Member Generation: Present and Future

OPALCO

Board Meeting

May 2021

Rates Review: Timeline

✔	May 2021	Member Generation Trends and Modeling
	June	Staff Analysis
	August	Guernsey Cost of Service Analysis (COSA) review
	September	Discussion of Rate Options
	Late September	Solar Town Hall - member feedback
	October	Rate Options Review
	November	Budget and 2022 Rate Proposal (first read)
	December	2022 Rate Structure (second read)
	January	Rate Implementation

Member Generation: Present and Future

Agenda

Understanding the Present

2020 Member Generation Analysis

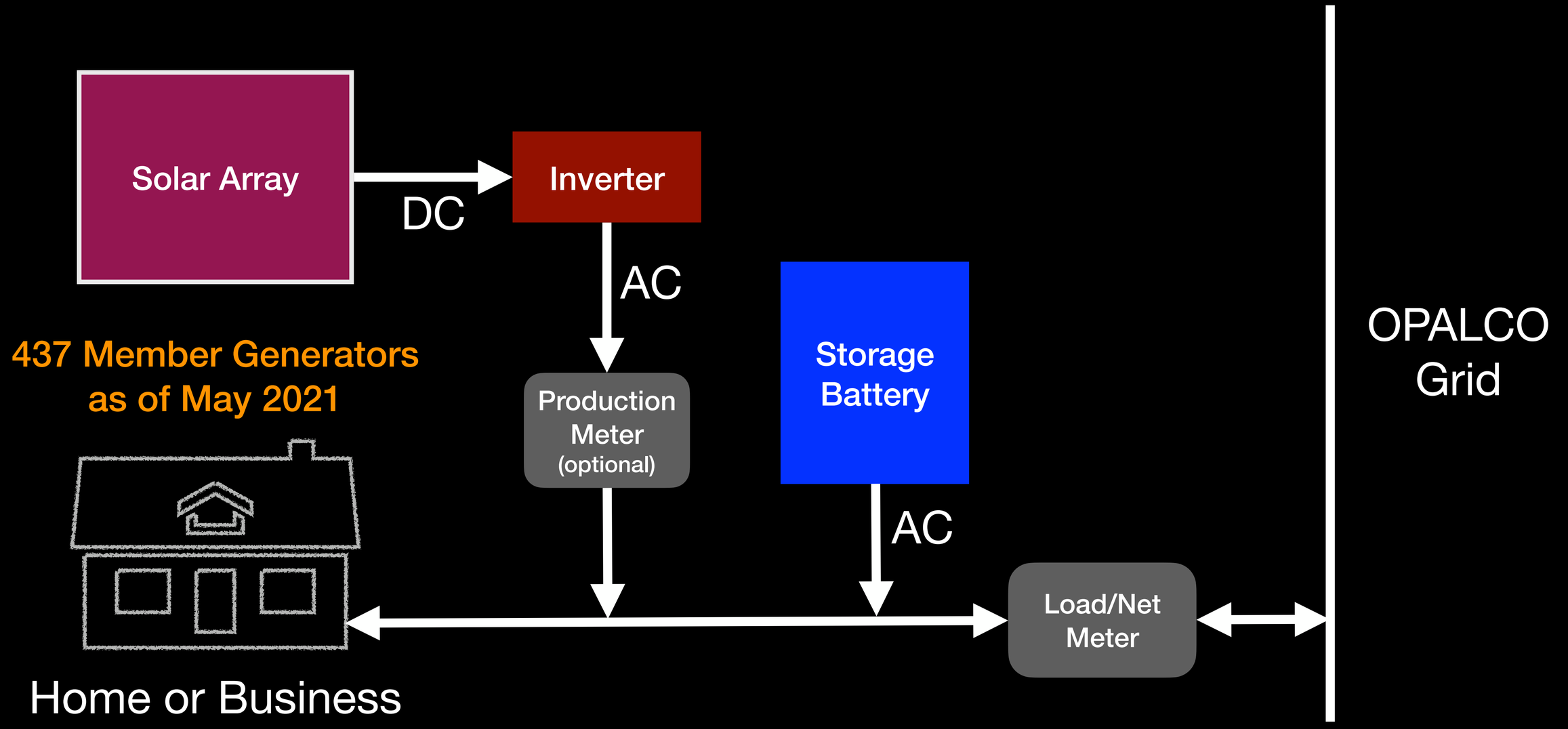
Thinking about the Future

Net-Zero Solar Example

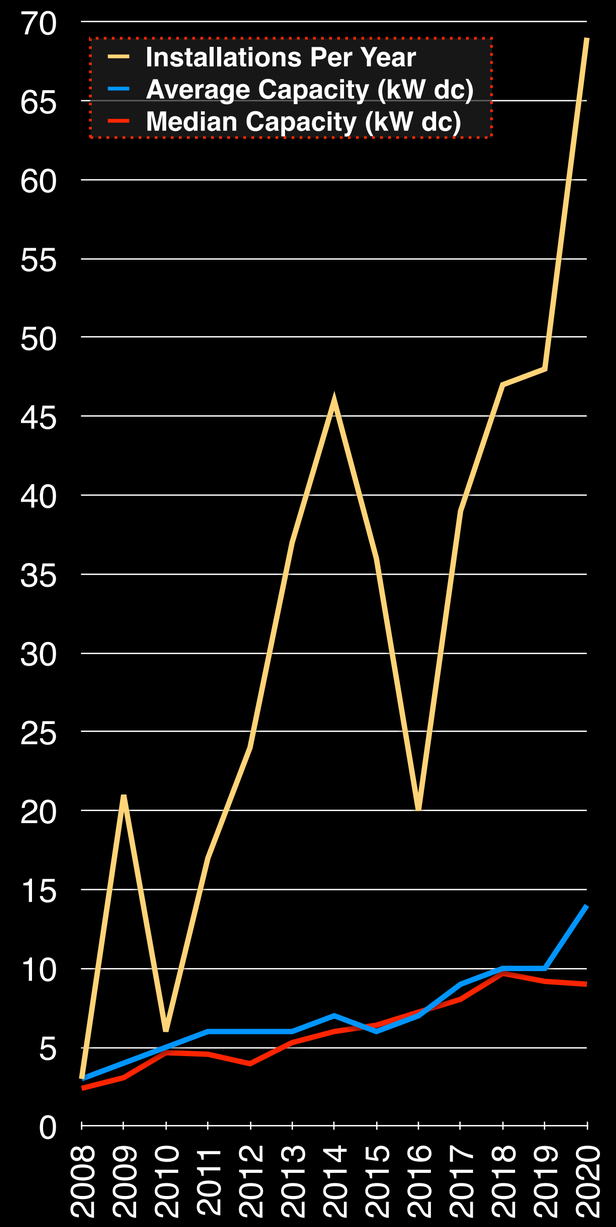
Discussion

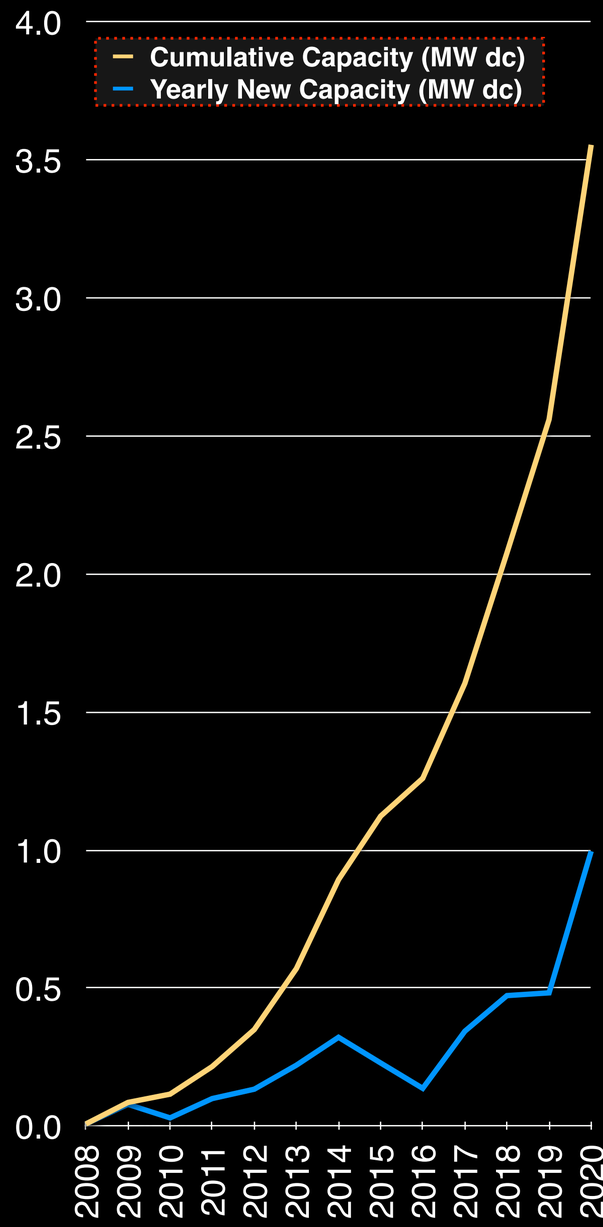
2020 Member Generation Analysis

Typical Member Solar + Storage Configuration



OPALCO Member Generation Trends: Installations, Capacity, Production





3,555 MWh AC Production in 2020
From 3.5 MW dc of total member generation capacity
Average 8.6 kW dc per installation

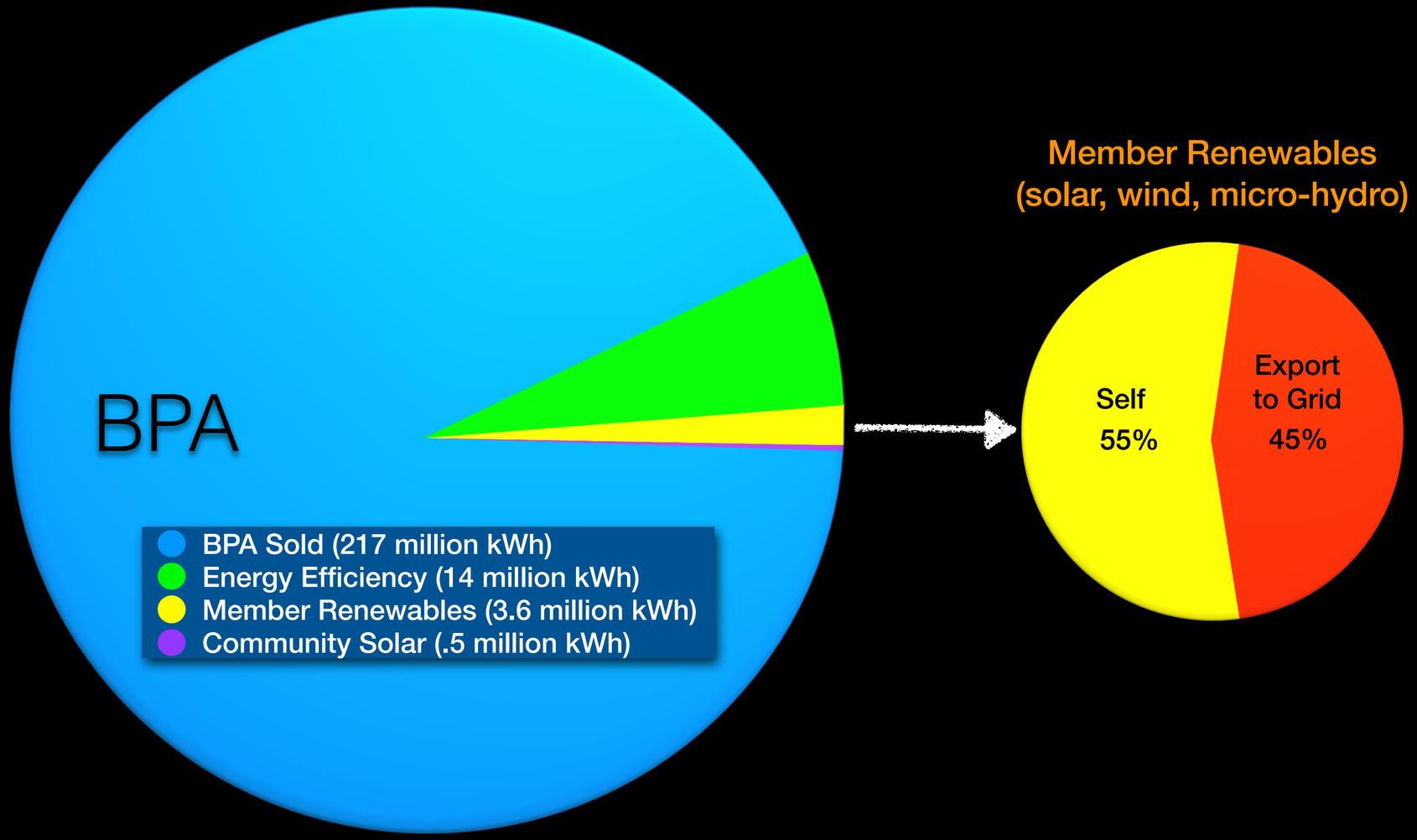
Total member generation capacity and production grew at 39% last year, with a five year average growth rate of 26%.

Installations grew at 44% last year, with a five year average growth rate of 22%.

Since 2000, retail solar cost has fallen dramatically, but in recent years price in SJC has stabilized in $3 per watt range, unsubsidized. OPALCO community solar can be built out for less that $2 per watt, due to economies of scale.

OPALCO 2020 Resource Mix: BPA, Energy Efficiency, Member Generation, Community Solar

2020 Energy Resource Mix

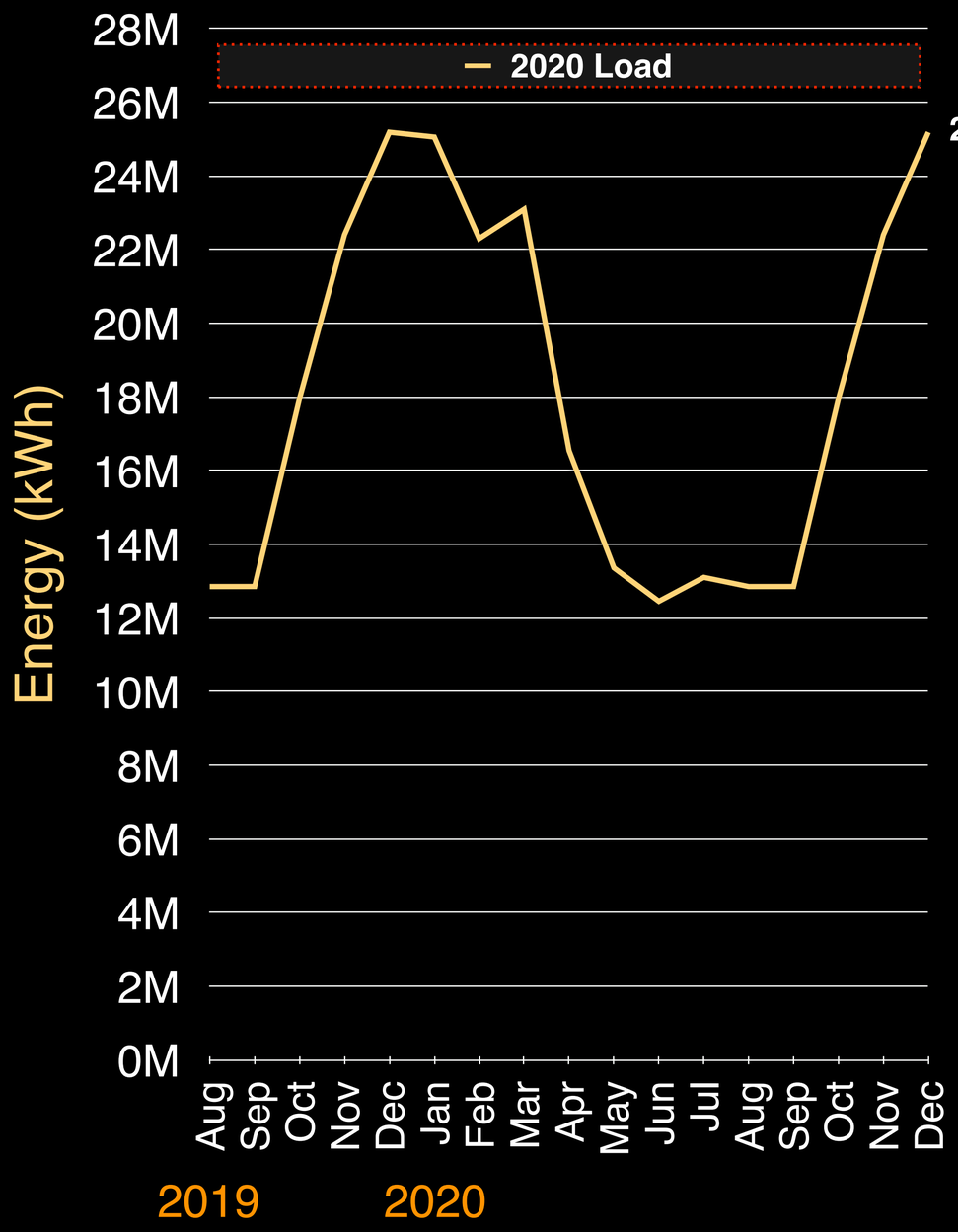


Member Renewables
(solar, wind, micro-hydro)

55% of member production went to reducing member's personal load (self), with remaining 45% exported to the grid, mostly during sunny summer months when load is low and insolation is high.

Monthly View

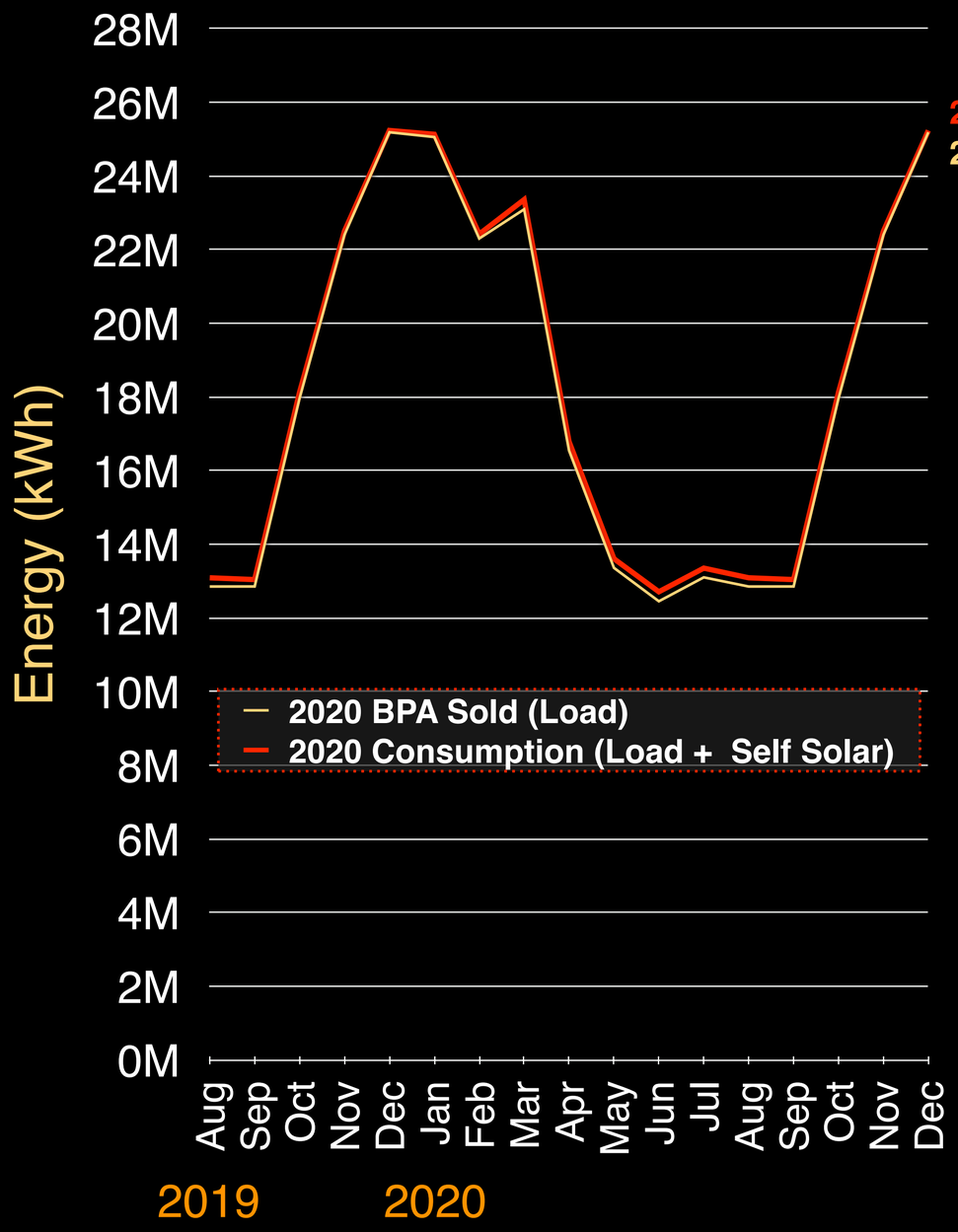
Monthly Energy Sales: 2020 Reference Load



Notes

- Reference Load based on 2020 system load from all members (residential, commercial, etc.)
- Load typically doubles in winter, compared to summer
- 18,882 kWh average annual load per typical member (residential and commercial)

Member Energy Consumption: BPA Sold + Member Self Solar

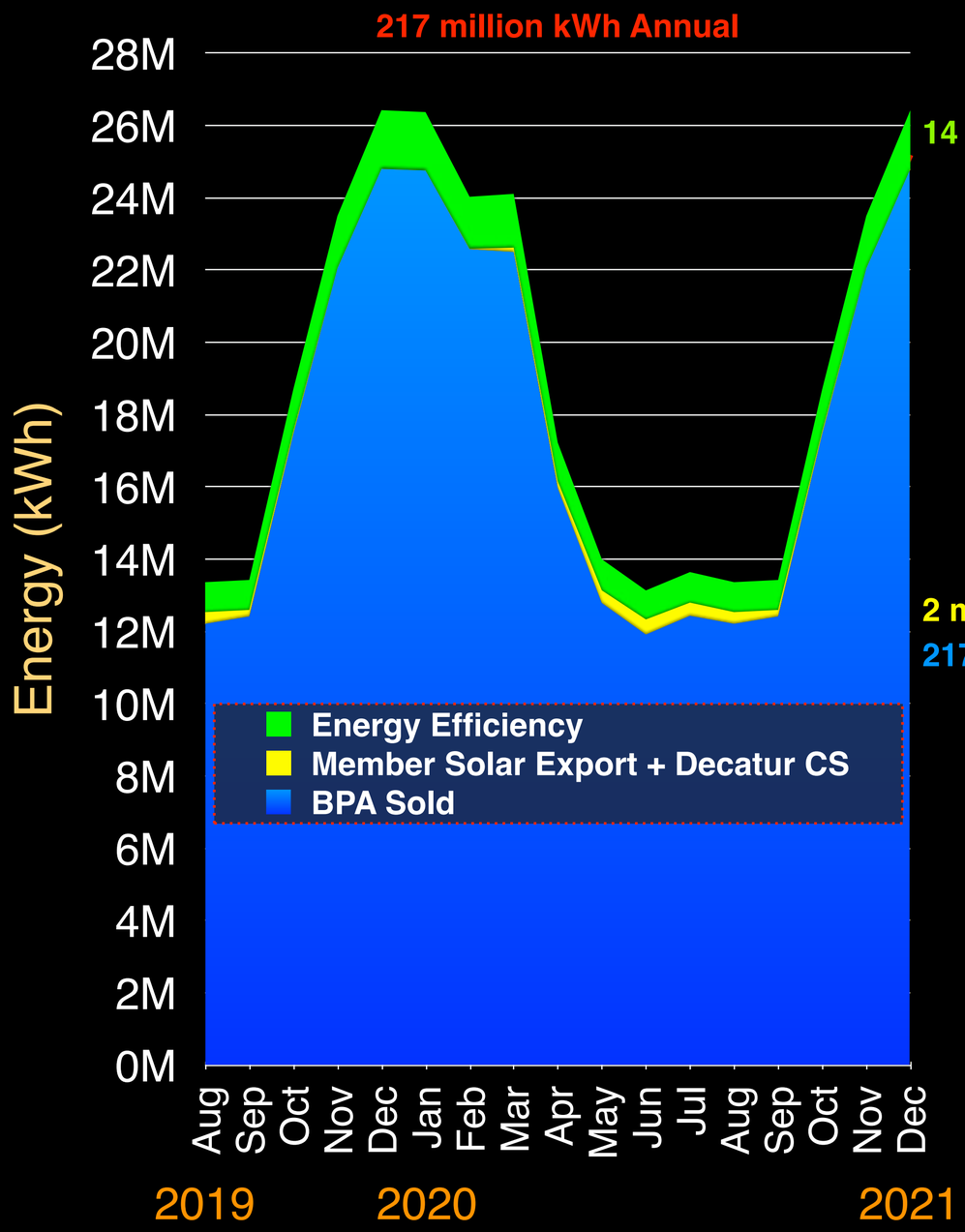


219 million kWh Annual Consumption
217 million kWh Annual BPA Sold

Notes

- Member generators produced about 2 million kWh of solar for internal use (not exported), which reduced their apparent load.
- Member solar production self solar (before export) is added to BPA sold to get total member consumption (red line)

