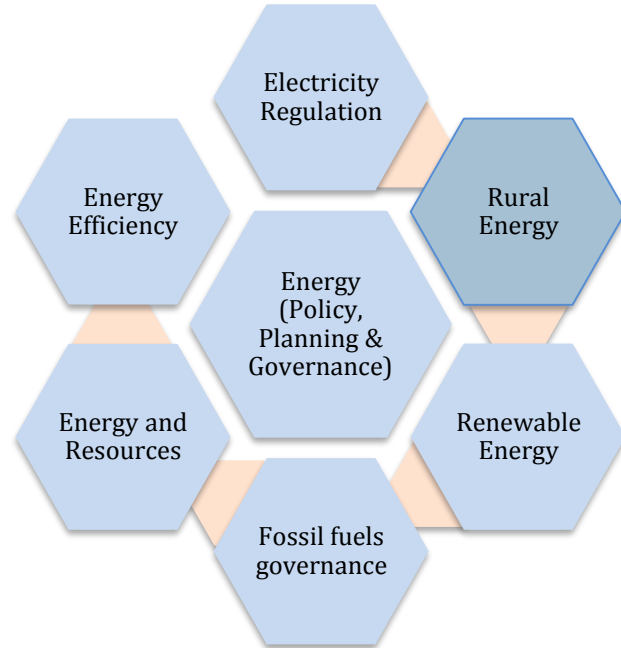# Electricity Consumption in Households
Insights from urban, semi-urban and rural Maharashtra and Uttar Pradesh

Shweta Kulkarni, Aditya Chunekar
Prayas (Energy Group)

Prayas (Energy Group)

- Not-for-profit organization founded in 1994
- Analysis based policy advocacy for promoting public interest.
- Focus on governance aspects & policy innovation
- Extensive engagement with civil society groups, peoples' movements, consumers groups and media.

About eMARC
Monitoring and Analysis of Residential Electricity Consumption

Need to better understand Residential Electricity Consumption…
Residential Electricity consumption has tripled since 2000 and contributes to a quarter of total electricity consumption. Understanding consumer behaviour and its response to energy efficiency programs is important to design them.

- A better way to manage the rising demand for electricity cost-effectively is to understand the current consumption patterns for it.
- This household level data on consumption is currently unavailable.
- eMARC records the actual load and consumption patterns of households across various socio-economic/geographic/climatic strata
- Records the actual load and consumption patterns of selected appliances : Refrigerator
- Generates publicly available datasets emarc.watchyourpower.org
- Current expanse in 125 households across Urban, Semi-Urban and Rural , Maharashtra and Uttar Pradesh

How does eMARC Work ?

Advanced energy meters deployed at consumer premises in urban and rural areas, which record minute by minute voltage, current, power, energy and PF data and entire data is made available at emarc.watchyourpower.org
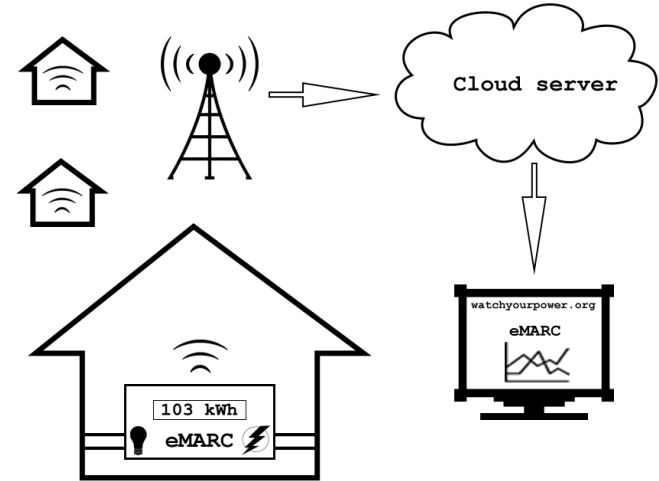
eMARC expanse

State	District
Uttar Pradesh	Gonda
	Kanpur Dehat
Maharashtra	Pune
	Aurangabad

eMARC locations

42 Households in Pune City
Data collection from January 2018

60 Households in Semi Urban and Rural Maharashtra
Data collection from June 2019
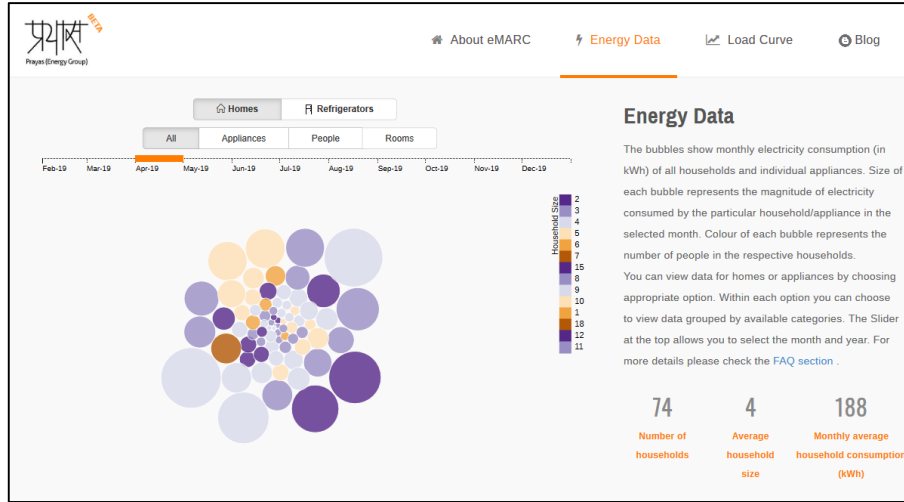
35 Households in Semi urban and rural
Uttar Pradesh
Data collection from June 2019

Uttar Pradesh	Maharashtra	Pune city

7
17

2
22

1
23

■ No supply   ■ Supply available
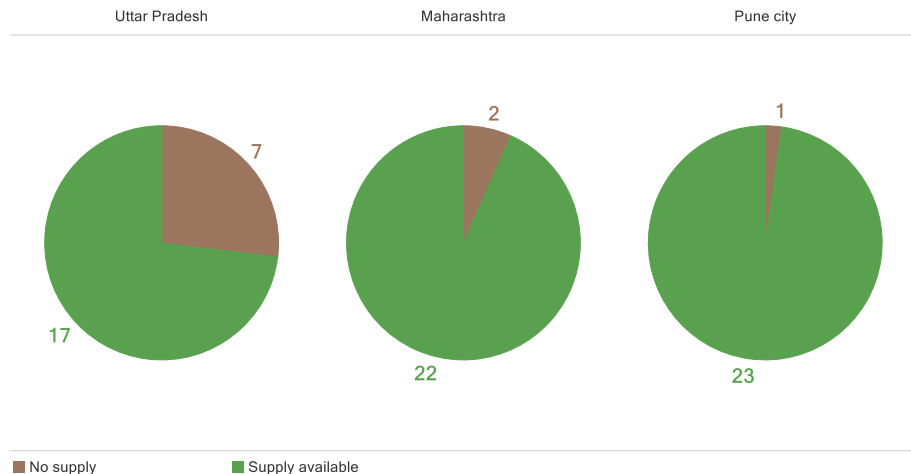
Website overview

