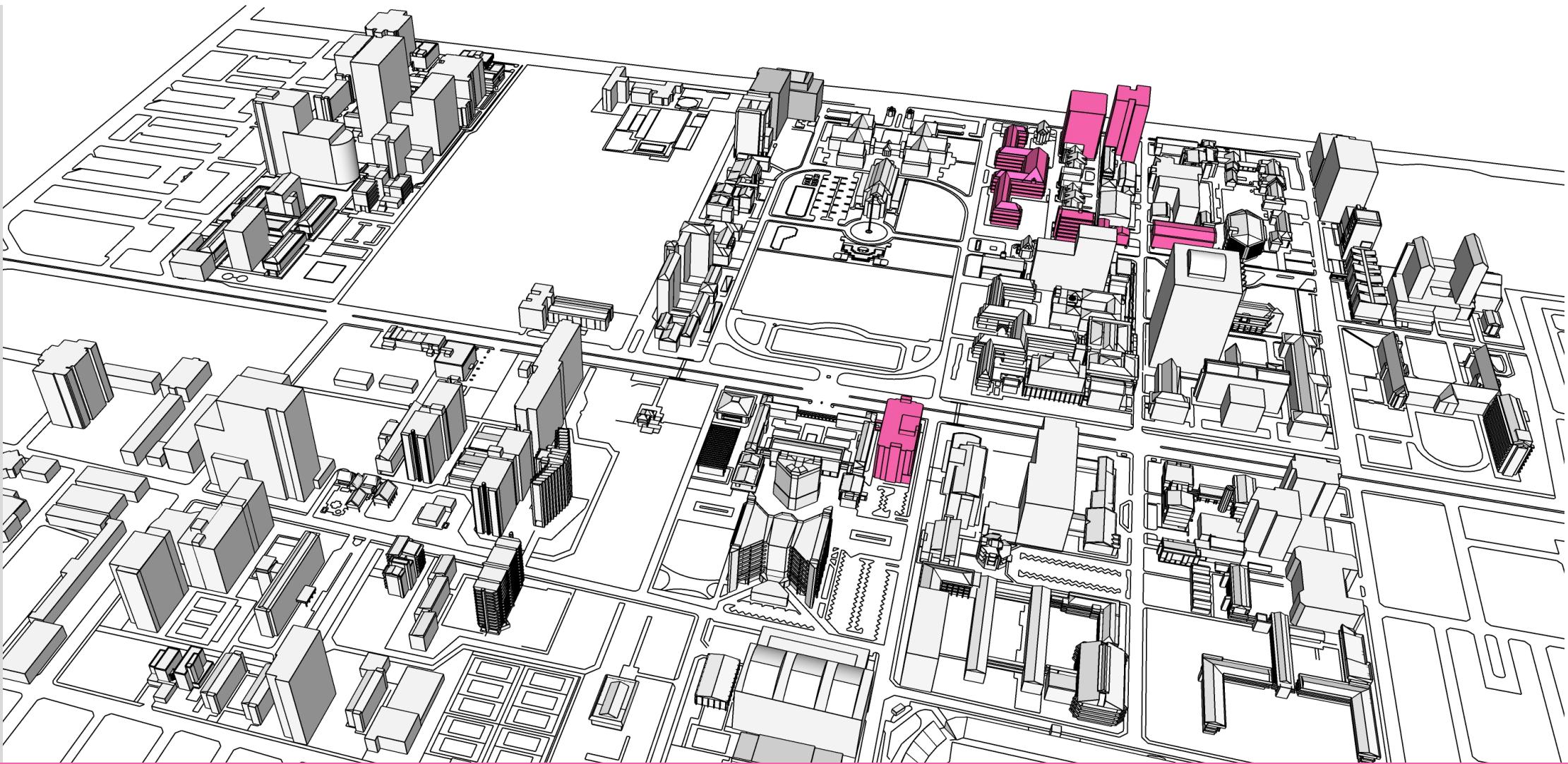




**E@**  
Energy Absolute



การไฟฟ้านครหลวง  
Metropolitan Electricity Authority



# Smart Energy @ CU Smart Campus

Dr. Manisa Pipattanasomporn (Smart Grid Research Unit, SGRU)