Monthly Energy Sources



14 million kWh annual energy efficiency

2 million kWh annual member generation exported

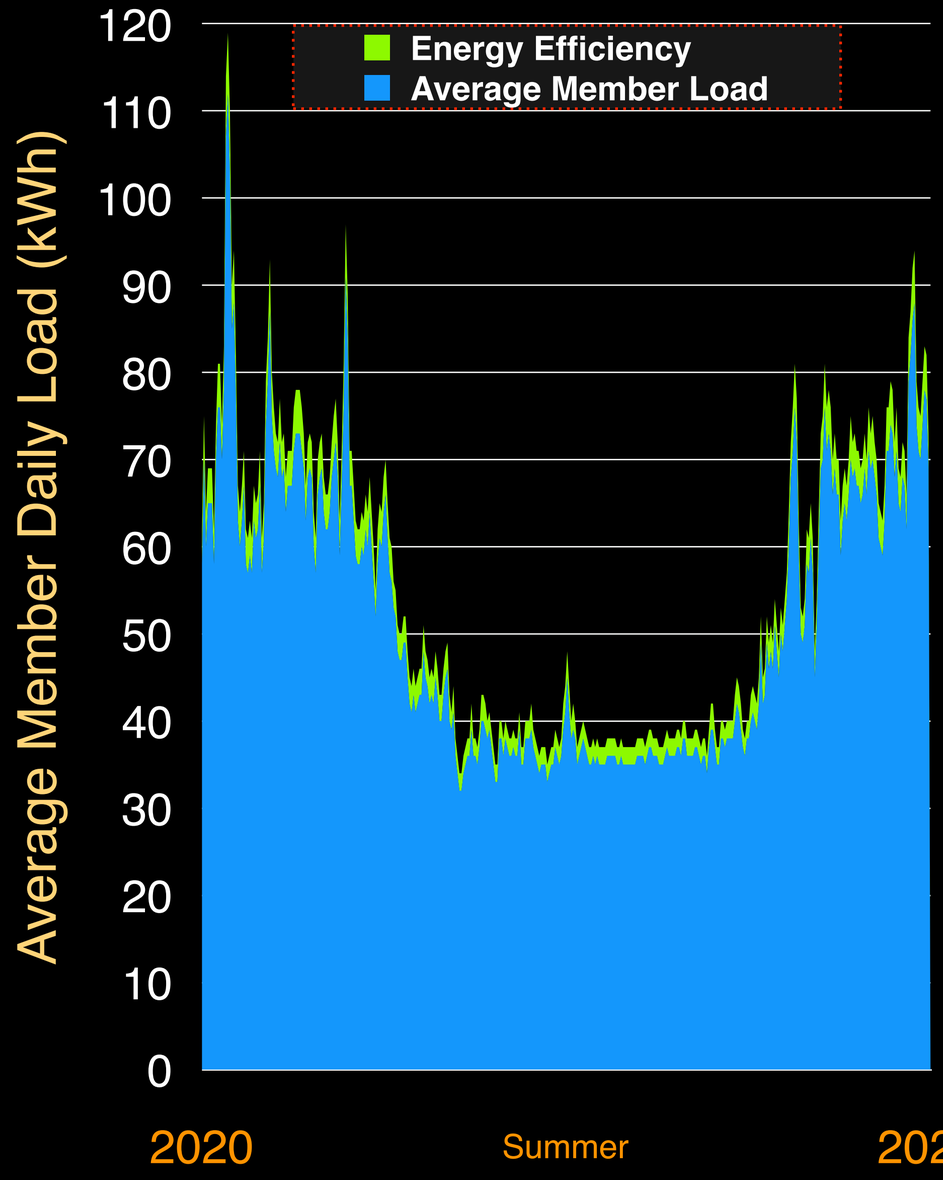
217 million kWh annual BPA sold

Careful!

Monthly Averages Obscure Critical Details

Daily View

2020 Average Member Daily Load: Residential and Commercial



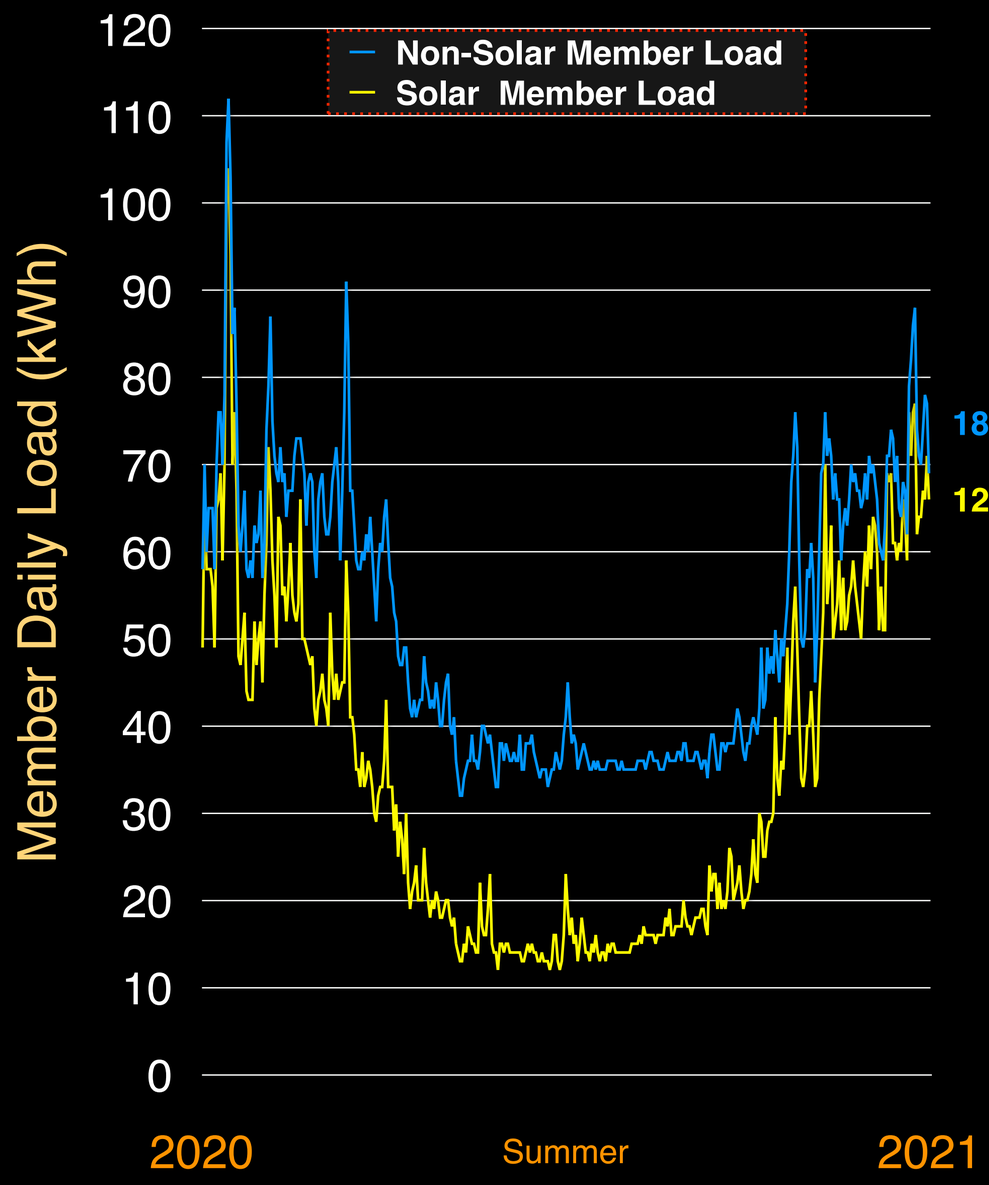
1,217 kWh Annual Energy Efficiency Savings

18,882 kWh Annual Load for typical member

Notes

- Reference Load based on 2020 system load from all members (residential, commercial, etc.)
- Member load typically doubles in winter.
- Energy Efficiency improvements have reduced load by 6%

2020 Average Member Daily Load: Non-solar and solar members



18,882 kWh annual regular non-solar member

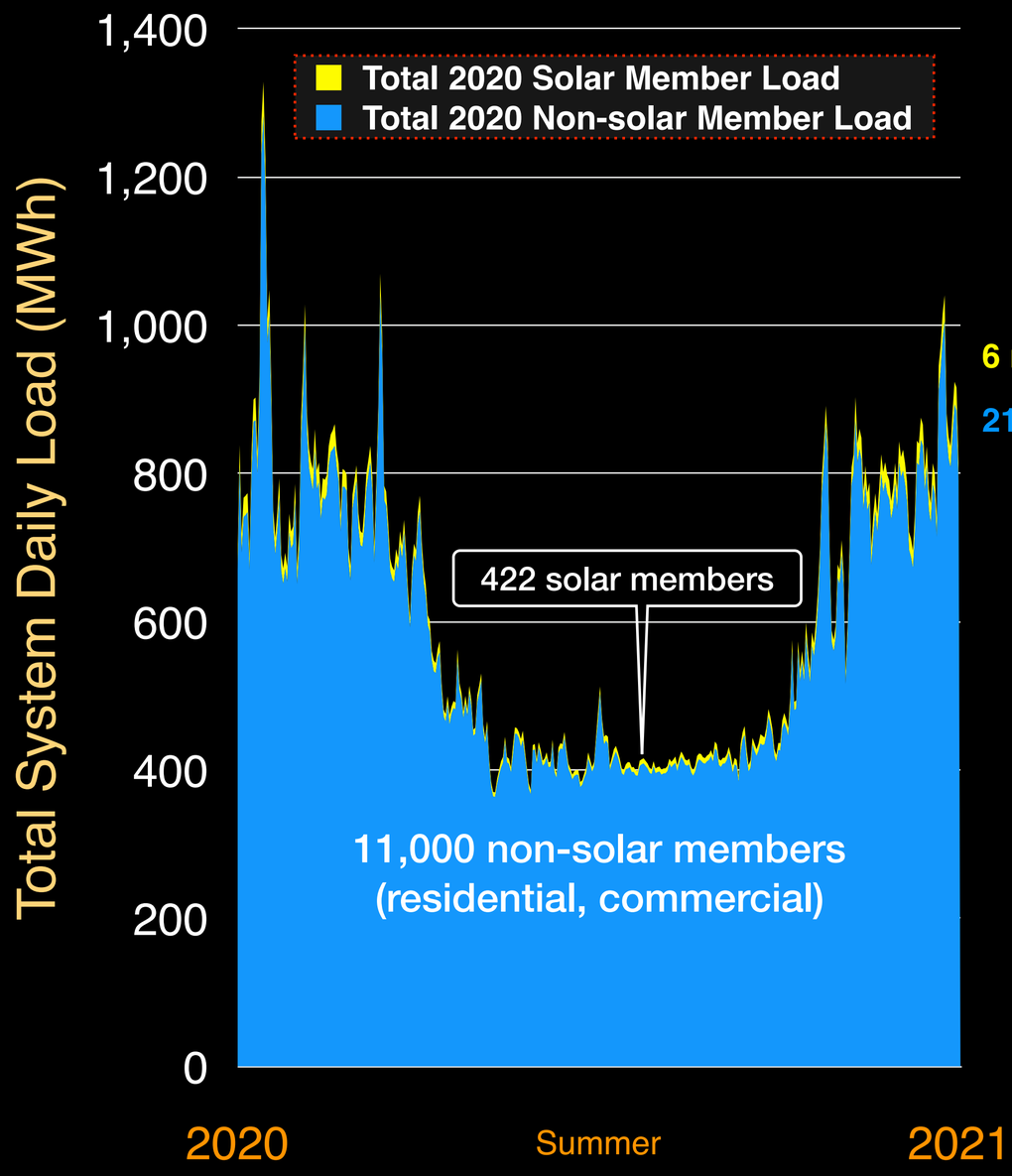
12,450 kWh annual solar member

In 2020, about 420 member generators produced an average of about 10,000 kWh each, reducing their load by 34%

Notes

- Winter solar production is about 20% of summer.
- Member load is mostly met using BPA, but a small and steadily increasing amount of the load is met using exported member solar, especially on sunny summer days.
- A typical 2020 solar member will import energy from the grid about 80% of the time - during nights, gray days, and especially in winter.
- Typical 2020 solar members export solar about 20% of the time, mostly on sunny summer days.

2020 Total System Daily Load: Regular and Solar Members



6 million kWh Annual Solar Member Load

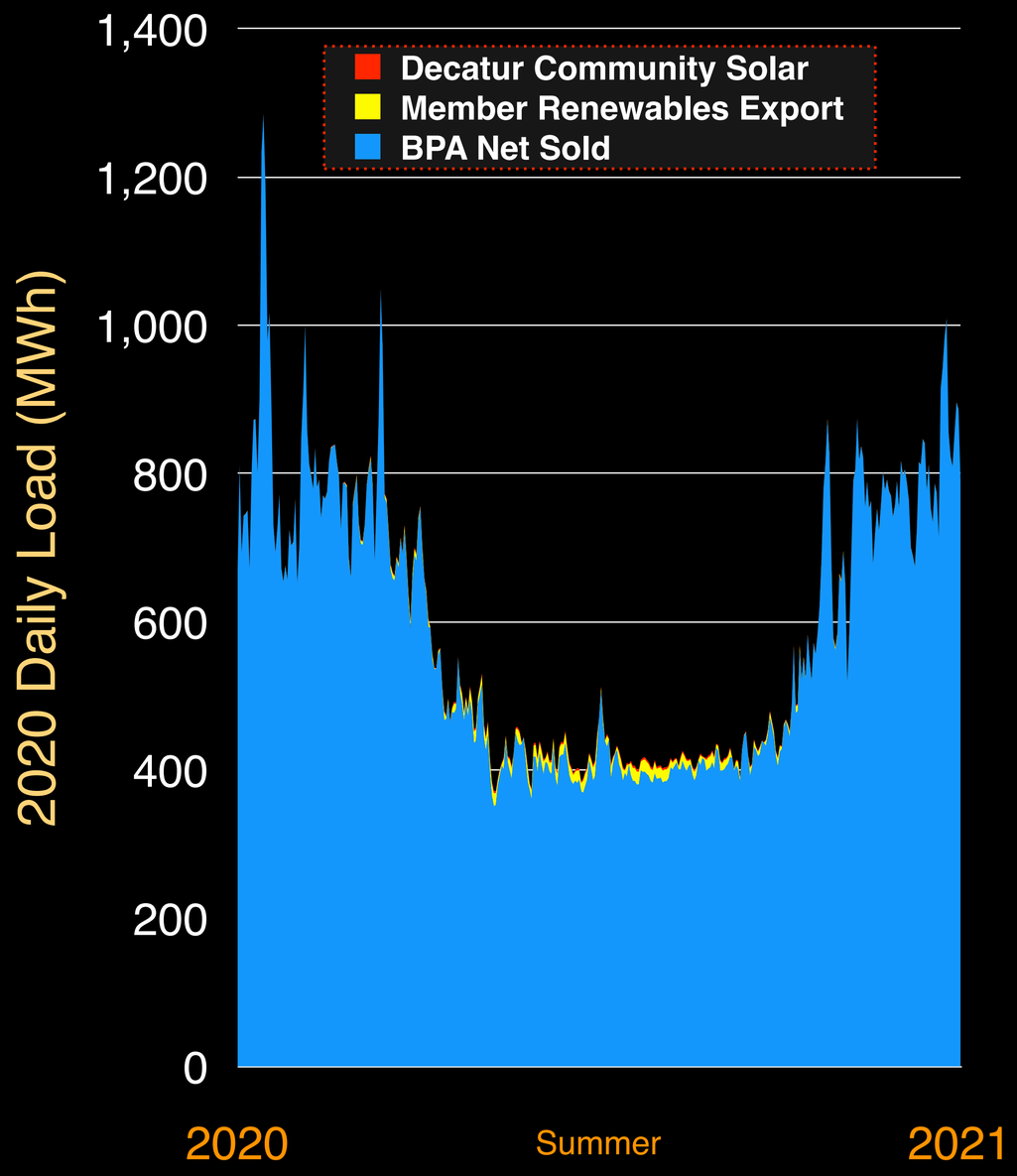
211 million kWh Annual Regular Member Load

Notes

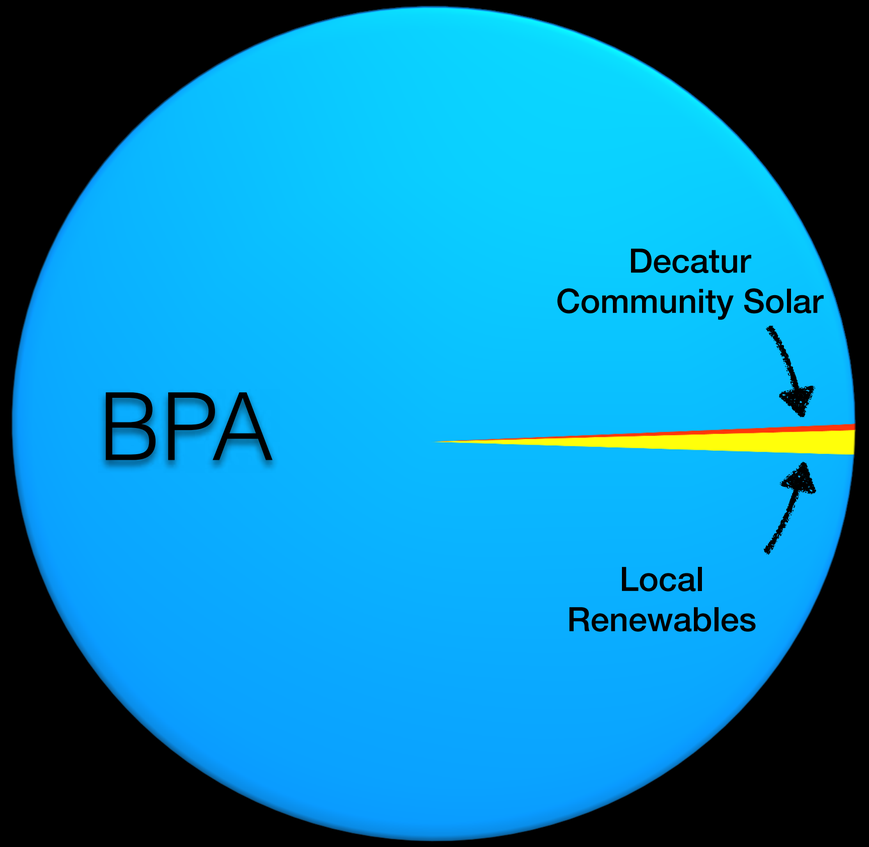
- While solar member annual load is reduced by 34%, since there are only 422 members (3.7% of members), the impact on total load is minimal (1.3% reduction).
- Member load typically doubles in winter.

Load Share	Members	Members %	All Load
Total Members	11,500	100%	100%
• Non-Solar	11,078	96%	97%
• Solar	422	4%	3%

2020 Daily Energy Sources: BPA, Community Solar and Member Generators



2020 Generation Resource Mix



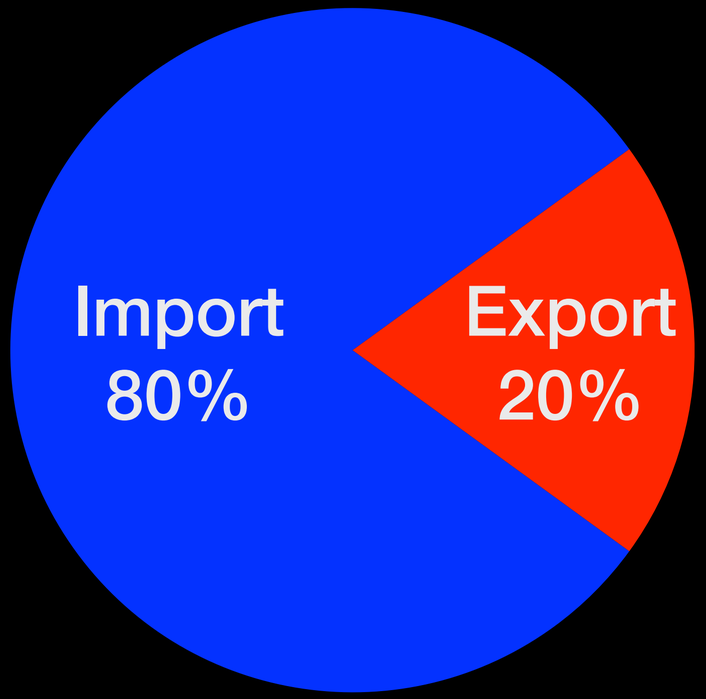
Notes

- 422 member generators produced 2 million kWh
- Decatur community solar array produces .5 million kWh
- Energy Efficiency is not shown

2020 OPALCO Member Generation: Import/Export Balance

Member generators are always using the grid, either importing or exporting energy. The OPALCO grid is increasingly transactional, helping members to buy and sell energy, as needed.

Annual Energy Import/Export



- A typical member generator will produce more solar in the summer than they need, and will export it to the grid, for billing credit, offsetting winter, when solar production is 20% of summer.
- Even though they produce a good portion of what they consume, they depend on the grid to firm their solar - during nights, gray days, and especially in winter.
- A typical member generator will import energy from the grid about 80% of the time - during nights, gray days, and especially in winter (chart at left).

Net-Zero Solar Member (NZSM) Analysis

to explore potential problems and opportunities
as member generation market share increases

net-zero is a common starting point for initial sizing a member solar project

Modeling Impact of Member Solar as Market Share Increases

What-If Model:
Explore impact if 50% of OPALCO members have net-zero solar (generate what they consume annually)

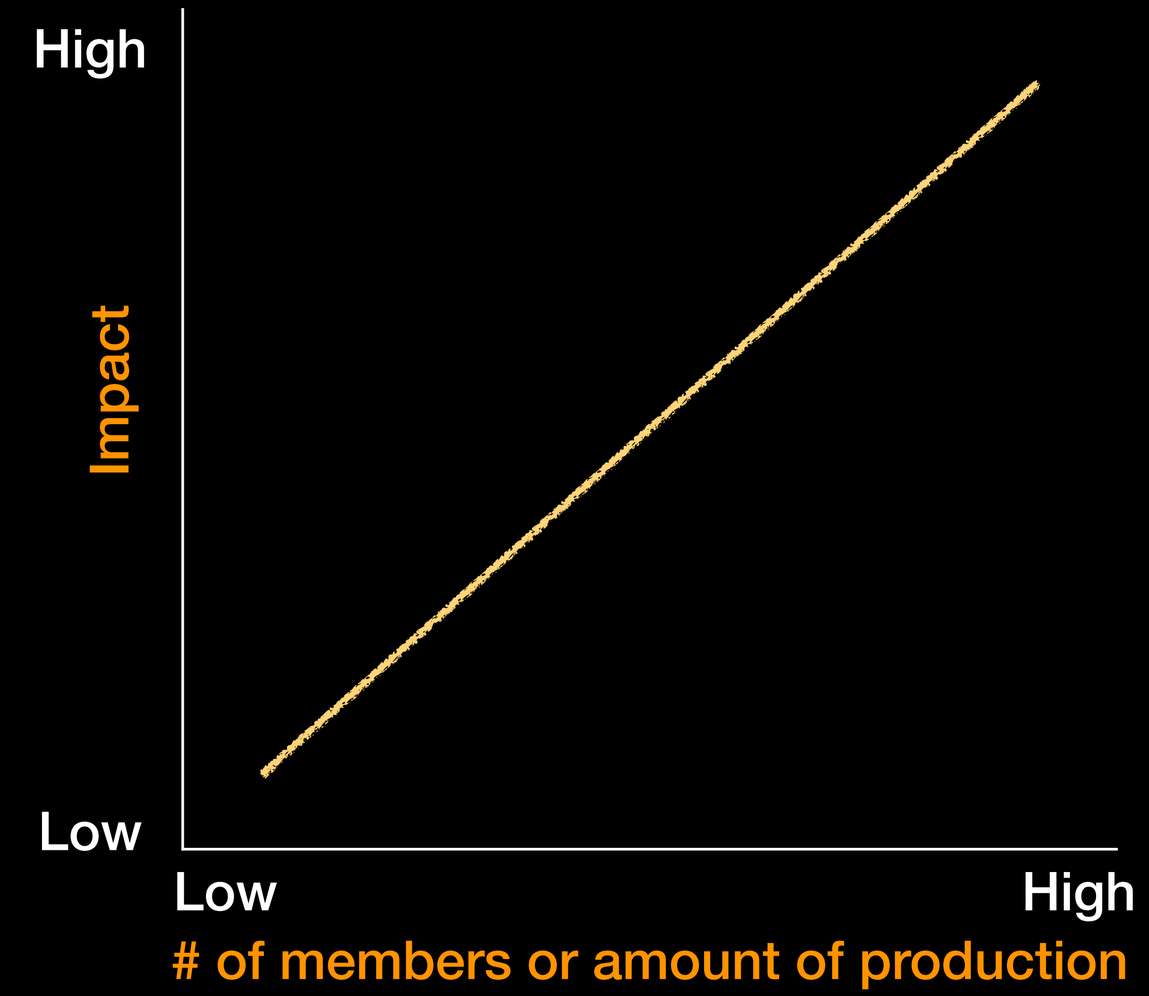
Impact Analysis:
load, generation, load shape, grid impact

Data:
2020 hourly system load , member generation, and Decatur Community Solar generation to establish reference load and solar generation shape for all members (residential, commercial, etc.)

