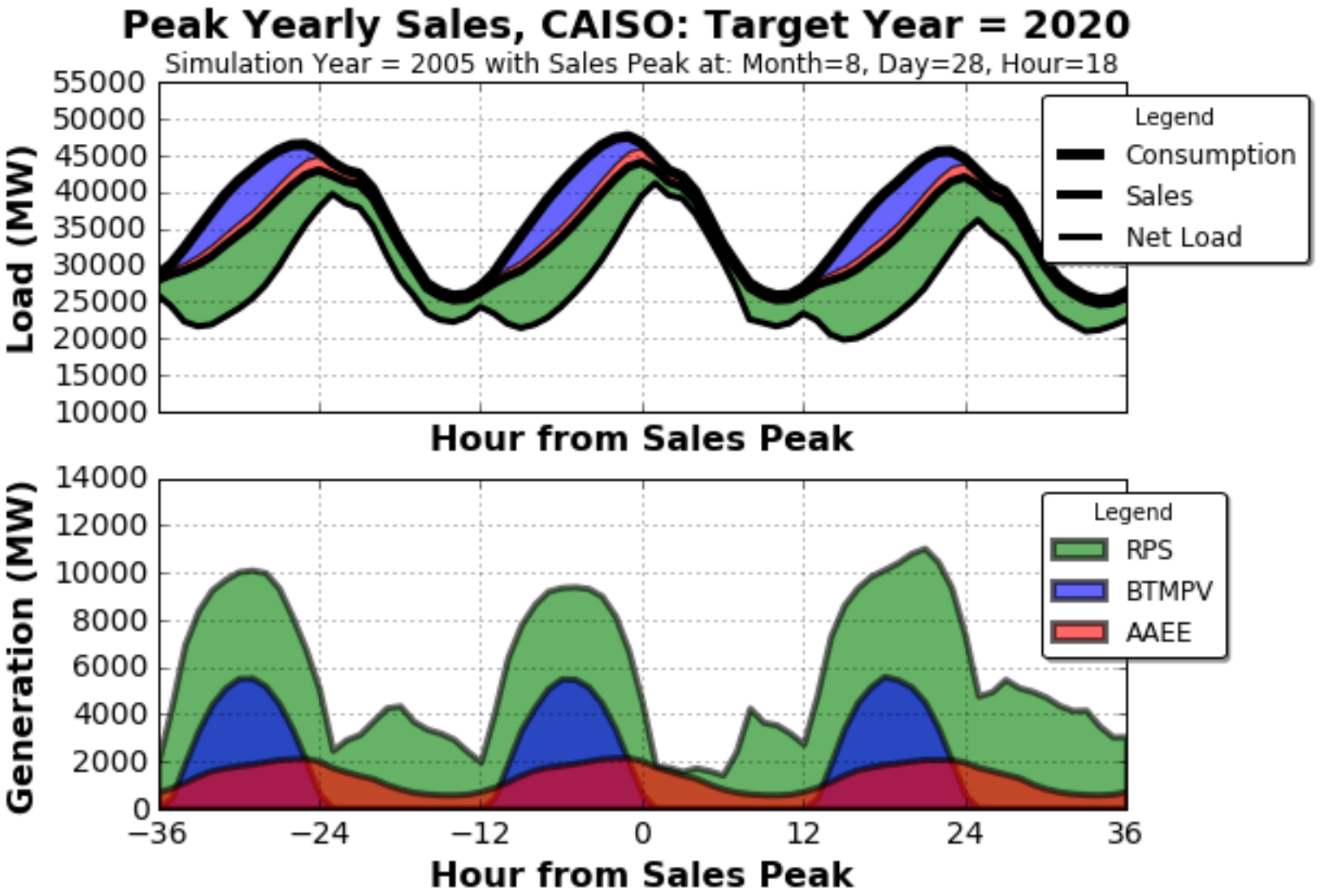
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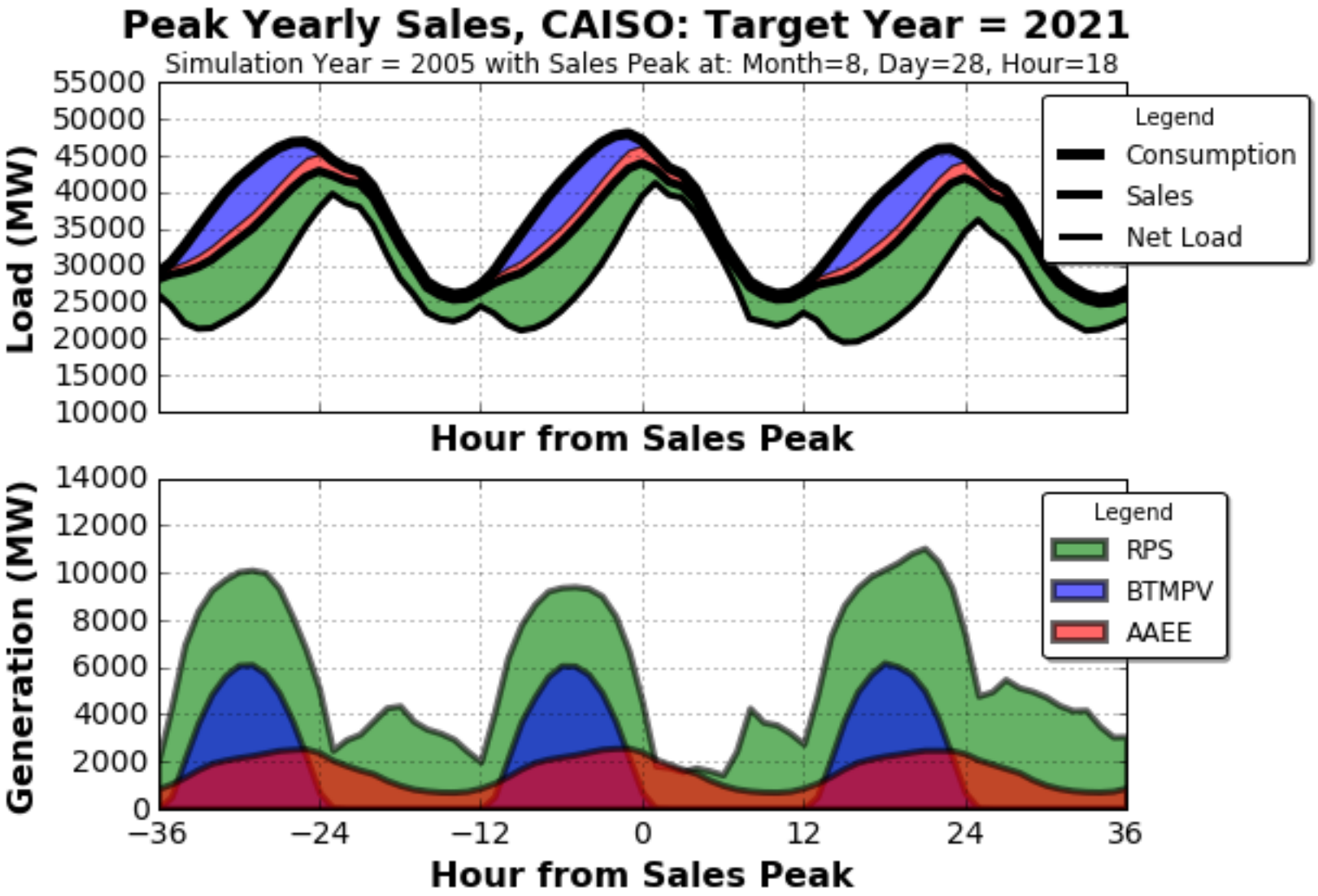
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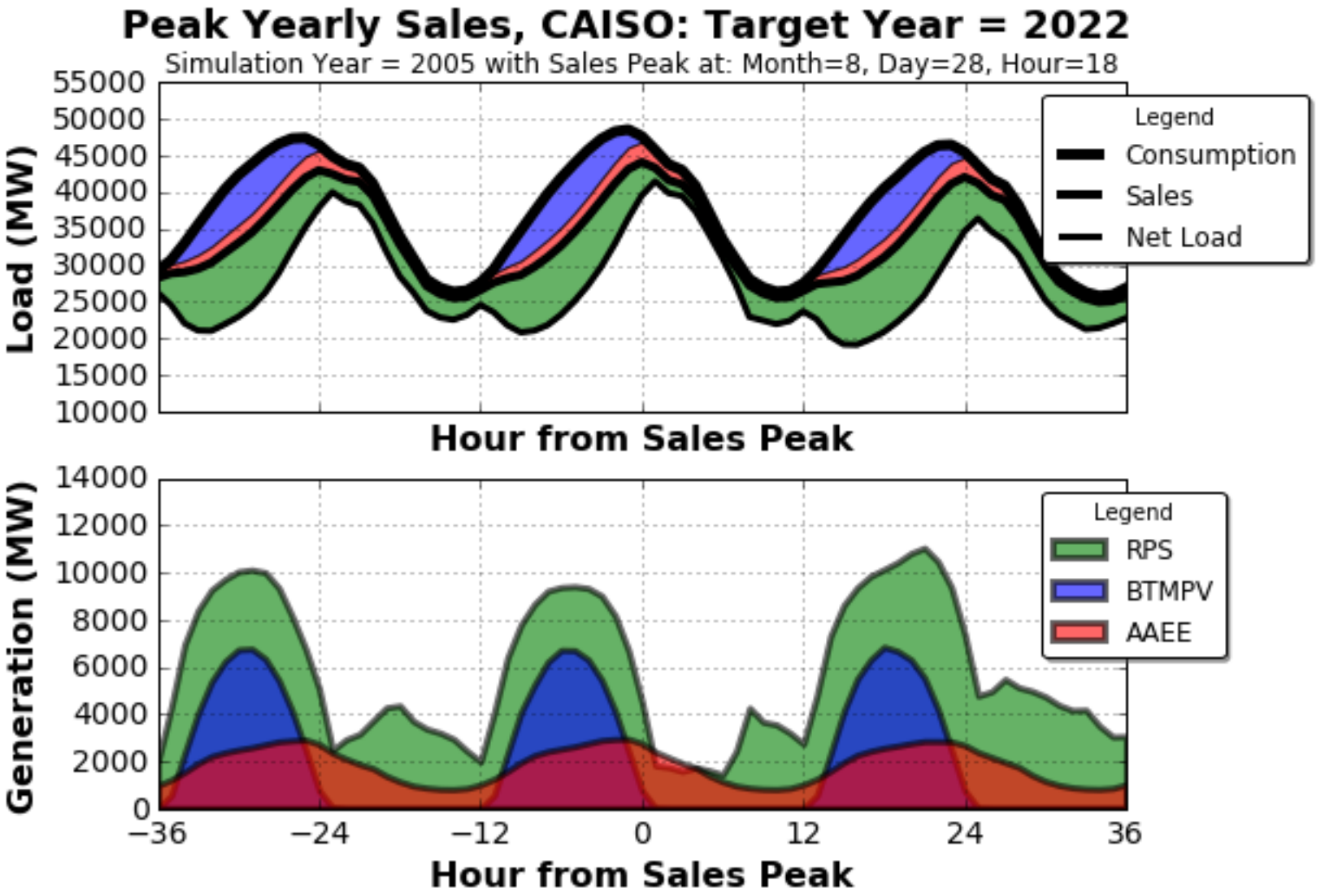
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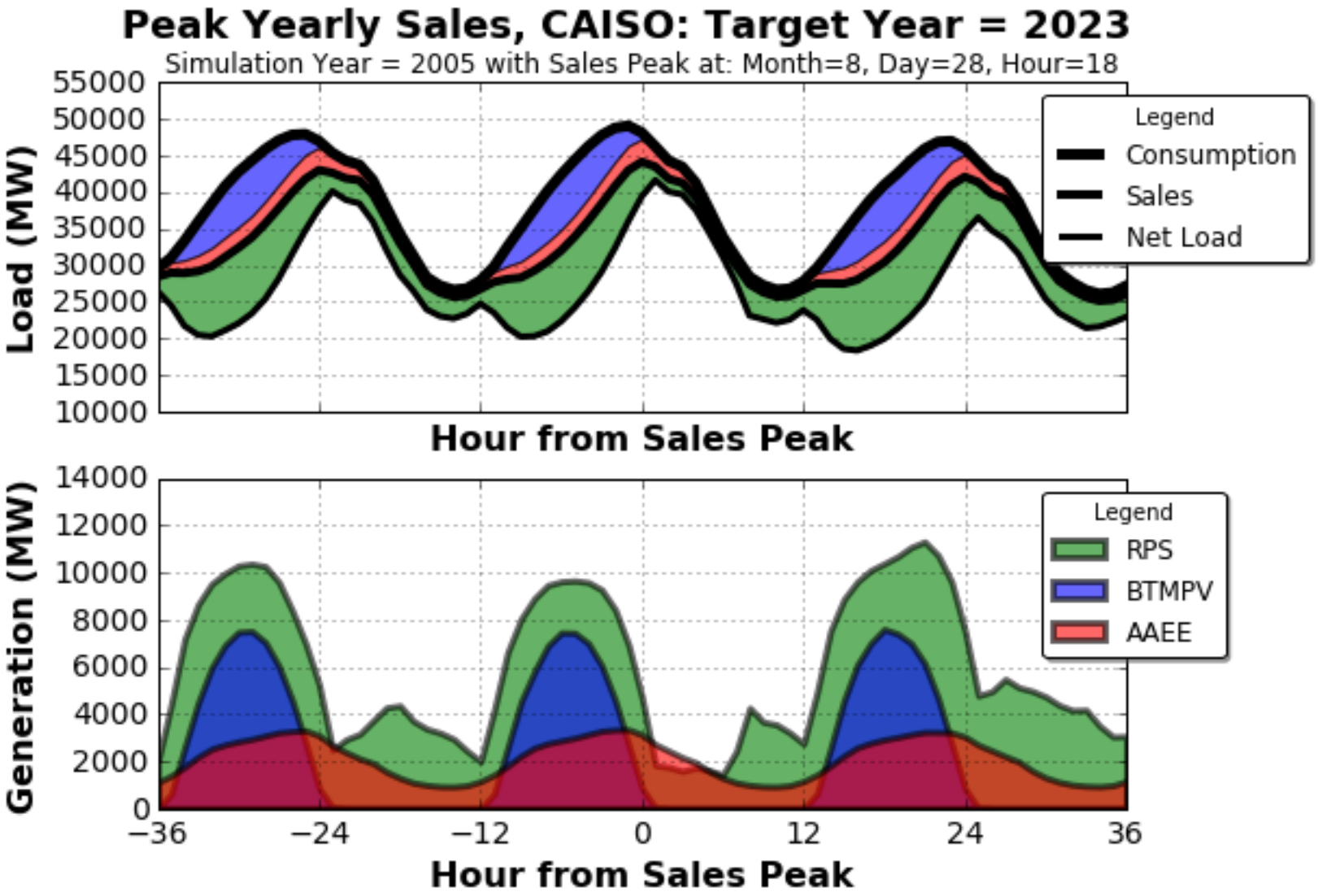
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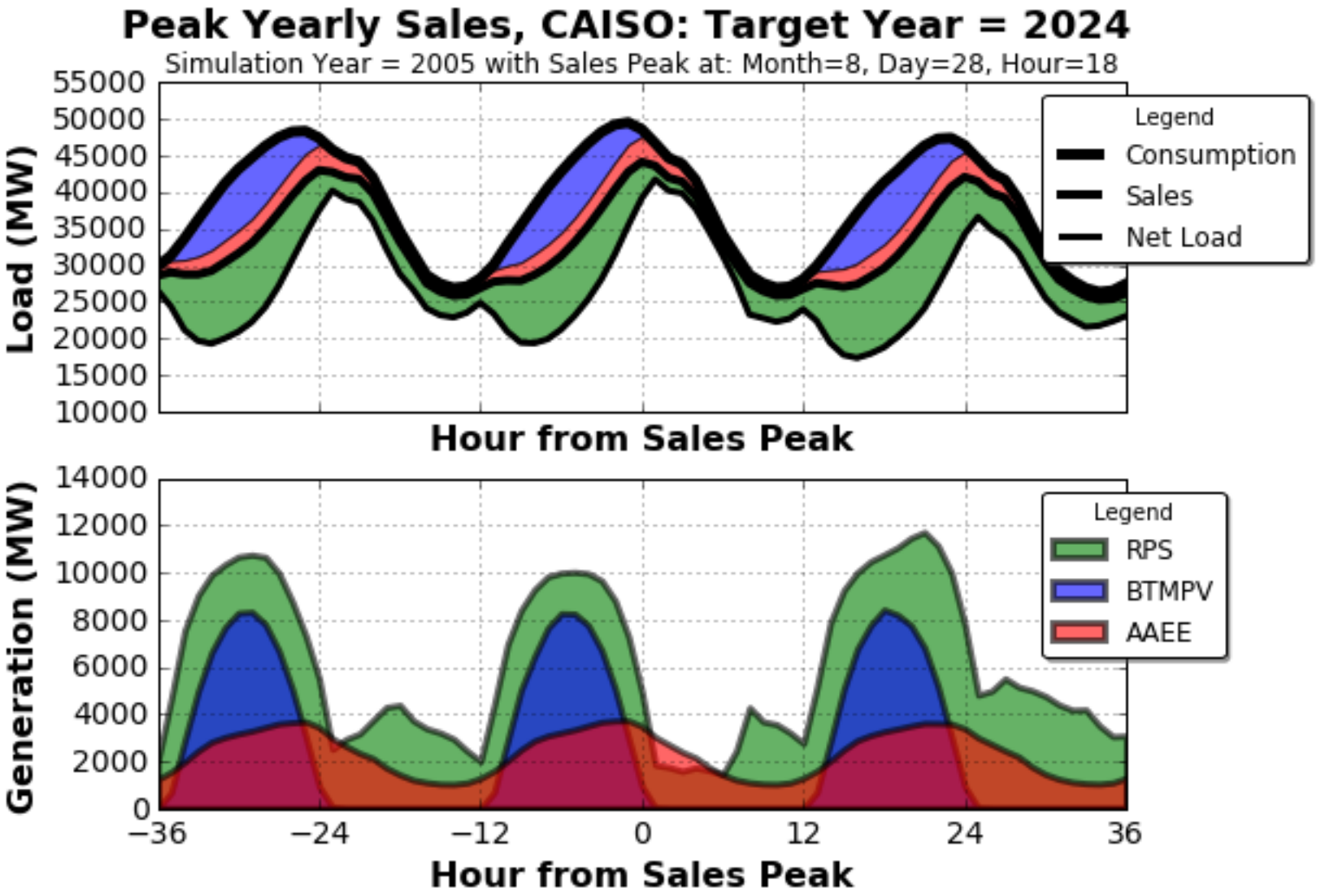
