

RESEARCH METHODS & MOTIVATIONS

2102790 Elec Eng Seminar

Jan 7, 2020

Outline

- Self introduction
- Research – What is research?
- Motivation – From where can you get motivation?
- Moving forward – How to go from here?

Getting to know the Instructor



Manisa Pipattanasomporn, PhD

Email: manisa.pip@chula.ac.th

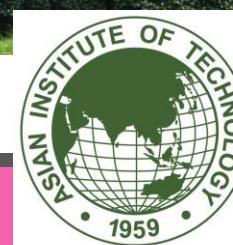
Website: mpipatta.github.io

BS: 1995-1999



Chulalongkorn University
จุฬาลงกรณ์มหาวิทยาลัย

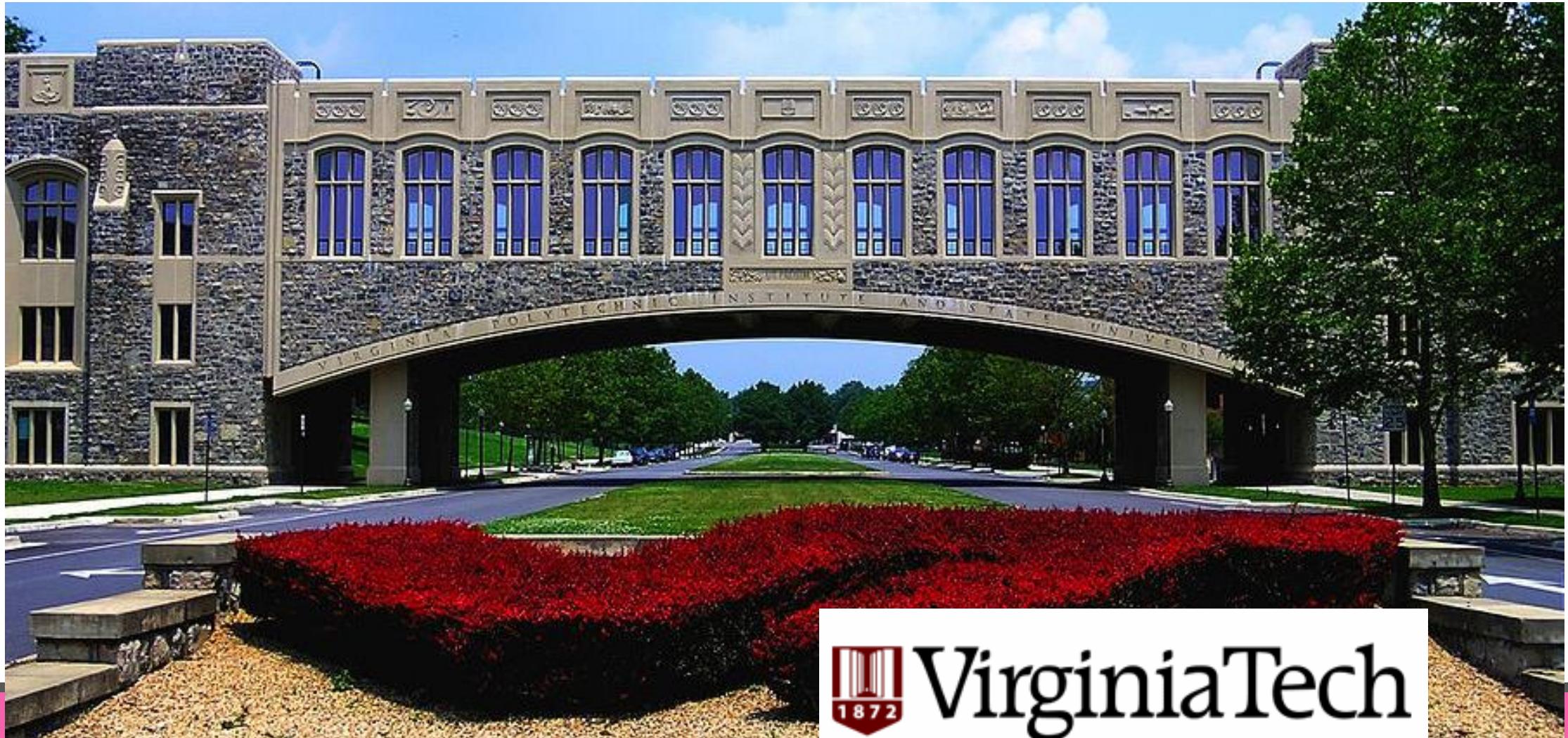
MS: 2000-2001



AIT
Asian Institute of Technology

PhD: 2001-2004

Academic: 2005-Present

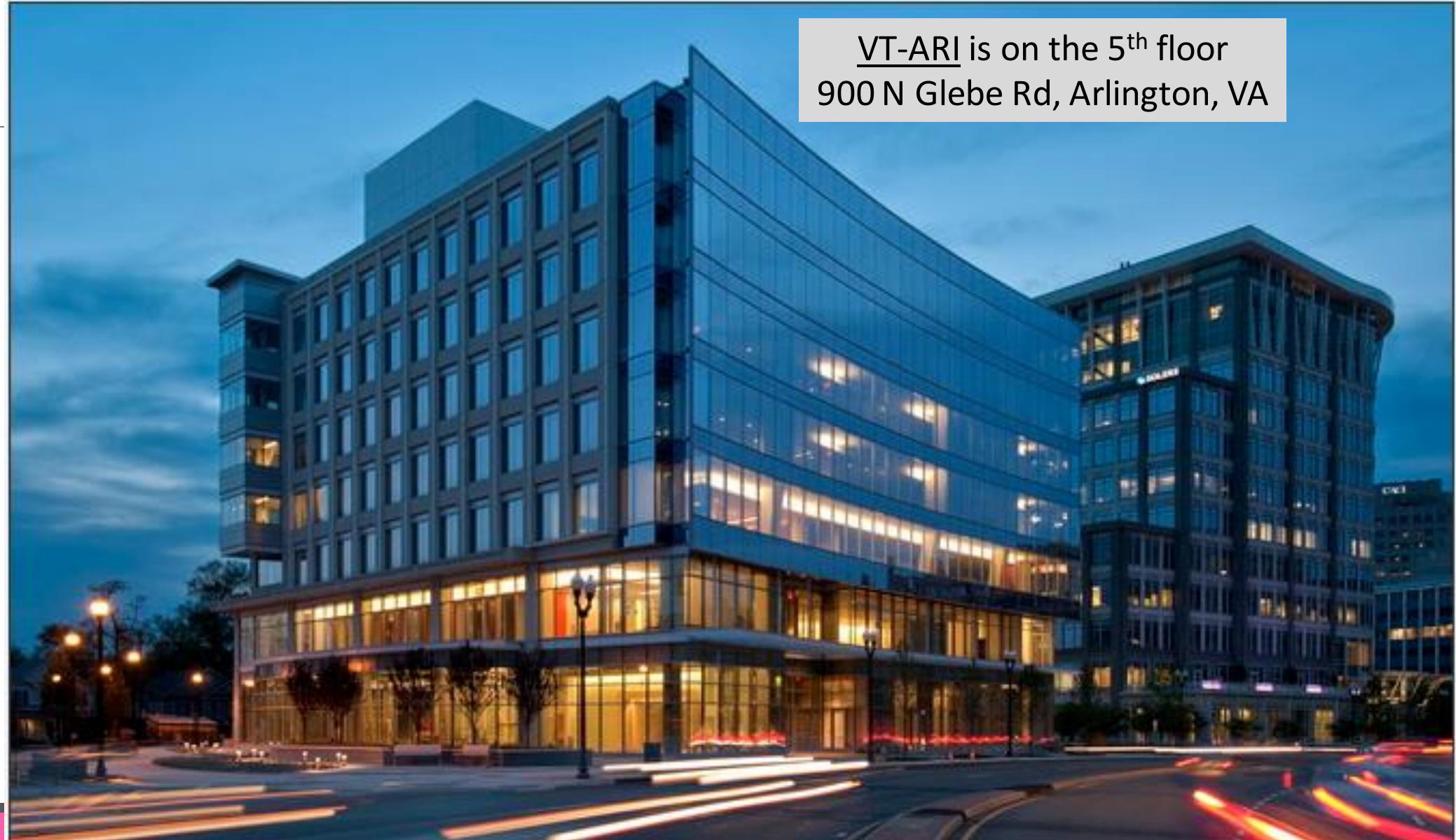


VirginiaTech

Virginia Tech - Advanced Research Institute (ARI)