Energy Consumption Data

Monthly energy consumption data for all households made public allows sort by
- Type of appliances owned
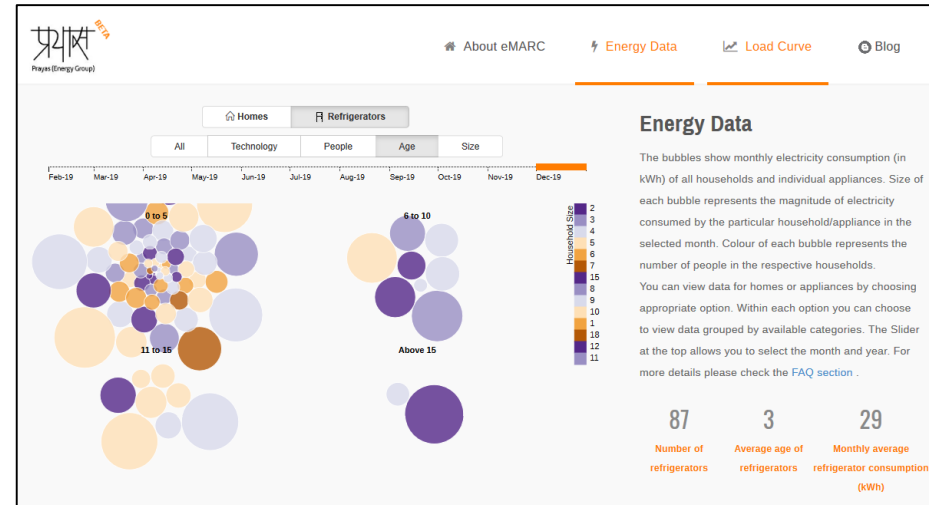- Household size
- Number of rooms

Monthly energy consumption data for all refrigerators allows sort by
- Technology of appliance
- Size of appliance
- Age of appliance
- Household size

Load Curves

Average monthly load curve data for all households made public allows to view data
- Over a month
- Across multiple days
- For a day
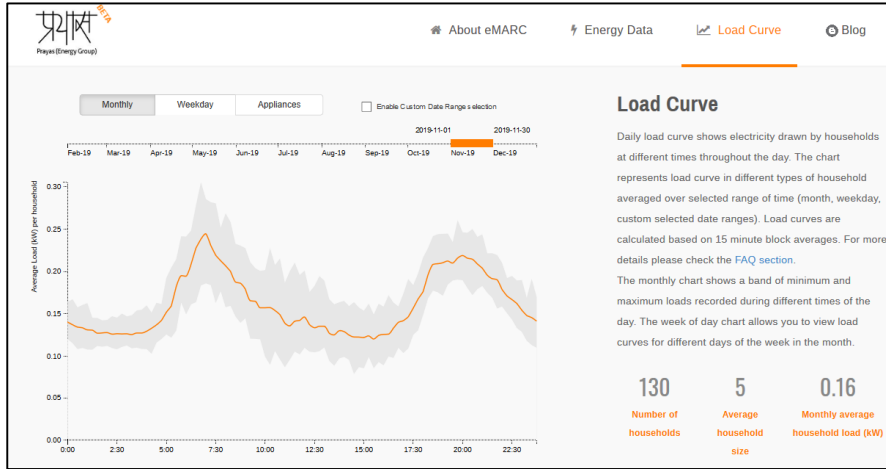
Average monthly load curve data for all households allows to view data
- By type of appliances owned
- Weekday and weekend curve
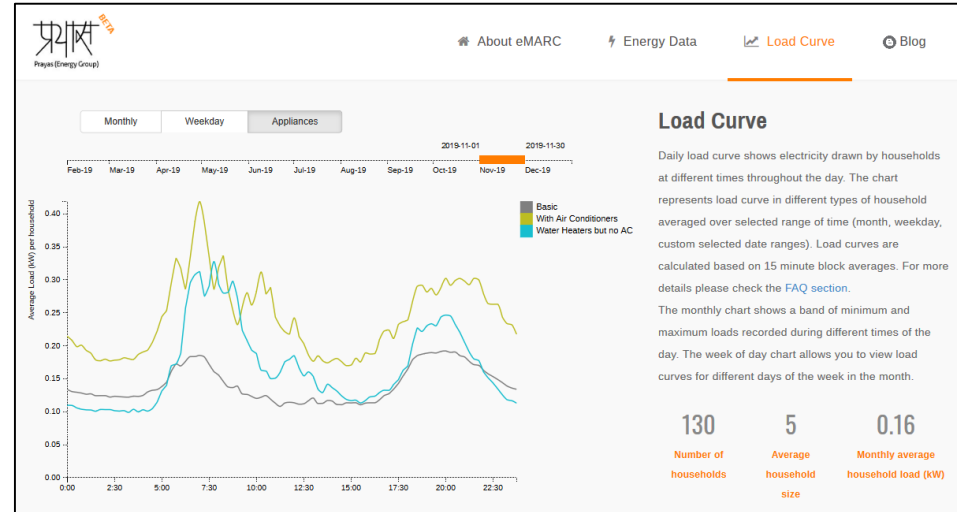
Snapshots of analysis using eMARC Data Pune City

Analysis presented includes…

- Monitoring data for Pune households for a period of 1 year

    April 2018 – March 2019

- Household data is segregated by appliances owned

    Basic: Households owning basic set of appliances like lights ,fans, refrigerators

    With water heaters : Households owning basic set of appliances + water heaters

    With Air conditioners: Households owning basic set of appliances + water heaters +ACs

- Energy consumption by households

- Energy consumption by refrigerators

- Load curves for households

- Load duration curves for households

- Preliminary analysis of semi-urban, rural households

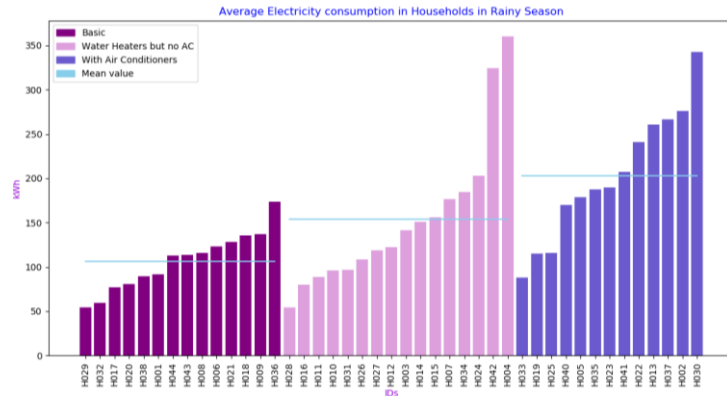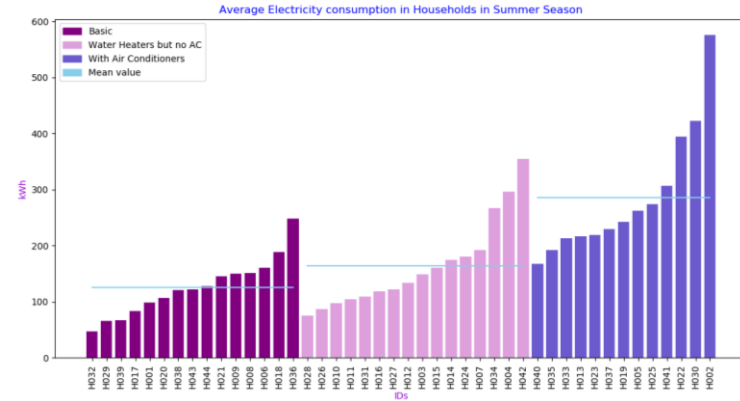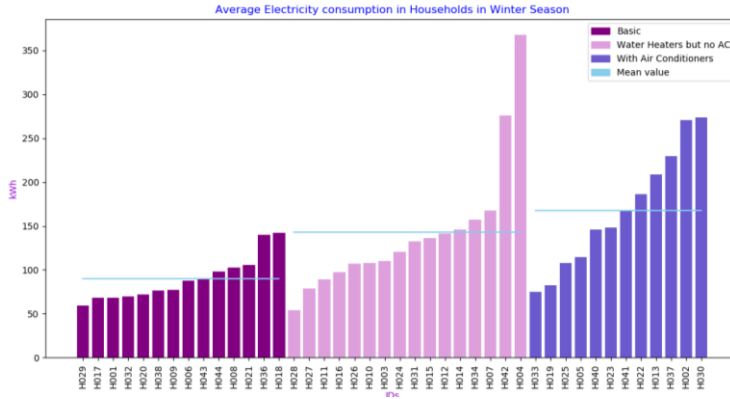# Electricity Consumption across households

