Instrumentation for Cooking Pattern Analysis in Peri-Urban Nepal

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Household Air Pollution

Household Air Pollution (HAP) accounts for over 21,000 premature deaths each year in Nepal according to Clean Cooking Alliance

From Wood-burning to Electric Stoves

- What is the barrier?
- How to maximize the adoption of electric induction stoves in an area where wood-burning cookstoves are dominating ?

Goals of Instrumentation Study

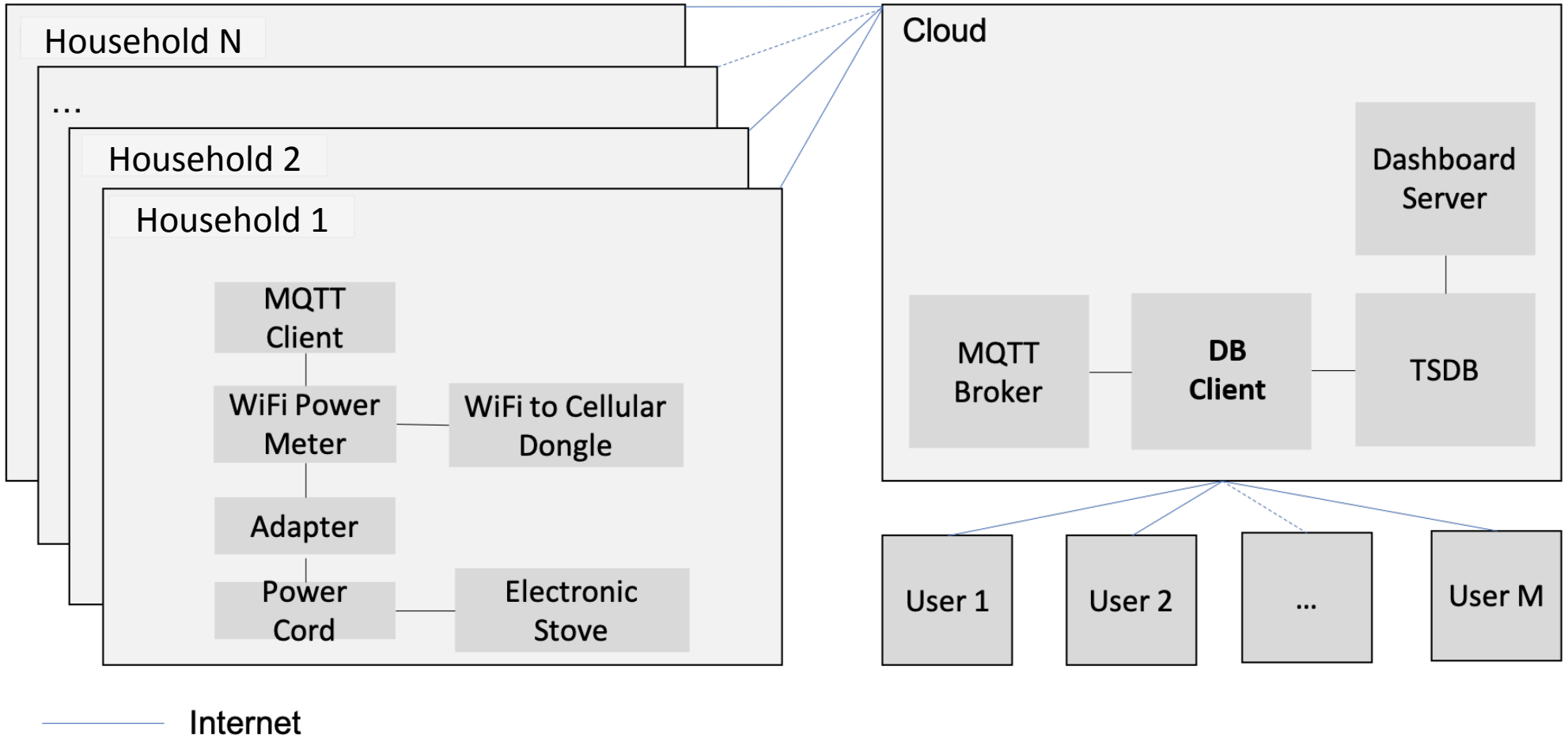
- Availability
  - The electricity infrastructure is ready?
- Affordability
  - Too expensive?
- Steps to maximize the adoption of electric stove

