Electric Distribution – Barriers and Opportunities to Decarbonization Pathway

MassCEC's Net Zero Grid Planning Lab Workshop #2

March 4, 2022

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Workshop Plans

Three collaborative workshops (Task 1)

February 3rd:	Distribution Planning
Today: **10am – 12pm ET**	**Identifying Barriers and Opportunities to Achieve**
April 13th: 2pm – 4pm ET	Distribution System Costs to Achieve

… to enable Massachusetts 2050 Decarbonization Roadmap

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Today's Agenda
10:00am – 12:00 pm

- Welcome
- Key Considerations of Pathway Elements
- Breakout Groups to consider site specific examples
- Plenary Review

Your active participation is appreciated!

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Pathway Considerations Focused on Today

- All Options Pathway
- Key Elements
  - ***Solar, Electric Vehicles, Electric Heating***
- Electrical Characteristics
  - ***Net Load Impacts*** ***(Coincidence / Load Curves)***
- Impacts and Barriers
  - ***Capacity Constraints***
    - *Substation*
    - *Feeder*
- Opportunities to mitigate barriers
  - *Infrastructure Expansion*
  - *Grid Modernization/Flexibility*
  - *Energy Efficiency and Flexible Loads*

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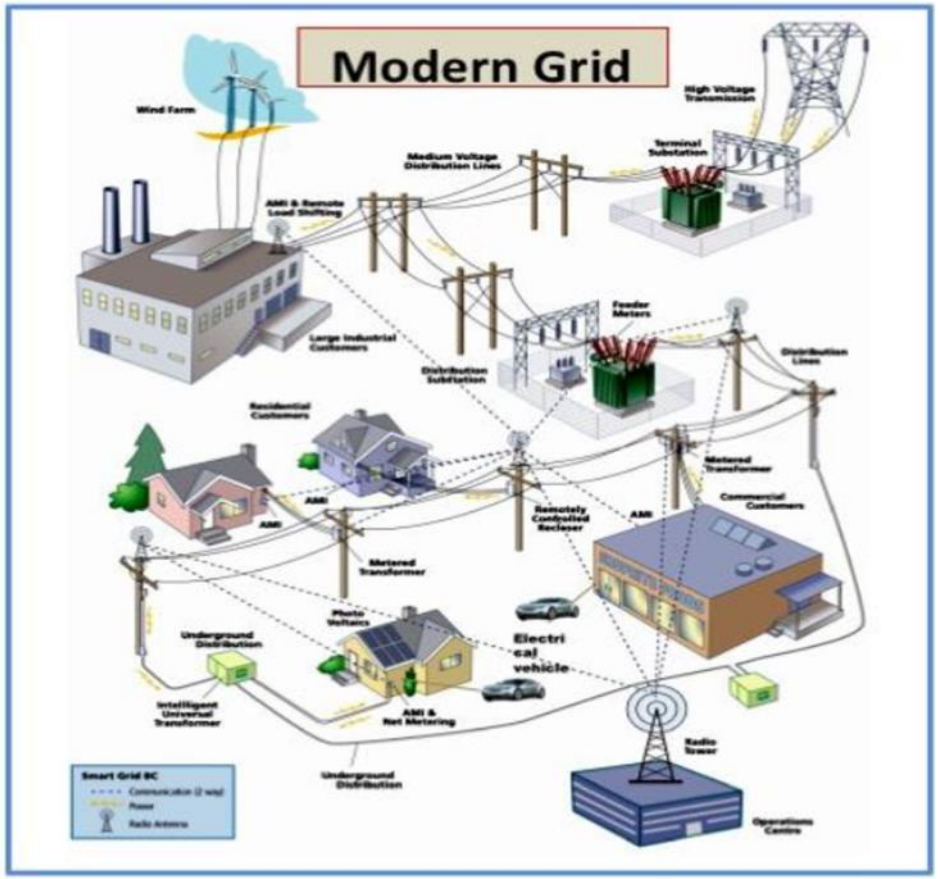
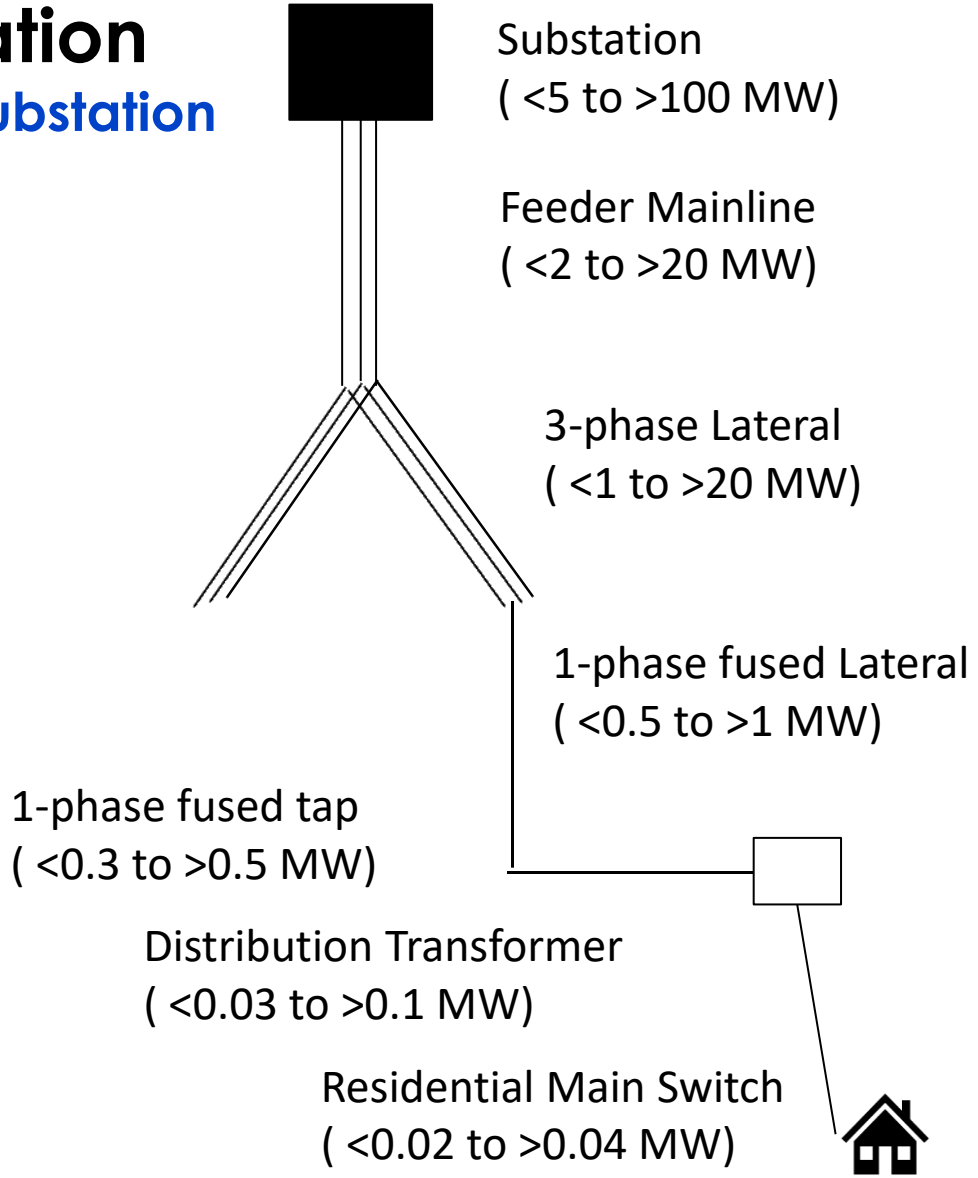
Distribution Capacity varies by location

Tends to decrease as you move away from the substation





Capacity is driven by equipment size, protection settings and operating voltage
Distribution primary voltage ranges from 4kV to 35kV

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What to expect in the breakout sessions…

- A realistic, but illustrative, example of planning assessment considering potential 2050 impacts of key elements of the All Options Pathway
  - Detailed forecasts and engineering analysis have NOT been completed
- Focus on Distribution Capacity related issues
  - Other factors such as Reliability, Asset Condition and Grid Modernization may influence more detailed engineering assessments
- Assessments in these examples focus on issues at the substation and/or feeder head level
  - Some constraints may not be identified until an interconnection study is performed

Plenary review to follow the breakout sessions

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Break-out Sessions

1. Four breakout groups each exploring a specific future impact example
2. Area Descriptions
    1. Eversource -
    2. Eversource - Commercial/Industrial Area – Southeastern MA
    3. National Grid – Residential Area – North Central MA
    4. National Grid – Commercial/Industrial Area – Merrimack Valley
3. Apply illustrative realistic future interconnection expectations
4. Review potential distribution system impacts, needs and solution sets

Enabling Massachusetts 2050 Decarbonization Roadmap

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Breakout Sessions (1 hour)

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Eversource

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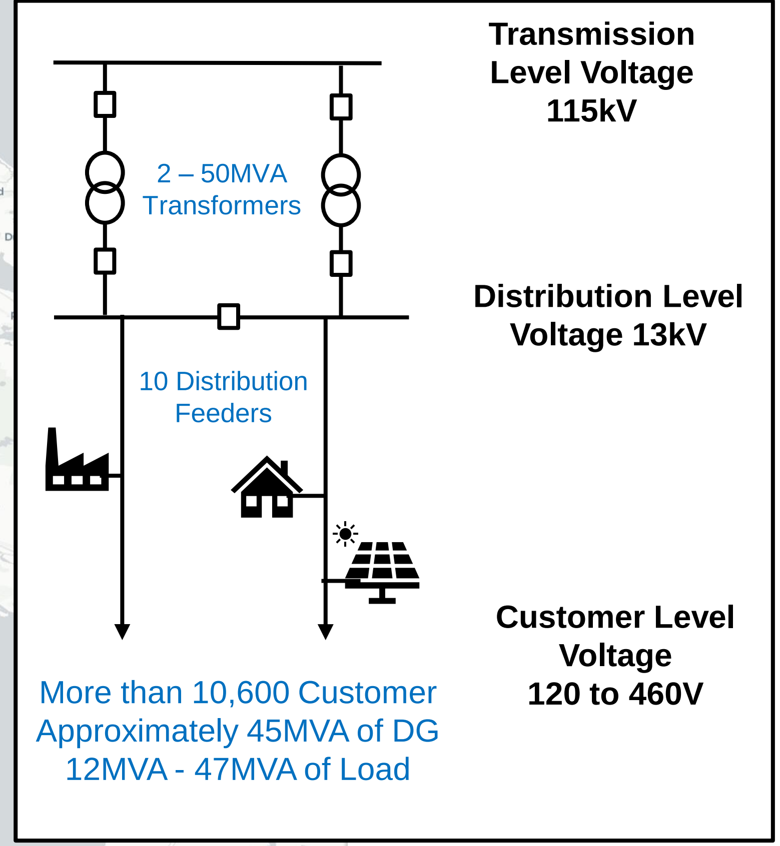
"Identifying Barriers and Opportunities": Planning Lab Workshop #2

INDUSTRIAL PARK

Agenda

- Background
- Definitions
- Solar Profile
- Electric Vehicle (EV) Profile
- Electric Heating Profile
- Combined Profiles
- Consideration for Mitigation
- Multi-Year Planning
- Non-Wires

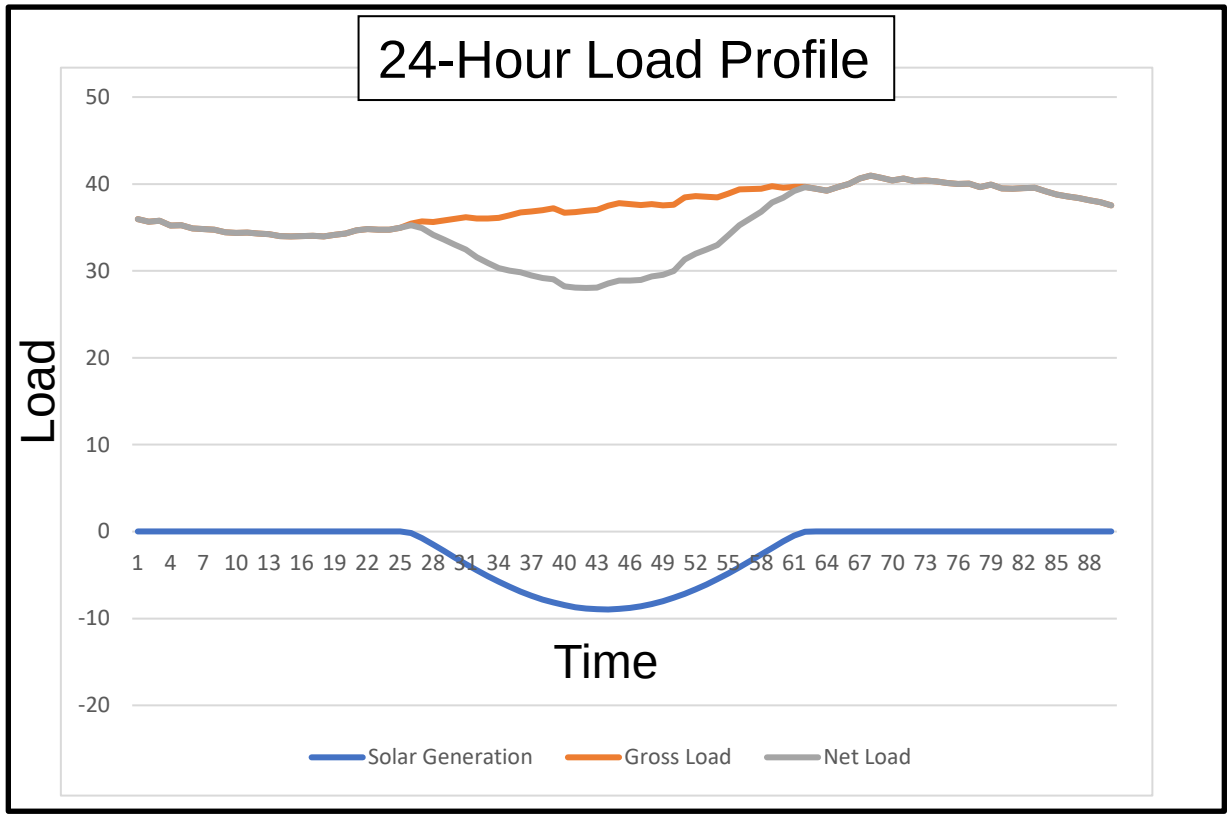
Background - Industrial Park

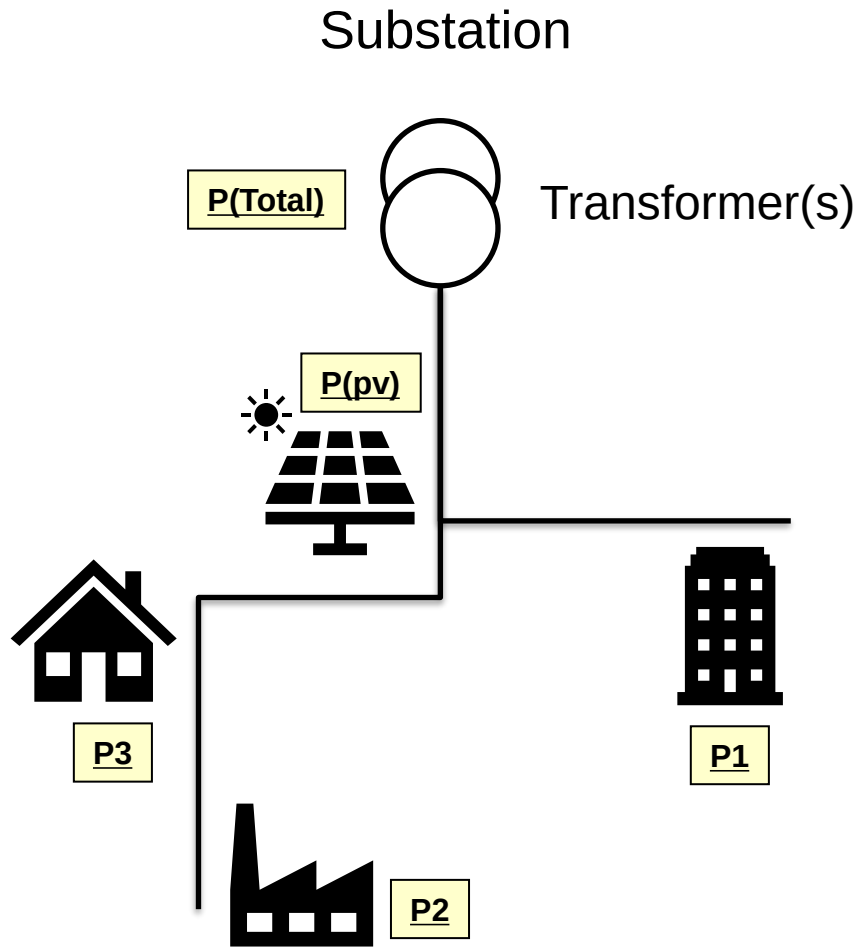


Small Residential Street ~ 50kVA
Commercial Buildings ~ 500kVA to 2MVA
Downton Boston Buildings ~ 1MVA to 5MVA

Definitions (Gross and Net Load)

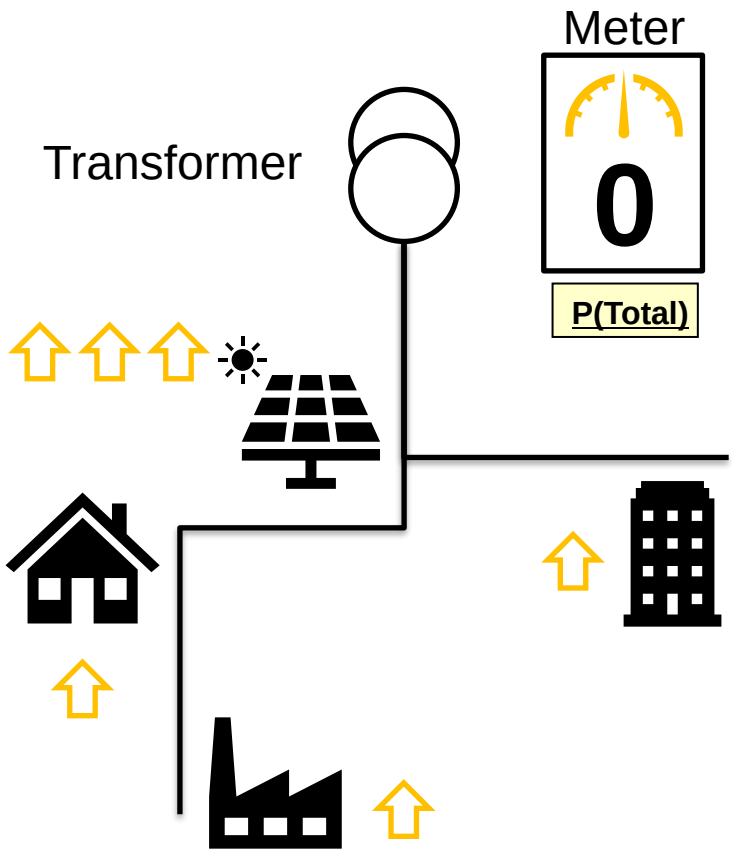
- Gross Load = P1+P2+P3
- Net Load = P1+P2+P3-P(pv)
- Gross Load = Net Load + P(pv)



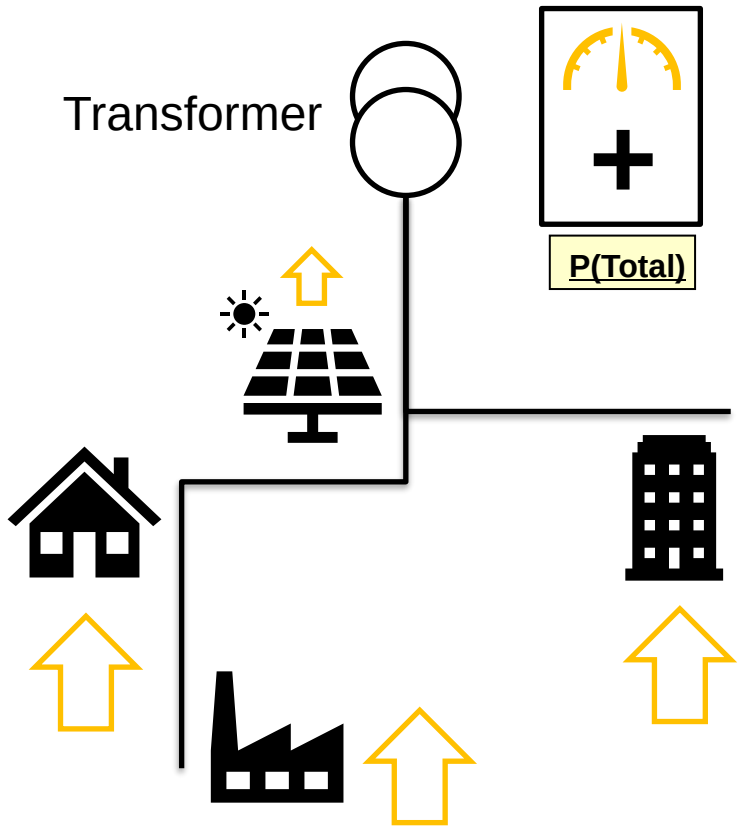


Definitions (Gross and Net Load)

Distributed Load = Generation

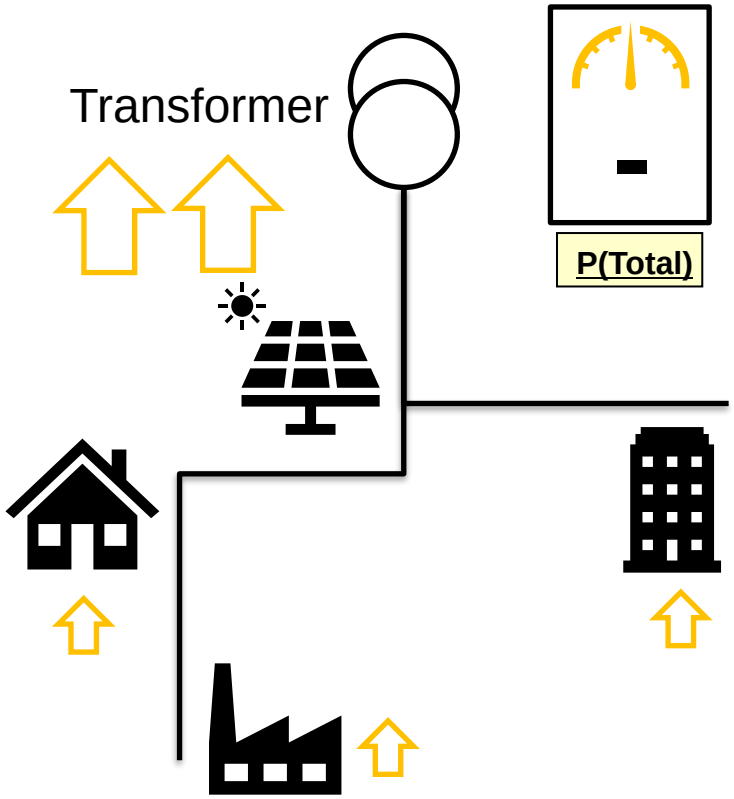


Distributed Load > Generation



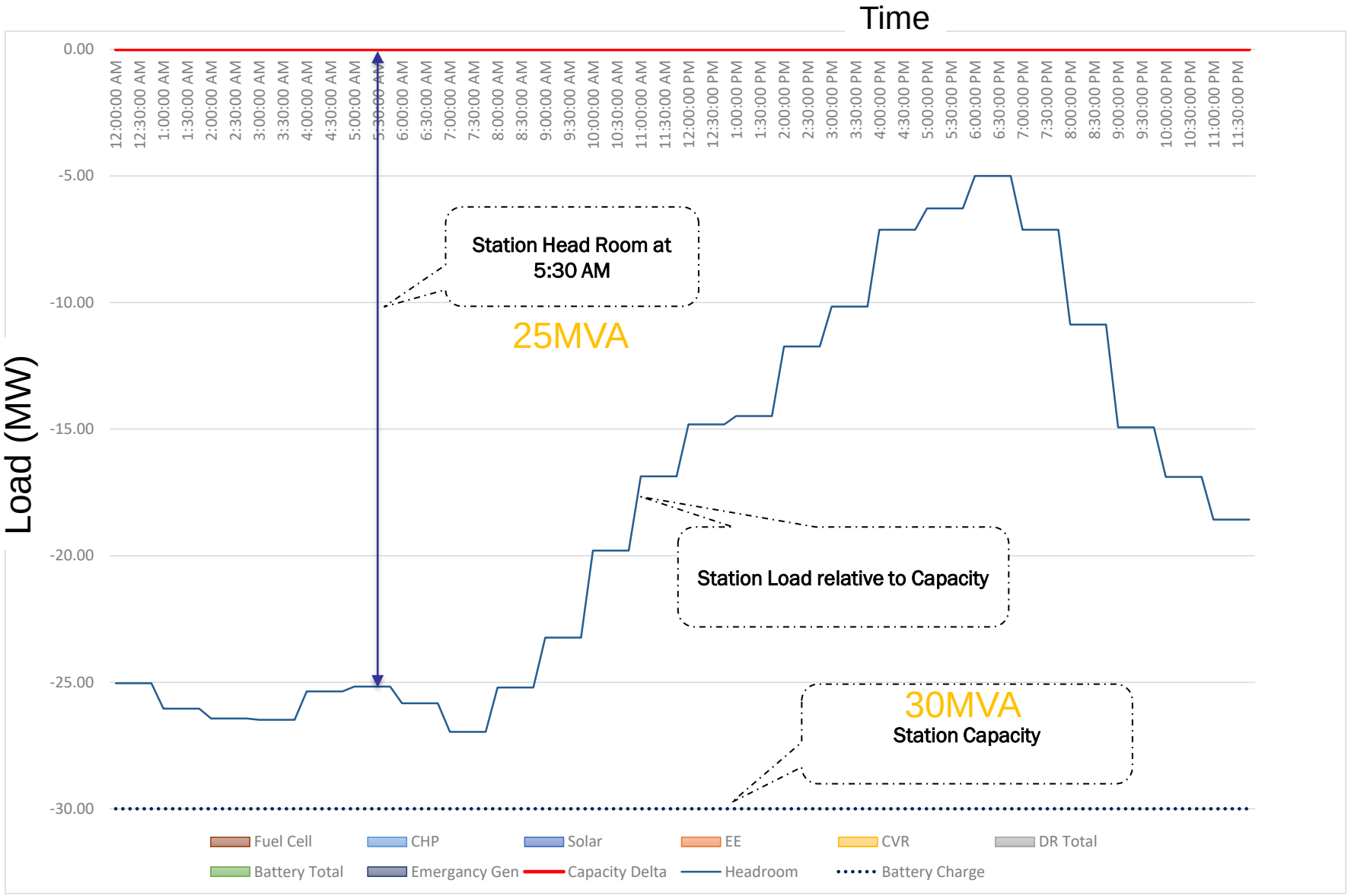
Headroom
Transformer capacity compared load

Distributed Load < Generation

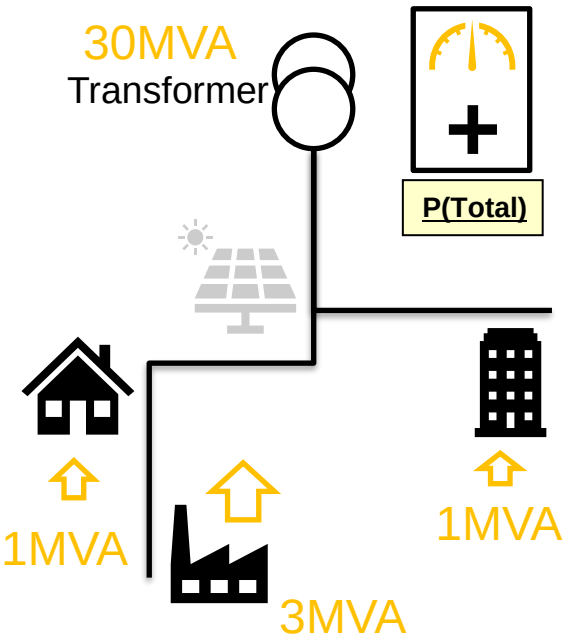


Hosting Capacity
Transformer capacity compared PV

Base Station Load Profile (Gross)



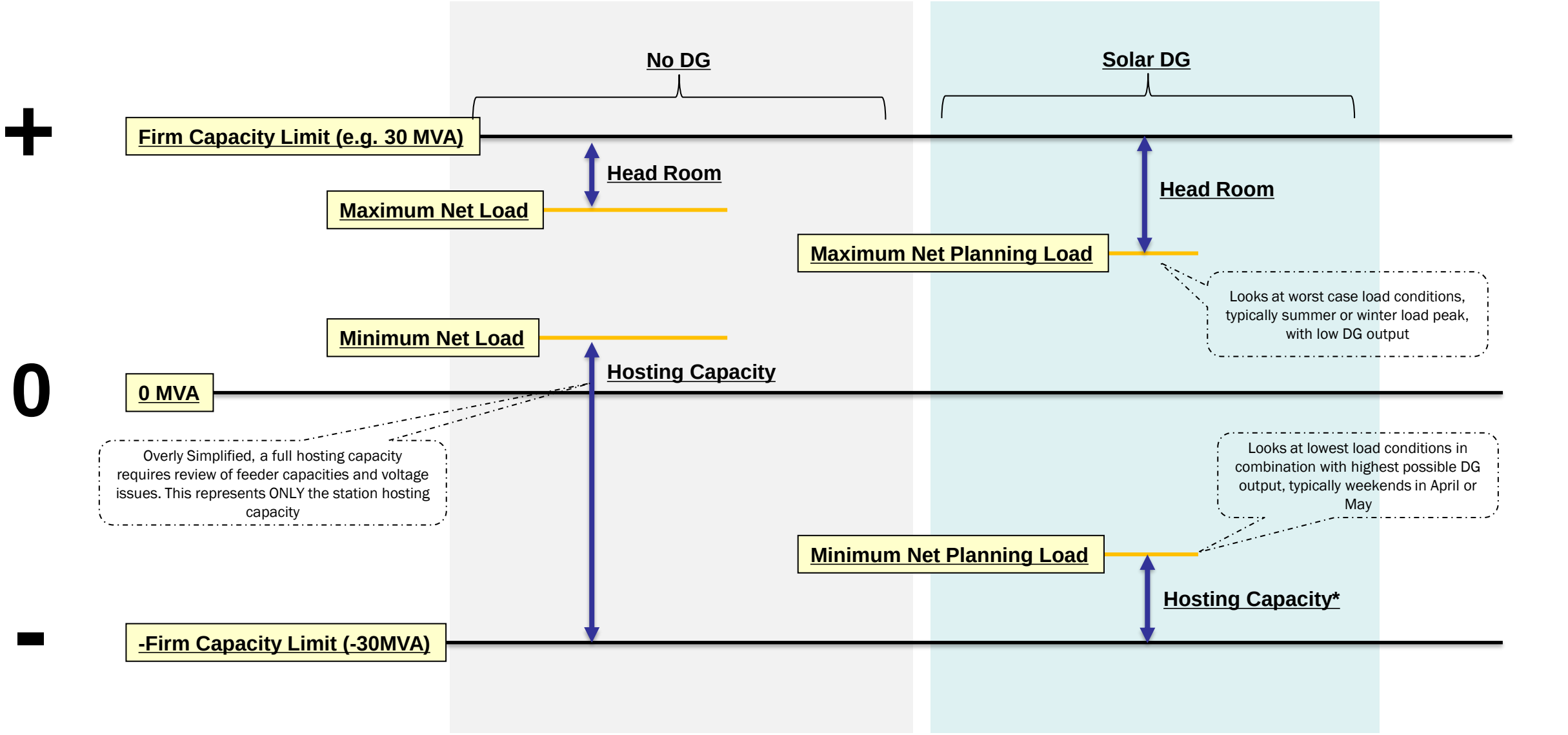
Distributed Load > Generation



Headroom
Transformer capacity compared load

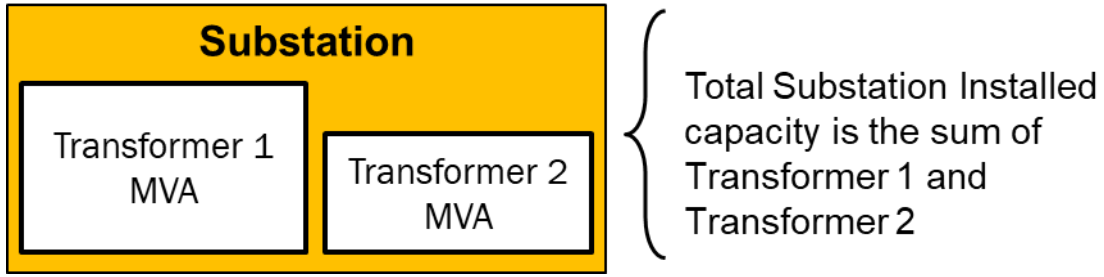
5:30 AM

Definitions (Headroom and Hosting Capacity)

