

Insights into home energy consumption in India

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Why India?



Previous residential deployments exist **ONLY** in developed countries



Why India?



Different socio-economic settings

How is a residential deployment in India different?

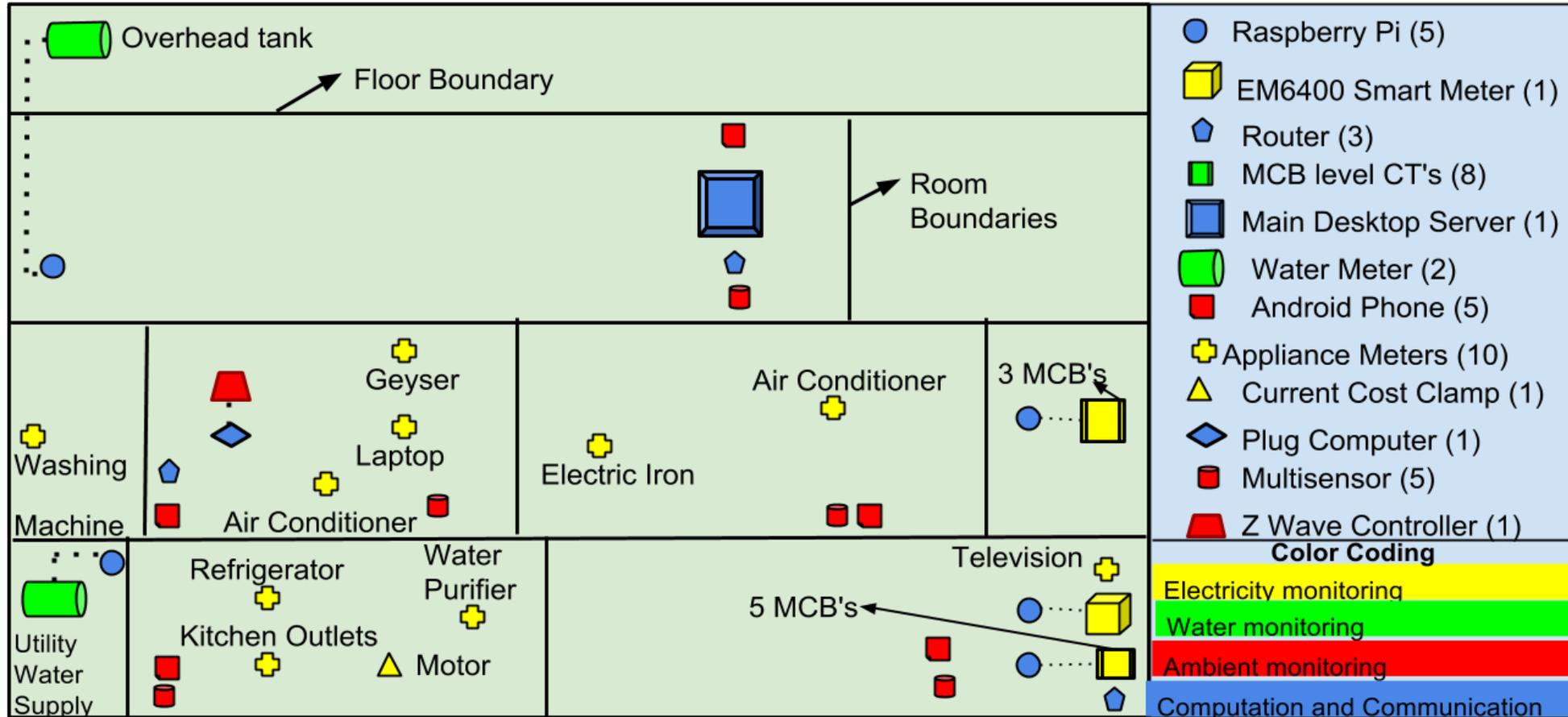


Deployment Overview



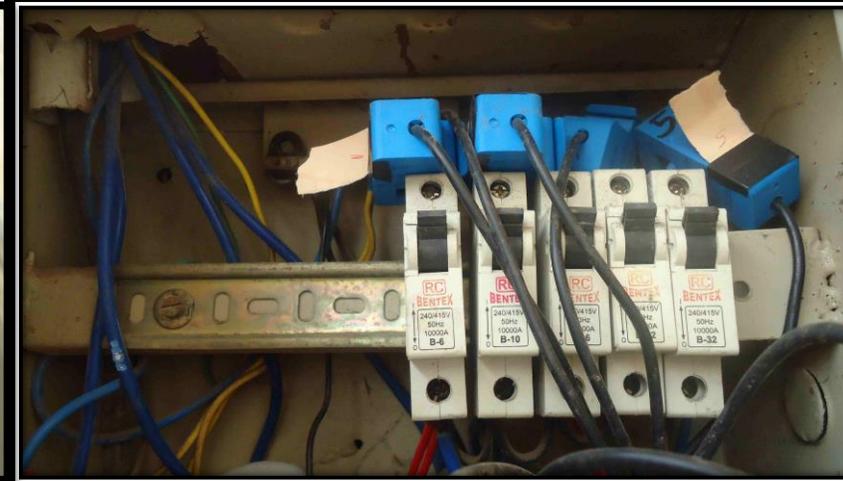
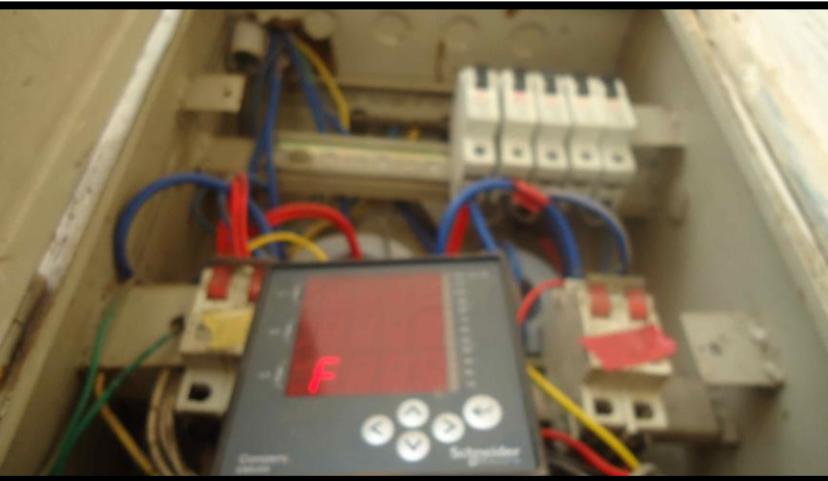
- Family characteristics:
 - Single family
 - 3 members
