

ESKWELABS COHORT 5

FORECASTING THE POWER DEMAND OF THE LUZON ELECTRICAL GRID USING CLUSTERING AND PREDICTIVE MODELING

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624MW

Low surplus of power in 2019;
short of contingency reserve of 647MW



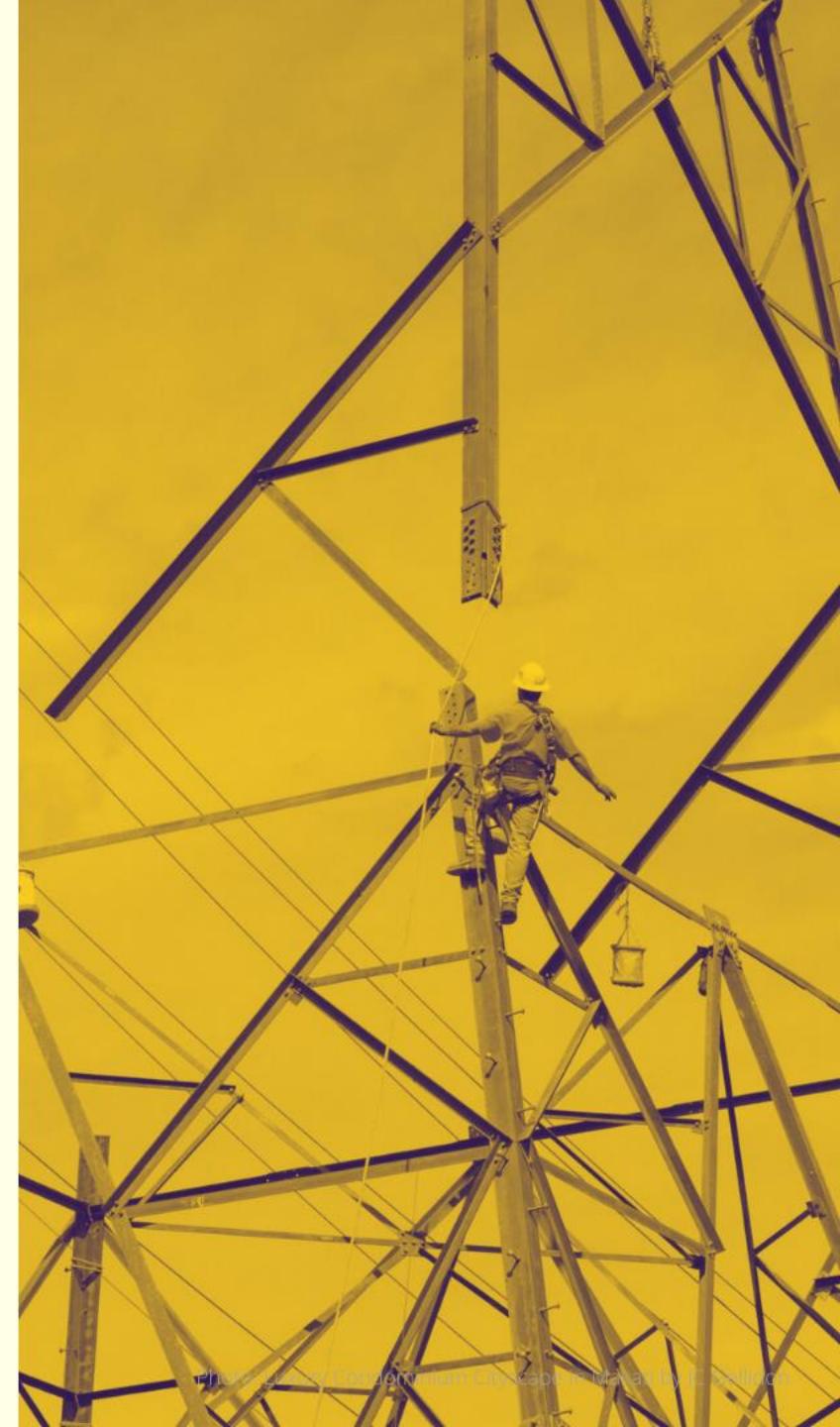
1,025MW

Average difference
between power demand and supply in 2019

High electricity demand per day leads to yellow and red alerts,
meaning unscheduled power outages.

SIGNIFICANCE

Forecasting electricity demand serves as the foundation in the **planning of additional power generation**. It can also be utilized to establish **energy security** within the system. Additionally, it could serve as the **basis for infrastructure development**. Lastly, it is also a good indicator of economic growth.



OBJECTIVES



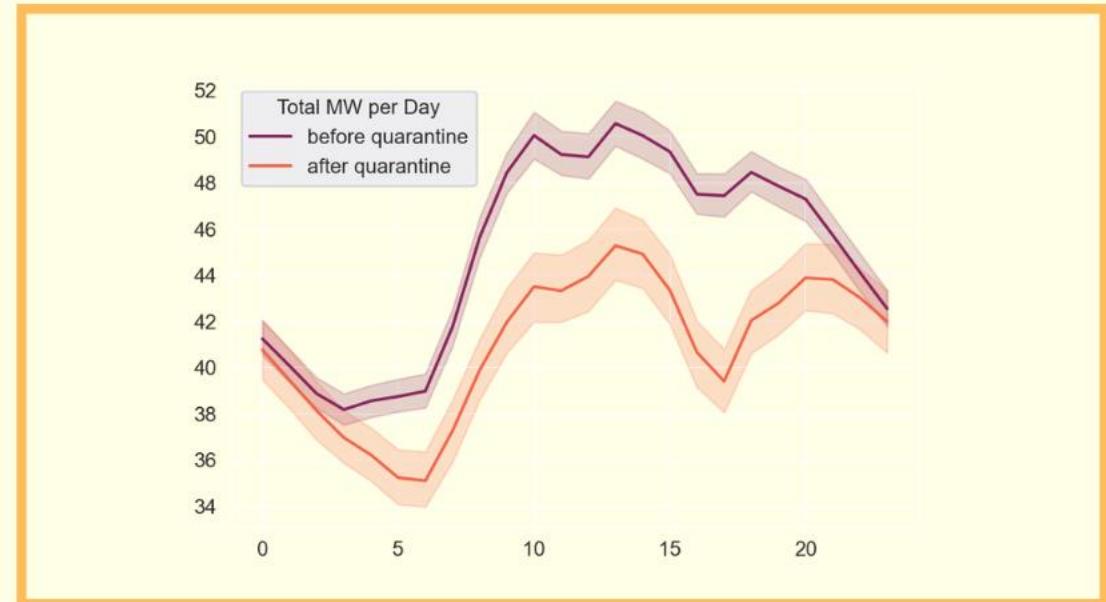
IEMOP
INDEPENDENT ELECTRICITY MARKET OPERATOR
PHILIPPINES

2 EXPLORATORY DATA ANALYSIS (EDA)

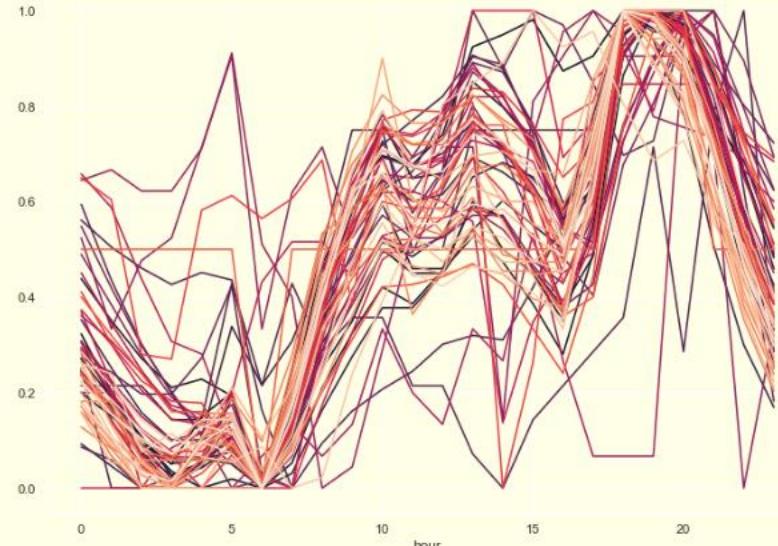
- Explore and clean data
- Gather insights from the data

1 DATA GATHERING

- Obtain data from the IEMOP website



OBJECTIVES

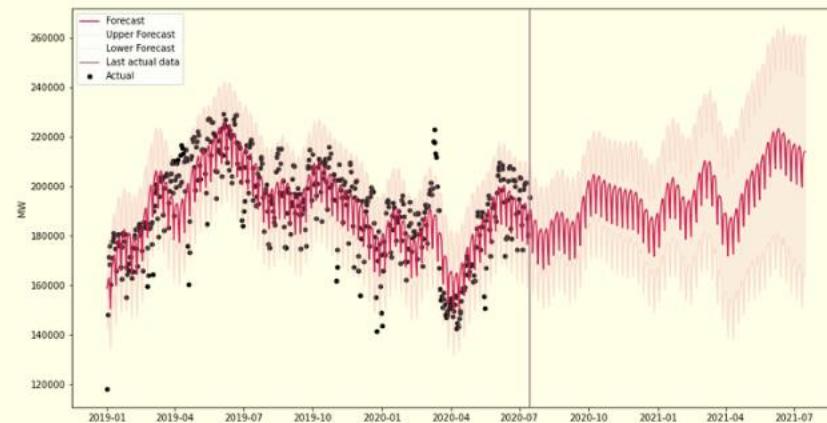


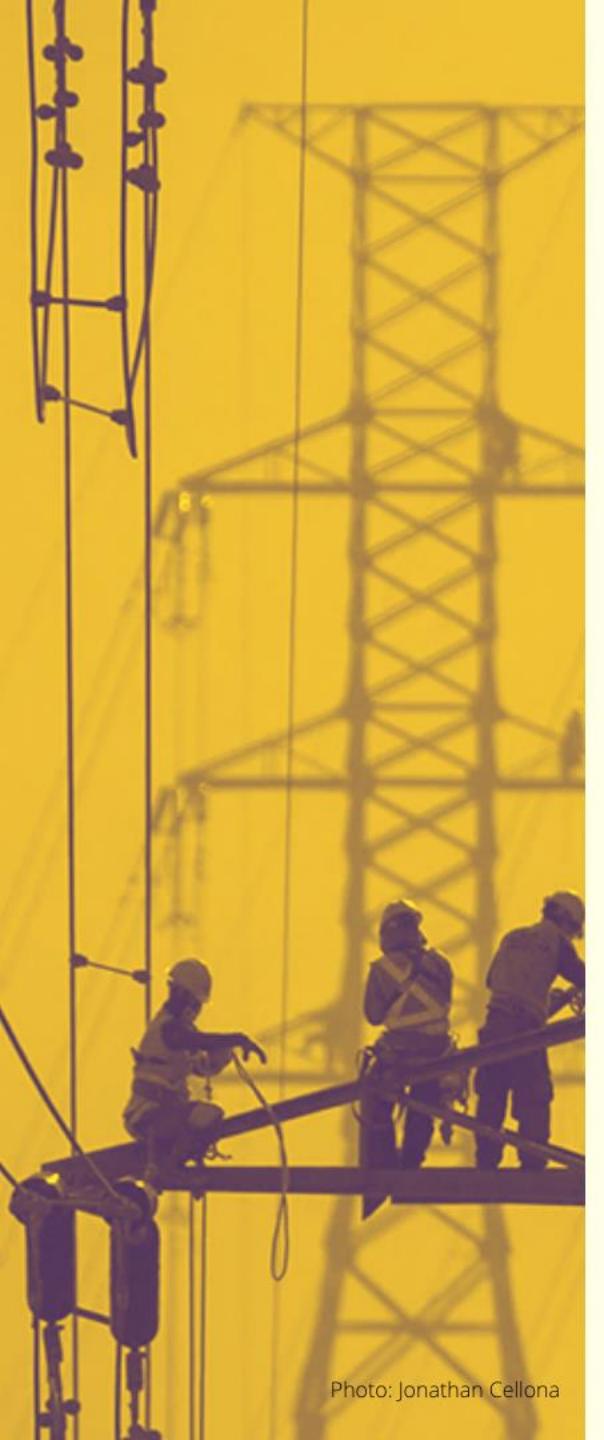
4 FORECASTING

- Estimate the power demand of clusters and Luzon in total, by using various time series models

3 CLUSTERING

- Find patterns in power demand
- Find similarities between resources, by using multilayered clustering algorithms
- Provide an alternative to forecasting total power demand (i.e. forecasting per cluster)





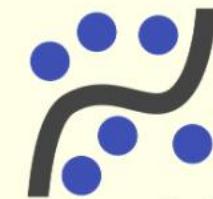
TOOLS



Python



Jupyter
Notebook



statsmodels



Facebook
Prophet



RAW DATA

Power demand data from 1-Jan-2019 to 15-Jul-2020
was extracted from the IEMOP database.