Annual Electricity Consumption in Households
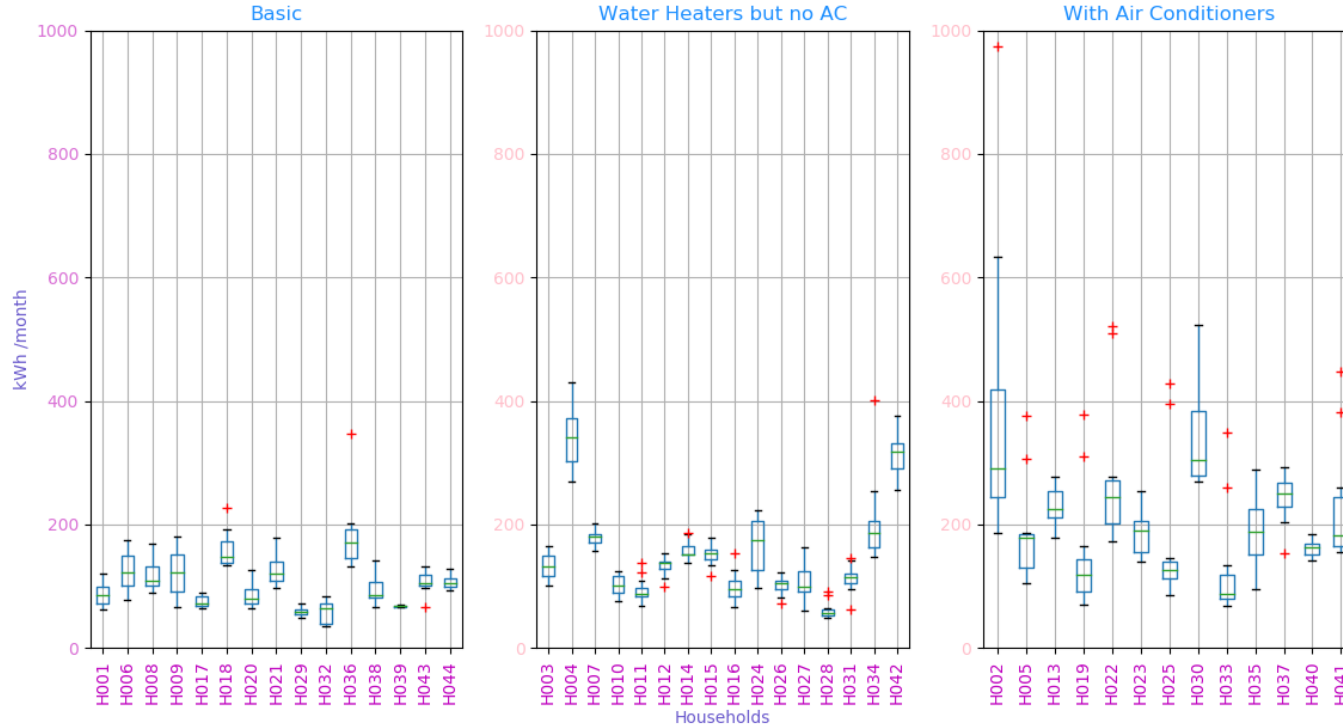
On an average most basic households consume less than 200 units.

The range of consumption varies significantly in Households with ACs
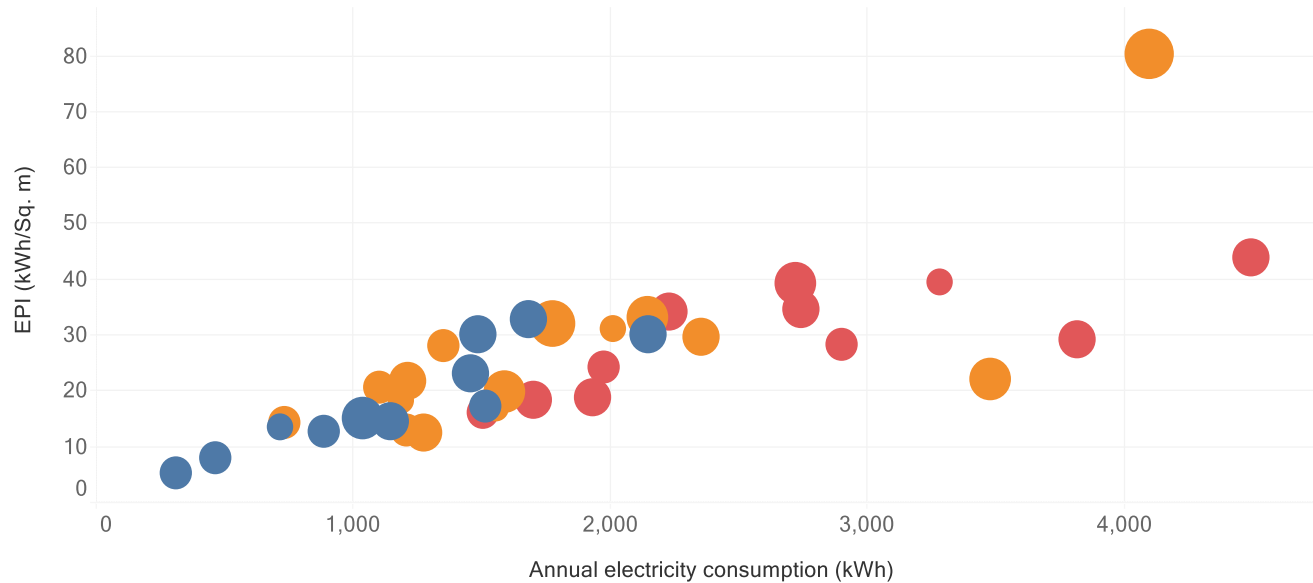
Variation in consumption across seasons