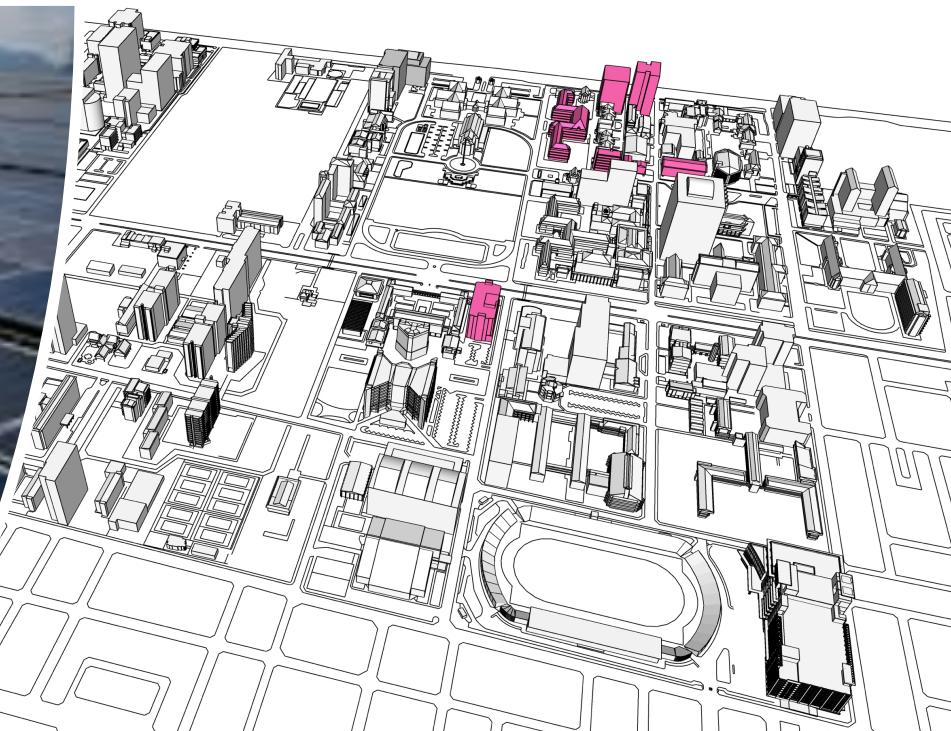
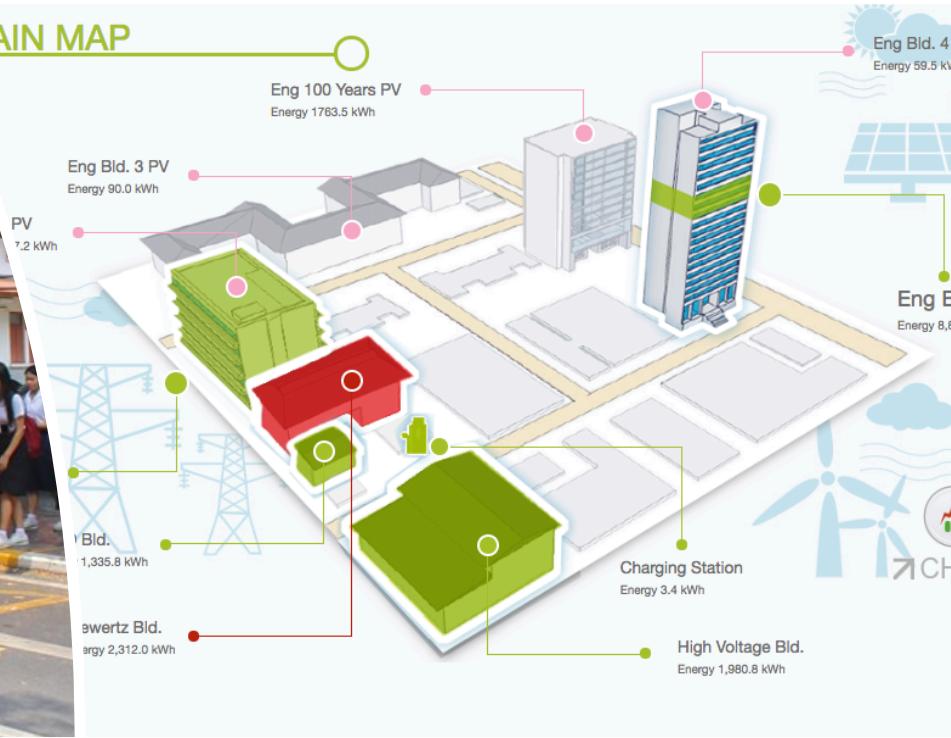
8 September 2020<sup>1</sup>

# Smart Energy @ CU

- > 200 buildings
- Electric vehicles and charging infrastructure
- > 1 MW of solar PV