4,954,278 entries

13,484 hours

264 resources

2 regions



CLEAN DATA

Our analyses are focused on the power demand from 1-Jan-2019 to 15-Jul-2020 in Luzon.

2,440,880 entries

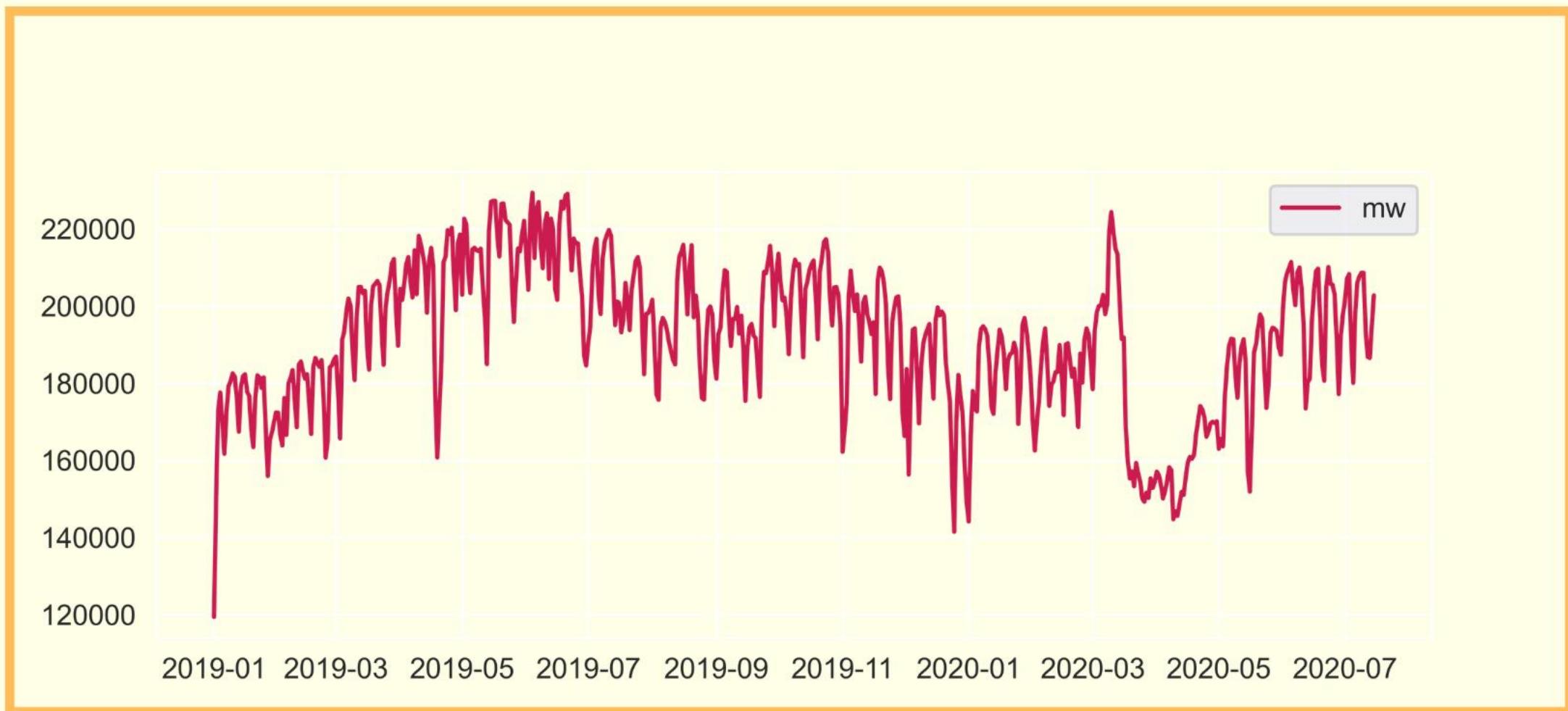
13,484 hours

183 resources

1 region



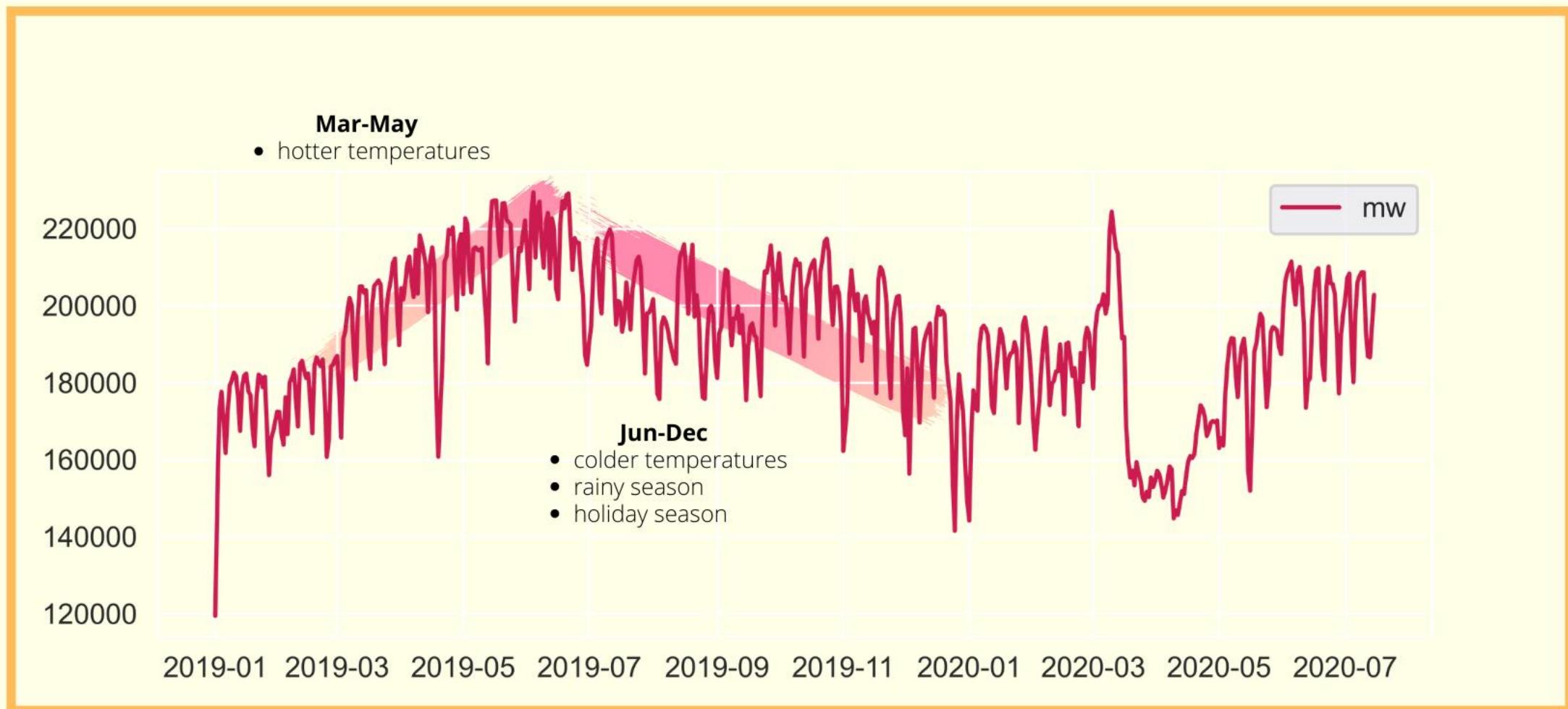
Total daily power demand of the Luzon grid,
from 1-Jan-2019 to 15-Jul-2020



Note: Using dataset with all 183 resources

Photo: TED ALJIBE/AFP via Getty Images

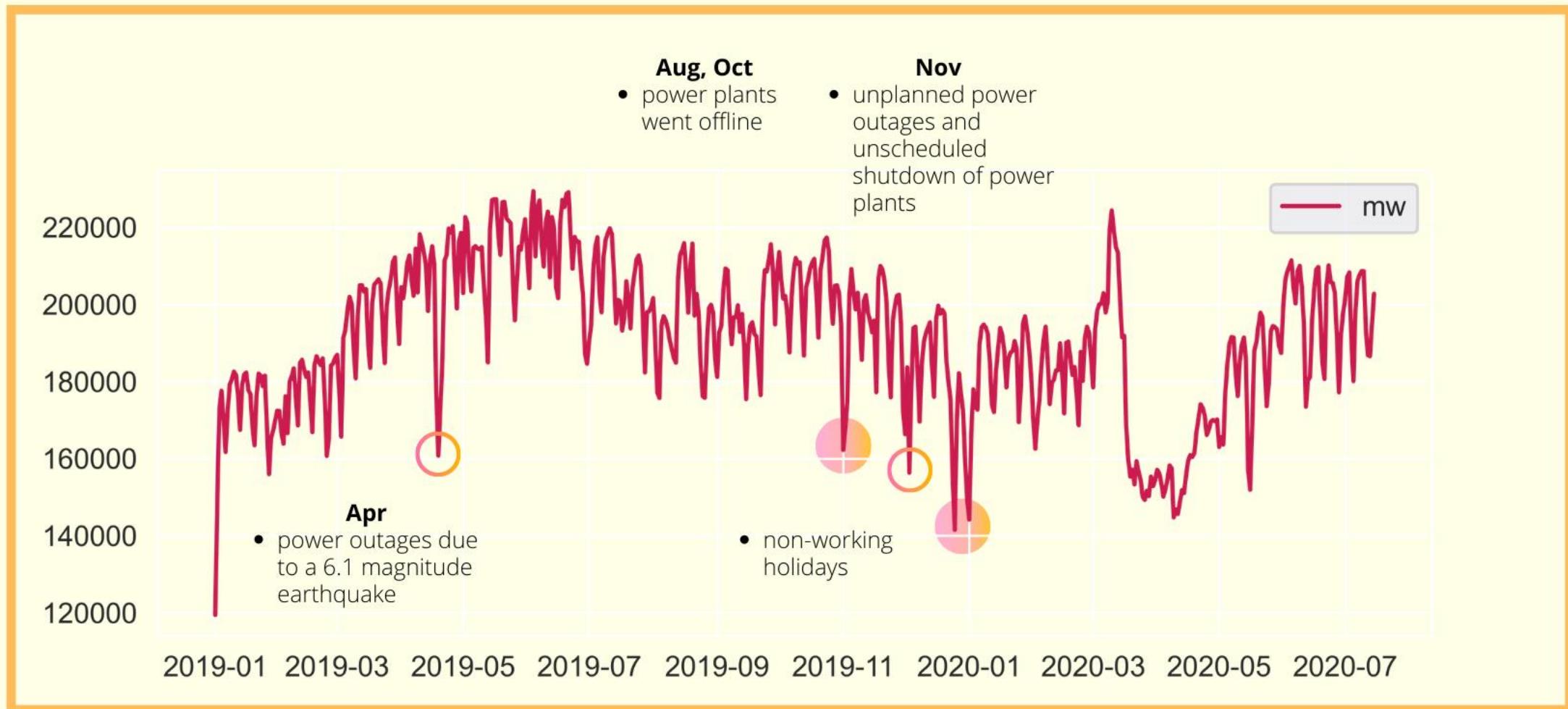
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Photo: TED ALJIBE/AFP via Getty Images