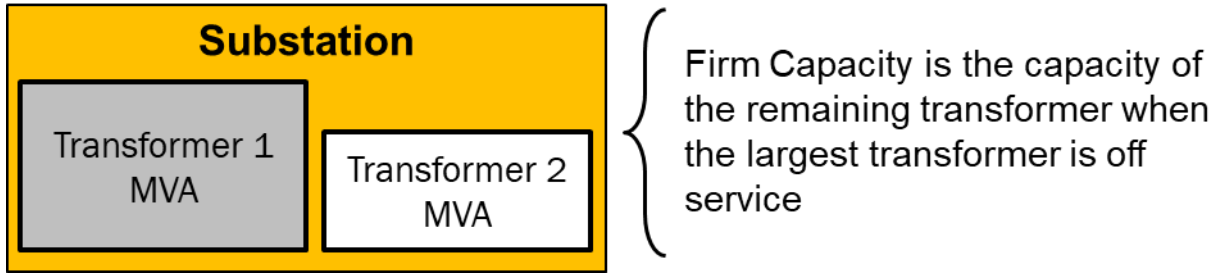


Definitions Capacity

- Installed Capacity
  - Sum of all installed transformers



- Firm (Operational) Capacity
  - Consideration of an N-1 event (loss of largest asset)
  - E.g. Station with two 62.5 MVA transformers as a firm capacity of 62.5 MVA

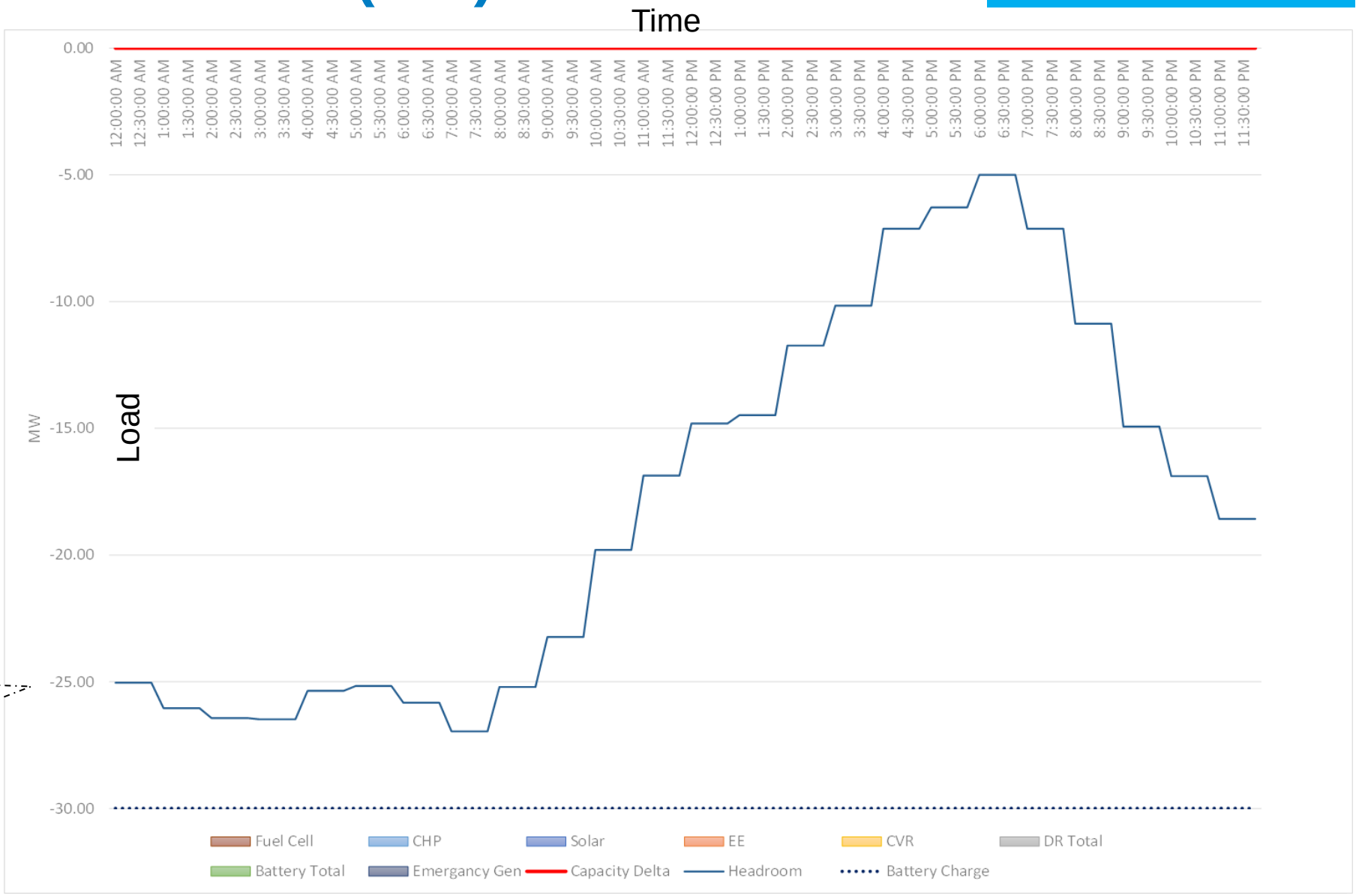


Base Station Load Profile (Net)

2. Based Load Profile Net

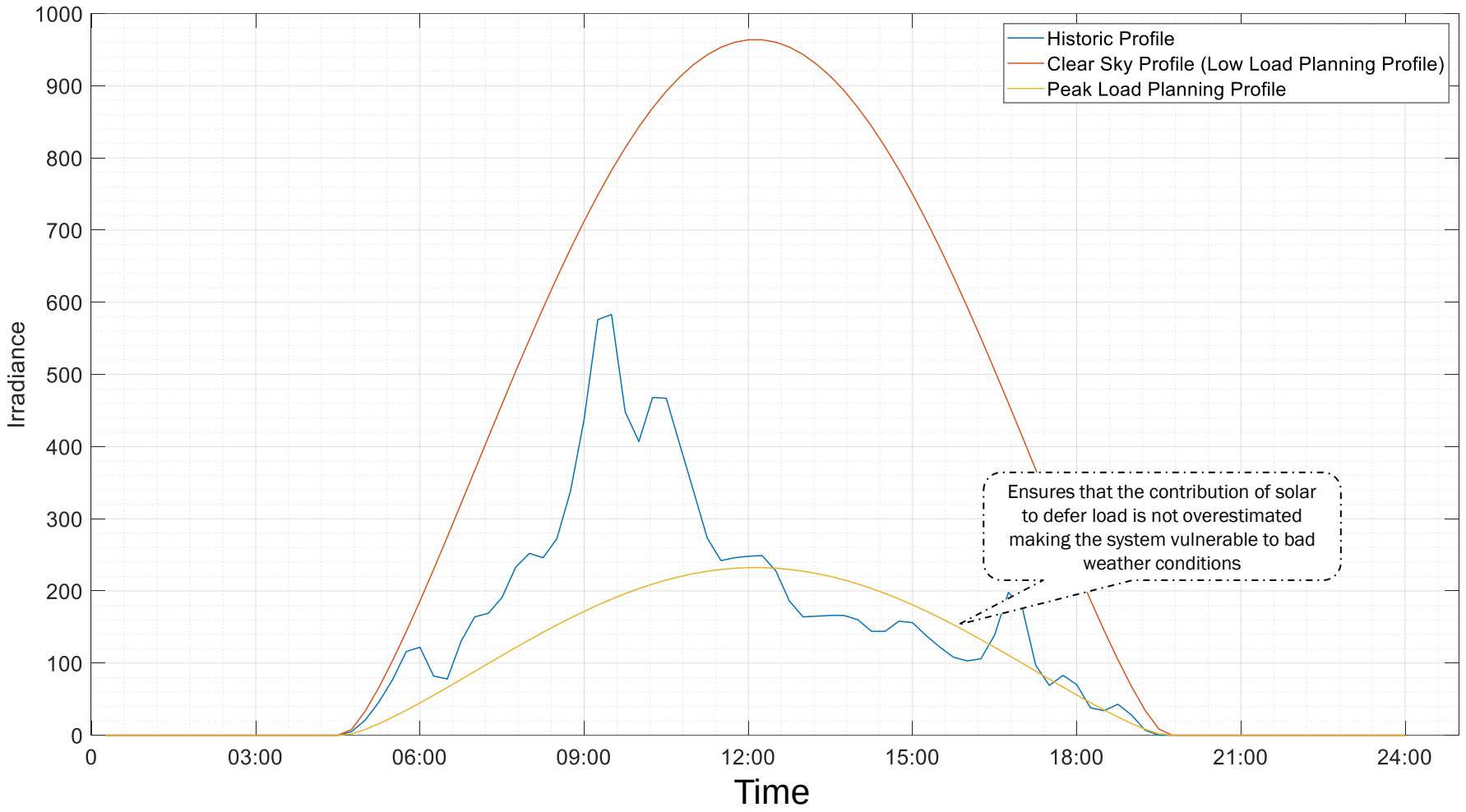
1. Gross Profile
2. 45 MW Solar
   - At Nominal Output

1. Based Load Profile Gross



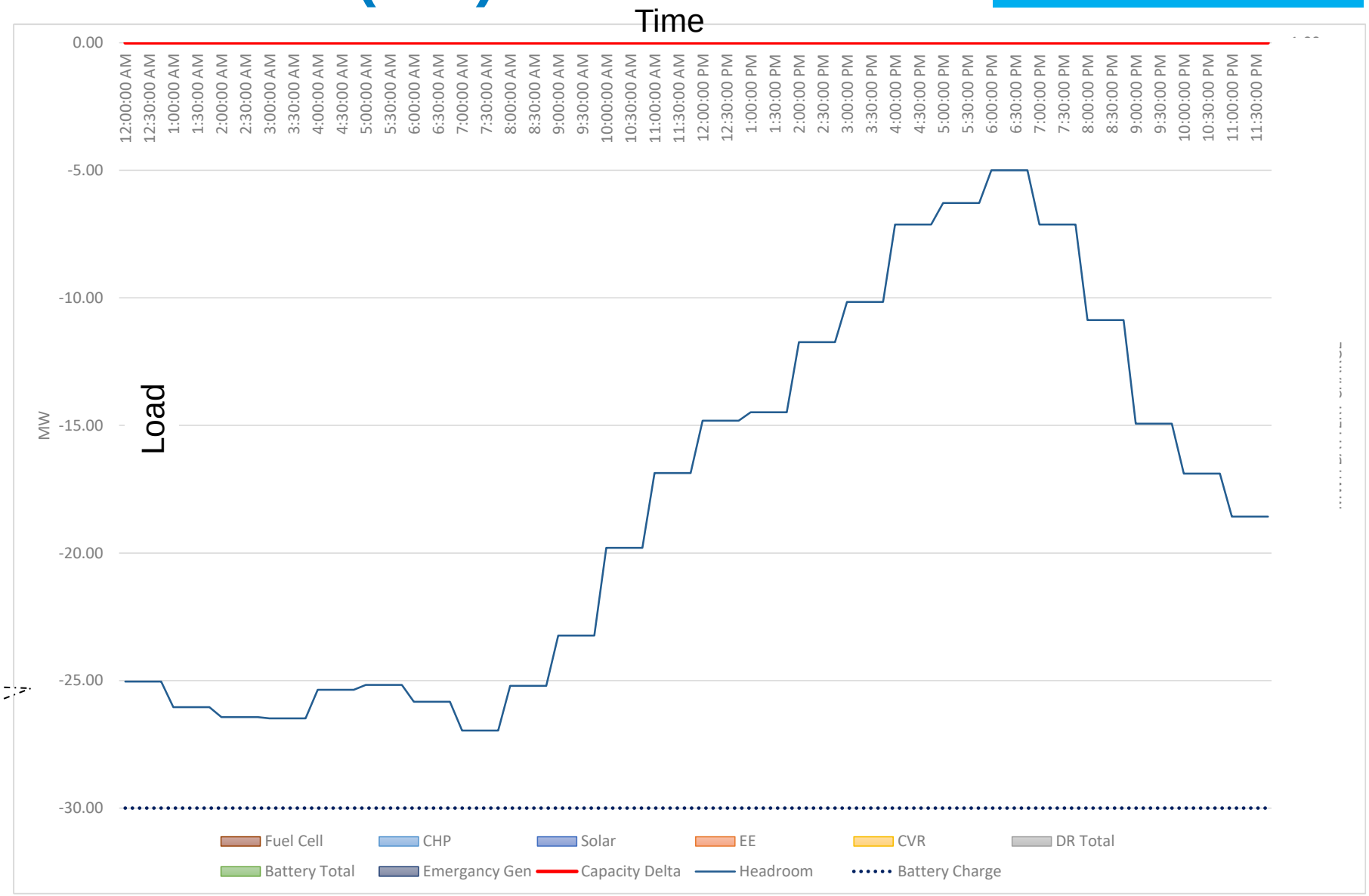
Definitions (Solar Profiles)

- Clear Sky Profiles
  - Used for planning low load conditions
- Historic Solar Profiles
  - Used for calculating gross load data
- Peal Load Planning Profile
  - Used for planning peak load conditions (considers a 90/10 weather probability)



Base Station Load Profile (Net)

1. Gross Profile
2. 45 MW Solar
3. **At Peak Planning** Profiles Output



1. Based Load Profile Gross

Base Station Load Profile (Net)

2. Based Load Profile Net

1. Gross Profile
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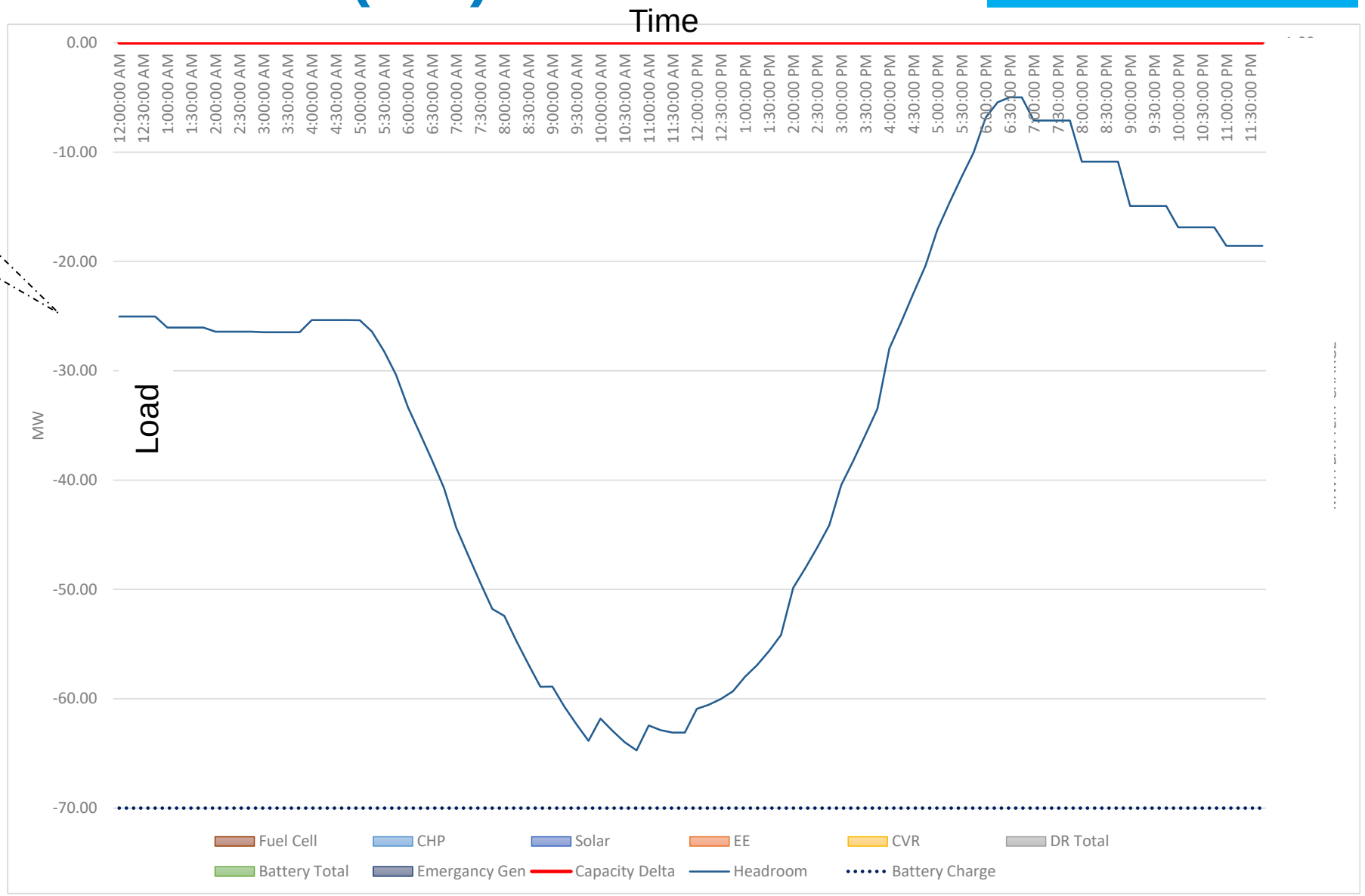
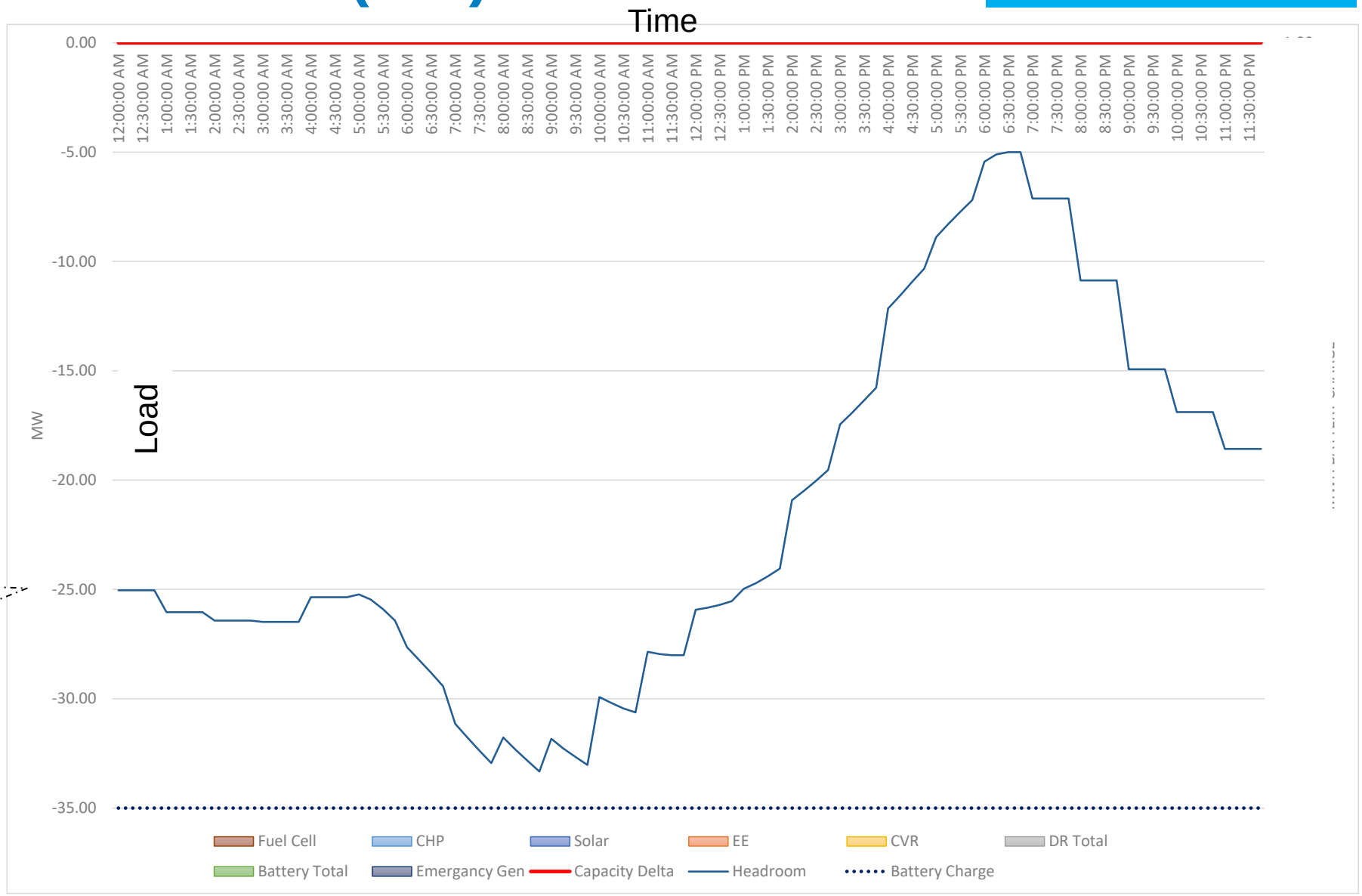


Base Station Load Profile (Net)

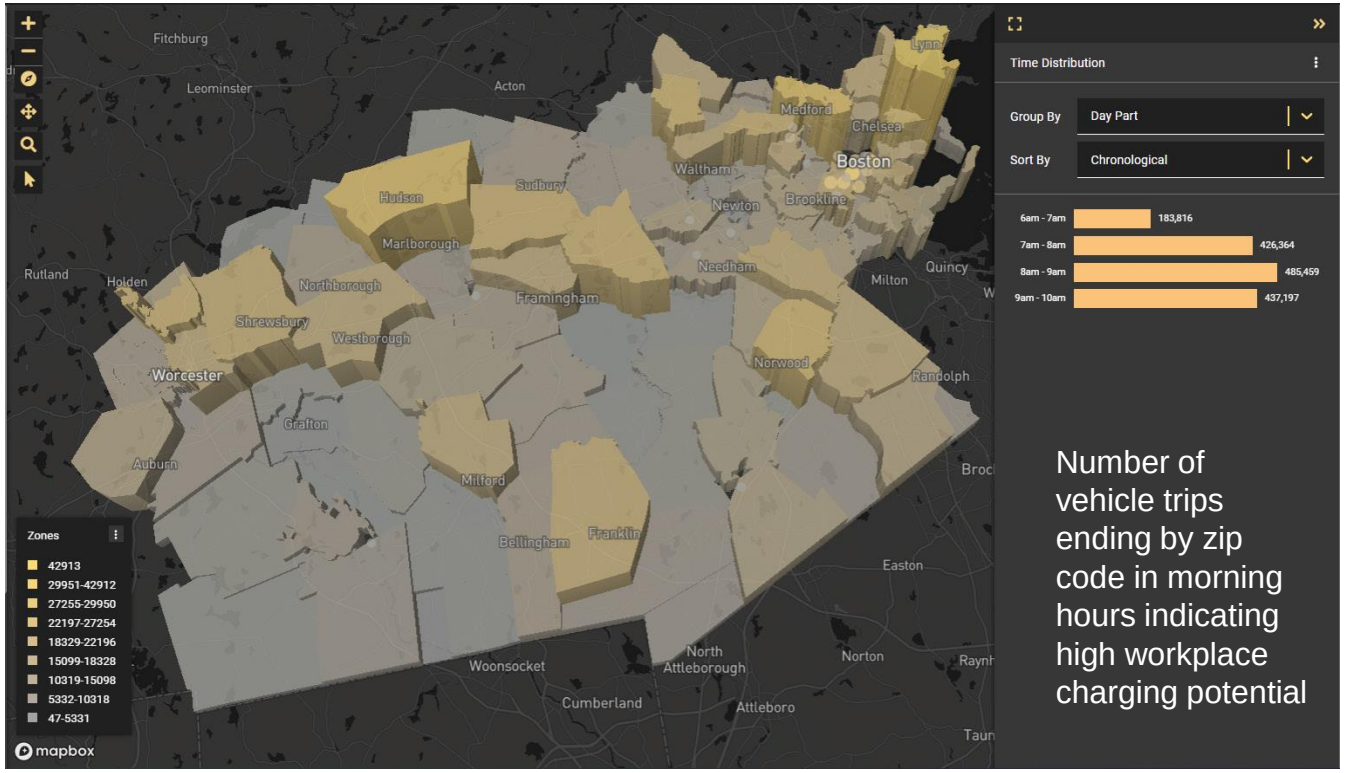
1. Gross Profile
2. 45 MW Solar
3. **<u>At Peak Planning</u>** Profiles Output

3. Based Load Profile <u>Net Planning</u>

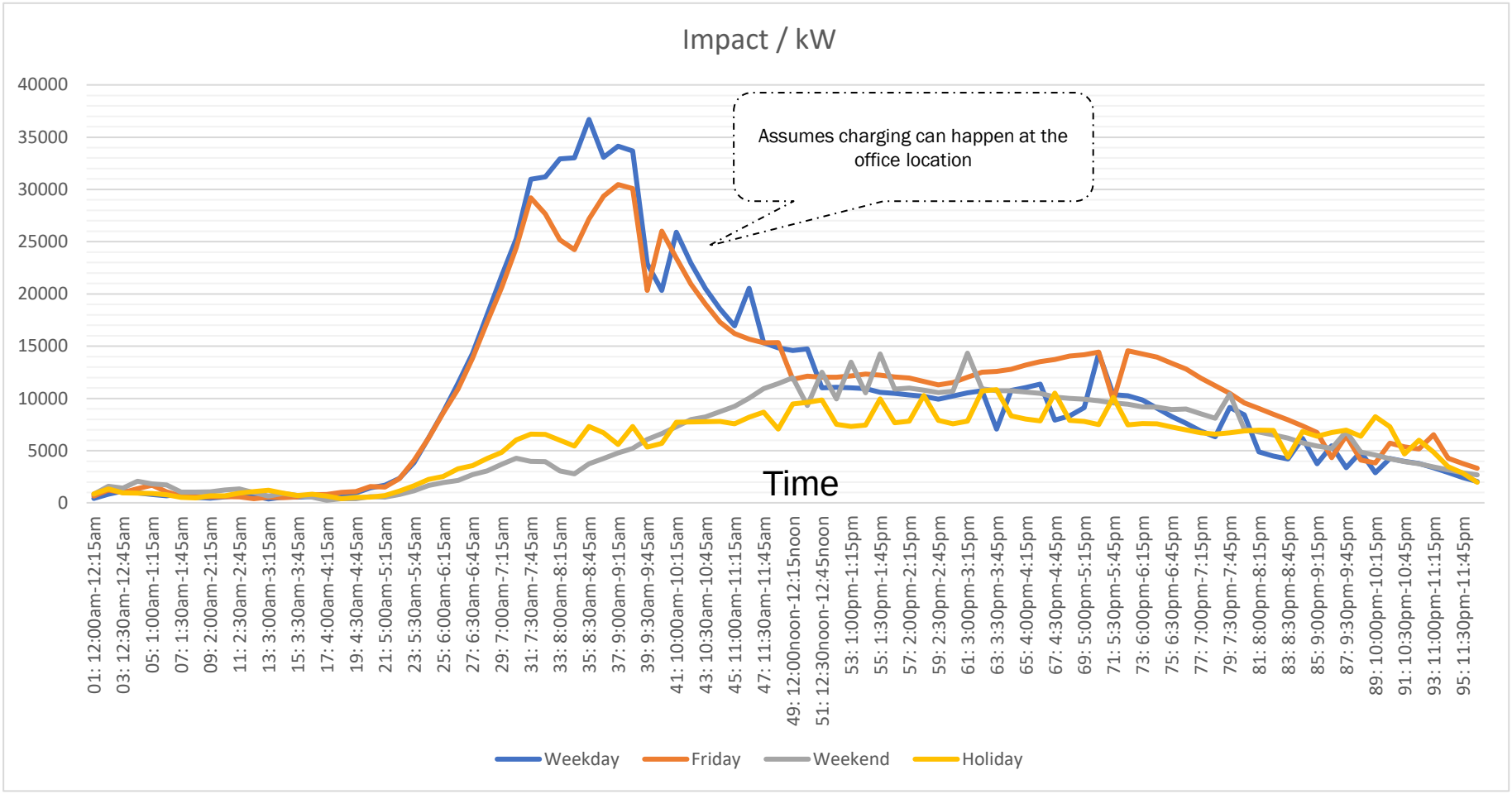


Electric Vehicle Charging

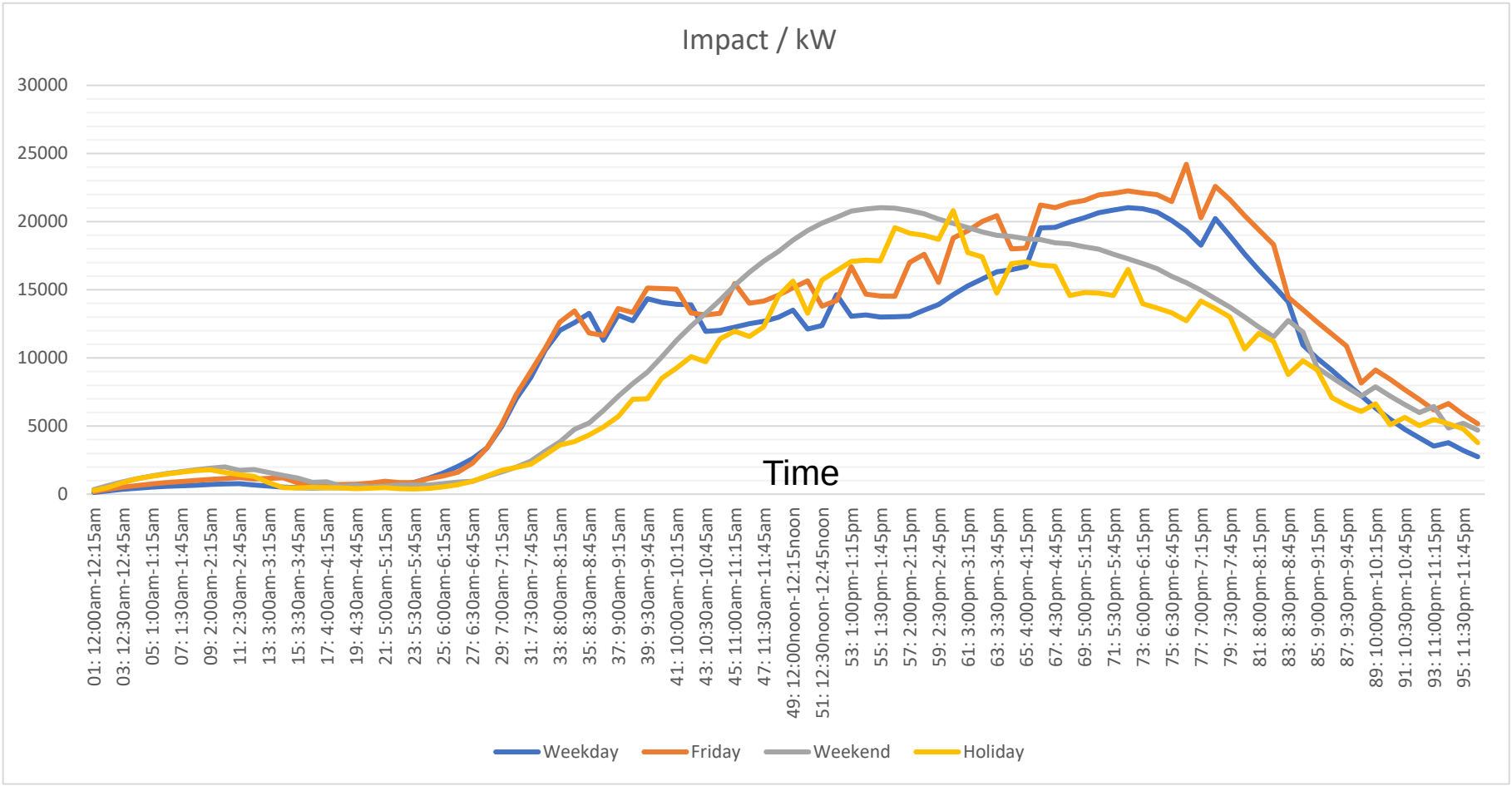
- Electric Vehicle Profiles are mainly driven by
  - Number of vehicles
  - Time of arrival
  - Distance Traveled
- They are not driven as much by
  - Charging Power
  - Size of Battery
  - How often vehicles plug in
- <u>STATION SPECIFIC</u> based on customer make up