Metrics

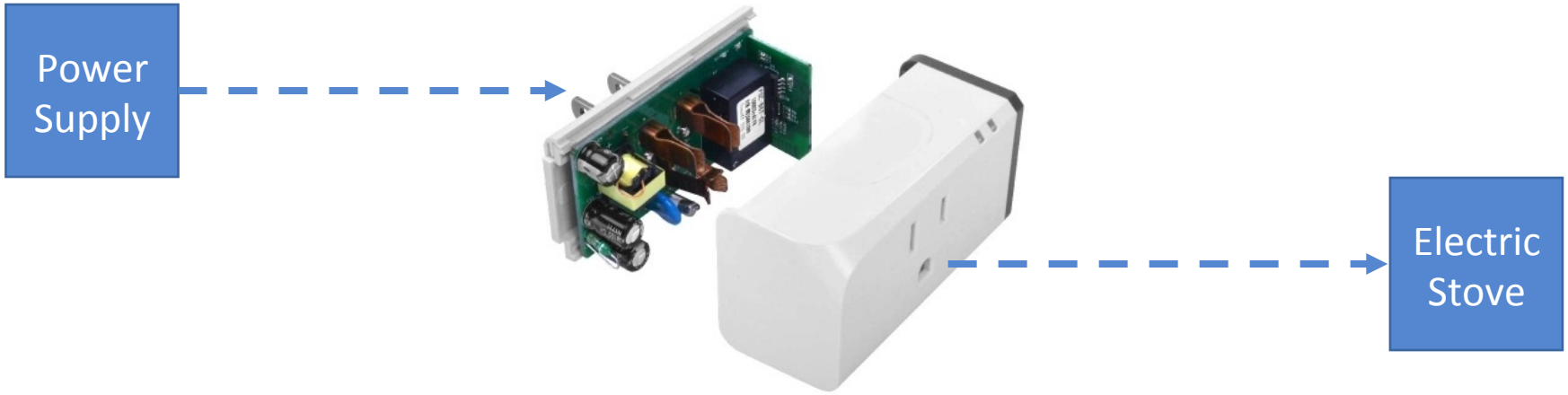
- Voltage
- Current
- Power
- Power Factor