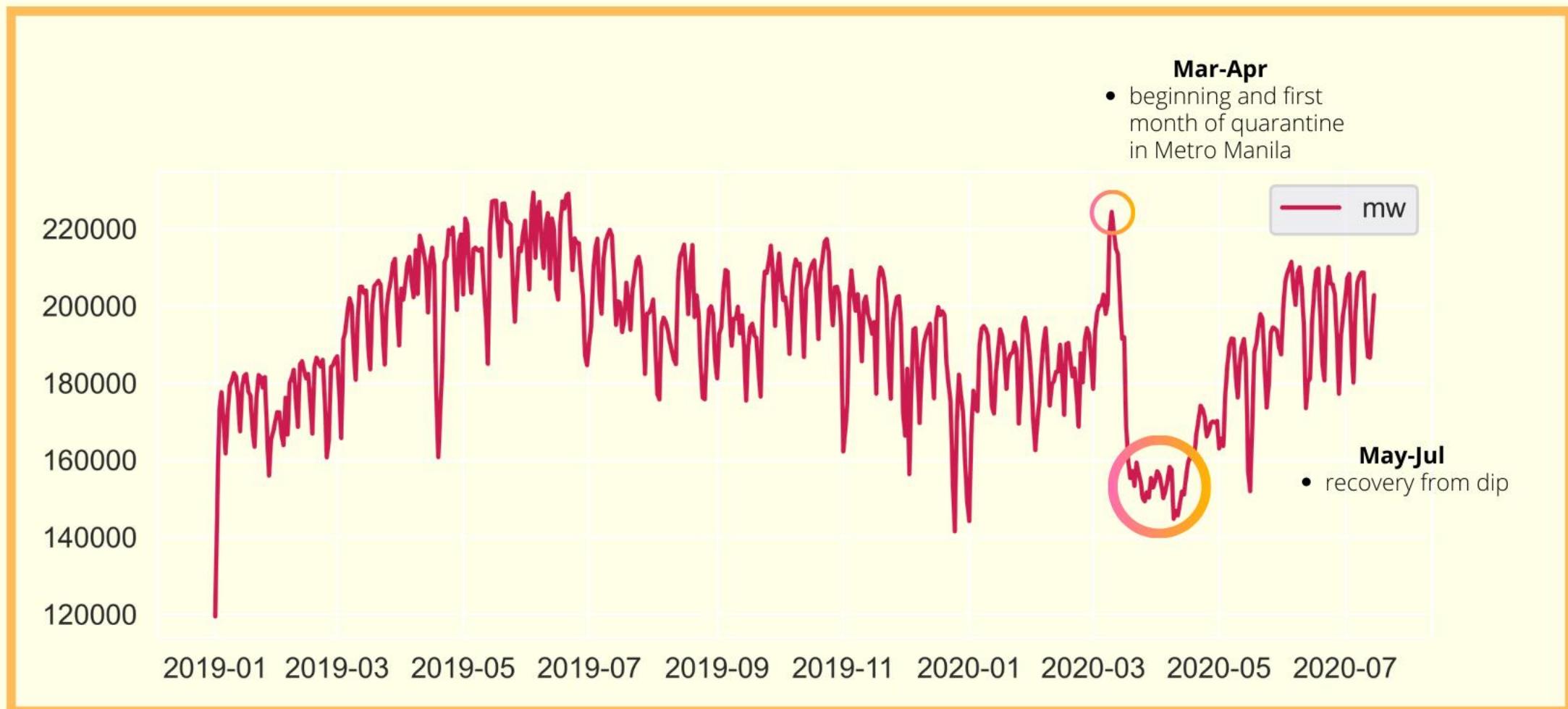
Total daily power demand of the Luzon grid, from 1-Jan-2019 to 15-Jul-2020



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Photo: TED ALJIBE/AFP via Getty Images

Total daily power demand of the Luzon grid,
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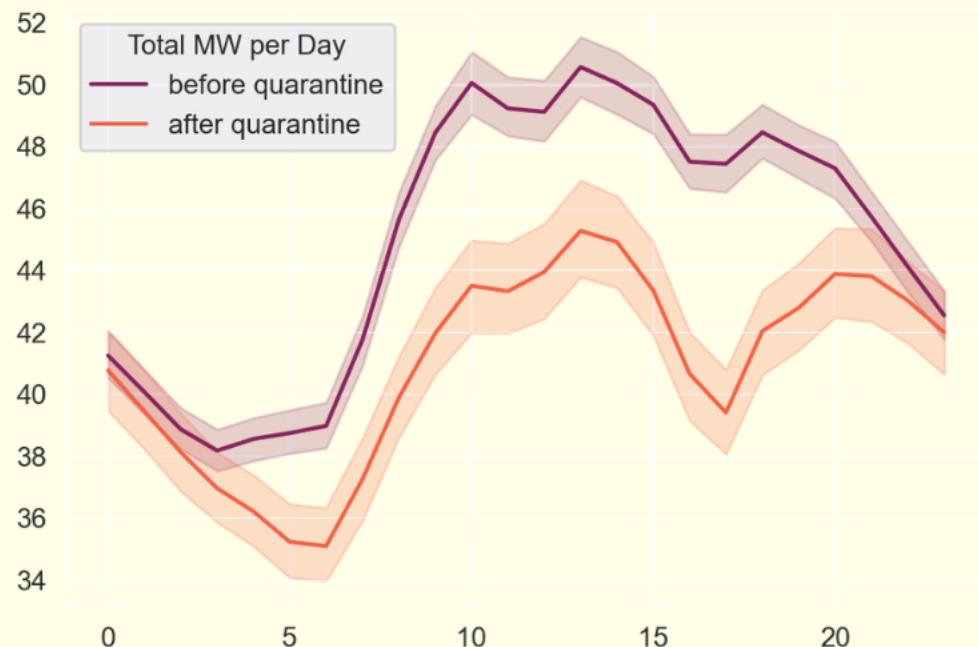


Note: Using dataset with all 183 resources

Photo: TED ALJIBE/AFP via Getty Images

EDA

Average power demand per hour per resource before and during quarantine*

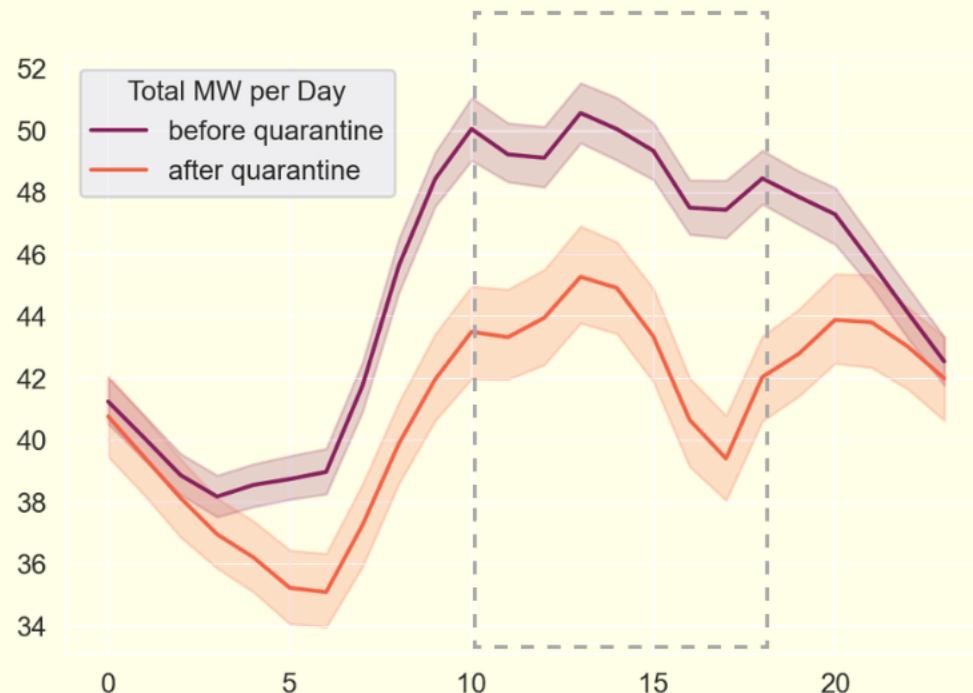


**POWER
CONSUMPTION
DECREASED
DURING QUARANTINE.**

Note: Quarantine in Metro Manila was enforced starting 15-Mar-2020.

EDA

Average power demand per hour per resource before and during quarantine*

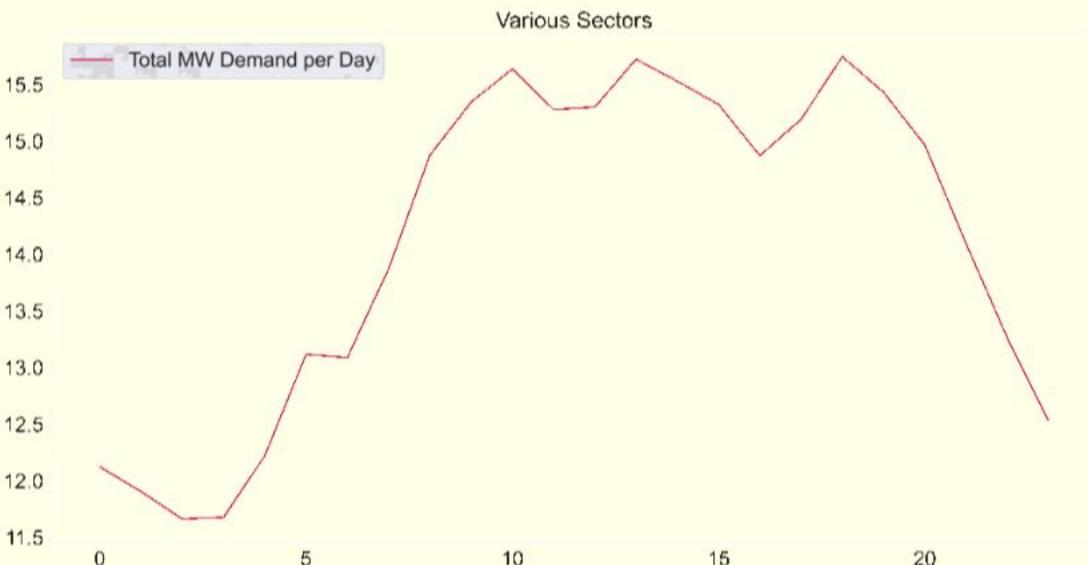


**POWER
CONSUMPTION
DECREASED
DURING QUARANTINE
ESPECIALLY DURING MORNING
SHIFT OFFICE HOURS.**

Note: Quarantine in Metro Manila was enforced starting 15-Mar-2020.