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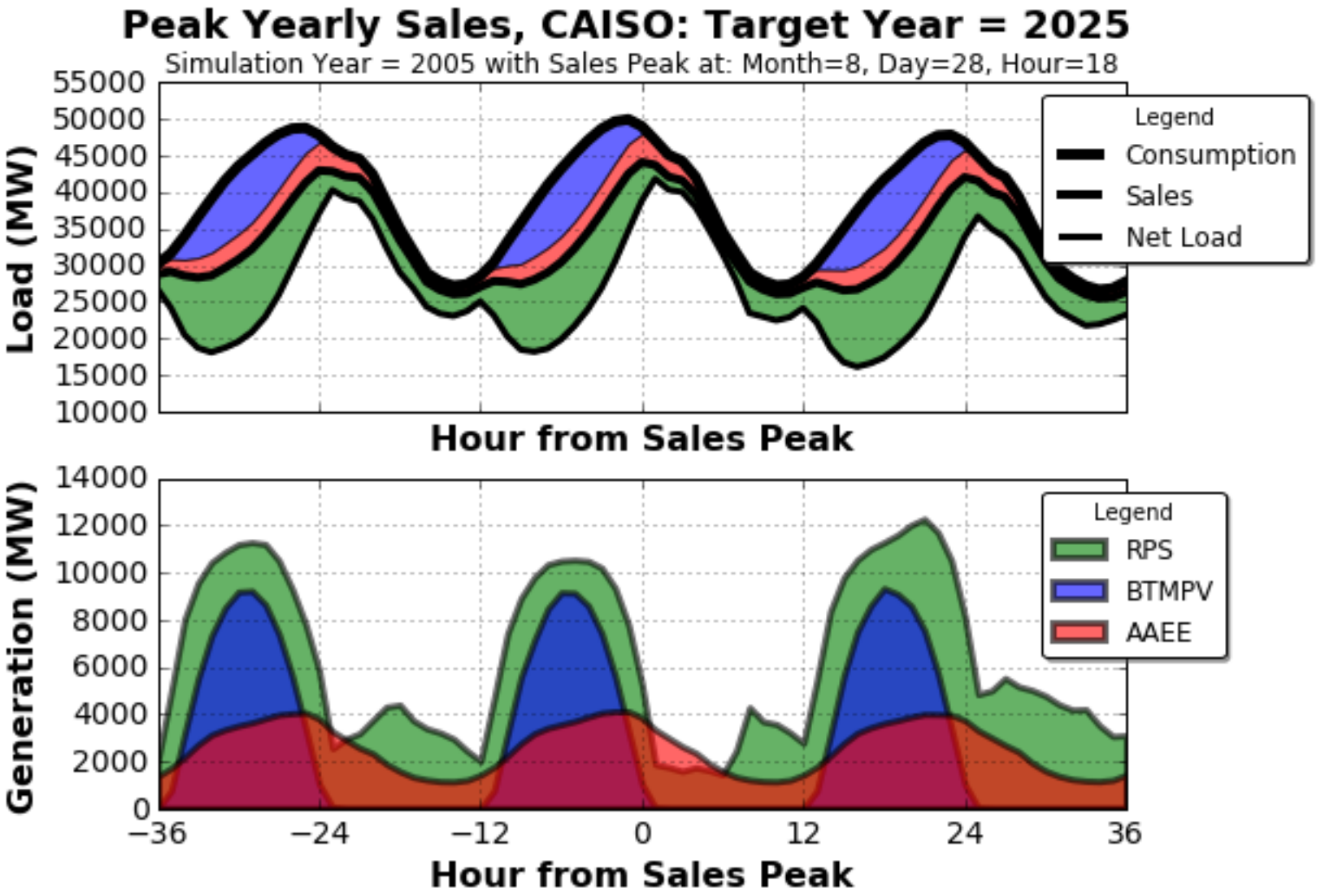
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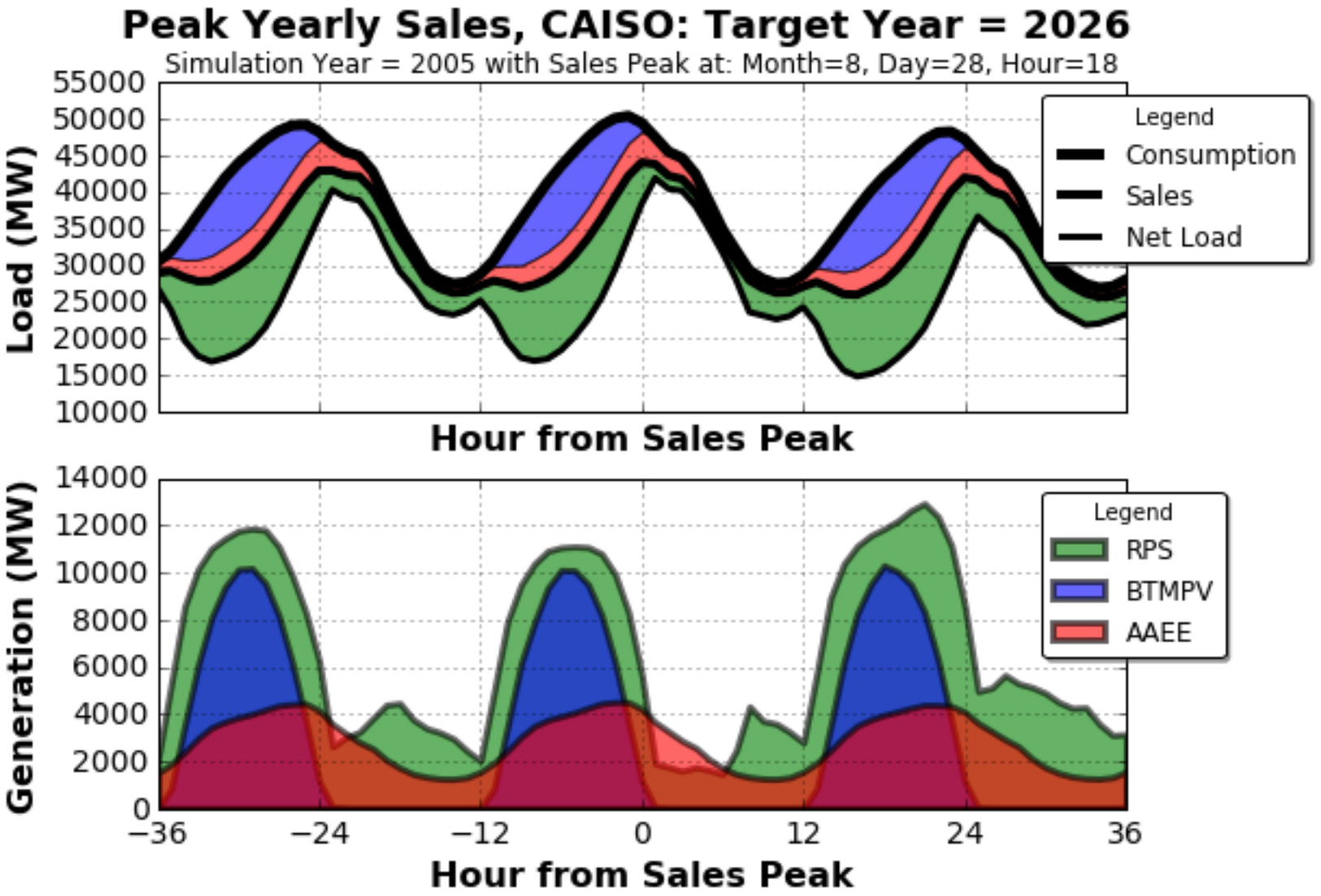
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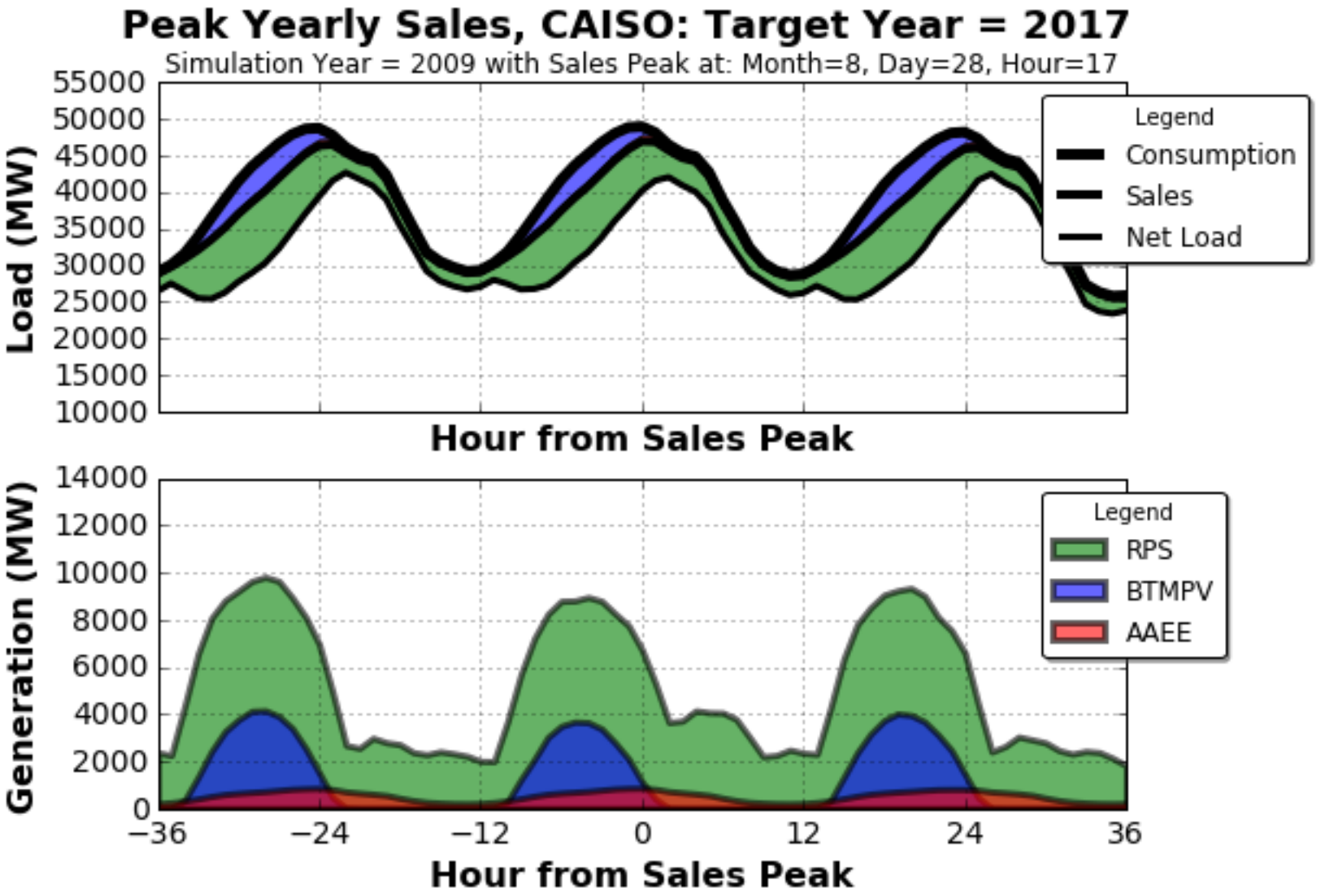
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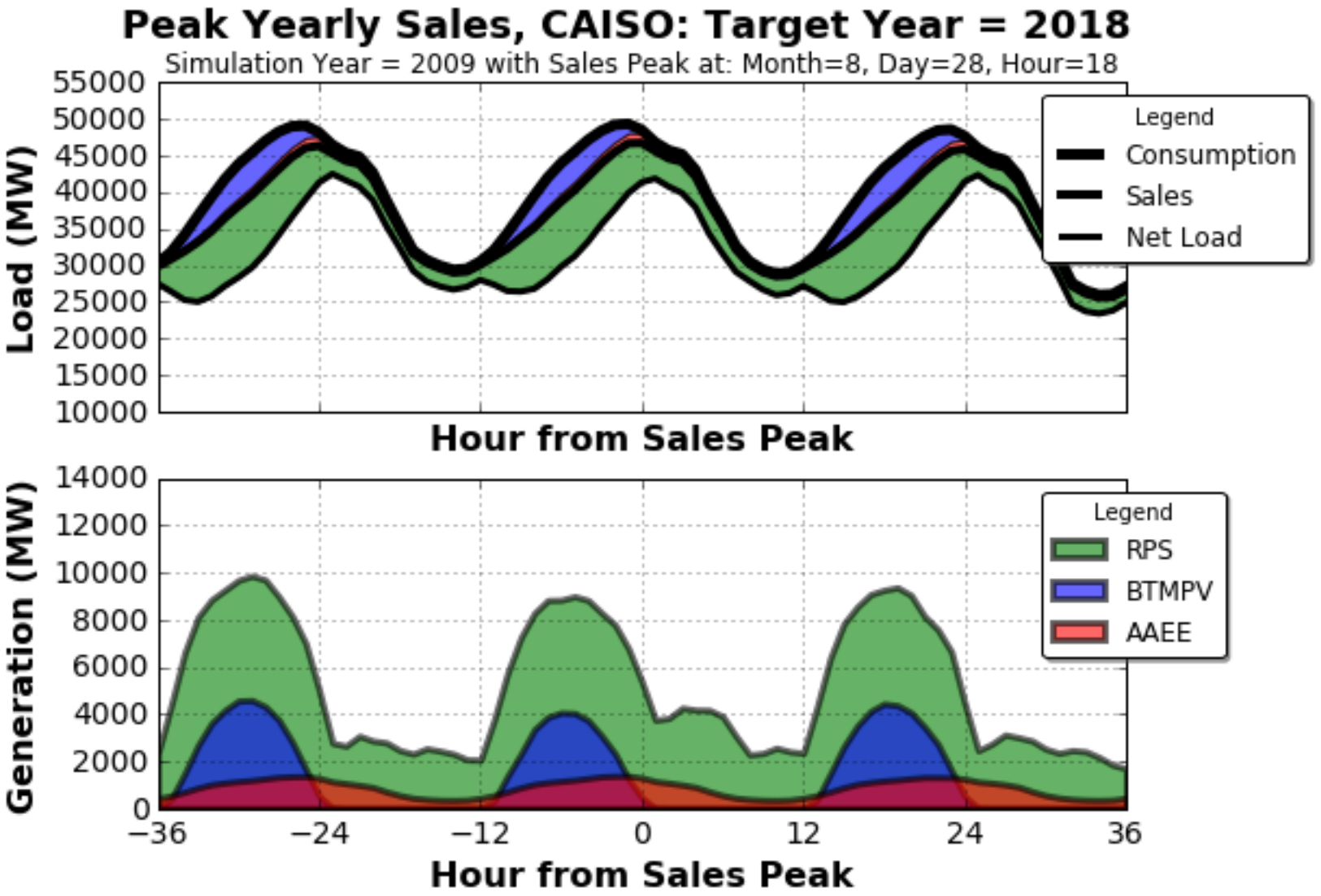