MAIN MAP



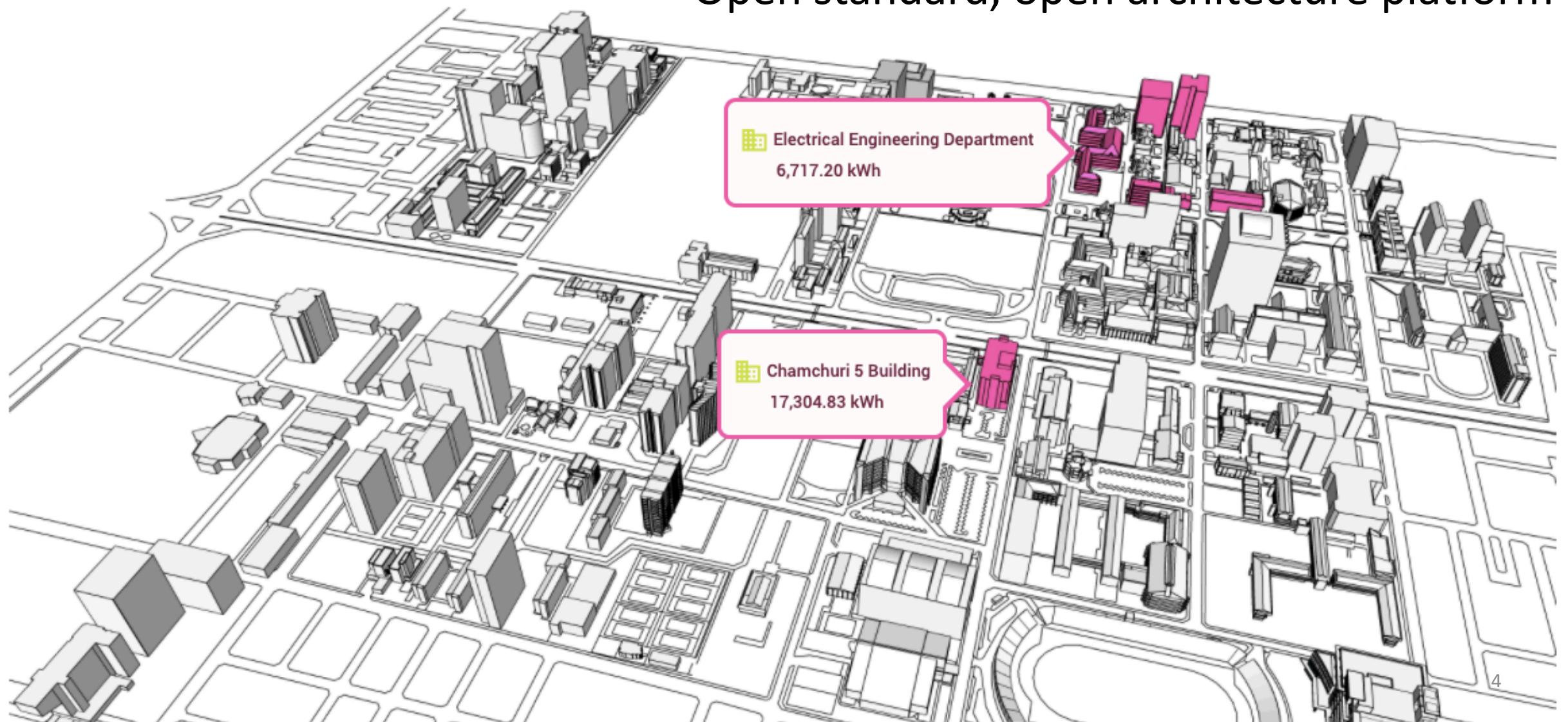
# CU Smart Energy - Project Objectives

- To establish a smart campus *living laboratory* at Chulalongkorn University that can demonstrate:
  - **Smart building operation** with ability to intelligently manage electricity consumption in buildings, perform demand response and participate in a local peer-to-peer (P2P) electricity market
  - **P2P electricity trading** among buildings, renewable energy sources, electric vehicles, and demand reduction capability



# CU-BEMS

- CUBEMS = Chulalongkorn University (CU)-Building Energy Management System (BEMS)
- Open standard, open architecture platform





# CU-BEMS Demo

CU-BEMS  
CHAMCHURI 5

21:37 Monday  
07, October 2019

cu-team-admin

MENU ADMIN PANEL ABOUT US Log Out

## STATUS OVERVIEW

OCT 7, 2019 Building Energy Management System

### Chamchuri 5 Building Energy Profile

1<sup>st</sup> - Today

**28,200.9 kWh**

**103%**

### Daily Energy Accumulation 5,156.9 kWh

Current Demand 25.3 kw

Peak Demand 737.1 kw



Warning Level 607.0 kw

Alert Level 682.8 kw

MAIN MAP

[www.bems.chula.ac.th](http://www.bems.chula.ac.th)

CU-BEMS  
CHAMCHURI 5

10:24 Monday  
07, October 2019

MENU ADMIN PANEL ABOUT US

## MAIN MAP

อาคารจามจุรี ๕ (Chamchuri 5 Building)  
24,818.10 kWh

Chamchuri 5 PV  
1.05 kWh



Chamchuri 5 PV

1.05

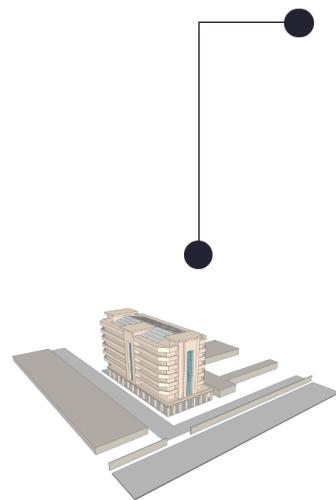
kWh

Phayatai Road



# CUBEMS-Floor Overview

## Floor Overview



### CHAMCHURI5

7 OCT 2019 | 21:38

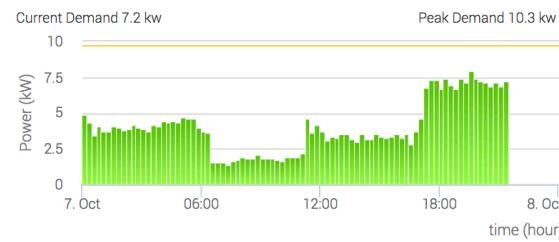
#### Floor 1

1<sup>st</sup> - Today

**696.8 kWh**

**19%**

Daily Energy Accumulation 696.8 kWh



#### Floor 2

1<sup>st</sup> - Today

**5,087.3 kWh**

**23%**

Daily Energy Accumulation 5,087.3 kWh



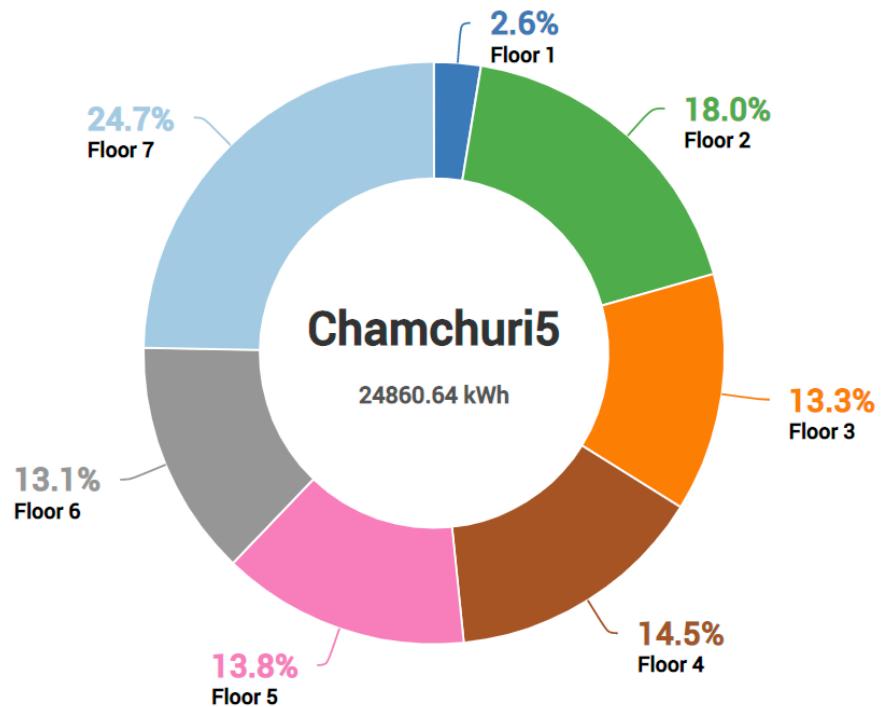
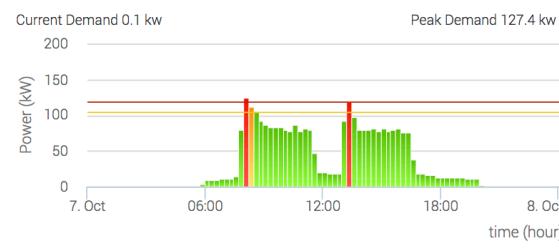
#### Floor 3