EDA

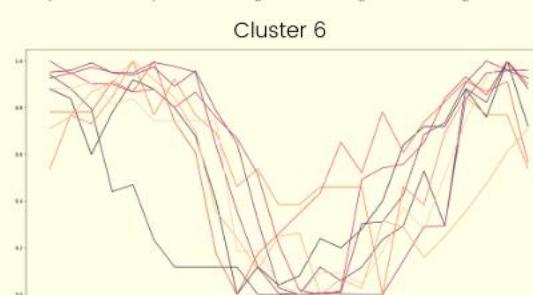
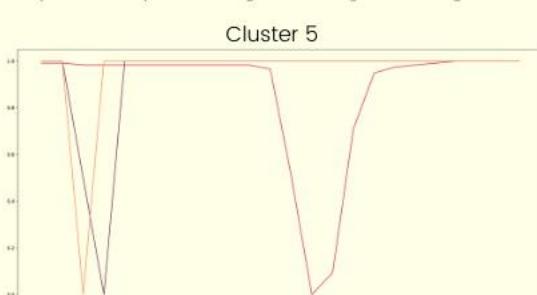
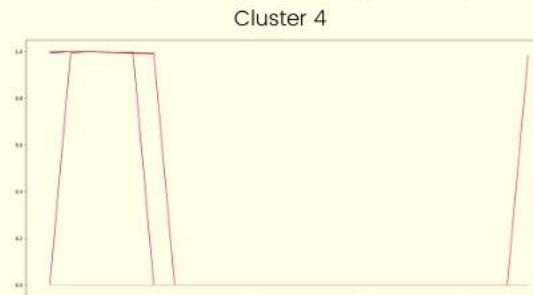
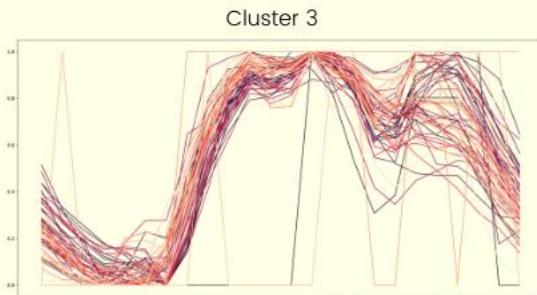
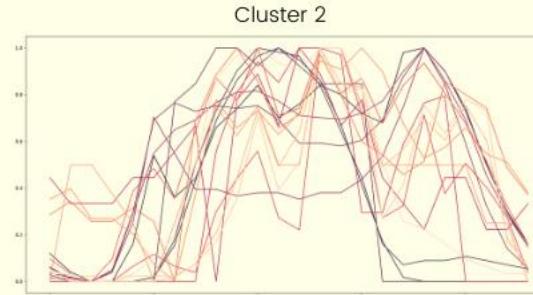
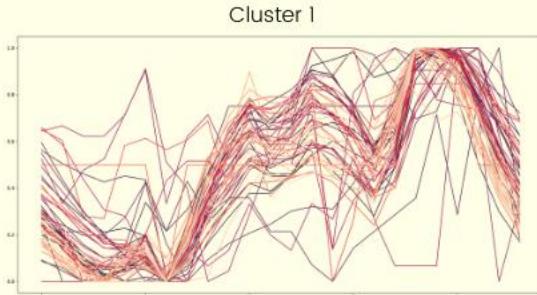
Average power demand per hour of resources,
from 1-Jan-2019 to 15-Jul-2020



LOOKING AT LUZON AS A WHOLE
DOES NOT ILLUSTRATE
**DIFFERENCES IN
BEHAVIOR
IN POWER DEMAND
AT THE RESOURCE LEVEL!**

EDA

Median power demand per hour per resource,
from 1-Jan-2019 to 15-Jul-2020



WE WERE ABLE TO
SEE PATTERNS
PER RESOURCE
AND
IDENTIFY SIMILARITIES
BETWEEN RESOURCES.



CLUSTERING

DATA PRE-PROCESSING

Normalize the median MW value of each resource per hour to focus on daily shape of power demand

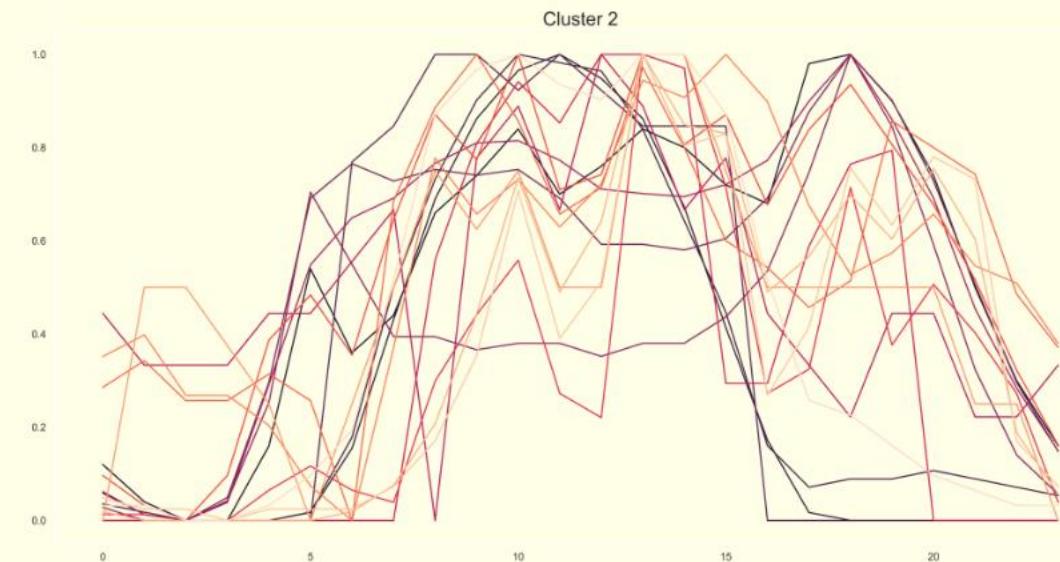
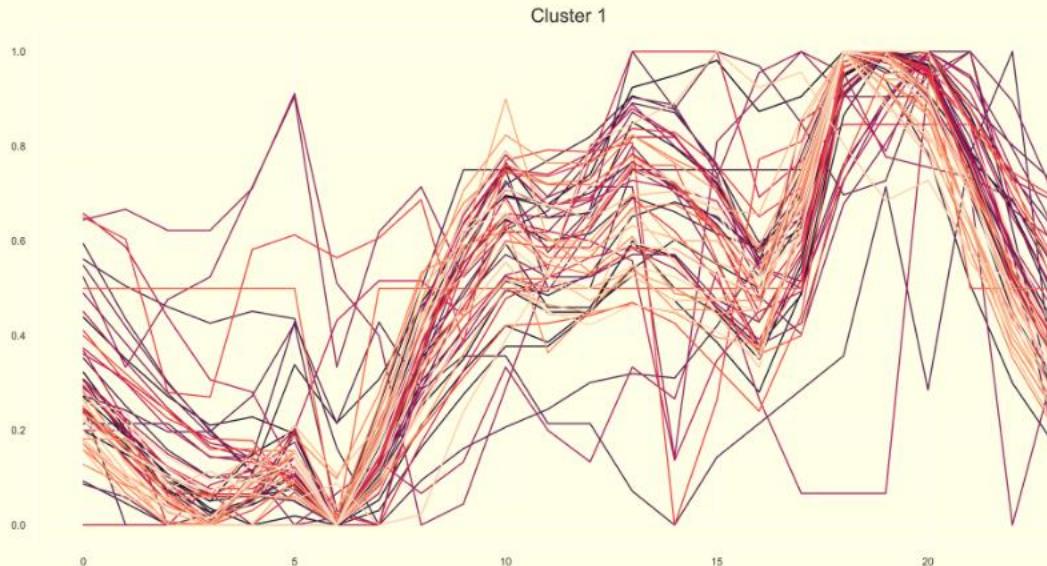
CLUSTERING ALGORITHM

Multilayered time series clustering algorithms were employed, with Hierarchical Agglomerative Clustering yielding the most sensible results.

OUTPUT

Six distinct clusters, interpreted by their sector affiliation based on the common movement of power demand in between resources

CLUSTERING



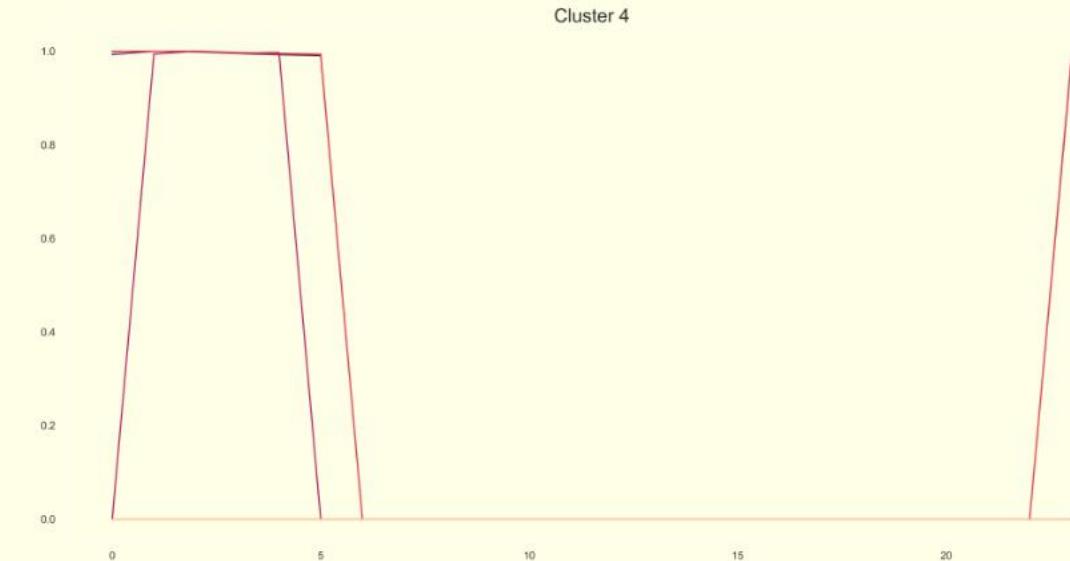
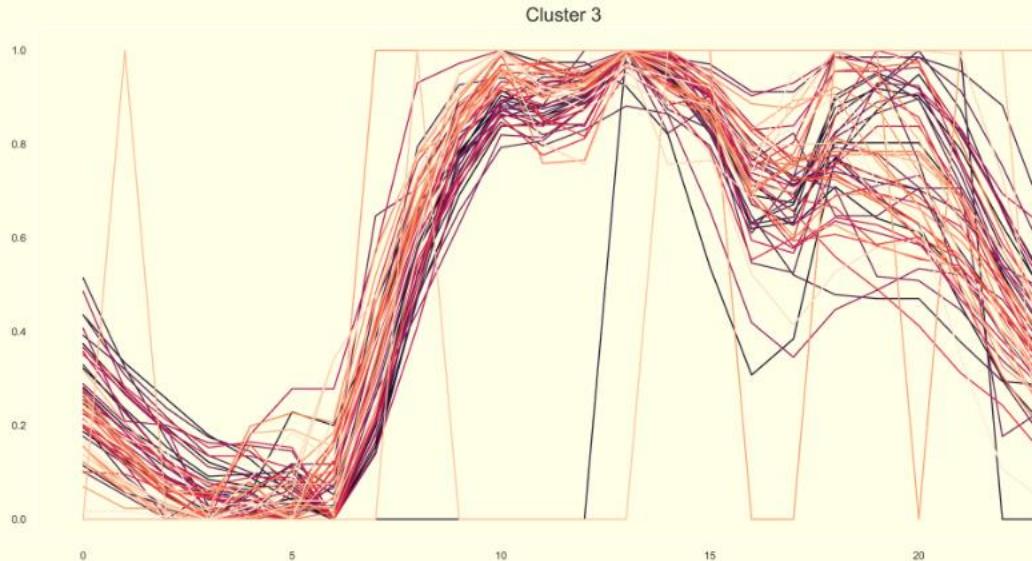
RESIDENTIAL SECTOR