 - Medium Income
- Home characteristics:
 - 3 storey
 - 720 sq. feet

Deployment Overview: Sensing



- Multiple sensing modalities: Electricity, Water, Ambient
- Water Energy nexus provides interesting insights

Electricity monitoring



Smart Meter

Circuit Breaker

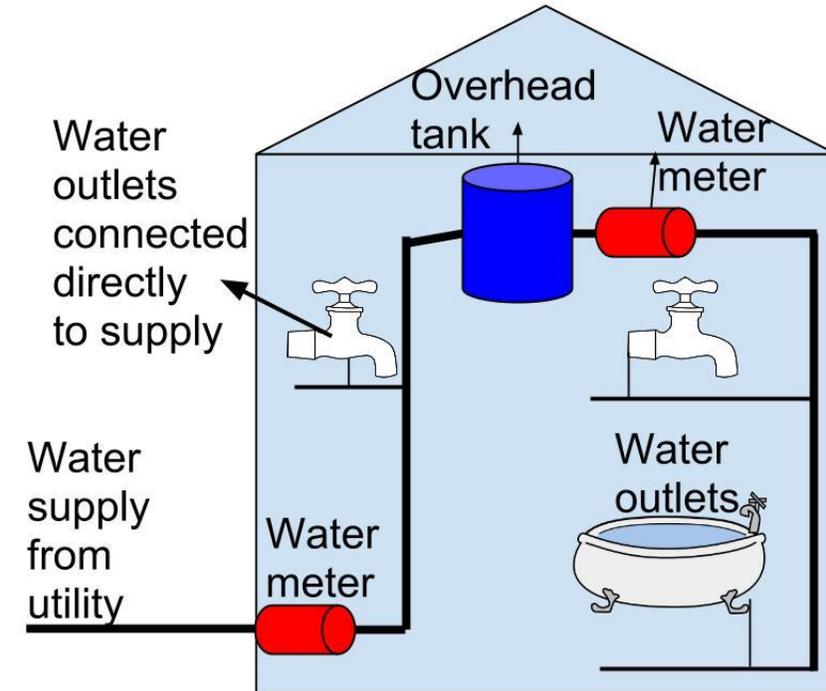
Appliance Level

- Measuring electricity consumption at Supply, MCB, Appliance
- Research questions:
 - Value of additional information (and associated cost)?
 - What level of invasiveness?