1<sup>st</sup> - Today

**3,770.6 kWh**

**24%**

Daily Energy Accumulation 3,770.6 kWh





# CUBEMS-Floor 7

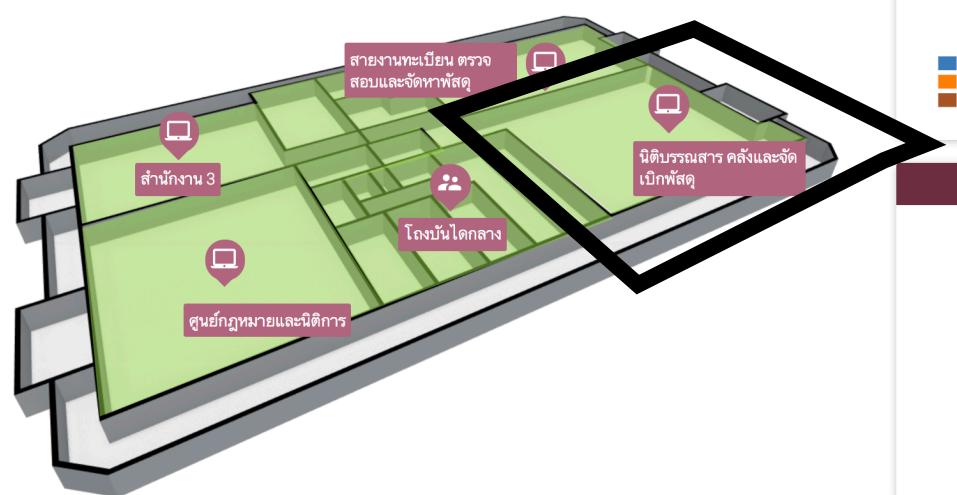
## Floor Section

### Chamchuri5 Floor 7

Area All

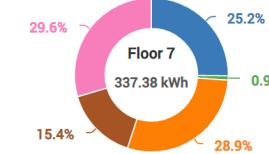
DAY MONTH YEAR

MAP MEANINGS

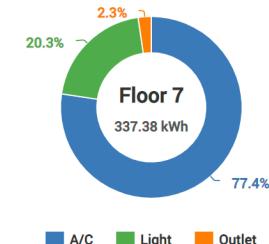


Home / Chamchuri5 / Floor 7

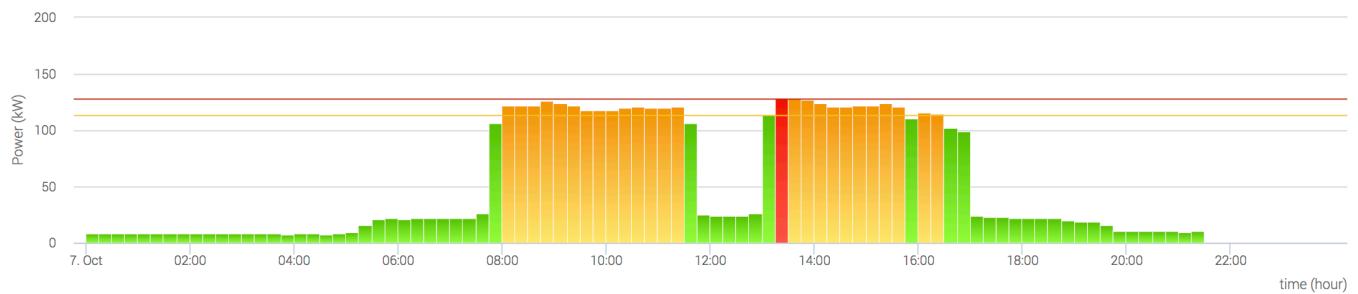
#### Floor Area Usage



#### Floor Load Usage



Area : Floor 7 | Daily Consumption

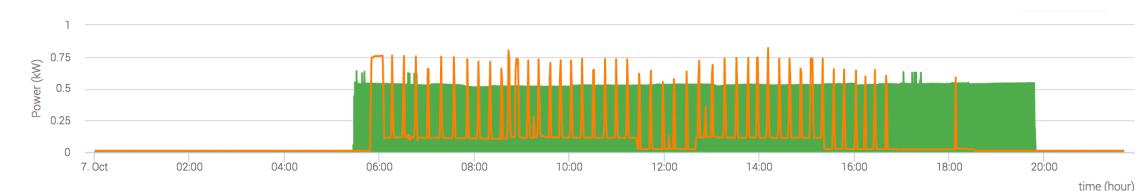


## AC load



Aircon smart\_meter4/energy

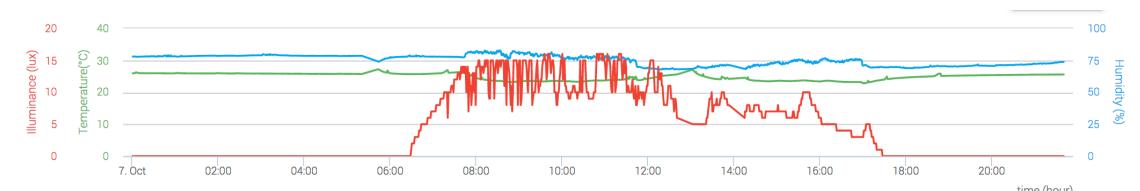
## Lighting/Plug loads



Light meter2/energy\_ch14  
meter2/energy\_ch20  
meter2/energy\_ch22  
meter2/energy\_ch28

