

# Disaggregation of Time Series Energy Consumption Data of Residential Buildings Using Data Analytics Approaches

Student: Grace Aduve, MS. Mechanical Engineering

Mentor: Patrick Phelan, Professor of Mechanical Engineering

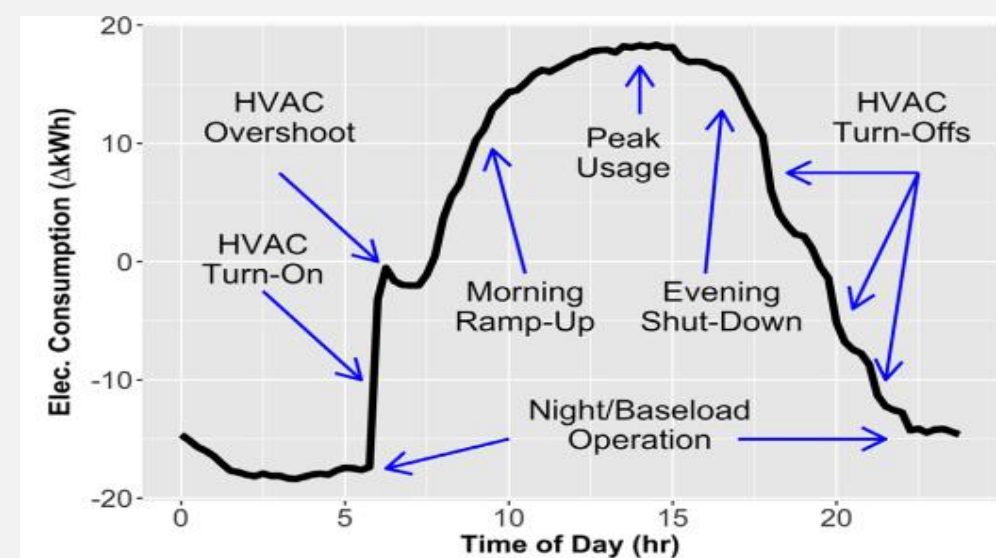
School for Engineering of Matter, Transport and Energy

## RESEARCH QUESTION

- Buildings, consuming ~40% of U.S. total energy, exhibit significant operational inefficiencies leaving an opportunity to implement various energy-efficiency measures. [3,4]
- This research answers the question “what is the amount of energy consumed by each component within a time series in a residential building?” and “which component causes excessive energy consumption in order to reduce demand growth?”.

## MOTIVATION

- Time series building energy data analyses in the past gave insights into building operation and characteristics, specific insights into HVAC scheduling, daily operational variation, and the relative impact of temperature and solar radiation complementary time series datasets. [1,2]



Source: <https://doi.org/10.1016/j.enbuild.2018.07.056> [1]

- This work improves these analyses by further revealing the daily operational characteristics of major end uses in a residential building, exposing the real sources of abnormalities in energy usage as well as unlock the potential of smart usage, cost savings and building energy efficiency.

## OBJECTIVE

- The main objective of this research is to utilize a 1-hour interval time series utility data of the whole building; information about building location, square footage, and type (residential apartment); and associated weather datasets to [2]:
  - Show the energy consumed by each component of the residential building
  - Find the source of high energy consumption.

## METHODOLOGY

- ❖ Read and clean both utility data and weather datasets
- ❖ Convert the data to date-time format using the *to datetime* function in Pandas library.

```
# Merging date and time
df['DateTime'] = df['Date'].astype('string') + " " + df['Time'].astype('string')
df['DateTime'] = pd.to_datetime(df['DateTime'], utc=False)
```

	Date	Time	Usage(kWh)	Demand(kW)	Hour	DateTime
144	2021-12-31	23:00:00	0.43	0.43	23	2021-12-31 23:00:00
145	2021-12-31	22:00:00	0.43	0.43	22	2021-12-31 22:00:00
146	2021-12-31	21:00:00	0.43	0.43	21	2021-12-31 21:00:00

- ❖ *TimeStamp* the data to locate the days of the week.

```
# Locating the day of the week
df['weekday'] = [pd.Timestamp(date).day_name() for date in df["Date"]]
df.head()
```

	Date	Time	Usage(kWh)	Demand(kW)	Hour	DateTime	weekday
144	2021-12-31	23:00:00	0.43	0.43	23	2021-12-31 23:00:00	Friday
145	2021-12-31	22:00:00	0.43	0.43	22	2021-12-31 22:00:00	Friday
146	2021-12-31	21:00:00	0.43	0.43	21	2021-12-31 21:00:00	Friday