Note!

The impact presented below is generally linear - regardless of number of members or amount of production.

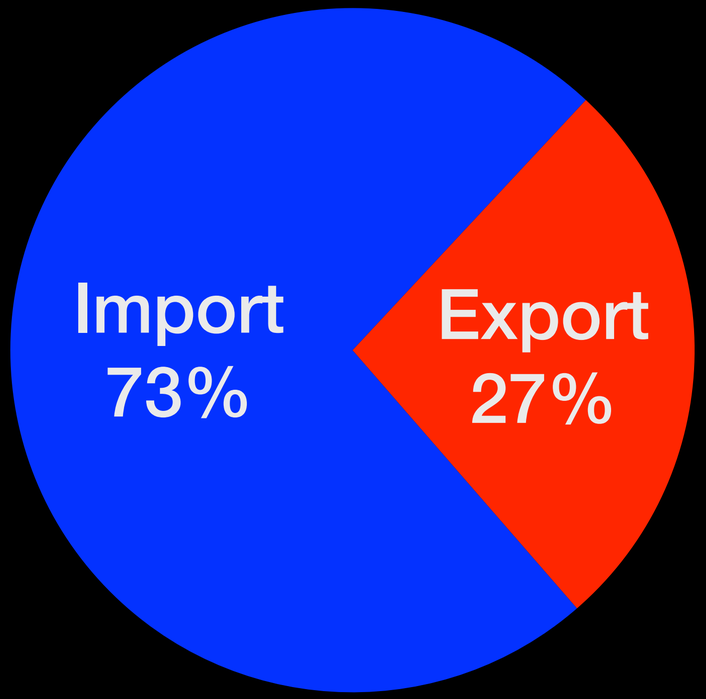
It scales.



What is a net-zero solar member (NZSM)?

A member that produces as much electric energy as they consume annually, typically using a solar array.

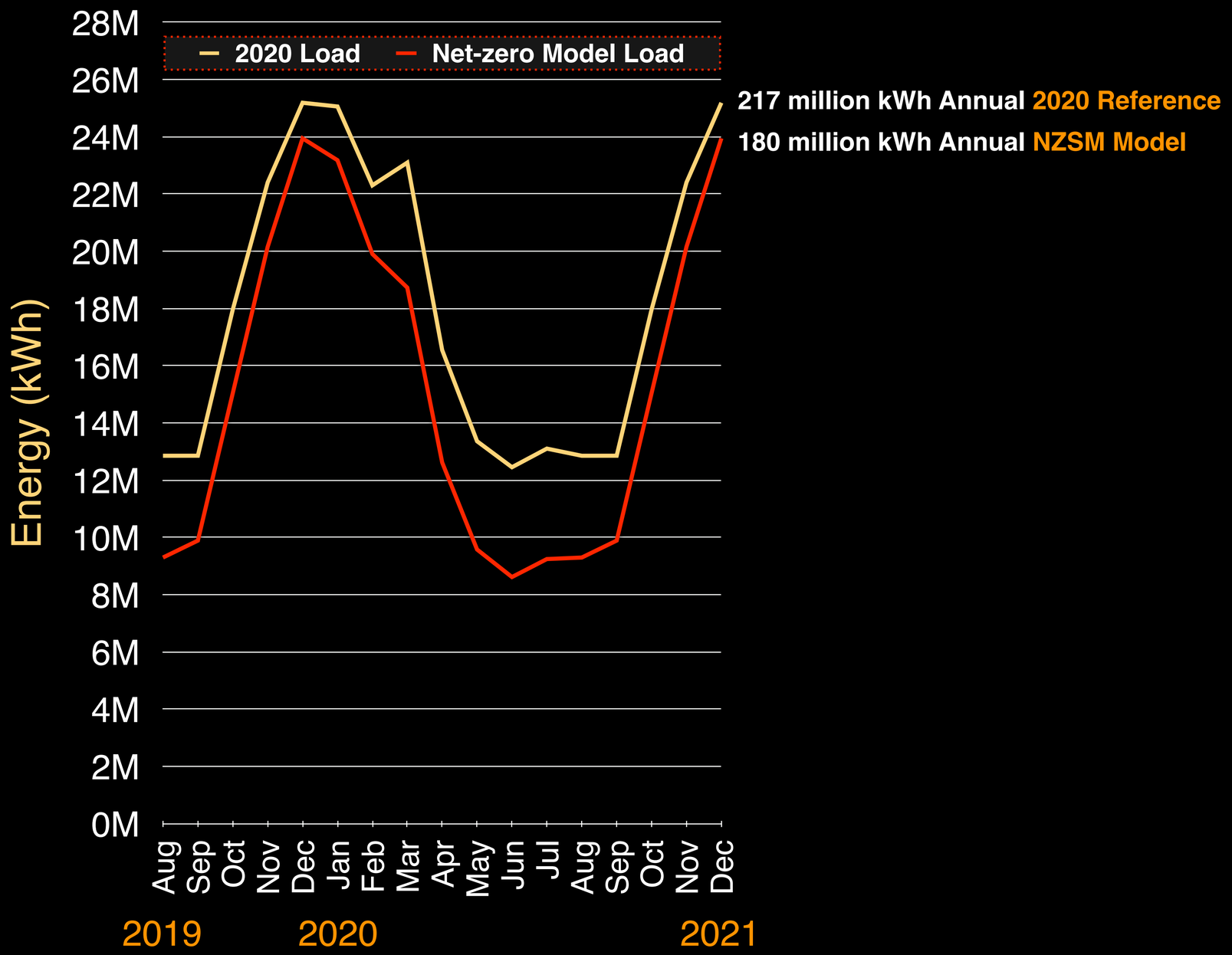
NZSM Annual Energy Import/Export



- The average OPALCO member (residential/commercial) consumes about 18,800 kWh per year, requiring a net-zero solar array of about 18 kW.
- A typical NZSM will over-produce solar in the summer, for billing credit, offsetting winter, when solar production is 20% of summer.
- Even though they produce as much as they consume yearly, they depend on the grid to firm their solar - during nights, gray days, and especially in winter.
- A typical NZSM will import energy from the grid about 73% of the time - during nights, gray days, and especially in winter (chart at left).

Monthly View

Monthly Energy Sales: 2020 and 50% Net-Zero Solar Model Load



Notes

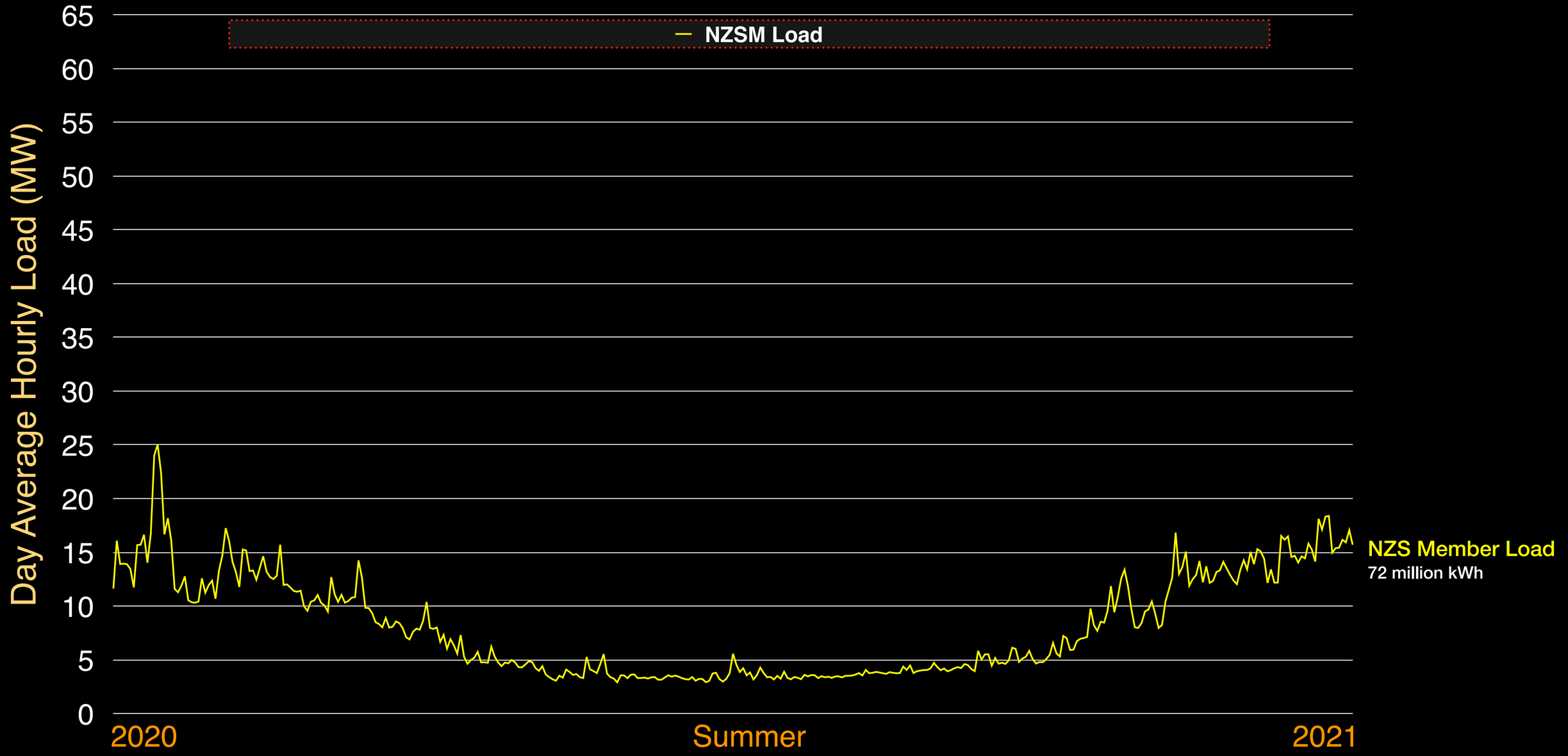
- Modeling 50% of OPALCO members have Net-zero solar system
- Solar output reference based on Decatur community solar array, scaled to member level
- Net-zero solar members reduce their OPALCO load, reducing total annual kWh sales by 37 million kWh
- Load reduction is weaker in winter when solar output is 20% of summer

Careful!

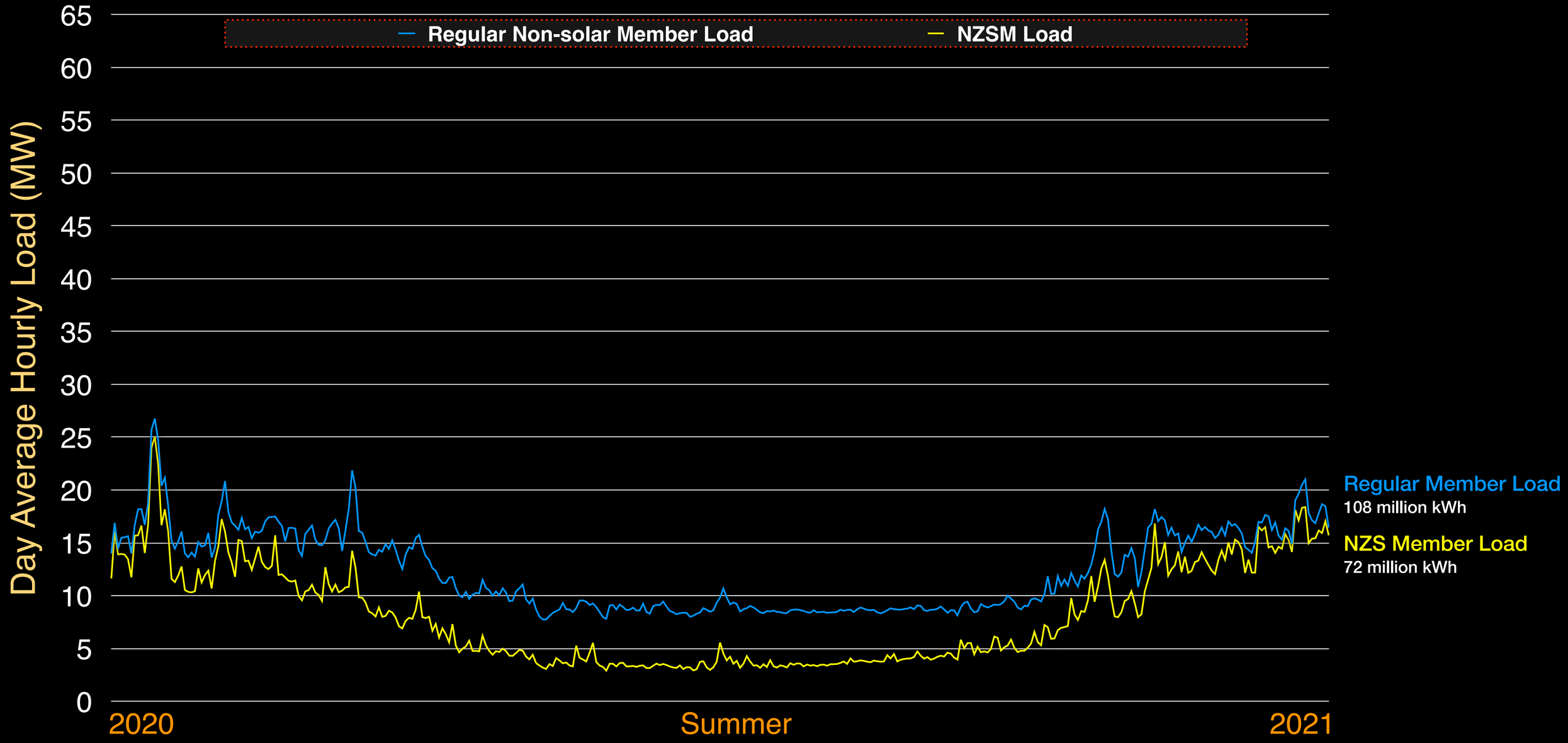
Monthly Averages Obscure Critical Details

Daily View

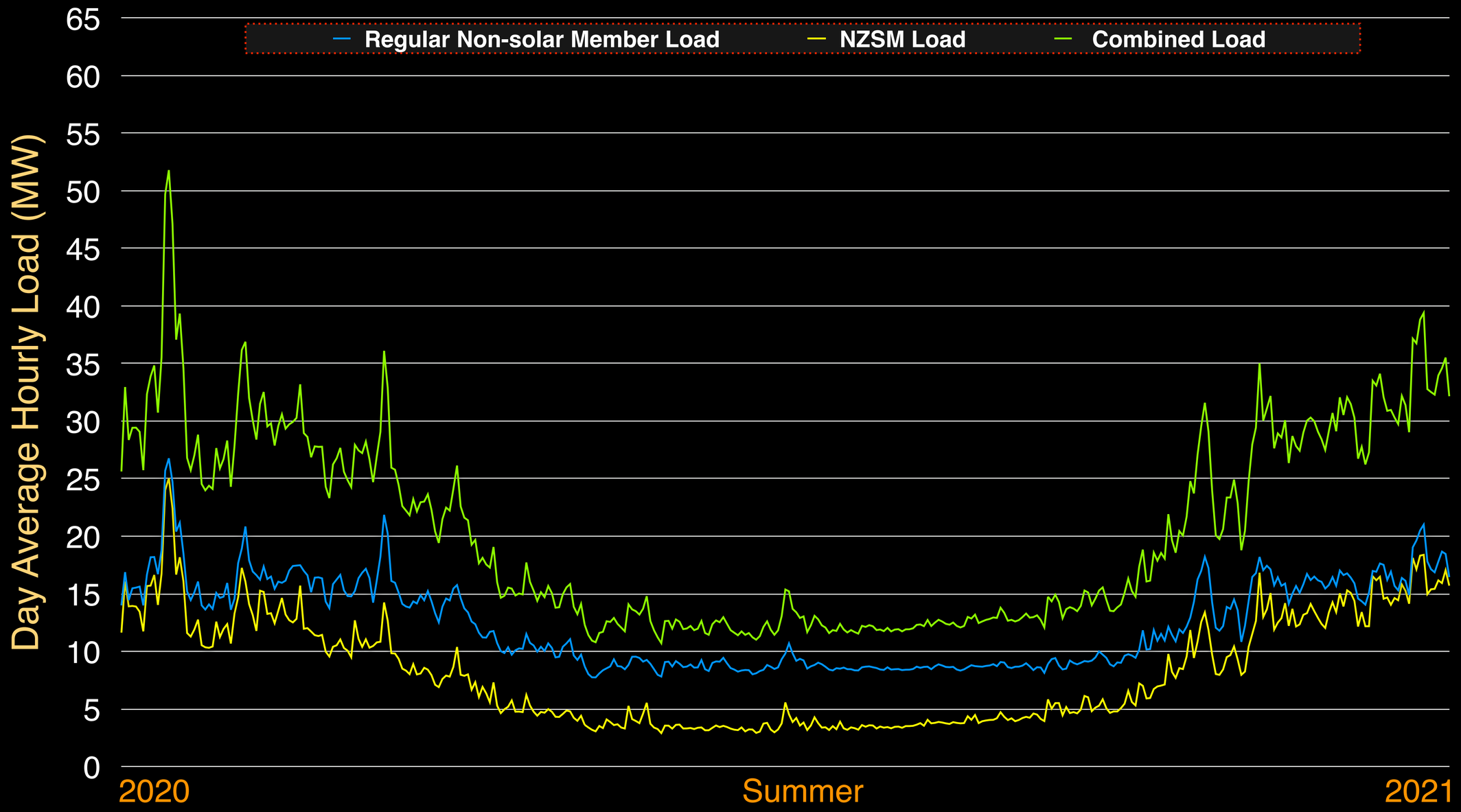
Day Average Hourly System Load: NZSM member



Day Average Hourly System Load: Regular and NZSM Member



Day Average Hourly System Load: Combined - Regular + NZSM Member

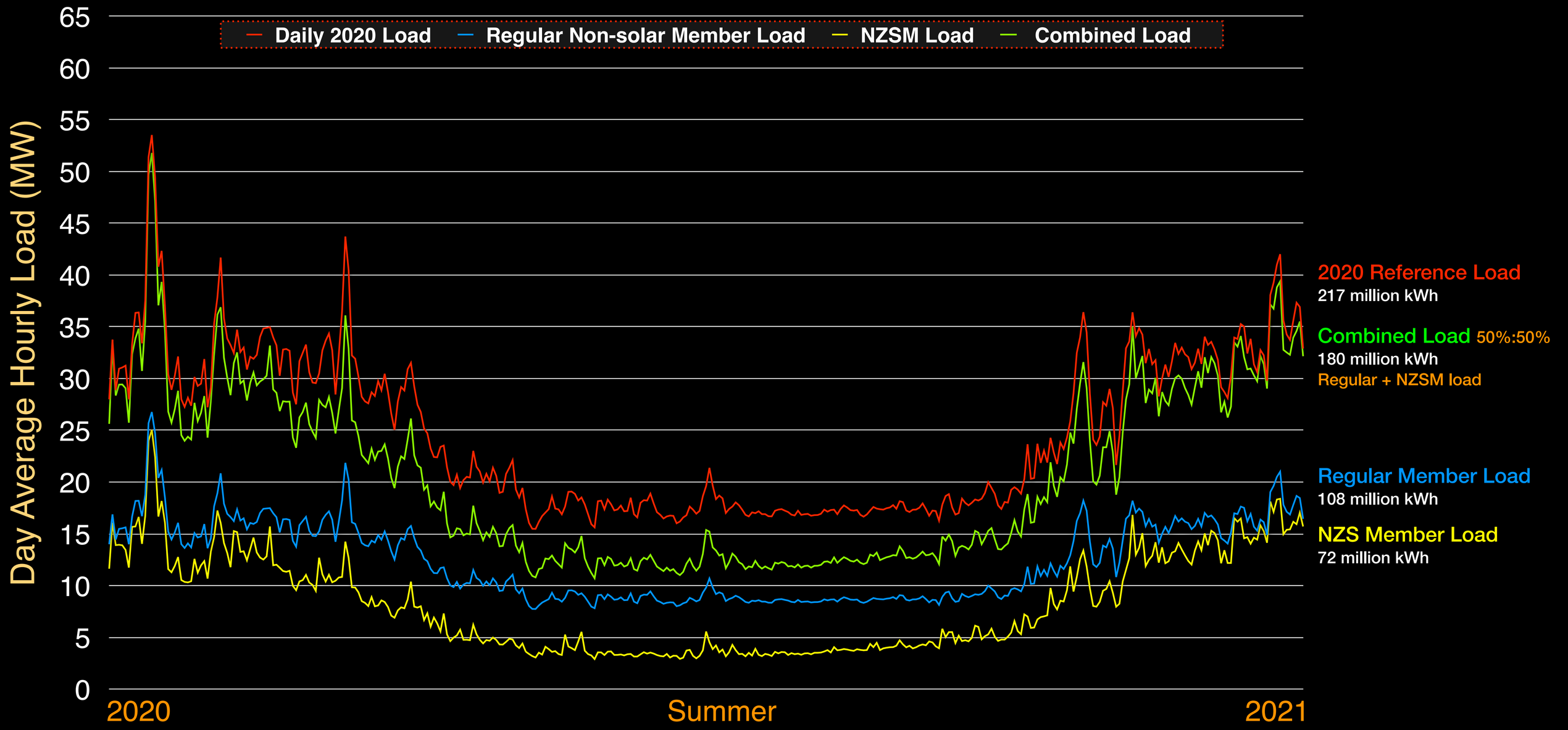


Combined Load 50%:50%
180 million kWh
Regular + NZSM load

Regular Member Load
108 million kWh

NZS Member Load
72 million kWh

Day Average Hourly System Load: 2020 Reference Load

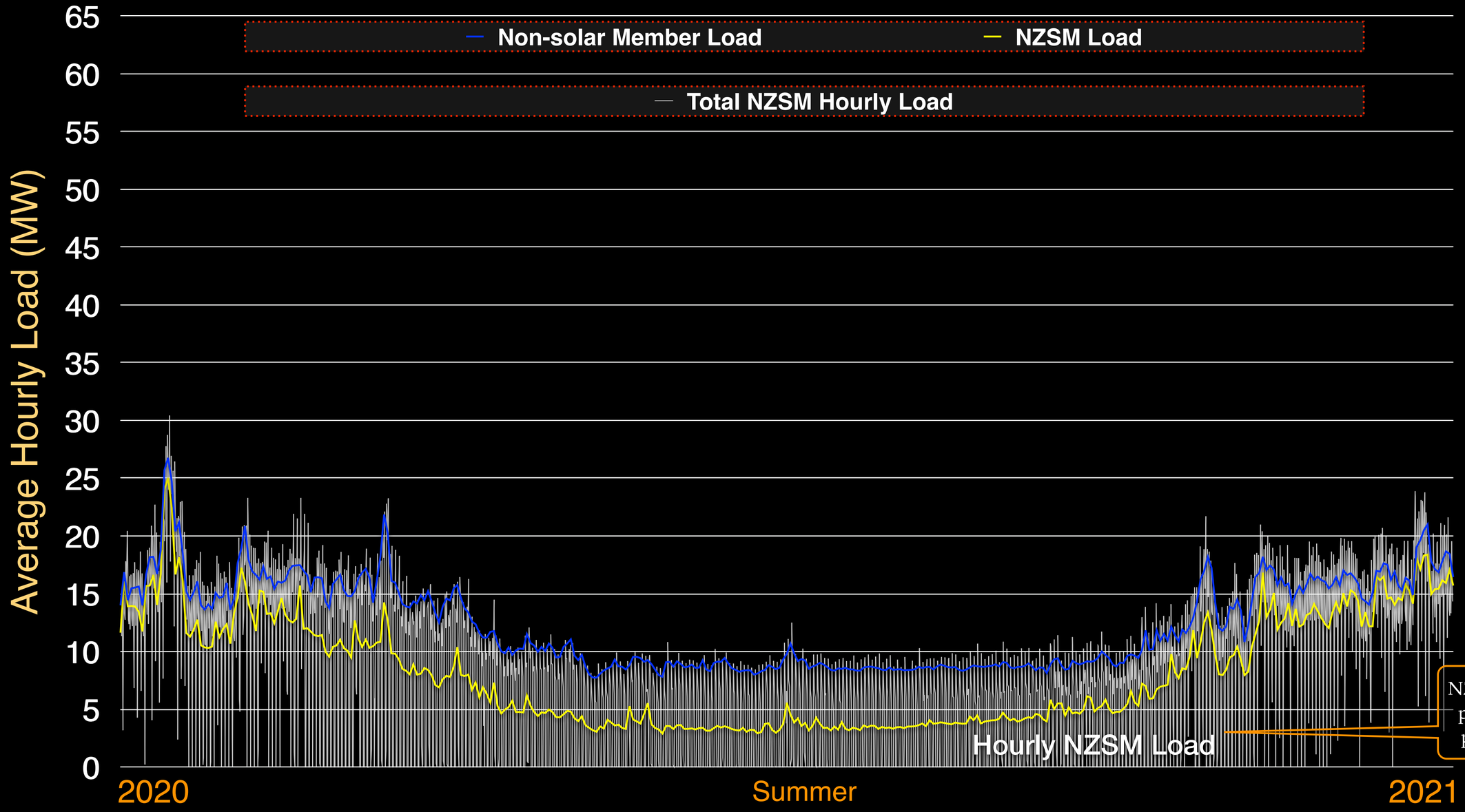


Careful!