Outlet meter2/energy\_ch03

## Sensors



Multisensor2 monitor/temperature monitor/humidity monitor/illuminance



# CUBEMS-Awareness



10:36 Monday

07, October 2019

cu-team-admin

MENU

ADMIN PANEL

ABOUT US

Log Out

## CHAMCHURI 5 ENERGY AWARDS

Current Ranking [1 Oct - Yesterday] ?

**1** กลุ่มภารกิจชาราชการและลูกจ้าง (64.81%)

**2** ฝ่ายอาคารสถานที่ (14.21%)

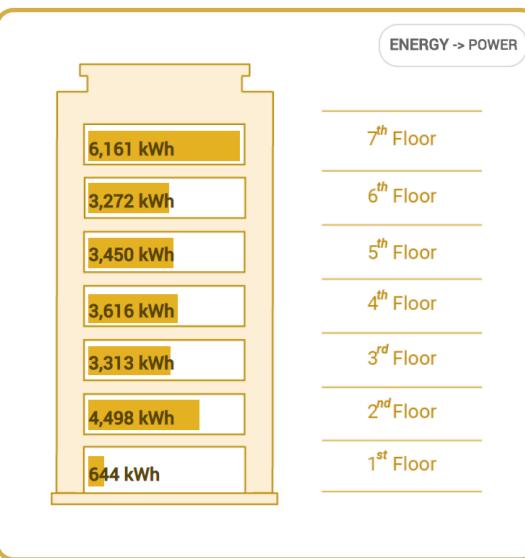
**3** สำนักทะเบียนและประมวลผล (10.35%)

PV  
-1.05 kWh

>>>

MEA  
24,954 kWh

>>>



Best Energy Saving Award (September 2019) ?

**1** กลุ่มภารกิจชาราชการและลูกจ้าง (19.63%)

**2** สำนักบริหารงานวิชาการ 2 (11.44%)

**3** ฝ่ายโครงสร้างพื้นฐานฯ (9.40%)

Best Improvement Award (September 2019) ?

**1** ฝ่ายโครงสร้างพื้นฐานฯ (15.82%)

**2** ศูนย์กฎหมายและนิติการ (12.92%)

**3** กลุ่มภารกิจชาราชการและลูกจ้าง (11.15%)

- Energy usage competition by zone and by floor of the building
- Energy award is notified via LINE.
- Peak demand reduction notification via LINE.





# SGRUdata.github.io

- Available building-level data for analytics
- 1.5 years, CSV format  
(July 1, 2018-Dec 31, 2019)
- 1-minute intervals

**Requested Citation:** CU-BEMS, smart building electricity consumption and indoor environmental sensor datasets, Scientific Data, vol. 7, no. 241, July 2020.

URL: <https://www.nature.com/articles/s41597-020-00582-3>

The screenshot shows the homepage of the Energy Research Data website. At the top right are navigation links: 'DOWNLOAD DATA', 'SAMPLE DATA ANALYTICS' (with a dropdown arrow), and 'LIVE CHAM5 CU-BEMS'. The main title 'Energy Research Data' is centered above a subtitle 'Smart Grid Research Unit, Chulalongkorn University'. Below the title is a large, light-yellow background image of a building's roof with solar panels. A detailed 3D architectural rendering of the 'Chamchuri 5 Building' is shown in the foreground, featuring its red brick facade and a solar panel array on its roof. Text labels next to the building identify it as 'Chamchuri 5 PV' and show energy consumption figures: '25,510.71 kWh' and '0.67 kWh'. The building is located at 'Phayatai Road'.

■ อาคารจามจุรี ๕ (Chamchuri 5 Building)  
25,510.71 kWh

■ Chamchuri 5 PV  
0.67 kWh

■ Phayatai Road

**Chamchuri 5** is a seven-story academic office building located at Chulalongkorn University. The building has the area of around 11,700 square meters (126,000 sqft). A typical building peak load is around 700kW.

The building is equipped with **CU-BEMS** --the building energy management system, developed at Chulalongkorn University. Since mid-2018, CU-BEMS has been used to measure power consumption of building loads by type, as well as indoor temperature, humidity and ambient light condition in each zone of the building.

This site archives historical data collected by **CU-BEMS** for this particular building.

**Data intervals:** one-minute

**Data format:** csv

**Data duration:** July 1, 2018 - June 30, 2019

Available data for download are: power consumption (kW) of AC, lighting, plug load, indoor temperature (deg C), humidity (%) and illuminance (lux).