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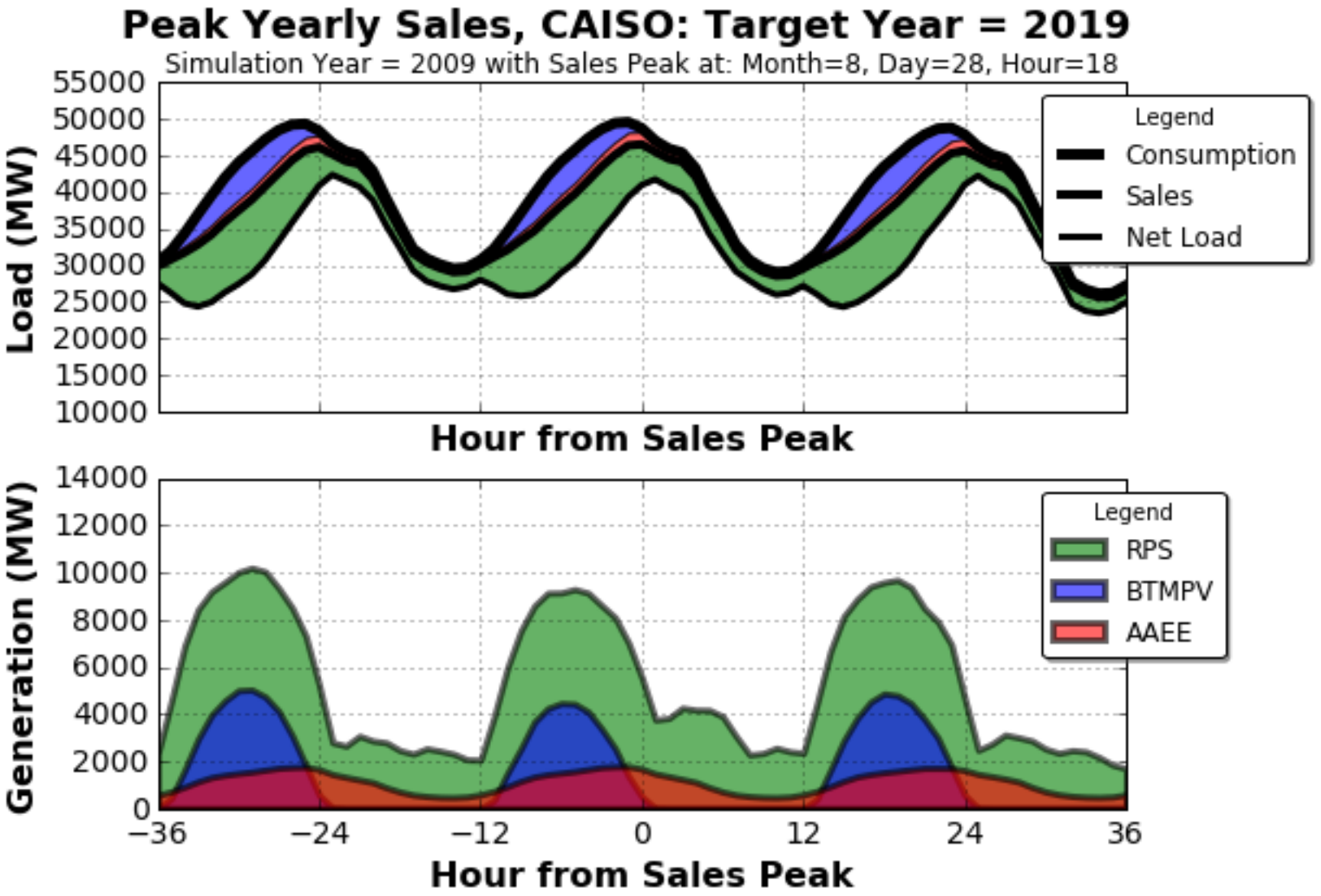
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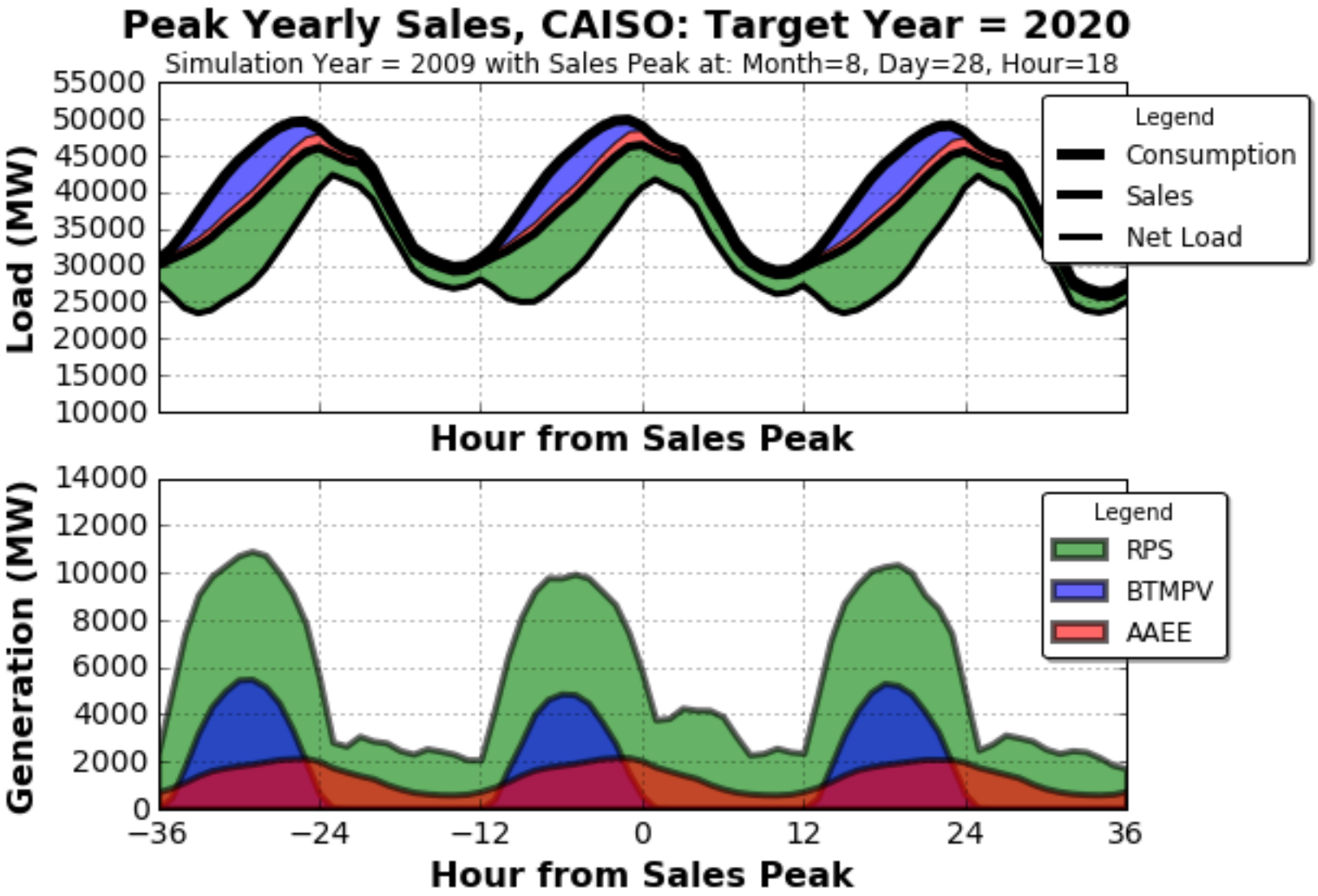
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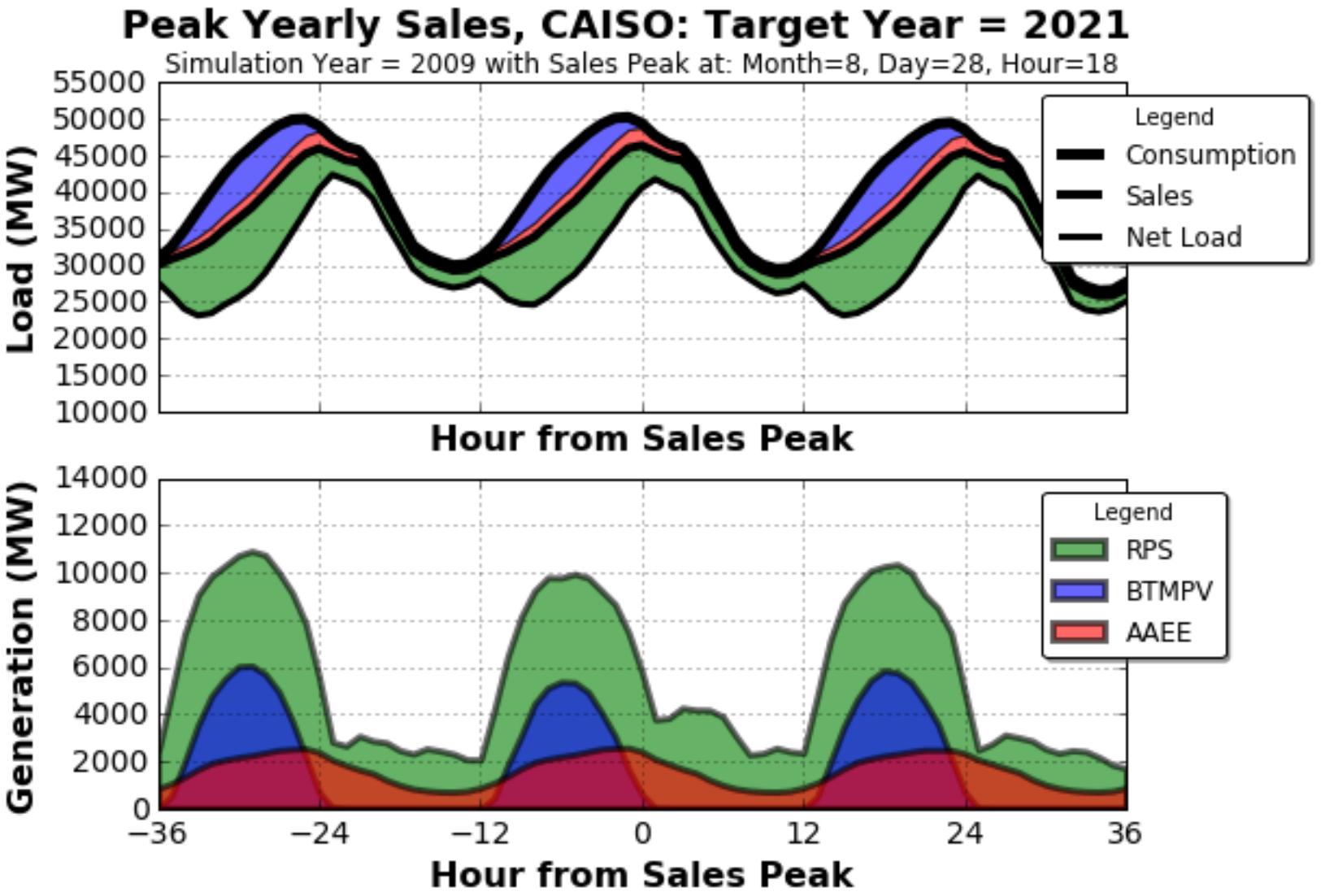
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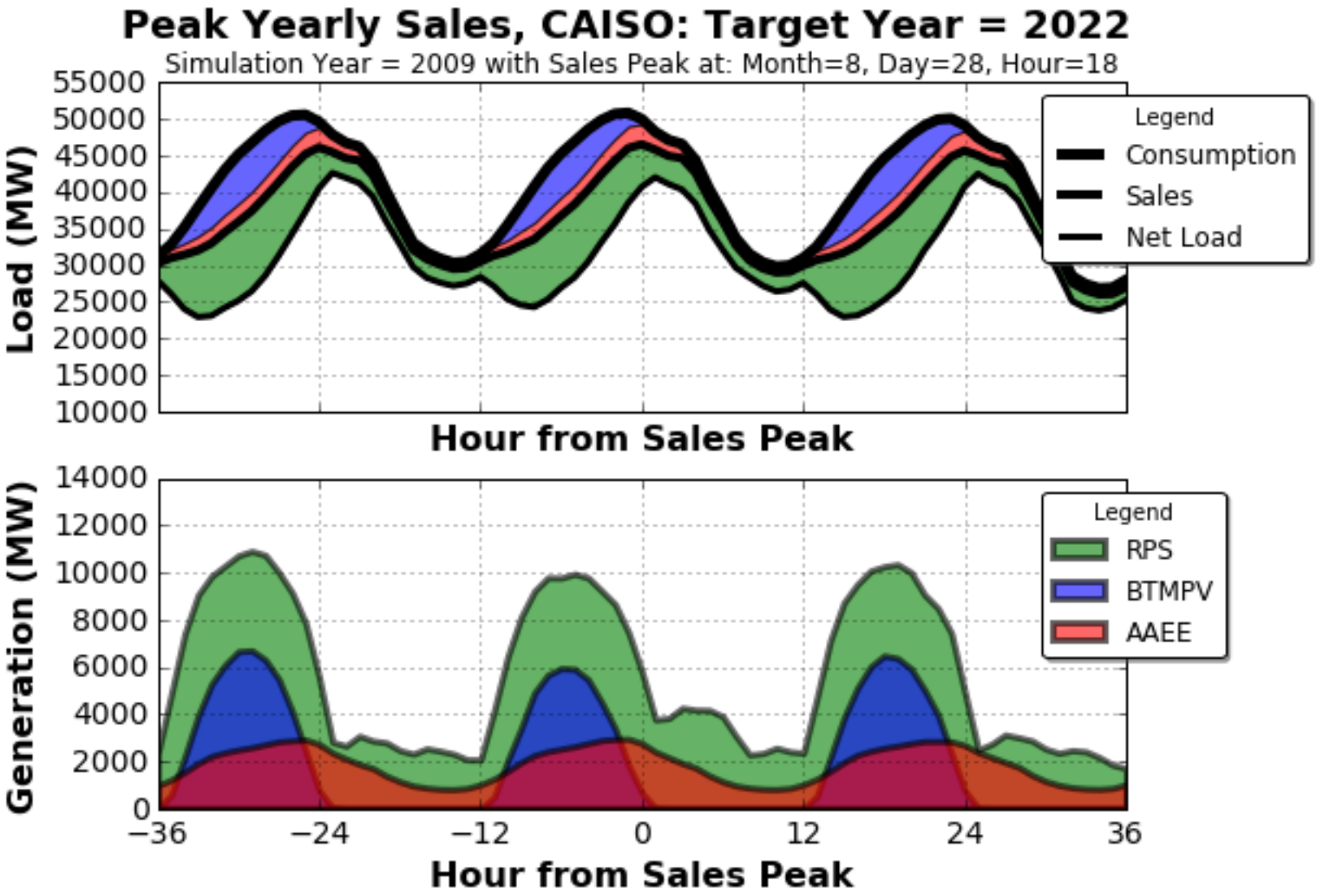
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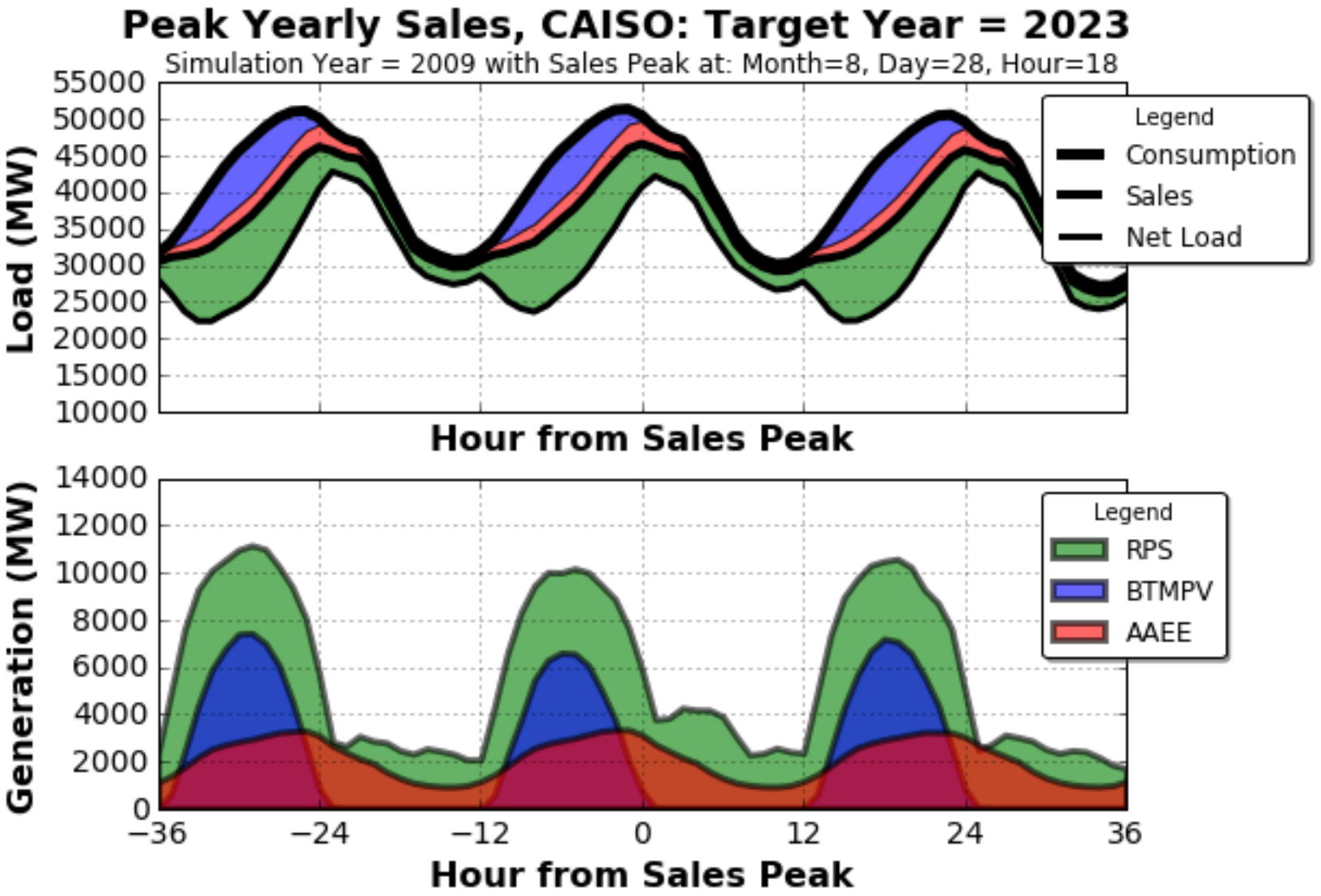