Daily Averages Obscure Critical Details

Hourly View

Day Average Hourly System Load: No Solar Export, With Annual kWh Sold



Notes

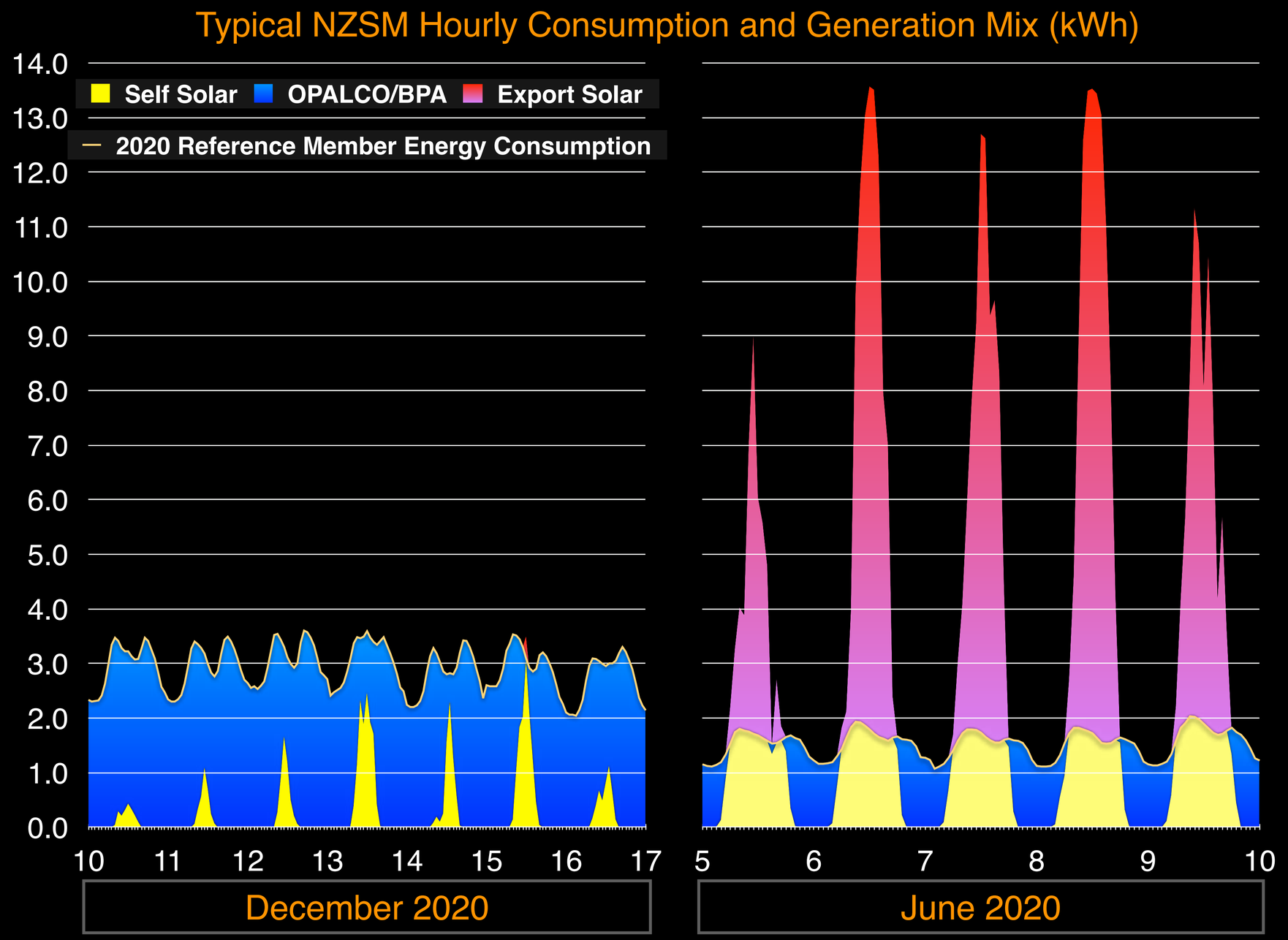
- Note how average hides very large hourly swings in load
- At night, NZSM load is similar to regular member, but during sunny days, it can be zero.

Regular Member Load
108 million kWh

NZSM Load
72 million kWh

NZSM load fluctuates daily, between peak and zero, depending on solar production, especially in summer.

Hourly Load and Solar Production Around Winter and Summer Solstice



During winter solstice, solar insolation is at a minimum.

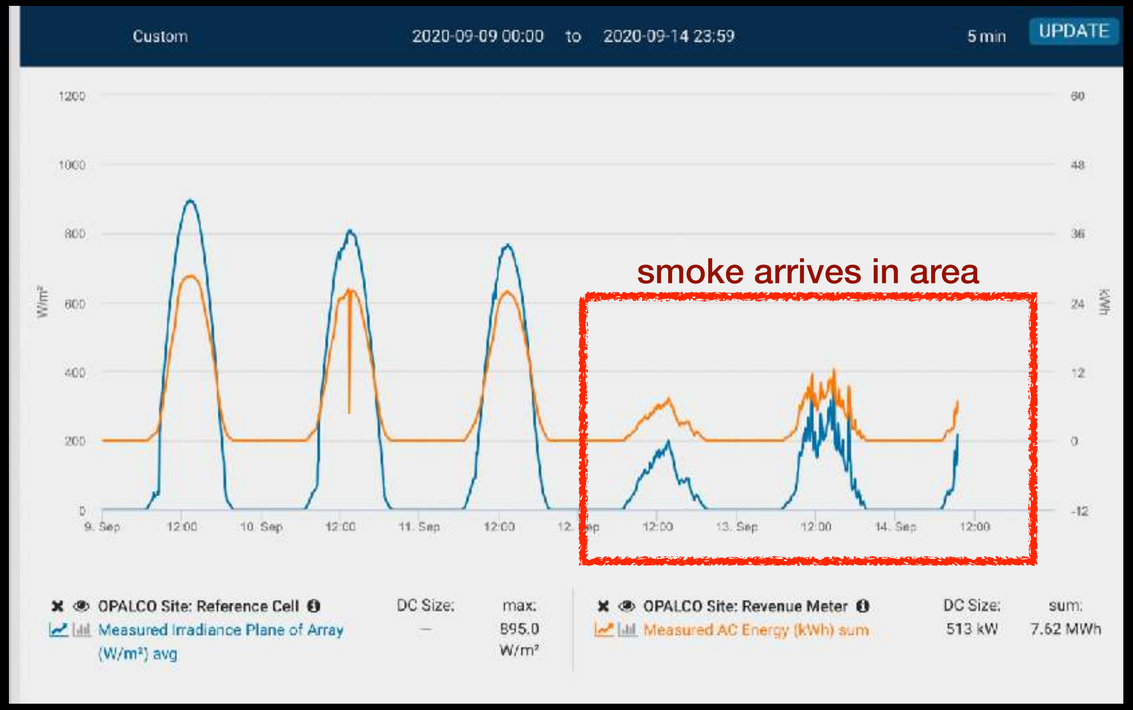
During summer solstice insolation is at a maximum.

Notes

- System load typically doubles in winter.
- Winter solar is about 20% of summer.
- A typical NZSM will import energy from the grid about 73% of the time - during nights, gray days, and especially in winter.
- Net-zero members export solar about 27% of the time, mostly on sunny summer days.
- Note cloud strikes on 5 and 9 June late afternoon, and a brief solar export on 15 December mid-day.

Climate Impact: Increased Fires Reduce Solar Output

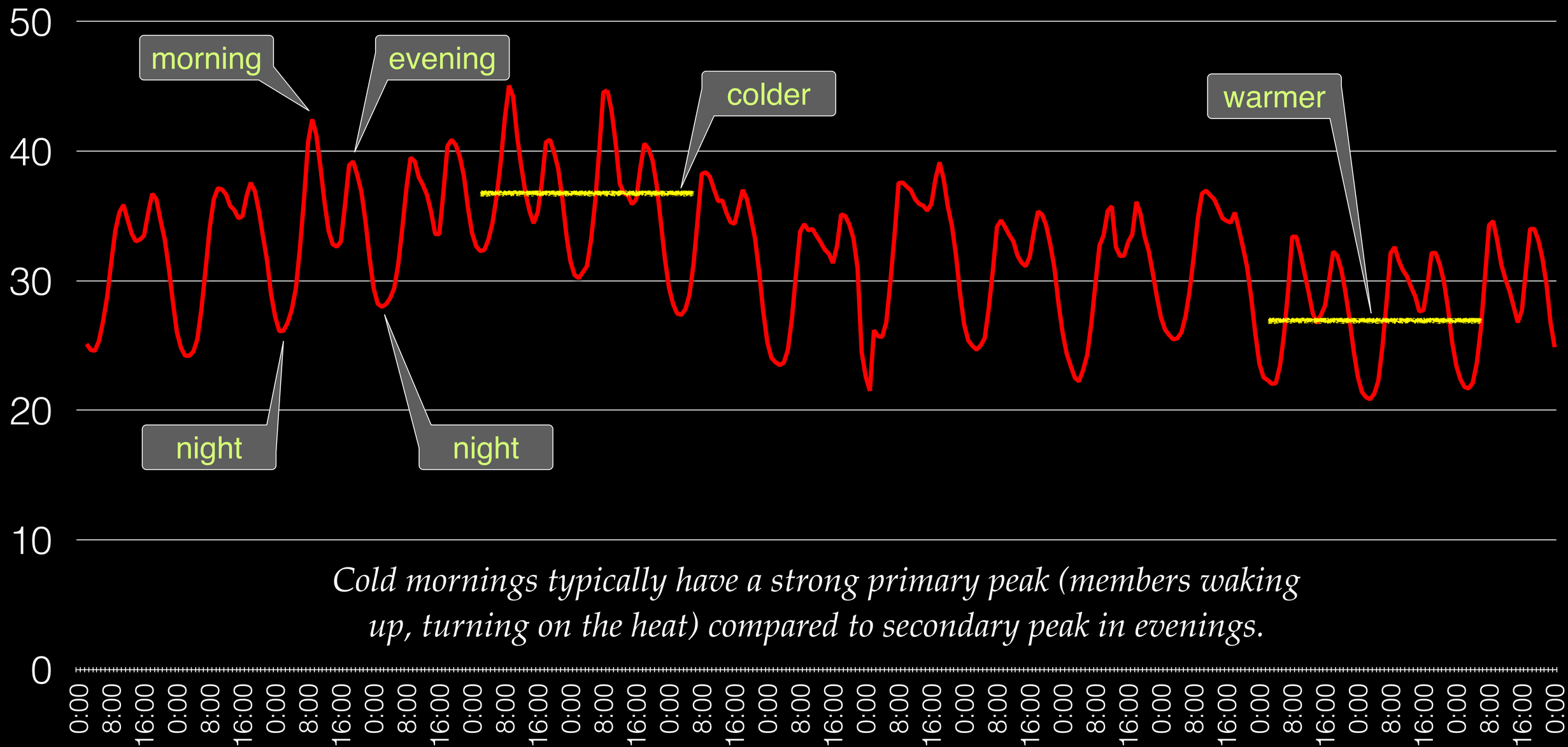
Decatur Array Output During 2020 Regional Fire Season



Load Shape

Focusing on impact on load shape,
with and without NZSM solar export

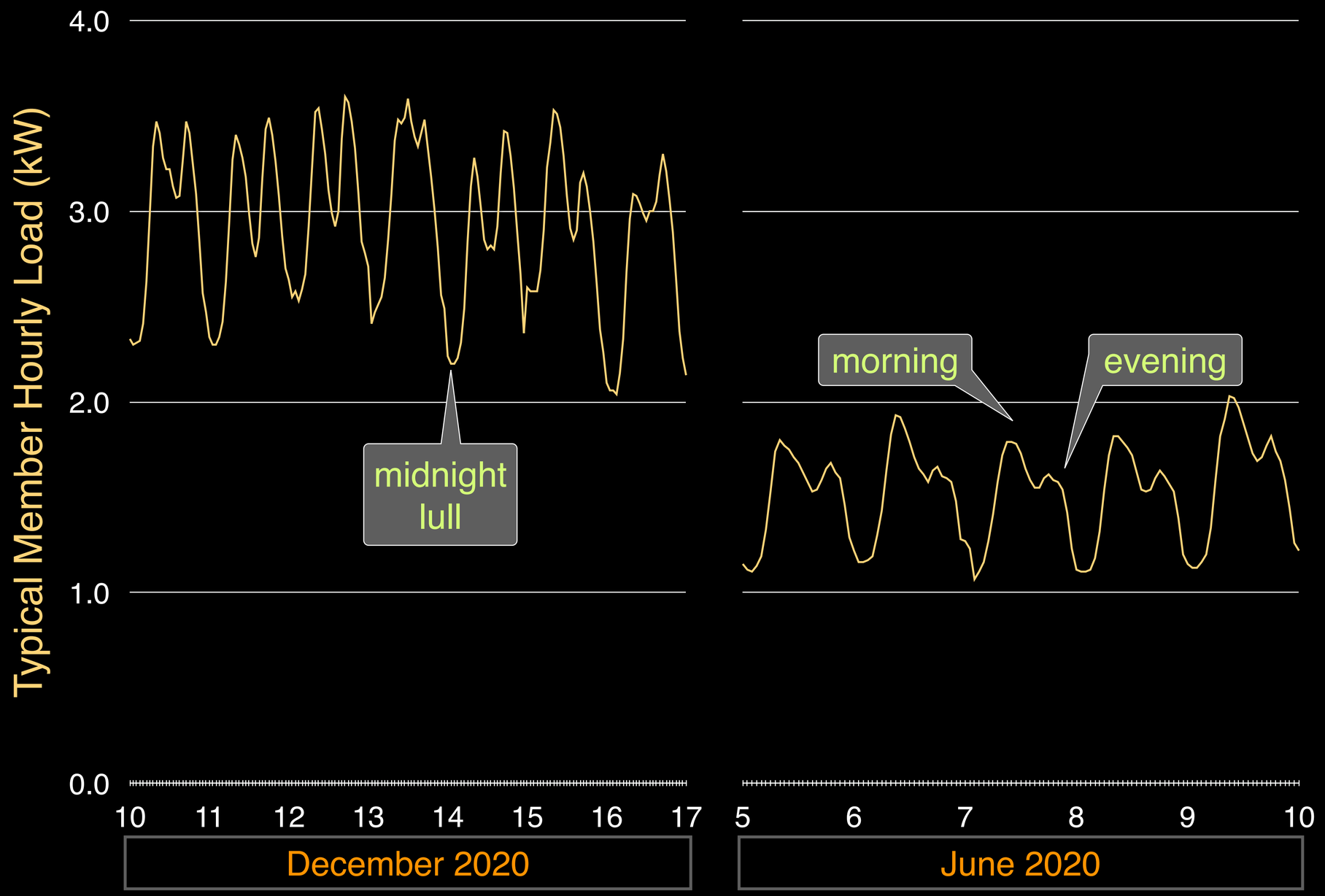
Typical Current OPALCO Hourly Winter System Load Example (MW)



Cold mornings typically have a strong primary peak (members waking up, turning on the heat) compared to secondary peak in evenings.

Time of Day Across 15 Days

2020 Typical Member Hourly Load Around Winter and Summer Solstice

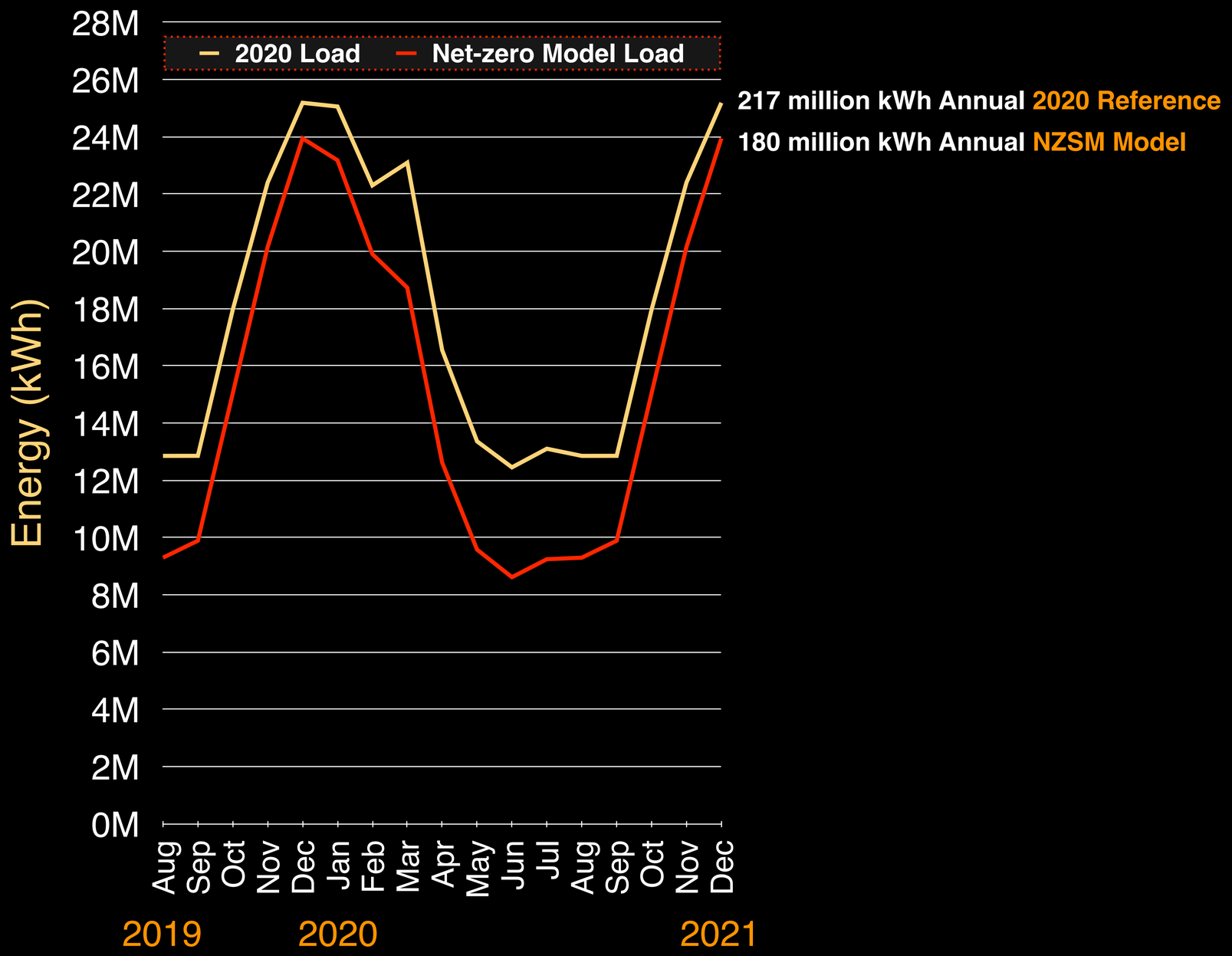


Winter load is typically double of summer load.

Notes

- Cold mornings typically have a strong primary peak, as members wake up and turn on the heat, and take a shower.
- A secondary peak occurs in evenings as people return home, turn up the heat and turn on the lights.
- The secondary peak is less pronounced in summer with longer daylight, minimal heating, and morning showers drawing on hot water, keeping the primary peak stronger.

Monthly Energy Sales: 2020 and 50% Net-Zero Solar Model Load



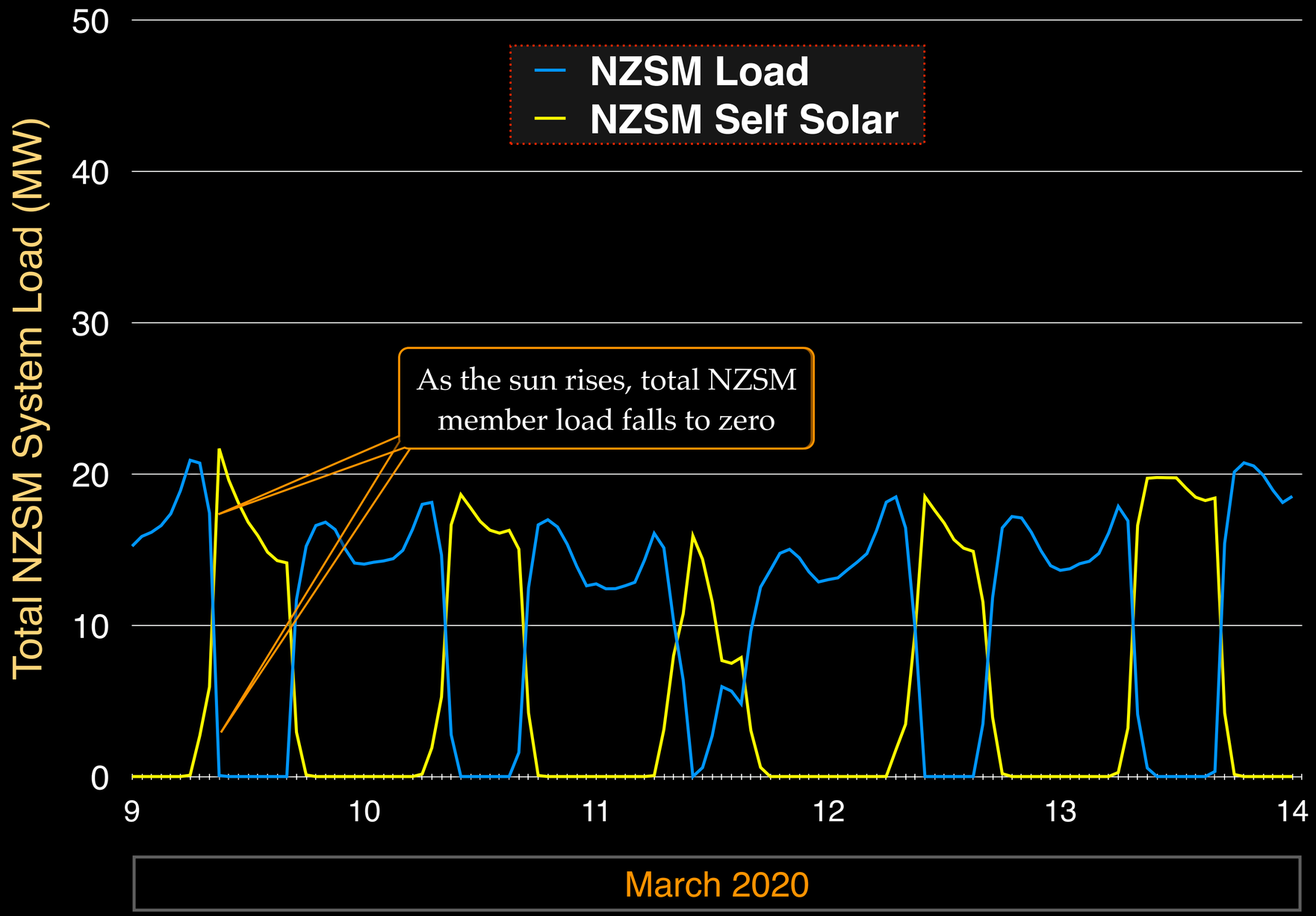
217 million kWh Annual 2020 Reference

180 million kWh Annual NZSM Model

Notes

- Winter load is typically double of summer load
- Net-zero solar members reduce their OPALCO load, reducing total annual kWh sales by 37 million kWh
- Load reduction is weaker in winter when solar output is 20% of summer