Sample EV Profile – Commercial Area
Industrial Park

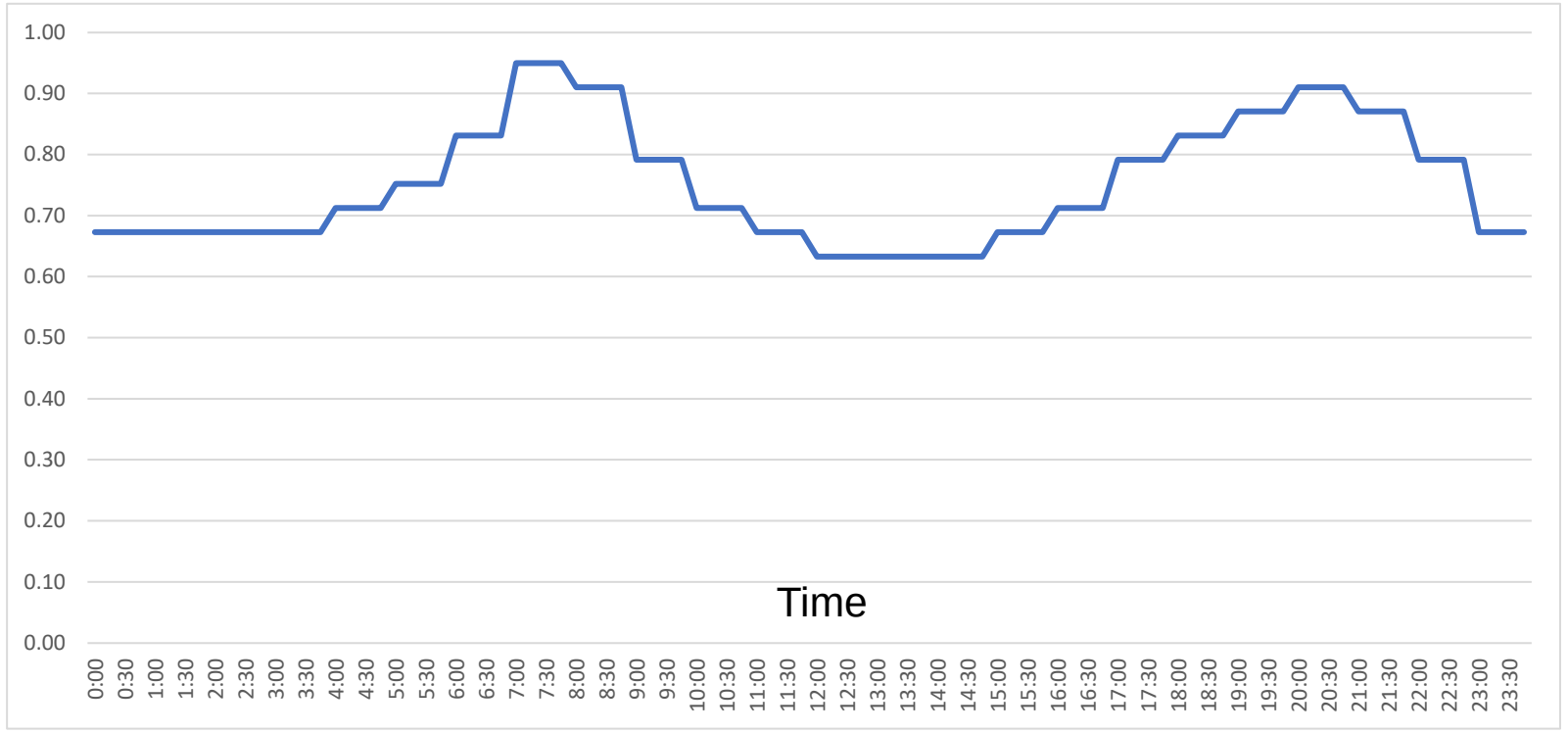


Sample EV Profile – Residential
Industrial Park

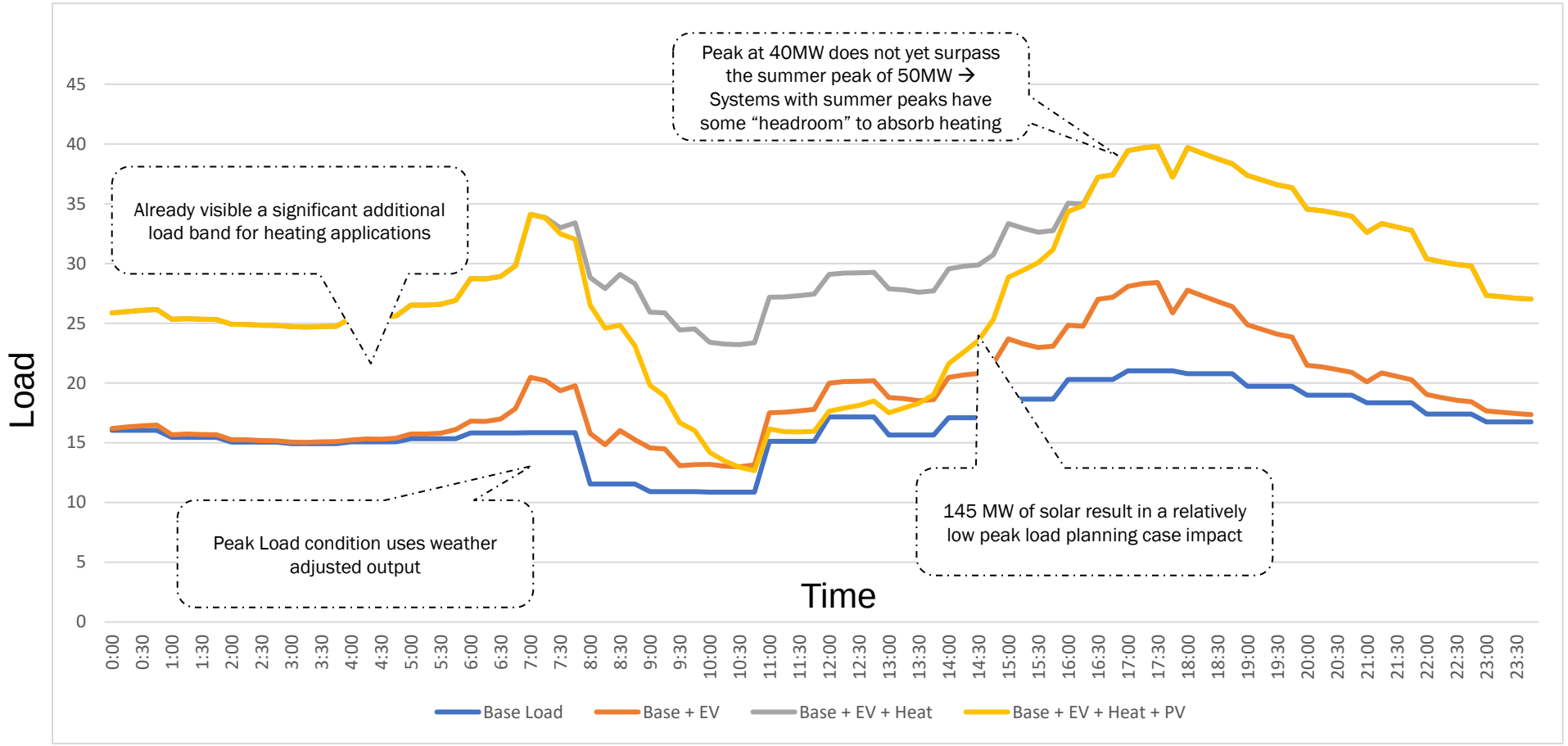


Electric heating Profiles

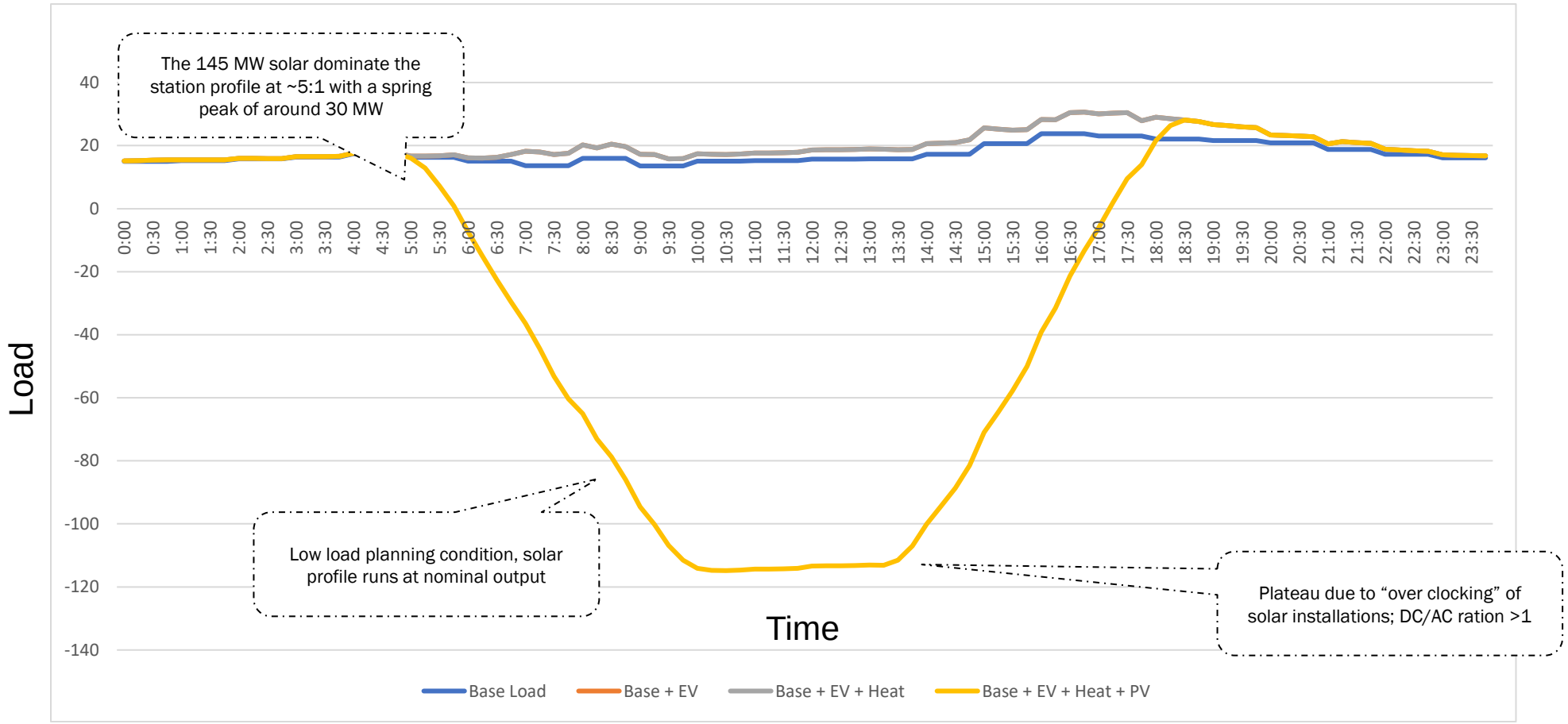
- Electric Heating Profiles are mainly driven by
  - Average MW/sqft peak heating demand
  - Total number of sqft electrically heated
  - External Temperatures
- STATION SPECIFIC



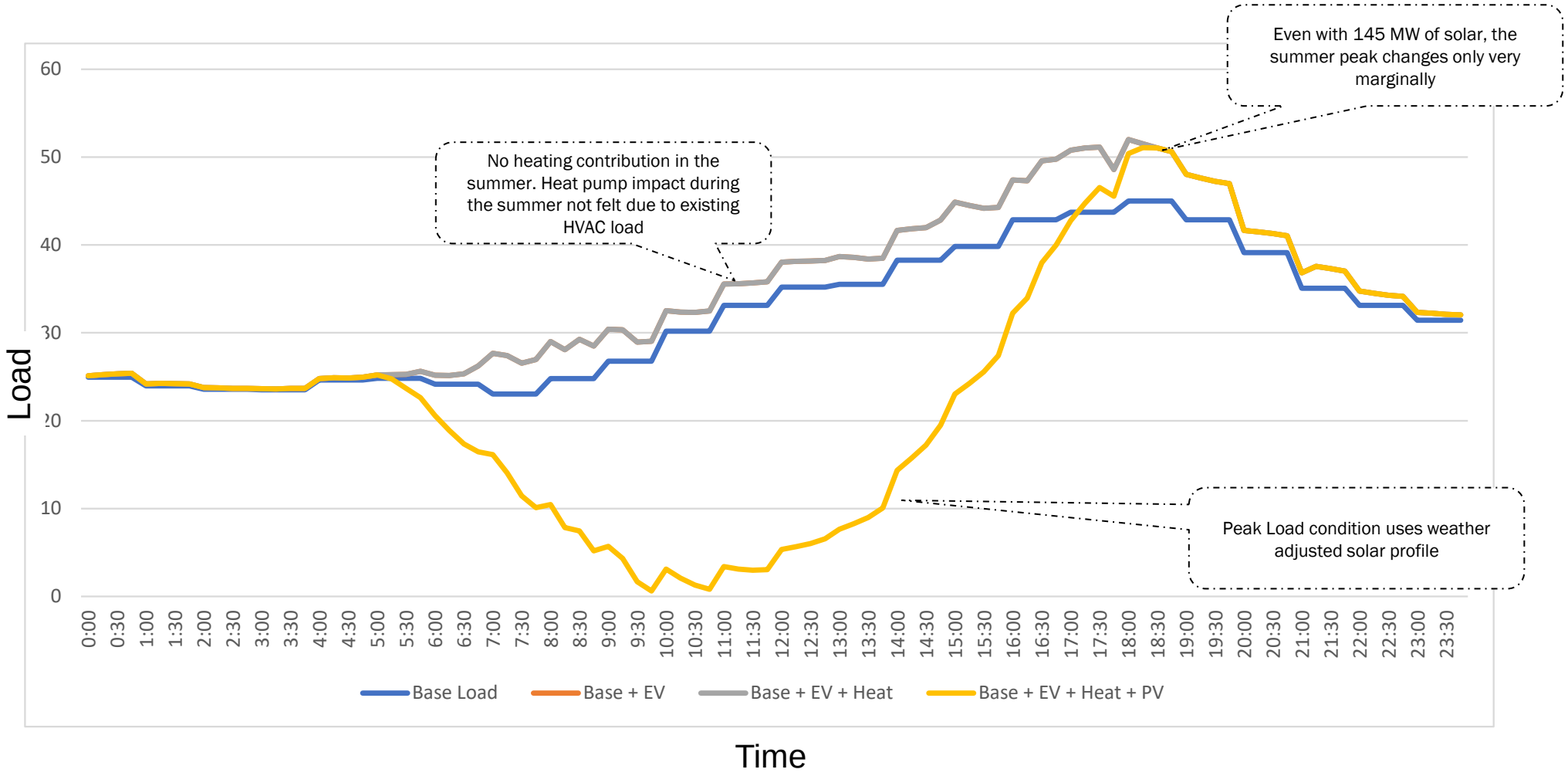
Combined Profile – Winter 2030
Industrial Park



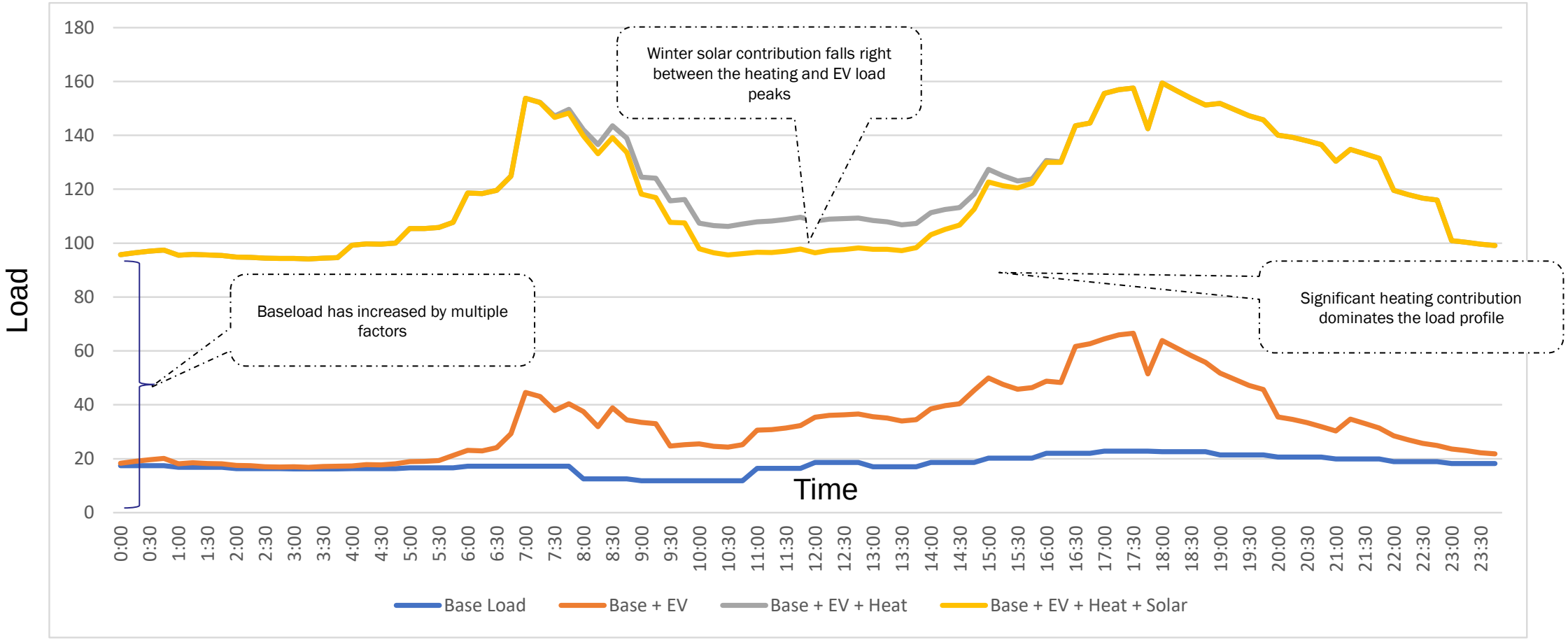
Combined Profile – Spring 2030



Combined Profile – Summer 2030



Combined Profile – Winter 2050



Considerations for Mitigation

- Developing a traditional solution for Station Capacity Issues
  - Evaluation of transfer capacity, feeder reconfiguration
  - Basic station upgrades such as transformer replacement (might be limited by switch gear)
  - Station rebuild for larger transformers typically to modern safety and reliability design standards

- Consideration of non-wires alternatives vs capacity projects
  - Can we defer the need from a technical standpoint? And how long can we defer the upgrade?
  - Can we defer the need from a benefit/cost ratio standpoint?
  - Can we defer the need from a reliability standpoint?

Multi-Year-8760 Modeling An Overview

Existing Model does **not** include upgrades

Existing Models uses Default 24-hr and 12-month profiles

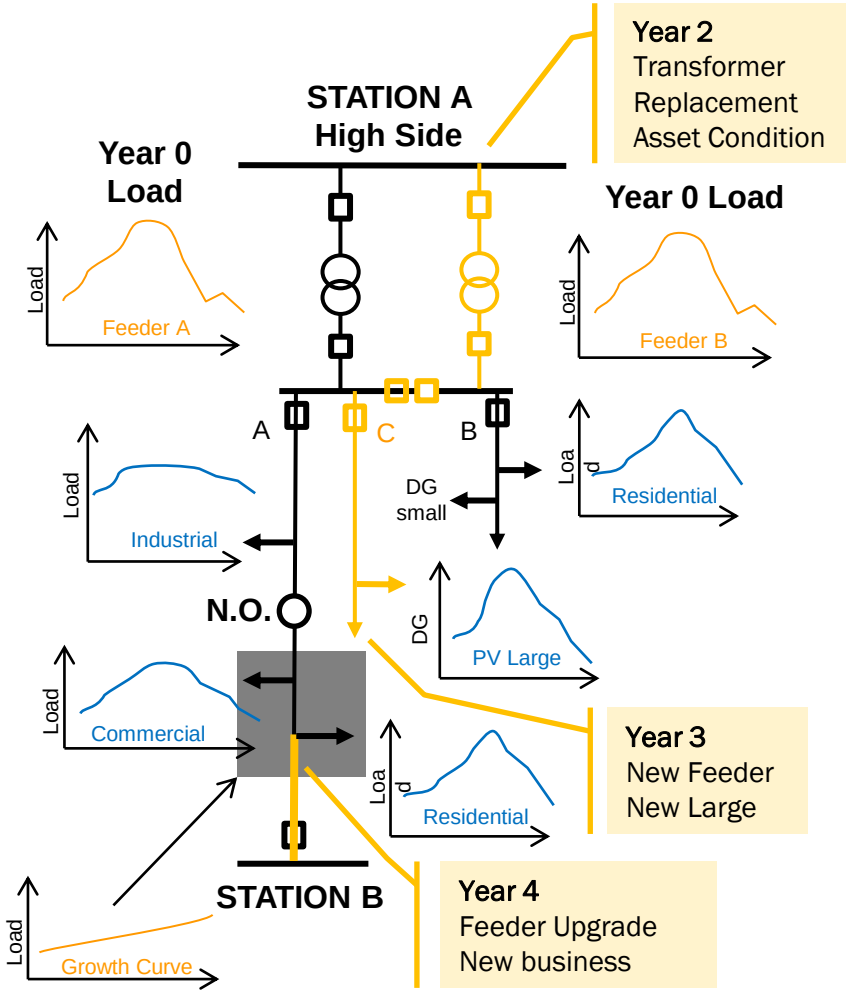
Planning Forecast Requirements

Instead of 24-hr and 12-month default profiles, a planning model now requires 8760 and 24-hr Schedules

Instead of single year 8760 profile a planning model requires 8760 profiles for Years 1 to 10 that accounts for Electrification, EE, EV, etc

Large Load, or Large DER Customers
- Years 1-5 Actual Customers with Work Order to be modeled based on in-service data

To account for new business installation with no work orders Years 3-10 to be modeled as Projection Growth Curves targeting specific areas



Planning Model Requirements

Changes that modify the Substation Rating or Normal Configuration:
- Emergency
- Years 1-5 Capital Plan
- Years 3-10 Proposed Upgrades

New Feeders, changes that modify existing feeder/line ratings, changes to normal feeder configuration:
- Emergency
- Years 1-5 Capital Plan
- Years 3-10 Proposed Upgrades

Significant Feeder Upgrade, Large Load, or Large DER Customers
Years 1-5 Capital Plan
Years 3-10 Proposed Upgrades

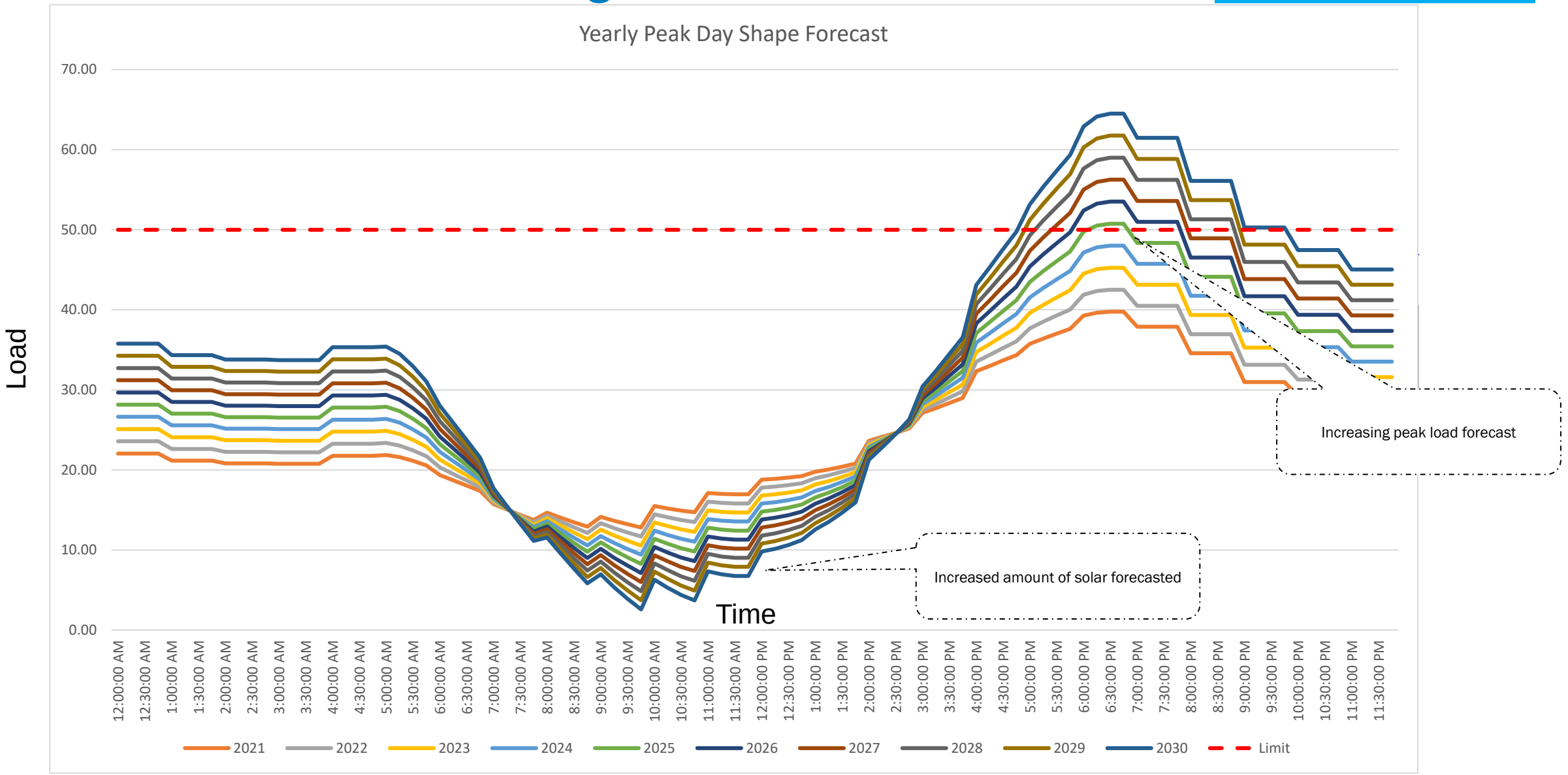
Changes to feeders that affects LCC Capability
Years 1-5 Capital Plan
Years 3-10 Proposed Upgrades

Considering Non – Wires Alternatives

A Non-Wires Alternative modifies the load to fit the asset,

rather than changing the asset to fit the load.