Water monitoring



Pulse based water meter



- Water supply available only for 2 hours in a day
 - Pumps used to store water in tanks- Water has EMBEDDED Energy
- Instrument the demand and the supply using Pulse based meters

Ambient sensing



- Energy consumption correlated with ambient settings
- Measure following ambient parameters
 - Light
 - Temperature
 - Motion
 - Sound level
 - Bluetooth, WiFi



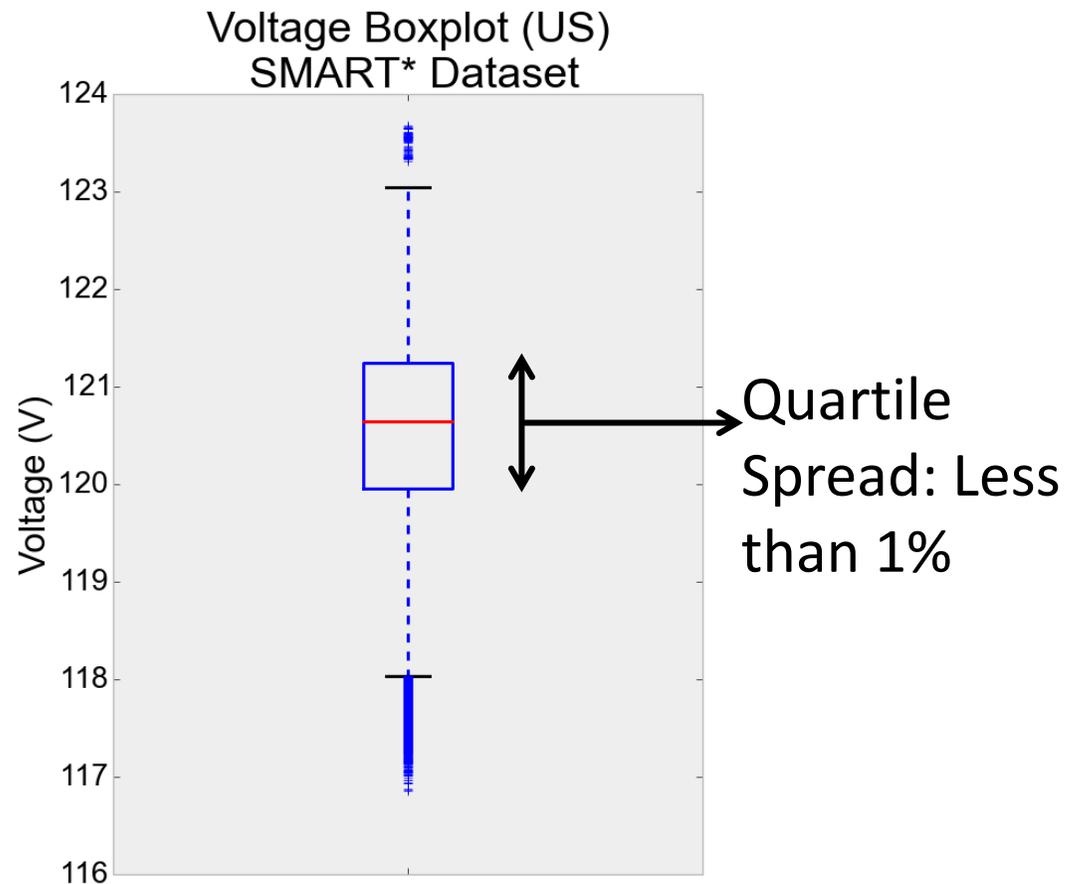
ZWave Multisensor +Android

Unique Features in India

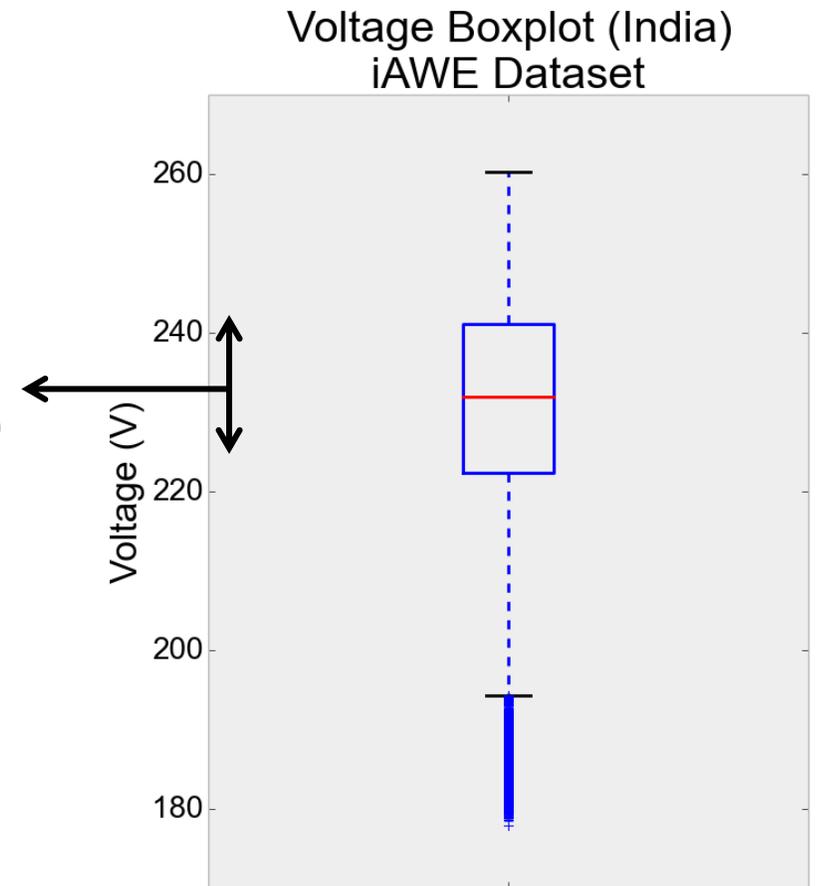
Unreliable Grid



1. Voltage fluctuation



Quartile Spread: 9%