| File name  | Zone No.  | AC | Light | Plug | Sensor | No of Columns |
|------------|-----------|----|-------|------|--------|---------------|
| Floor1.csv | Zone 1    | 0  | 1     | 0    | 0      | 11            |
|            | Zone 2    | 4  | 1     | 1    | 0      |               |
|            | Zone 3    | 0  | 1     | 1    | 0      |               |
|            | Zone 4    | 0  | 1     | 1    | 0      |               |
| Floor2.csv | Zone 1    | 1  | 1     | 1    | 3      | 36            |
|            | Zone 2    | 14 | 1     | 1    | 3      |               |
|            | Zone 3    | 0  | 1     | 1    | 3      |               |
|            | Zone 4    | 1  | 1     | 1    | 3      |               |
| Floor3.csv | Zone 1    | 4  | 1     | 1    | 3      | 29            |
|            | Zone 2    | 1  | 1     | 1    | 3      |               |
|            | Zone 3    | 0  | 1     | 1    | 0      |               |
|            | Zone 4    | 1  | 1     | 1    | 3      |               |
|            | Zone 5    | 1  | 1     | 1    | 3      |               |
| Floor4.csv | Zone 1    | 4  | 1     | 1    | 3      | 29            |
|            | Zone 2    | 1  | 1     | 1    | 3      |               |
|            | Zone 3    | 0  | 1     | 1    | 0      |               |
|            | Zone 4    | 1  | 1     | 1    | 3      |               |
|            | Zone 5    | 1  | 1     | 1    | 3      |               |
| Floor5.csv | Zone 1    | 4  | 1     | 1    | 3      | 29            |
|            | Zone 2    | 1  | 1     | 1    | 3      |               |
|            | Zone 3    | 0  | 1     | 1    | 0      |               |
|            | Zone 4    | 1  | 1     | 1    | 3      |               |
|            | Zone 5    | 1  | 1     | 1    | 3      |               |
| Floor6.csv | Zone 1    | 1  | 1     | 1    | 3      | 29            |
|            | Zone 2    | 1  | 1     | 1    | 3      |               |
|            | Zone 3    | 0  | 1     | 1    | 0      |               |
|            | Zone 4    | 4  | 1     | 1    | 3      |               |
|            | Zone 5    | 1  | 1     | 1    | 3      |               |
| Floor7.csv | Zone 1    | 4  | 1     | 1    | 3      | 29            |
|            | Zone 2    | 1  | 1     | 1    | 3      |               |
|            | Zone 3    | 0  | 1     | 1    | 0      |               |
|            | Zone 4    | 1  | 1     | 1    | 3      |               |
|            | Zone 5    | 1  | 1     | 1    | 3      |               |
| TOTAL      | All zones | 55 | 33    | 32   | 72     | 192           |

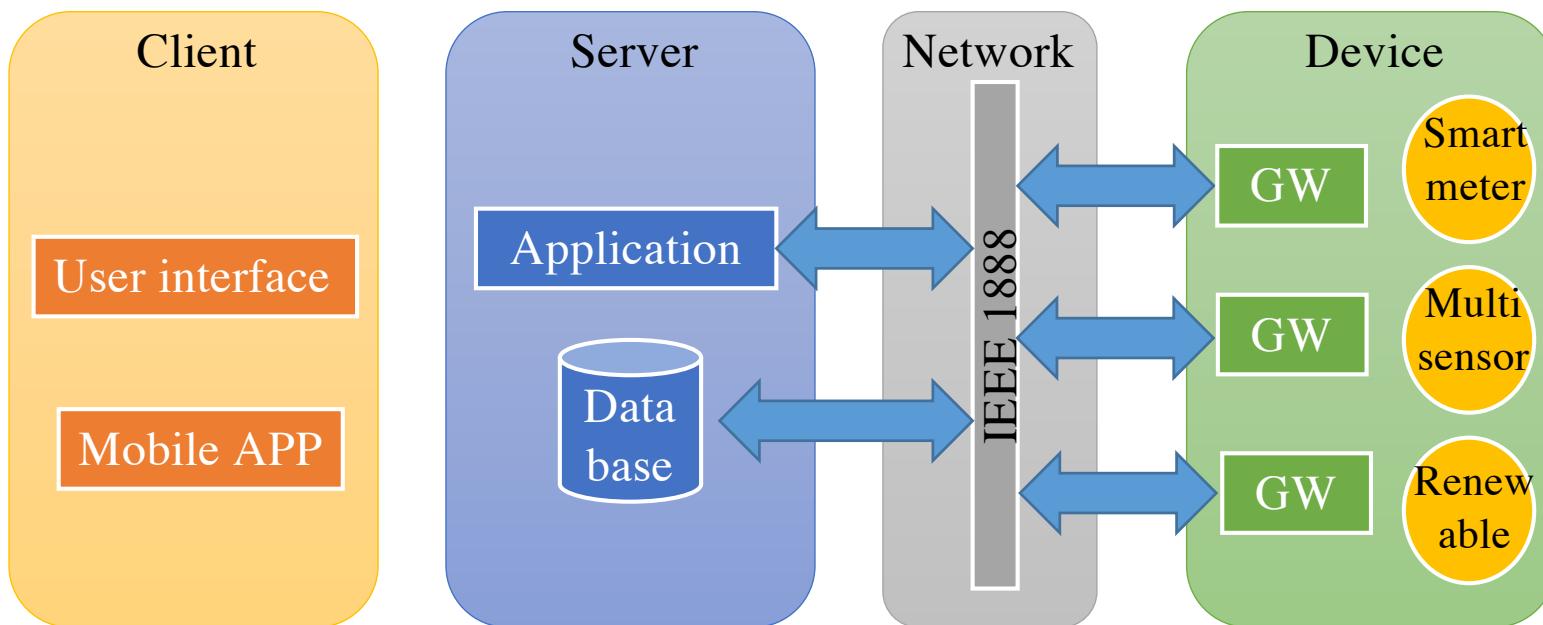


# CHAM5 Data

- Power consumption (kW)
  - ✓ AC
  - ✓ Lighting
  - ✓ Plug load
  - ✓ Zone, Floor, Building
- Temperature (deg C)
- Humidity (% RH)
- Ambient light (Lux)
- Outdoor weather data