Average Electricity consumption in Households in Winter Season

Average Electricity consumption in Households in Summer Season

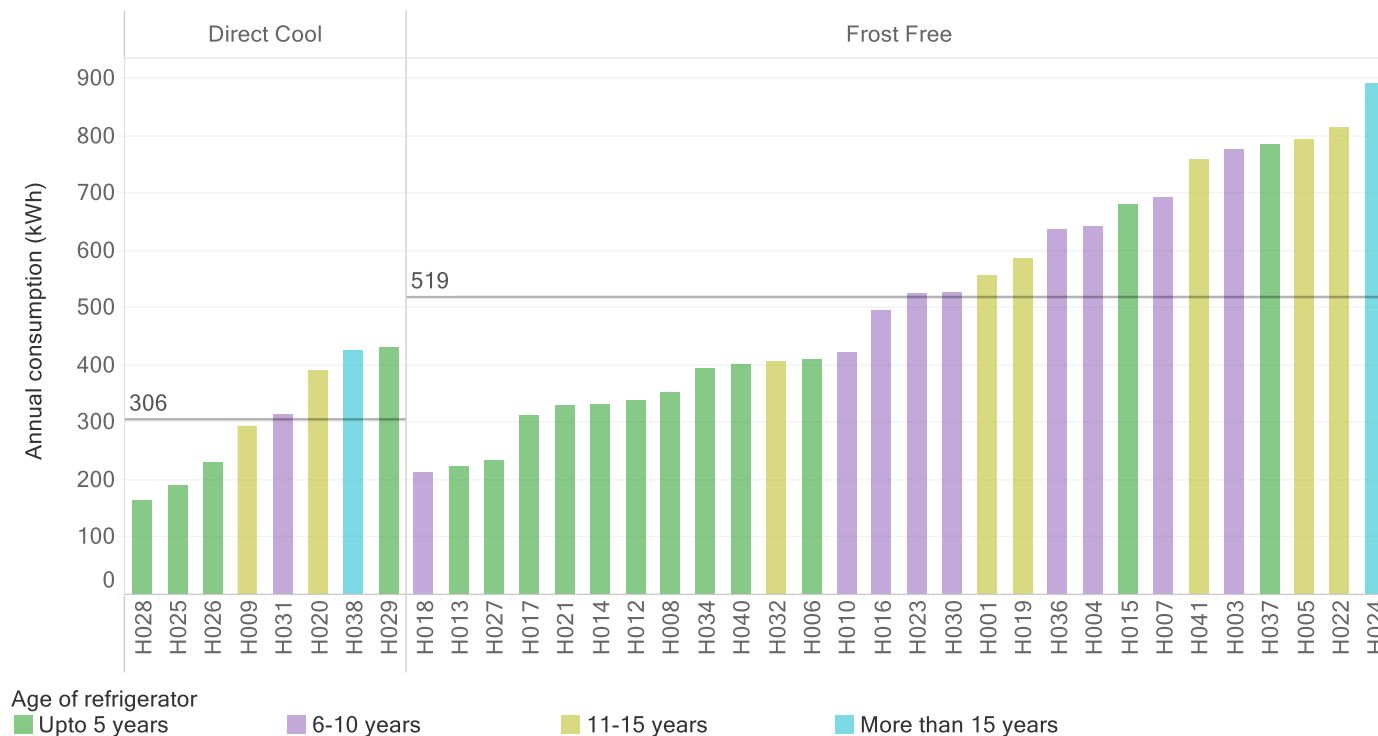Average Electricity consumption in Households in Rainy Season

Energy consumption

- Remains almost consistent through the year in households with water heaters
- Increases only slightly in households having only basic appliances

EPI of households

- BEE

  4 Star 29 < EPI <37

  5 Star   EPI < 29

- Observed

  Basic <29

  With water heaters <30

  With Air Conditioner < 40

Household type
- Basic
- Water Heaters but no AC
- With Air Conditioners

Household size
2   5
3   6
4   7

Annual Electricity Consumption of Refrigerators

Refrigerator electricity consumption

Share of Refrigerator consumption as percentage of annual electricity consumption of households
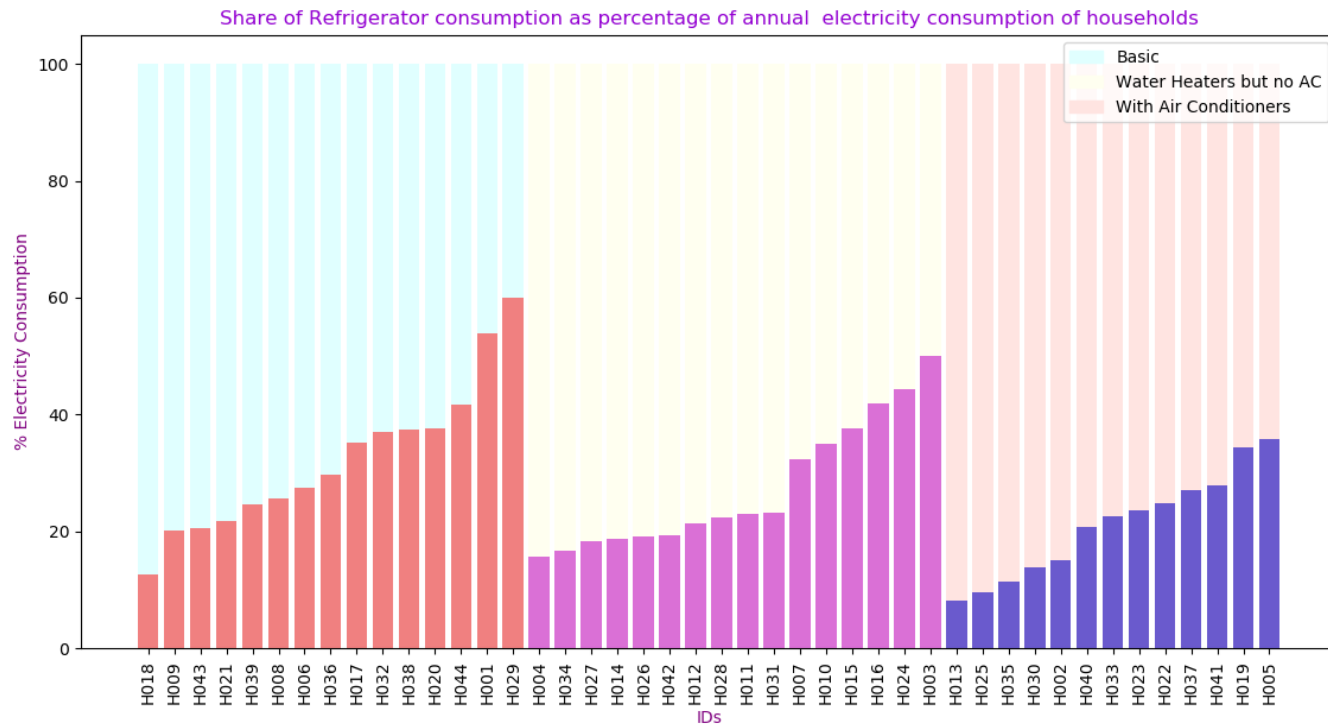
Seasonal variation of consumption in Refrigerators
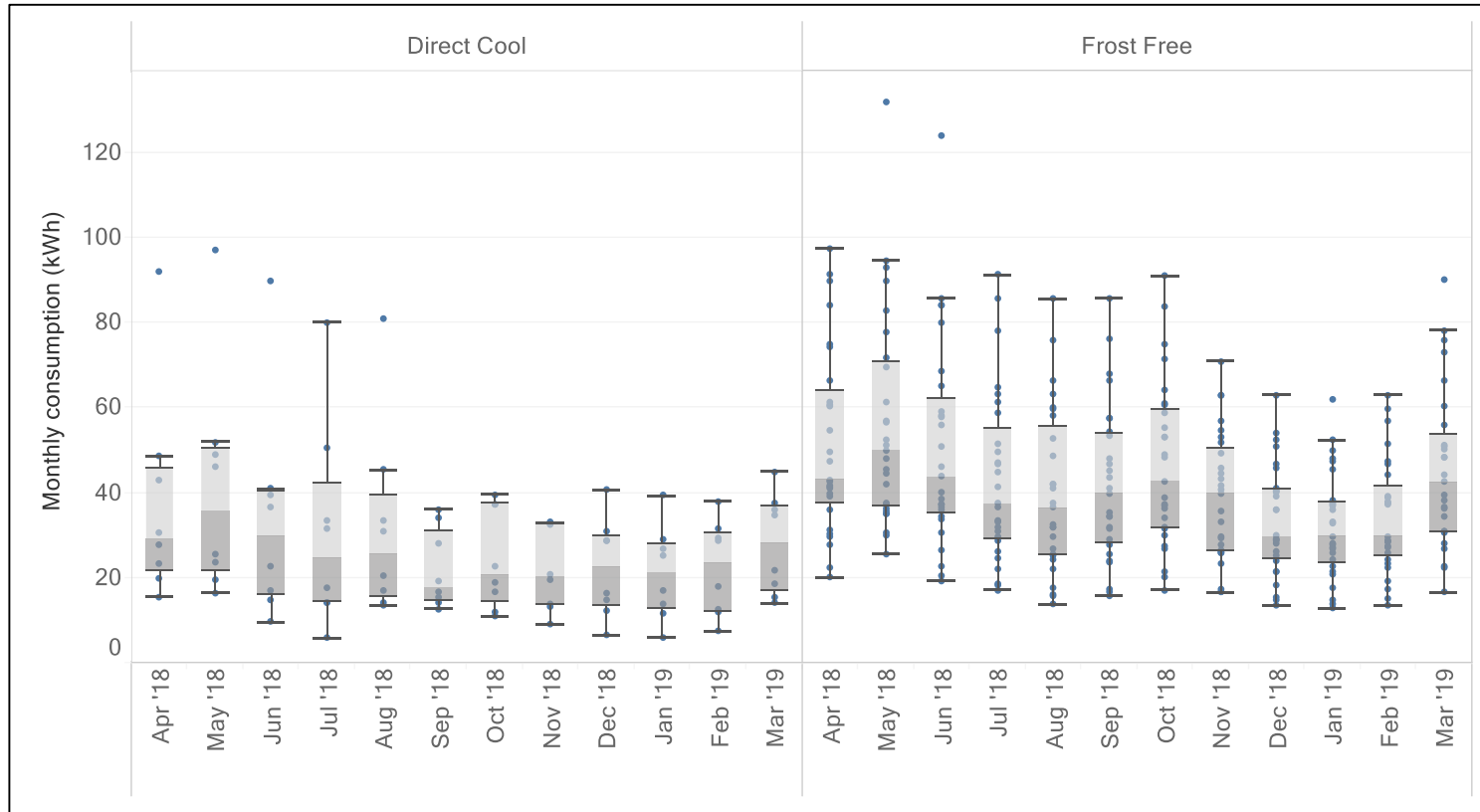
# Load Patterns