Load Shape Analysis: Total NZSM System Load, No Solar Export

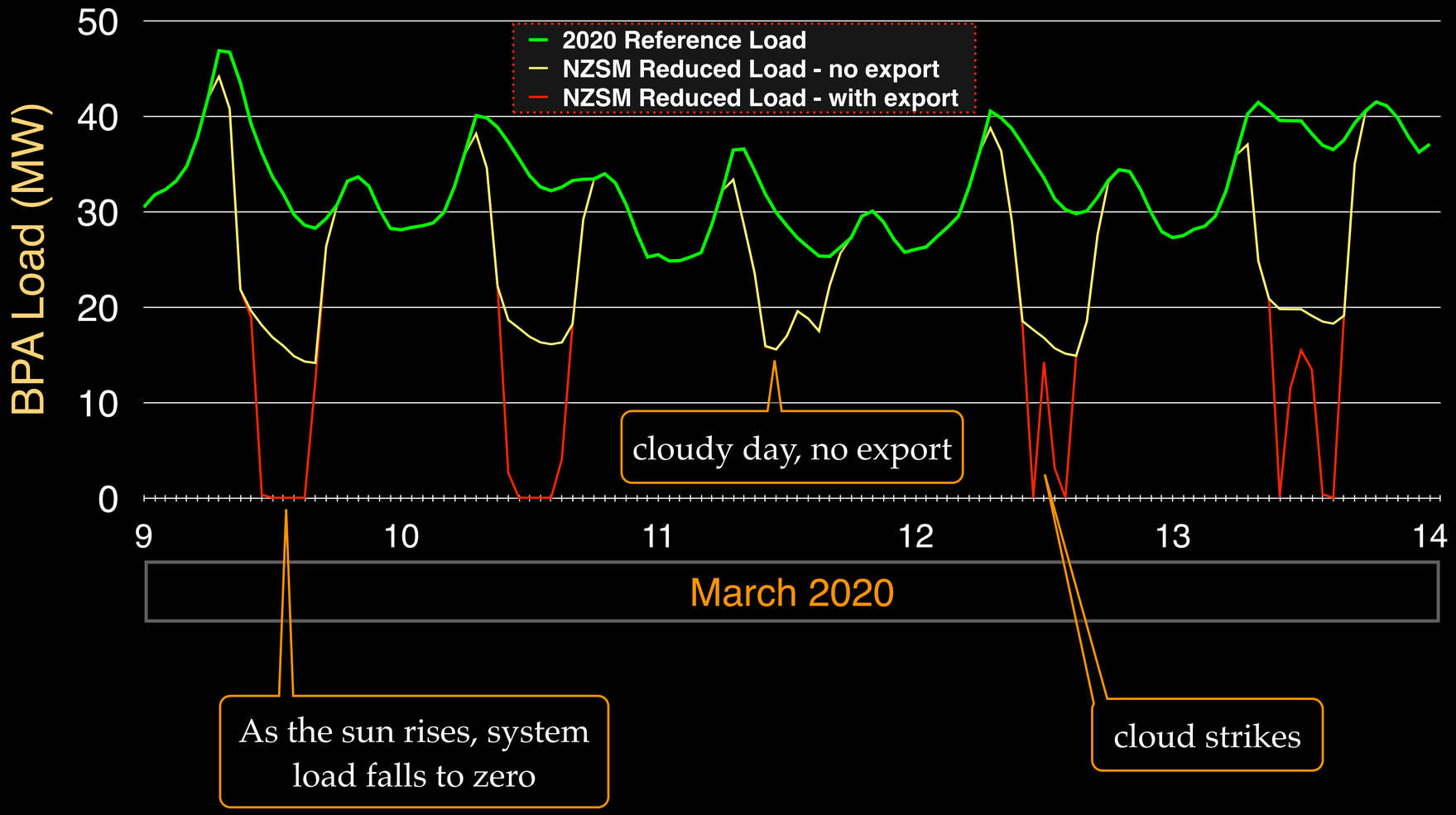


Week of 9 March 2020 was a cold clear sunny week, with dramatic load changes as the sun rises and sets

Notes

- On sunny days, as sun rises, NZSM load rapidly falls to zero.
- As sun sets, load rapidly increases to normal regular non-solar member load.
- This rapid decrease/increase in demand is similar to California's Duck Curve problem, where firming resources need to quickly track the changes to maintain stable power and protect sensitive member appliances.
- As more OPALCO members adopt solar, rapid load changes increase in frequency and intensity.

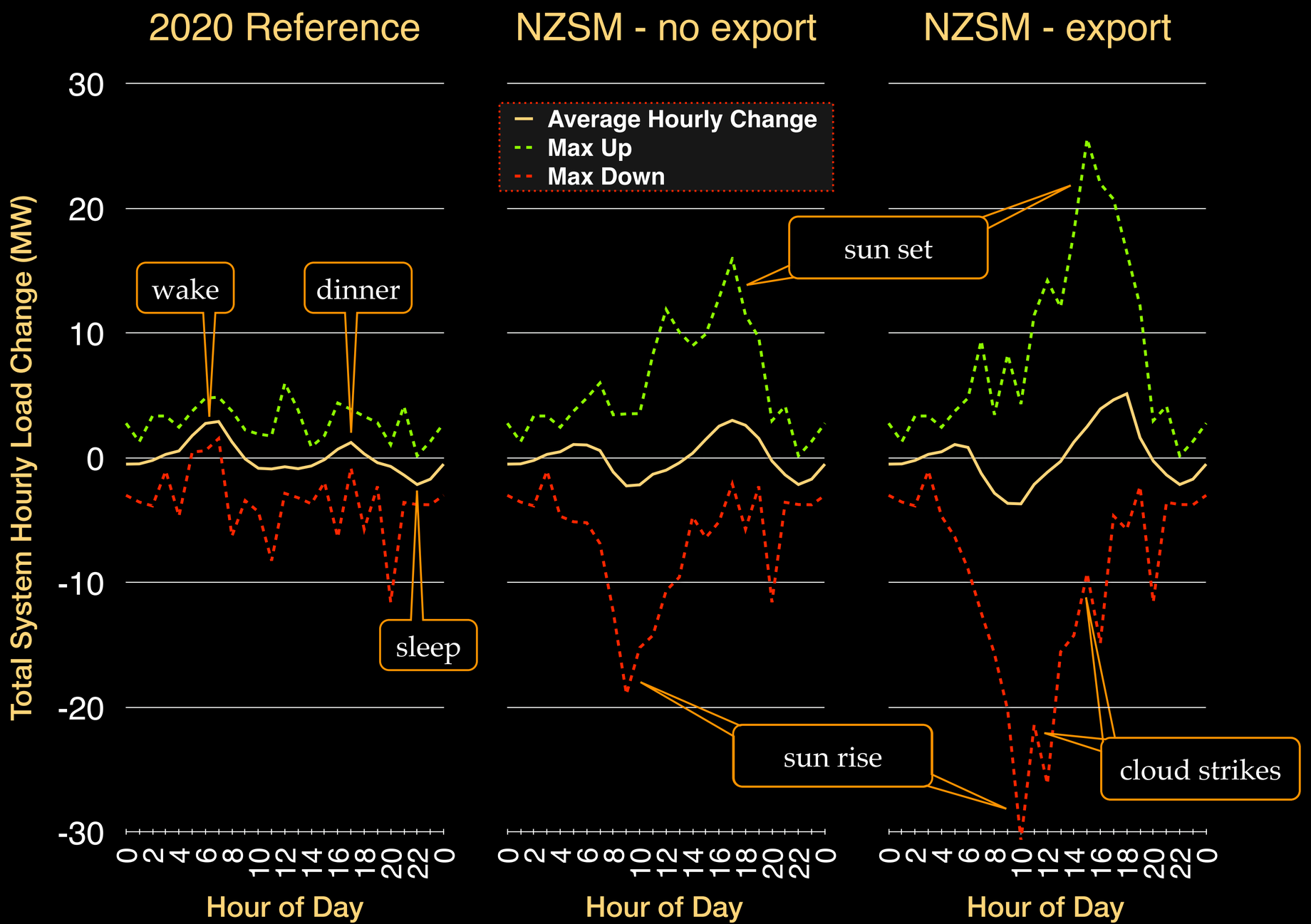
Load Shape Analysis: 2020 Reference load, NZSM Model System Load (with and without export)



Notes

- The green line is the 2020 reference load of OPALCO's system.
- The yellow line is the system load in the NZSM model (50% regular members + 50% NZSM members). The reduction from 2020 load is due to NZSM self generated solar only. No NZSM export is considered.
- The red line is the system load in the NZSM model, with NZSM export.
- Note the shear fall and rise of the yellow and red line load. The next slide explores those rapid changes.

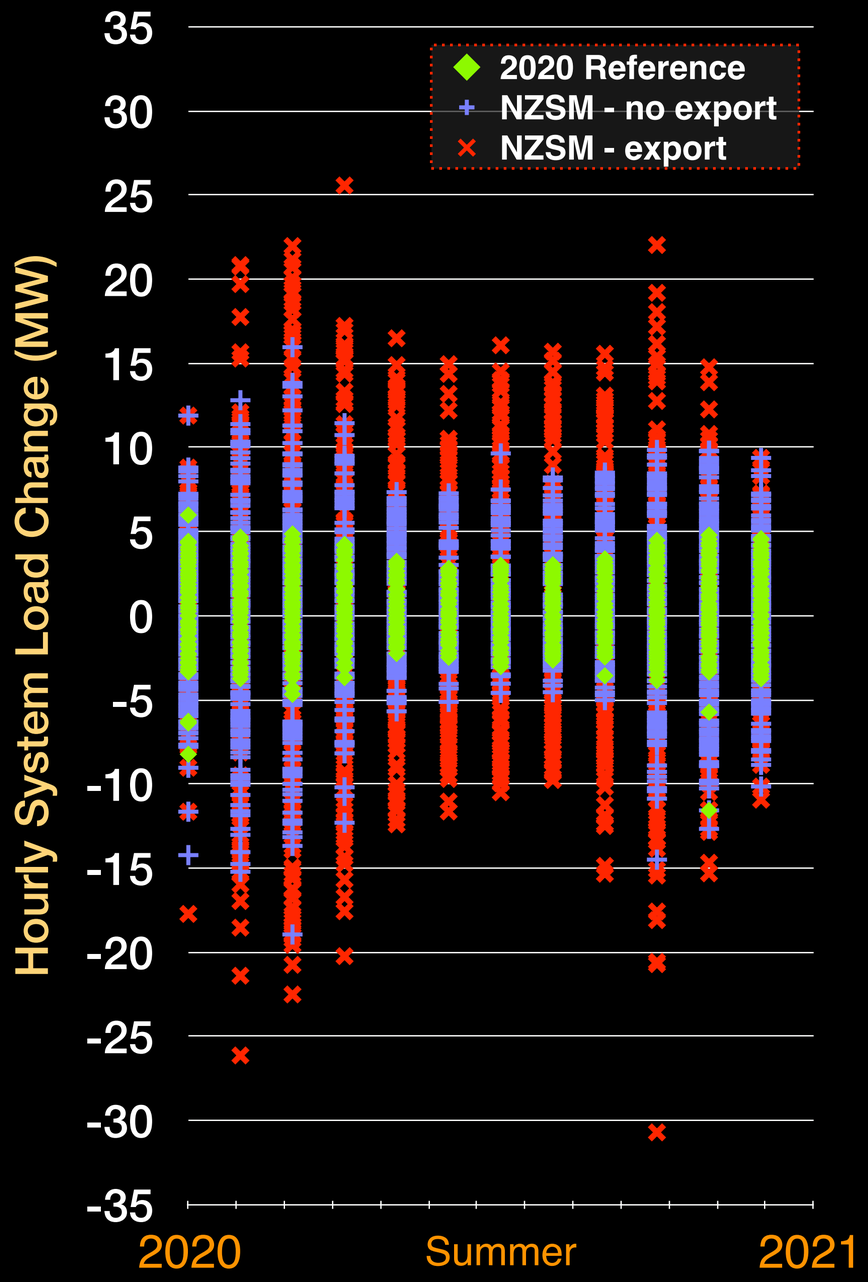
Load Shape Analysis: Avg, Max Up, Max Down Hourly Change for 2020 Reference, NZSM No Export and NZSM Export

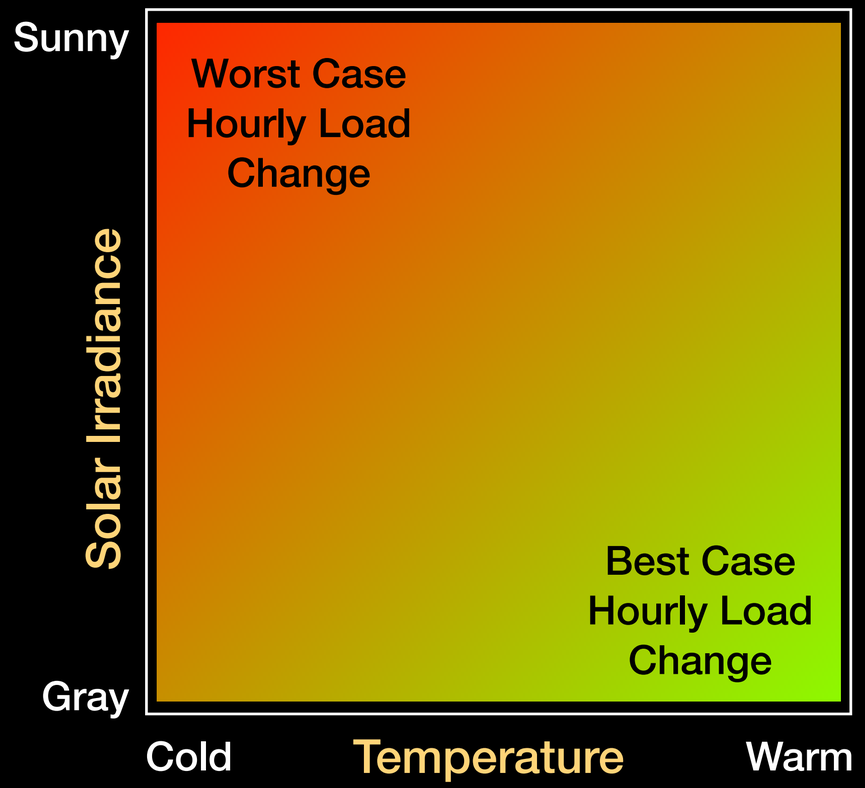


Notes

- The average, max up and max down change in hourly load are displayed for 2020 Reference, NZSM no export, and NZSM with export.
- The yellow line is the average change in system load, in a given hour, each day of the year, for each scenario.
- The green line is the maximum change up.
- The red line is the maximum change down.
- Note the increasingly amplified movements - load changing downward as the sun rises, and load changing upward as the sun sets.
- The NZSM export chart shows further amplification of load changes, due to export of solar energy to grid, offsetting firm BPA with intermittent solar. The rapid downward movements are due to cloud strikes.

Load Shape Analysis: Seasonal View of Hourly Change for 2020 Reference, NZSM No Export and NZSM Export

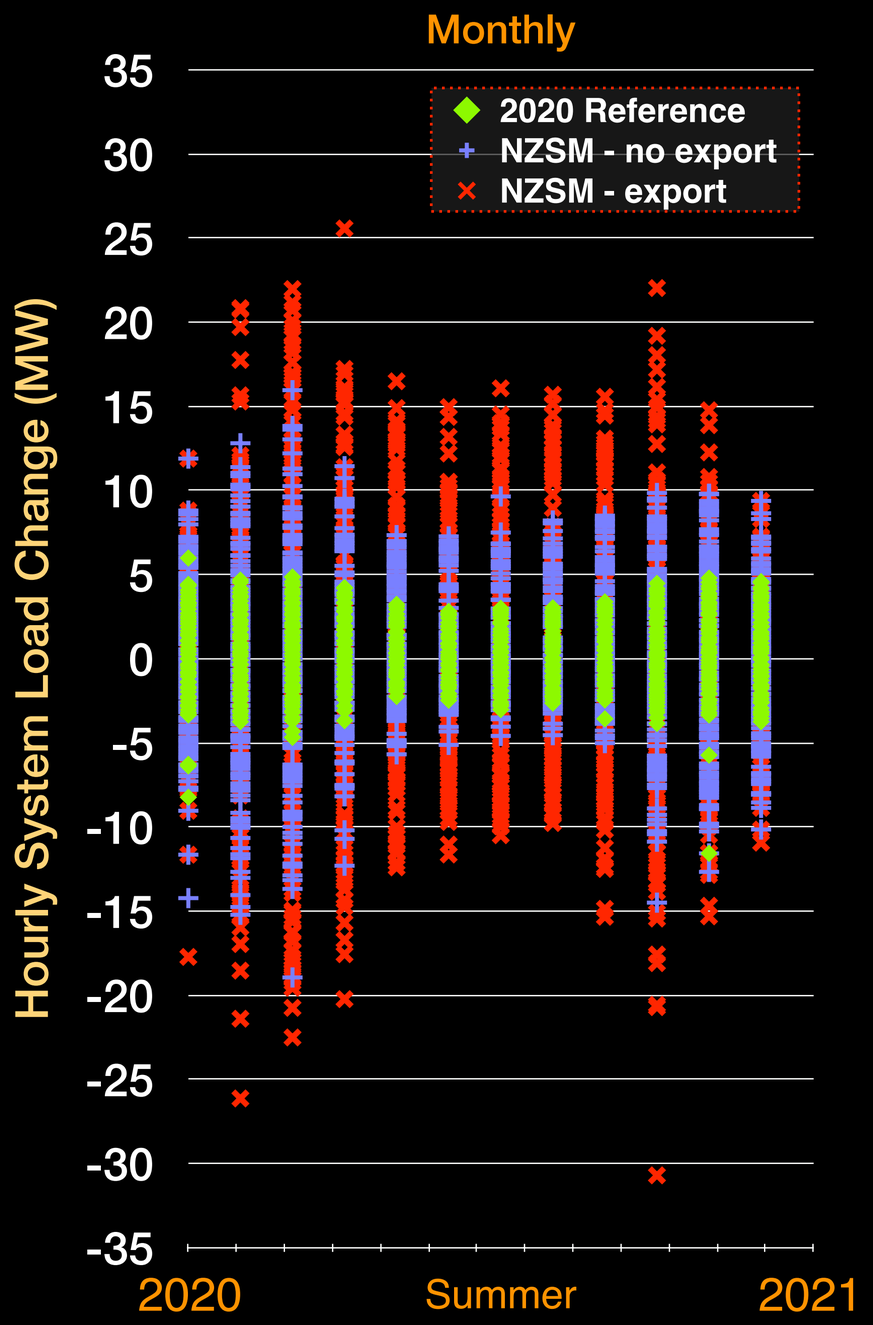


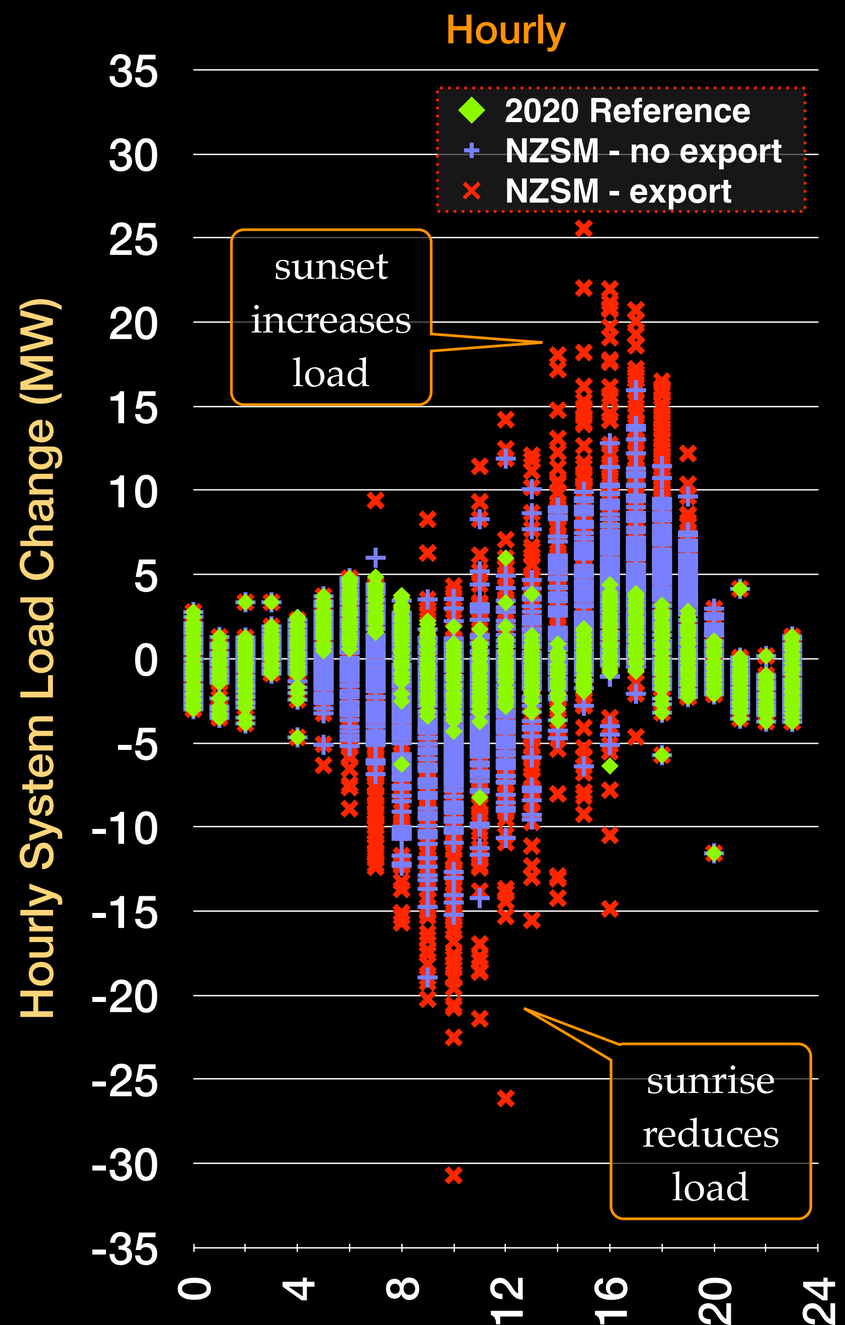


Notes

- Scattergraph of over 26,000 hourly data points for 2020 Reference Load, and NZSM with and without export.
- Worst case hourly change happens in shoulder seasons, when days are cold (bigger load) but clear (more solar).
- Export case is most dramatic because, on sunny days, it can literally take a cold morning peak load and drive it to zero, in a matter of an hour or two, as the sun rises on a clear day. And the reverse happens at the end of the day as the sun sets, and clear cold night rushes load back to peak.
- 2020 Reference Load is typical confined to movements within +/- 5 MW. NZSM has over 600 events that are triple that range.

Load Shape Analysis: Seasonal and Hourly View of Hourly Change for 2020 Reference, NZSM No Export and NZSM Export





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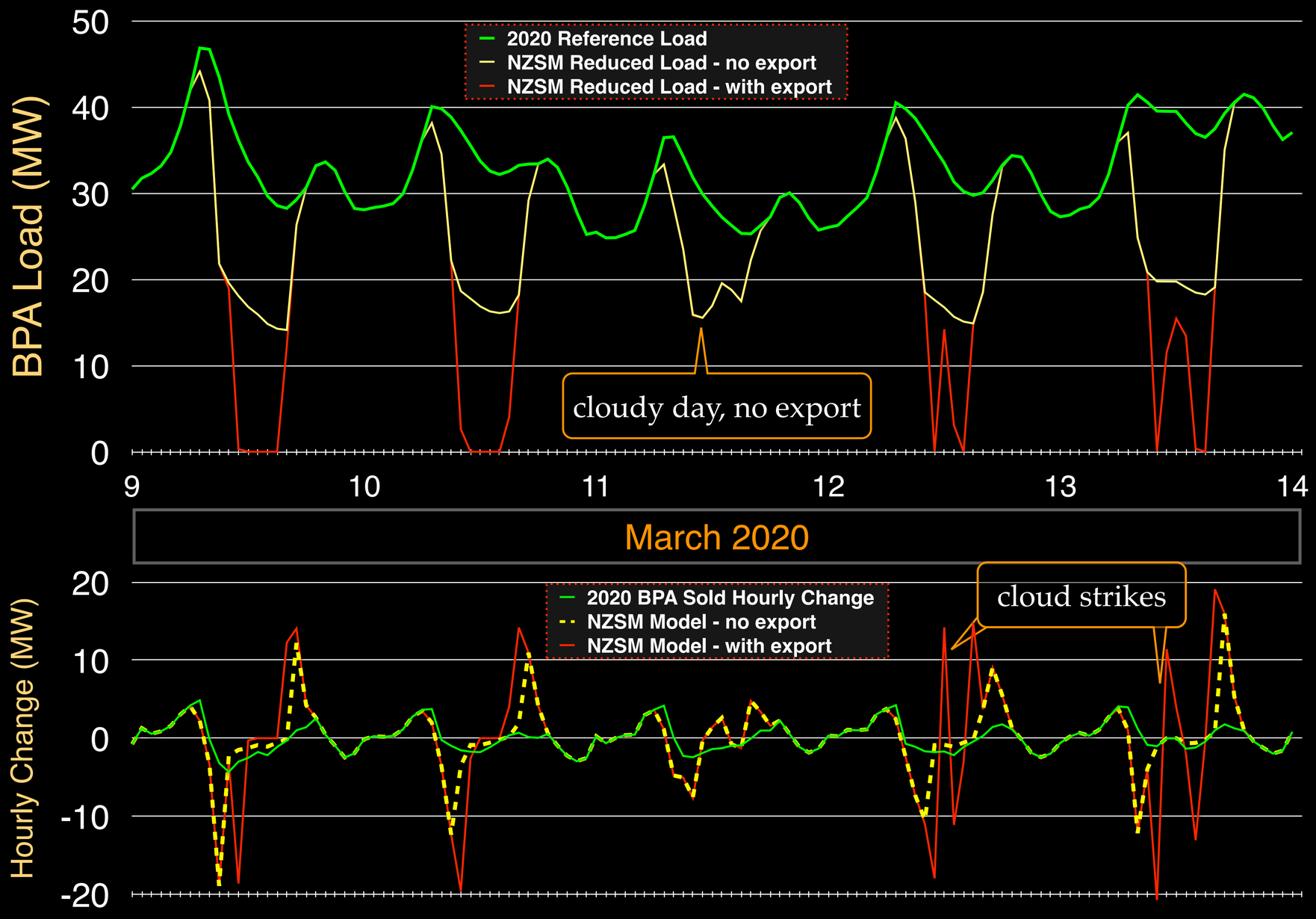
- 2020 Reference Load is typical confined to movements within +/- 5 MW. NZSM has over 600 events that are triple that range.