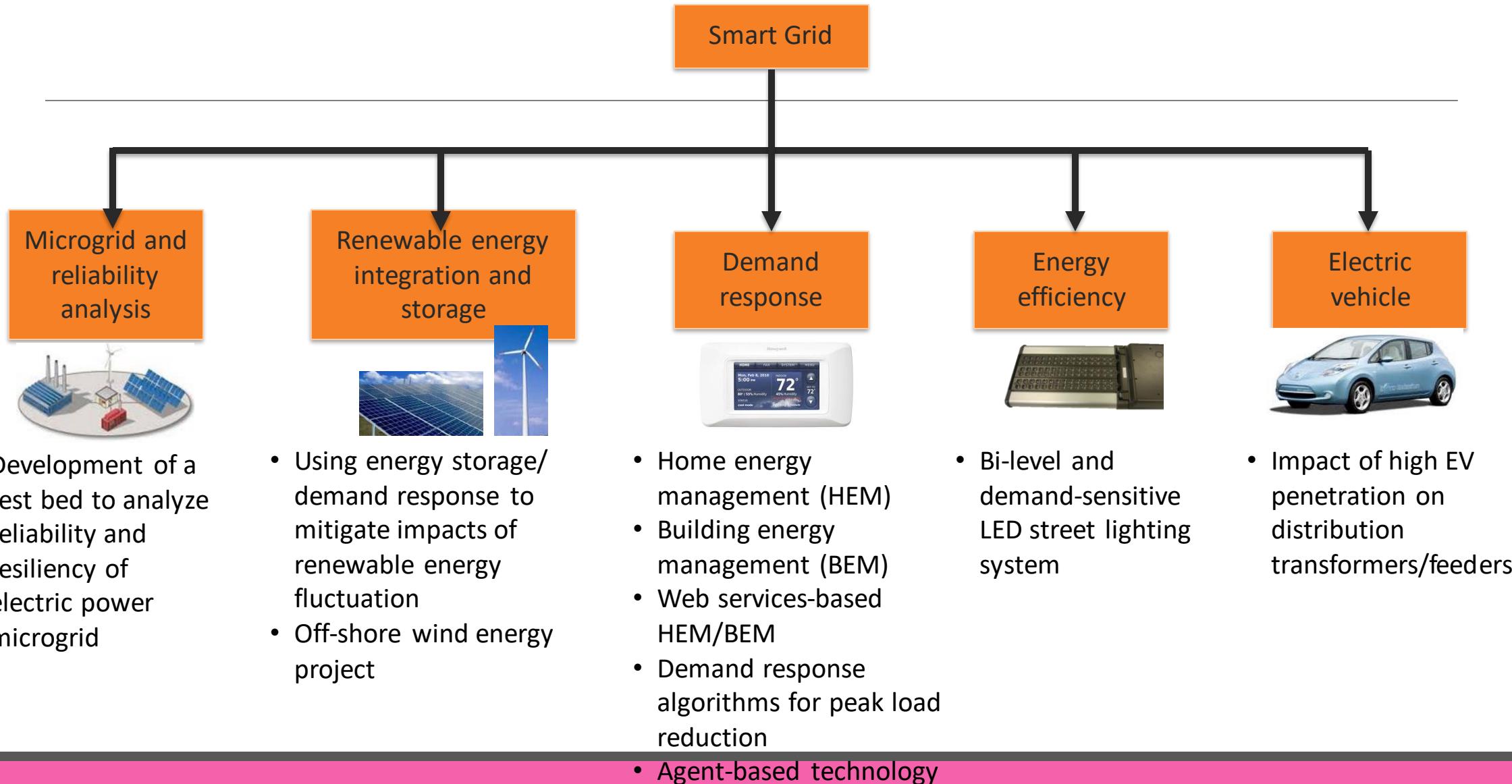


Virginia Tech - Advanced Research Institute (ARI)