Load duration curve

Sample Households

Household with Water heater : Household Size 7 , use of water heater 11 months

Household with two Air Conditioners : Usage of air conditioner 3 months in a year

Household with Basic Appliance : Age of Fridge 30 years
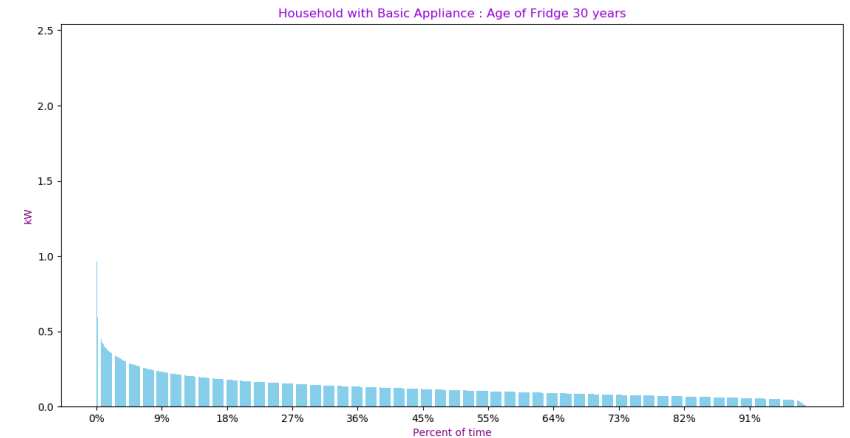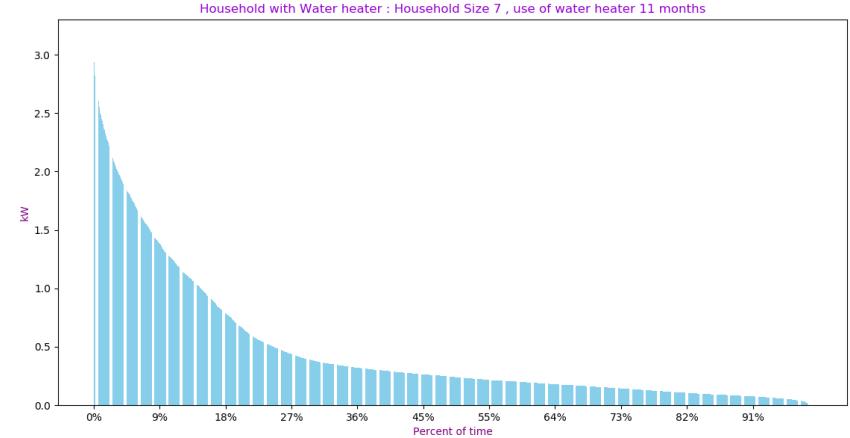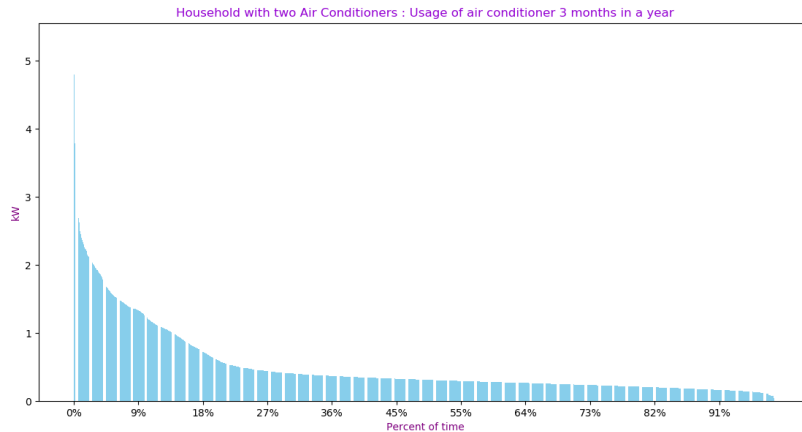
Variation in Load Curves
Weekend vs. Weekday