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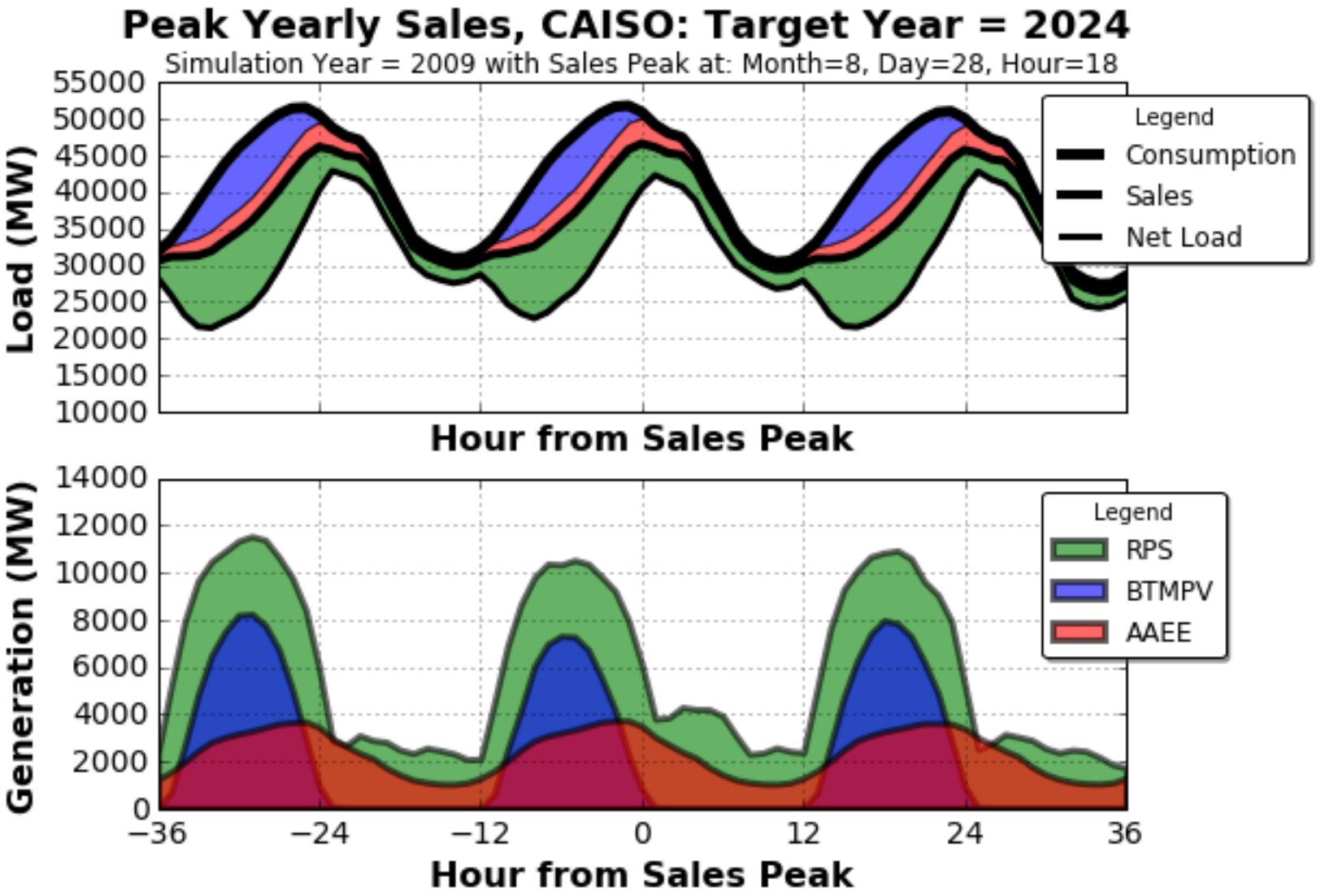
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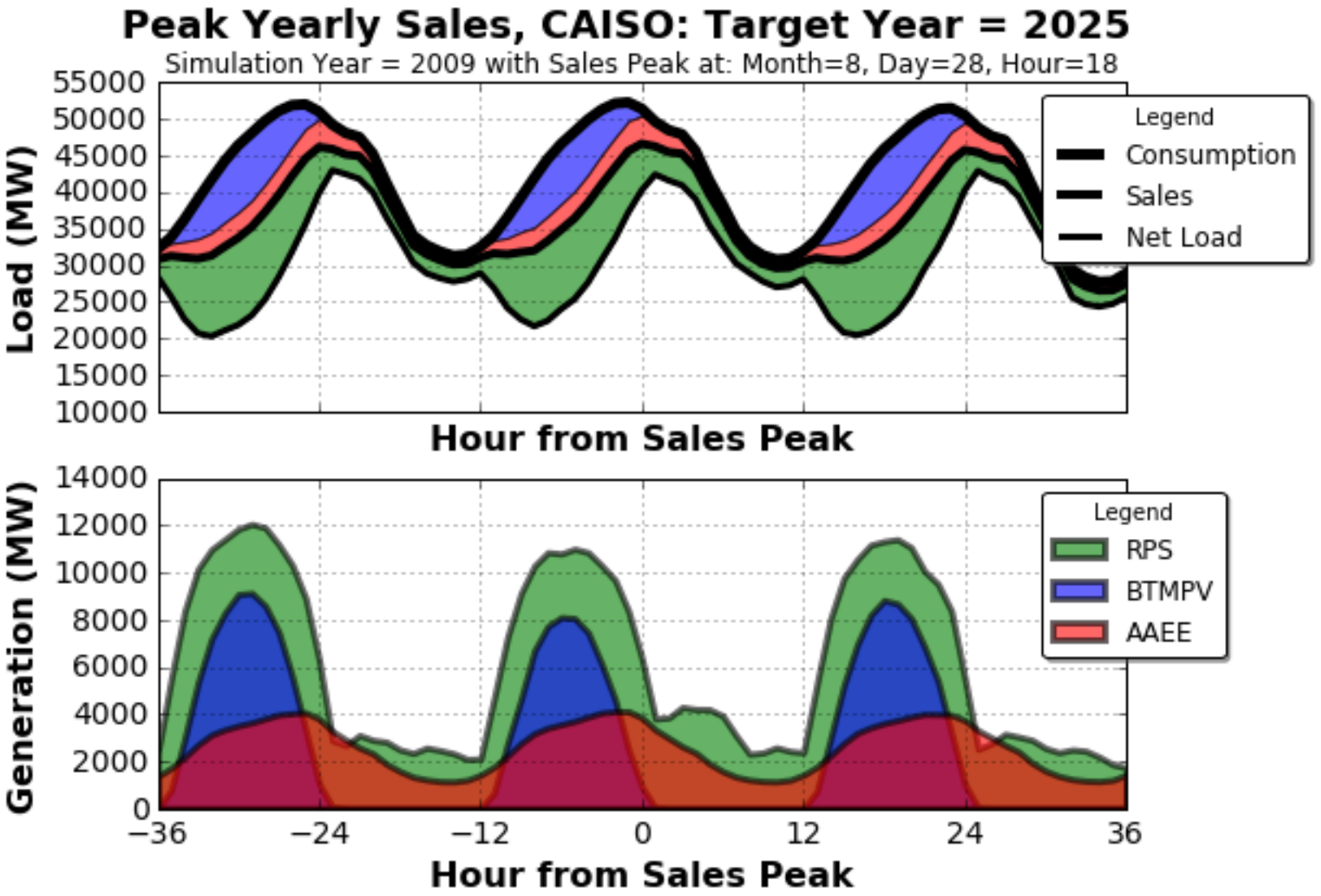
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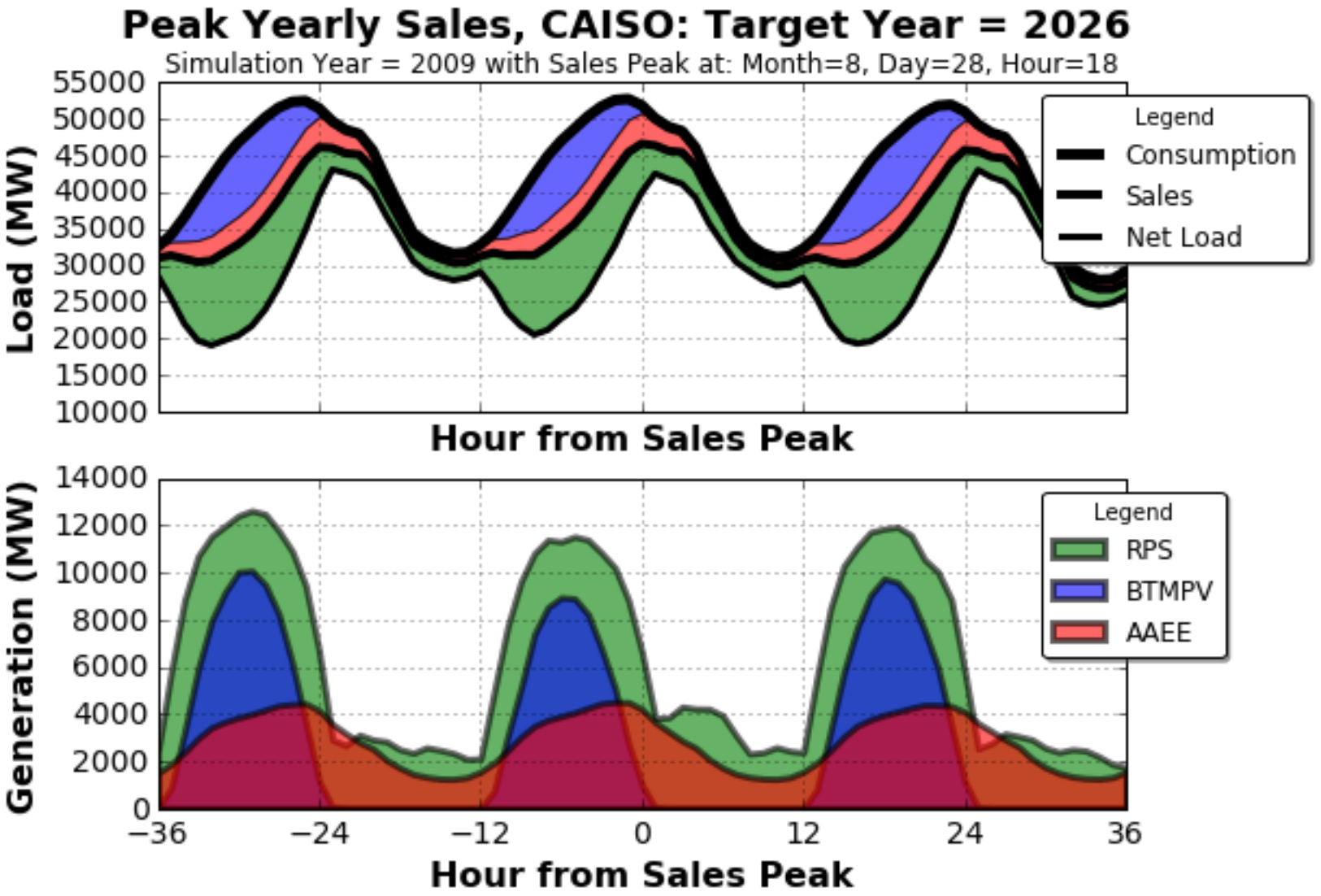
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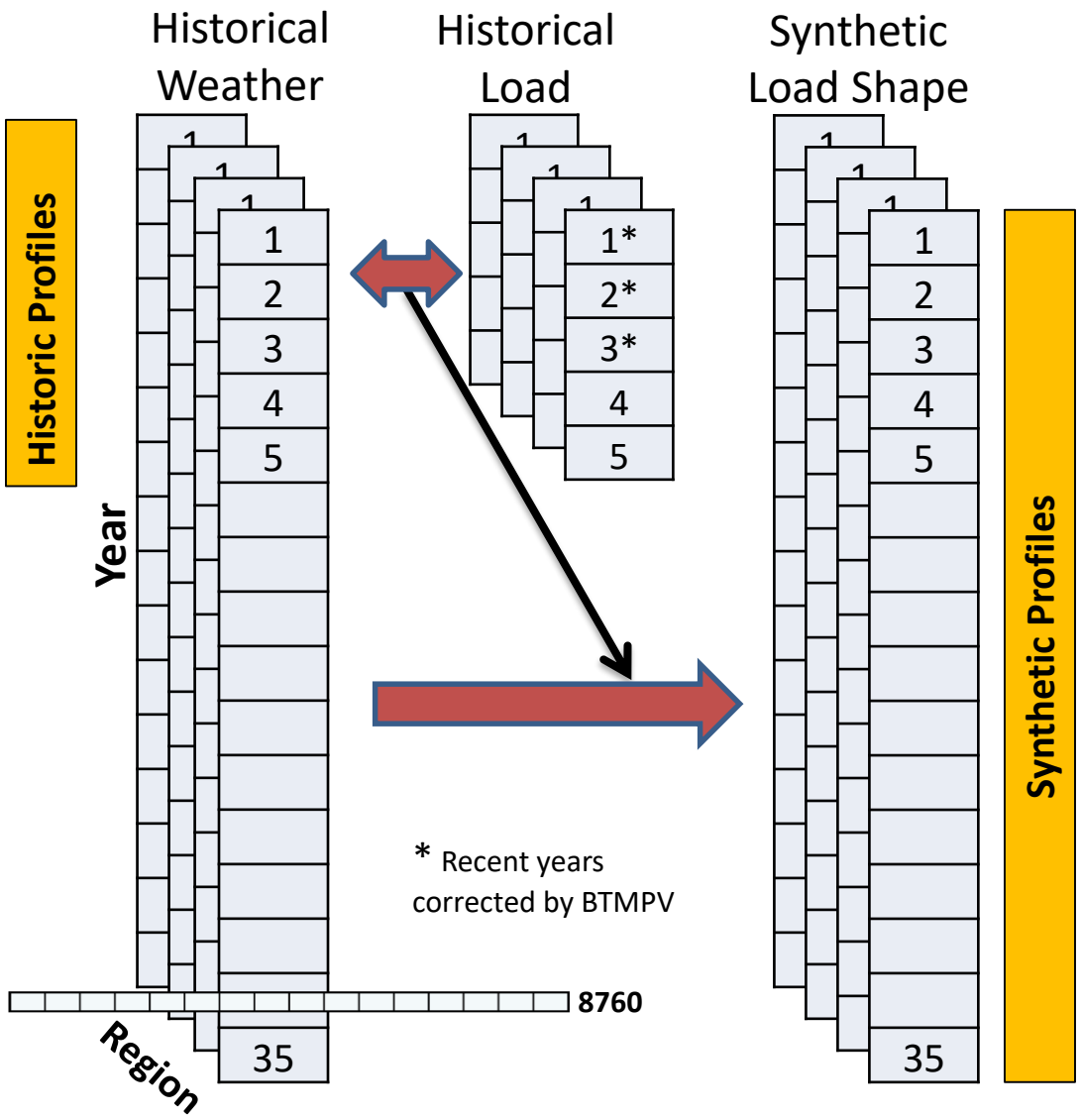
Background: Peak Load Shift Analysis