System Design

System Overview

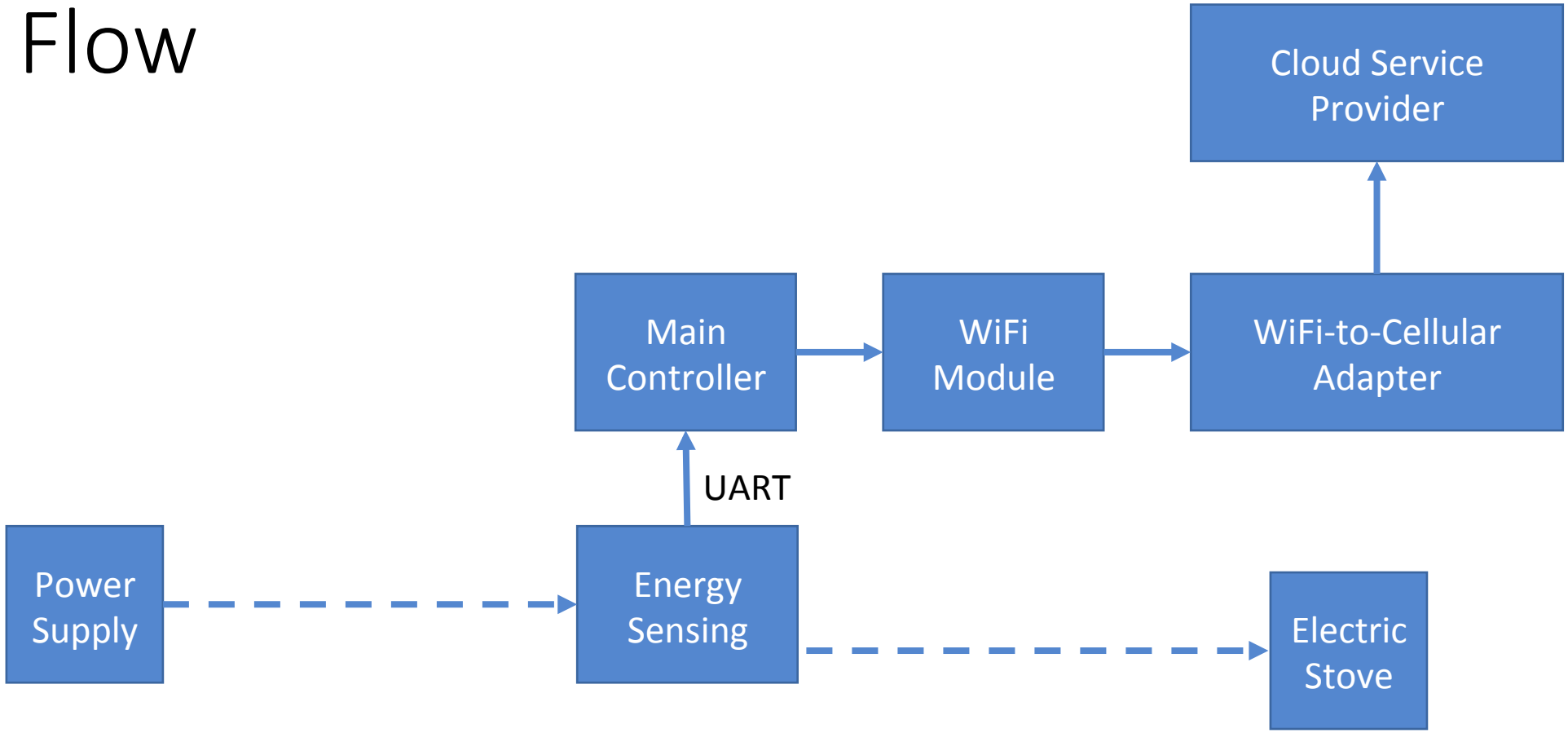


Device Implementation



https://www.itead.cc/sonoff-s31.html

Data Flow

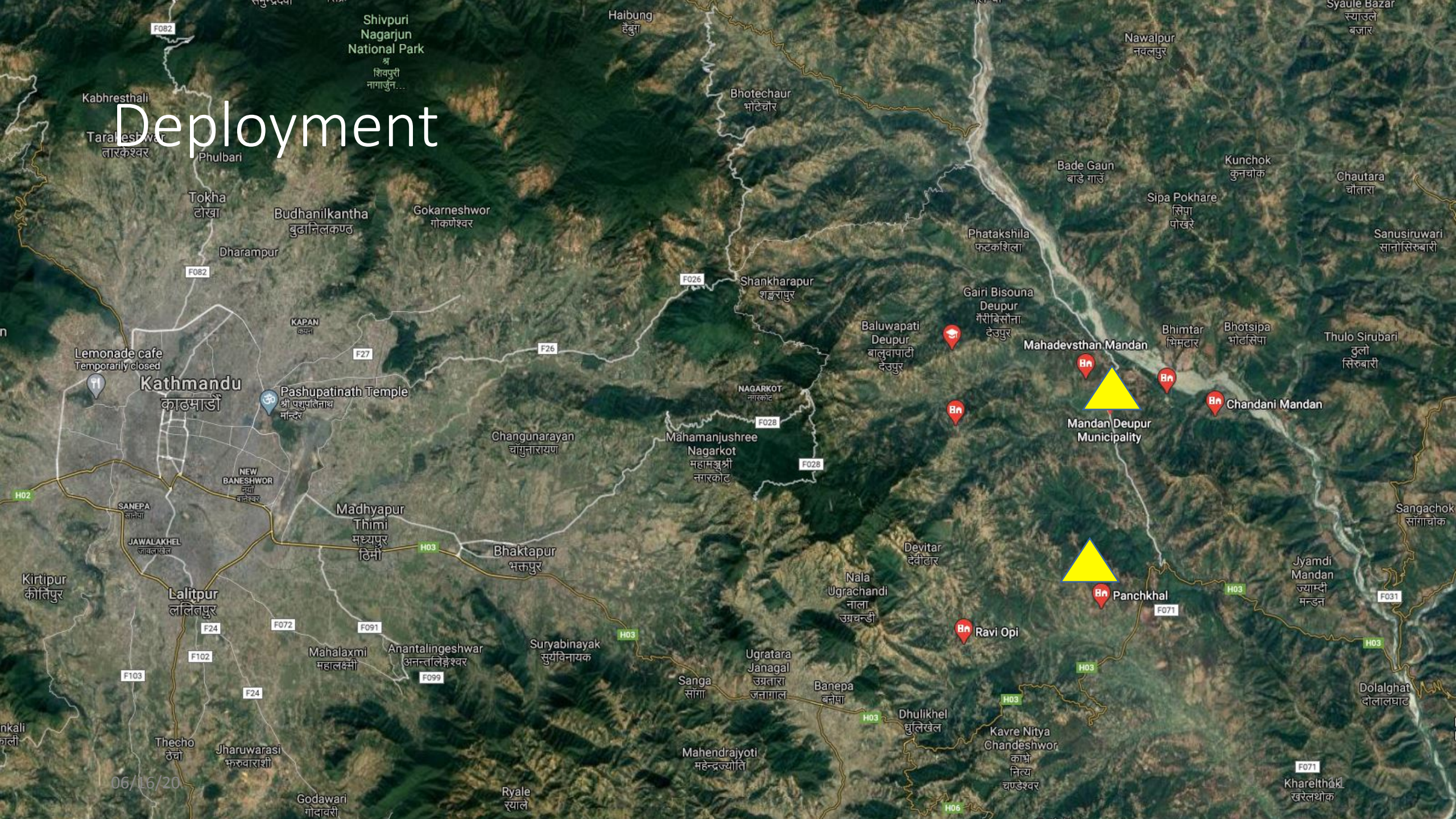

Cloud Service Provider
Main Controller
WiFi Module
WiFi-to-Cellular Adapter
UART
Power Supply
Energy Sensing
Electric Stove

Implementation

- ESP8266
  - Low-cost WiFi microchip
  - 32bit CPU @ 80MHz
  - A full TCP/IP stack
  - Microcontroller
  - 128 KB Memory
  - 1 MB Flash
- CSE7766
  - Single-phase power sensing chip
  - UART
- Software
  - Open Source Tasmota firmware running on ESP8266
  - Sampling rate: 10s
  - Flexible configuration
  - Hacking required