Considerations for Mitigation – Forecast

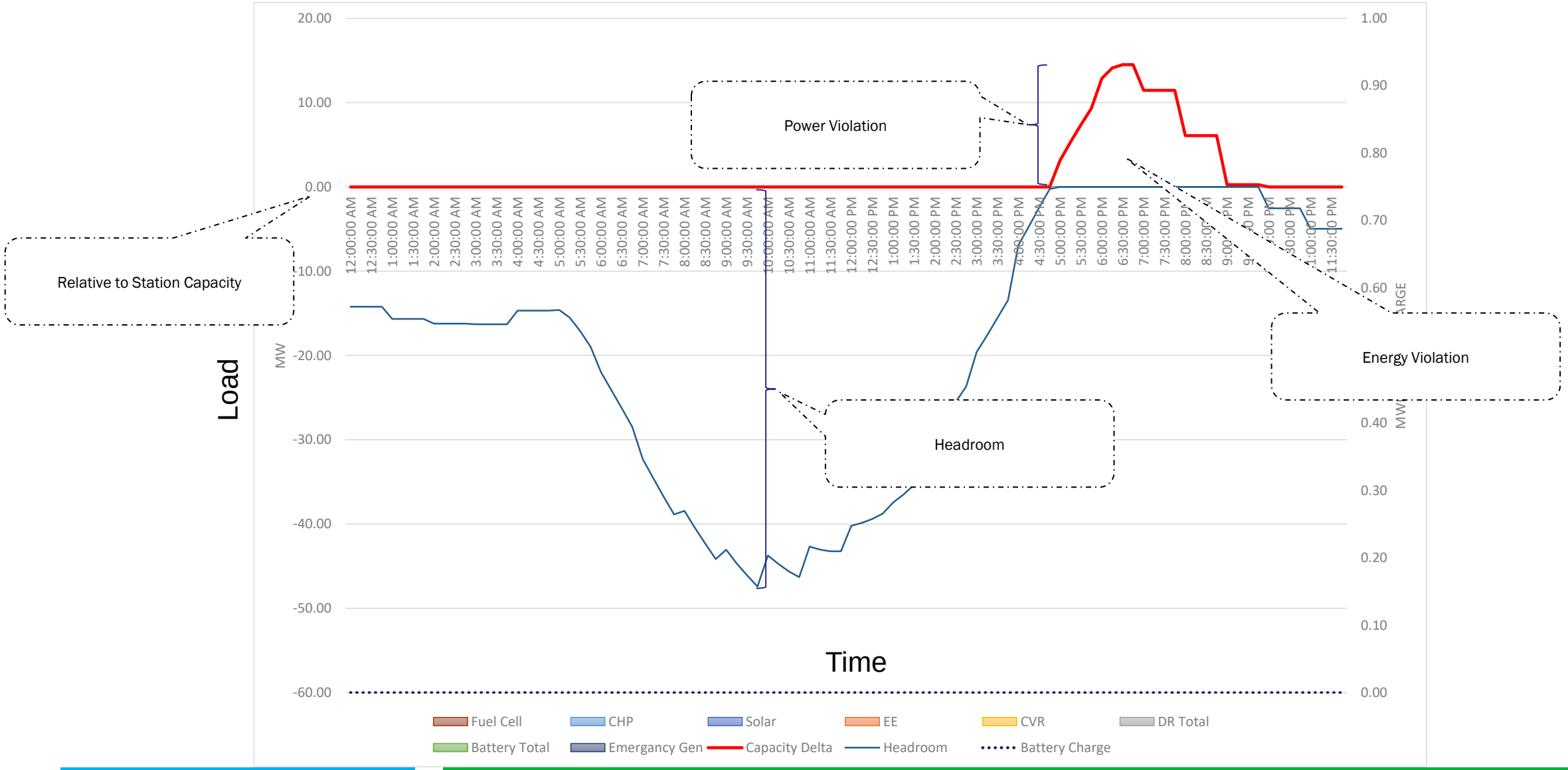


Considerations for Mitigation

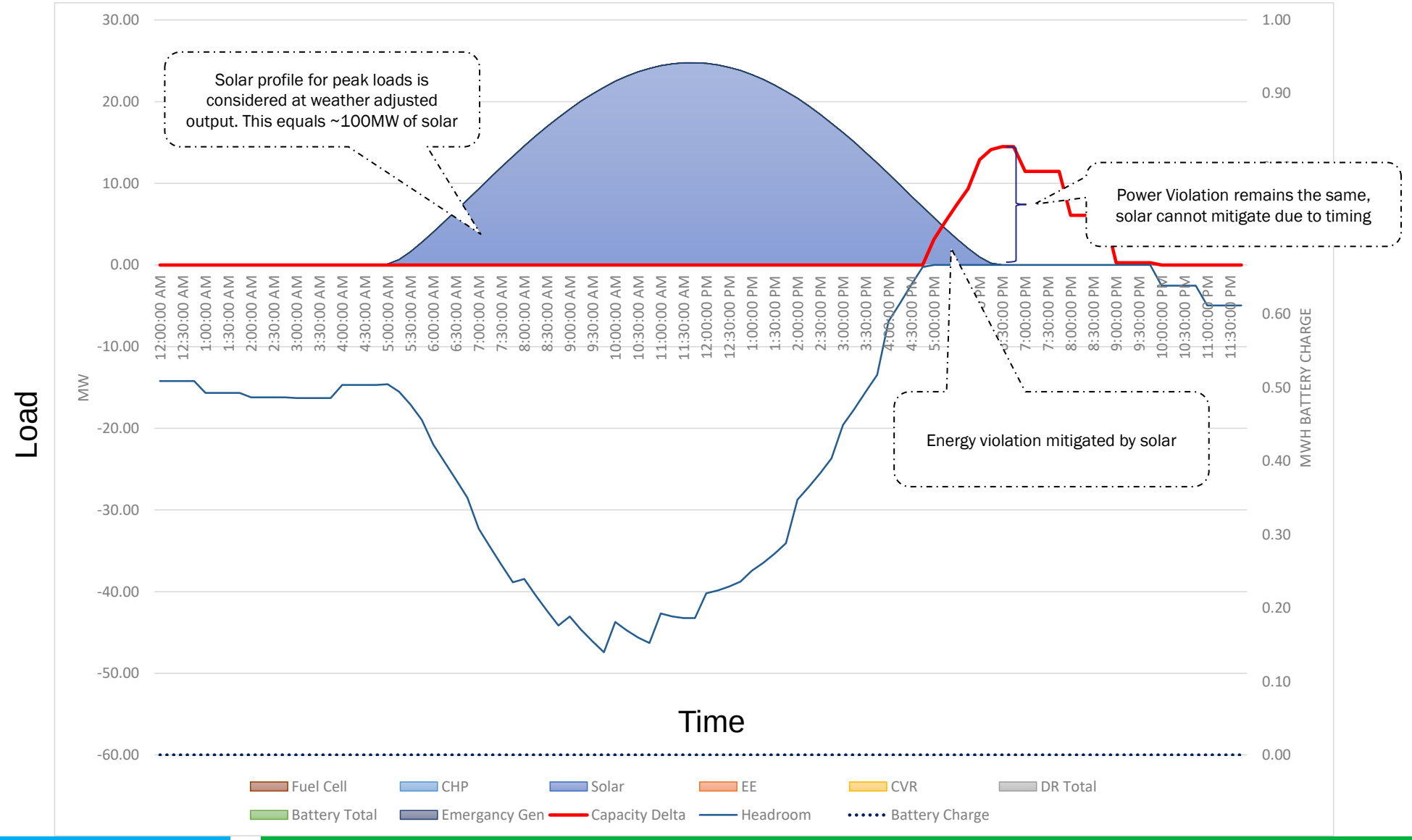
Different NWA Solutions have different limitations whereas traditional options do not

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Yearly Constraint Events	0	0	0	0	0	1	2	5	7	13	19
Peak Day	8/24/2020	8/25/2021	8/25/2022	8/25/2023	8/24/2024	8/25/2025	8/25/2026	8/25/2027	8/24/2028	8/25/2029	8/25/2030
Peak Time	6:30:00 PM	6:30:00 PM	6:30:00 PM	6:30:00 PM	6:30:00 PM	6:30:00 PM	6:30:00 PM	6:30:00 PM	6:30:00 PM	6:30:00 PM	6:30:00 PM
Peak Constraint Power / MW	0.00	0.00	0.00	0.00	0.00	0.75	3.50	6.25	9.00	11.75	14.50
Peak Constraint Energy / MWh	0.00	0.00	0.00	0.00	0.00	0.50	4.13	10.13	18.22	27.94	38.11
Annual Constraint Energy / MWh	0.00	0.00	0.00	0.00	0.00	0.50	4.73	15.91	40.45	84.51	158.15
Annual Number of Constraint Hrs	0.0	0.0	0.0	0.0	0.0	0.8	2.8	7.3	13.0	25.0	38.3

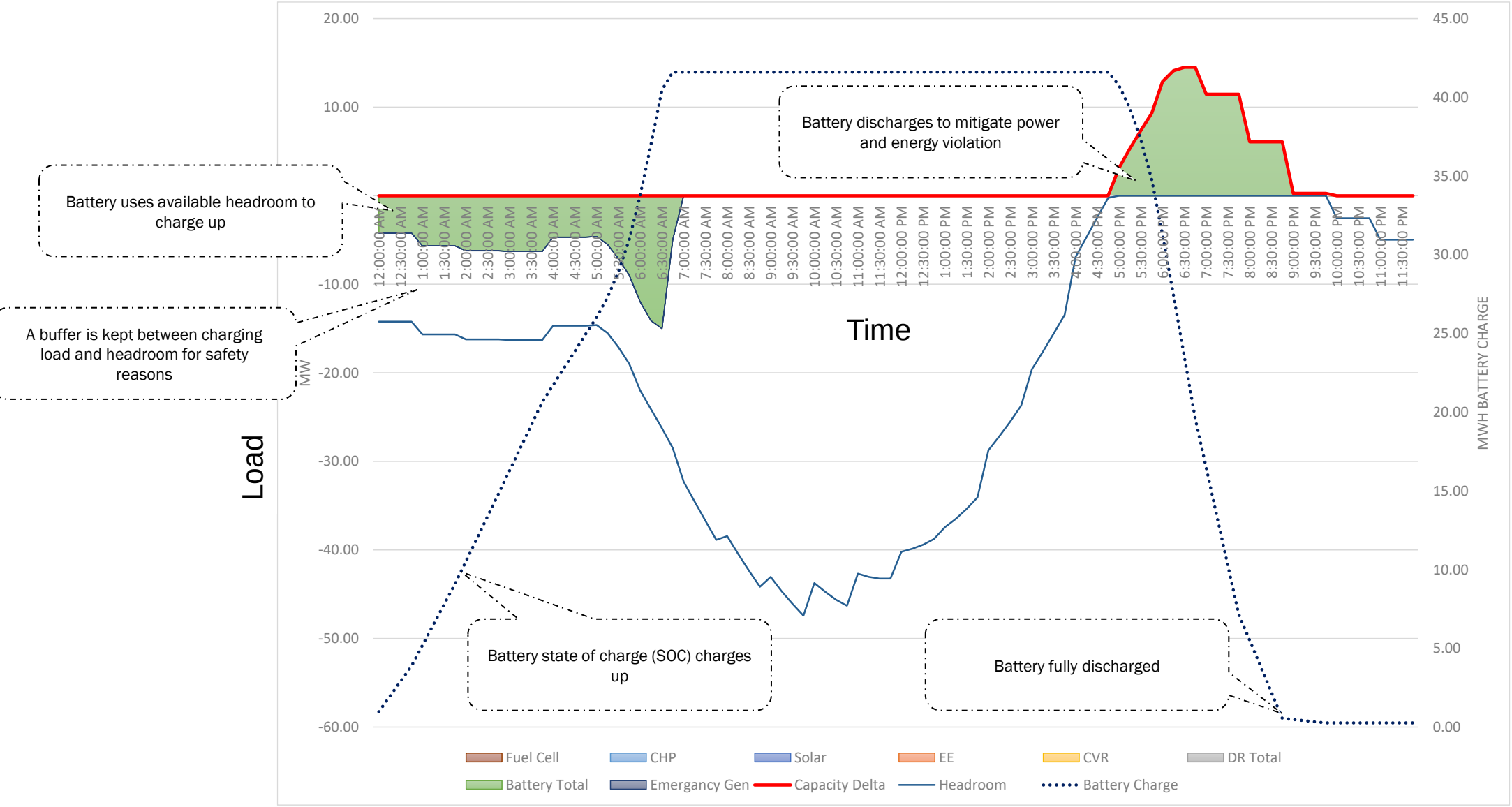
Considerations for Mitigation



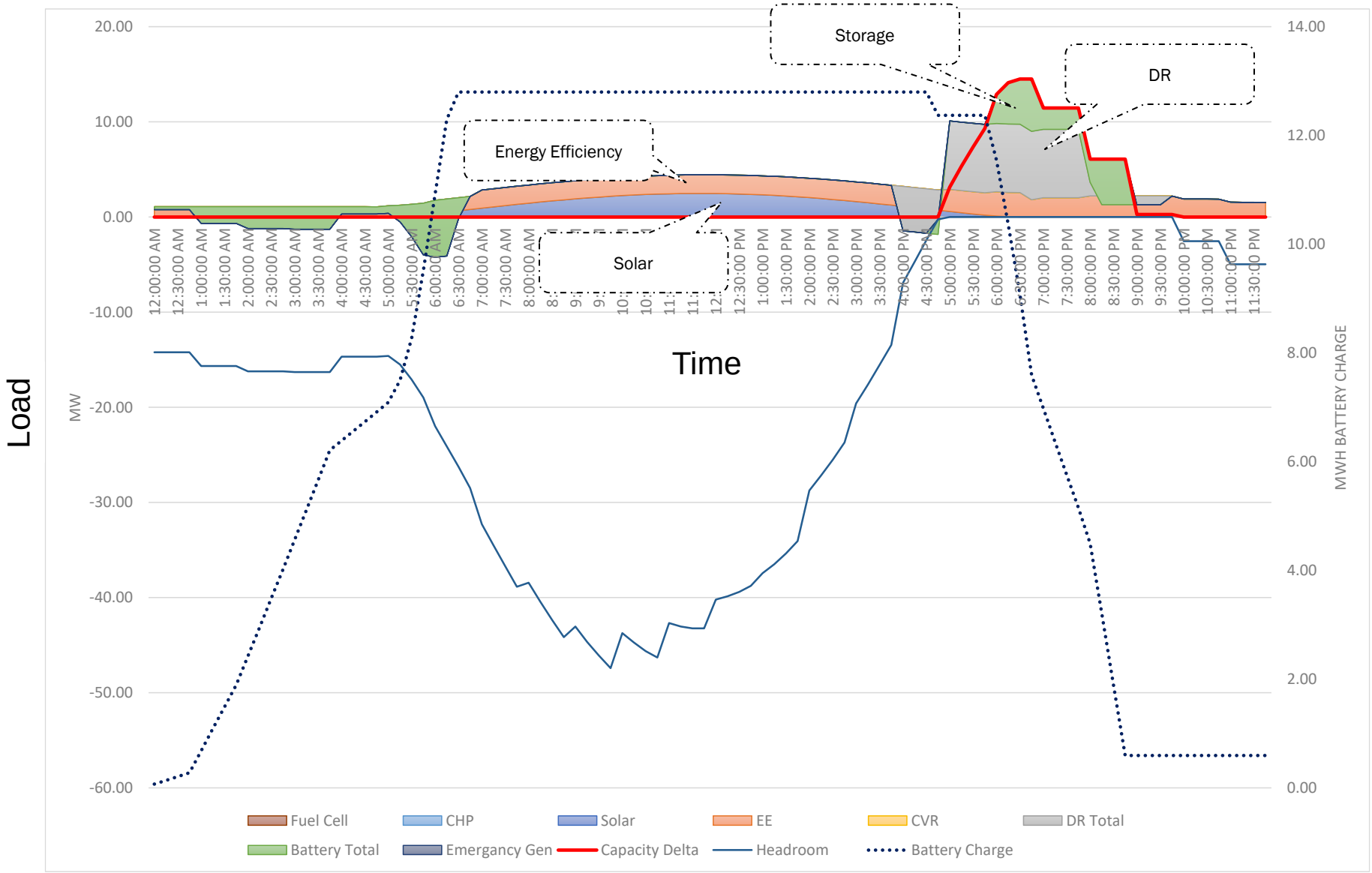
Considerations for Mitigation – Solar Profile



Considerations for Mitigation – Storage



Considerations for Mitigation – Multiple



Considerations for Mitigation – Benefit Cost

- Evaluation of financial feasibility determined by rate payer impact
- Deferral of project at maximum to end of life replacement of asset
  - A 50 Million replacement in 2040 compares to a 70 Million upgrade in 2030 as
  - Net present value of cumulative revenue requirements of 20 Million plus
  - Net present value of change in cumulative revenue requirements incurred through pulling up the 50 Million replacement.

NWA Worksheet						
Remaining Largest Capacity Delta			0.00	MW	Traditional Solution Cummulative NPV RevReq	$ 123,551,596
Remaining Energy Delta			0.00	MWh	Potential Deferral of Investment / Years	5
Required Battery Power			5.50	MW	Traditional Solution Deferral NPV	$ 19,461,776
Required Battery Capacity			15.25	MWh	NWA Solution Worksheet Cumulative NPV RevReq	$ 37,490,403
Daily Battery Cycle Capacity			88%		Benefit Cost Ratio	0.52
Expected BESS Energy Losses for NWA Service			43.47	MWh	Total Annual CO2 Emissions (metric tons/selected year)	28,038
CapEx	Total	$	7,854,750	Today's $	Emissions Reduction Solar (metric tons/year)	-2,304
Yearly O&M	Total	$	301,824	Today's $	Emissions Reduction EE (metric tons/year)	-232
One Time Program	Total	$	4,107,461	Today's $	Emissions Reduction Fuel Cells (metric tons/year)	0
Program / y	Total	$	1,823,906	Today's $	Emissions Reduction Gas Turbine (metric tons/selected year)	0.00
Property	Total	$	-	Today's $	Emissions Reduction Diesel Generation (metric tons/selected	0.00
					Emissions Reduction for NWA Storage (metric tons/selected ye	15.01

Thank You

QUESTIONS?

National Grid 1

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Identifying Barriers and Opportunities": Planning Lab Workshop #2 Residential Scenario

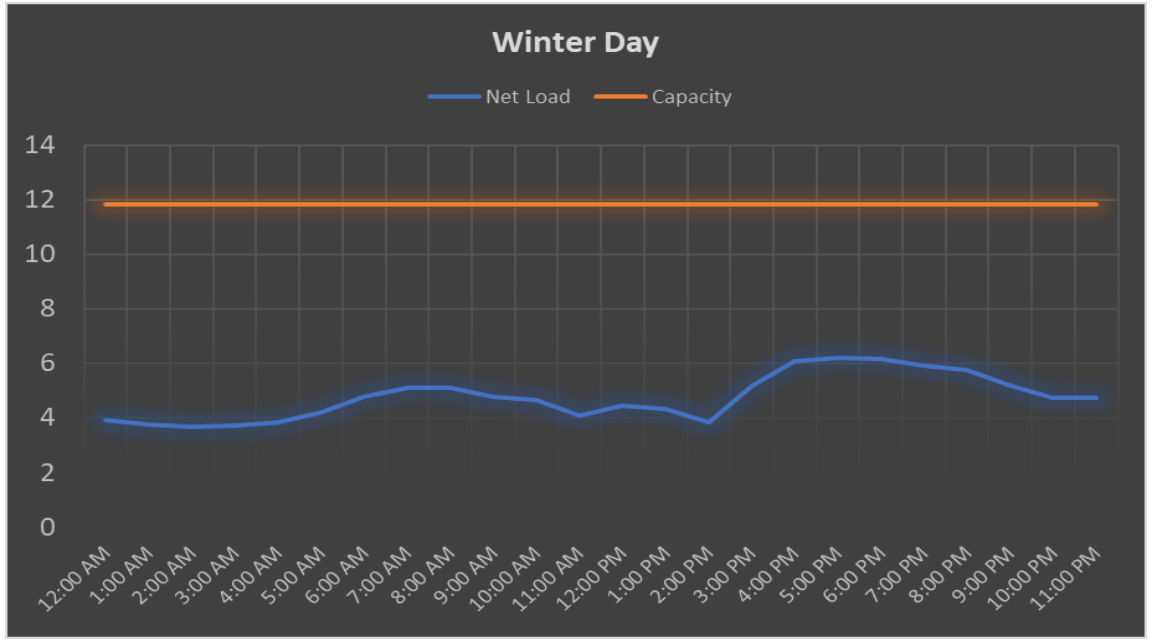
Samer Arafa

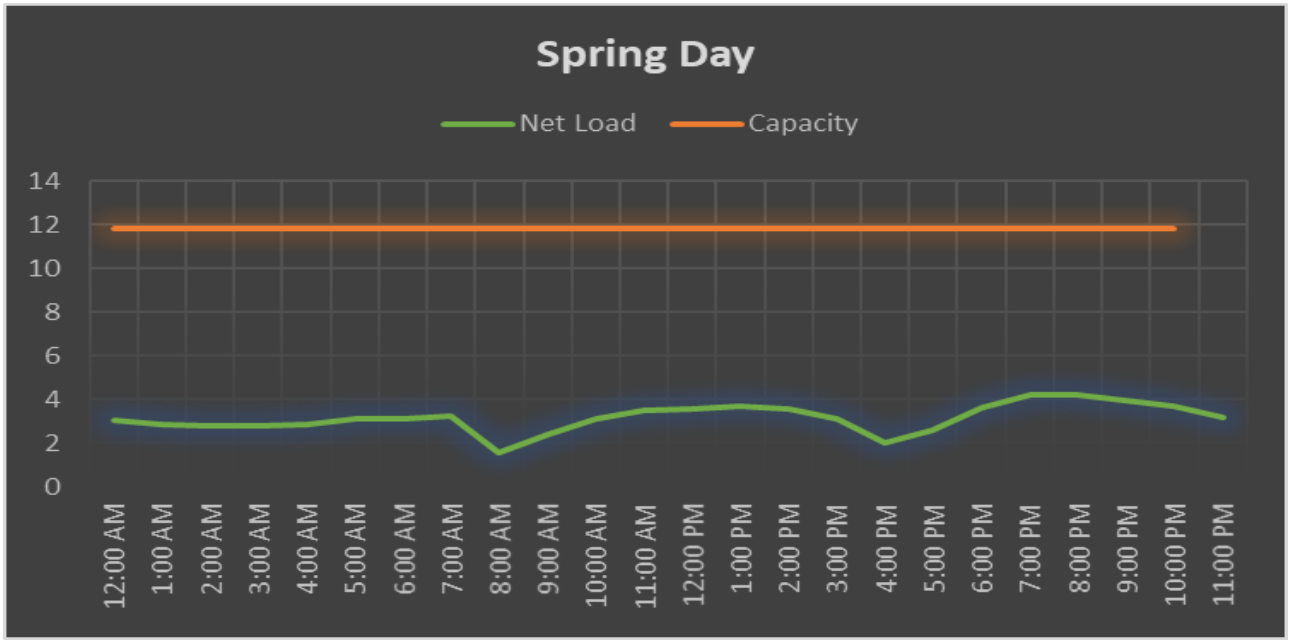
March 4, 2022

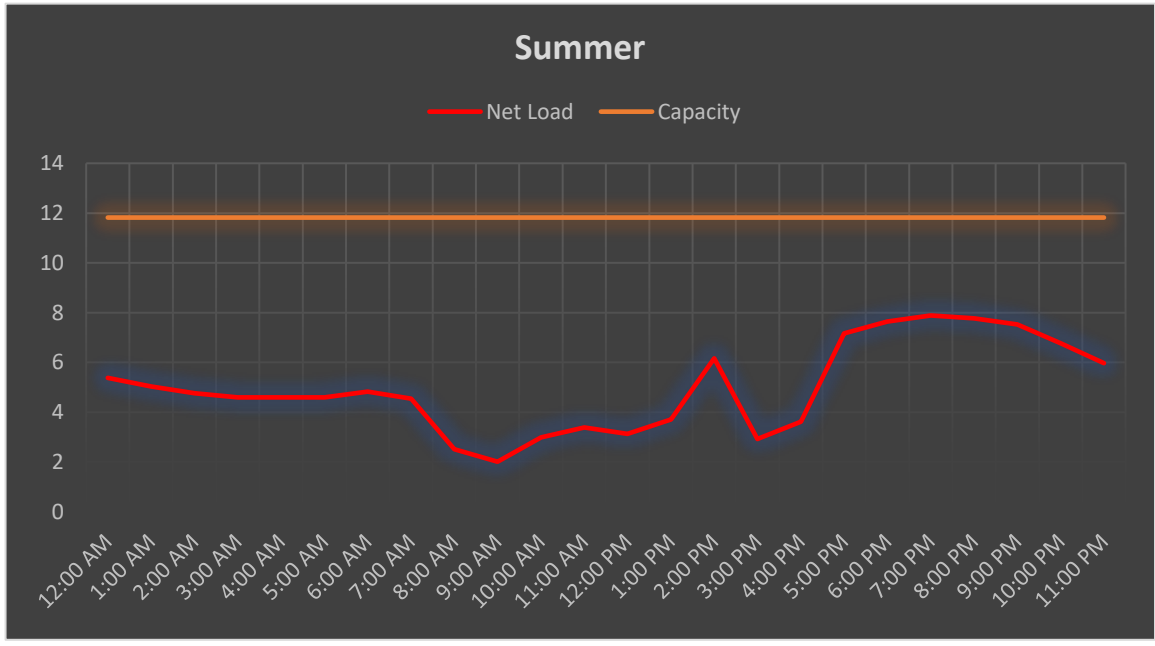
Base Case 2021 Load Profile

Key Insights:

- Summer Load (8MW) is the closest the feeder reaches its Capacity (11.83MW). Mostly caused by Air conditioning.
- 8am on a feeder with 3332 customers we see close to zero MW in the spring, what is happening?
- Afternoon load is the lowest due to 14MW of solar currently installed.



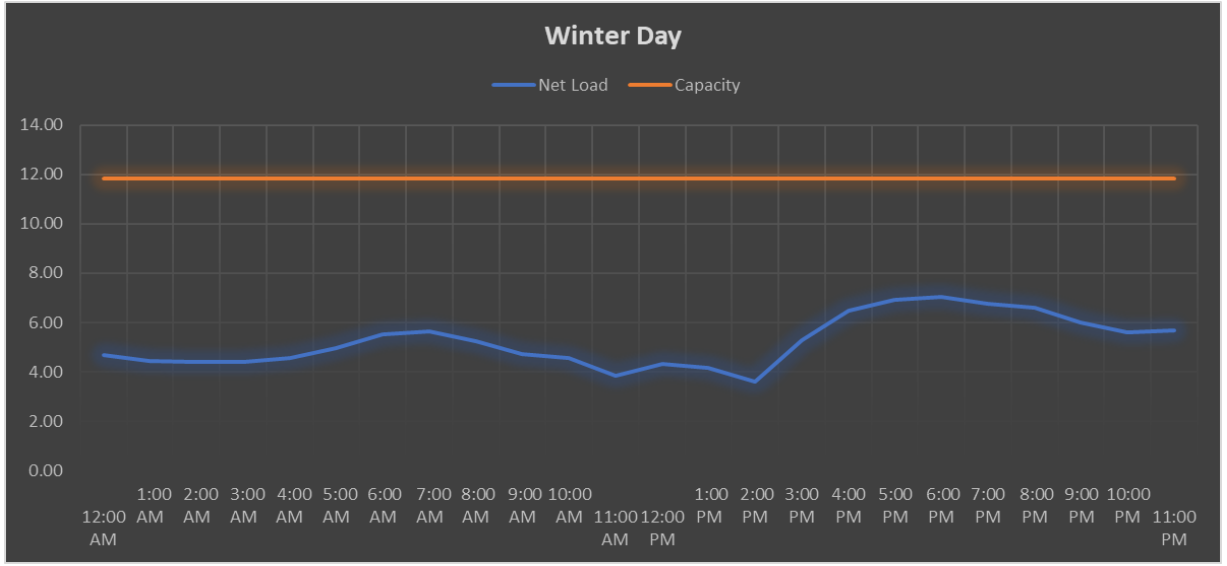


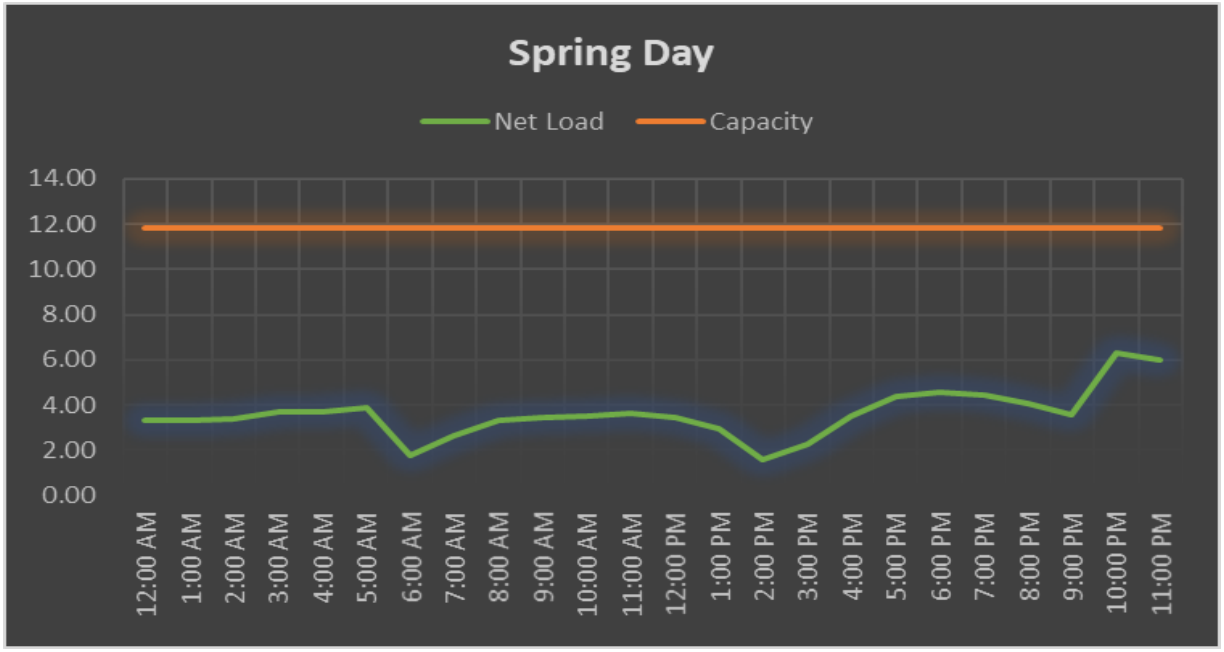


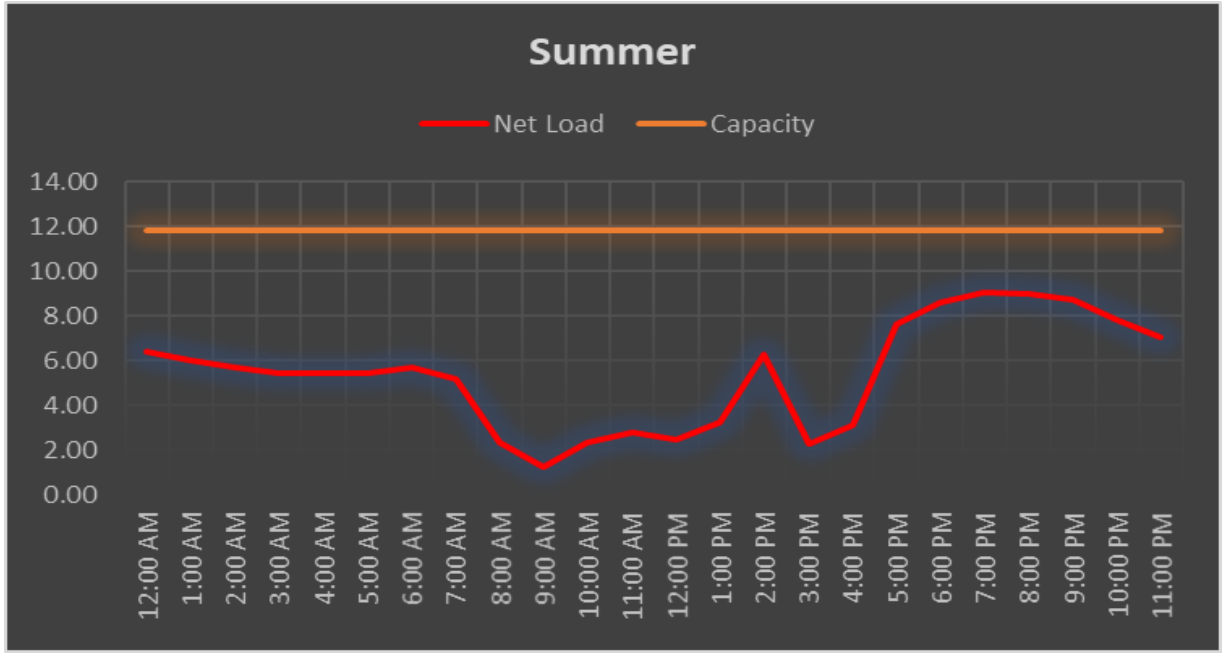
Net Load Normal Growth by 2050 with Energy Efficiency

Key Insights:

- Summer load is expected to grow naturally reaching closer to feeder capacity limits assuming 0.74% economic growth.
- Improvements in Energy Efficiency will help limit load growth.