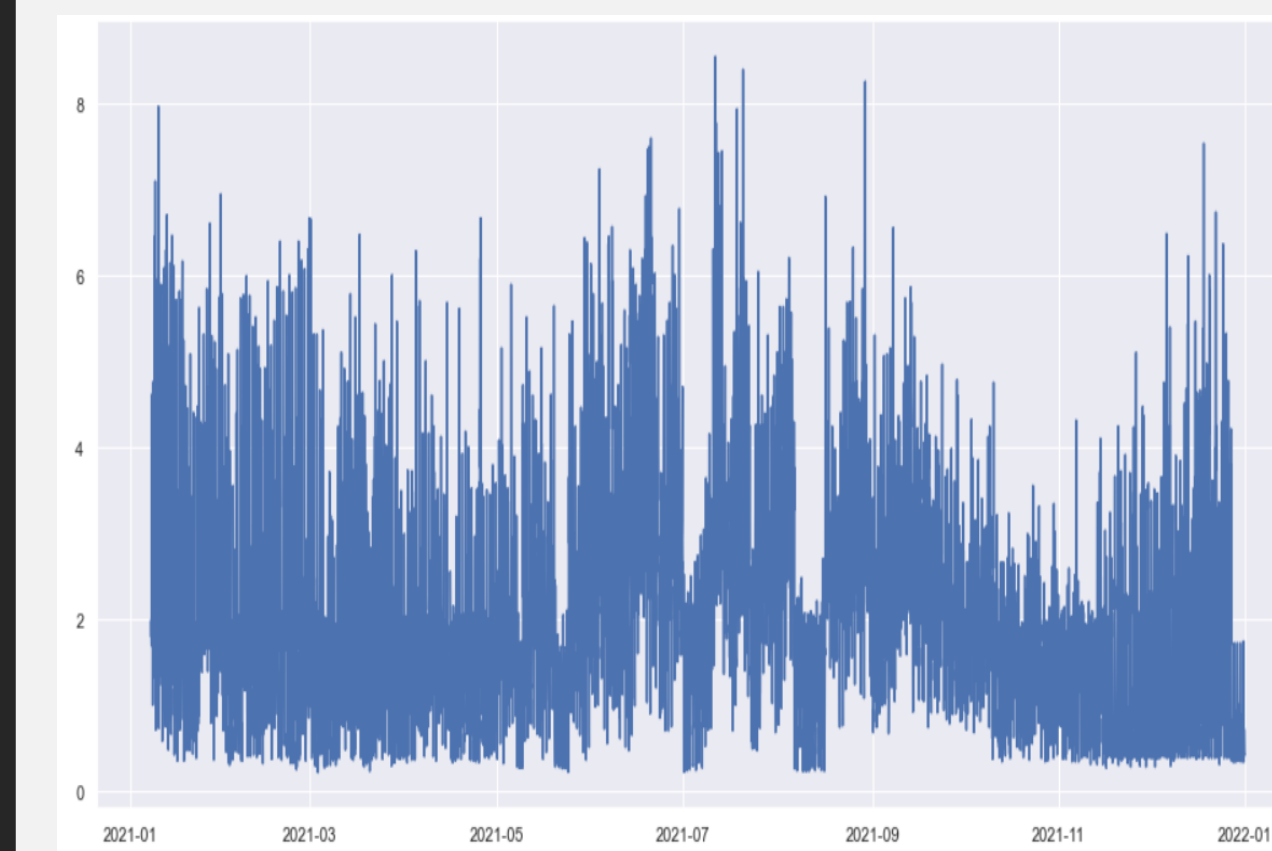
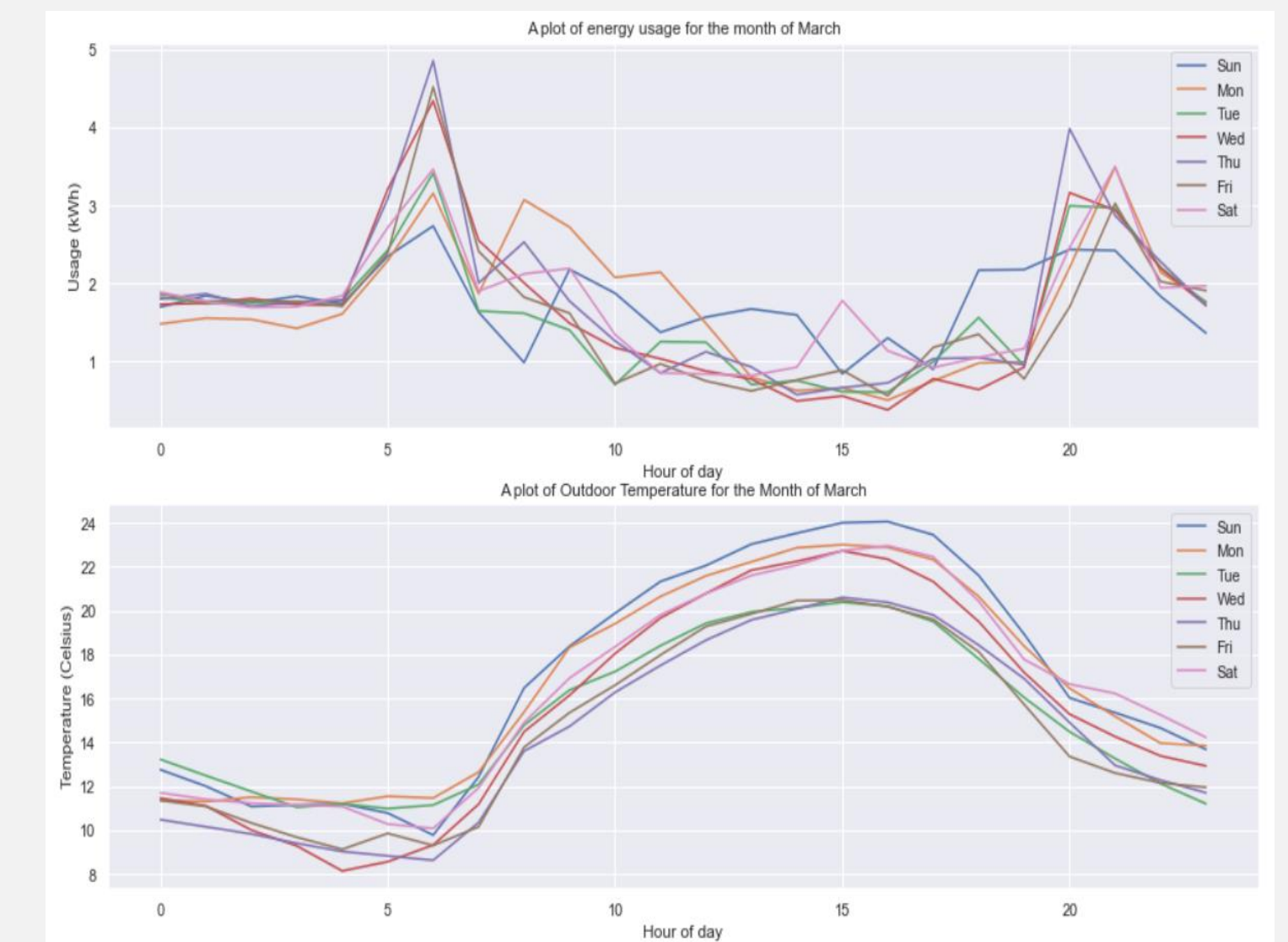
- ❖ Disaggregate the data into callable months and weekdays.

```
#Function to select Aggregate
def selectAggregate(month_num, weekday):
    dataframe = selectMonth(month_num)
    dataframe = dataframe[['Usage(kWh)', 'weekday', 'Hour']].groupby(['weekday', 'Hour']).mean().reset_index()
    return dataframe[dataframe['weekday']==weekday][['Hour', 'Usage(kWh)']].set_index('Hour')
```

## REFERENCES



## RESULTS



## DISCUSSION

- ✓ HVAC turn-on, overshoot and morning ramp-up explains the early peak loading.
- ✓ Low consumption during on-peak hours can be explained by absence and/or precooling or preheating.
- ✓ Evening peak is a result of HVAC turn-on and bedtime preparations (preheating or precooling).
- ✓ Energy saving methods include load scheduling, precooling/preheating and smart usage.

## MOVING FORWARD

- ❑ Determine the component consumption through analytical solution.
- ❑ Apply analytical knowledge to disaggregate energy usage data into component consumptions.
- ❑ Validate results using data loggers to monitor real time building energy usage.
- ❑ Visualize the seasonality, trends, and anomaly/randomness of consumption data.

## Acknowledgement

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