- 35 (1980 – 2014) Weather Years
- 25 Transmission Regions for WECC
  - 8 for CA
  - 17 outside CA
- Synthetic load profiles based on historical weather, scaled to target year peak and average annual consumption
- **Installed capacities are the basis of renewable generation in target year**

Peak Load Shift Analysis

- Recent Historical Sales and Weather Trains the Model
- Historical spatial and temporal correlation between load and weather is preserved in the model
- 2015 CEC IEPR Forecast:
  - Historical load shapes are adjusted to match both peak and average annual load
  - Average across 35 synthetic / historical year matches IEPR

CEC Load Forecast

- Load forecast from 2015 CEC IEPR
  - Known issue with peak and average annual BTM PV correction
  - Start this analysis with forms 1.5a/b for Mid Net Load, No AAEE
  - Correct for BTM PV adjustment
    - Add BTM PV peak and average annual contribution using exact same correction
    - This produces Mid Load Consumption, No AAEE with minimal propagation of uncertainty
    - Use BTM PV capacity to generate hourly BTM PV generation
  - Use annual hourly AAEE curves by zone as provided by CEC
  - All values grossed up to system

Hyperlinks to Final Adopted 2015 CEC Forecasts
Forms 1.2, 1.4
Forms 1.5a,b

Forecast Grid Behavior, CAISO

Region	Year	Peak (MW) at Peak:			BTMPV (MW) at Peak:			AAEE (MW) at Peak:		
		Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)
CAISO	2017	48,659	46,273	**5**	1,600	647	**60**	830	785	**5**
	2018	49,019	46,113	**6**	1,764	705	**60**	1,305	1,231	**6**
	2019	49,249	45,923	**7**	1,931	772	**60**	1,681	1,575	**6**
	2020	49,570	45,838	**8**	2,105	847	**60**	2,038	1,883	**8**
	2021	49,943	45,826	**8**	2,246	927	**59**	2,412	2,228	**8**
	2022	50,516	45,972	**9**	2,486	941	**62**	2,763	2,551	**8**
	2023	51,045	46,040	**10**	2,759	1,035	**63**	3,129	2,888	**8**
	2024	51,509	46,046	**11**	3,059	823	**73**	3,491	3,215	**8**
	2025	51,948	46,040	**11**	3,386	908	**73**	3,855	3,543	**8**
	2026	52,413	46,038	**12**	3,849	454	**88**	4,200	3,579	**15**

$$Sales = Consumption - BTMPV - AAEE$$

$$D(\%) = \frac{Consumption - Sales}{Consumption}$$

Forecast Grid Behavior, PGE

Region	Year	Peak (MW) at Peak:			BTMPV (MW) at Peak:			AAEE (MW) at Peak:		
		Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)
PGE	2017	21,577	20,795	**4**	872	141	**84**	359	327	**9**
	2018	21,785	20,814	**4**	950	154	**84**	568	520	**8**
	2019	21,934	20,794	**5**	1,032	121	**88**	730	653	**11**
	2020	22,132	20,834	**6**	1,122	131	**88**	884	791	**11**
	2021	22,368	20,896	**7**	1,230	144	**88**	1,048	924	**12**
	2022	22,662	21,024	**7**	1,356	141	**90**	1,200	1,019	**15**
	2023	22,977	21,180	**8**	1,500	156	**90**	1,357	1,147	**15**
	2024	23,248	21,308	**8**	1,660	173	**90**	1,509	1,258	**17**
	2025	23,450	21,370	**9**	1,832	191	**90**	1,662	1,374	**17**
	2026	23,723	21,500	**9**	2,019	210	**90**	1,815	1,500	**17**

$$Sales = Consumption - BTMPV - AAEE$$

$$D(\%) = \frac{Consumption - Sales}{Consumption}$$

Forecast Grid Behavior, SDGE

Region	Year	Peak (MW) at Peak:			BTMPV (MW) at Peak:			AAEE (MW) at Peak:		
		Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)
SDGE	2017	4,990	4,729	**5**	312	45	**86**	86	84	**3**
	2018	5,024	4,717	**6**	348	43	**88**	134	129	**4**
	2019	5,050	4,703	**7**	380	47	**88**	170	164	**4**
	2020	5,071	4,687	**8**	411	50	**88**	205	195	**4**
	2021	5,110	4,689	**8**	448	55	**88**	240	227	**6**
	2022	5,177	4,720	**9**	490	60	**88**	275	258	**6**
	2023	5,220	4,723	**10**	536	55	**90**	311	281	**10**
	2024	5,262	4,722	**10**	585	12	**98**	346	298	**14**
	2025	5,305	4,739	**11**	637	13	**98**	381	303	**21**
	2026	5,347	4,755	**11**	691	0	**100**	416	314	**24**

$$Sales = Consumption - BTMPV - AAEE$$

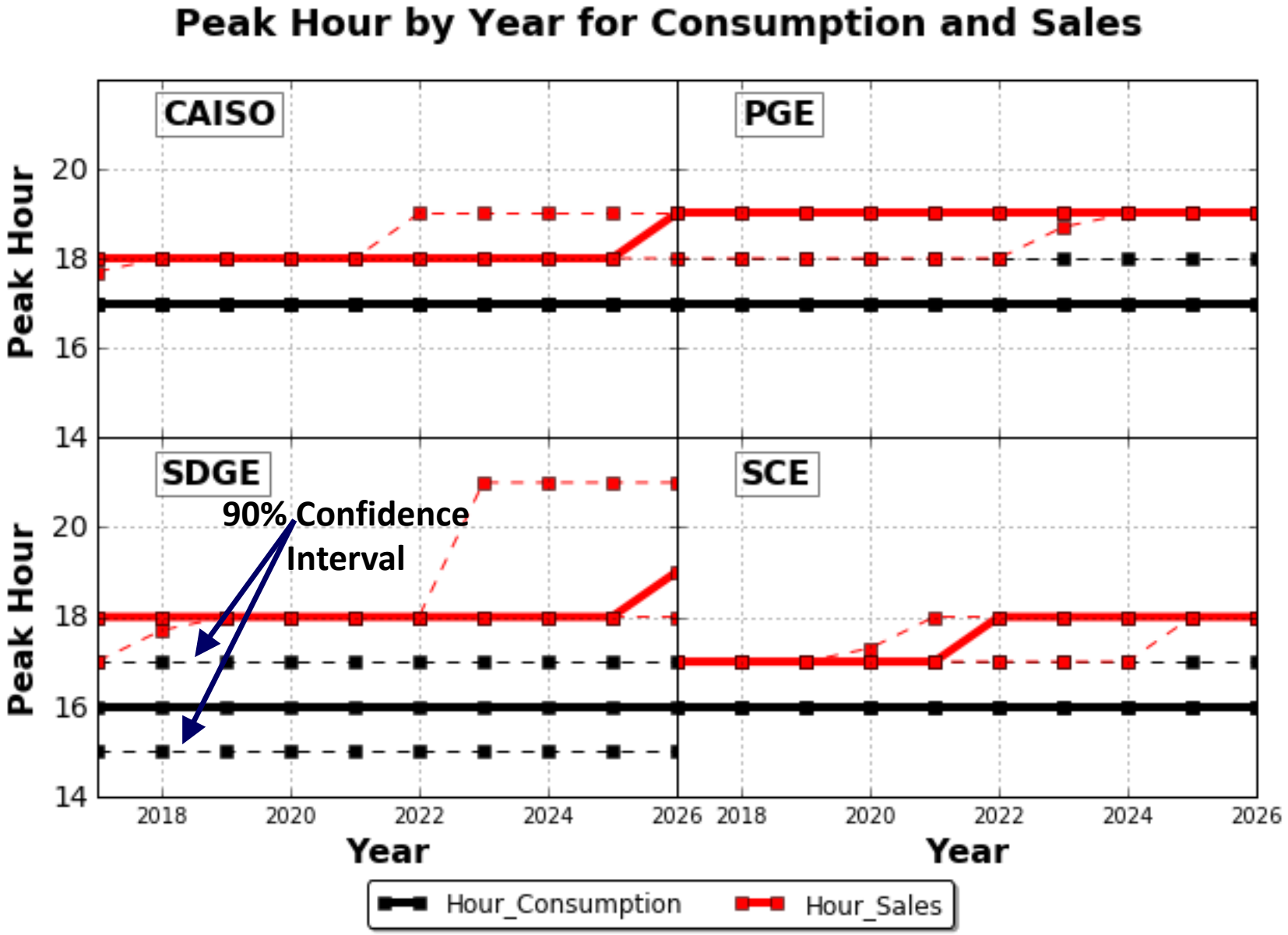
$$D(\%) = \frac{Consumption - Sales}{Consumption}$$