https://www.itead.cc/sonoff-s31.html

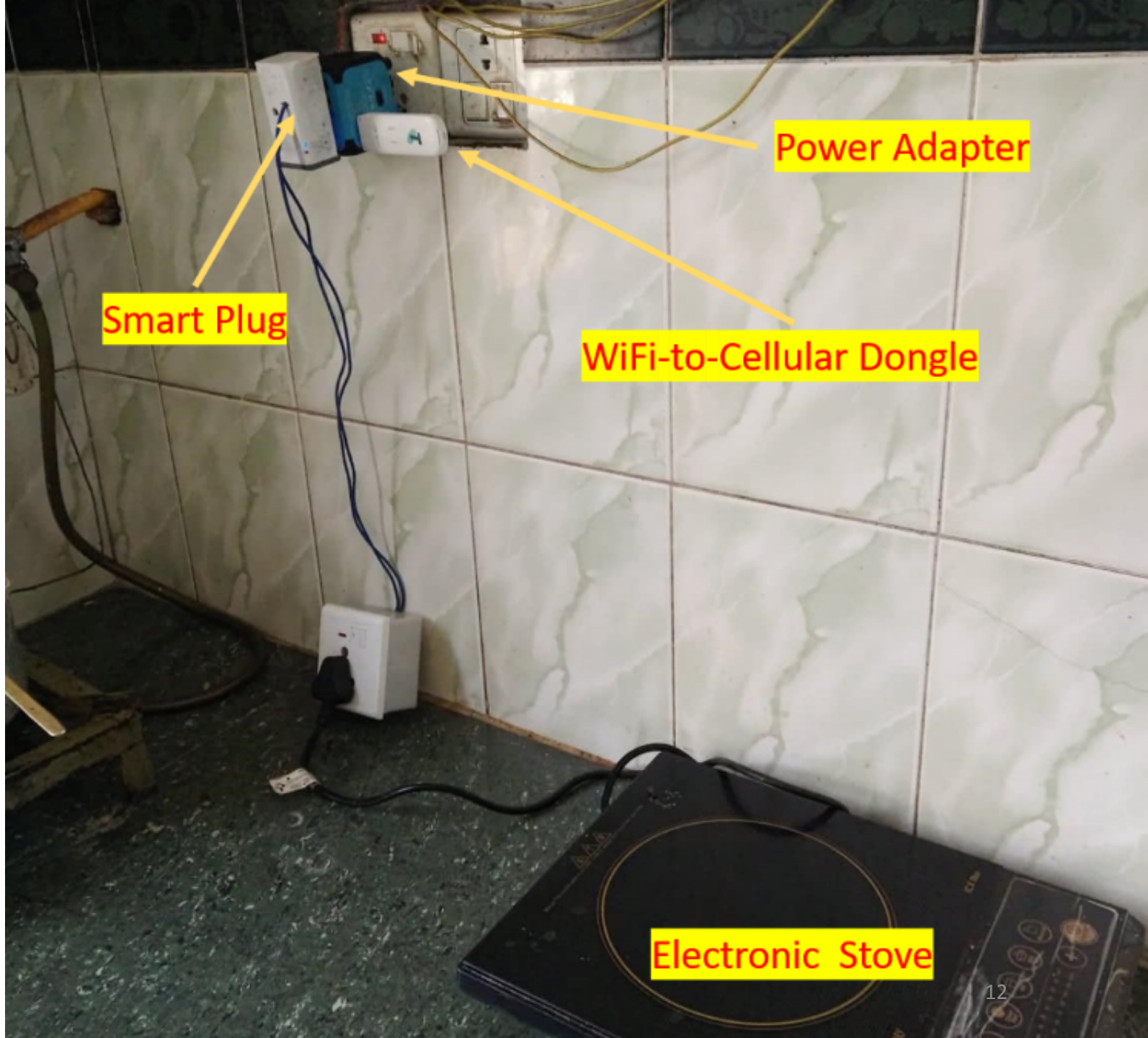
Deployment


Shivpuri Nagarjun National Park
Haibung
Nawalpur
Bhotechaur
Kabhresthali
Phulbari
Tokha
Budhanilkantha
Gokarneshwor
Dharampur
Bade Gaun
Kunchok
Chautara
Sipa Pokhare
Phatakshila
Sanusiruwari
Shankharapur
Gairi Bisouna Deupur
Baluwapati Deupur
Mahadevsthan Mandan
Bhimtar
Bhotsipa
Thulo Sirubari
KAPAN
Lemonade cafe
Temporarily closed
Kathmandu
Pashupatinath Temple
NAGARKOT
Chandani Mandan
Mandan Deupur Municipality
Changunarayan
Mahamanjushree Nagarkot
NEW BANESHWOR
SANEPA
JAWALAKHEL
Madhyapur Thimi
Bhaktapur
Sangachok
Devitar
Kirtipur
Lalitpur
Nala Ugrachandi
Jyamdi Mandan
Panchkhal
Ravi Opi
Suryabinayak
Mahalaxmi
Anantalingeshwar
Ugratara Janagal
Sanga
Banepa
Dolalghat
Dhulikhel
Kavre Nitya Chandeshwor
Thecho
Jharuwarasi
Mahendrajyoti
Ryale
Godawari
Kharelthok
F082
F026
F27
F28
F072
F091
F24
F102
F103
F099
F031
F071
H02
H03
H06