# CU-BEMS Architecture



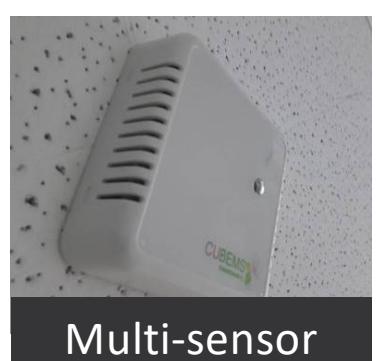
- Compatible with: Wi-Fi, LAN, BACnet, Modbus, ZigBee smart energy and 6LoWPAN



Smart Light SW



Smart Plug



Multi-sensor

Power meters (36 channels)



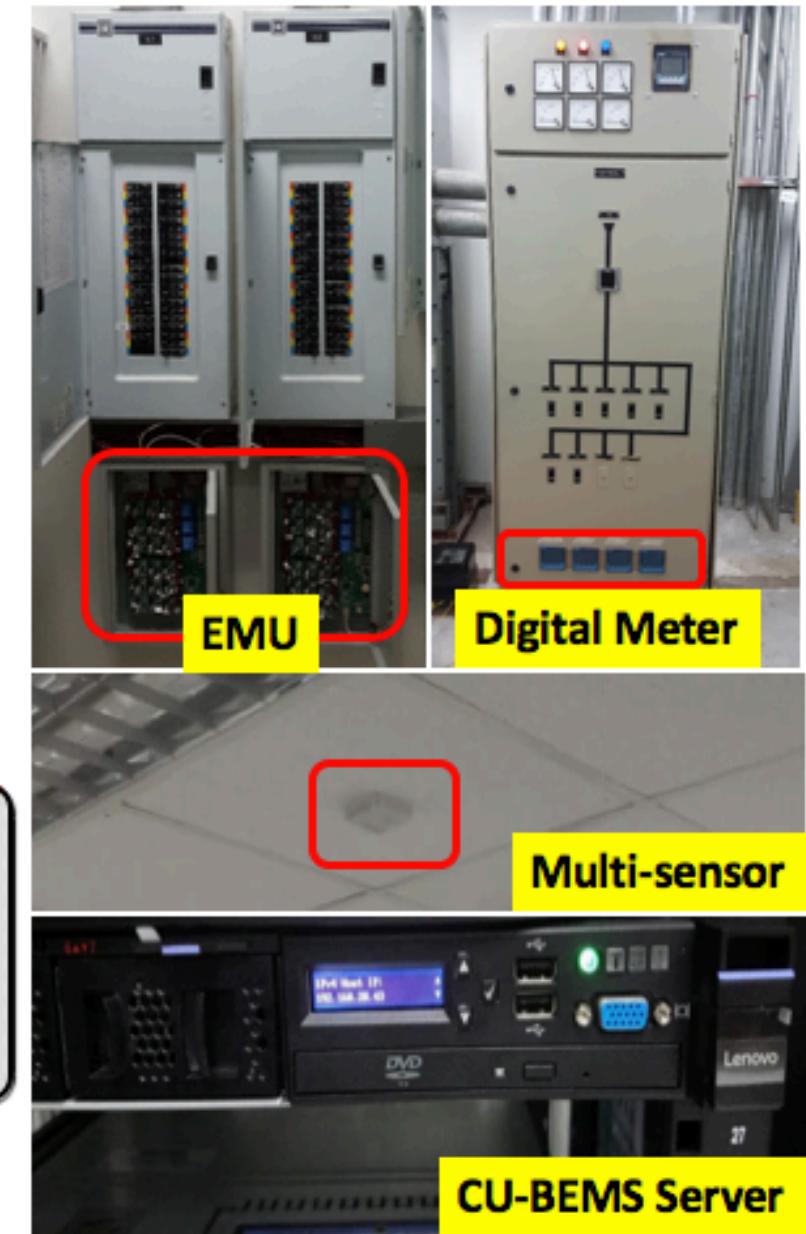
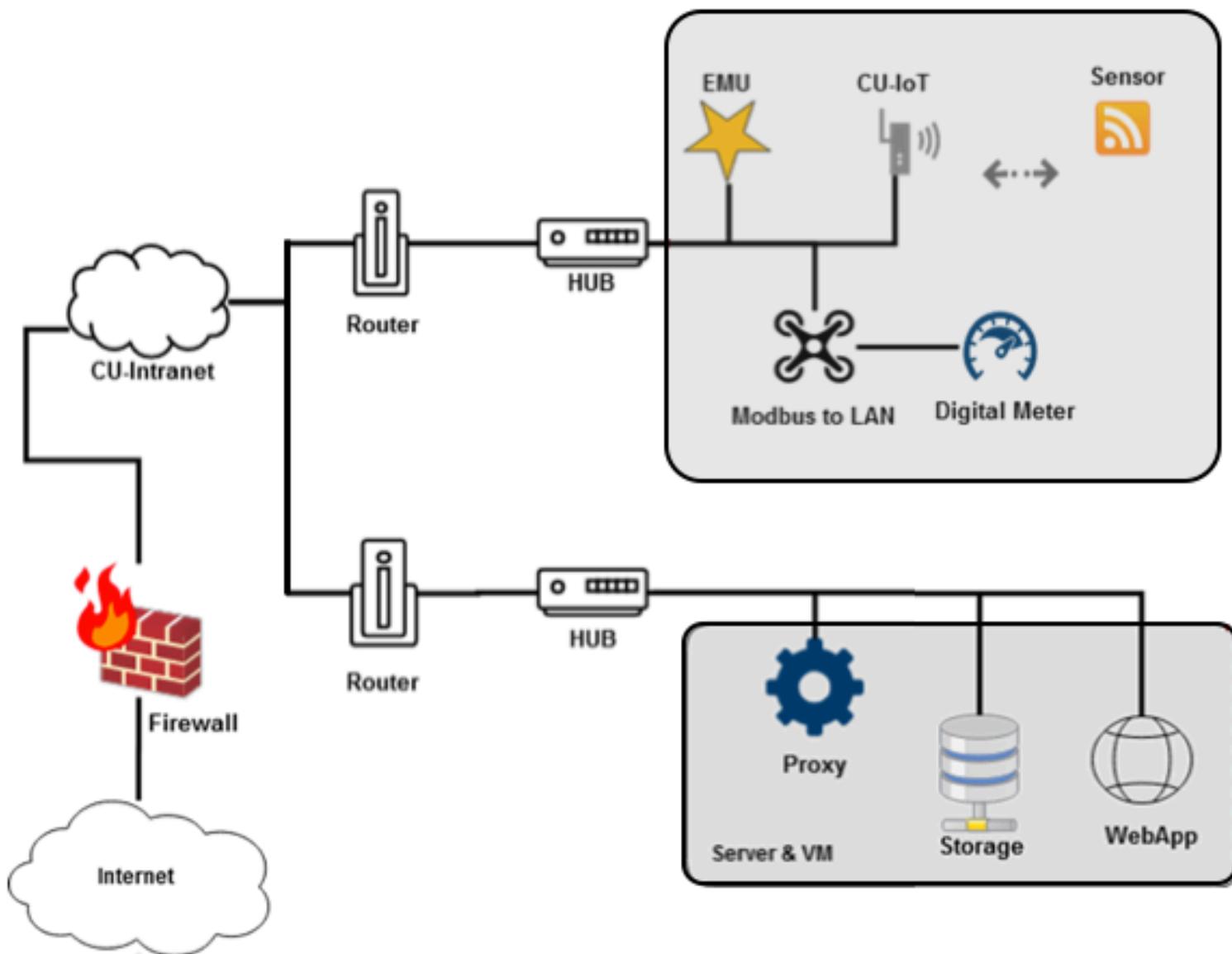
## Hardware