Load Shape Analysis: BPA Load, Hourly Change in Load



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- The red line is the system load in the NZSM model, with NZSM export.
- Note the shear fall and rise of the yellow and red line load. The next slide summarizes the annual impact of those rapid changes.

Load Shape Hourly Change: Statistical Analysis Summary

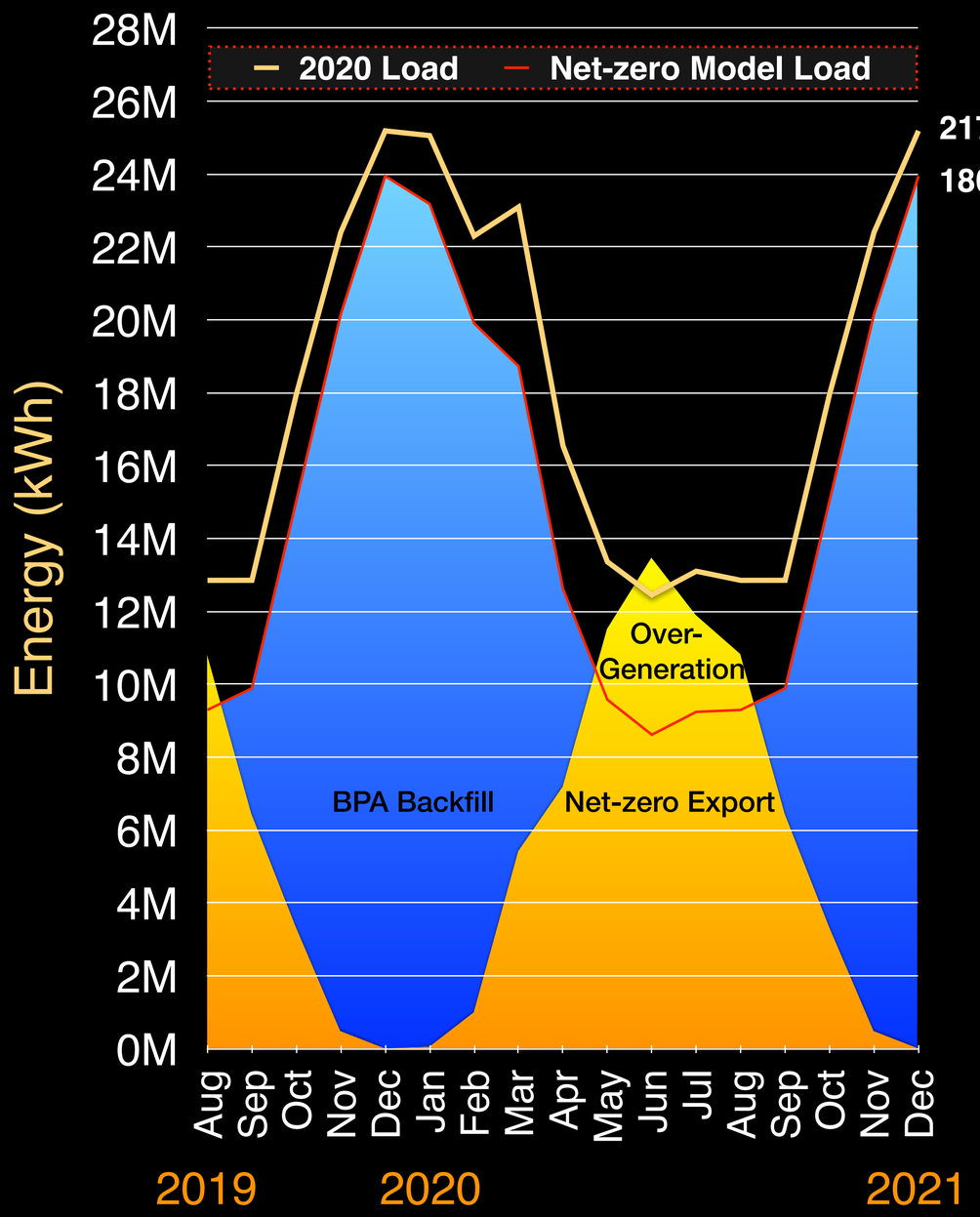
Hourly Load Change	2020 Reference	NZSM no export	NZSM with export
Standard Deviation	1.5 MW	2.6 MW	4 MW
Max Spike Up	6 MW	16 MW	26 MW
Max Spike Down	-11.5 MW	-19 MW	-31 MW
Count > 2020 Up Max		286	527
Count > 2020 Down Max		22	112

Notes

- NZSM hourly load has over 639 spikes larger than than any that occurred in 2020.
- Climate Impact: reducing stream flow, increasing fire season, etc. all increase day ahead market firming resources risk.
- Climate Impact: Fluctuation of hydro system with climate impact on seasonal flow, especially summer time.
- Buying on short-term market (Energy Imbalance Market (EIM)and Energy Day Ahead Market (EDAM)), to firm spikes in load, becomes very unpredictable and expensive.
- Will require rethinking protection schema given large bi-directional power spikes.

Export and Over-Generation

Representational Monthly Energy Sales: Generation to meet Net-Zero Model Load



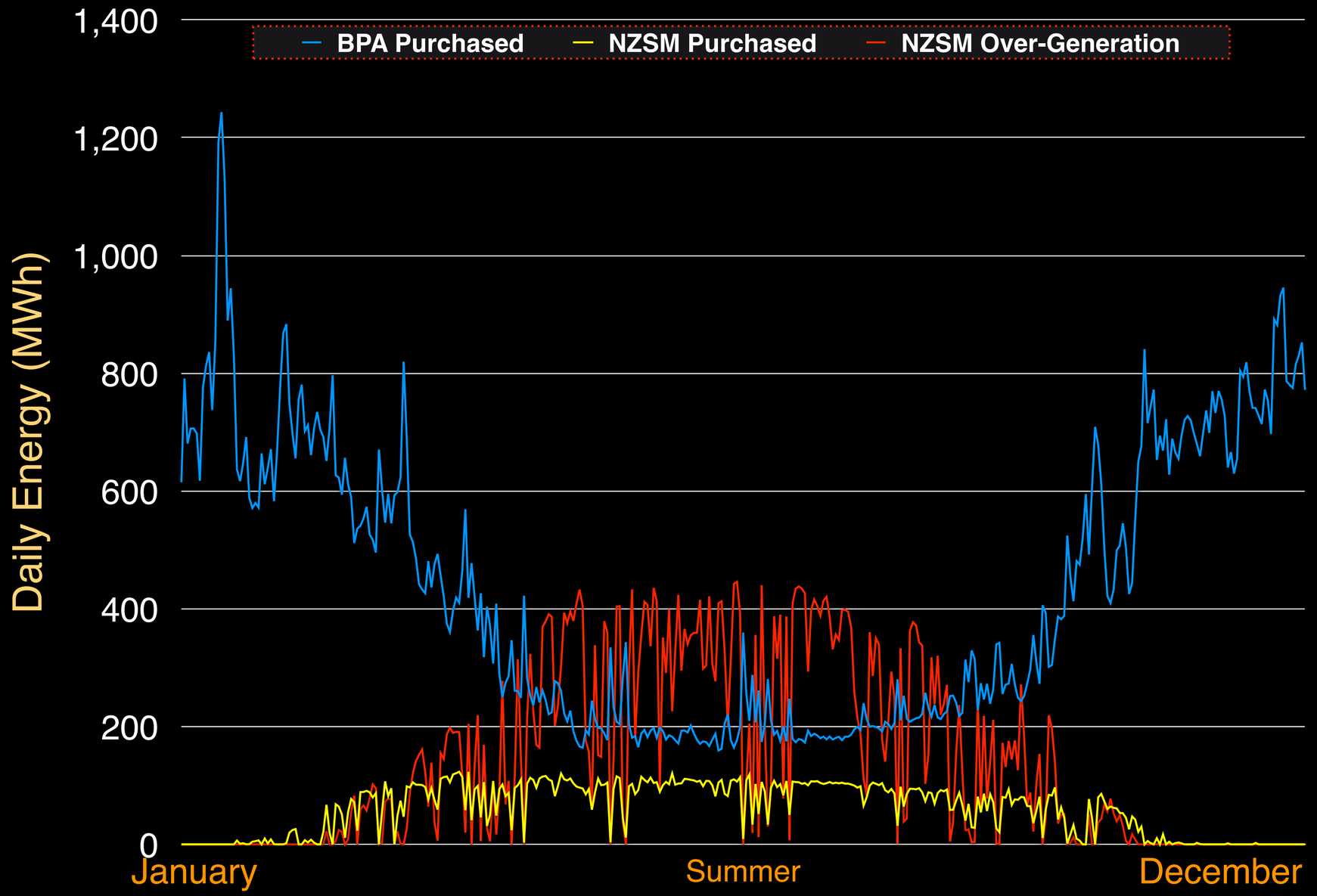
217 million kWh Annual 2020 Reference

180 million kWh Annual NZSM Model

Notes

- Goal: use member exported solar first, and backfill with mainland power
- Winter is typically 92% BPA, 8% solar
- Summer is typically 65% BPA, 35% solar
- During summer days, net-zero solar production exceeds member load so is mostly exported to OPALCO grid, 72% is over-generation, exceeding what we need to meet total system load.
- Over-Generation: Summer daily solar export exceeds total system daily load, so is either:
  - curtailed,
  - sold to mainland at market rates,
  - stored in longterm storage (e.g. hydrogen fuel cell)
- Though summer is net solar export, at night and during cloudy days, BPA is needed to firm solar (see previous hourly slides)

Daily Energy Mix: BPA, NZSM with Solar Export and Over-Generation



BPA Backfill
158 million kWh

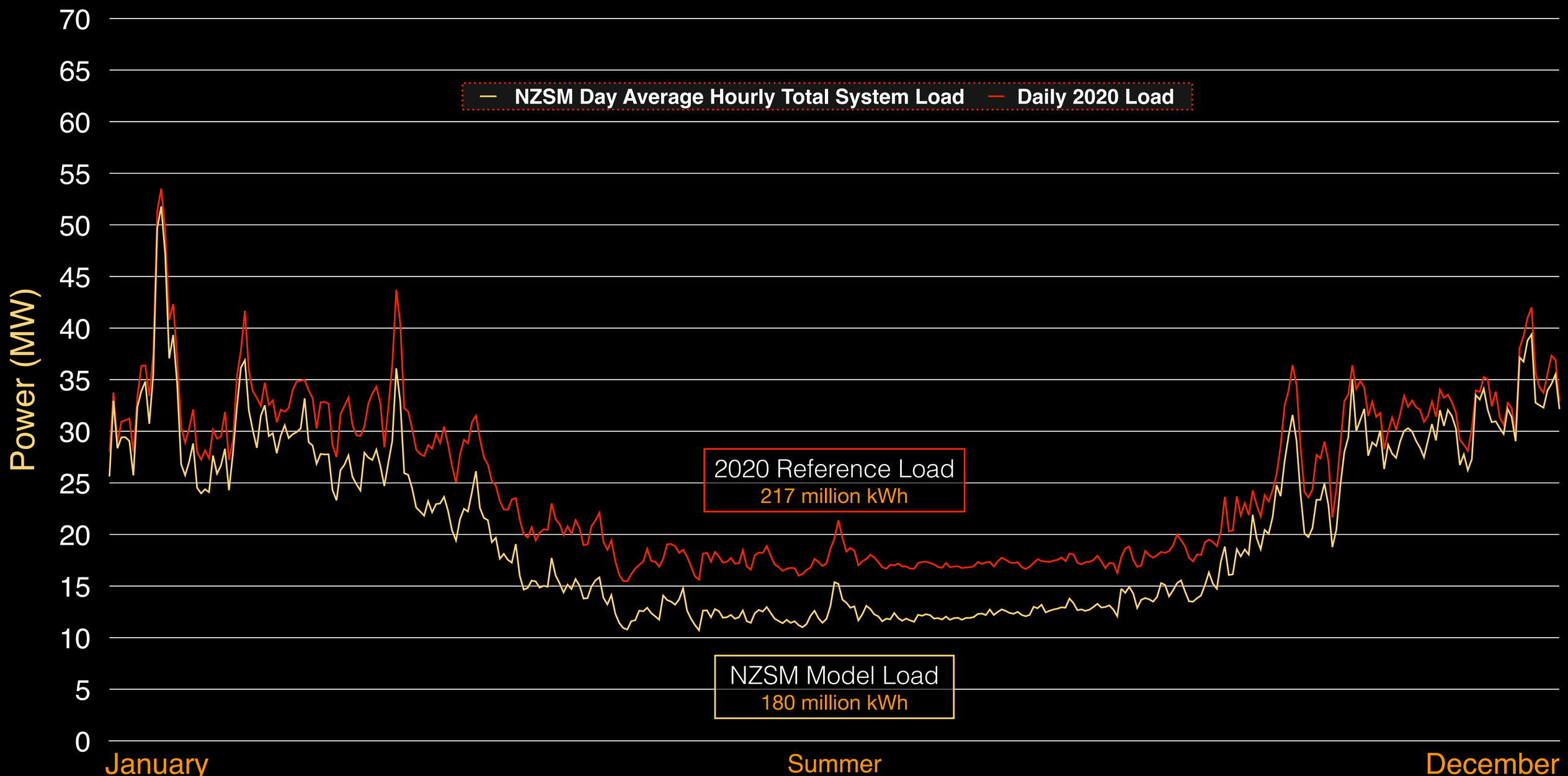
NZSM Over-generation
50 million kWh

NZSM Purchased
22 million kWh

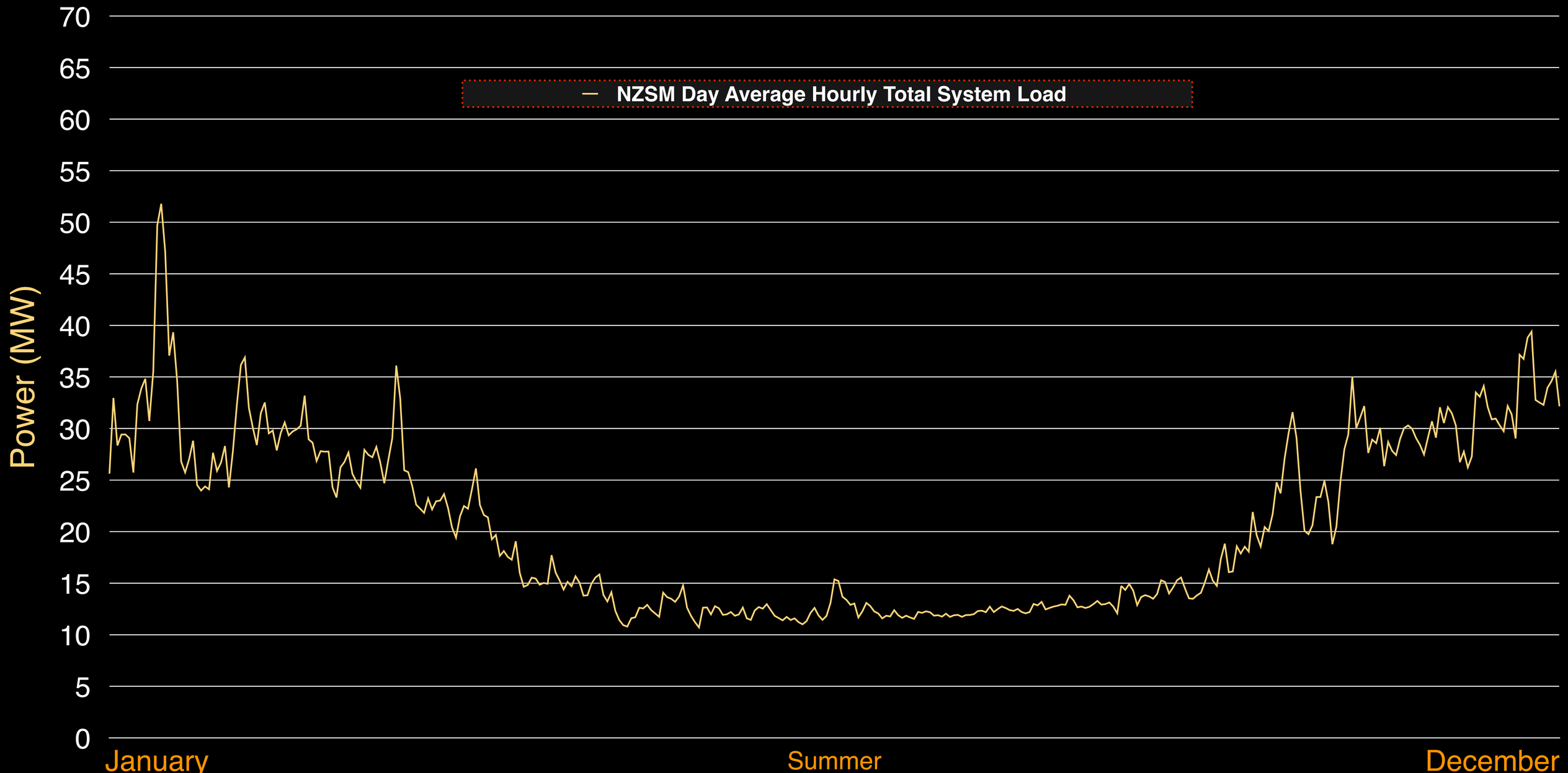
Notes

- NZSM Purchased: Is used to serve system load first.
- BPA Purchased: Is used to backfill system load when member solar export is not enough.
- Over-Generation: Summer daily solar export exceeds total system daily load, so is either:
  - curtailed,
  - sold to mainland at market rates,
  - stored in longterm storage (e.g. hydrogen fuel cell)

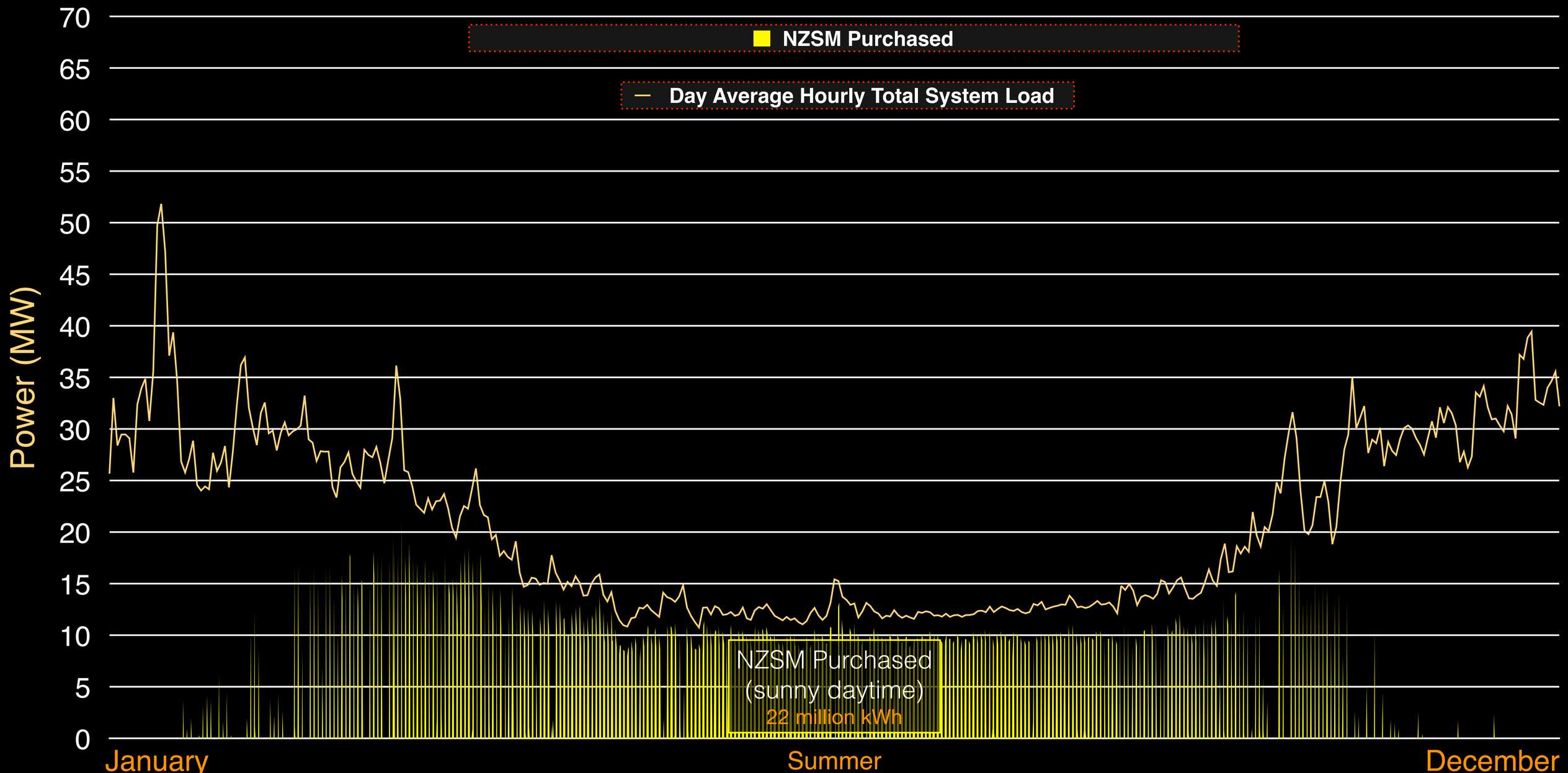
Day Average Hourly System Load: 2020 and NZSM Model



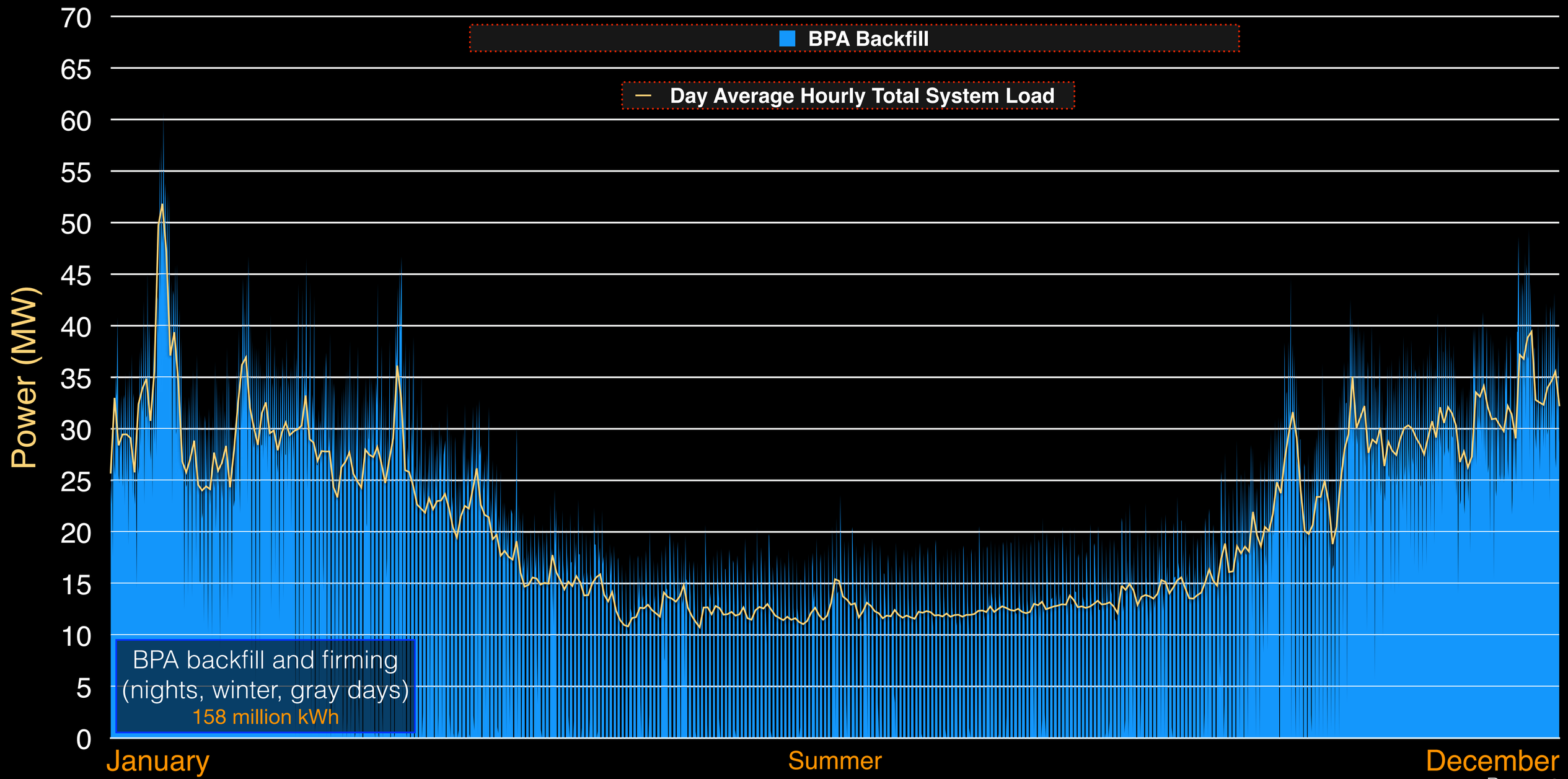
Day Average Hourly System Load: NZSM Load