- 59 resources
- 25,812MW daily power demand

VARIOUS SECTORS

- 17 resources
- 5,795MW daily power demand

CLUSTERING



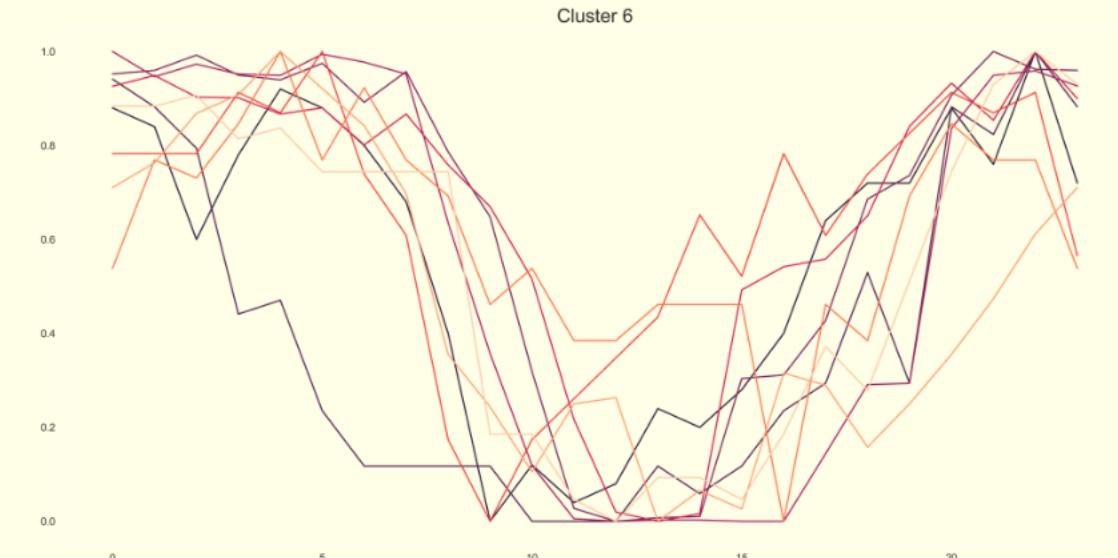
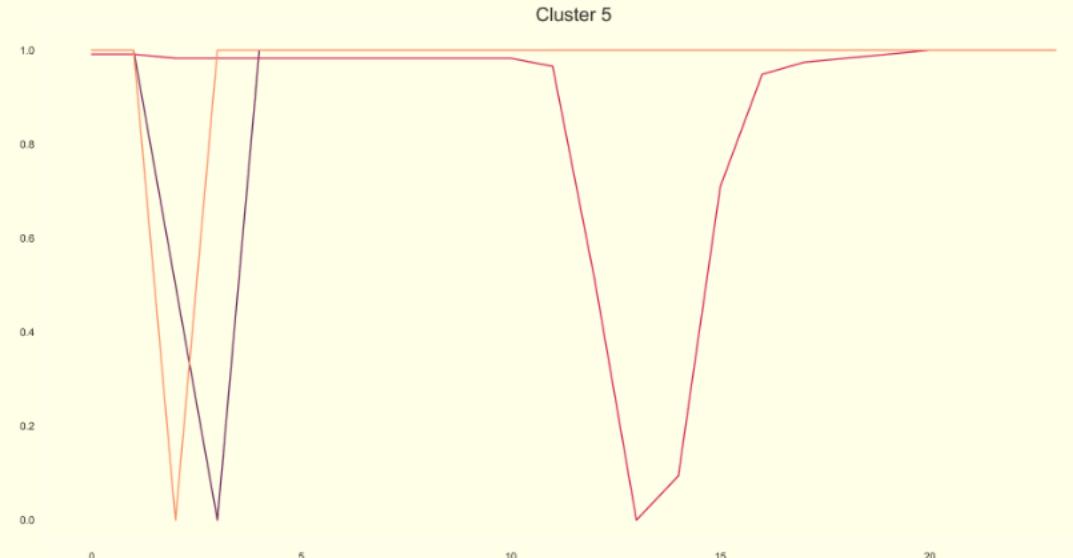
COMMERCIAL SECTOR

- 59 resources
- 152,841MW daily power demand

POWER GENERATION UNITS

- 6 resources
- 4,412MW daily power demand

CLUSTERING



INDUSTRIAL SECTOR

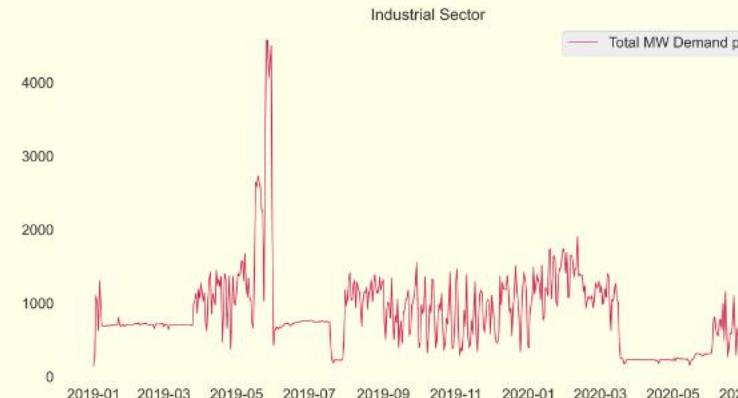
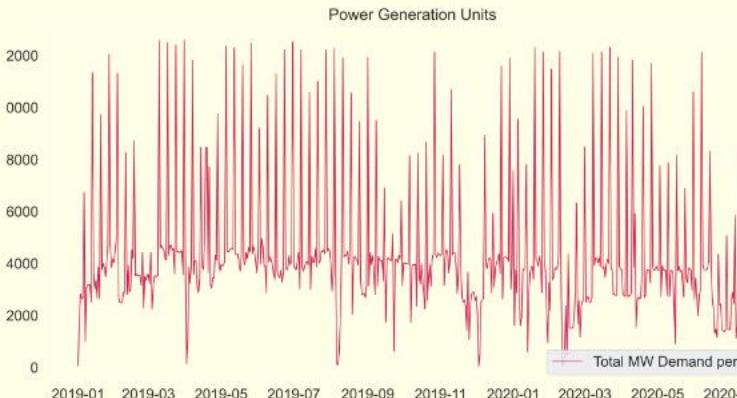
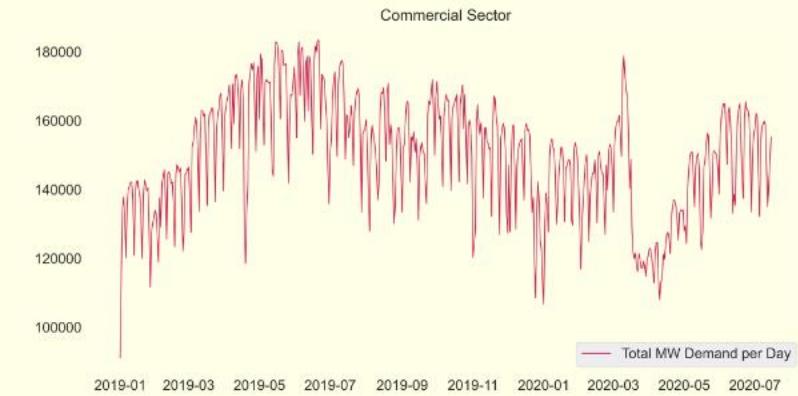
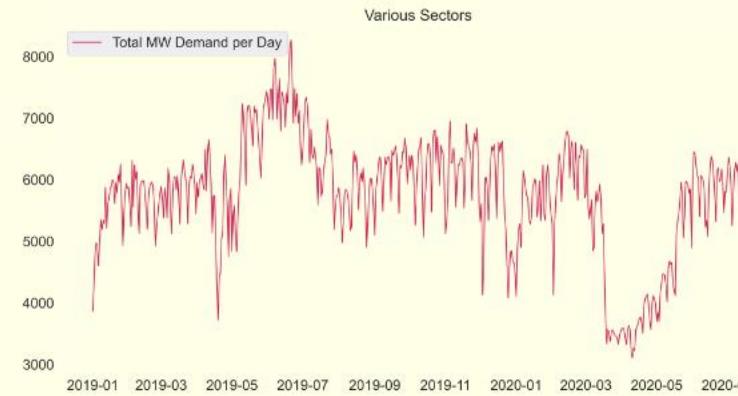
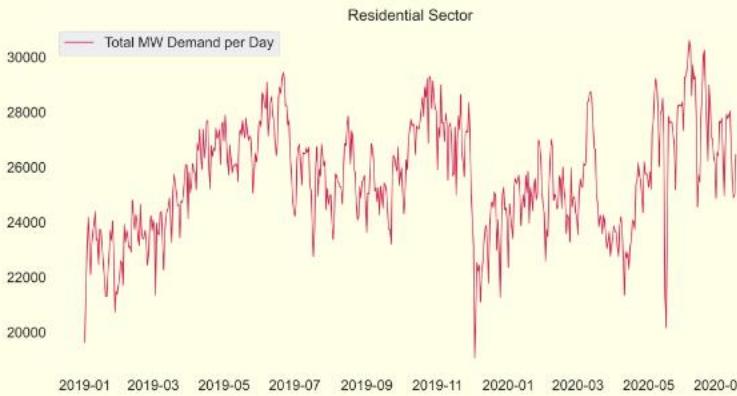
- 3 resources
- 879MW daily power demand