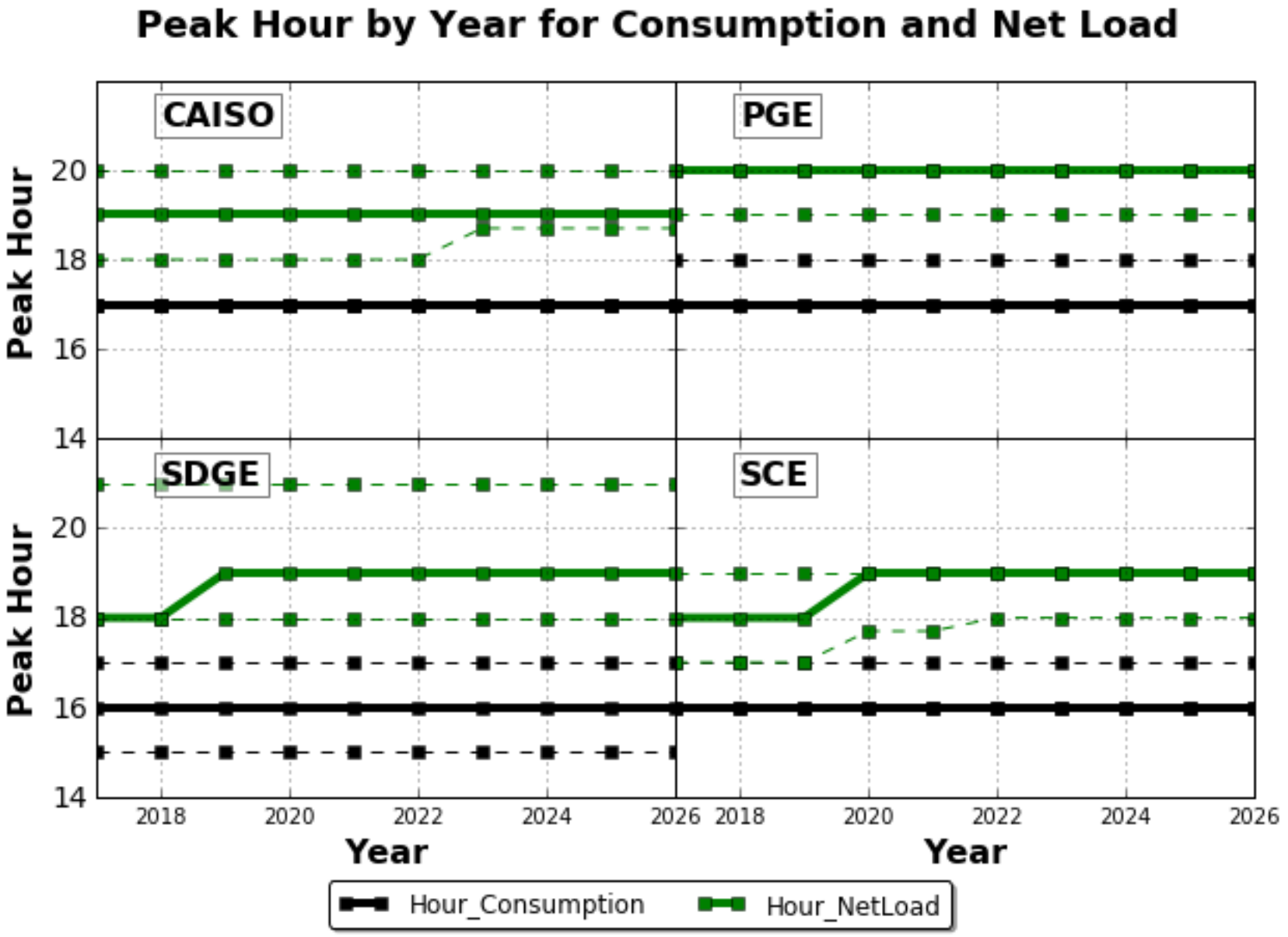
Forecast Grid Behavior, SCE

Region	Year	Peak (MW) at Peak:			BTMPV (MW) at Peak:			AAEE (MW) at Peak:		
		Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)
SCE	2017	23,921	23,028	**4**	773	460	**40**	394	387	**2**
	2018	24,057	22,881	**5**	869	497	**43**	621	610	**2**
	2019	24,120	22,705	**6**	966	552	**43**	796	786	**1**
	2020	24,234	22,599	**7**	1,062	607	**43**	963	943	**2**
	2021	24,349	22,478	**8**	1,182	535	**55**	1,138	1,096	**4**
	2022	24,586	22,494	**9**	1,323	378	**71**	1,301	1,250	**4**
	2023	24,779	22,478	**9**	1,482	318	**79**	1,475	1,411	**4**
	2024	24,947	22,496	**10**	1,657	276	**83**	1,645	1,550	**6**
	2025	25,153	22,518	**10**	1,851	309	**83**	1,820	1,645	**10**
	2026	25,321	22,500	**11**	2,058	343	**83**	1,998	1,793	**10**

$$Sales = Consumption - BTMPV - AAEE$$

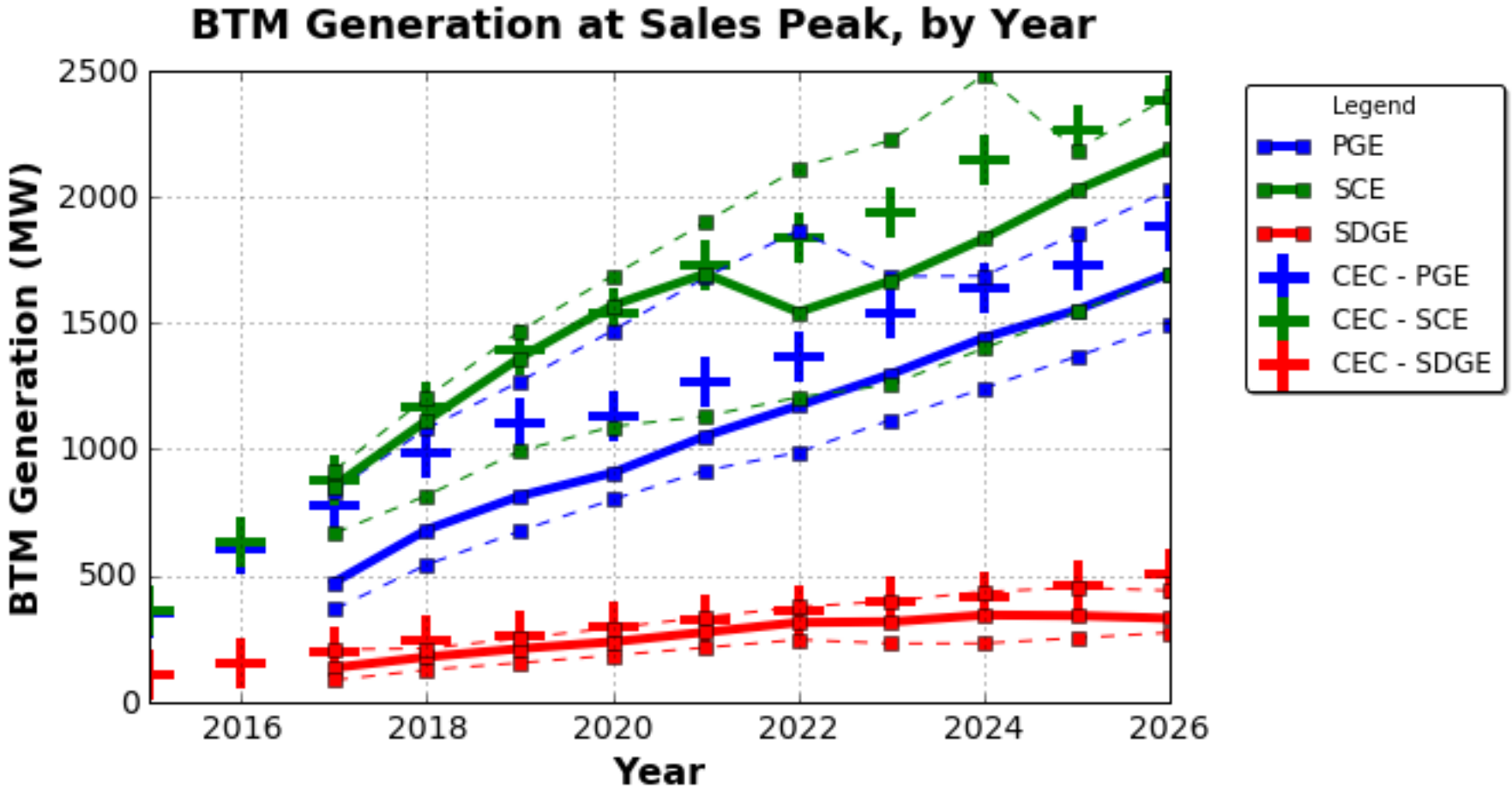
$$D(\%) = \frac{Consumption - Sales}{Consumption}$$

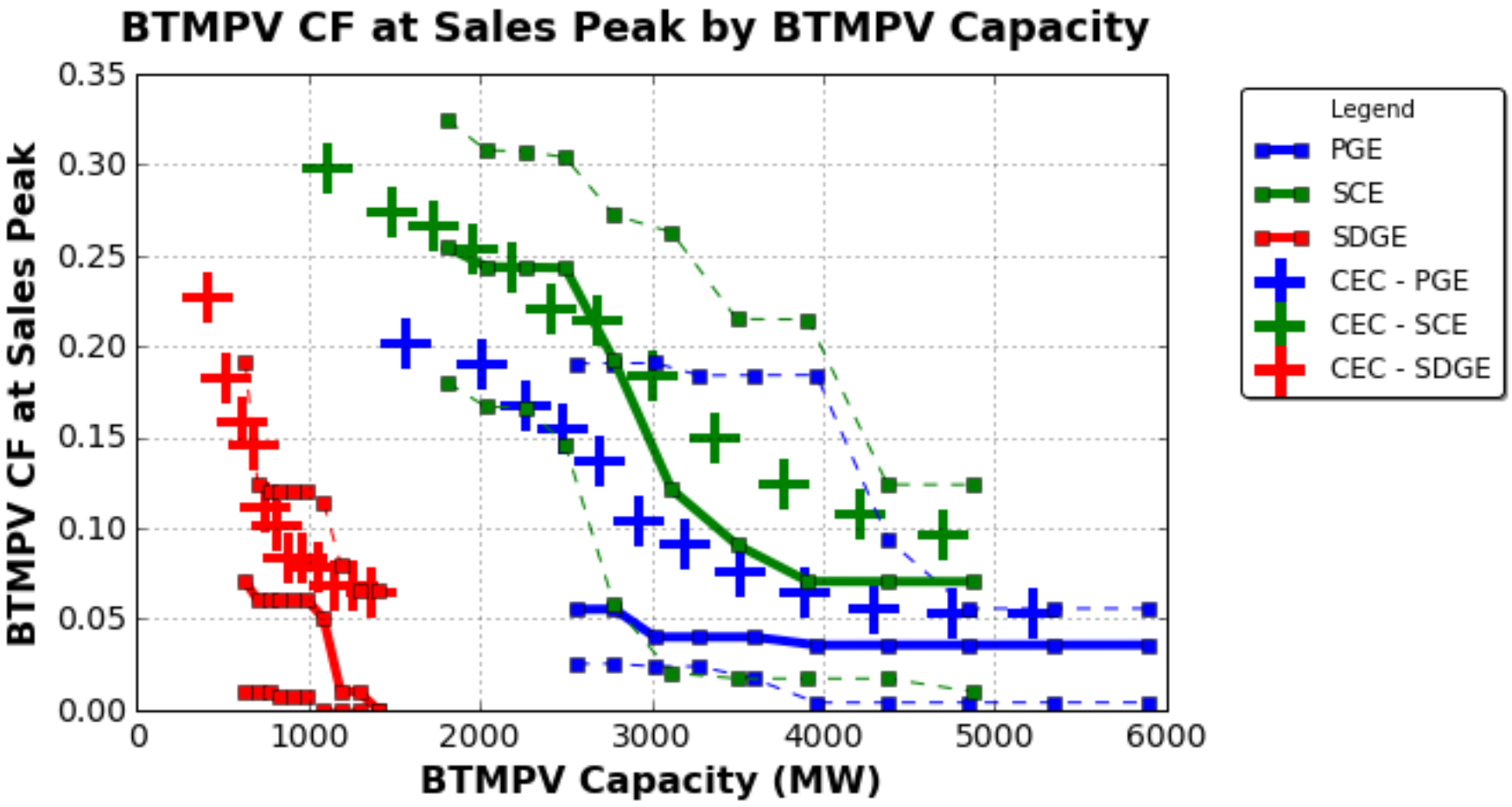

Peak Hour by Year for Consumption and Sales
CAISO
PGE
SDGE
SCE
90% Confidence Interval
Peak Hour
Year
20
18
16
14
2018
2020
2022
2024
2026
Hour_Consumption
Hour_Sales


Peak Hour by Year for Consumption and Net Load
CAISO
PGE
SDGE
SCE
Peak Hour
20
18
16
14
2018
2020
2022
2024
2026
Year
Hour_Consumption
Hour_NetLoad

Comparison with CEC Results

- Known issue with original 2015 IEPR forecast
- Initial update only contains BTM PV and AAEE contribution at sale peak
- This limited comparison is reasonable


BTM Generation at Sales Peak, by Year
BTM Generation (MW)
2500
2000
1500
1000
500
0
2016
2018
2020
2022
2024
2026
Year
Legend
PGE
SCE
SDGE
CEC - PGE
CEC - SCE
CEC - SDGE