Unique Features in India

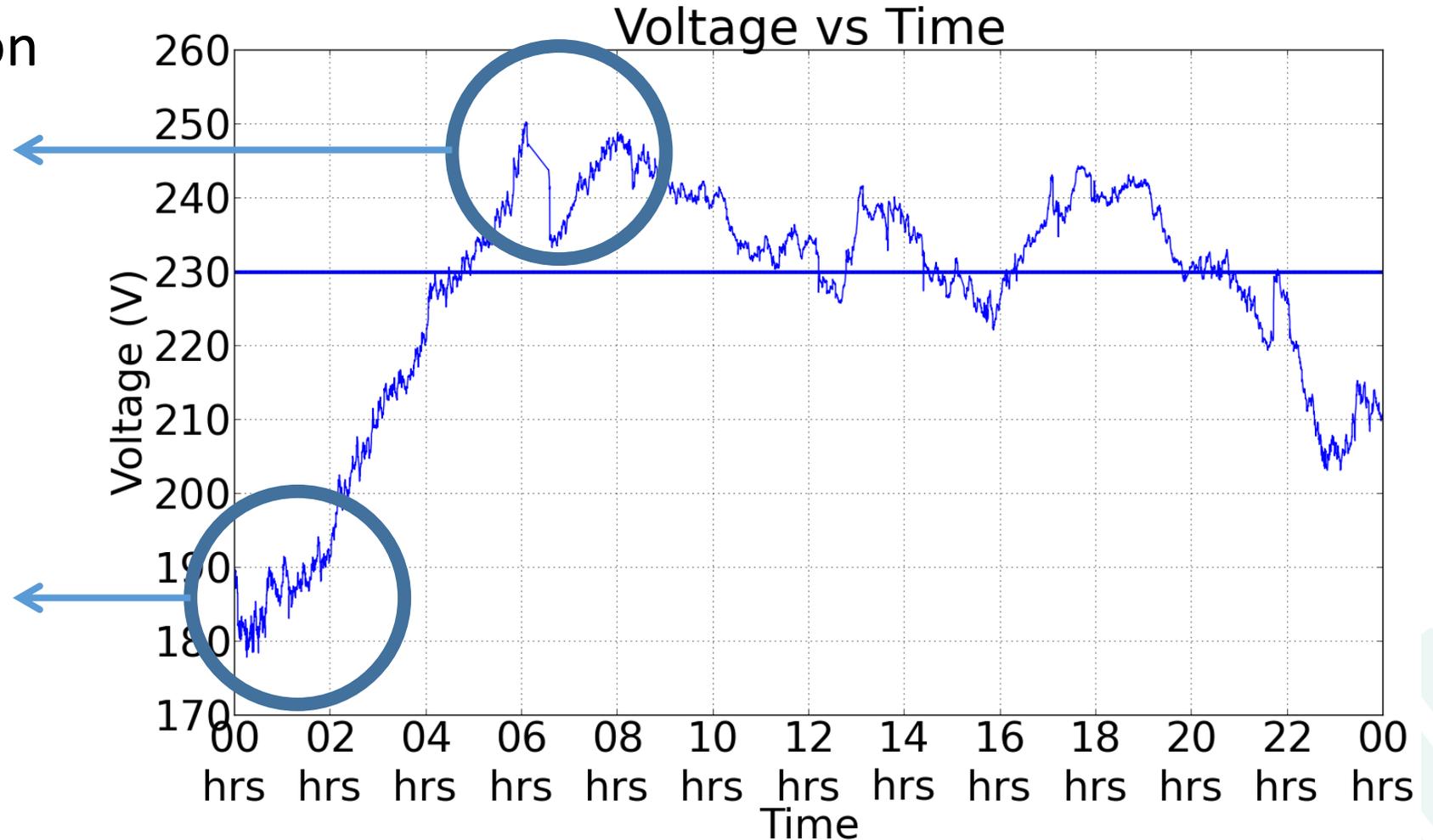
Unreliable Grid



1. Voltage fluctuation

Highest voltage typically seen early morning

Lowest voltage typically seen around midnight- ACs in most home are ON

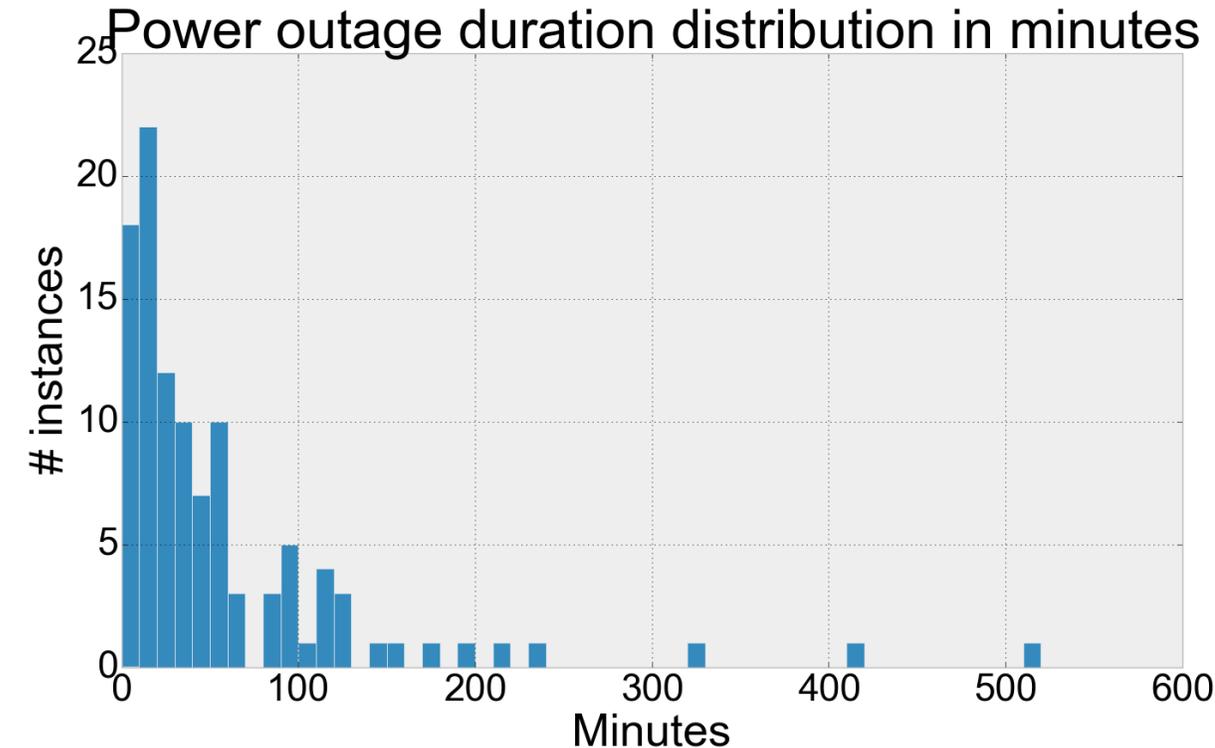
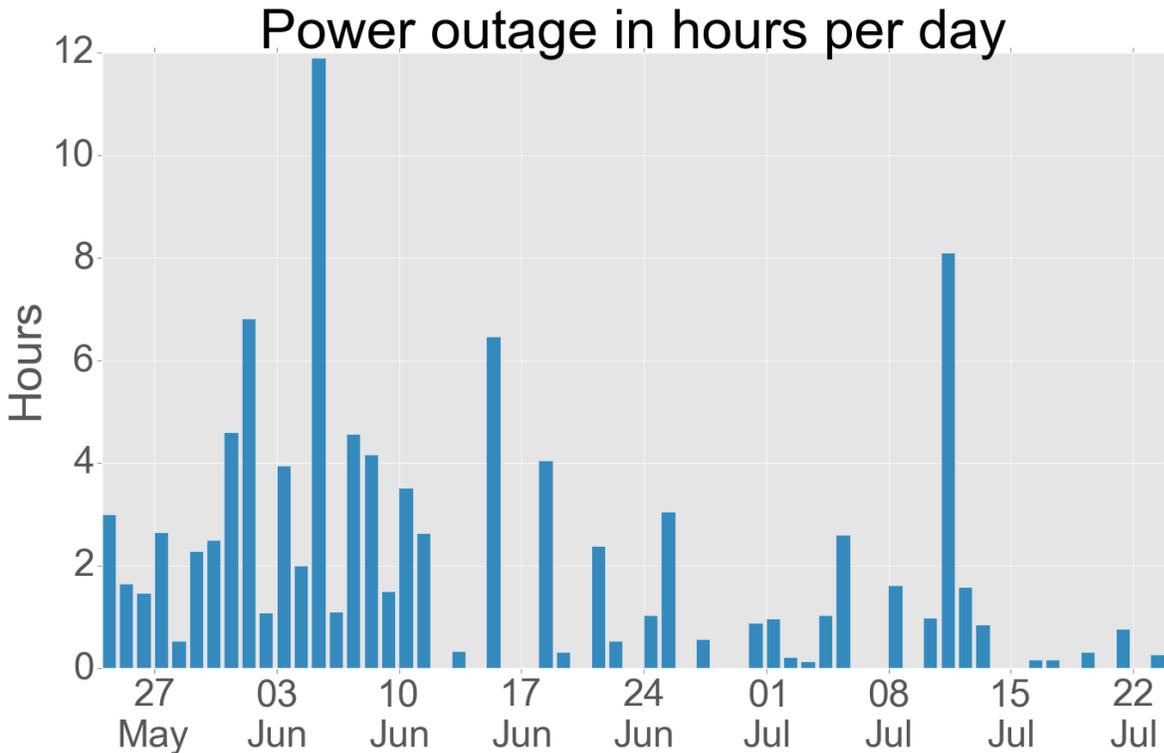