COMMERCIAL SECTOR

- 9 resources
- 4,228MW daily power demand

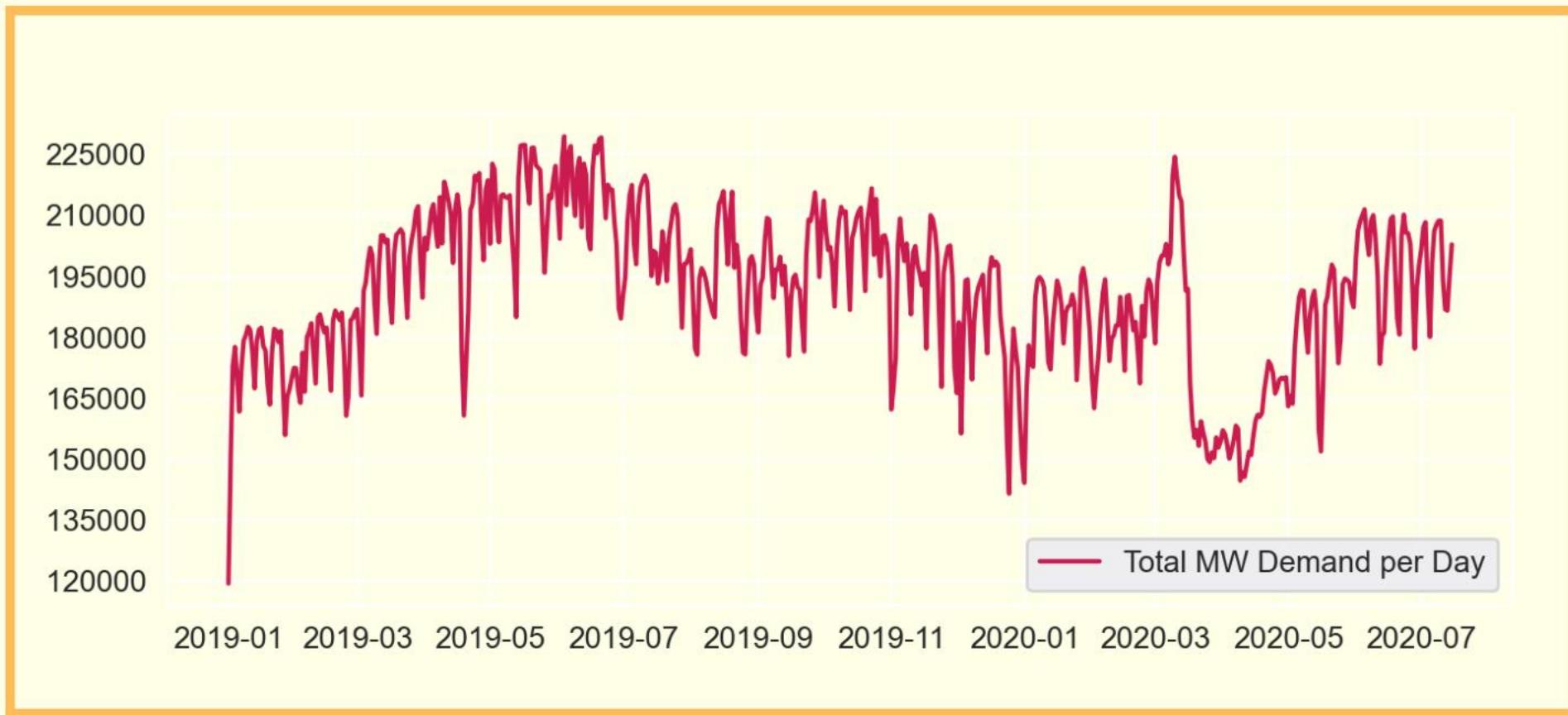
CLUSTERING

HISTORICAL TOTAL DAILY POWER DEMAND PER CLUSTER



FORECASTING

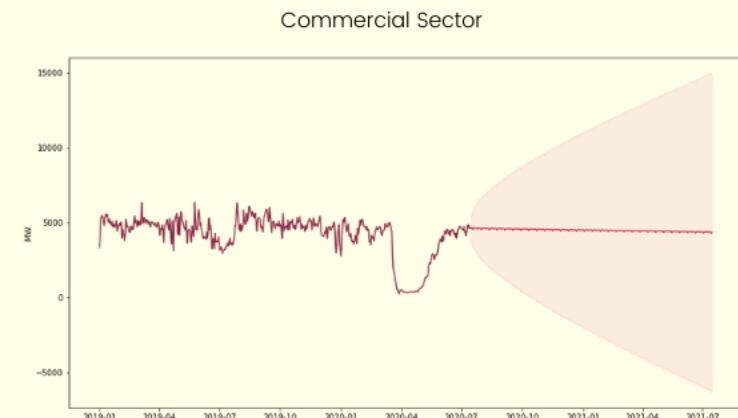
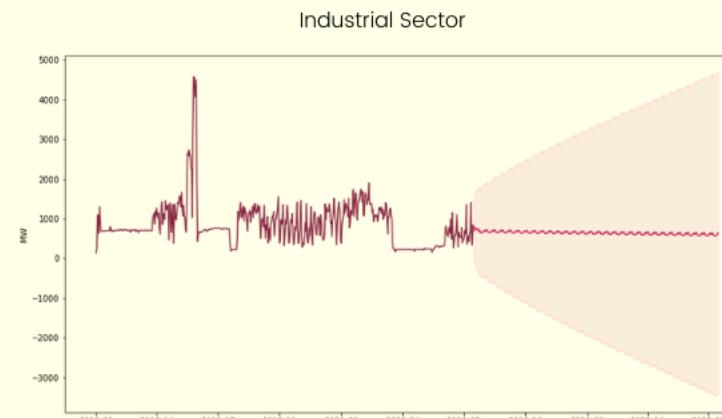
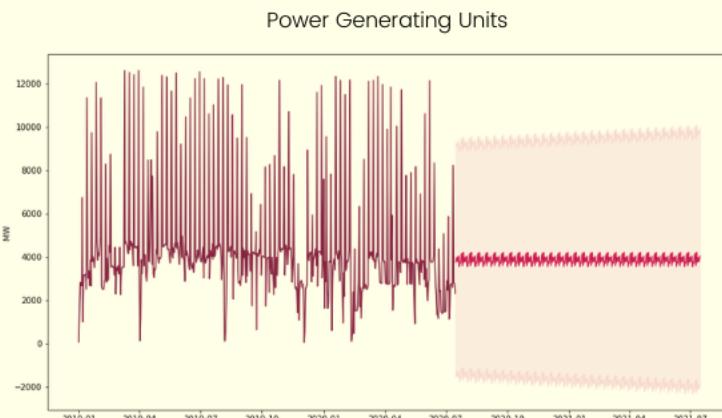
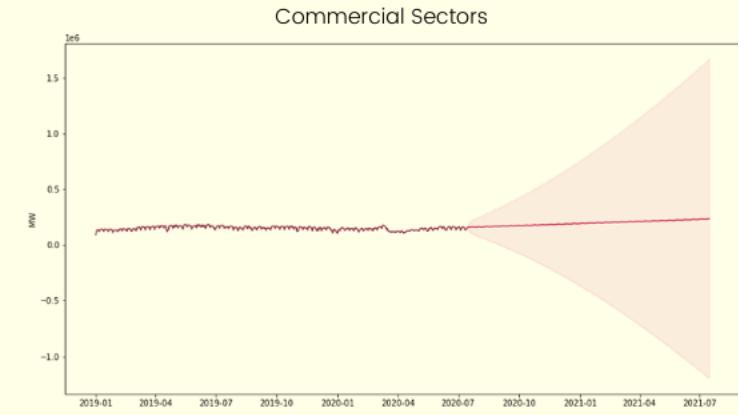
ACTUAL – TOTAL DAILY POWER DEMAND OF THE LUZON GRID