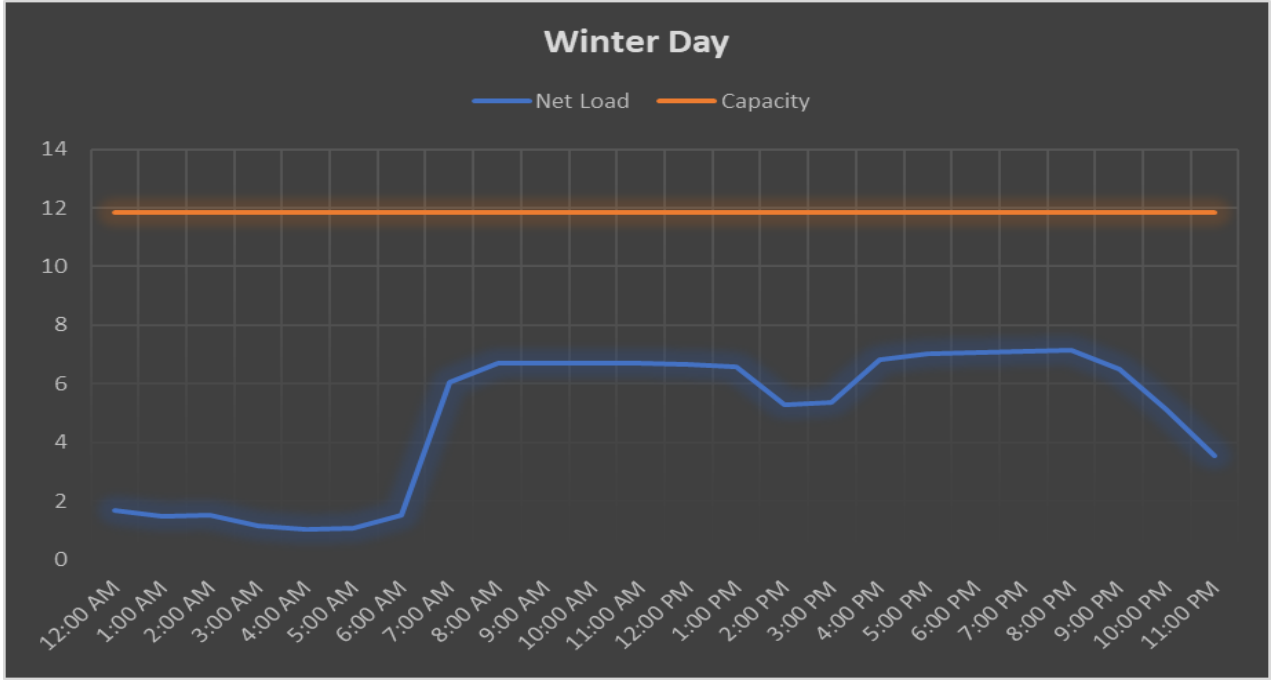


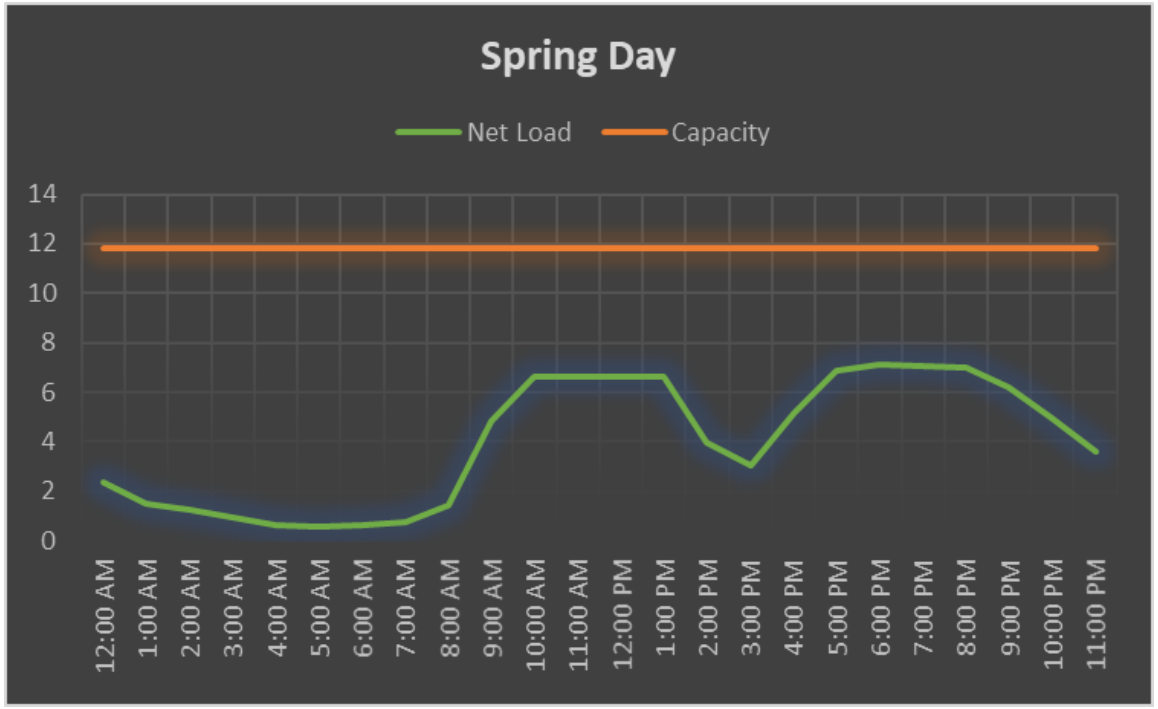


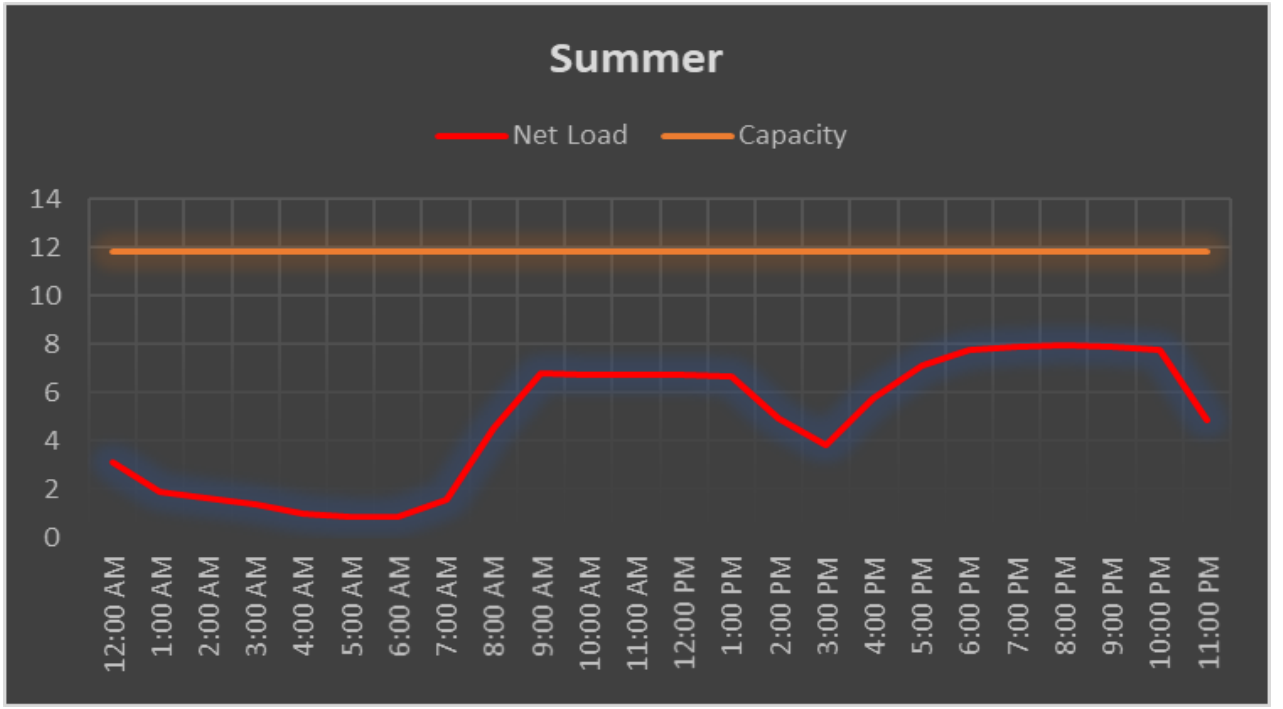
EV Load For 2050

Key Insights:

- Is 8MW reasonable for 3332 customers?
- EV charging behaviors don't change with the seasons.
- EV customers also likely to charge at work or directly after they come home.



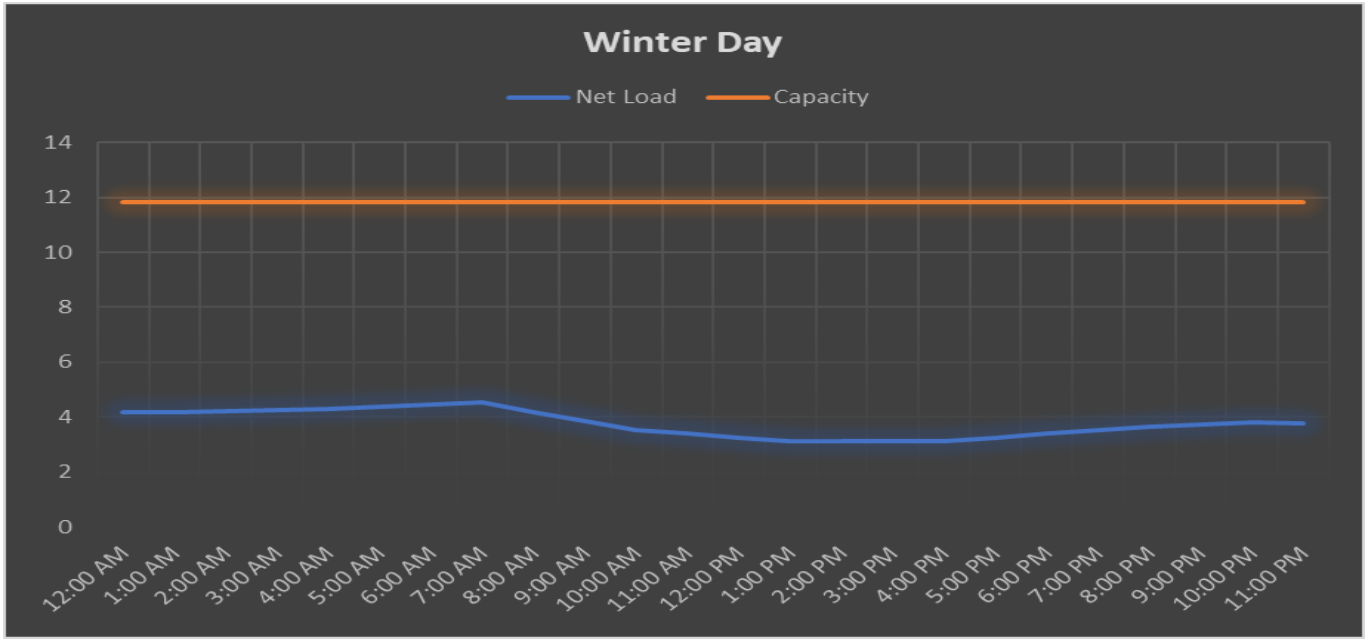


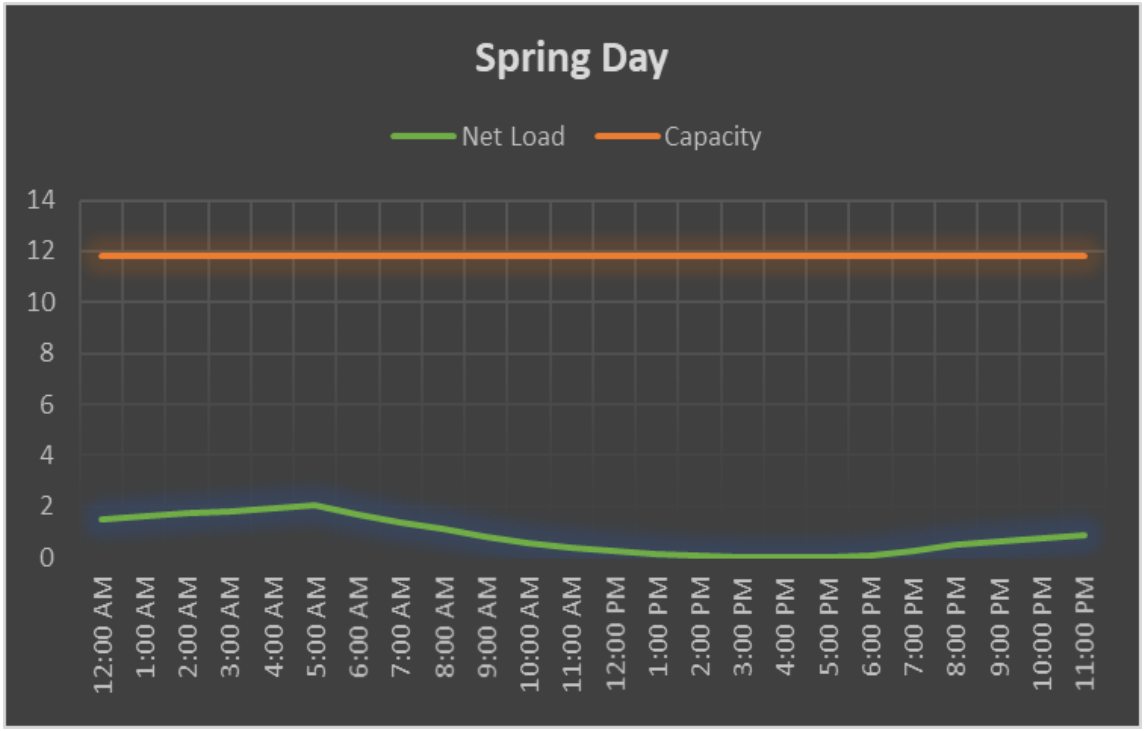


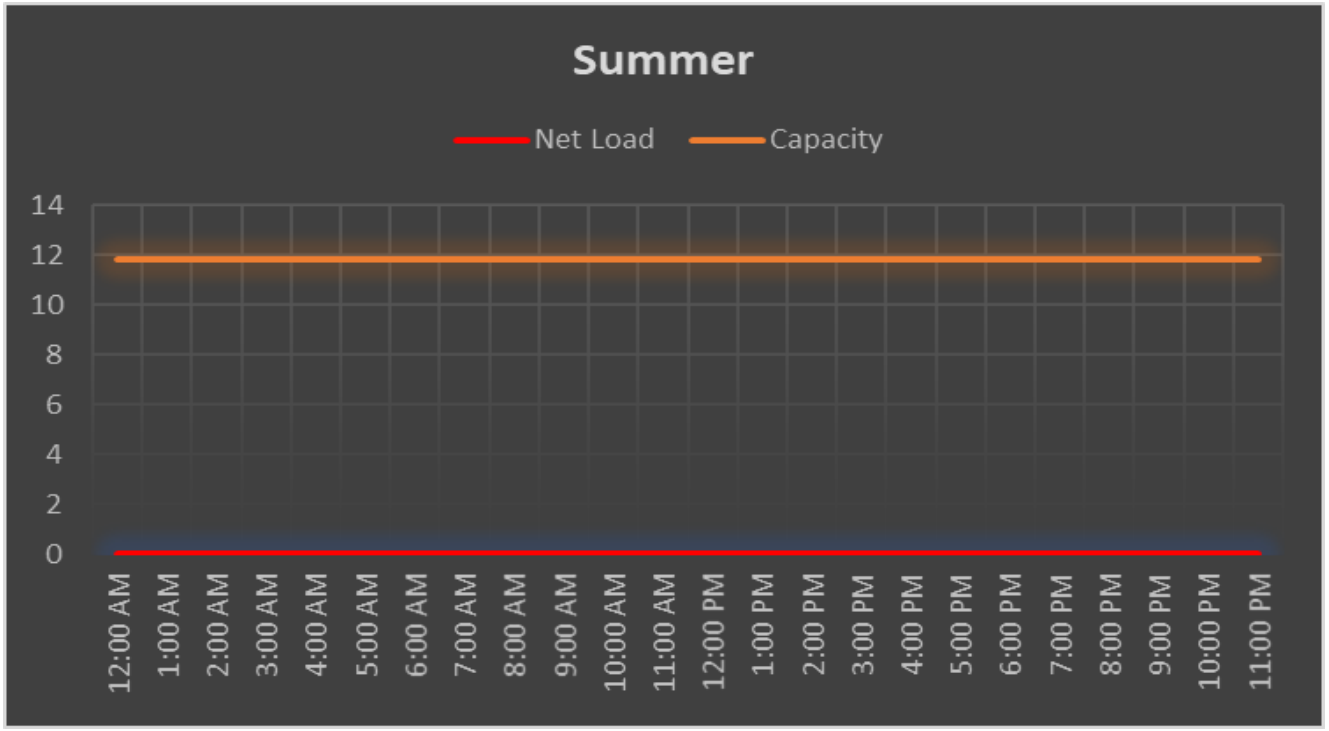
EHP Load For 2050

Key Insights:

- Is 4MW reasonable for 3332 customers?
- EHP's are winter only loads
- EHP's will peak early morning hours.



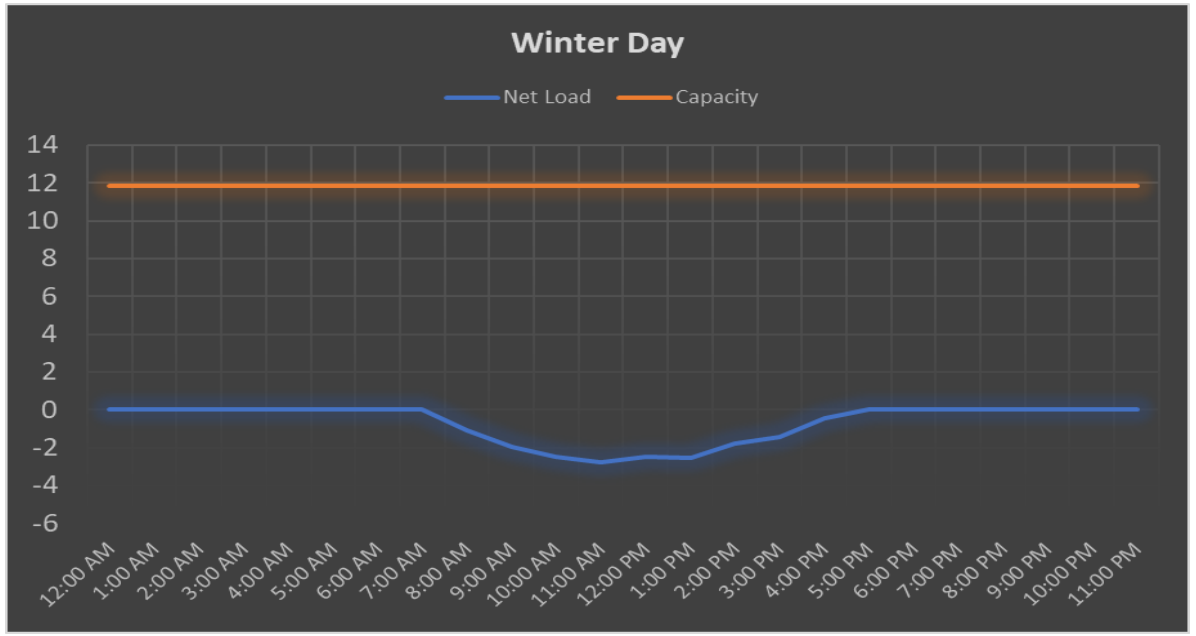


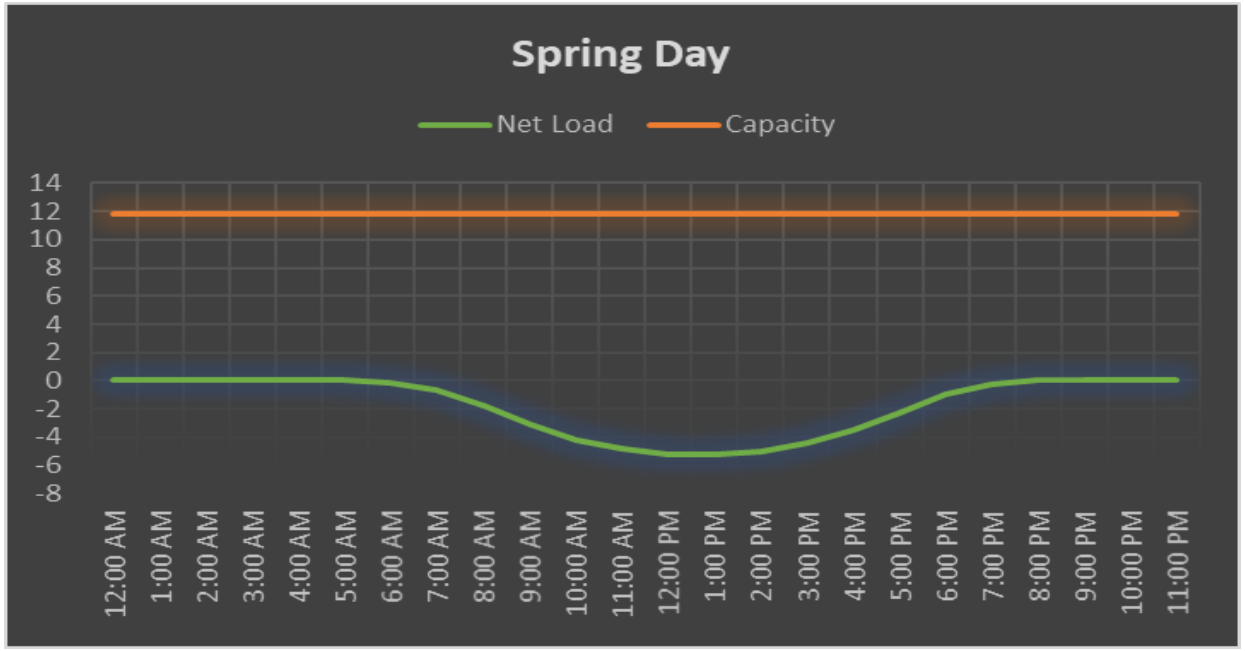


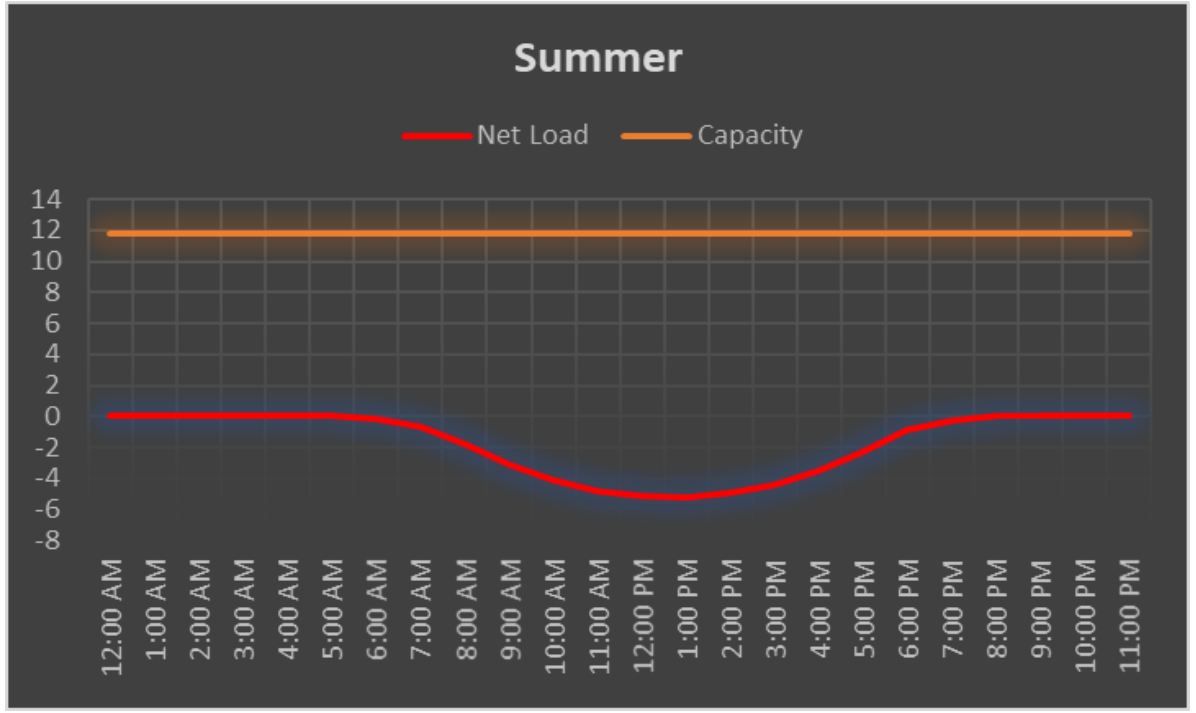
Additional Solar added by 2050

Key Insights:

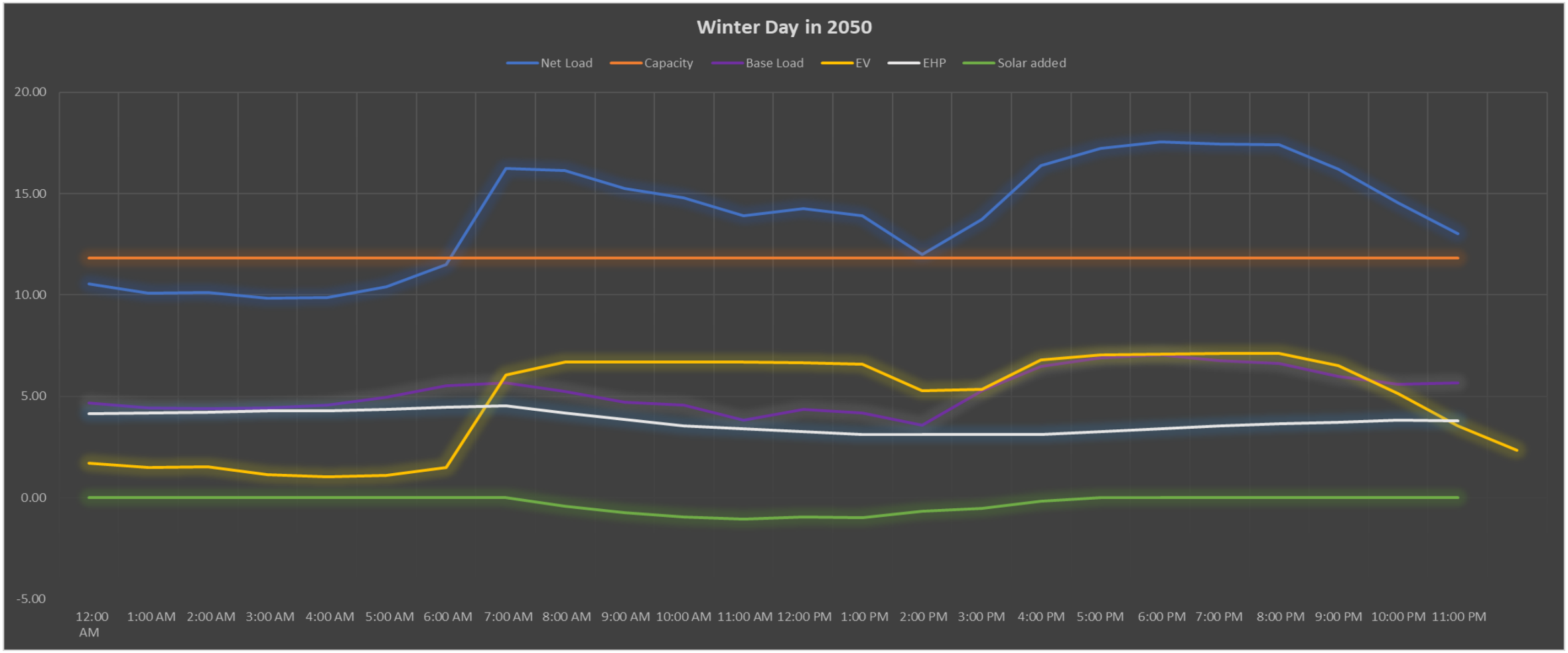
- Despite the feeder being fully saturated with 14MW of solar (not shown), we are assuming we can add 6MW of Solar as load increases overtime.
- Winter peaks reduced due to weak irradiance or possible snow coverage.







Net Load (By Components) Breakout by 2050

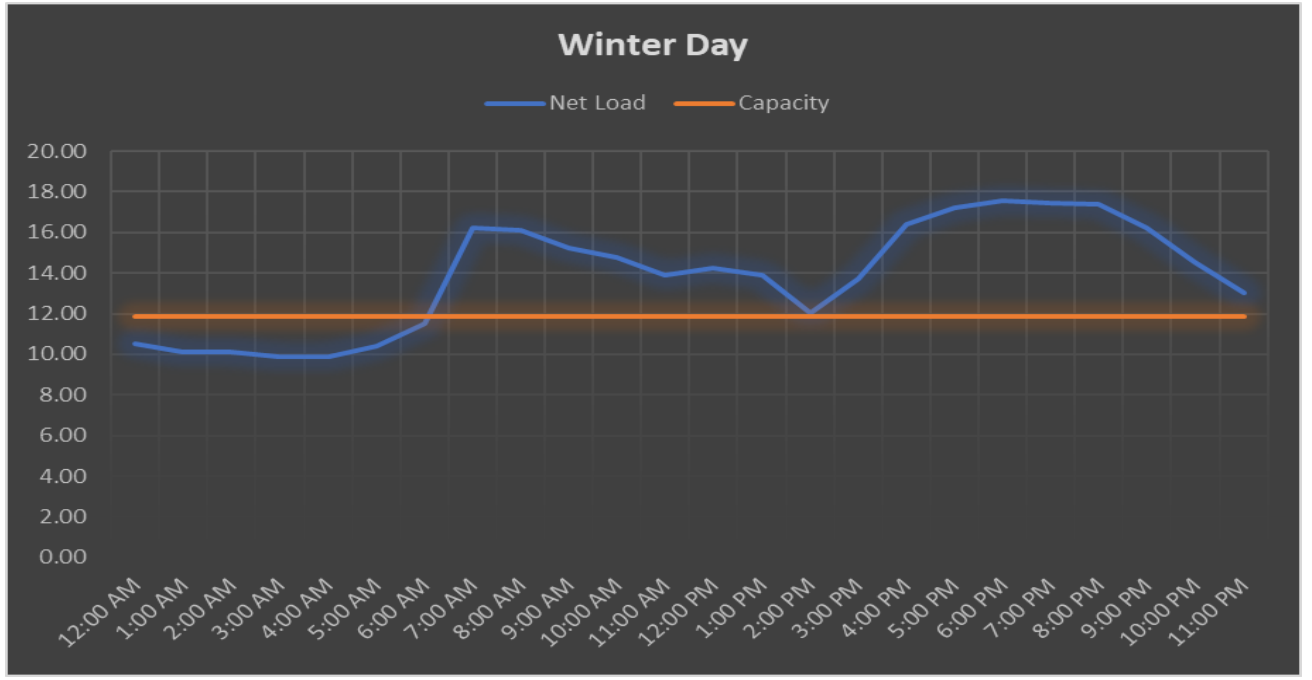


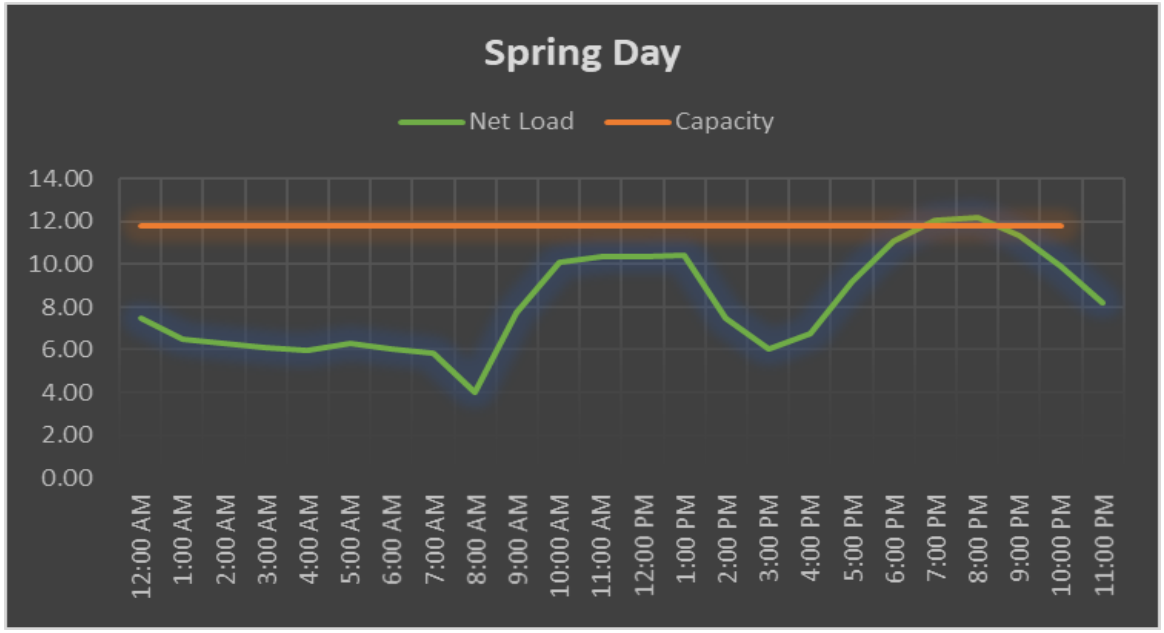
Reminder: Base Load includes existing DG as of 2021

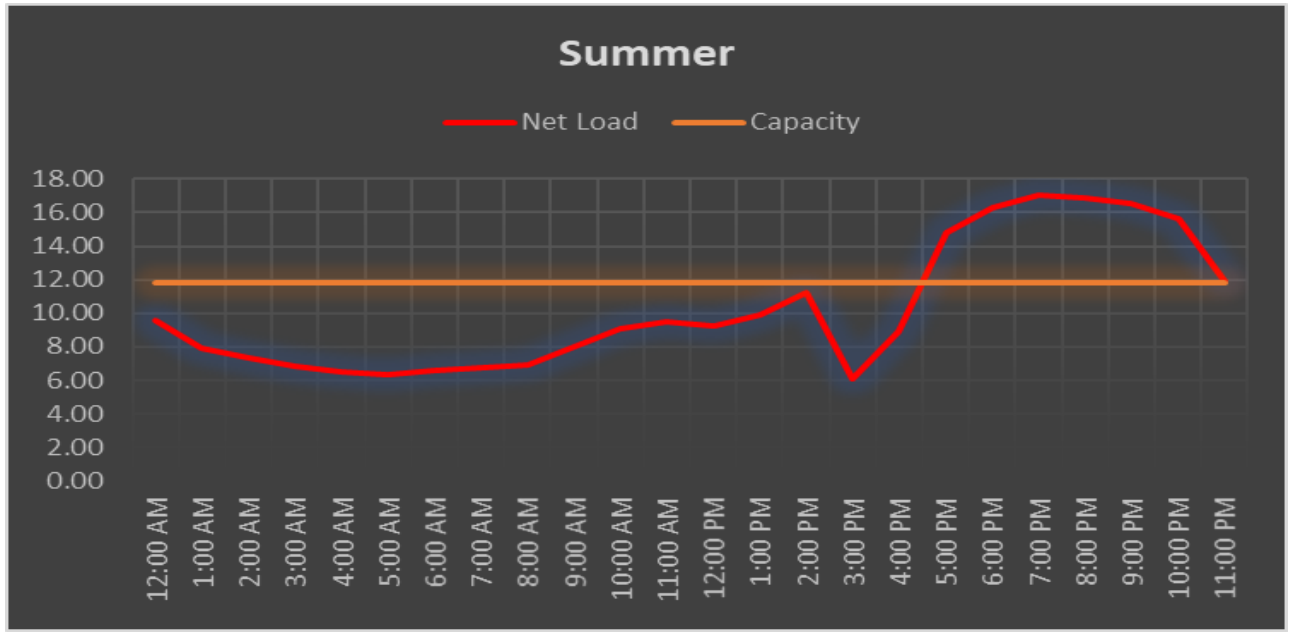
Total Load (excluding forecasted generation) For 2050

Key Insights:

- Winter load begins to become more challenging than summer due to EHP's consuming more power than Air Conditioning.