Unique Features in India

Unreliable Grid



2. Blackouts



Observed power outages upto 12 hours a day!

Single power outages of upto 9 hrs observed!

Unique Features in India

Unreliable Grid



3. Learning

- System Design: System should be capable of resuming in same state as it was before outage (Batteries way too difficult to manage 😞)
- Inferences: Need to measure voltage in addition to current for NILM approaches!

Unique Features in India

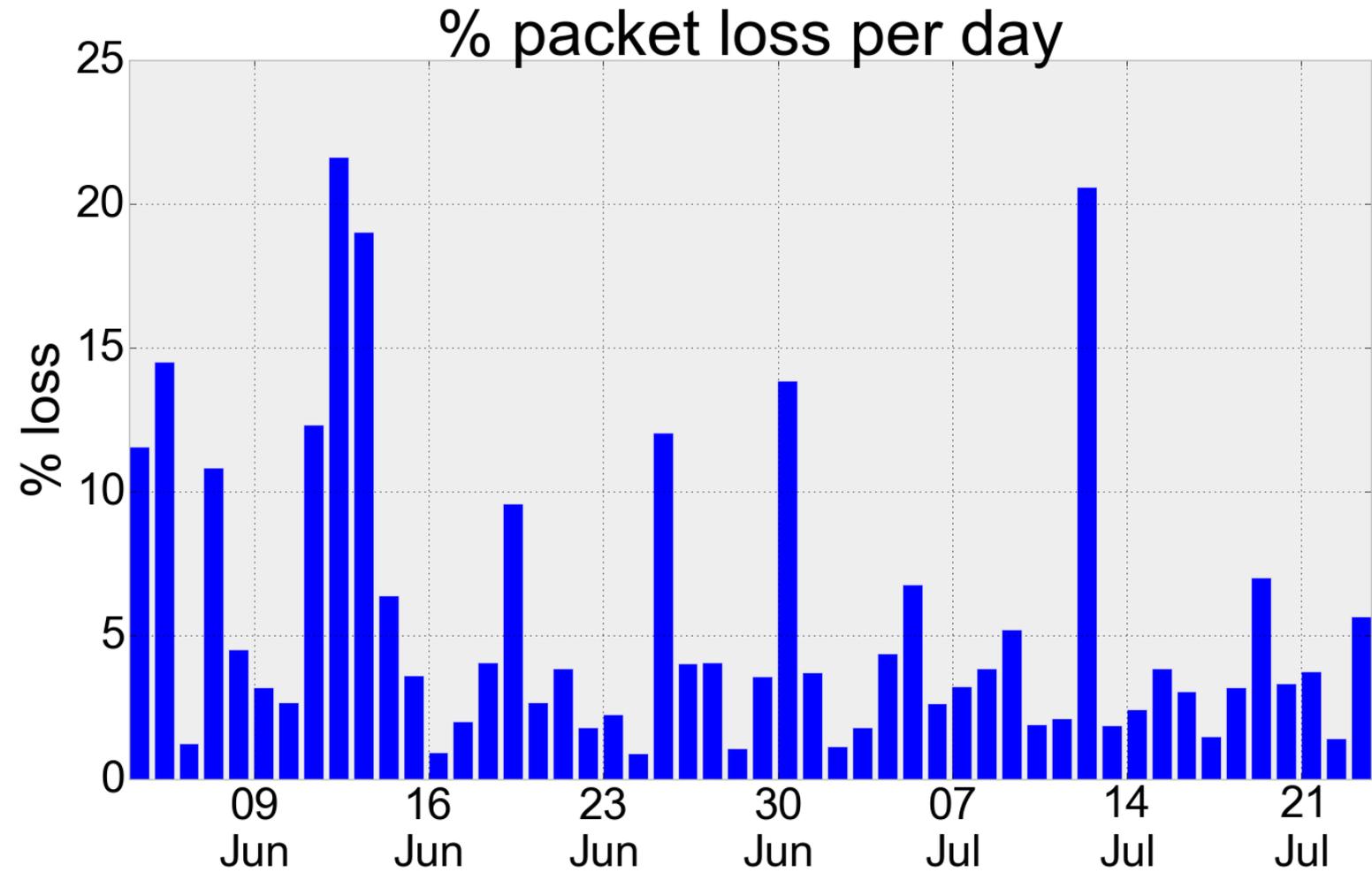
Unreliable network- Internet



Observed up to 1/4th packet loss on some days

Learning

- Need to account for unreliable internet
- Need to do local storage of data