Note: Using dataset with all 153 resources

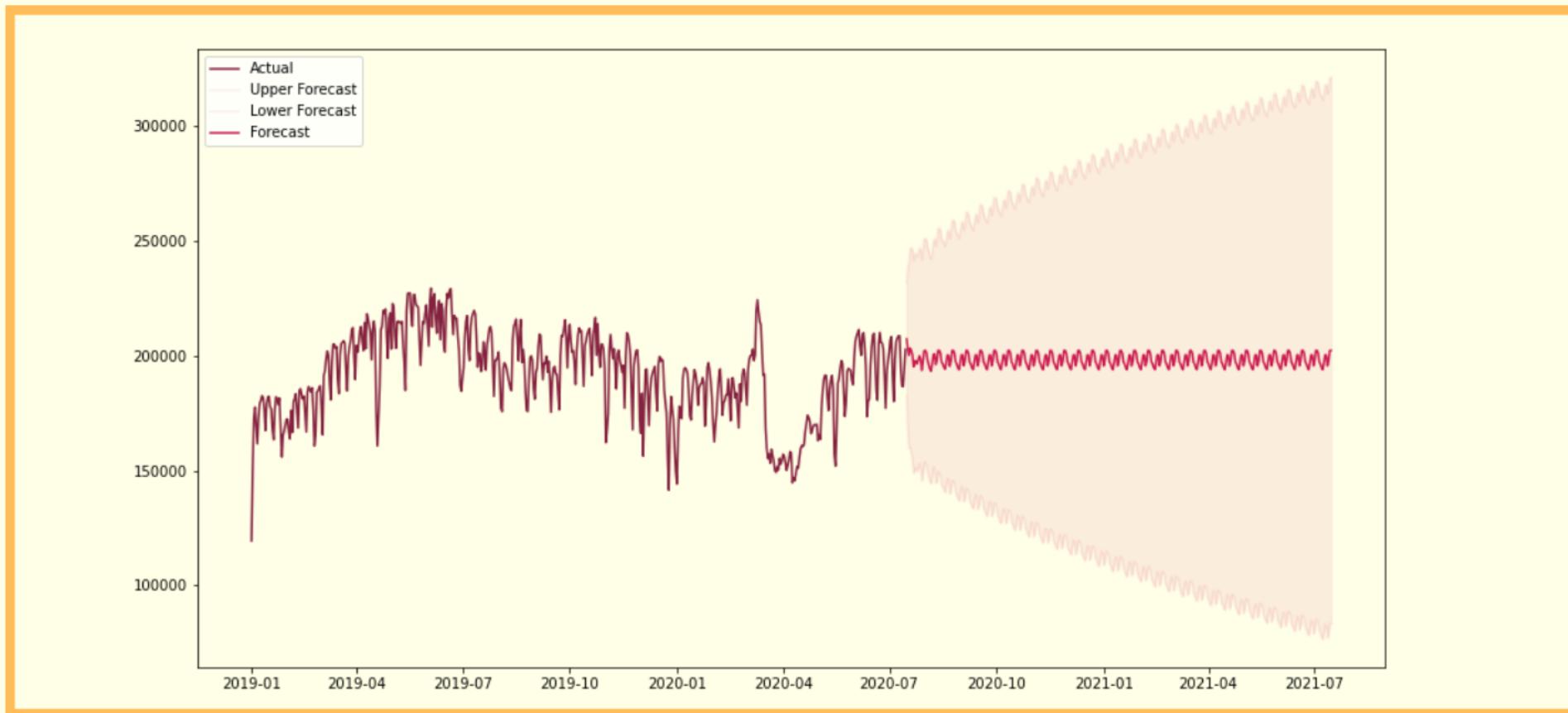
FORECASTING

ARIMA – TOTAL DAILY POWER DEMAND PER CLUSTER



FORECASTING

ARIMA – TOTAL DAILY POWER DEMAND OF THE LUZON GRID

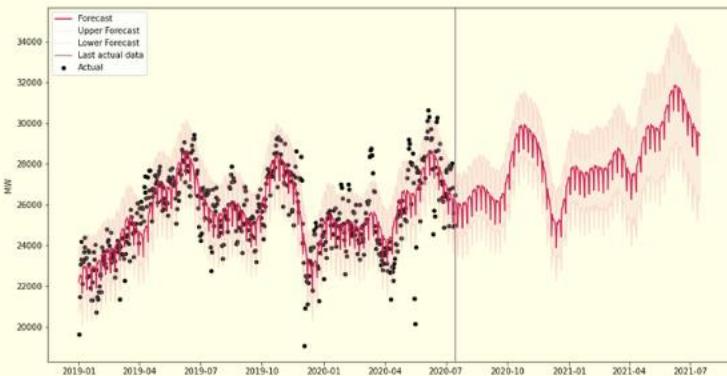


Note: Using dataset with all 153 resources

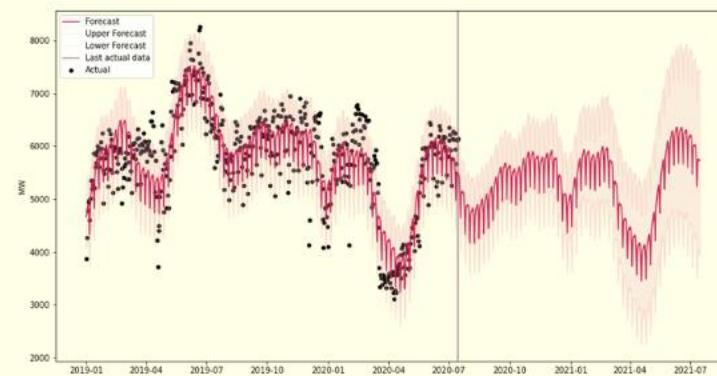
FORECASTING

FB PROPHET – TOTAL DAILY POWER DEMAND PER CLUSTER

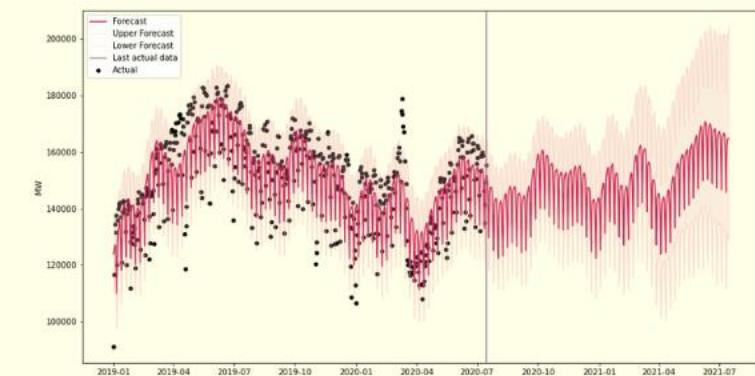
Residential Sector



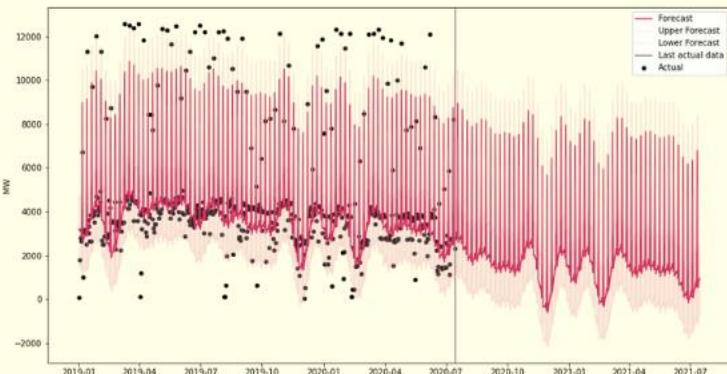
Various Sectors



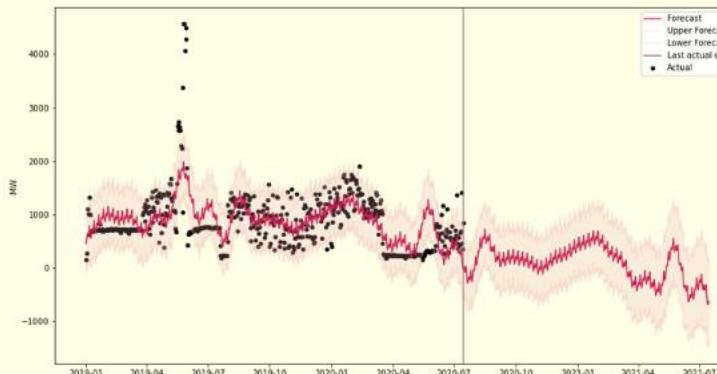
Commercial Sectors



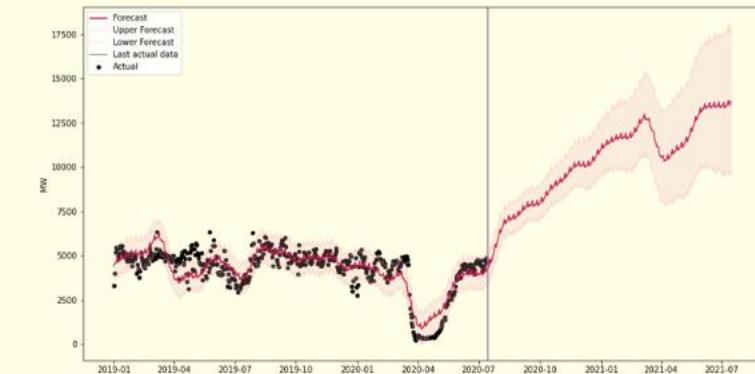
Power Generating Units



Industrial Sector



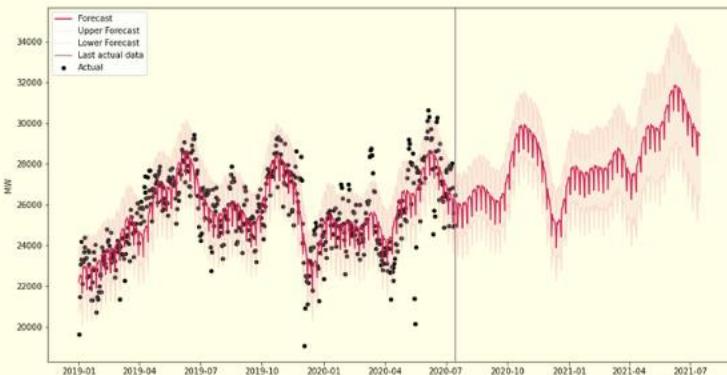
Commercial Sector



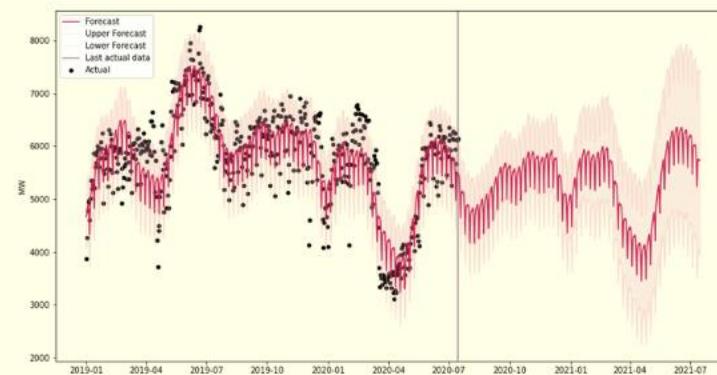
FORECASTING

FB PROPHET – TOTAL DAILY POWER DEMAND PER CLUSTER

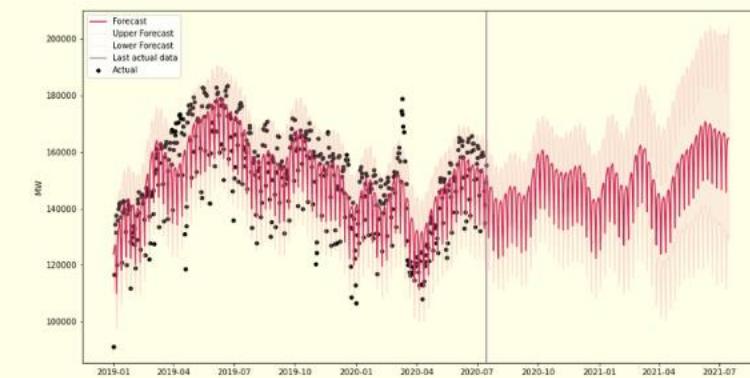
Residential Sector



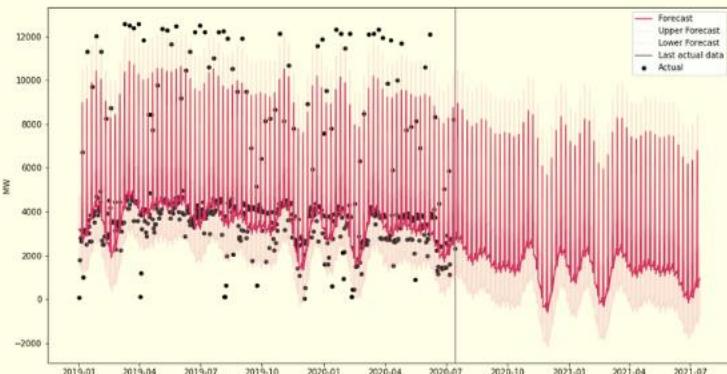
Various Sectors



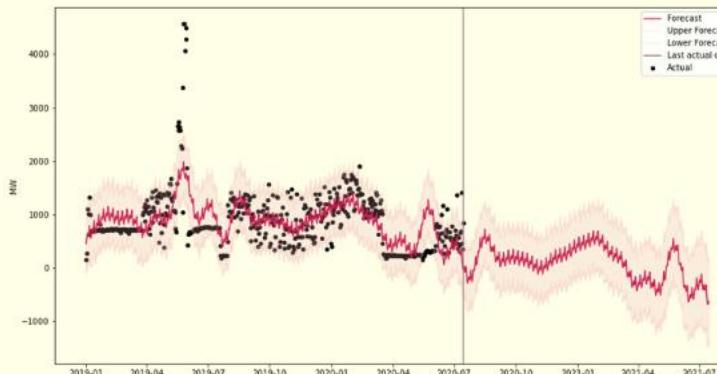
Commercial Sectors



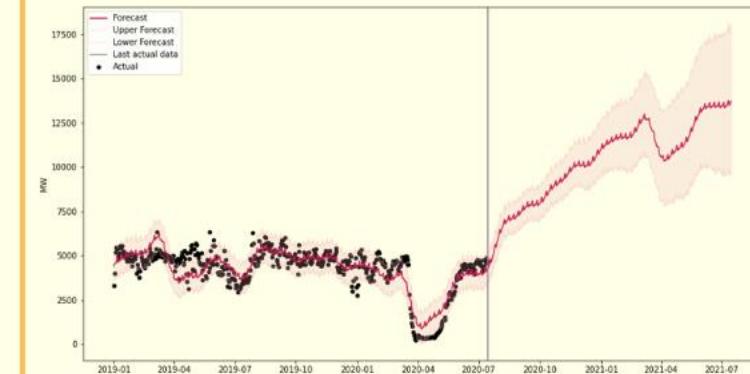
Power Generating Units



Industrial Sector

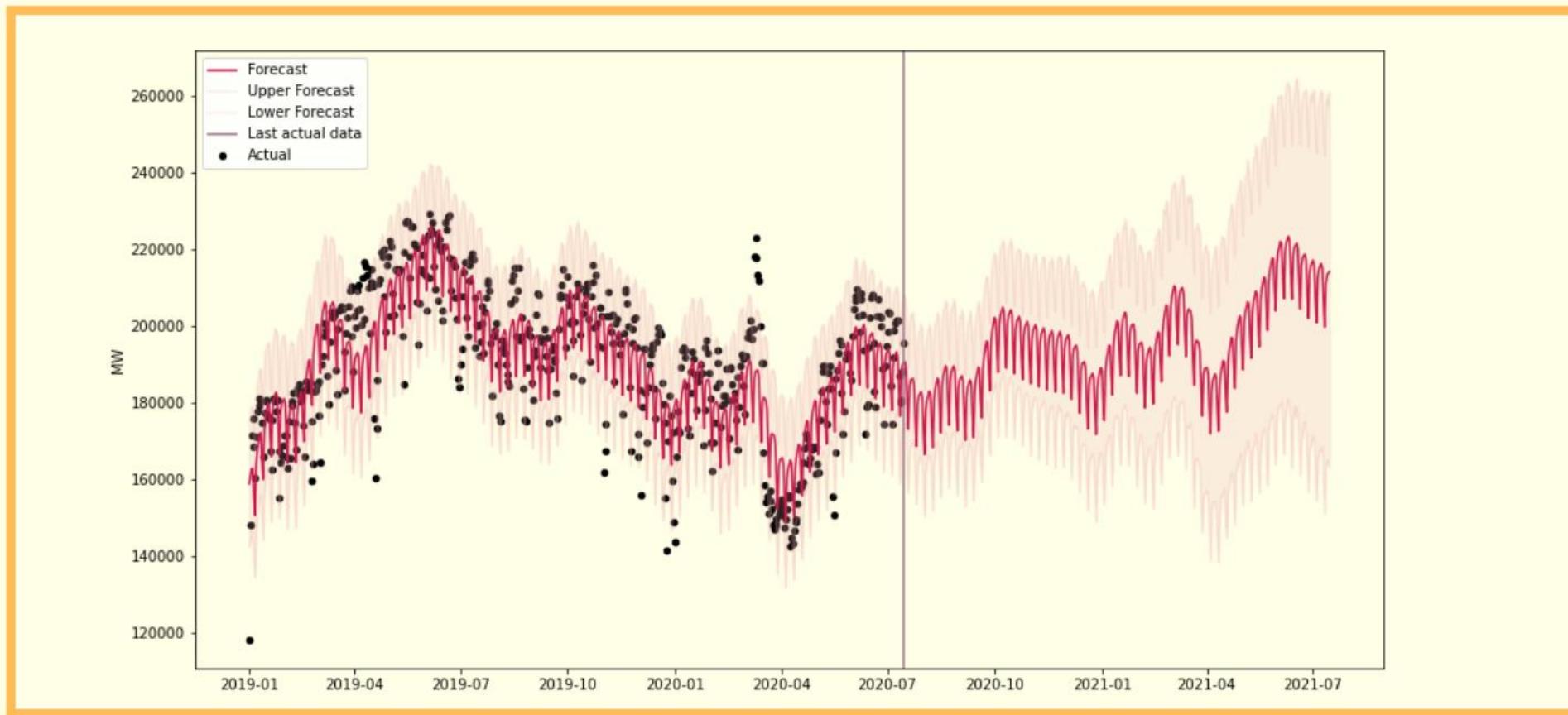


Commercial Sector



FORECASTING

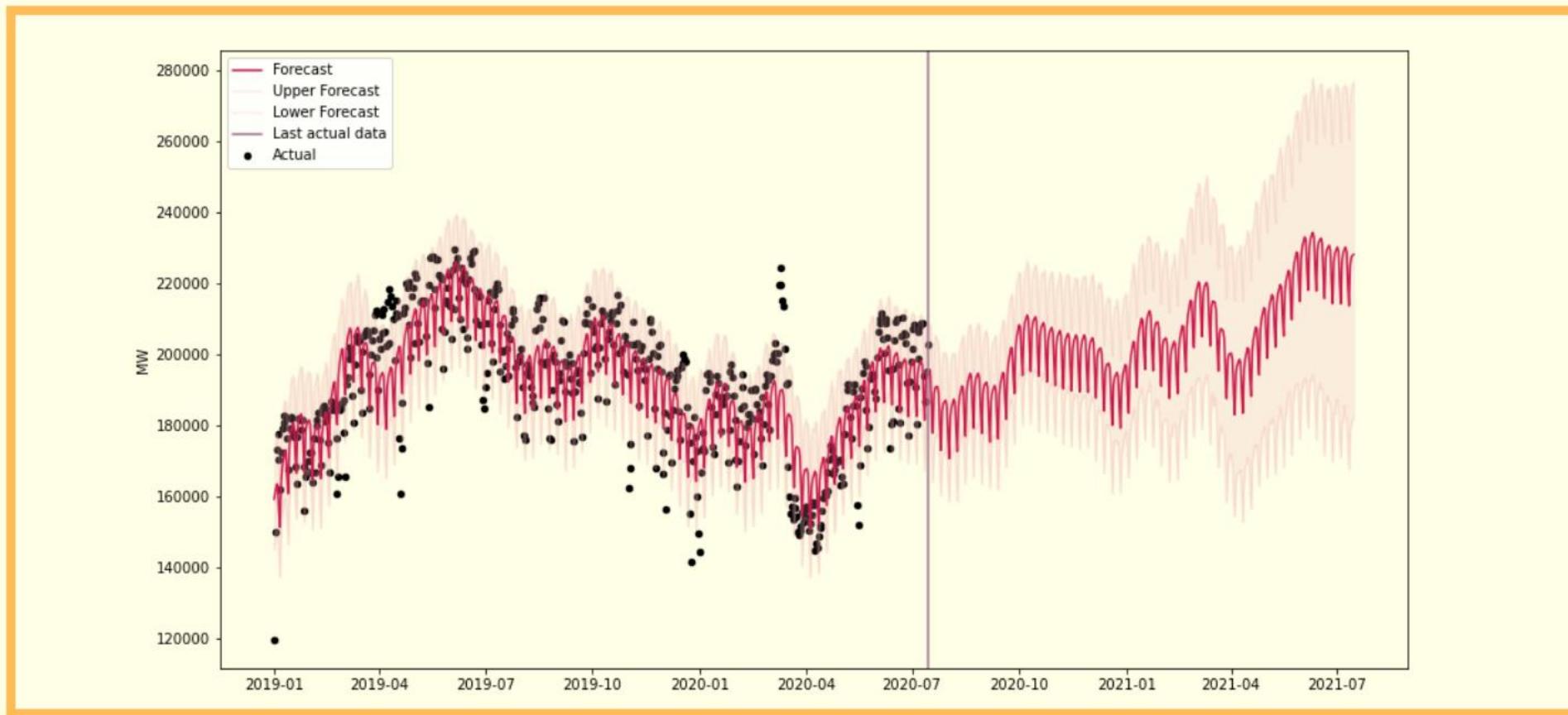
FB PROPHET – TOTAL DAILY POWER DEMAND OF CLUSTERS



Note: Summed power demand forecast of the six clusters

FORECASTING

FB PROPHET – TOTAL DAILY POWER DEMAND OF THE LUZON GRID



Note: Using dataset with all 153 resources

MODEL OVERVIEW

BASED ON OUR FORECASTING

ARIMA

- Results a straight line due to weak seasonality
- Generally works best if the data is more stationary



FB PROPHET

- Models the forecasts with trends, seasonality, cyclic patterns, and irregularities
- Works well with messy data with outliers, missing data, and sudden dips or spikes.

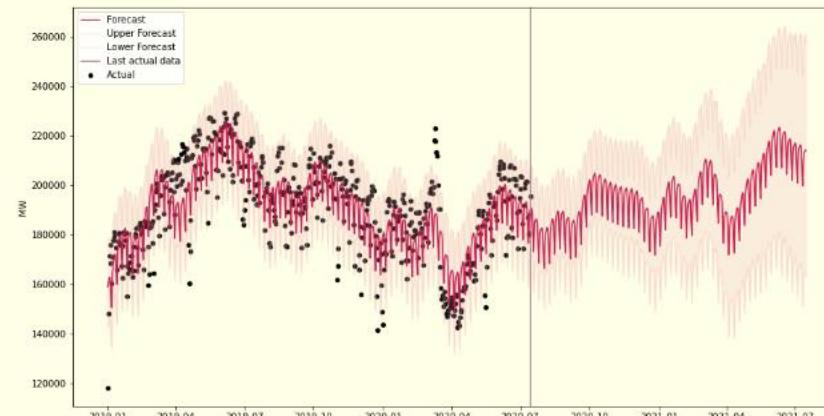
CONCLUSIONS

CHOSEN MODEL: FB PROPHET

LUZON ELECTRICAL POWER GRID

Power demand is seen to normalize and to increase by 4.0%, on average, in the following year.