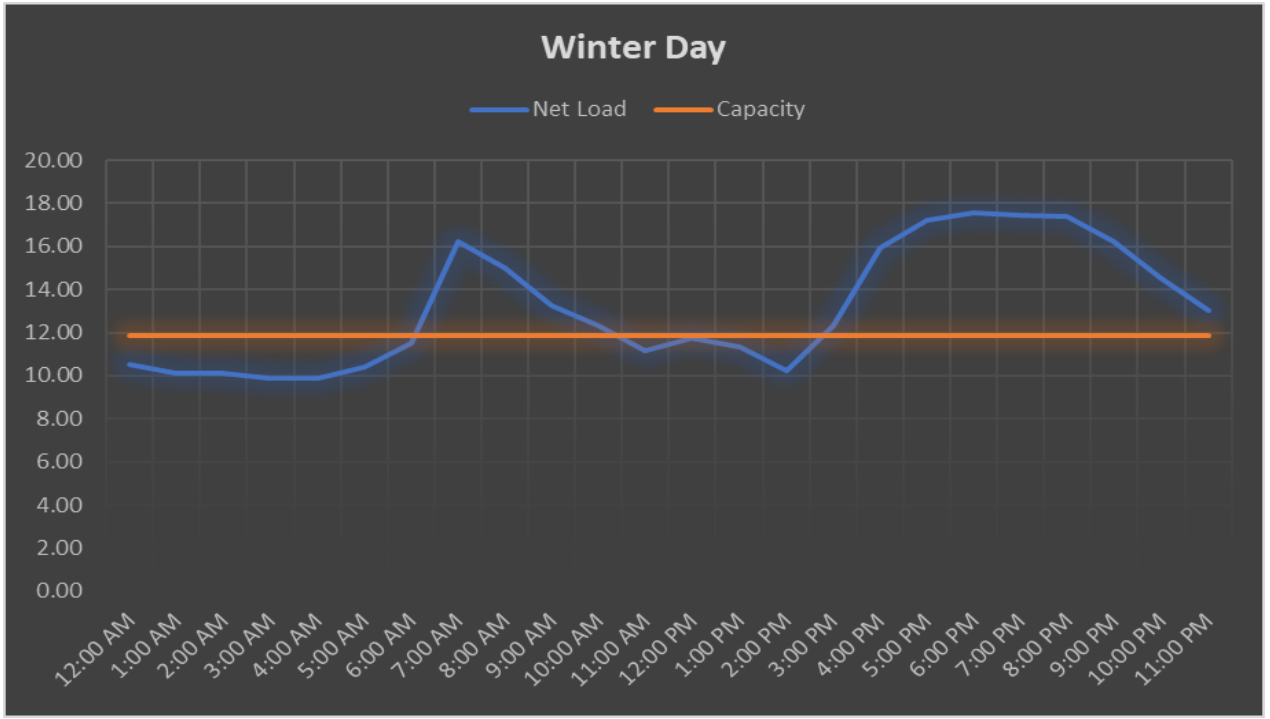


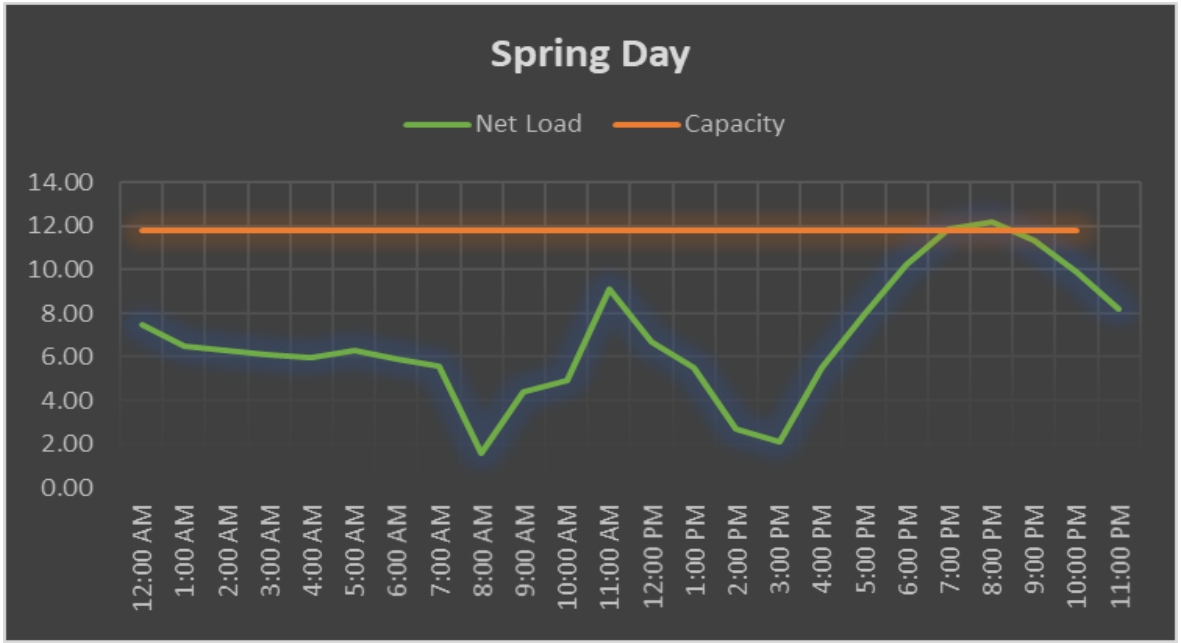


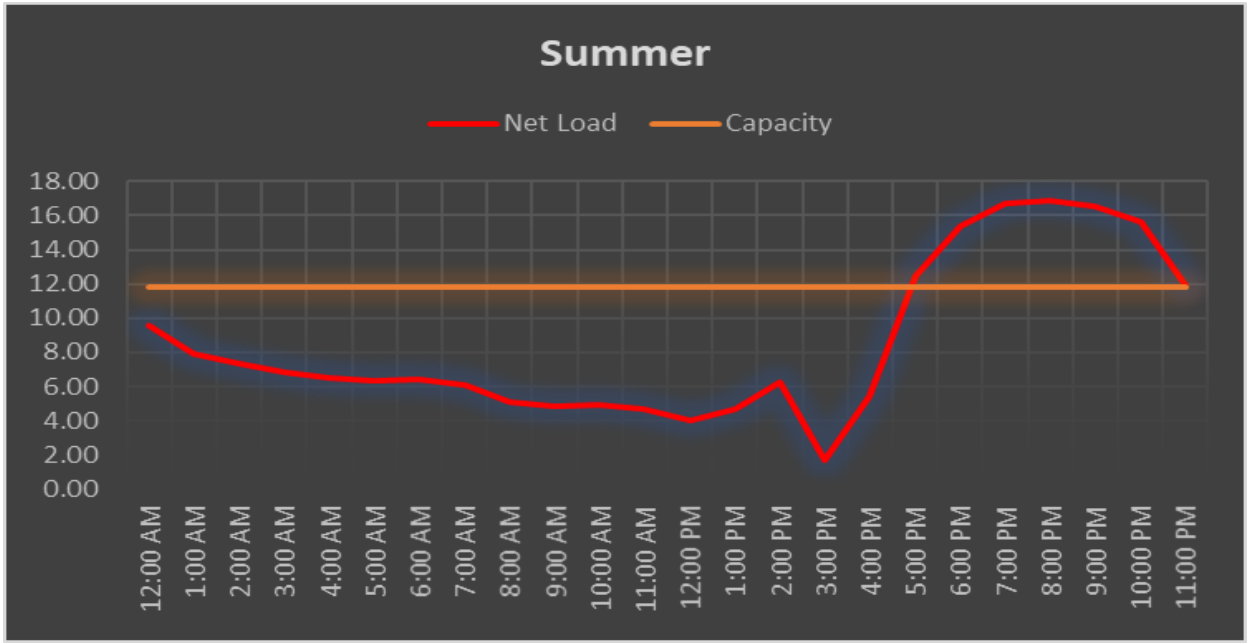
Net Load (Load + DG) by 2050

Key Insights:

- Winter exceeds capacity limits throughout the day.
- Summer load higher in the evening due to EV charging and drop in solar production.



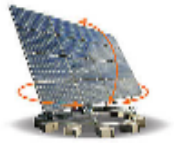




Excessive DG Solution- Active Resource Integration

Key Insights:

- The added 6MW of DG would bring the total DG on the feeder to 20MW, exceeding both the feeder and transformer capacity .
- Assumption is that the EV load will be available to balance the solar generation.
- The Company will need to monitor the load in real time to curtail the solar in case the load drops for any reason.



Notify Renewable Generators

Forecast Day-Ahead Curtailment Needs

Day-Ahead Window

Real-Time Window

Curtail Renewable Generators as needed

Identify Real-Time Curtailment Needs

Monitor Loading on Limiting Elements

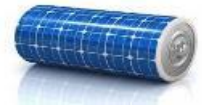
Options to Solve Summer Challenges:

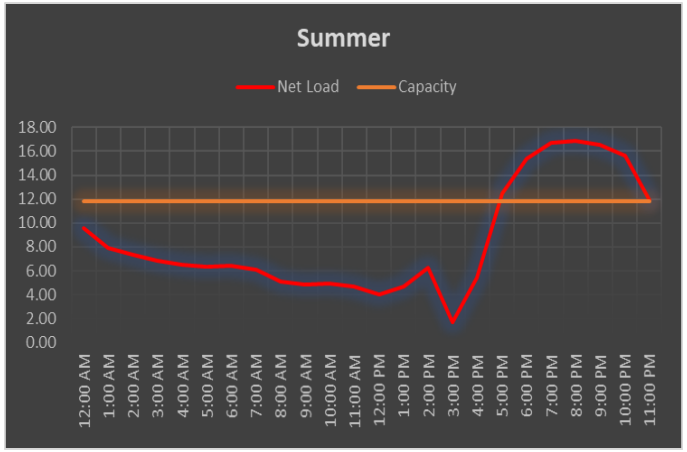
- The traditional solution is to upgrade the limiting elements on the on the system.
- Flexible load and Energy Storage operation developed through Grid Mod will allow for loads to be shifted from peak operation hours using DERMS technology.
- These solutions will only defer upgrades, eventually asset conditions may trigger upgrade needs.

Forecast Day-Ahead System Needs

Day-Ahead Window

Notify Flexible Load through Marketplace Events





Activate Flexible loads then Curtail Renewable Generators as neede

Real-Time Window

Identify Real-Time System Needs

Monitor Loading on Limiting Elements net of flexible loads

Options to Solve Winter Challenges:

Key Insights:

- The net load on the feeder exceeds the load during most of the day in the winter.
- Flexible load and short-term energy storage are not strong options.

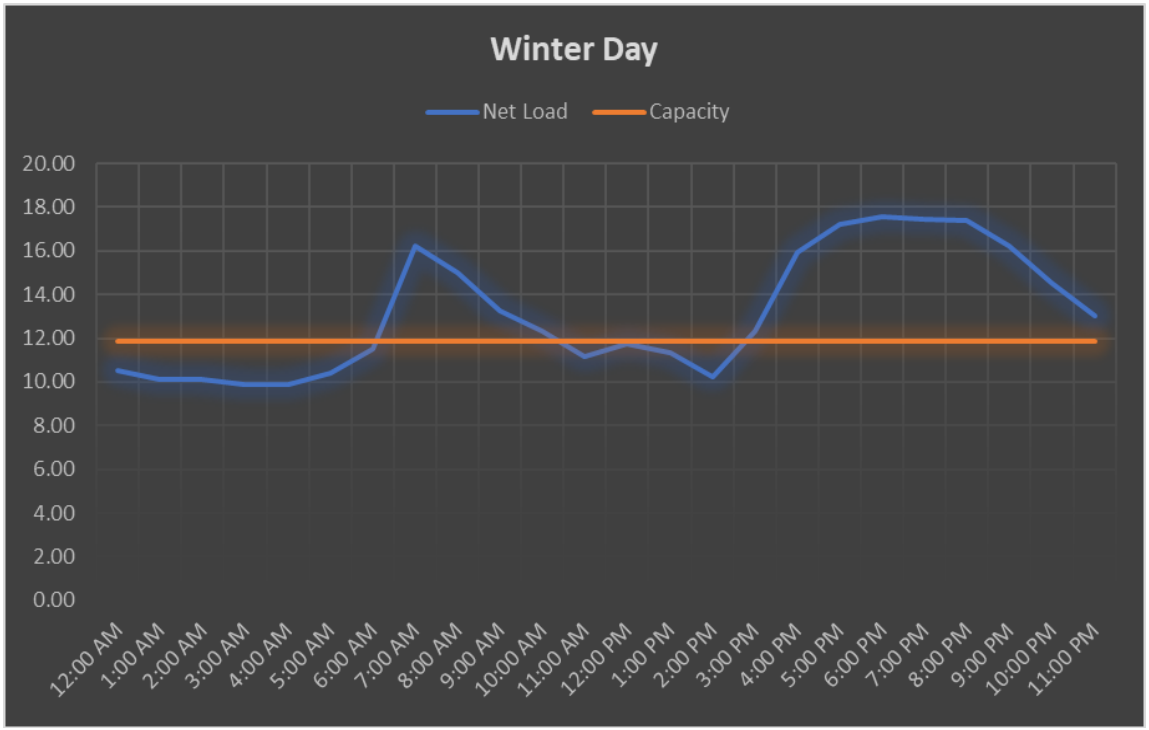
Options can be:

1- Upgrade existing wired system or Substation transformer (reconductor, dual feed, etc.)

2-Serving load from neighboring feeders if they have capacity (reallocating load).

4- Long term energy storage.

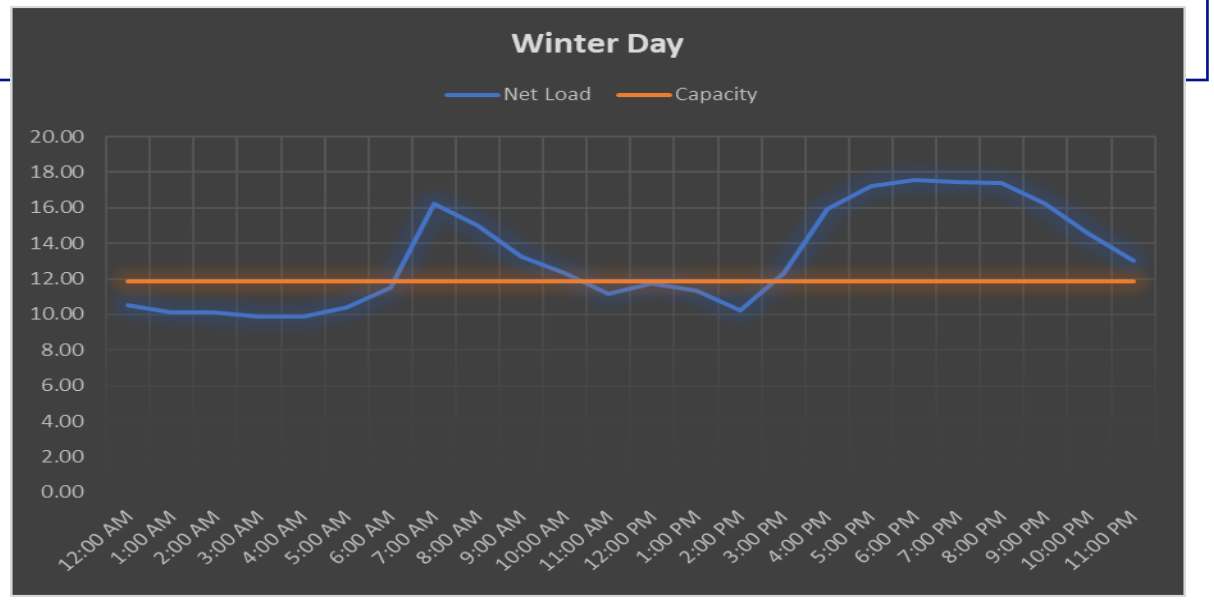
5- New technologies such as using a home freezer as a demand response solution.



Serving from Neighbouring Feeders

Key Insights:

- The challenge is that the substation transformer is only rated for 14MVA while the forecasted peak load on the single feeder in our analysis reaches 18MVA.
- If the total load across the all feeders is greater than the station transformer nameplate rating, the transformer will need to be upgraded, which is among the most costly options



Question

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National Grid

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nationalgrid

National Grid 2

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Identifying Barriers and Opportunities": Planning Lab Workshop #2 Industrial Scenario

Douglas Ayer

March 4, 2022

nationalgrid

Challenges of the Urban Grid in 2050

Things to Consider?

1-Feeder Level device limits: e.g., wire has the thermal capacity to carry the maximum current of load or generation at any given time.

2-Substation Level limits: e.g., the substation transformer can handle the aggregate load of all feeders on the system. (limited discussion today)

3-Tranmssion Level Limits: e.g., long underloaded transmission lines have voltage rise "Ferranti Effect" (out of scope in today's discussion)

4-Reliablity: e.g., Voltage and Frequency stays within acceptable limits (out of scope in today's discussion)

5-Resilliency: e.g., ability to recover quickly after an outage (out of scope in today's discussion)

6- Asset Conditions : e.g., CA wildfires were caused by "severe wear" on steel parts (out of scope in today's discussion)

Feeder Overview

Serves Areas: Haverhill

Length: 7.4 miles

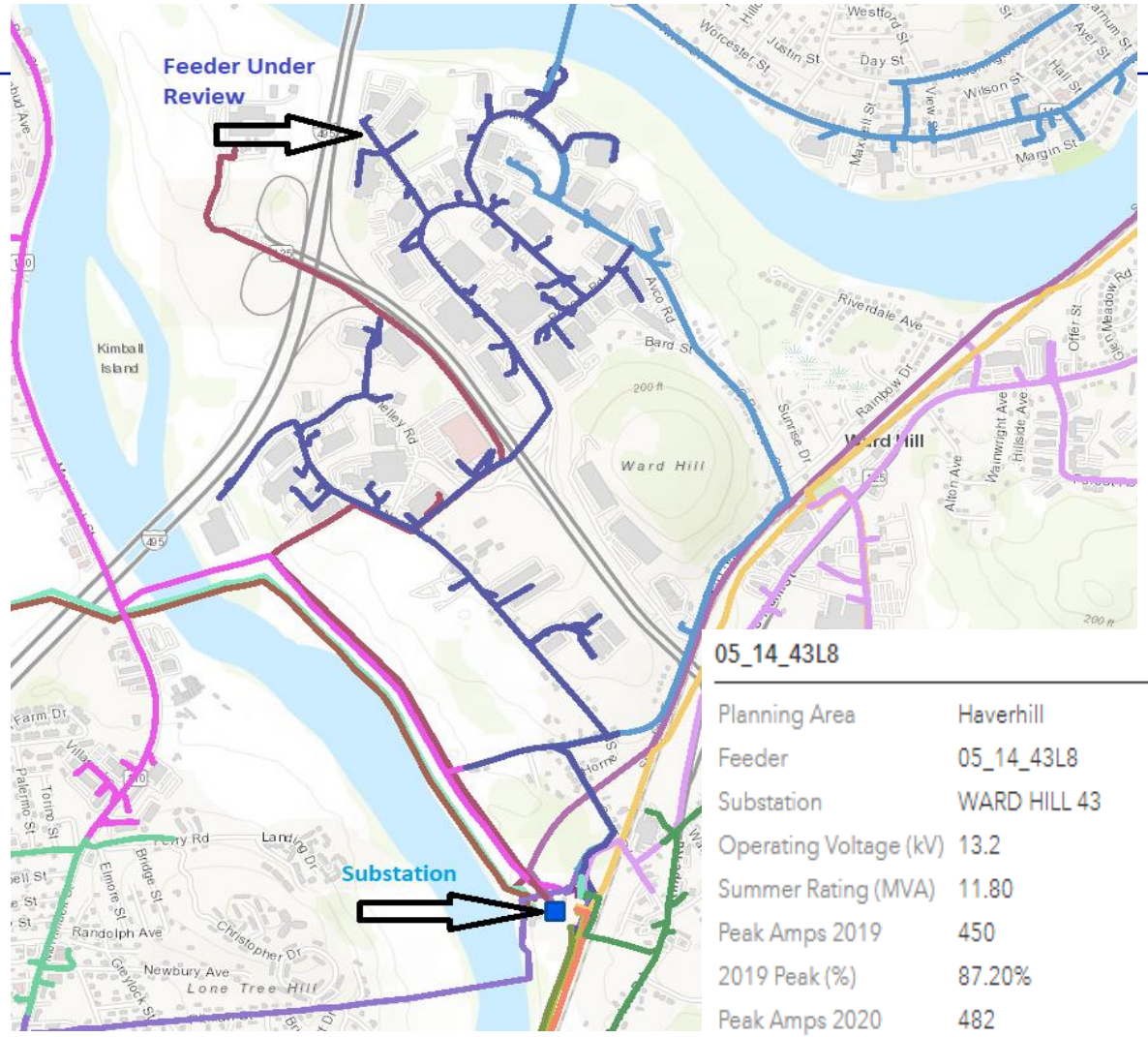
Type: Commercial

# of Customers : 208

Feeder Capacity : 11.80 MVA

Future Loads Considered: Economic Growth. Improvements in Energy Efficiency will help reduce load. Fleet Electric Vehicles and Commercial Heating.

Future Generation Considered: Roof top solar and Limited Ground Mount Solar.



https://ngrid.apps.nationalgrid.com/NGSysDataPortal/MA/index.html

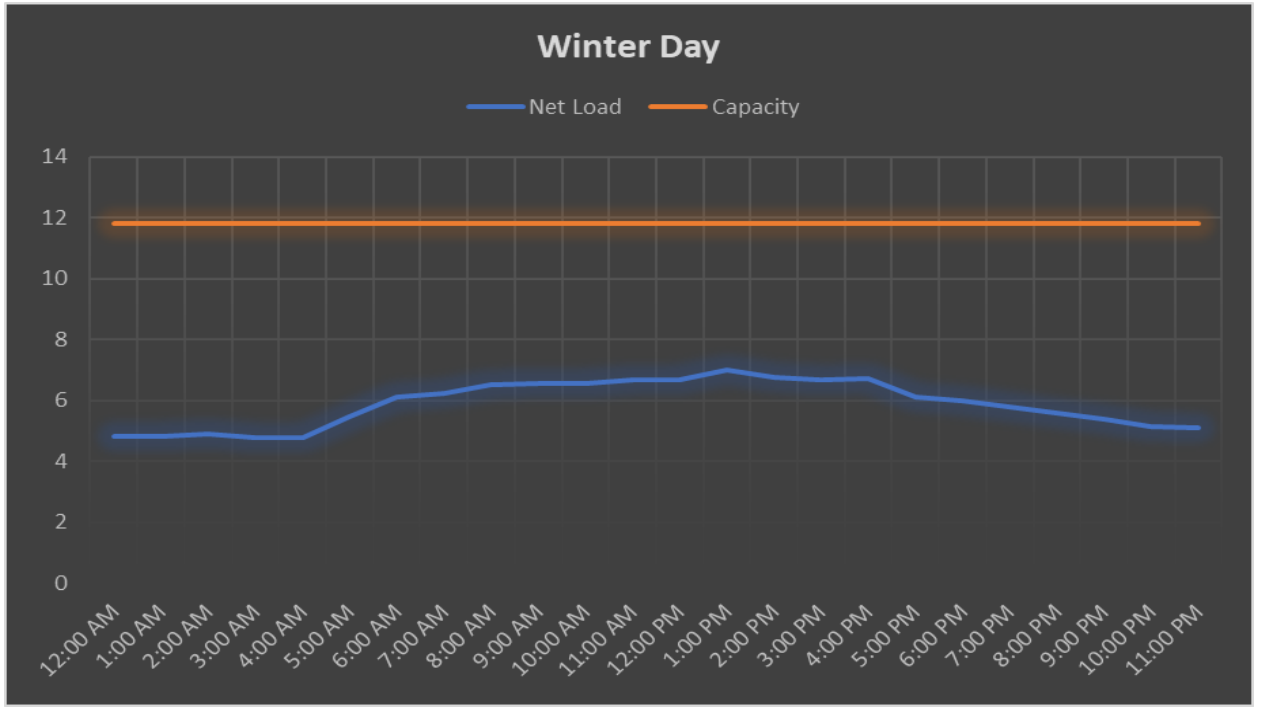
05_14_43L8

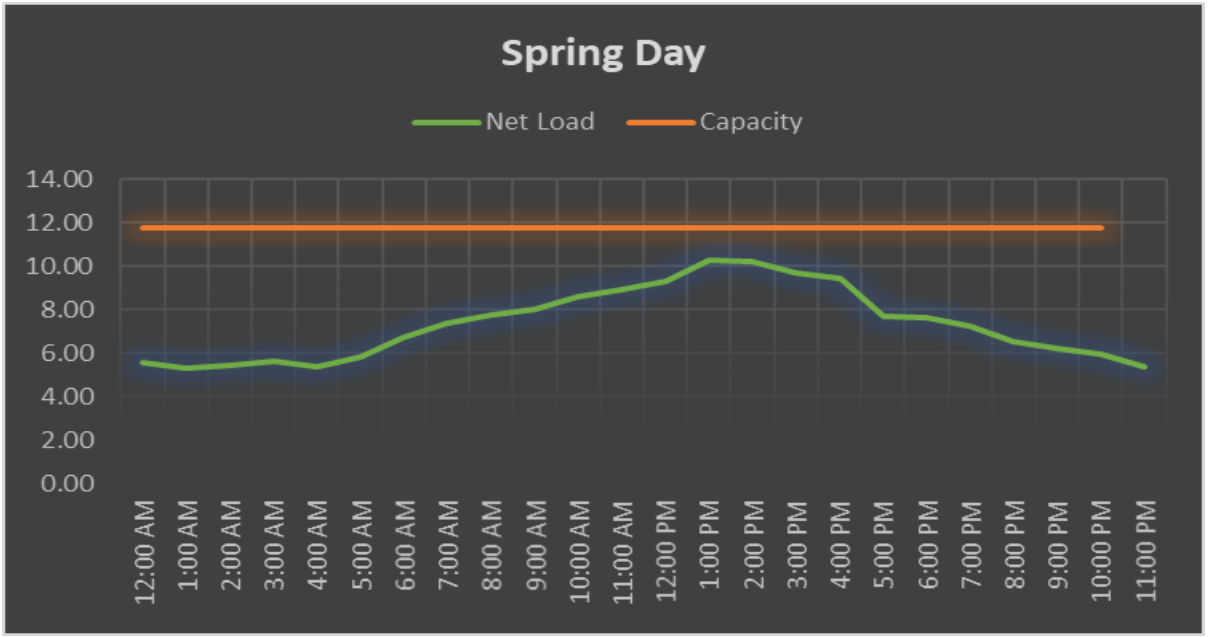
Planning Area	Haverhill
Feeder	05_14_43L8
Substation	WARD HILL 43
Operating Voltage (kV)	13.2
Summer Rating (MVA)	11.80
Peak Amps 2019	450
2019 Peak (%)	87.20%
Peak Amps 2020	482
2020 Peak (MVA)	11
2021 Forecast (MVA)	10.9
2022 Forecast (MVA)	10.9

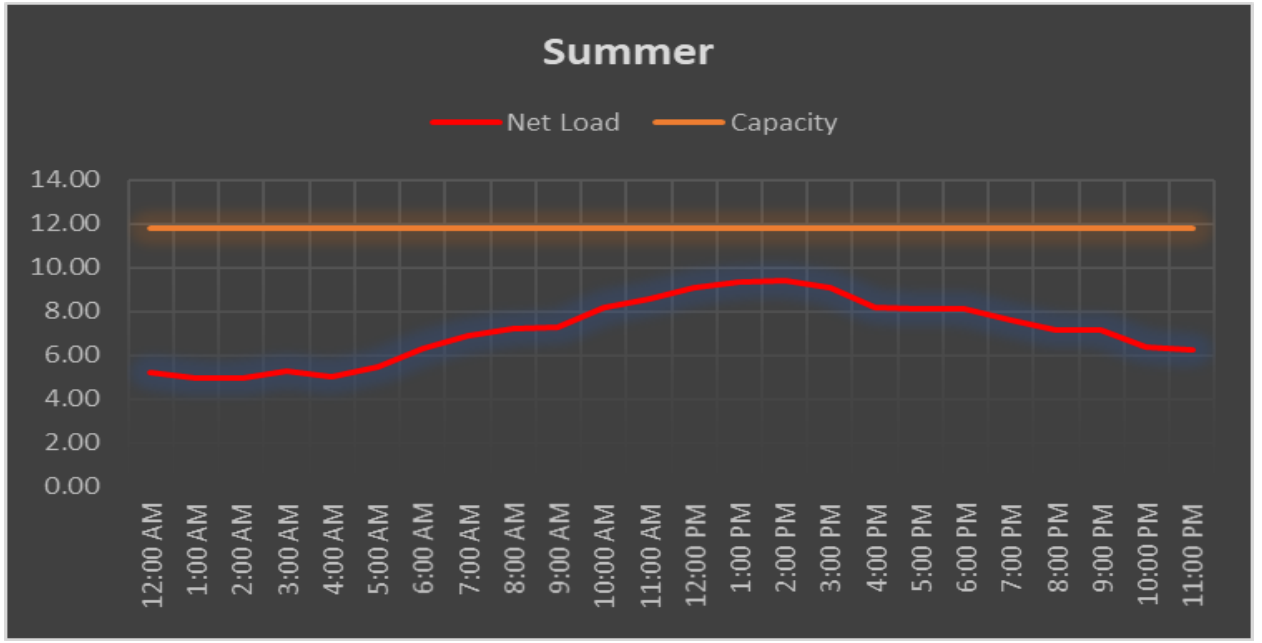
Base Case 2021 Load Profile

Key Insights:

- Peak Load was reached in the spring not summer.
- Afternoon load the highest.
- Load in Spring and Summer share similar characteristics



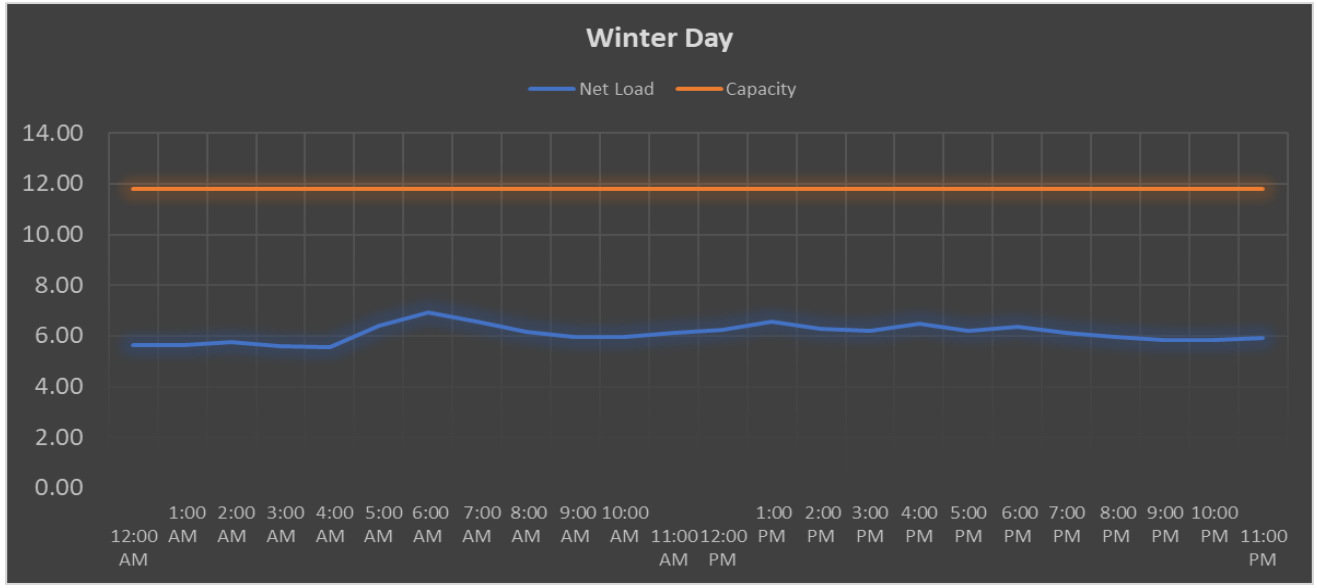


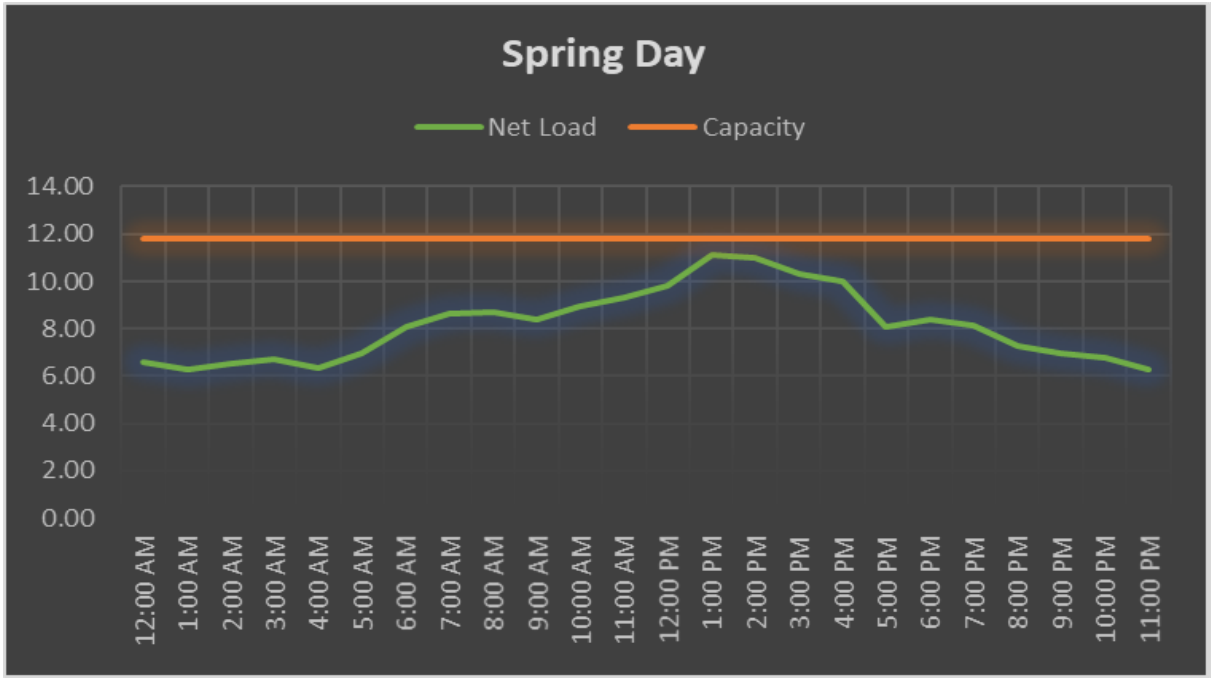


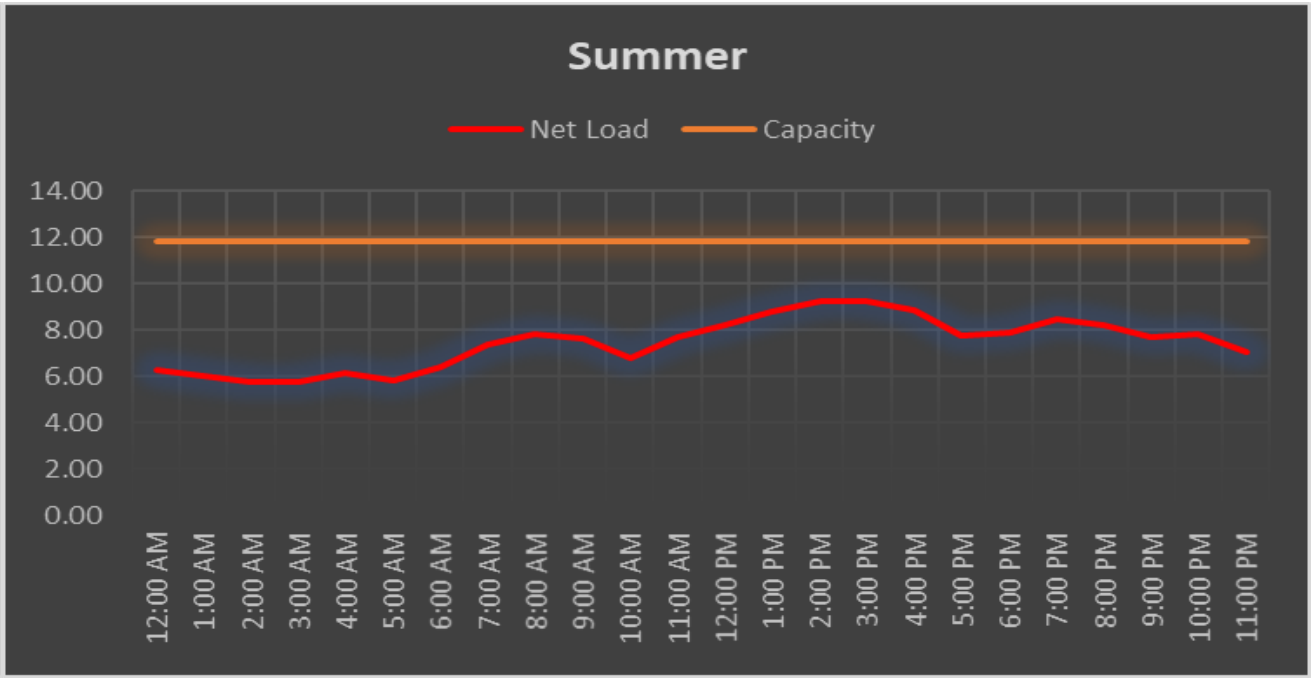
Natural Economic Growth by 2050 with Energy Efficiency

Key Insights:

- Load is expected to grow naturally reaching close to feeder capacity limits assuming 0.74% economic growth.
- Improvements in Energy Efficiency will help slow download growth.



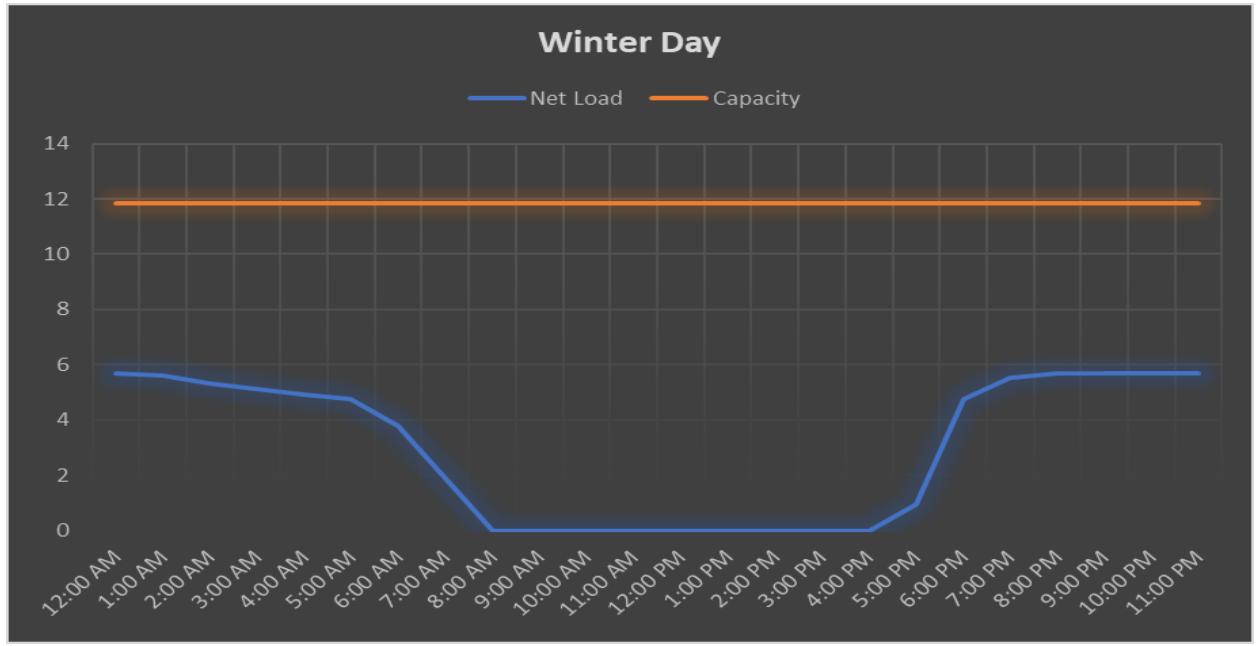


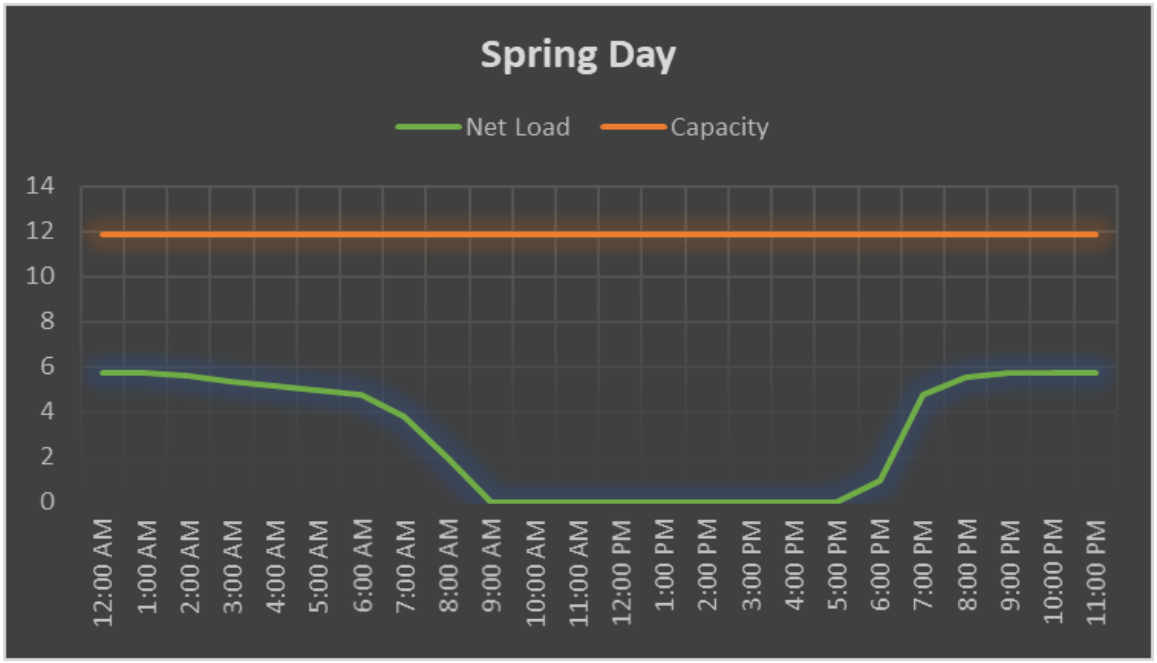


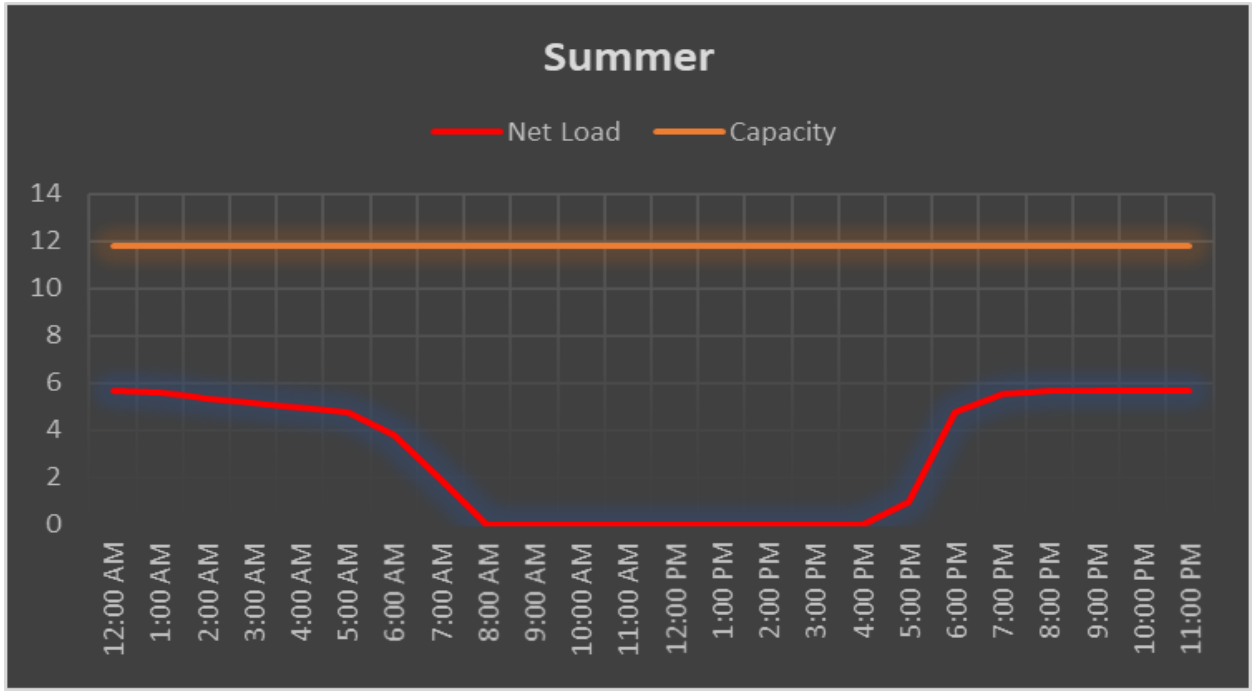
Fleet EV Load For 2050

Key Insights:

- The Company is currently studying 1.9MW in the area.
- Assumption in graph is we will see 3 times that over the next 30 years
- Assuming charging off peak operation hours and similar behavior throughout the year.



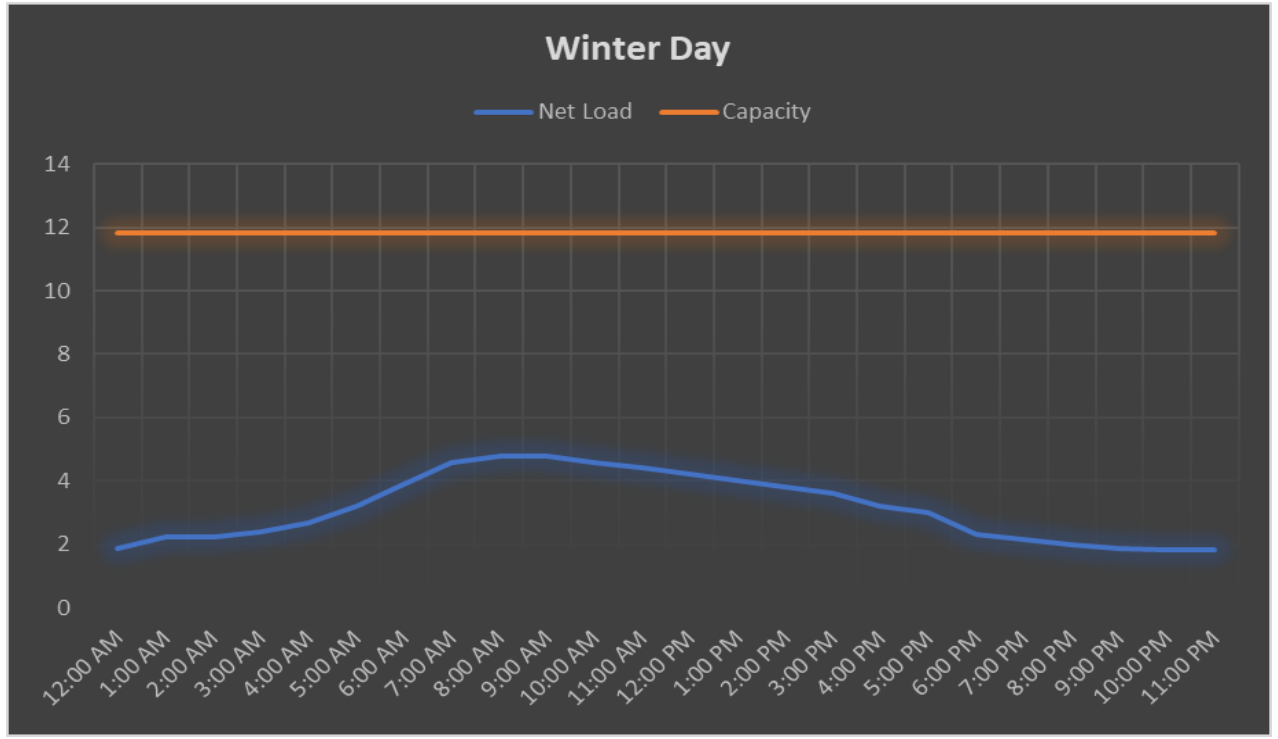


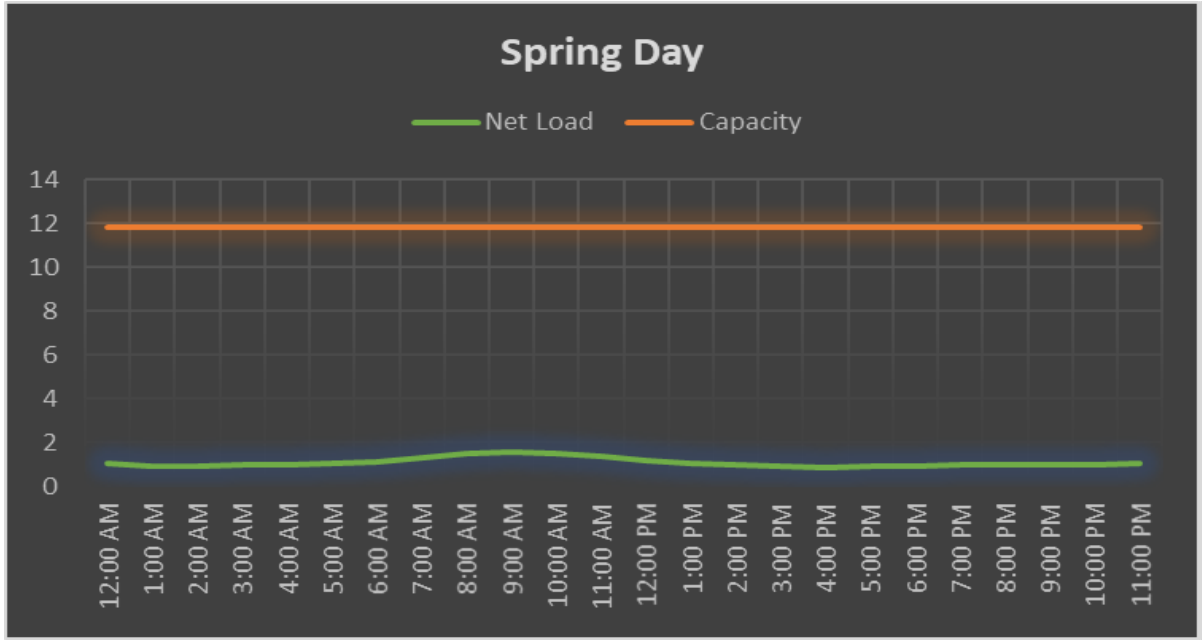


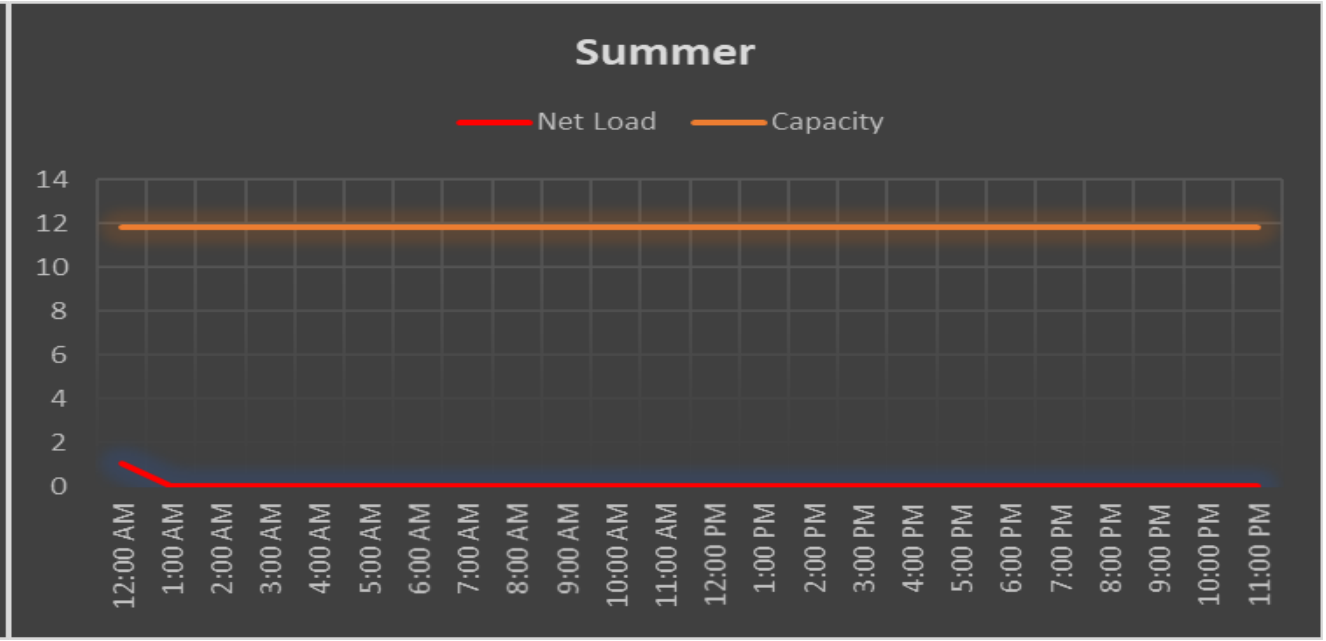
Commercial Electric Heating Load For 2050

Key Insights:

- Assumption is 5MW winter peaking heat pump load.
- Assuming EHP's are impacting winter loads mostly.
- EHP's will peak early morning hours.



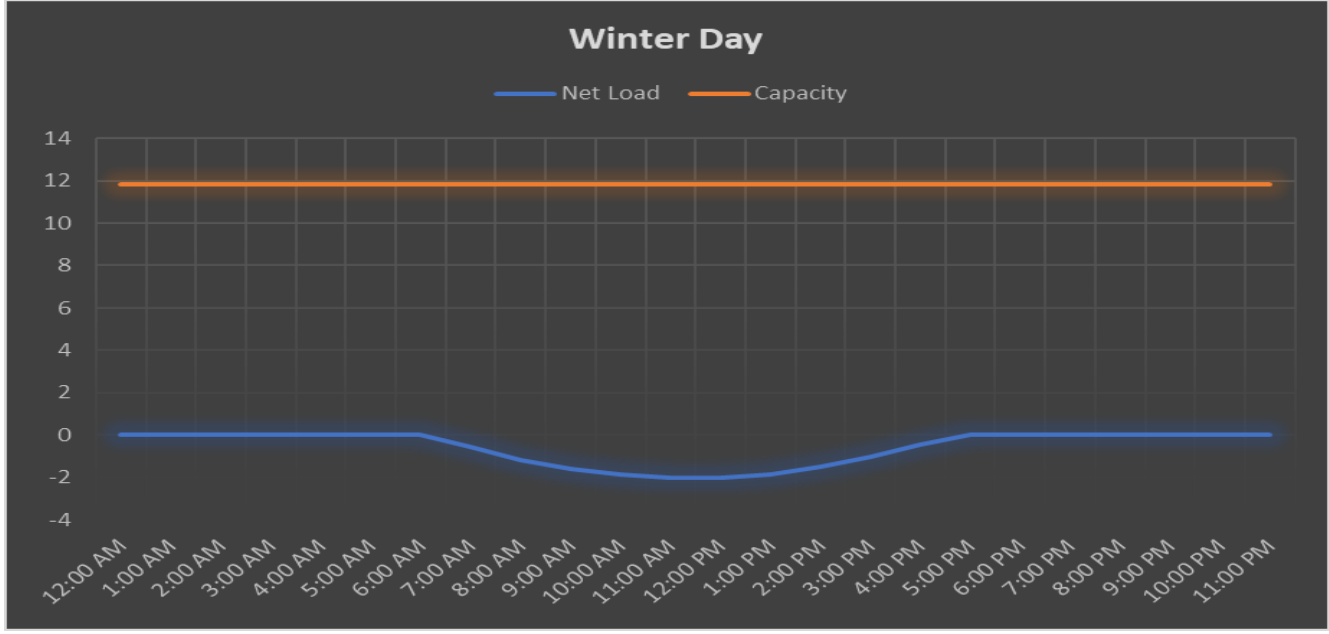


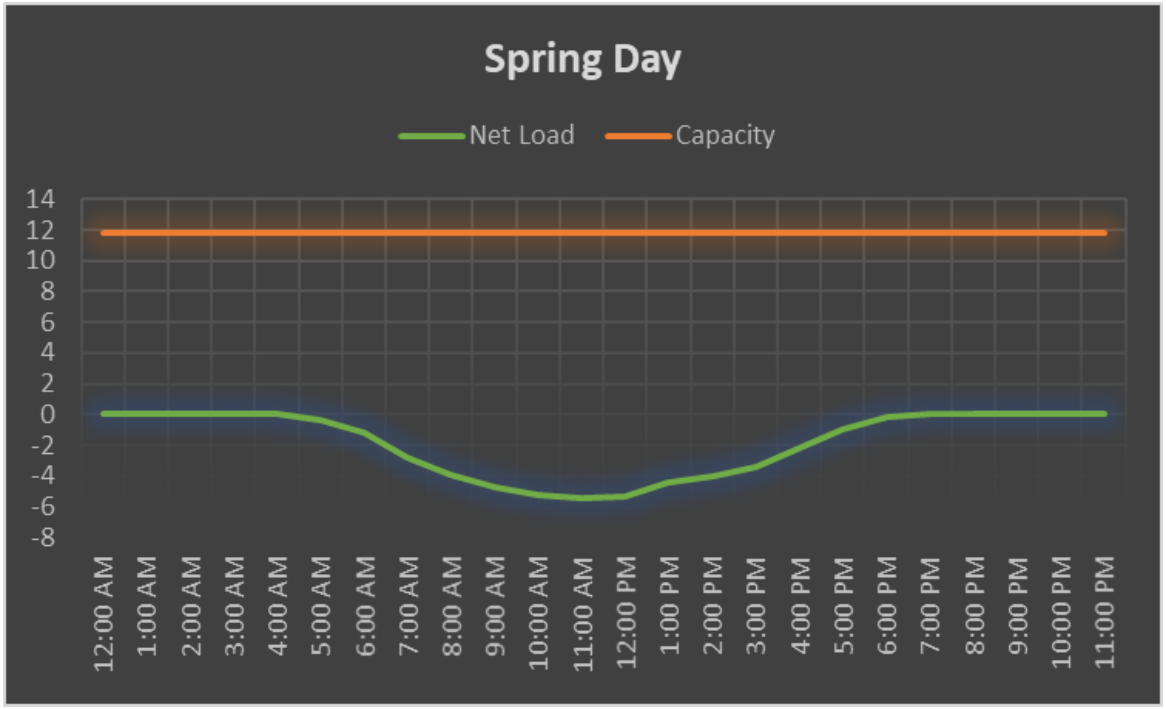


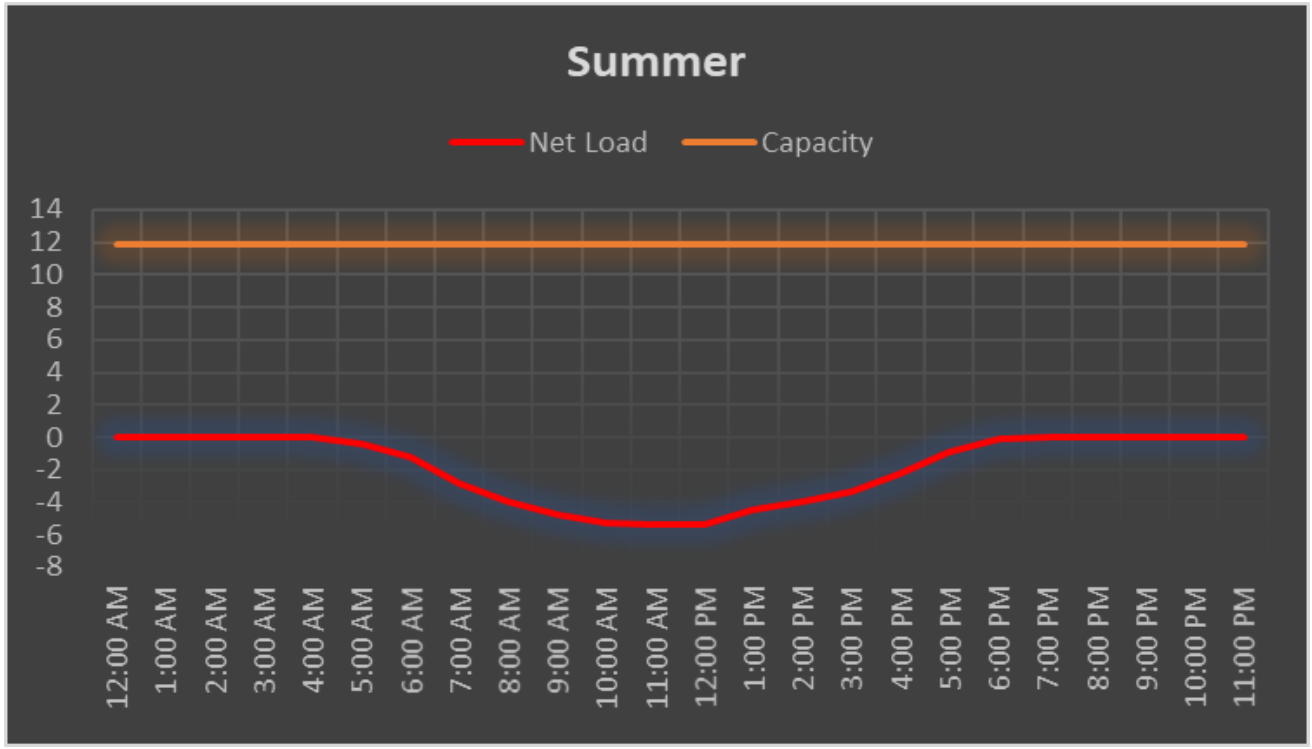
Solar Generation by 2050

Key Insights:

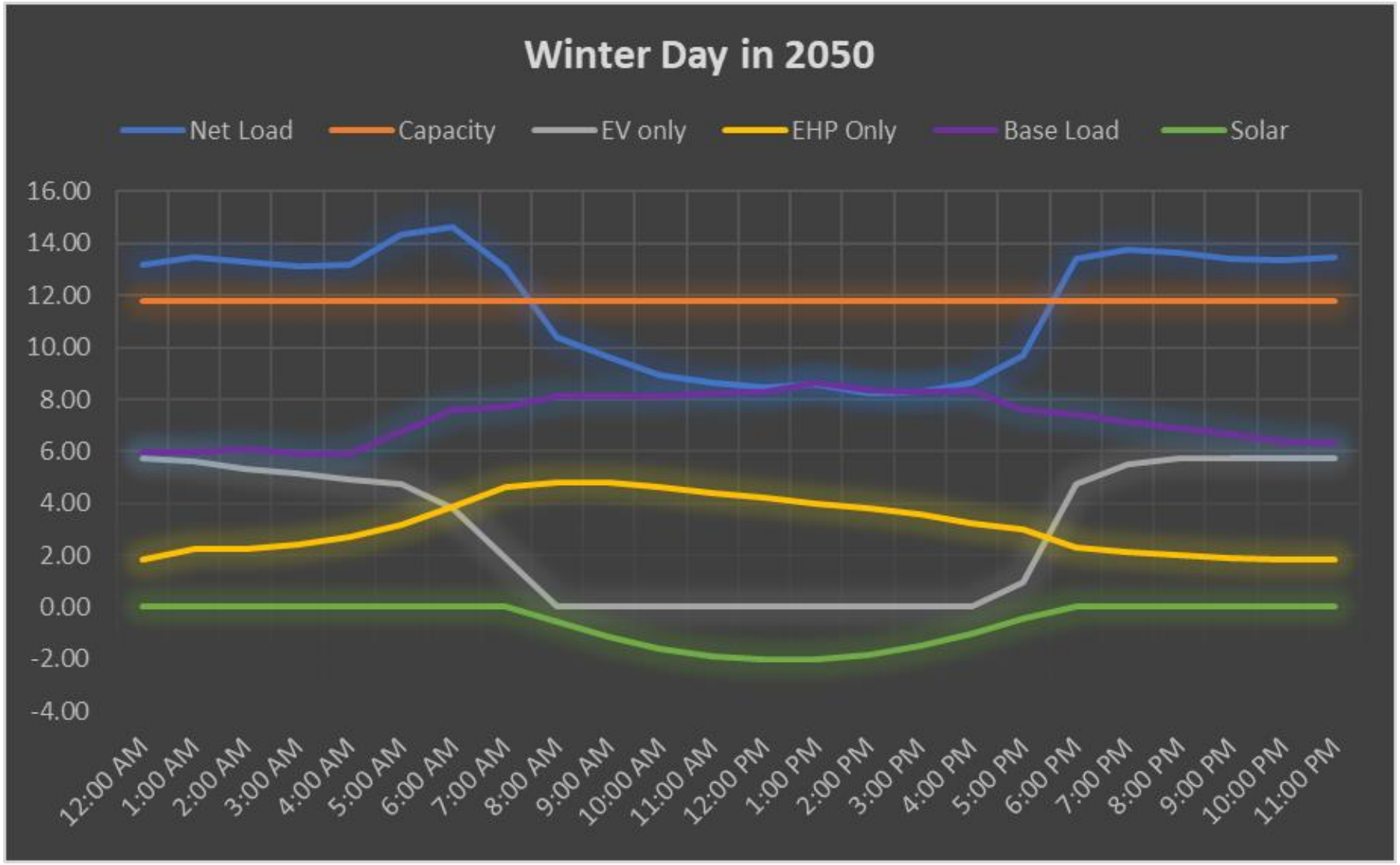
- Winter solar production reduced due to weak irradiance or possible snow coverage.
- Limited land available for ground mount solar.







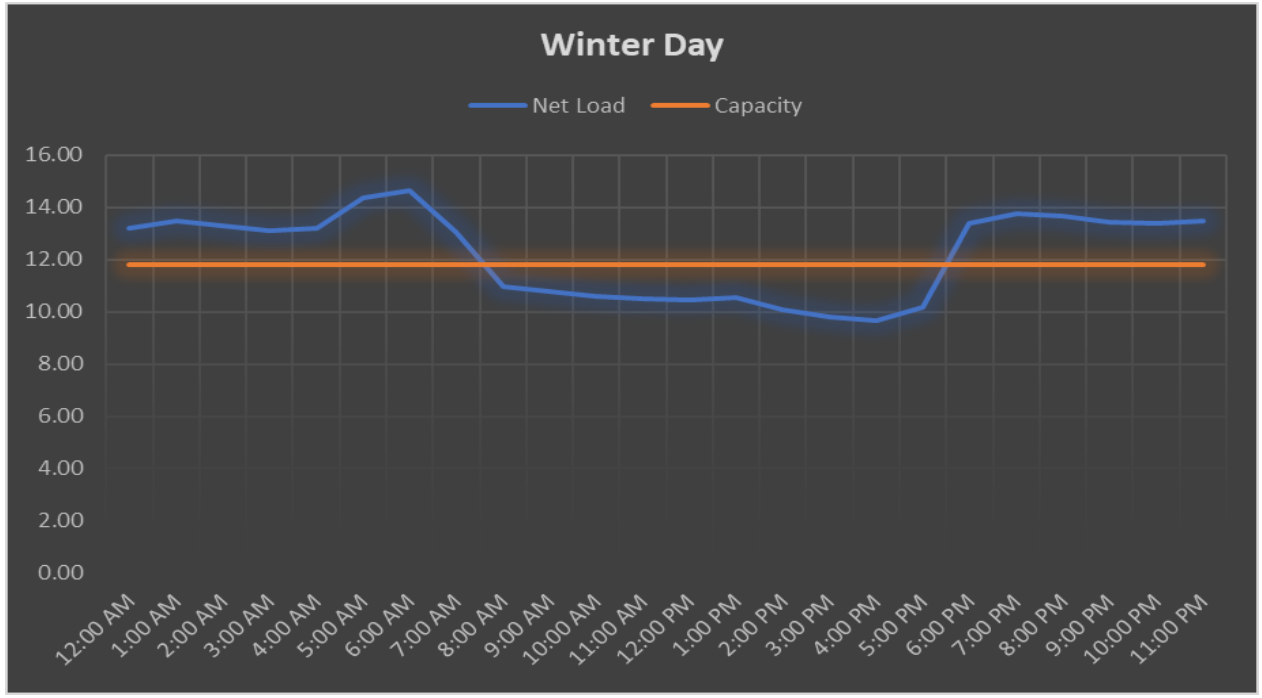
Net Load (By Components) Breakout by 2050

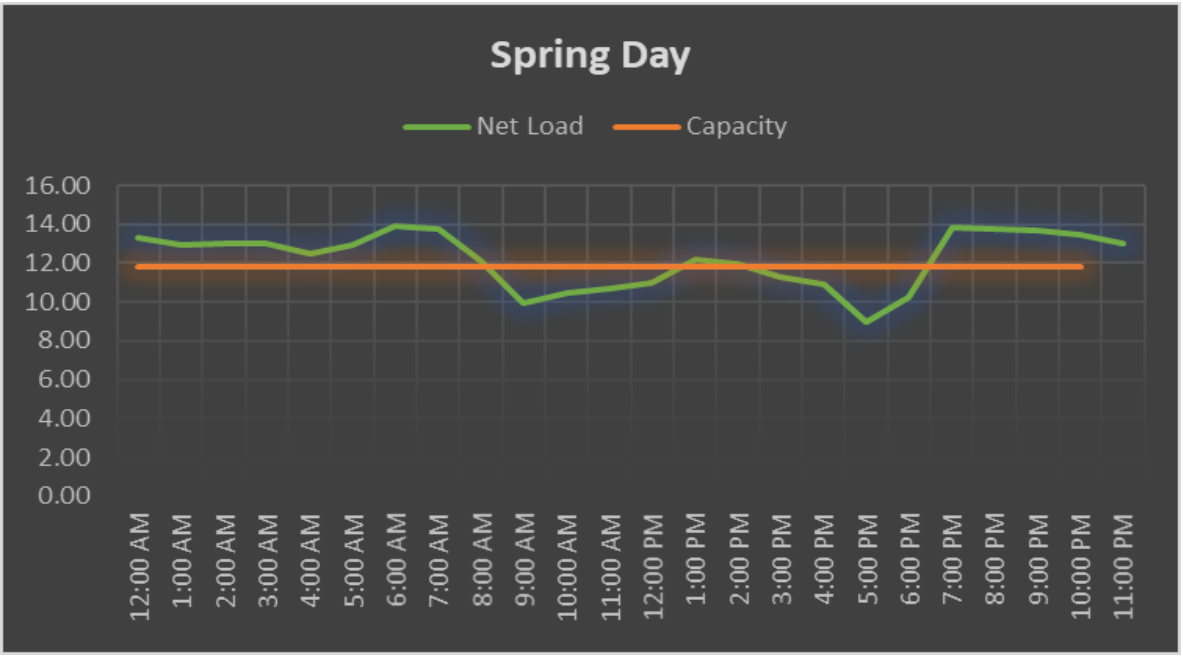


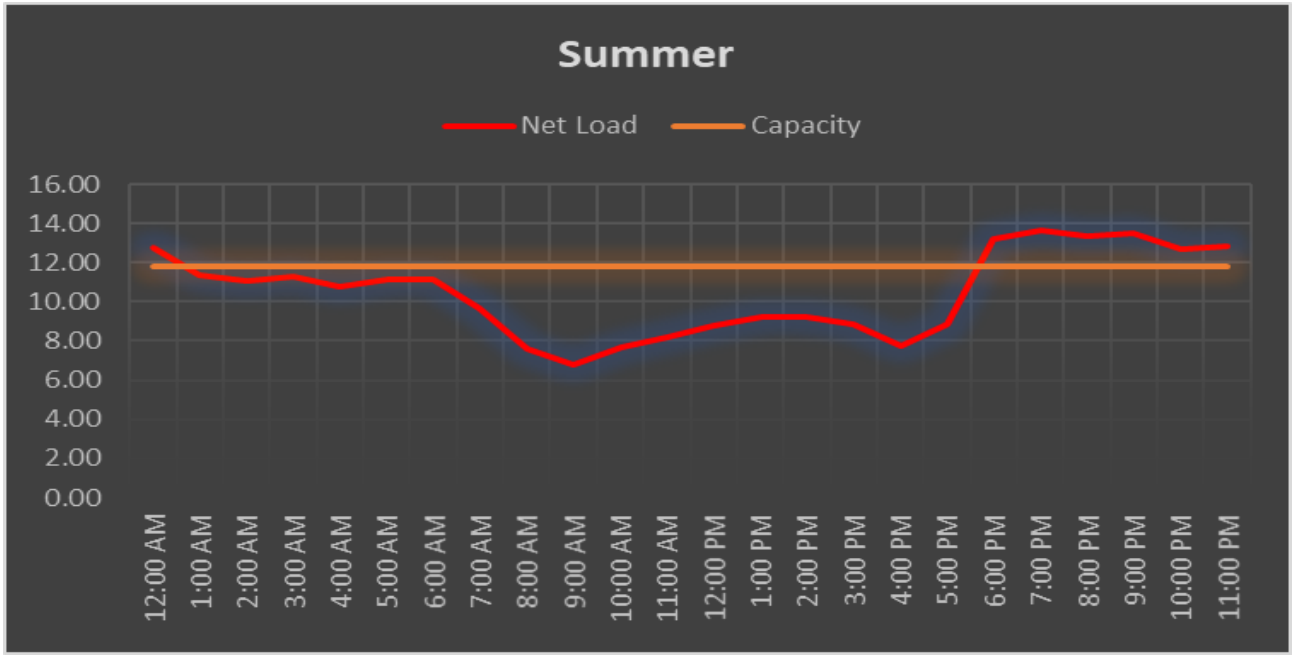
Total Load (excluding generation) For 2050

Key Insights:

- High Evening load caused fleet charging and normal operations.
- High Morning load caused by heating, cooling and normal operations.



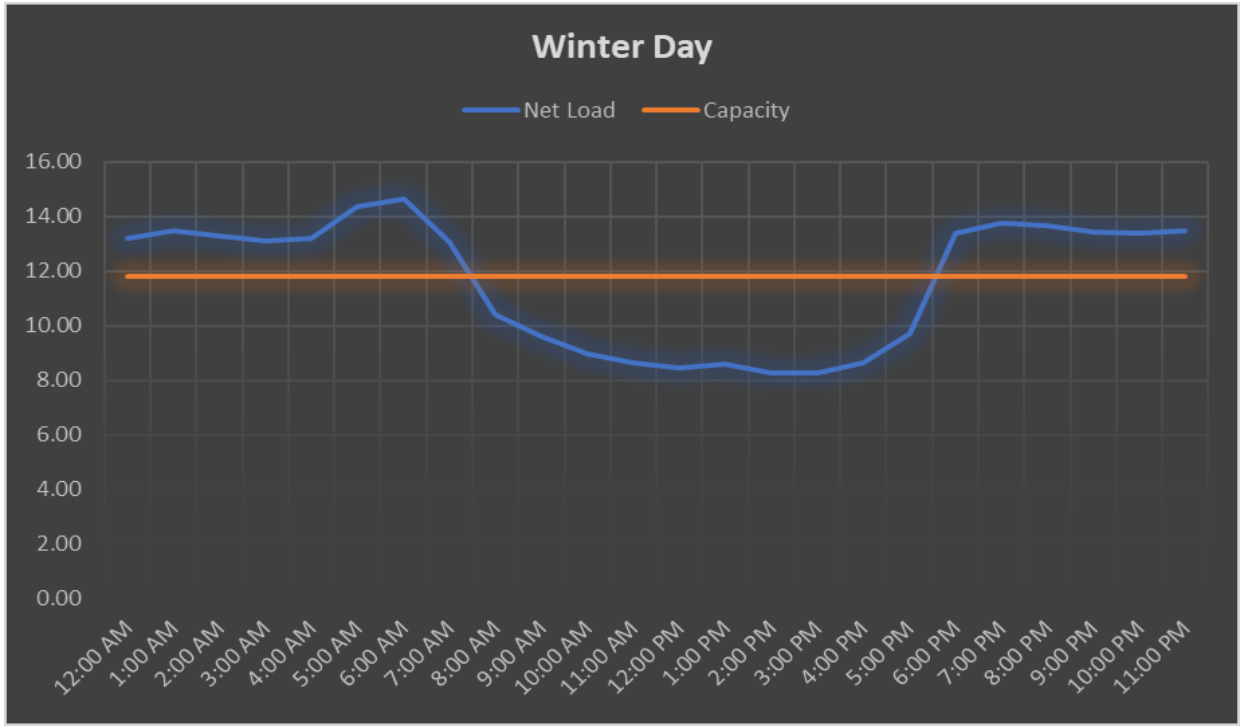


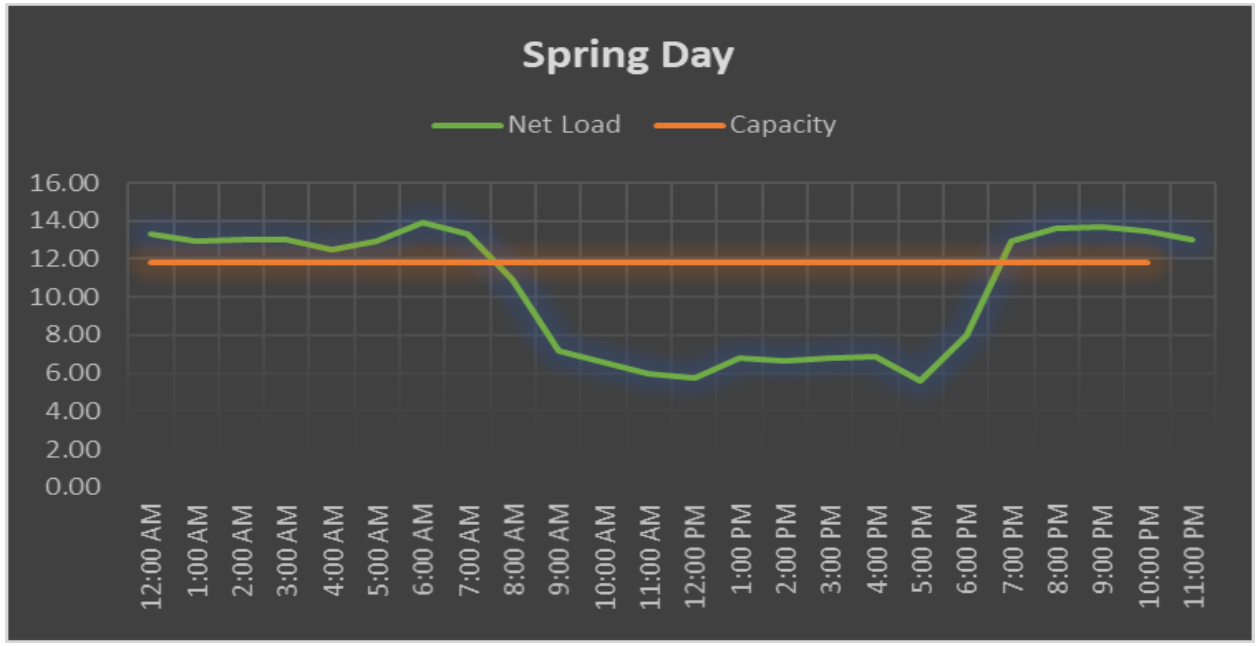


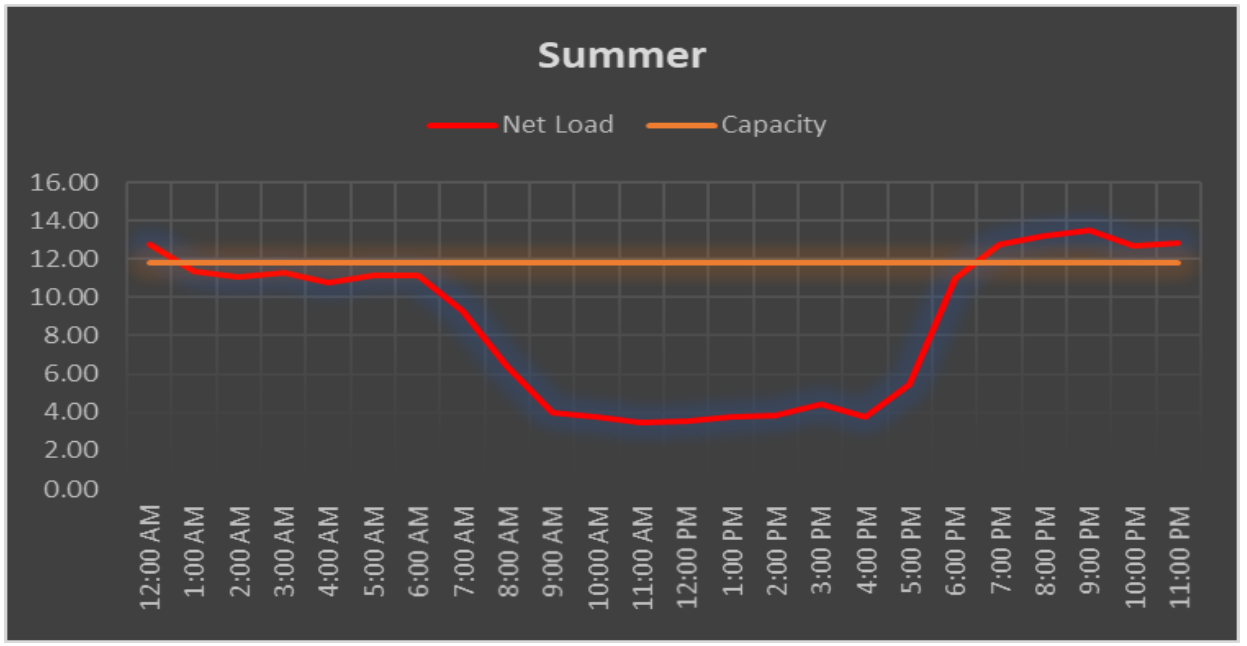
Net Load (Load + DG) by 2050

Key Insights:

- Winter becomes the most challenging part of the year.
- load higher in the evening due to EV charging and drop in solar production.







Options to Solve Summer and Spring Challenges:

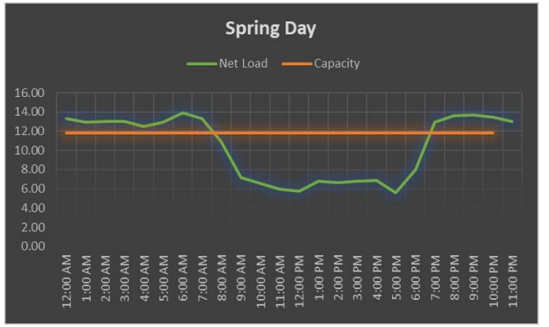
Key Insights:

- The traditional solution is to upgrade the limiting elements on the on the system.
- The least cost option would be for fleet EV customers to agree to customized charging schedules.
- Flexible load and Energy Storage operation developed through Grid Mod will allow for loads to be shifted from peak operation hours using DERMS technology.
- These solutions will only defer upgrades, eventually asset conditions may trigger upgrade needs.

Forecast Day-Ahead System Needs

Day-Ahead Window

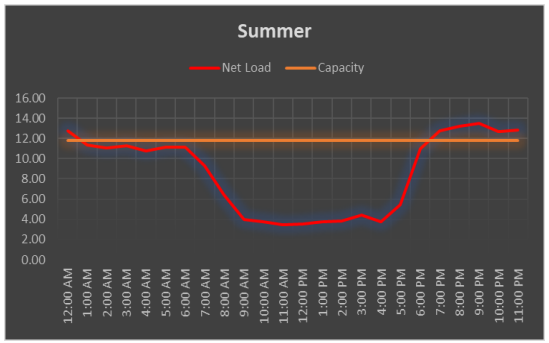
Notify Flexible Load through Marketplace Events



Activate Flexible loads then Curtail Renewable Generators as needed

Real-Time Window

Monitor Loading on Limiting Elements net of flexible loads



Identify Real-Time System Needs

Options to Solving Winter Challenges:

Key Insights:

- The net load on the feeder exceeds the load during most of the day in the winter.
- Flexible load and short-term energy storage are not strong options.

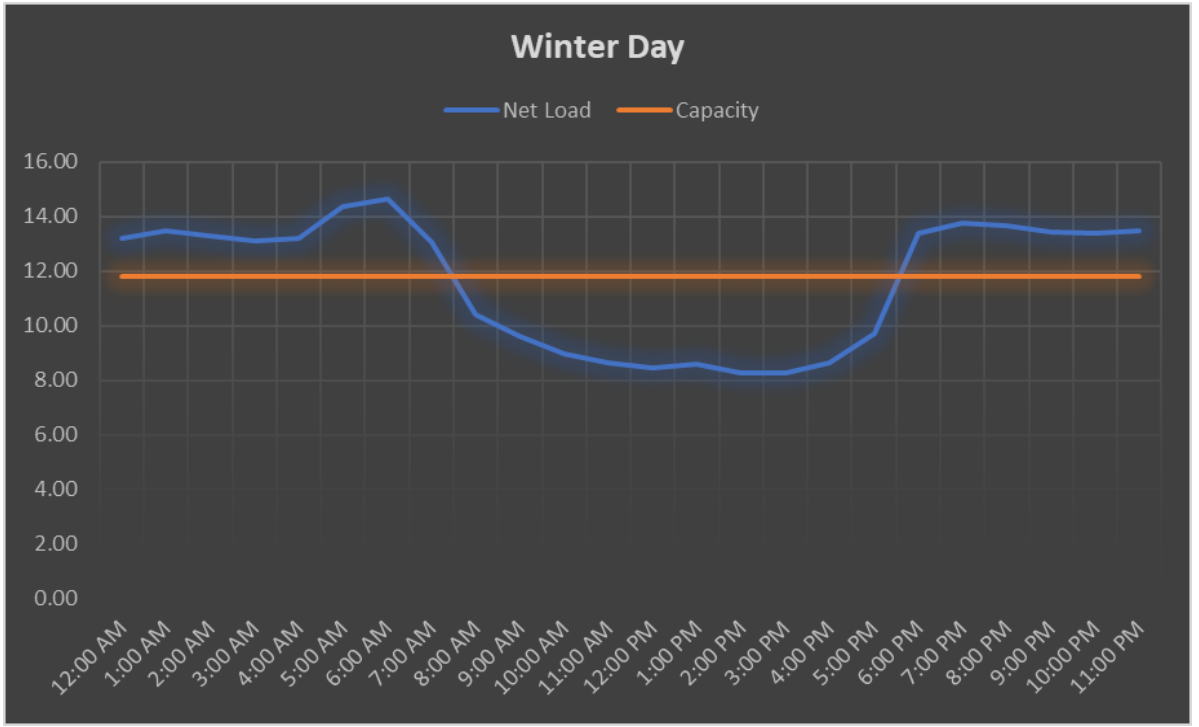
Options can be:

1- Upgrade existing wired system (reconductor, dual feed, etc.)

2-Serving load from neighboring feeders if they have capacity (reallocating load).

4- Long term energy storage.

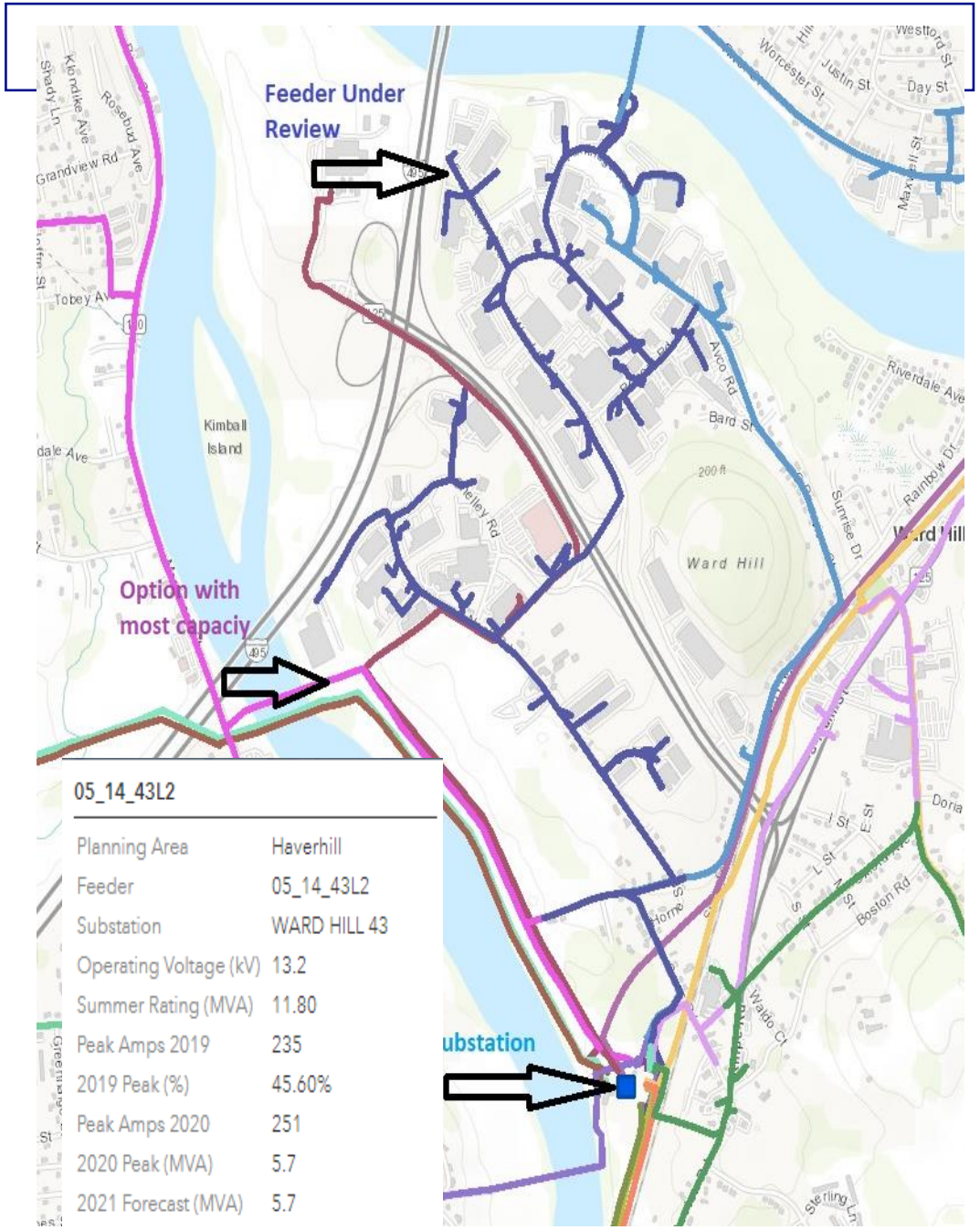
5- New technologies such as using a freezer as a demand response solution.



Serving from Neighbouring Feeders

Key Insights:

- The best feeder to serve the additional load is 05_14_43L2. Records show it is at 50% capacity with applications currently in, putting it near or over rated capacity.
- The challenge is that we are expecting additional load on the neighboring feeders as well.
- The Wardhill Substation shown has a name plate capacity of 55MVA. The substation feeds 7 feeders with a total capacity 75MVA.
- If the total load across the 7 feeders is greater than the station transformer nameplate rating, the transformer will need to be upgraded, which is among the most costly options.



Question

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Plenary Discussion

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Plenary Discussion Points

- Identified Impacts
  - 1
  - 2
  - 3
- Potential Barriers
  - 1
  - 2
  - 3
- Innovative Opportunities
  - 1
  - 2
  - 3

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