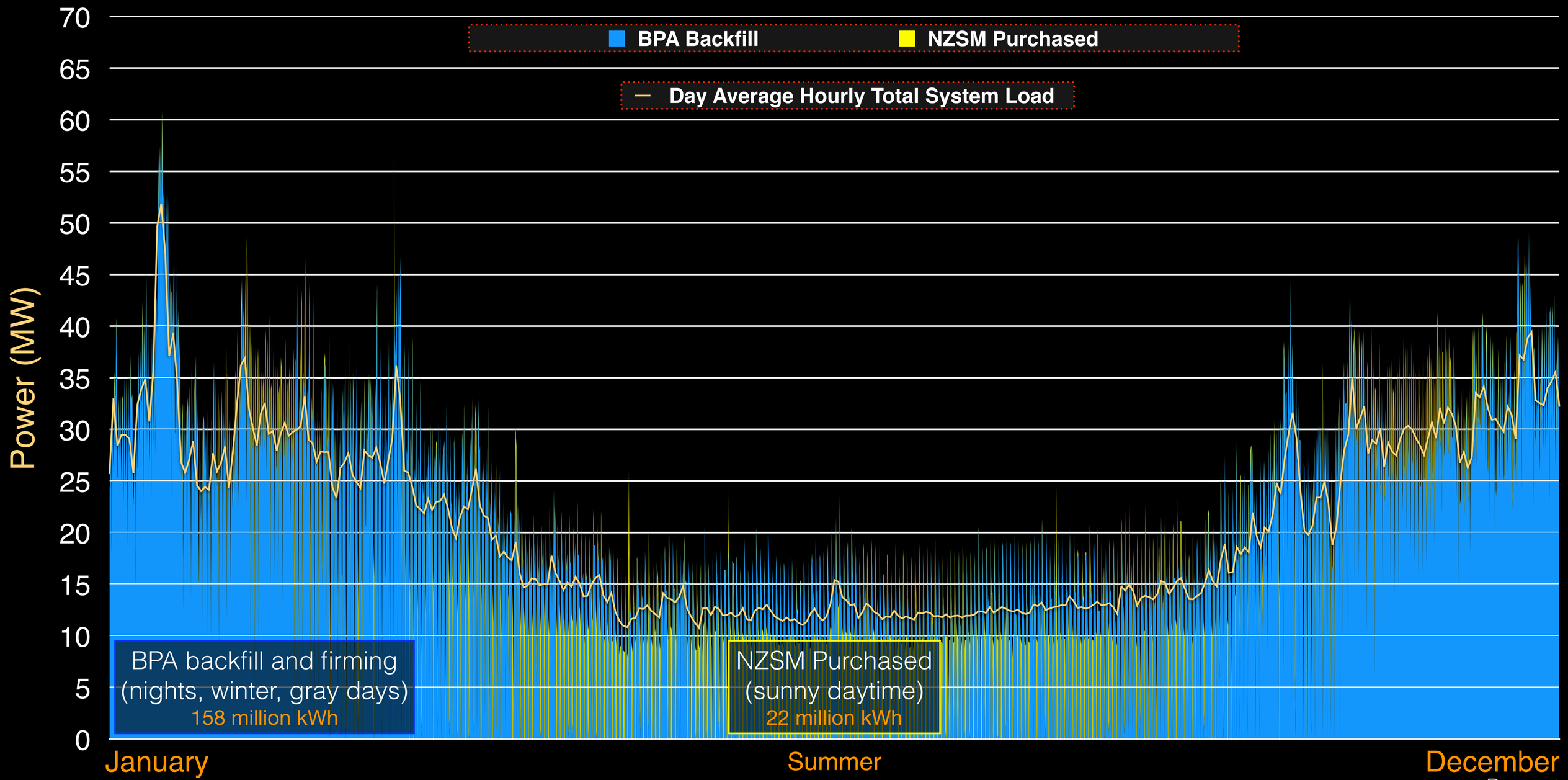
NZSM Hourly Generation Mix: NZSM Purchased



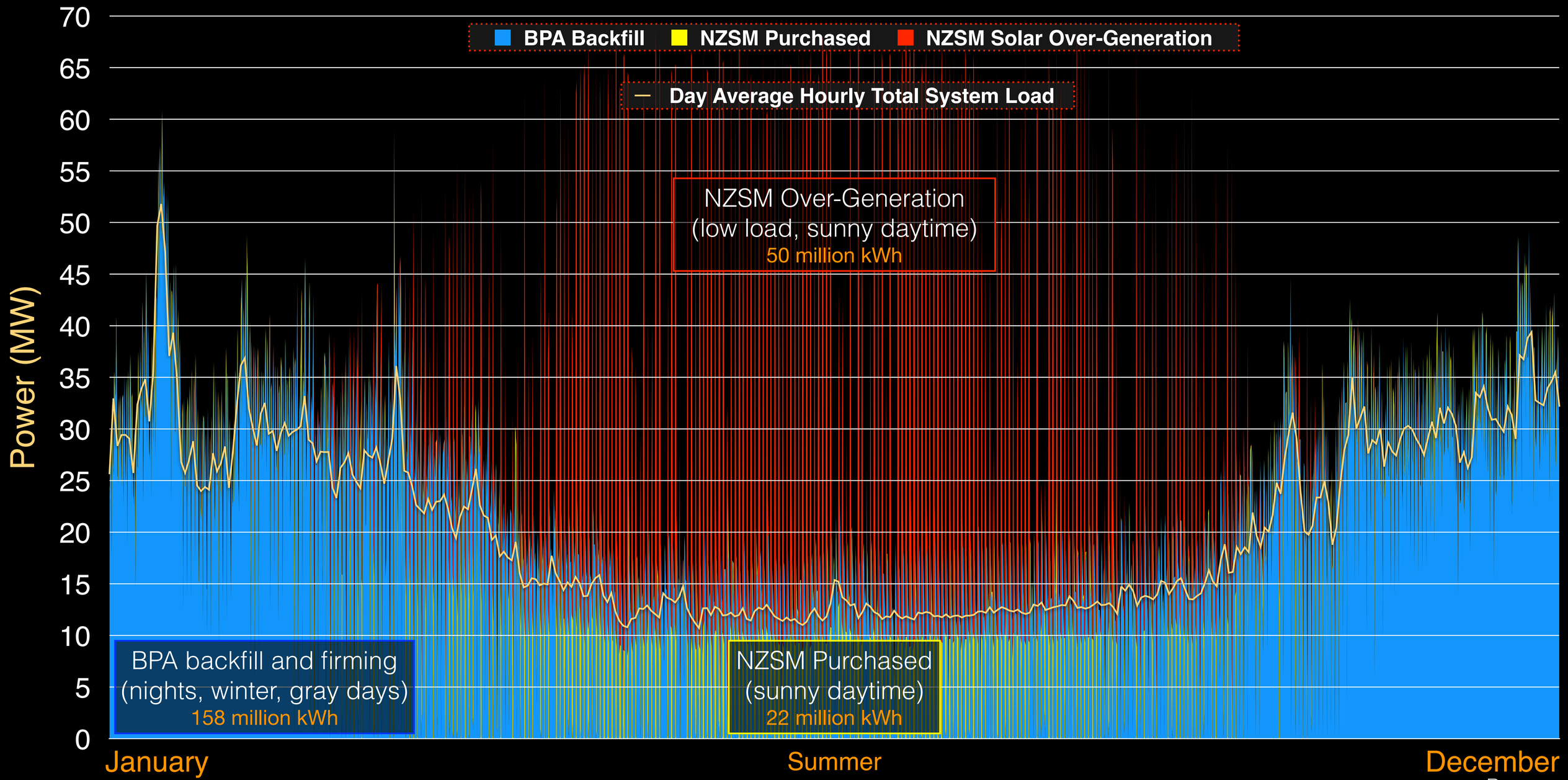
NZSM Hourly Generation Mix: BPA Backfill



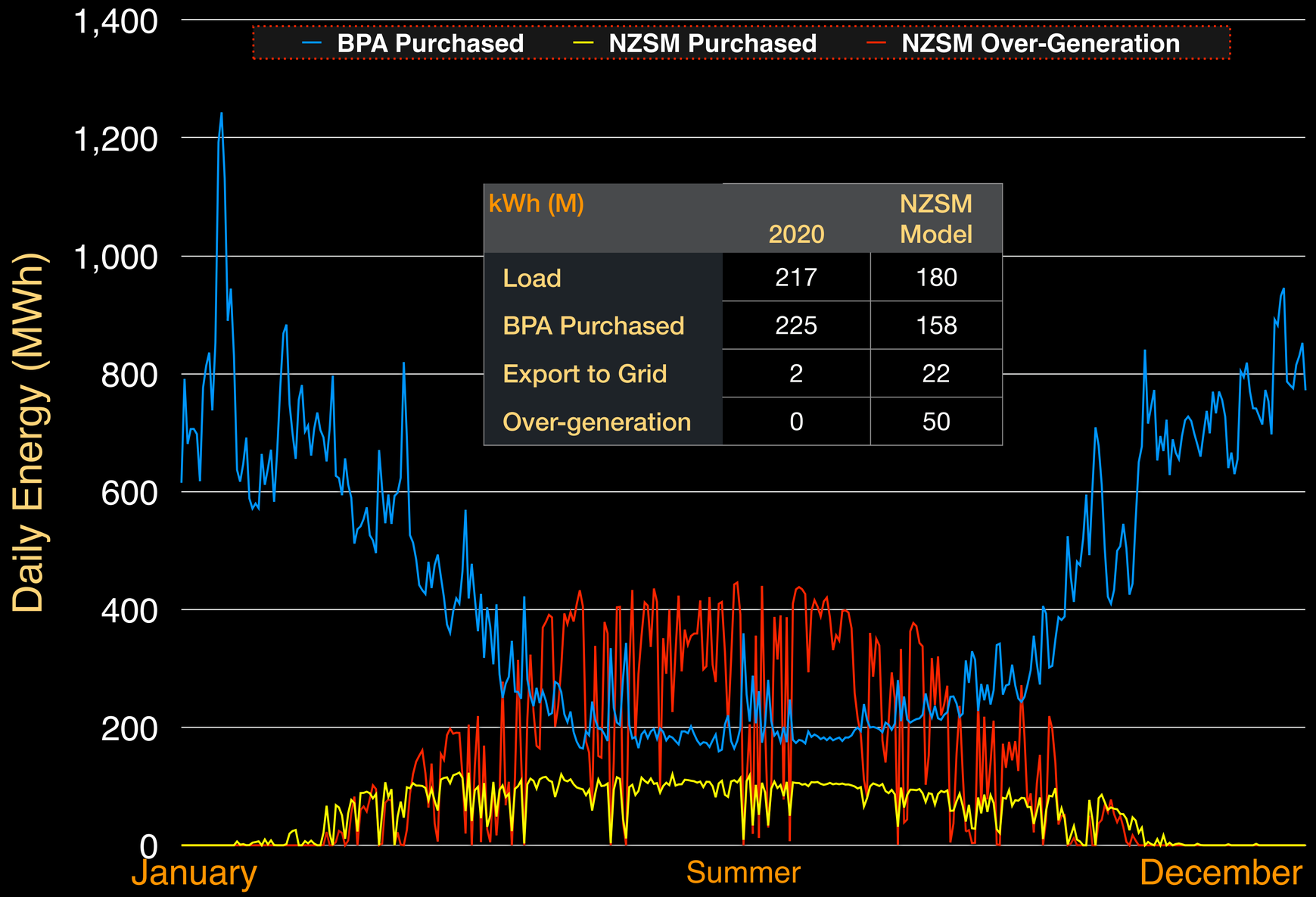
NZSM Hourly Generation Mix: BPA, NZSM Purchased



NZSM Hourly Generation Mix: BPA, NZSM Purchased, Over-Generation



Daily Energy Mix: 2020 Reference and NZSM Model Summary



kWh (M)	2020	NZSM Model
Load	217	180
BPA Purchased	225	158
Export to Grid	2	22
Over-generation	0	50

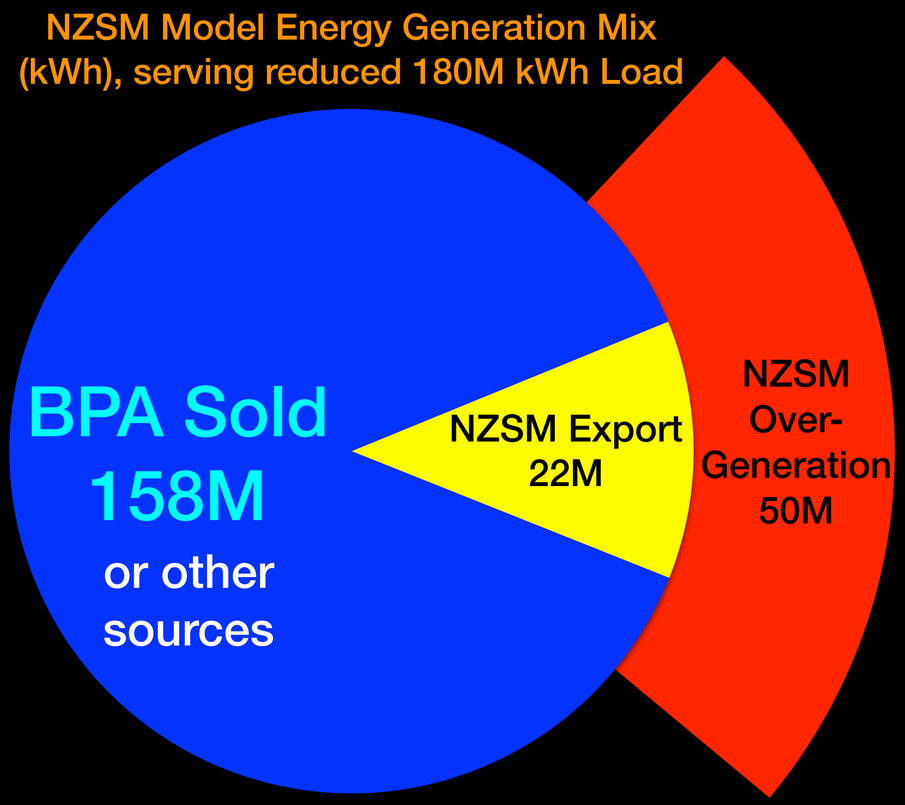
BPA Purchased
158 million kWh

NZSM Over-Generation
50 million kWh

Summer daily solar export exceeds total system daily load, so is either:
- curtailed,
- sell to BPA?
- stored in longterm storage for winter (e.g. hydrogen fuel cell, >50% loss)

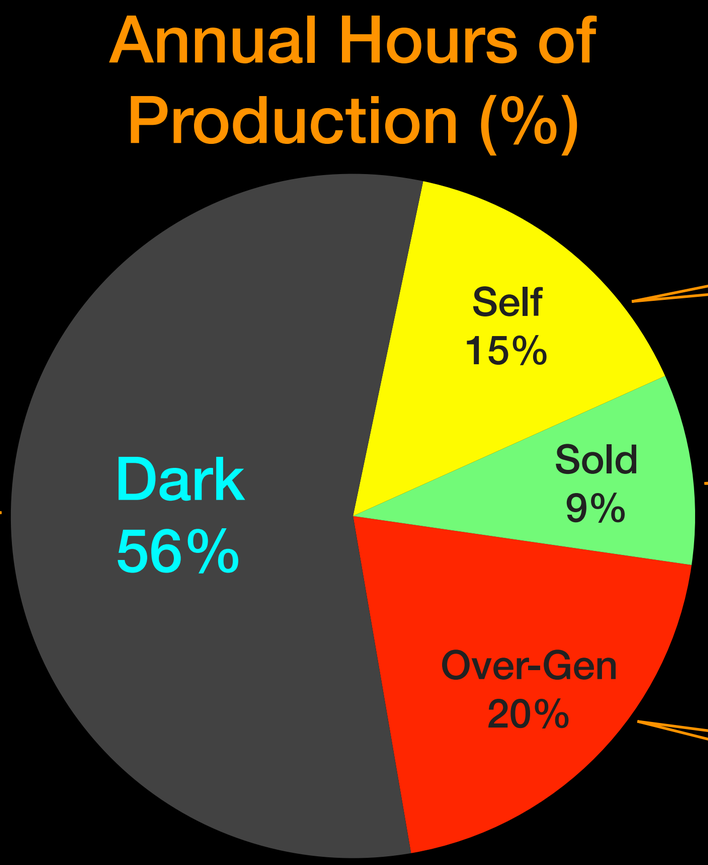
NZSM Purchased for resale to regular members
22 million kWh

NZSM Model Summary



- 5,750 NZSM members, 5,750 regular members (no generation)
- Resultant Energy Mix to serve 180 million kWh load
  - BPA 88% (158 million kWh)
  - Local Solar 12% (22 million kWh)
- NZSM members will collectively produce 109 million kWh annually
  - 37 million kWh for self (reducing total annual kWh sold to 180 million)
  - 22 million kWh resold to OPALCO for regular member load, displacing BPA
  - 50 million kWh over-generation (curtailed?, sold to BPA?, stored for winter?)
- NZSM members collectively would have 110,000 kW of solar capacity
  - covering 660 acres of surface, mostly rooftop
  - 19 kW dc capacity each (average among residential and commercial members)
- NB: Over-generation starts to happen after 12.5% of members are NZSM (1,438).

What portion of the year does NZSM solar provide power?



Reduces system load from 217 million kWh to 180 million kWh

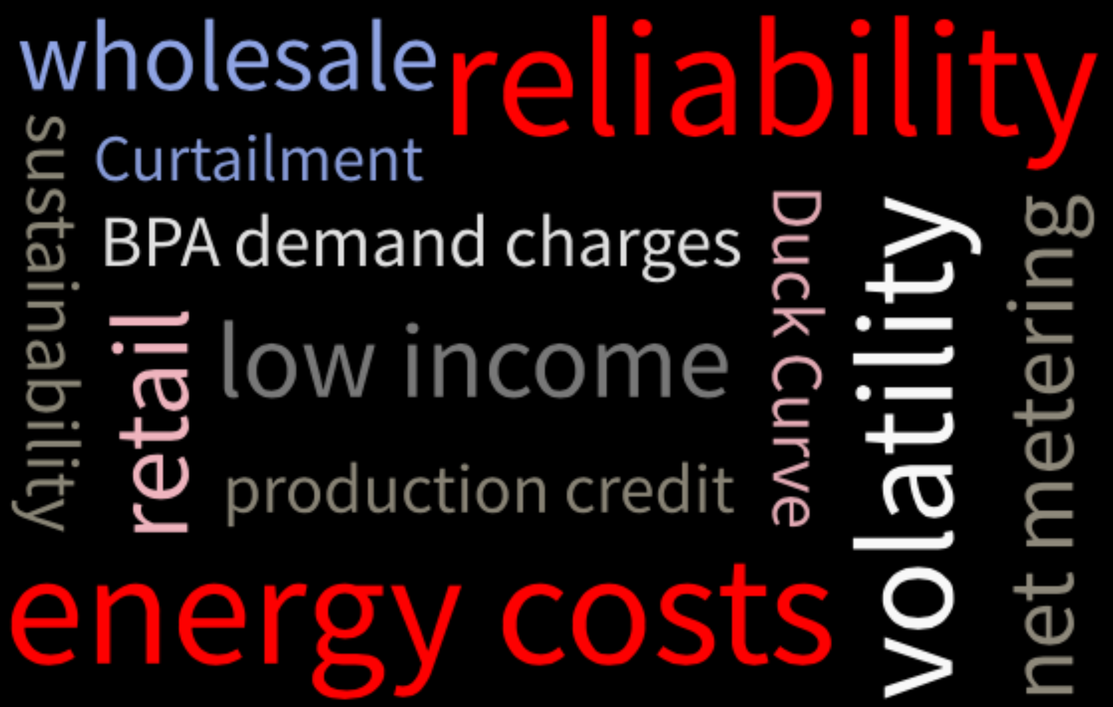
Sold to OPALCO to meet other member's load, replacing BPA.

Exceeds load. Must be curtailed, sold to mainland or stored for winter.

Northwest has half the capacity factor of the Southwest. Longer nights in winter during peak load. Lower loads in summer during peak sun.

Discussion

pros and cons
local resilience
reliability
over-generation
curtailment
longterm storage
sell to BPA
load shape
load reduction



grid modernization requirements to support increased load spikes and bi-directional
how to maintain firm power, and manage cost of power
how to balance needs of solar and non-solar members

Rates Review: Timeline

✔	May 2021	Member Generation Trends and Modeling
	June	Staff Analysis
	August	Guernsey Cost of Service Analysis (COSA) review
	September	Discussion of Rate Options
	Late September	Solar Town Hall - member feedback
	October	Rate Options Review
	November	Budget and 2022 Rate Proposal (first read)
	December	2022 Rate Structure (second read)
	January	Rate Implementation

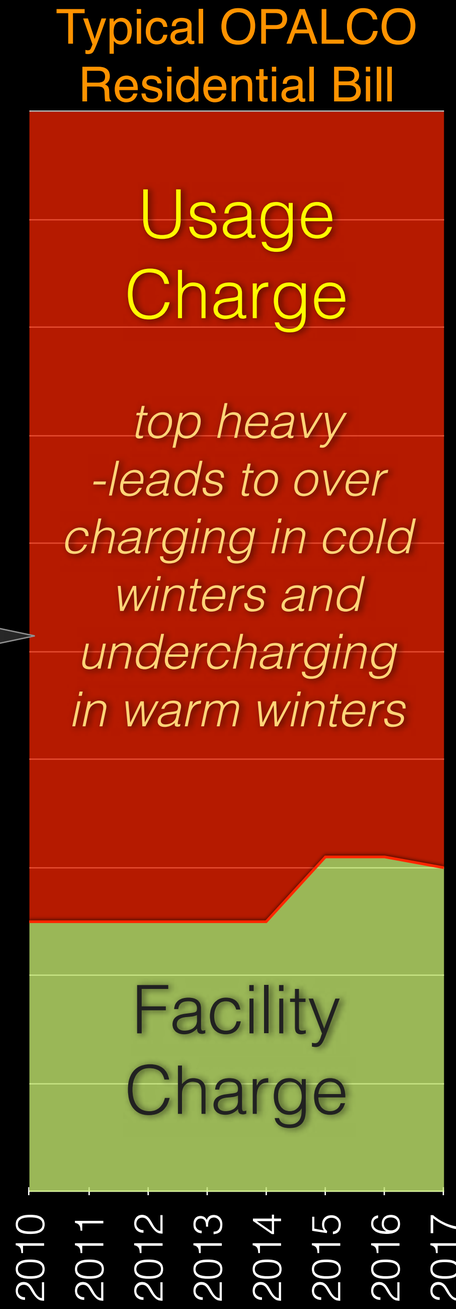
Thank You!