Total Daily Power Demand of the Luzon Grid in MW



Note: Summed power demand forecast of the six clusters

CONCLUSIONS

CHOSEN MODEL: FB PROPHET

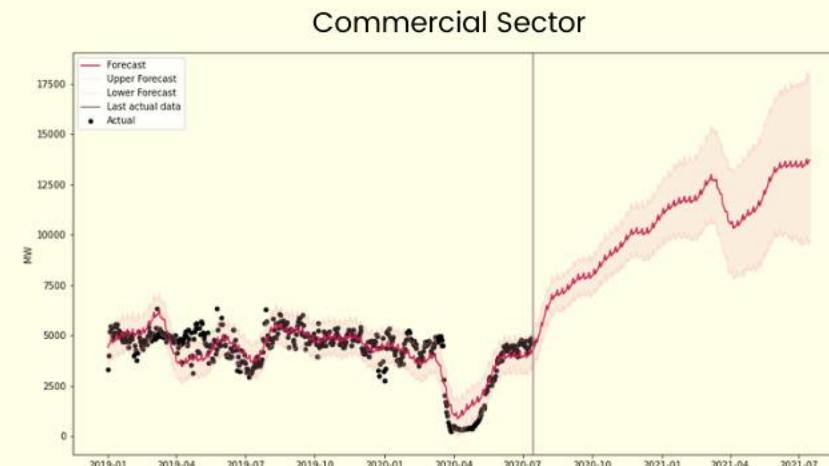
CLUSTERS

Commercial Sector

Power demand increased continuously until March 2021, same as the Metro Manila quarantine in 2020. A dip in power demand was forecasted again in similar dates also.

Other sectors

Power demand is seen to normalize after the quarantine in Metro Manila



RECOMMENDATIONS



INCREASE HISTORICAL DATA

To use data from a longer time period in order to strengthen the bases of our analyses in order to estimate a more reliable, longer horizon



IMPROVE PERFORMANCE OF THE MODELS

To use K-Fold for cross validation and varying the train-test splits in order to select the best model dynamics



CONSIDER HOLIDAYS OR SPECIAL EVENTS

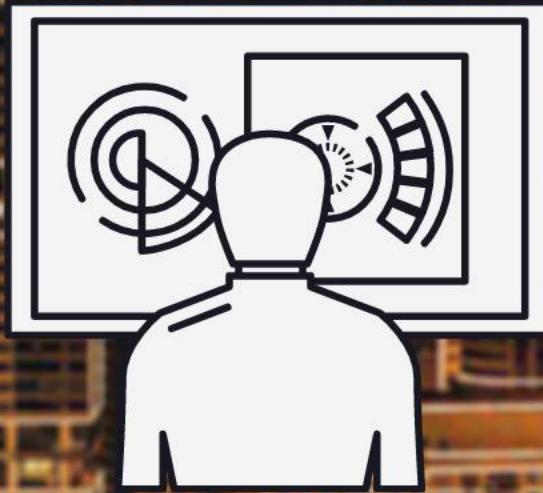
To tune the FB Prophet model to take in dates to be considered as a holiday or special events that would give more insights on that time period on a yearly basis



INCORPORATE ANALYSIS ON SUPPLY

To analyze the power demand and supply dynamics by looking at the supply side

CALL TO ACTION



ENERGY POLICY

- Start the planning and construction of additional power generation units to meet current and future demands
- Look into infrastructure that would prevent the need for power outages
- Focus on the use of renewable energy sources to lessen carbon footprint

CALL TO ACTION



WE CAN HELP!

- Conserve energy by avoiding unnecessary use of electricity
- To those who can afford it, invest in personal/home renewable energy systems
- We hope we are able to inspire you to pursue a career in development and what data science can tell us

THE TEAM



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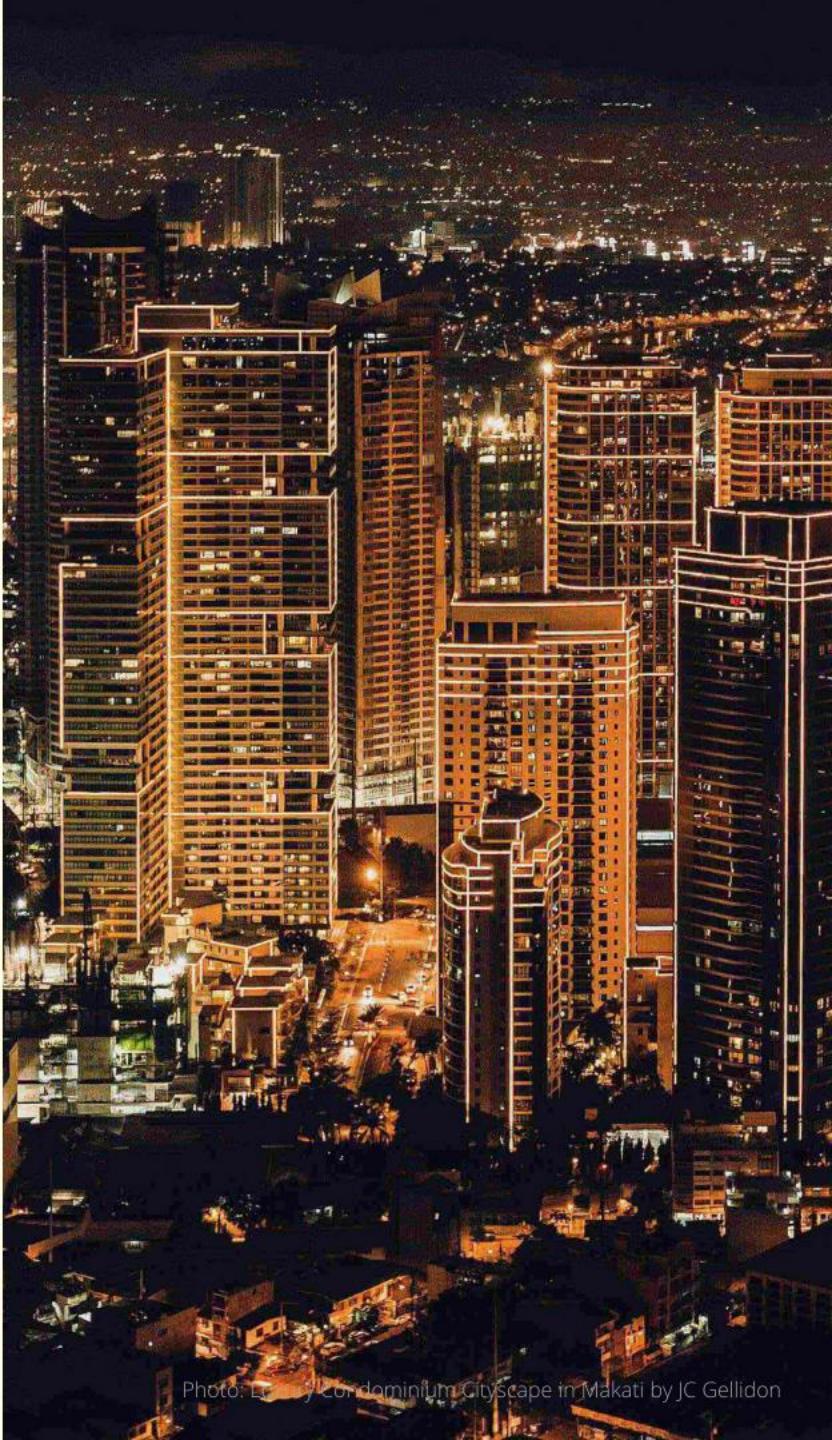


Photo: Leony's Condominium Cityscape in Makati by JC Gellidon



**THANK YOU
FOR YOUR TIME!**