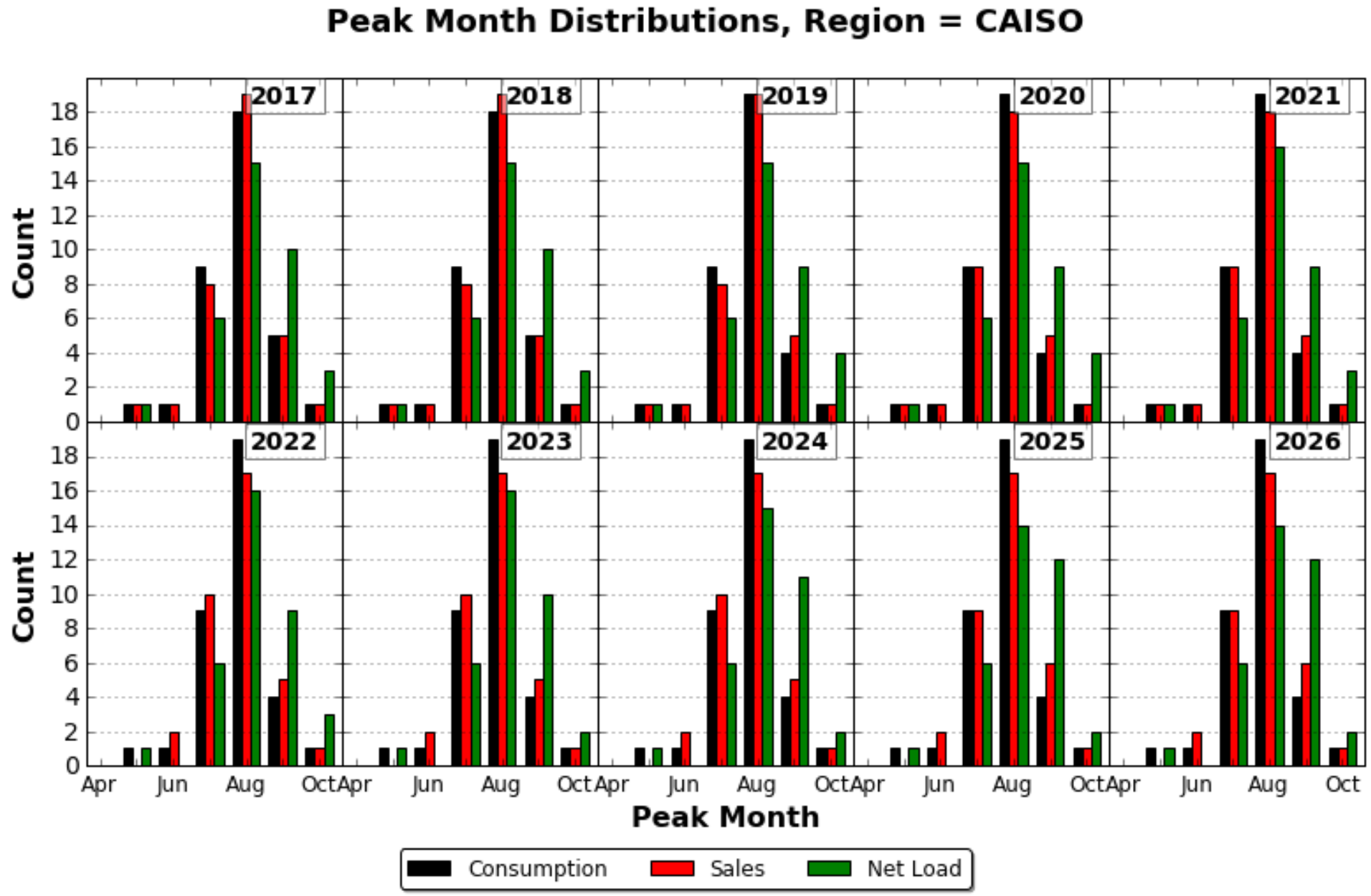


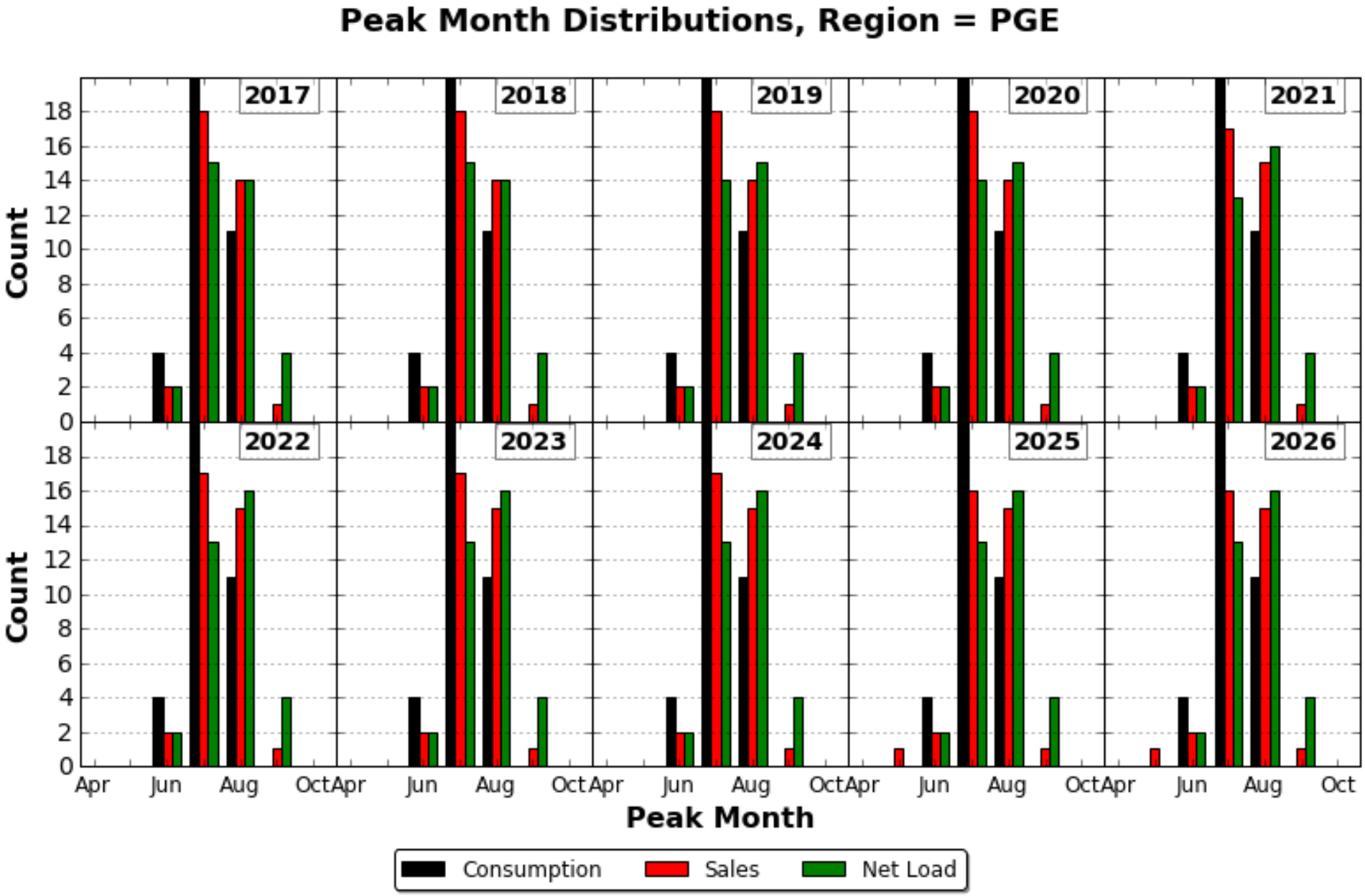
Capacity Factor (CF) at Sales Peak:

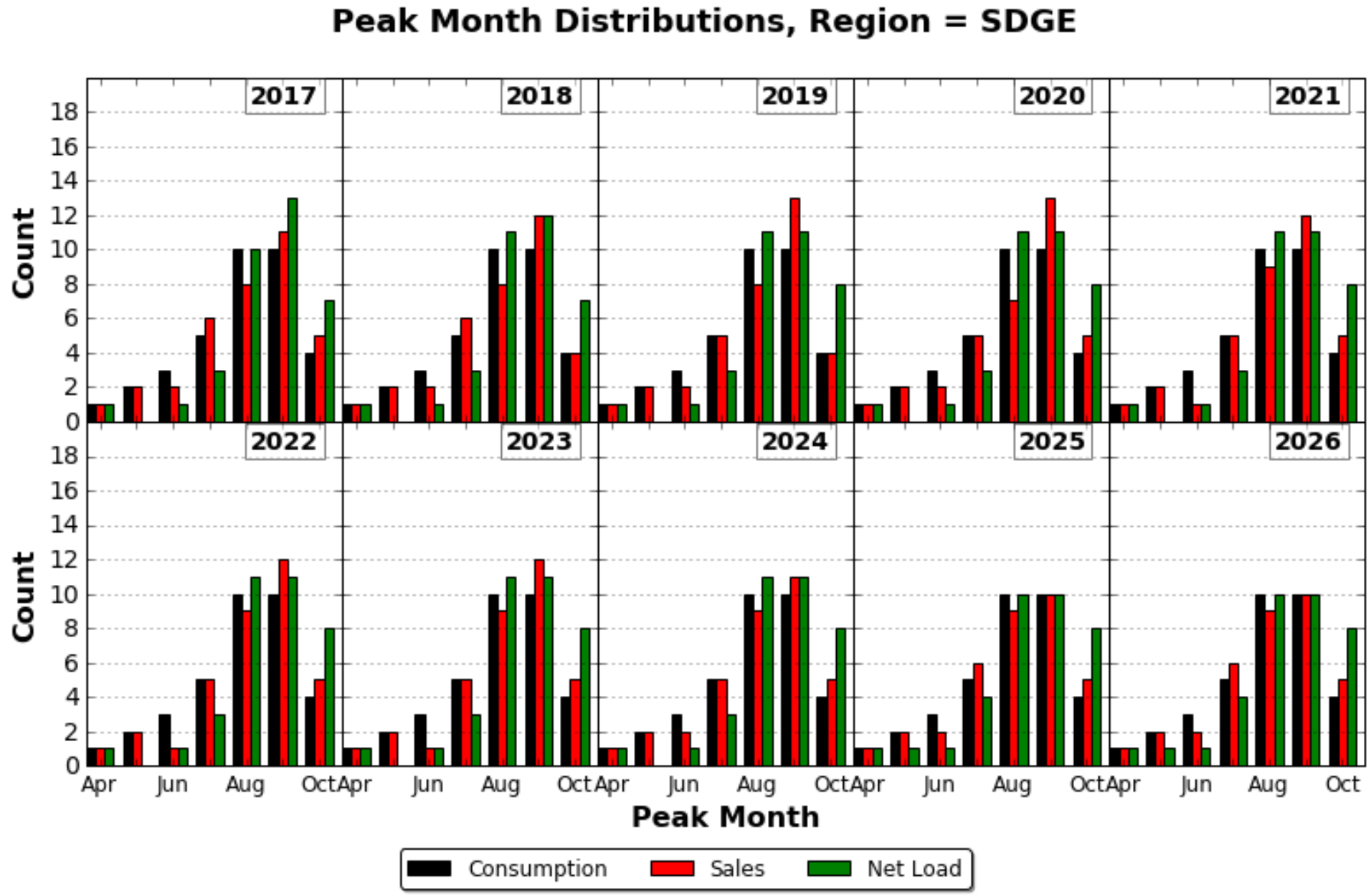
- The ratio of BTMPV generation to BTMPV capacity at the hour of Peak Net Load

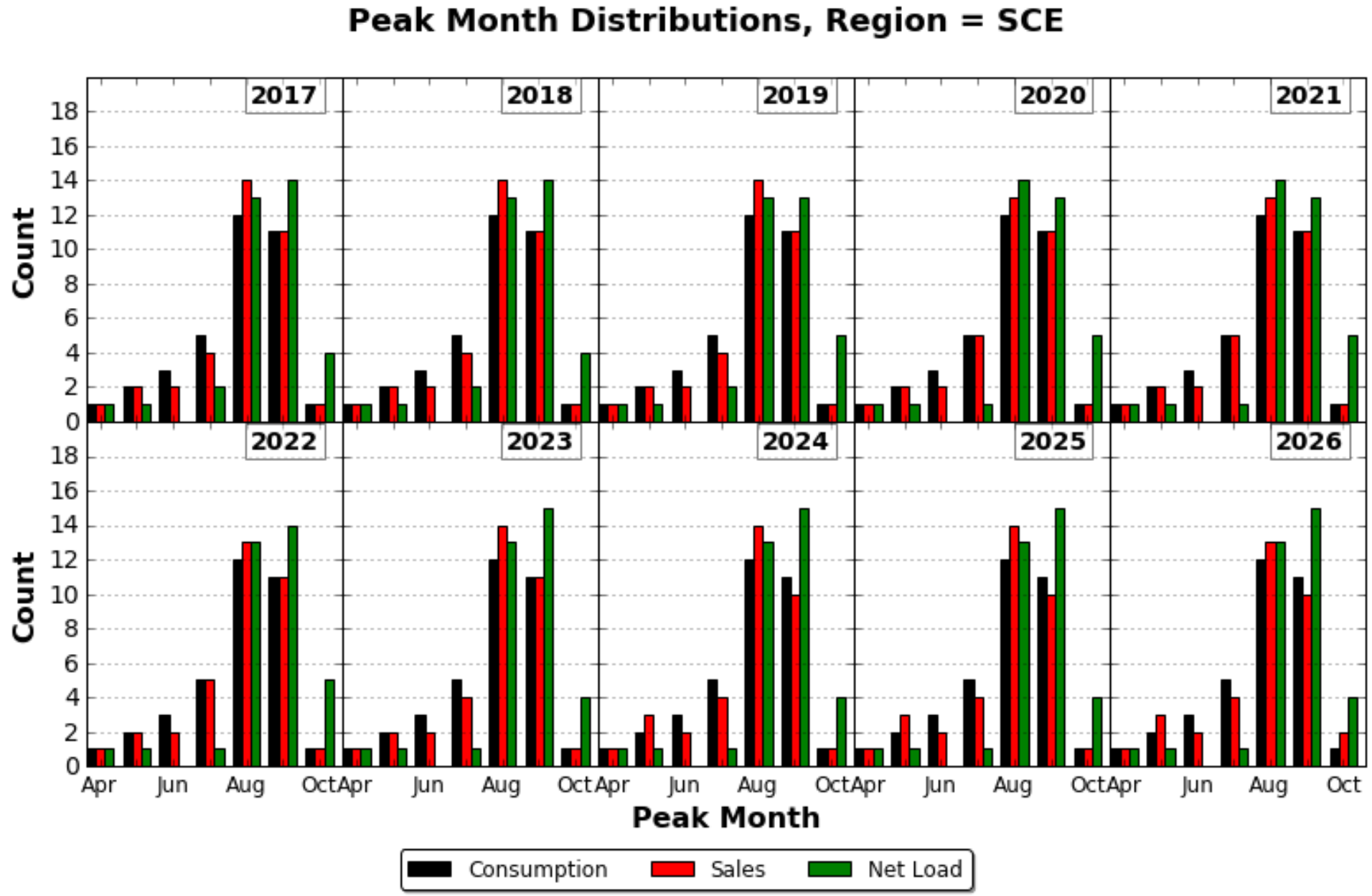
Peak Month Distributions

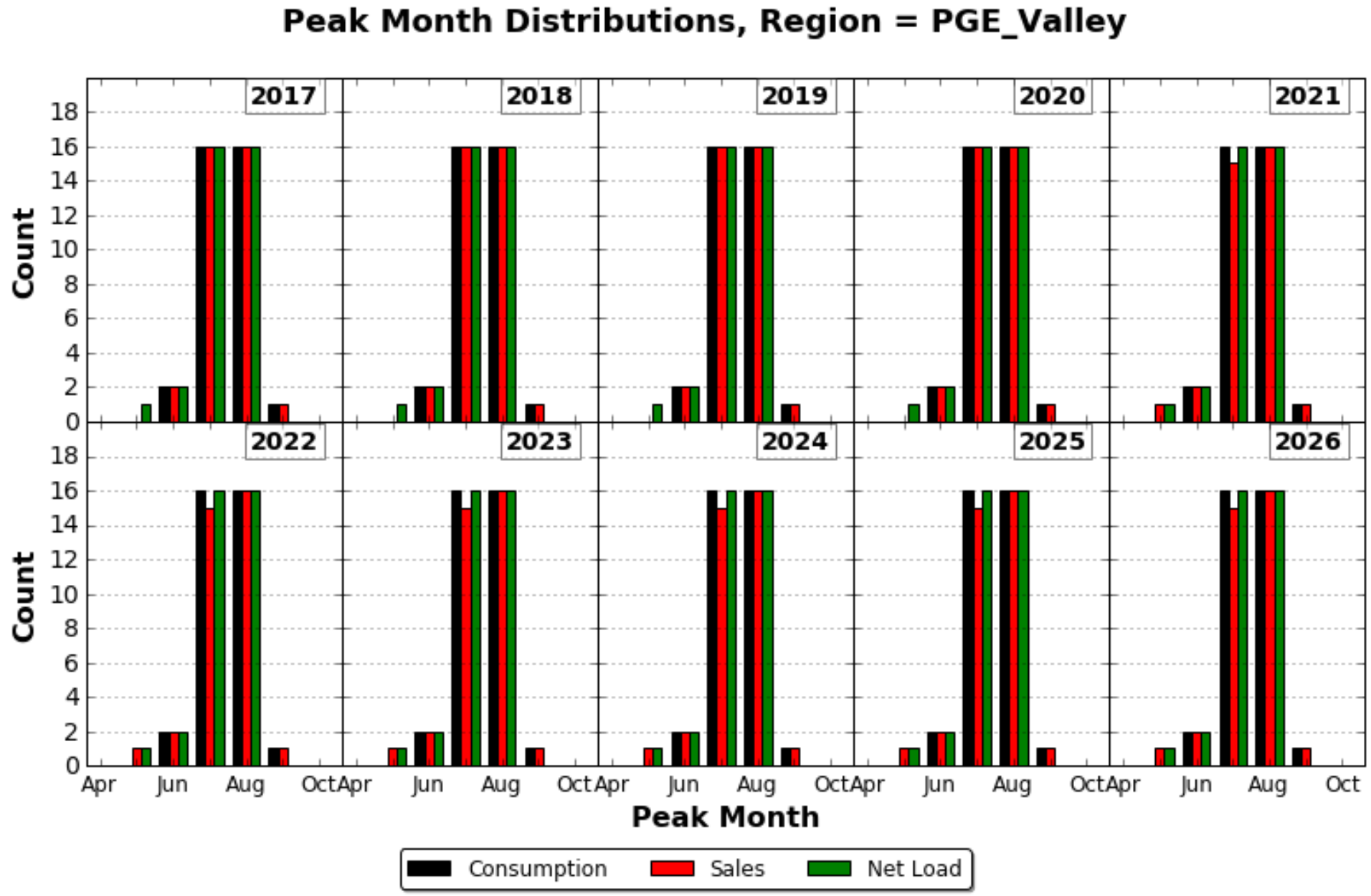
- Where do peak months occur for:
  - Consumption
  - Sales
  - Net Load
- We can examine distribution of peak months for set of 35 synthetic profiles across regions
  - CAISO, PGE, SDGE, SCE
  - Note that consumption is independent of:
    - BTM PV, AAEE, RPS