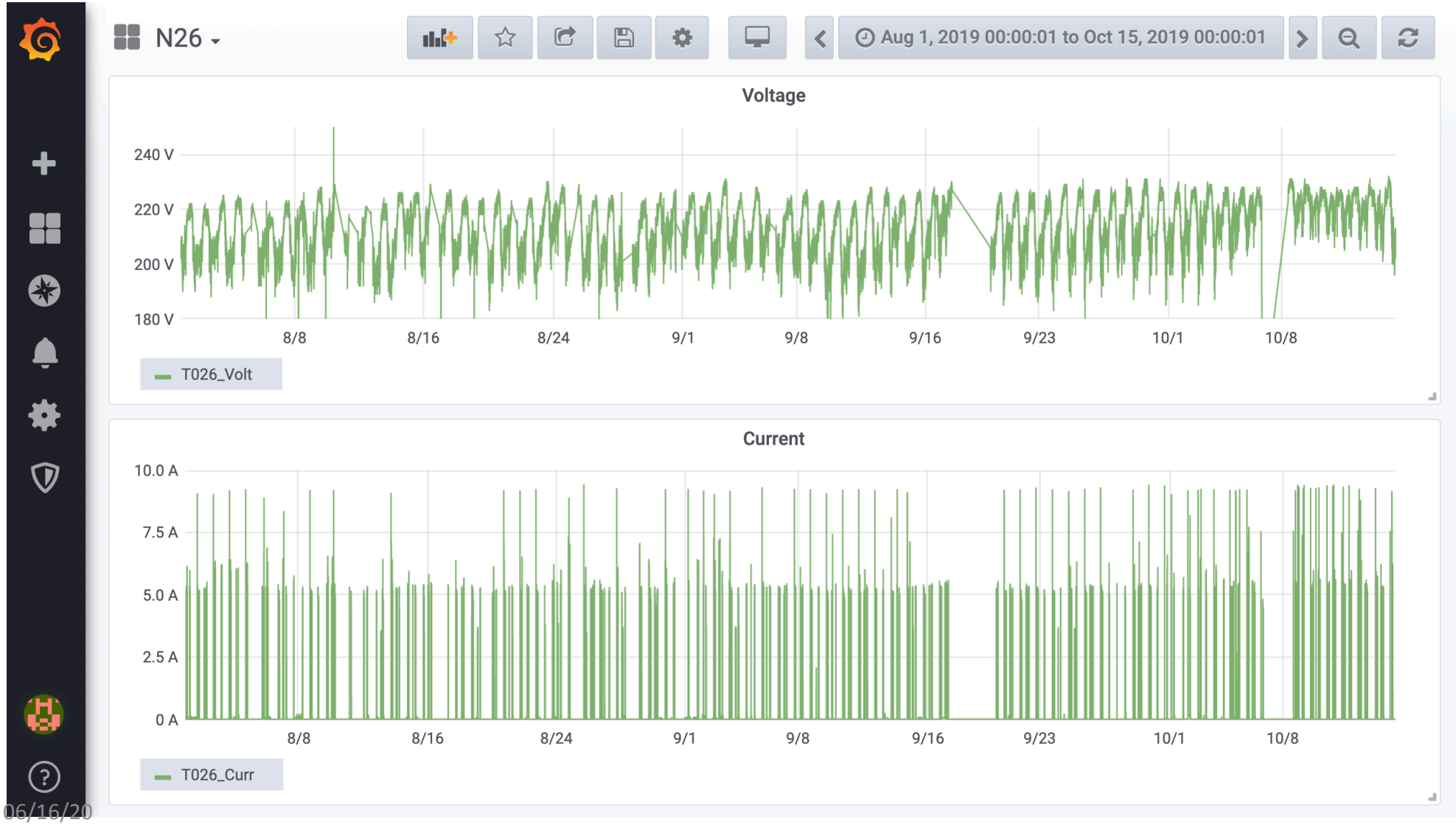
Deployment

- Near real-time data streaming
- 35 households
- 28 operational between

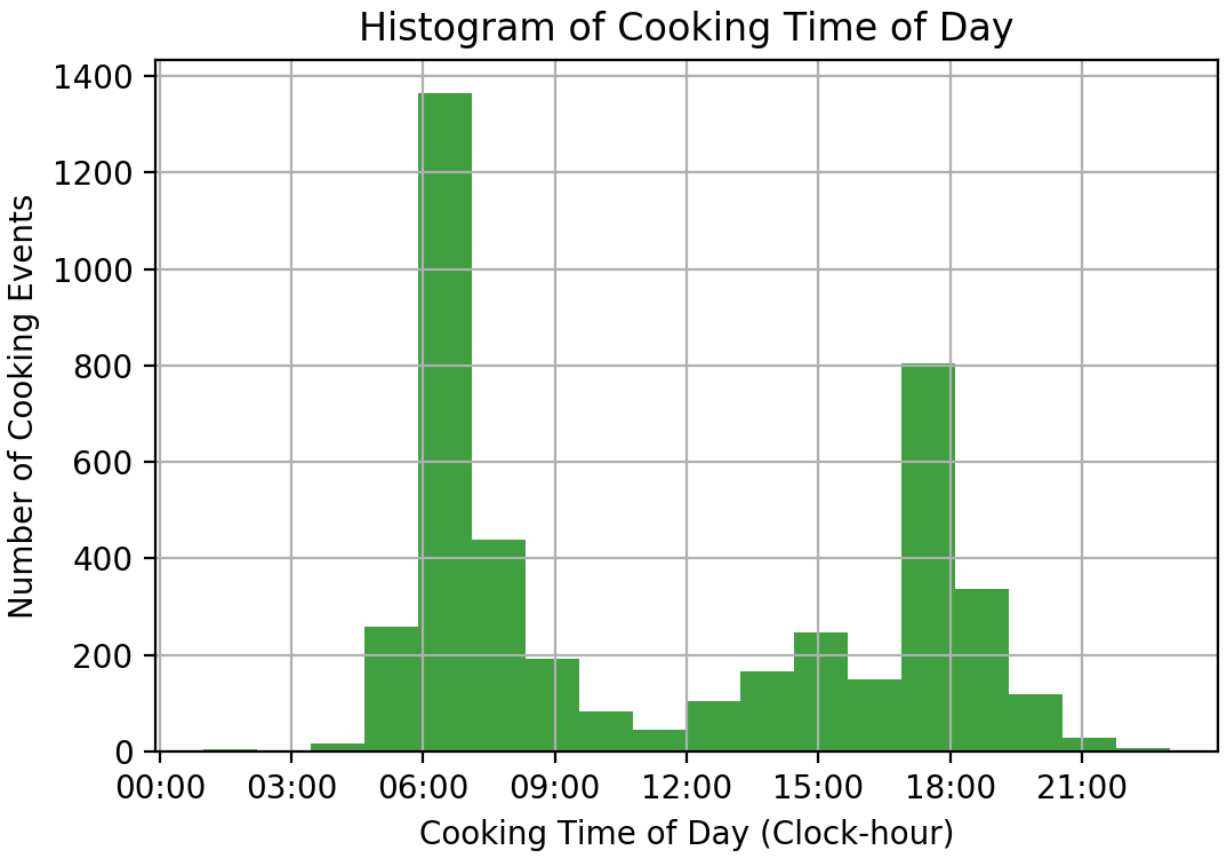
  Aug/1/2019 – Oct/15/2019
- 7 failed due to hardware/ software/network issues.