Shift in peak consumption by few hours over weekday and weekend
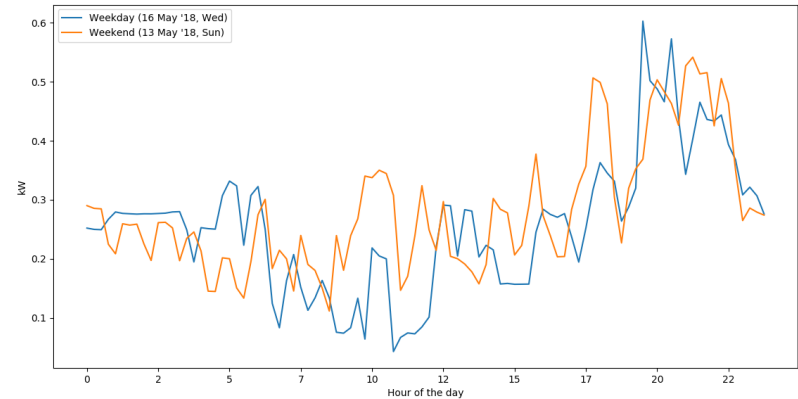
Use of air conditioner during day-time on weekends
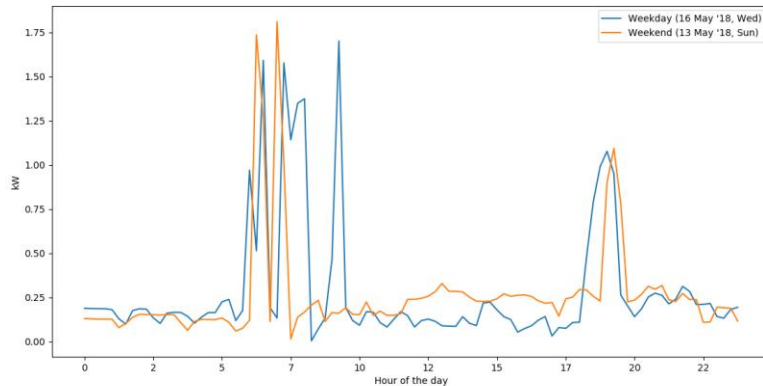
Load Curve (15 min) for Household with Air conditioner
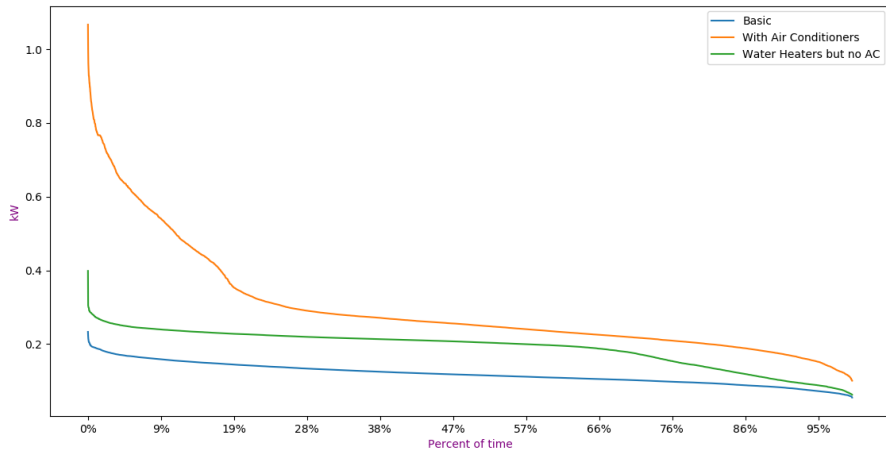

Load Curve (15 min) for Household with Water Heater
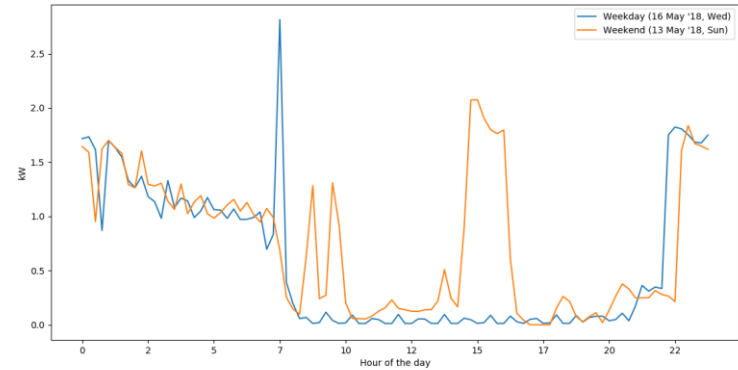
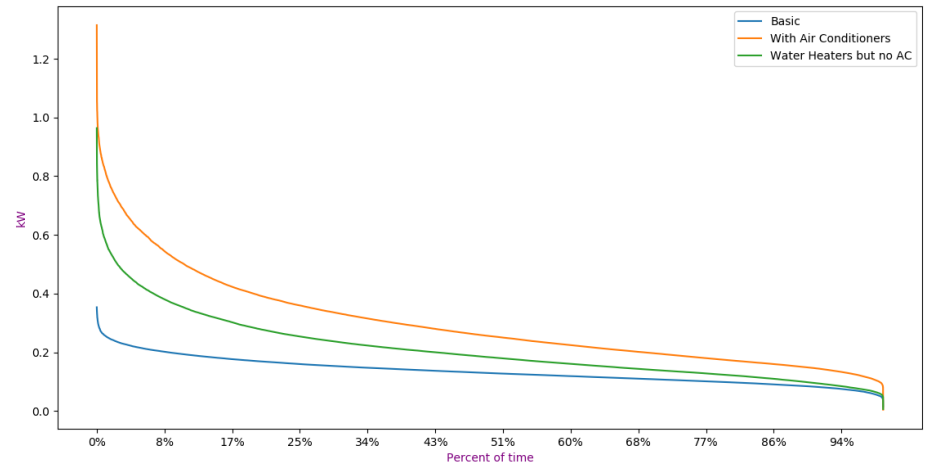Load Curve (15 min) for Basic type Household