Multi-sensor



# Communications

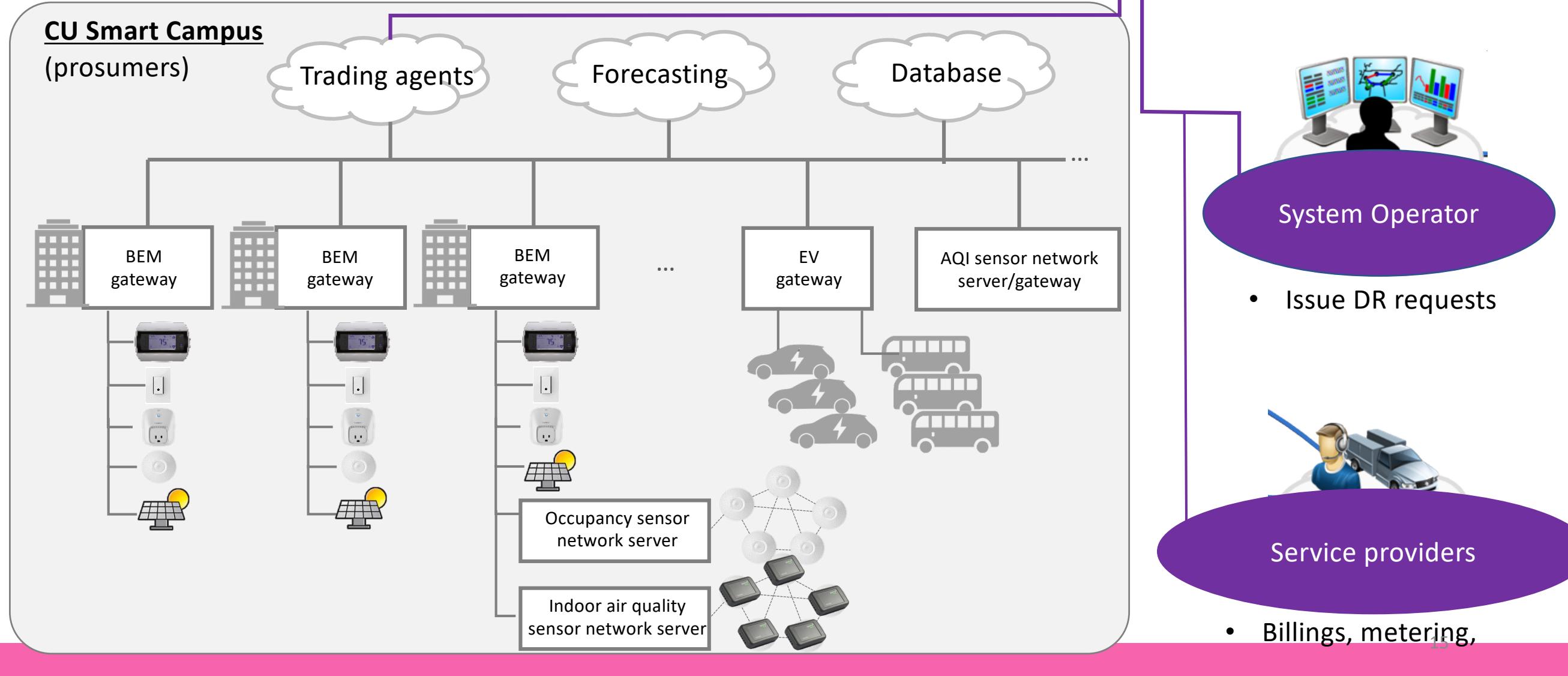


# P2P Electricity Trading



Year 1-2: 6 อาคาร (monitoring by load type)  
Year 3: 200 อาคาร (building level)

# High-level Architecture (CU Smart Campus)



# Thank you!

Question:  
[manisa.pip@chula.ac.th](mailto:manisa.pip@chula.ac.th)