Dashboard Overview



Cooking Time

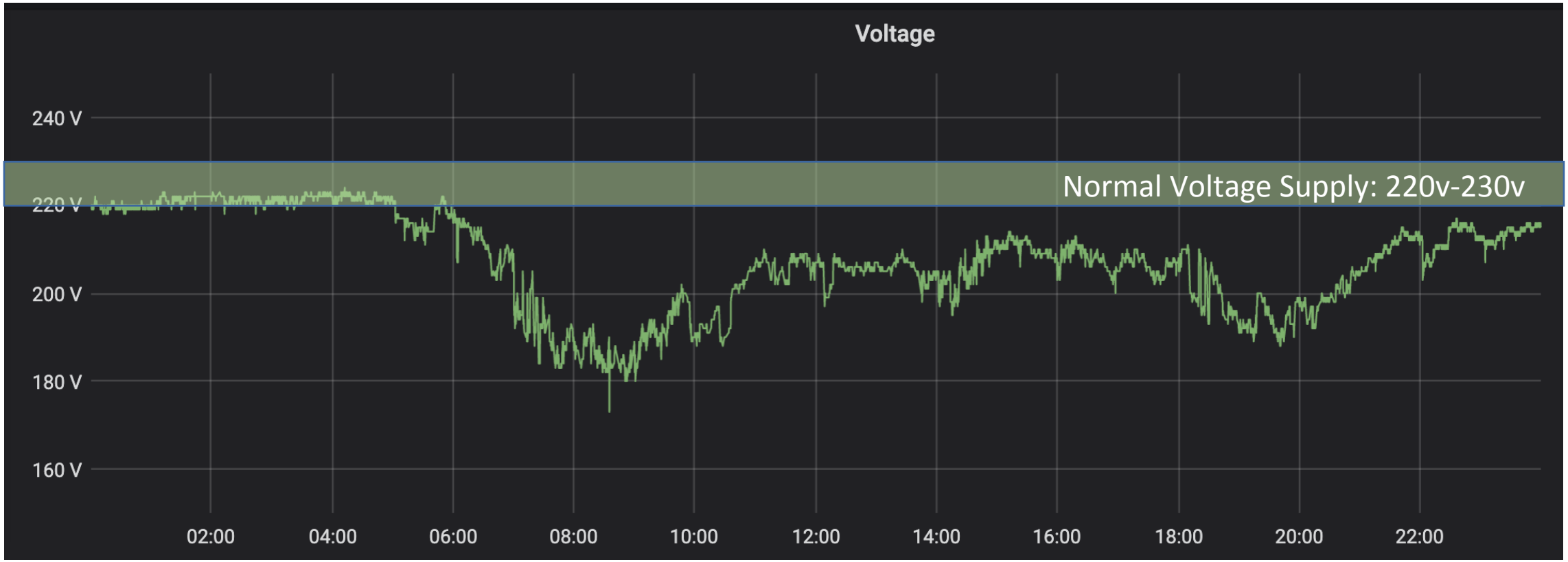


The first peak	**6-8am**
The second peak	**230-330pm**
The third peak	**530-730pm**

Just for cooking:
Average Power Draw: 811 watts
Number of estimated homes: 5.7 million
Estimated electricity load: **4.6** Gigawatts
Current load capacity: **1** Gigawatts