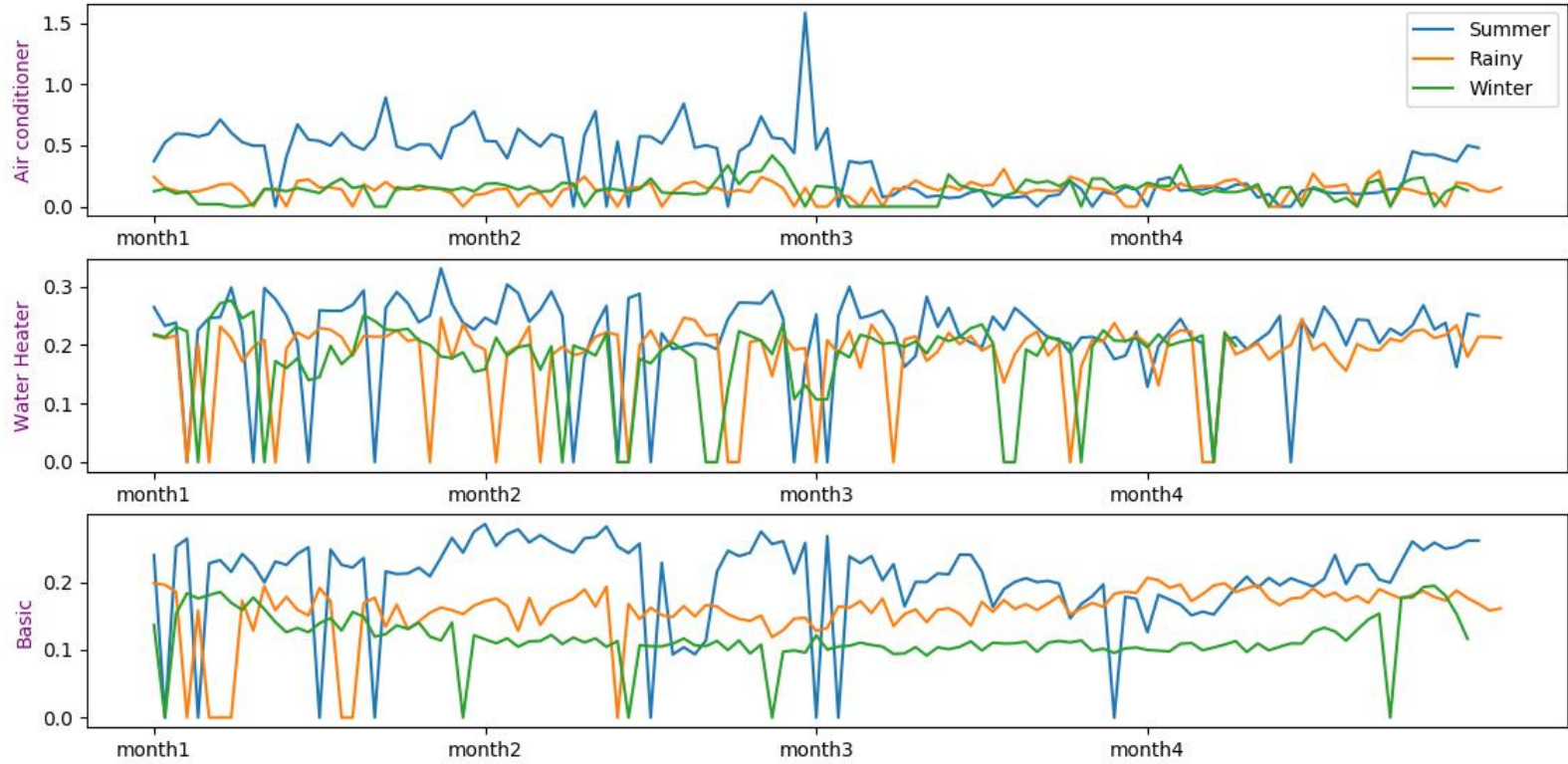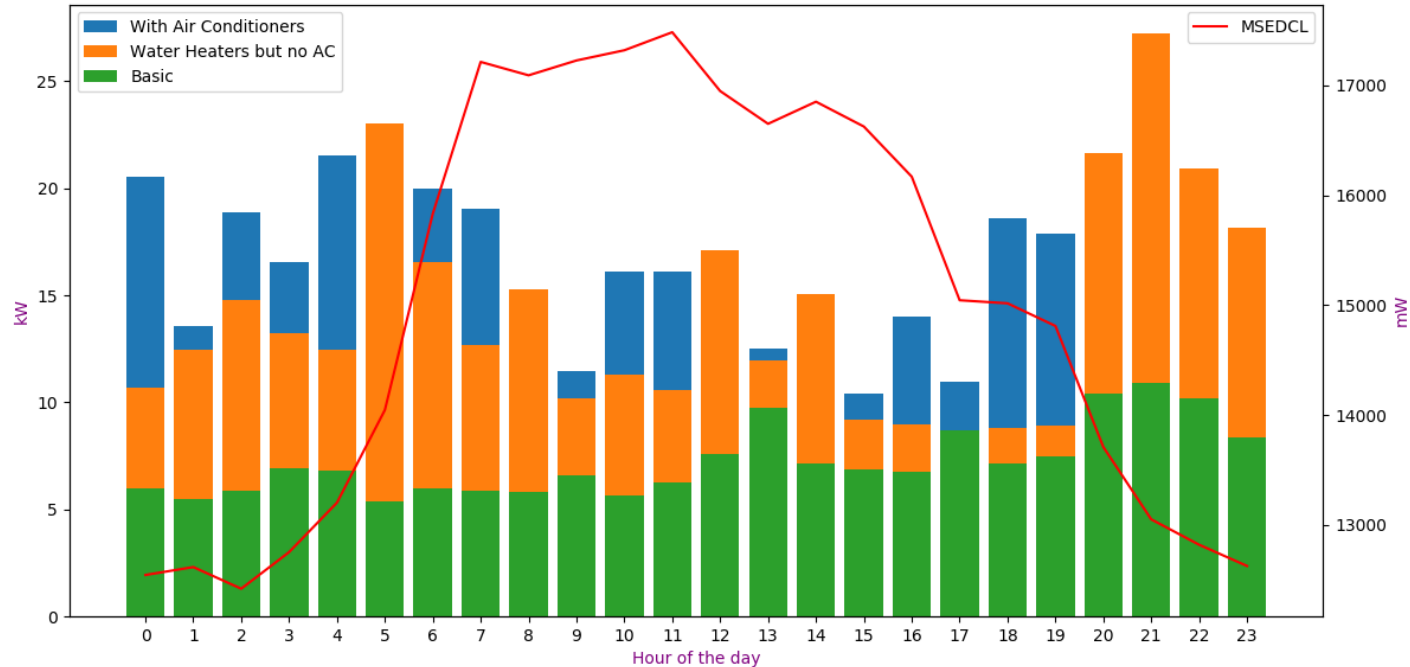# Load Duration Curve: Hourly resolution vs. 15 min resolution

Seasonwise Load Curve (kW) for different household types

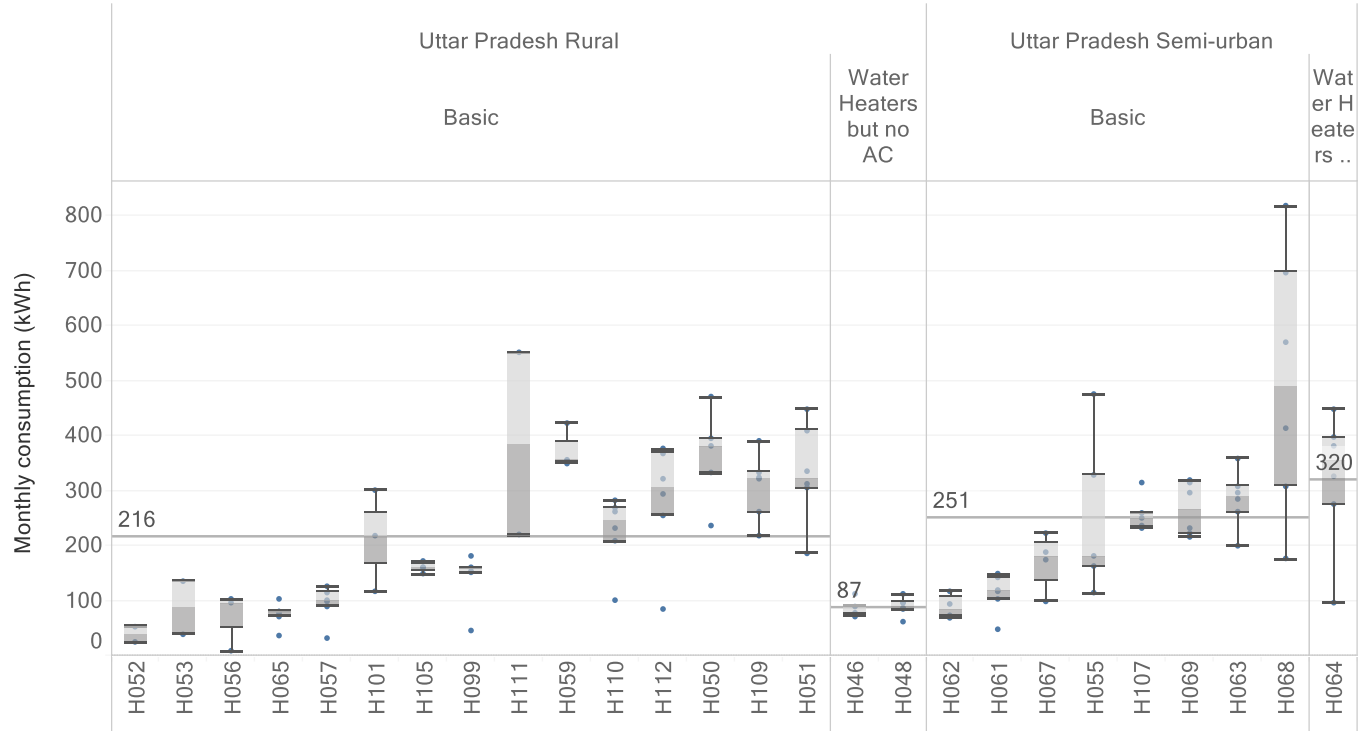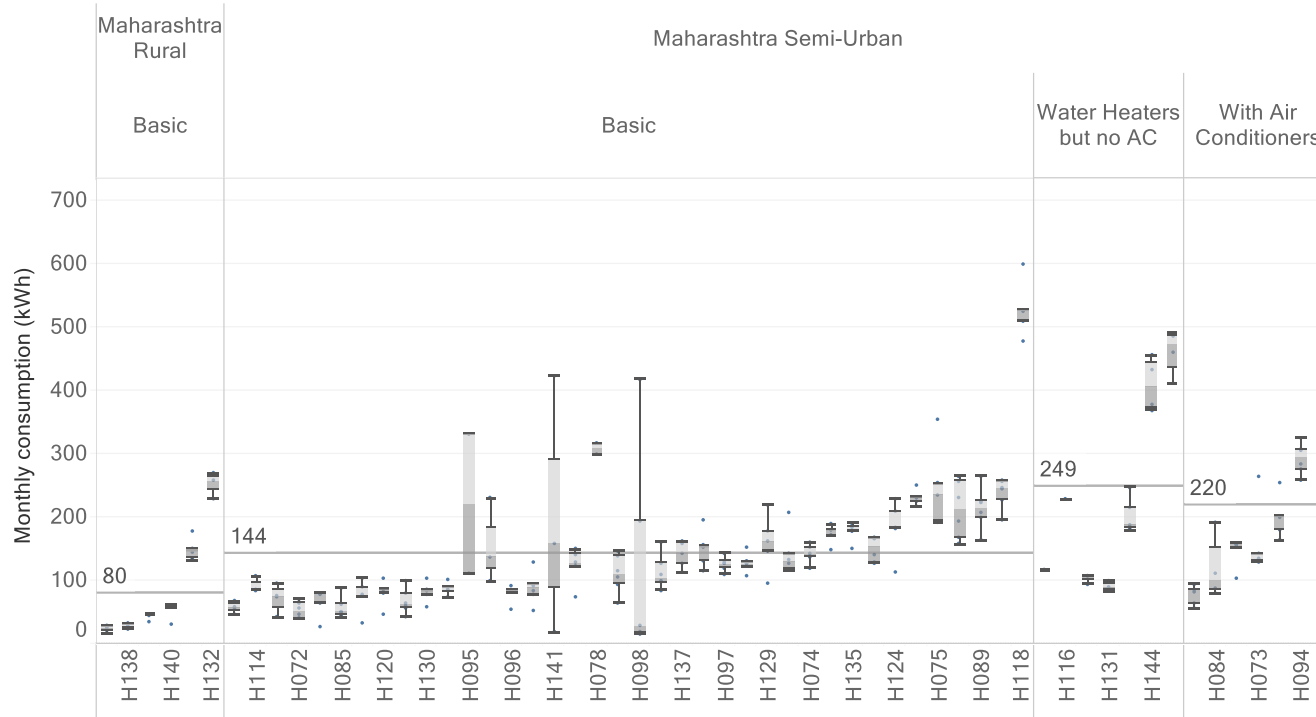# MSEDCL Load curve and eMARC household curves