- We followed Sense-Local store- Upload



Unique Features in India

Load specifics



- Bathroom level water heating-
 - Runs off electricity as opposed to gas
 - Contributes ~60% of total energy in winters
- Room level air conditioning
 - Used only in summers
 - Control is de-centralized
- These two loads are fairly easy to disaggregate- Easy to act upon to reduce energy footprint

iAWE: Indian Dataset for **A**mbient, **W**ater and **E**lectricity sensing

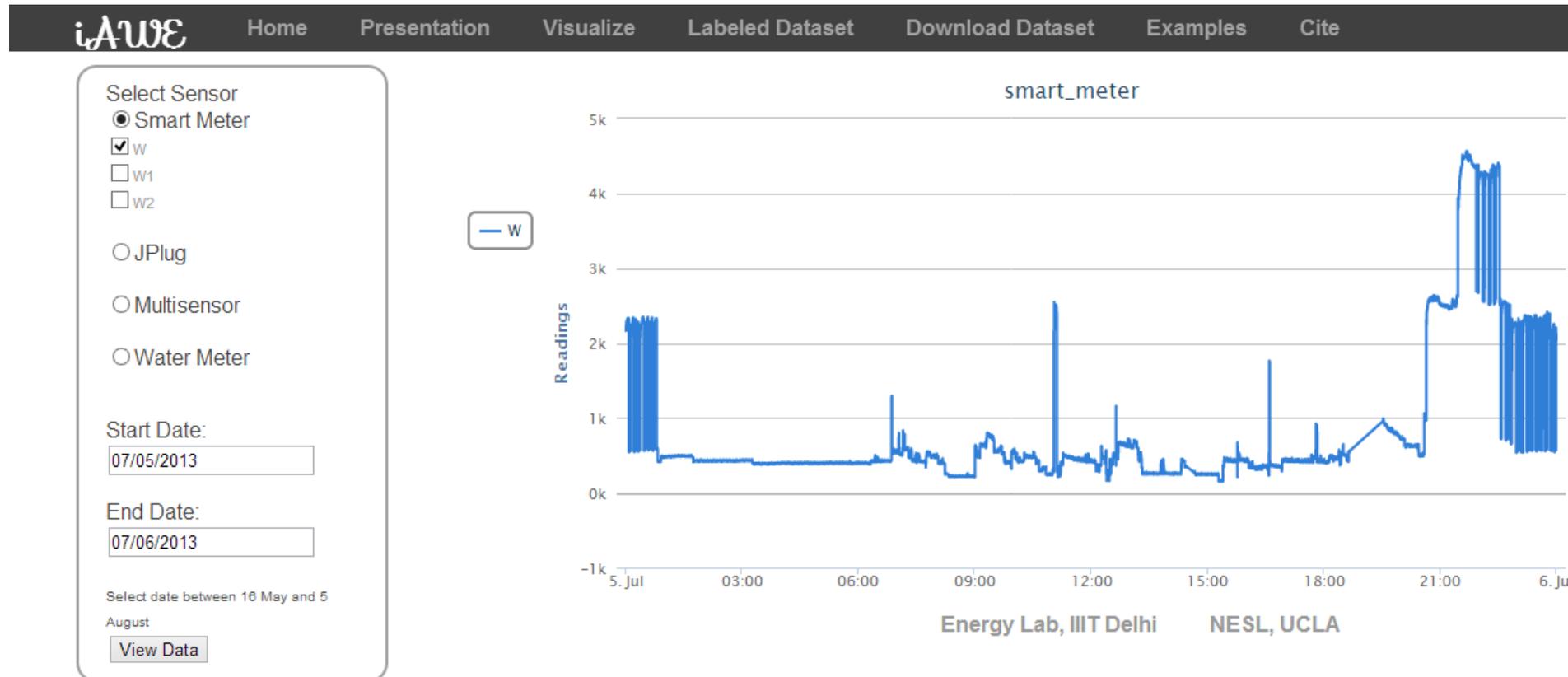


- 2+ months of data
 - 1 day fully labeled data
 - Rest semi-labeled
- Electricity, Water, Ambient conditions at different granularities
- Dataset released for public use