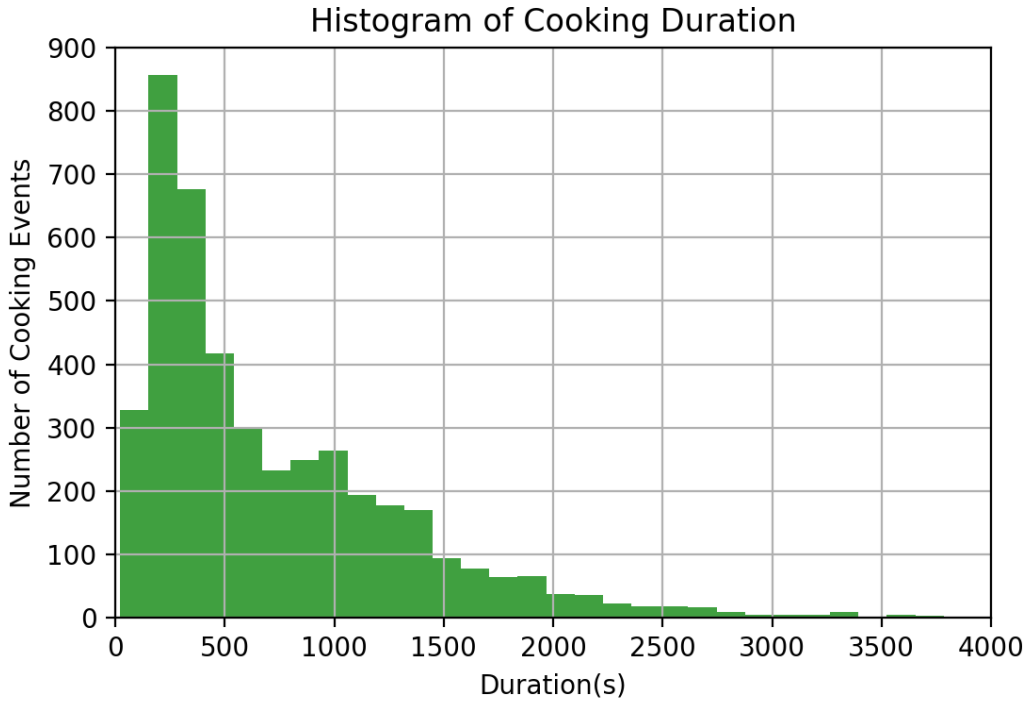
The demand will be 4 times higher than the capacity!

Voltage Variations

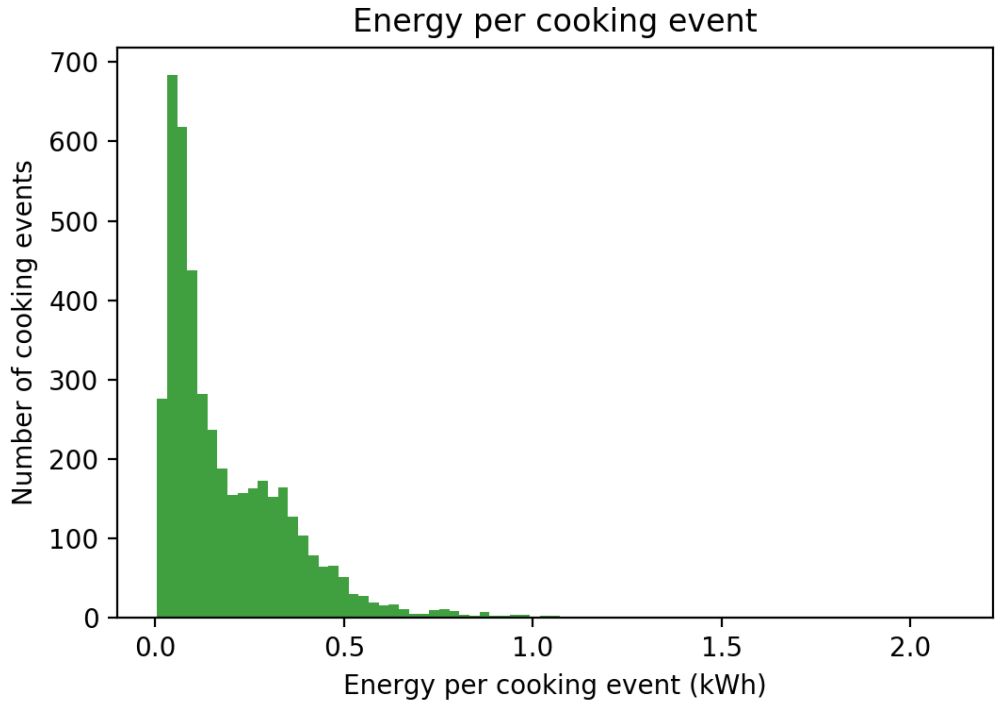


During peak hours, the supply voltage can drop to 180v, may cause deteriorating electric stove performance!

Electricity Use and Cost for Cooking



Q1	Median	Q3
266s	505s	1040s



Q1	Median	Q3
0.06 kwh	0.12kwh	0.28kwh

The daily energy consumption by the induction stove was 0.73 kWh, which is around 0.02 dollars/day.

Discussion

- Decoupling meter from the device
  - User behavior
- Data outage
  - Network or power outage
  - Irregular sampling
- Platform Improvement
  - Device diagnostics

Conclusions

- Load management should anticipate large cooking-related peak when electric cooking is adopted by a large number of households.
- Electric cooking initiatives should educate the consumers about the low energy cost of electric cooking.