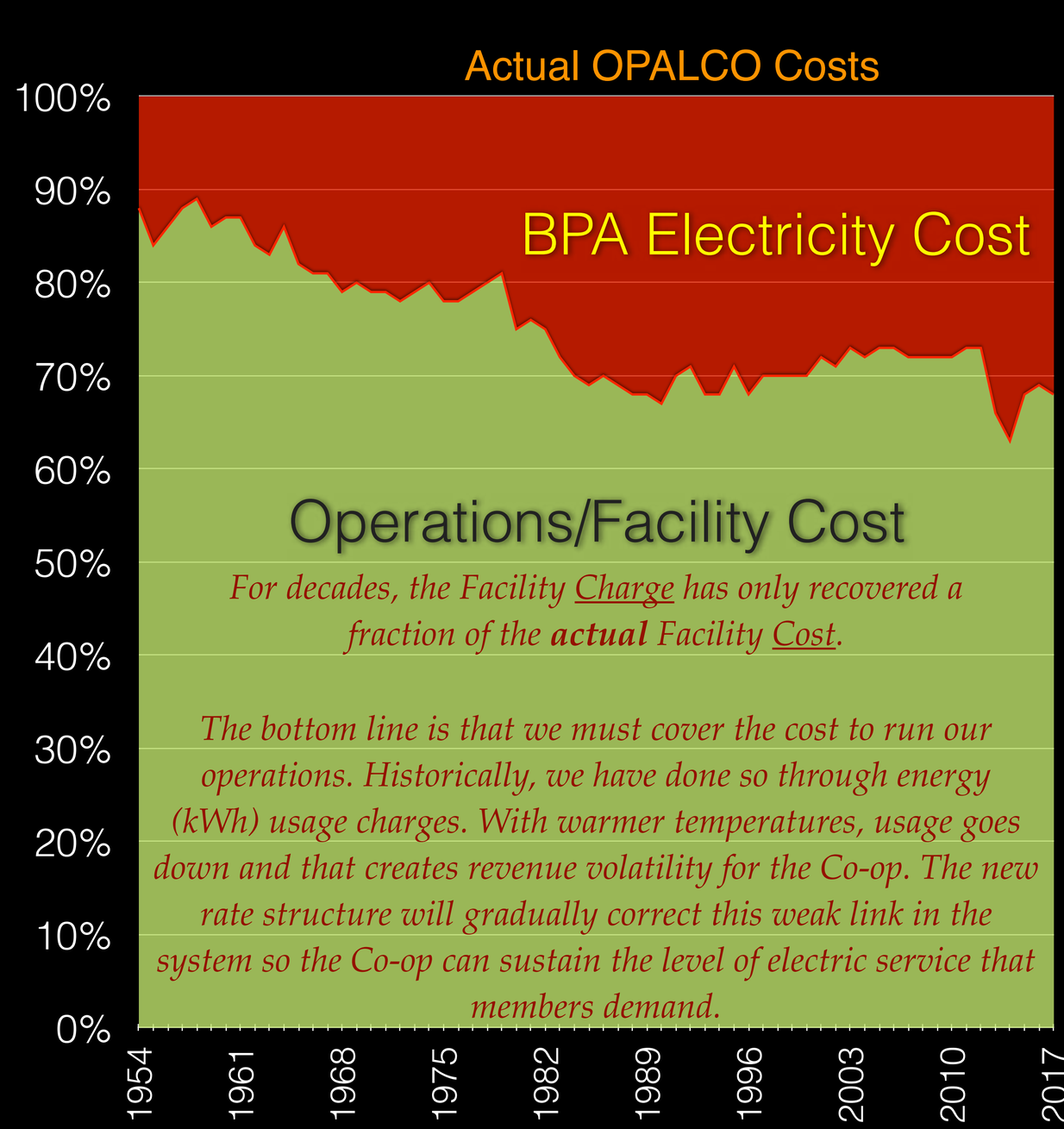
Appendix

Billed Versus Actual Cost as a % of Total Cost

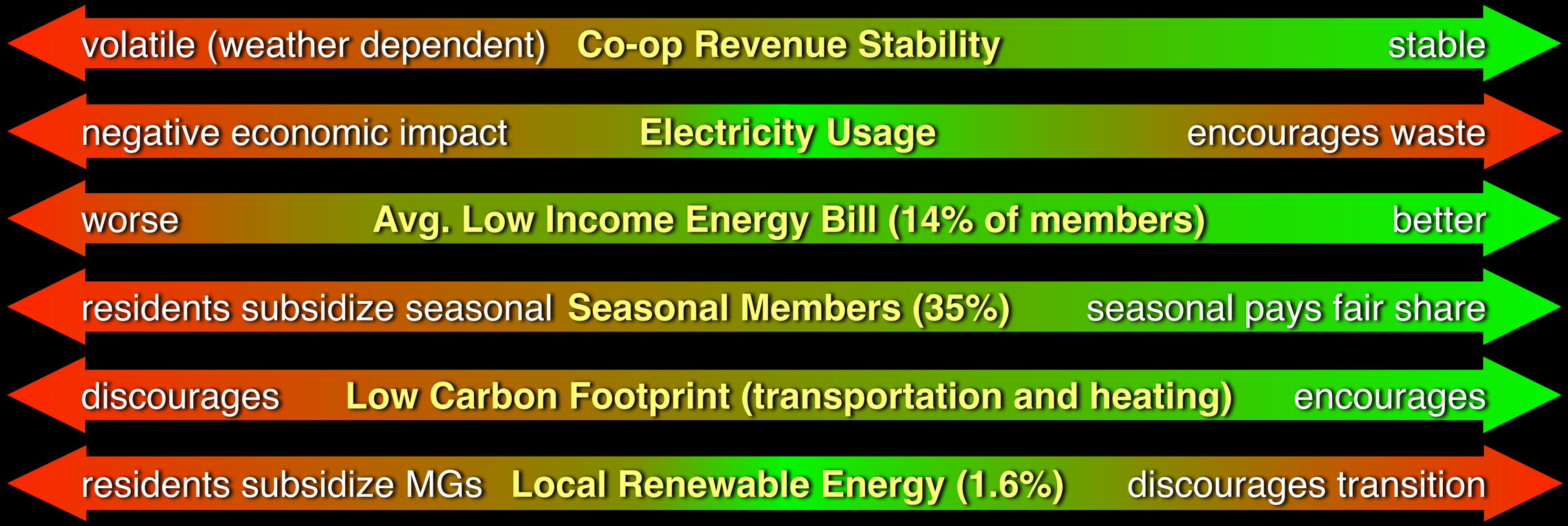
Rule of Thumb

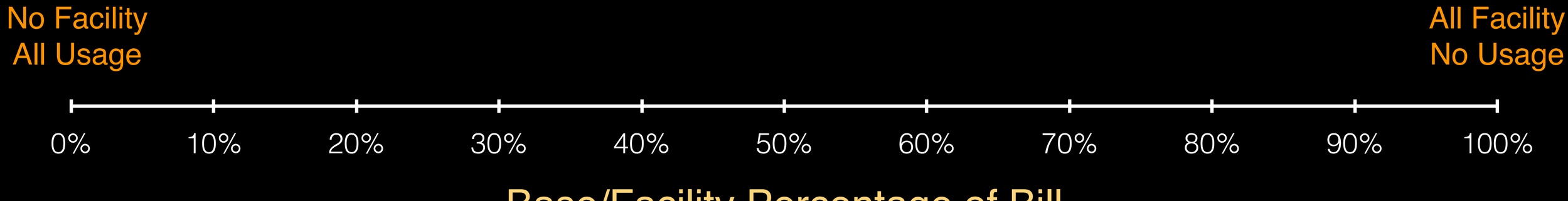
Bill = Rates x Weather



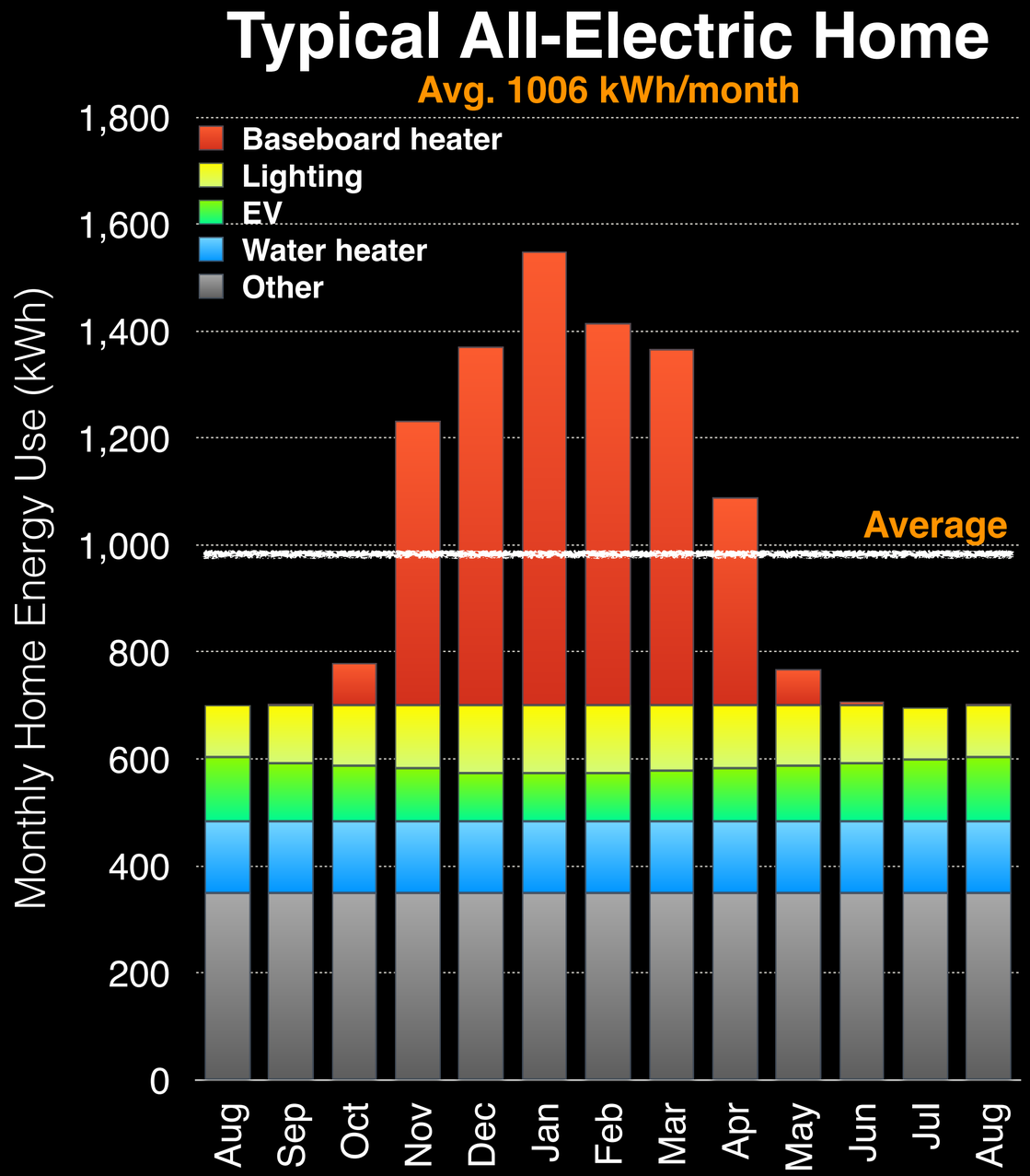


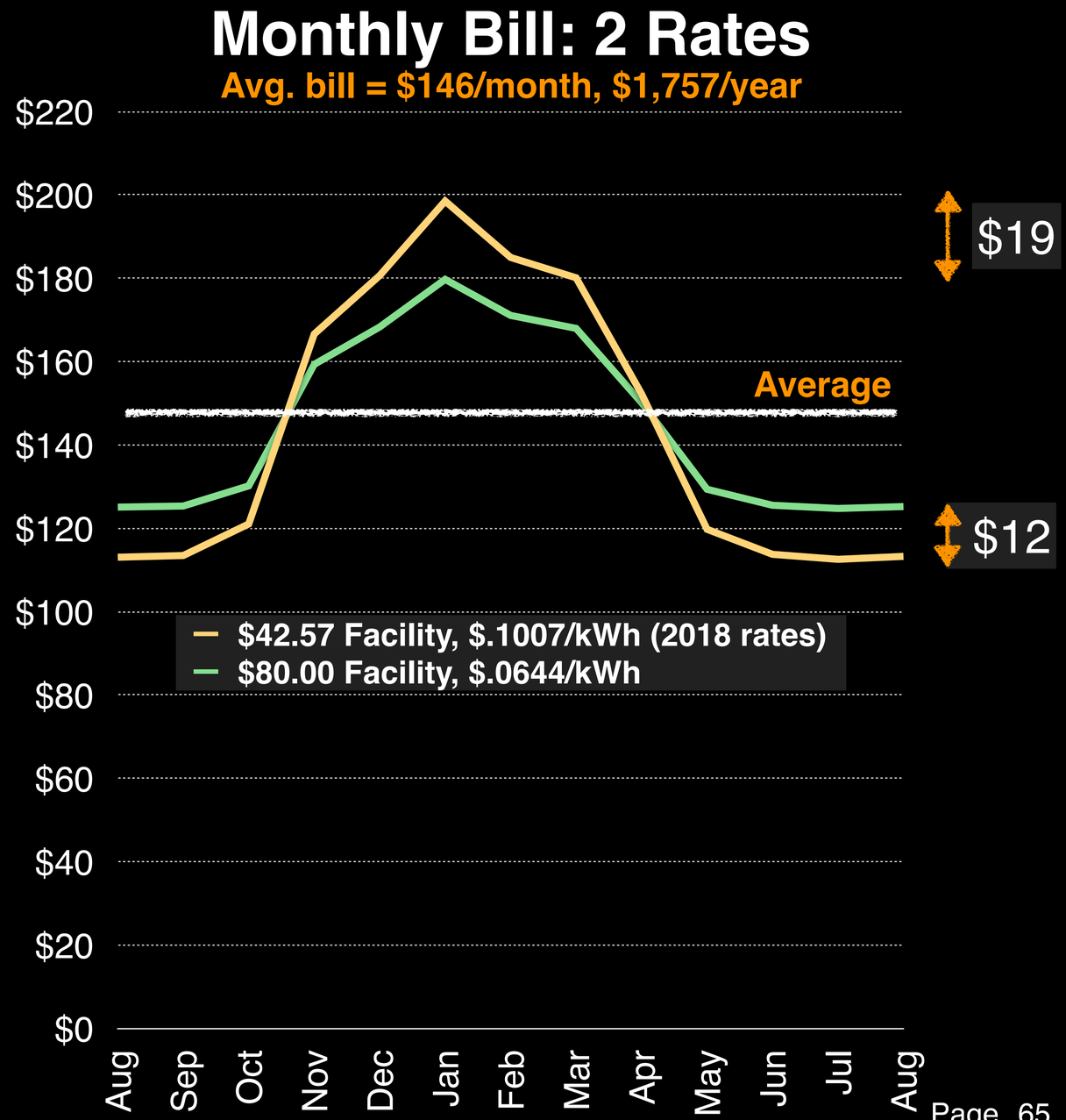
OPALCO Facility Charge Analysis



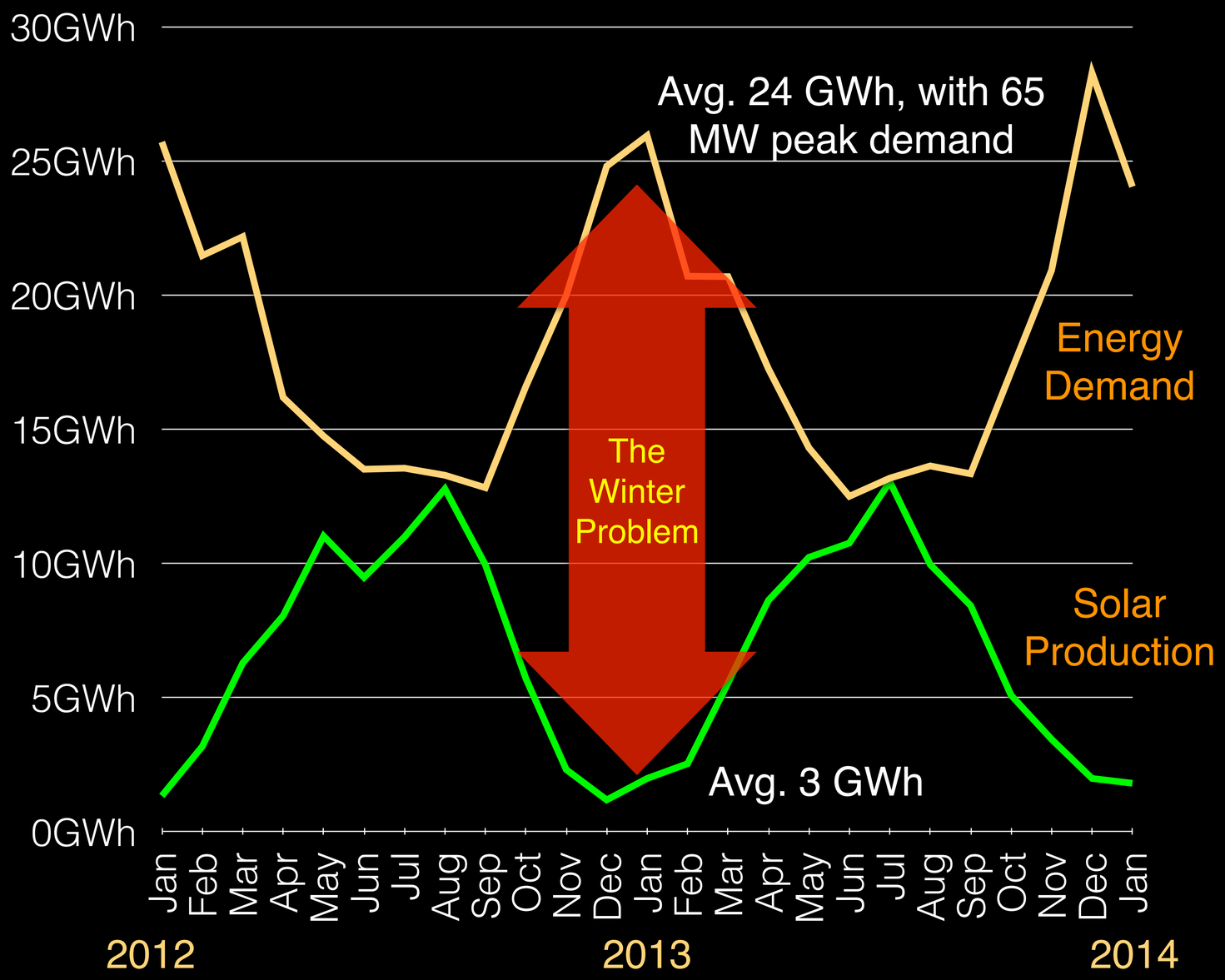


Typical Monthly Residential Energy Use: All Electric Home, Three Rates





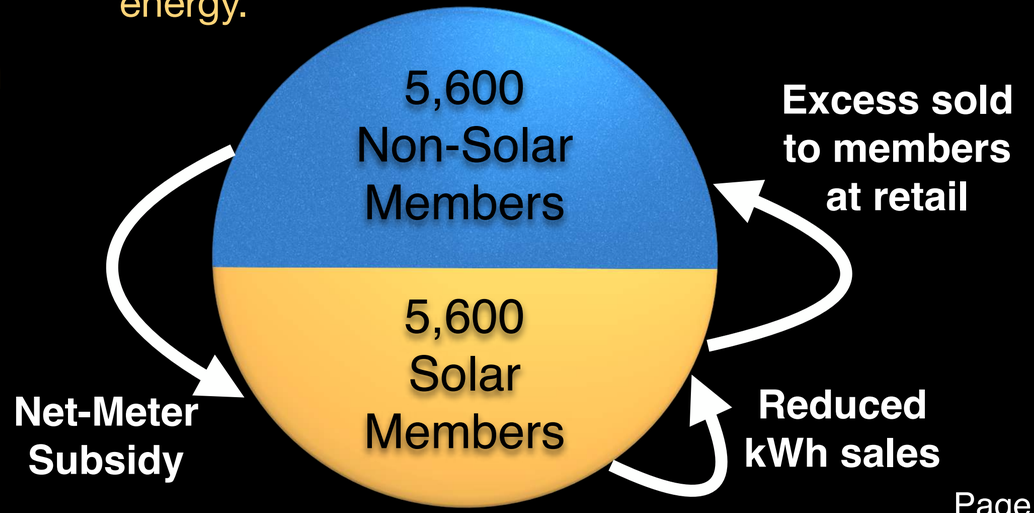
Side-effects of local energy production: Economics and Subsidies



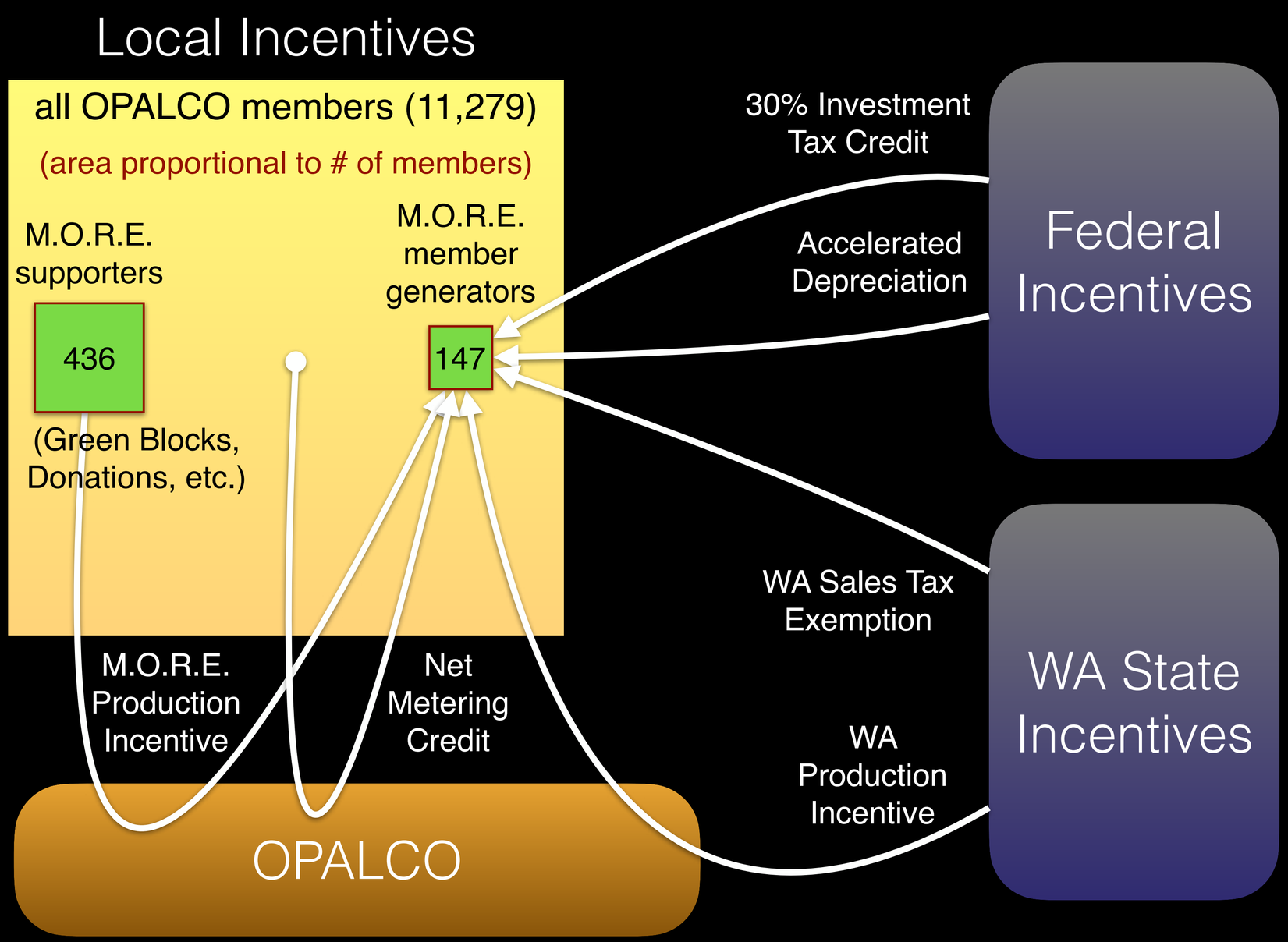
Source: OPALCO, PVWatts

Example Notes & Assumptions

- Solar production from 5,600 rooftop arrays of 13.4 kW each = 75 MW, producing 82.6 million kWh per year, mostly in summer.
- Solar system cost $150 million = $27,000 per rooftop ($2/Watt, not including financing and grid integration)
- Solar would produce 41% of energy consumed. In-home reduces OPALCO kWh sales, excess replaces 4¢/kWh hydro with 12¢/kWh net-meter energy. Since retail kWh sales pay a portion of facility cost, non-solar members subsidize solar members for the shortfall in facility, as well as the increased cost of energy.



M.O.R.E. Member Generator Incentives and Subsidies



Notes:

M.O.R.E. member total kWh generated drives WA production and and M.O.R.E. incentive payments.

OPALCO net metering credit based on net kWh after usage. Net metering rate is retail (versus BPA wholesale), hence all members pay subsidy to member generators.

Typically solar member generators shift excess summer production to winter consumption, using the grid as a seasonal battery.

OPALCO receives, administers and distributes WA and M.O.R.E. incentives.

WA incentive payments are subject to $100,000 WA annual cap.