iAWE: Indian Dataset for **A**mbient, **W**ater and **E**lectricity sensing



Dataset explorer



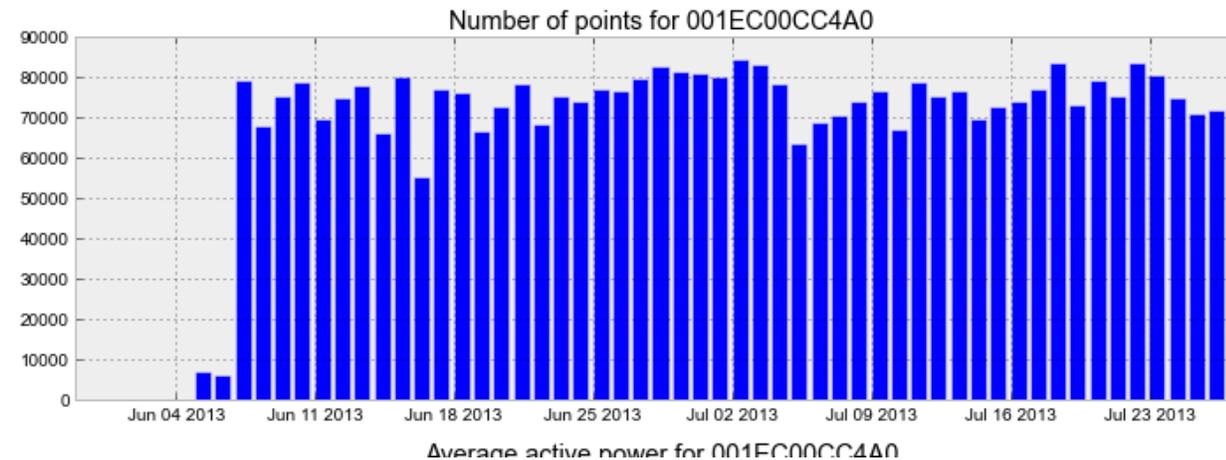
iAWE: Indian Dataset for **A**mbient, **W**ater and **E**lectricity sensing



Sample IPython notebooks- Code to interact with data and view results

```
if result.values[0][0] is not None:
    stats[jplug]['mean'].append(result.values[0][0])
else:
    stats[jplug]['mean'].append(0)

plt.figure()
plt.subplot(2,1,1)
plt.bar(stats[jplug]['X'],stats[jplug]['count'])
plt.title("Number of points for %s" %jplug)
plt.subplot(2,1,2)
plt.bar(stats[jplug]['X'],stats[jplug]['mean'])
plt.title("Average active power for %s" %jplug)
plt.ylabel('Average Active Power (W)')
plt.tight_layout()
```



iAWE: Indian Dataset for **A**mbient, **W**ater and **E**lectricity sensing



Entire project maintained as open source on Github

https://github.com/nipunreddevil/Home_Deployment/

<https://github.com/nipunreddevil/iawe-website>

The screenshot shows a GitHub issue titled "Noisy SMPS" opened by nipunreddevil 6 months ago. The issue is marked as "Closed" and has 3 comments. It is assigned to manojgulati and has no milestone. The issue description states: "SMPS makes a little noise. Have seen this before. Want to confirm what noise level is permissible." The issue has two participants: manojgulati and nipunreddevil. The comments are as follows:

- manojgulati commented 6 months ago: "The room where you have installed your desktop is usually hot also a lot of dust is accumulating there. Please move the desktop to a better place. Cleaning SMPS fan might help."
- nipunreddevil commented 5 months ago: "Noise levels at an all time high. Previous experience with laptop shows that it may shutdown due to over heating. Need to clean the fan."
- nipunreddevil commented 5 months ago: "Cleaned the Desktop. Literally a kg of dust!! Will add this as a unique aspect of Indian deployments in forthcoming paper."

Labels: enhancement, non_critical

Demo



<http://energy.iiitd.edu.in:5000/>

Conclusions



- Developing countries provide unique challenges for residential deployments
 - Unreliable grid
 - Unreliable network
 - Load specifics
- Validated previous work in residential sensing
- Release iAWE dataset
- “Behind every successful residential deployment, there is a very cooperative (and angry 😊) family”

Acknowledgements



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