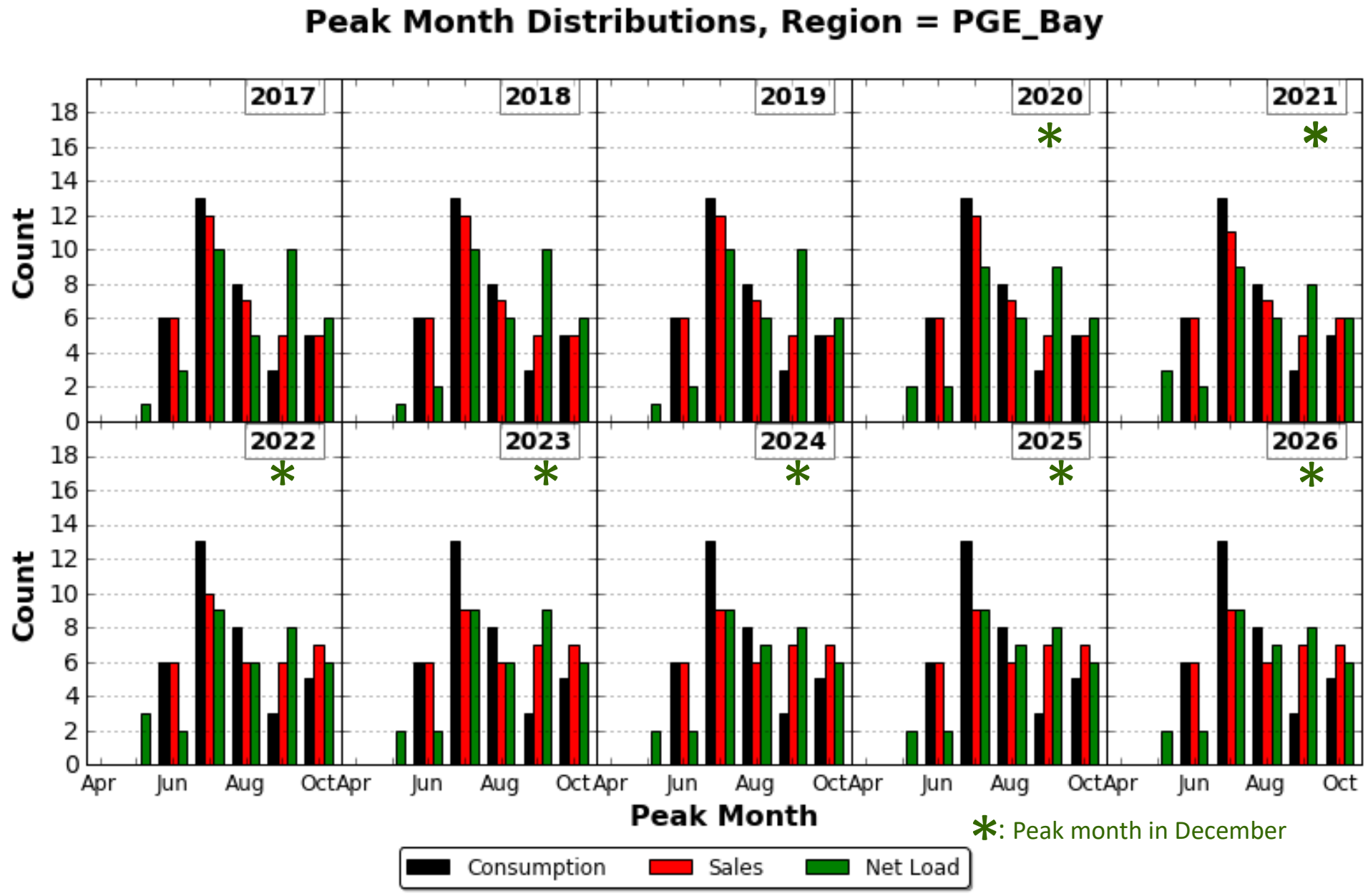

Peak Month Distributions, Region = CAISO
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Count
Count
0
2
4
6
8
10
12
14
16
18
Apr
Jun
Aug
Oct
Peak Month
Consumption
Sales
Net Load

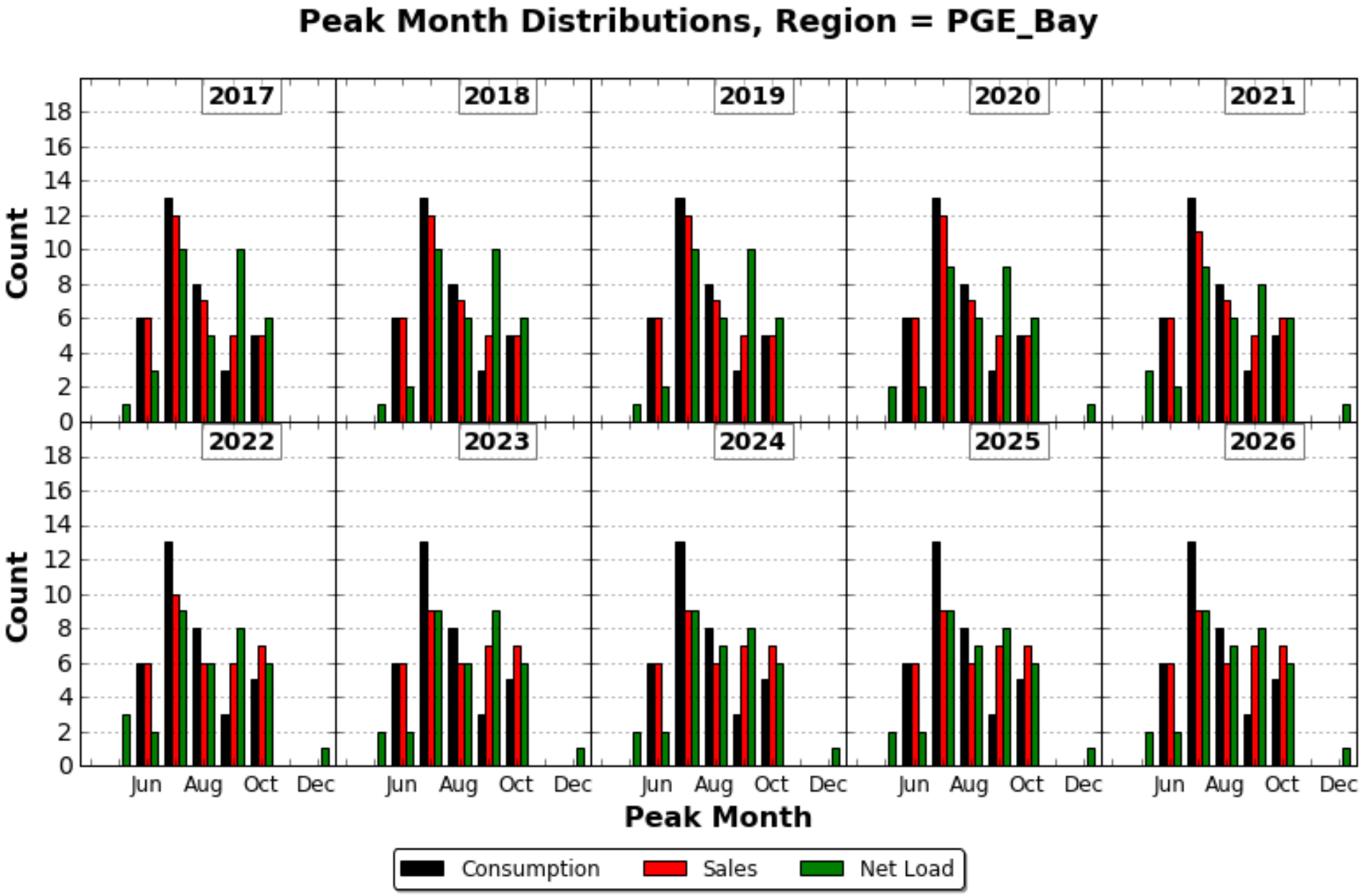

Peak Month Distributions, Region = PGE
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Count
Count
0
2
4
6
8
10
12
14
16
18
Apr
Jun
Aug
Oct
Peak Month
Consumption
Sales
Net Load


Peak Month Distributions, Region = SDGE
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Count
Count
0
2
4
6
8
10
12
14
16
18
Apr
Jun
Aug
Oct
Peak Month
Consumption
Sales
Net Load


Peak Month Distributions, Region = SCE
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Count
Count
0
2
4
6
8
10
12
14
16
18
Apr
Jun
Aug
Oct
Peak Month
Consumption
Sales
Net Load


Peak Month Distributions, Region = PGE_Valley
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Count
Count
0
2
4
6
8
10
12
14
16
18
Apr
Jun
Aug
Oct
Peak Month
Consumption
Sales
Net Load


Peak Month Distributions, Region = PGE_Bay
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Count
Count
0
2
4
6
8
10
12
14
16
18
Apr
Jun
Aug
Oct
Peak Month
*: Peak month in December
Consumption
Sales
Net Load


Peak Month Distributions, Region = PGE_Bay
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Count
Count
0
2
4
6
8
10
12
14
16
18
Jun
Aug
Oct
Dec
Peak Month
Consumption
Sales
Net Load

$$\frac{1}{35} = 0.0286$$

Multipliers

- Ratio of sales peak at 1-in-N to 1-in-2
- CEC results from 'Forms 1.5 – Mid'

	1-in-5		1-in-10		1-in-20	
Region	**CPUC**	**CEC**	**CPUC**	**CEC**	**CPUC**	**CEC**
PGE	1.021	1.045	1.034	1.068	1.073	1.085
SDGE	1.025	1.074	1.037	1.115	1.045	1.143
SCE	1.029	1.058	1.036	1.100	1.039	1.110

Conclusions / Next Steps

- Very limited comparison to CEC data
  - BTM generation comparison is reasonable
  - Waiting for additional information
  - CPUC 1-in-N multipliers are smaller than CEC
- Transmission zones behave differently
  - Beginning to see how peak hours will shift
- This same data set can be used to analyze:
  - Exceedance distributions
  - Distributions of maximum daily ramp rates

Thank you

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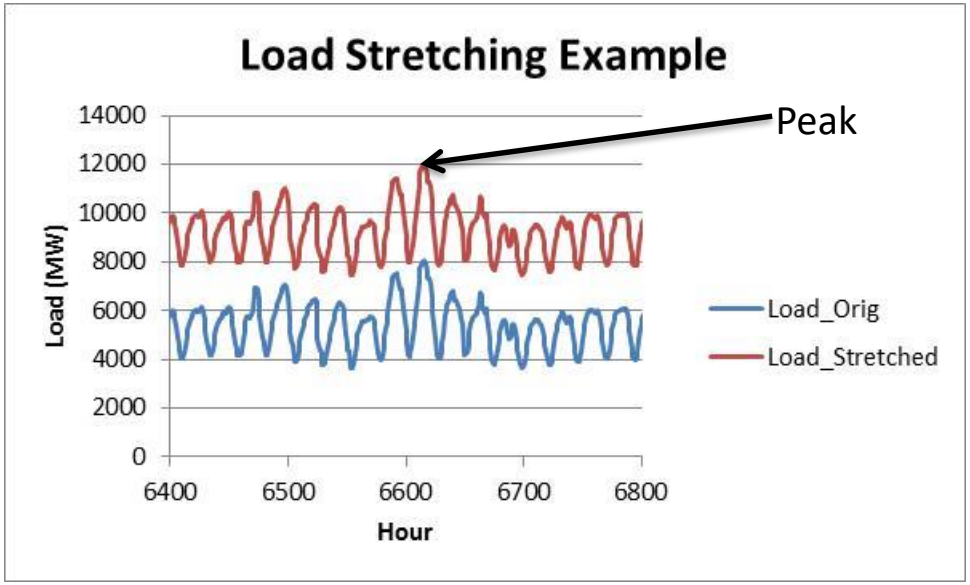
Additional Slides

How Are Load Shapes Scaled?

- We want to transform load shape to match forecast ***peak*** and ***average***
- We want to preserve historical load shapes
  - Distribution of peak and average annual across historical load shapes is also preserved
- Use linear transformation: $Y_t = aX_t + b$



Forecast Grid Behavior, PGE Bay

Region	Year	Peak (MW) at Peak:			BTMPV (MW) at Peak:			AAEE (MW) at Peak:		
		Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)
PGE Bay	2017	9,342	8,890	**5**	320	53	**83**	153	141	**8**
	2018	9,437	8,900	**6**	355	59	**83**	242	221	**9**
	2019	9,512	8,909	**6**	390	65	**83**	312	284	**9**
	2020	9,598	8,911	**7**	430	72	**83**	378	344	**9**
	2021	9,708	8,937	**8**	476	79	**83**	448	401	**10**
	2022	9,835	8,978	**9**	528	88	**83**	513	451	**12**
	2023	9,984	9,052	**9**	588	98	**83**	581	511	**12**
	2024	10,117	9,119	**10**	654	109	**83**	647	569	**12**
	2025	10,215	9,138	**11**	724	121	**83**	713	619	**13**
	2026	10,350	9,198	**11**	800	133	**83**	782	676	**14**

$$Sales = Consumption - BTMPV - AAEE$$

$$D(\%) = \frac{Consumption - Sales}{Consumption}$$

Forecast Grid Behavior, PGE Valley

Region	Year	Peak (MW) at Peak:			BTMPV (MW) at Peak:			AAEE (MW) at Peak:		
		Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)	Cnsmptn	Sales	D(%)
PGE Valley	2017	12,687	12,351	**3**	208	37	**82**	192	173	**10**
	2018	12,806	12,360	**3**	222	39	**82**	302	273	**10**
	2019	12,882	12,351	**4**	237	42	**82**	385	349	**9**
	2020	13,001	12,391	**5**	254	45	**82**	466	420	**10**
	2021	13,134	12,438	**5**	274	48	**82**	554	498	**10**
	2022	13,308	12,532	**6**	299	53	**82**	636	571	**10**
	2023	13,483	12,624	**6**	328	58	**82**	719	631	**12**
	2024	13,629	12,690	**7**	361	64	**82**	800	701	**12**
	2025	13,736	12,716	**7**	396	70	**82**	882	771	**13**
	2026	13,882	12,781	**8**	435	51	**88**	963	833	**14**

$$Sales = Consumption - BTMPV - AAEE$$

$$D(\%) = \frac{Consumption - Sales}{Consumption}$$