Load Curve for 1st Oct'18

Preliminary analysis : Uttar Pradesh

Preliminary analysis : Maharashtra

Observations

- Load patterns that can help identify theft
- Need to assess use of inverters adding to household energy consumption
- Regular use of water heaters a very urban phenomenon
- Usage of refrigerators ;different across Maharashtra and Uttar Pradesh

What next …

- Working on clustering based algorithms to test accuracy of pattern identification and classification of households
- Working on testing Load disaggregation techniques to identify appliance signatures which can give more insights on efficiency of appliances
- Some machine learning based techniques which can be used for load forecasting and further demand estimation
- We hope to plug this information into larger grid modelling and energy economy modelling exercises

Thank you!

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Energy consumption variation across months
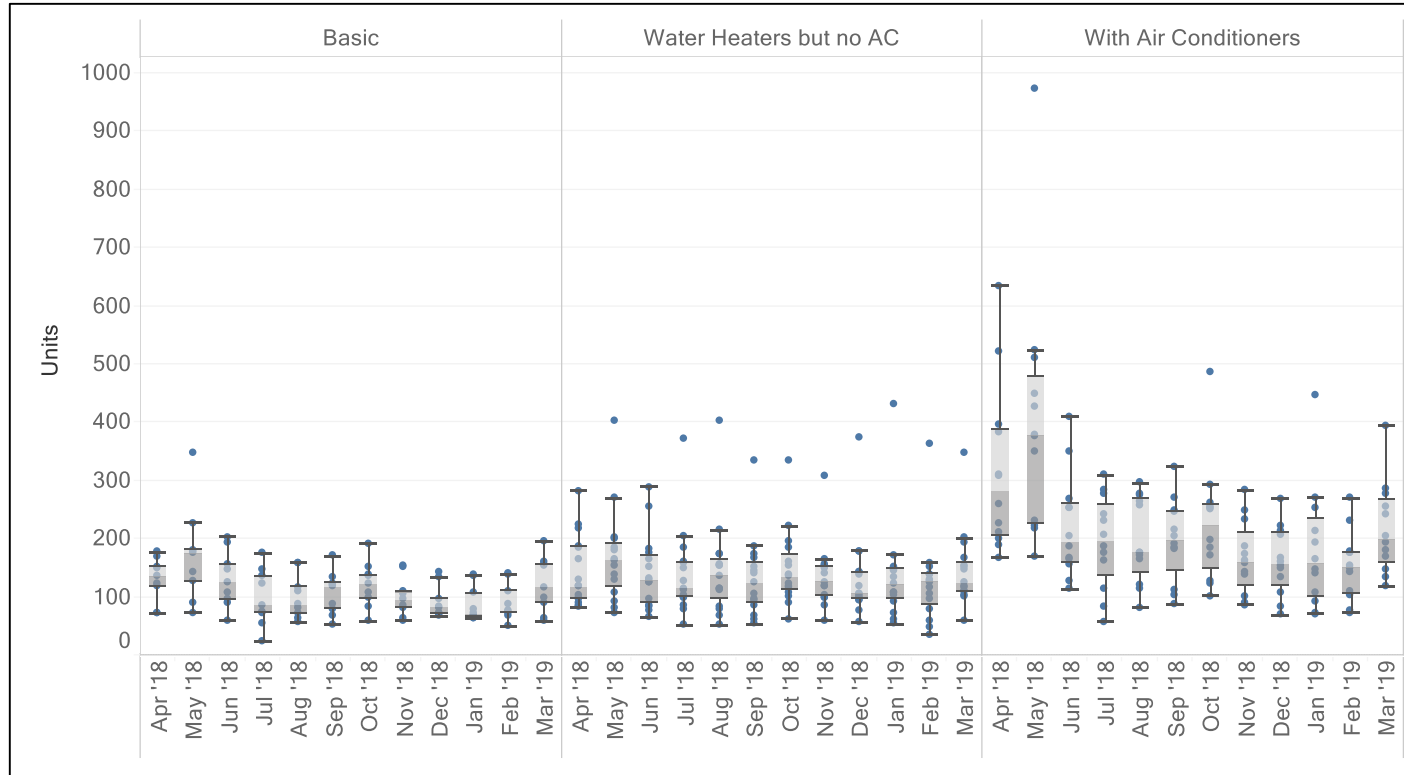
Increase in consumption is coincidental with hot weather

Mains Load Duration Curve (in kW, 15 min resilution): Apr'18 - Mar'19