VT-ARI is on the 5th floor
900 N Glebe Rd, Arlington, VA

Research Areas



Your Concentration

- Power
- Control
- Electronics
- Telecommunication

“RESEARCH”

research noun

 Save Word

re·search | \ri-'sərch (听), 'rē-,sərch (听) \

Definition of *research*

1 : careful or diligent search

2 : studious inquiry or examination

especially : investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws

3 : the collecting of information about a particular subject



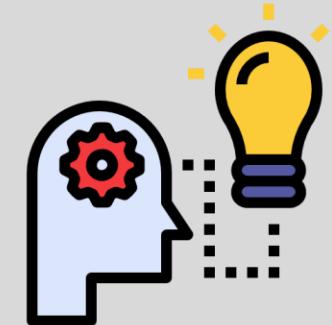
RESEARCH METHOD



Literature Search
(WHY)



Objective
(What)



Methodology
(How)



Results &
Contributions

Motivation

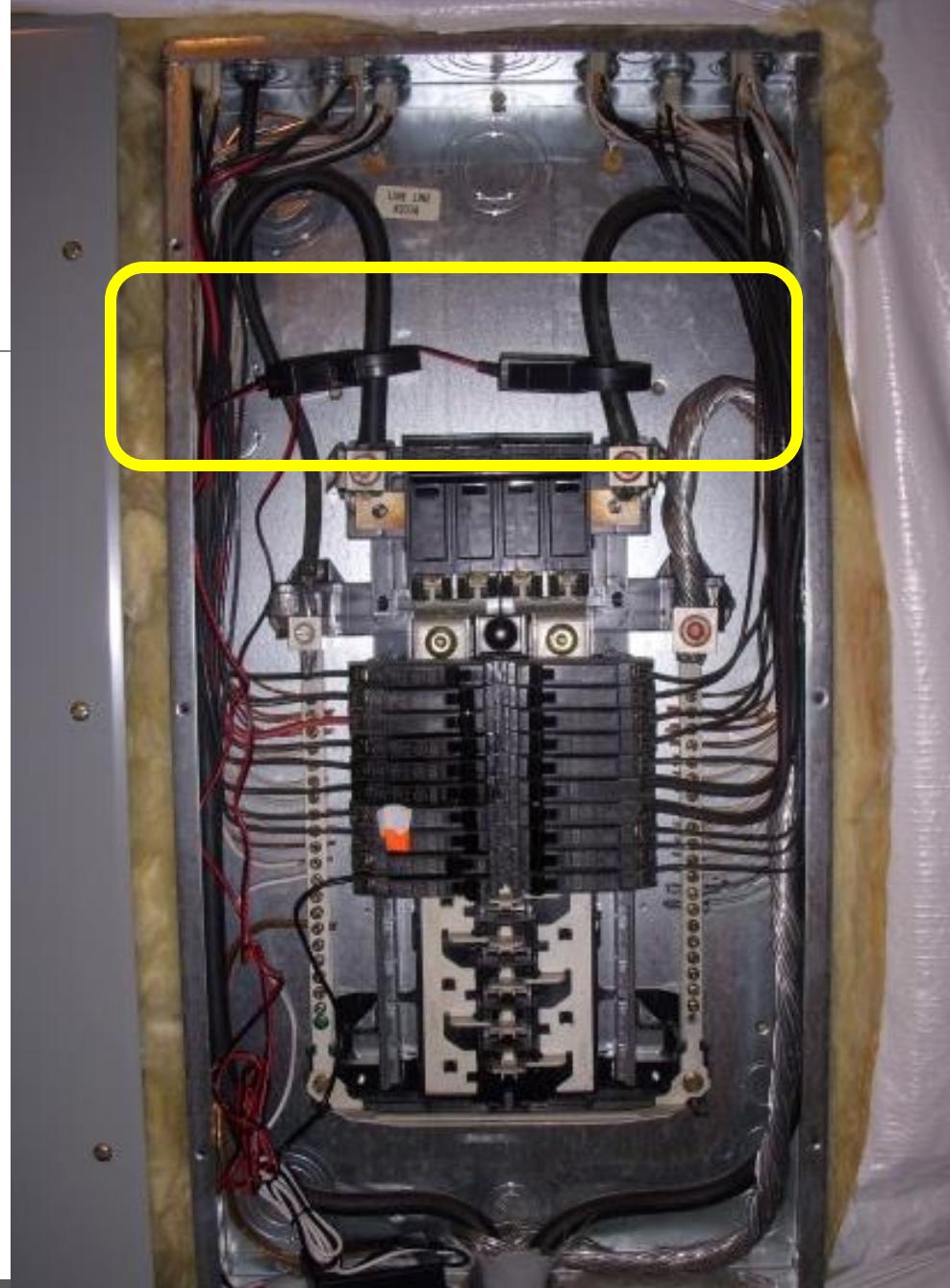
Curiosity + Current Trend



1070 sqft (100 m²)



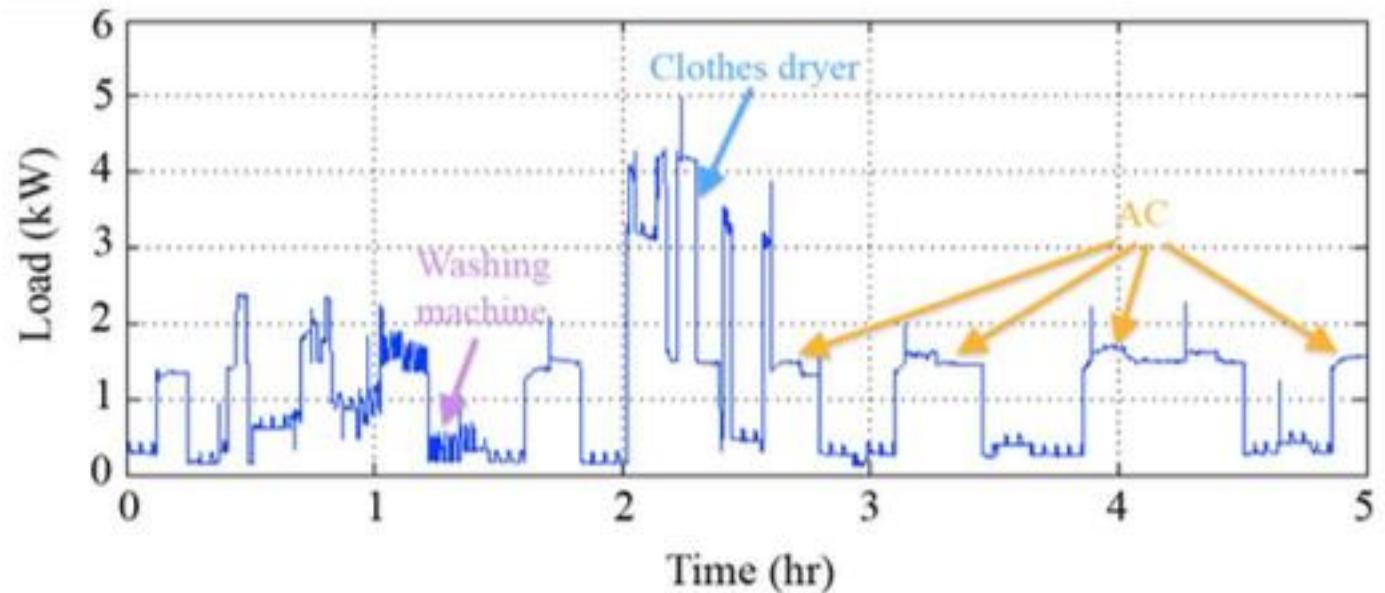
Measurement Paper



Source: <http://www.swblabs.com/article/the-energy-detective-ted-install>

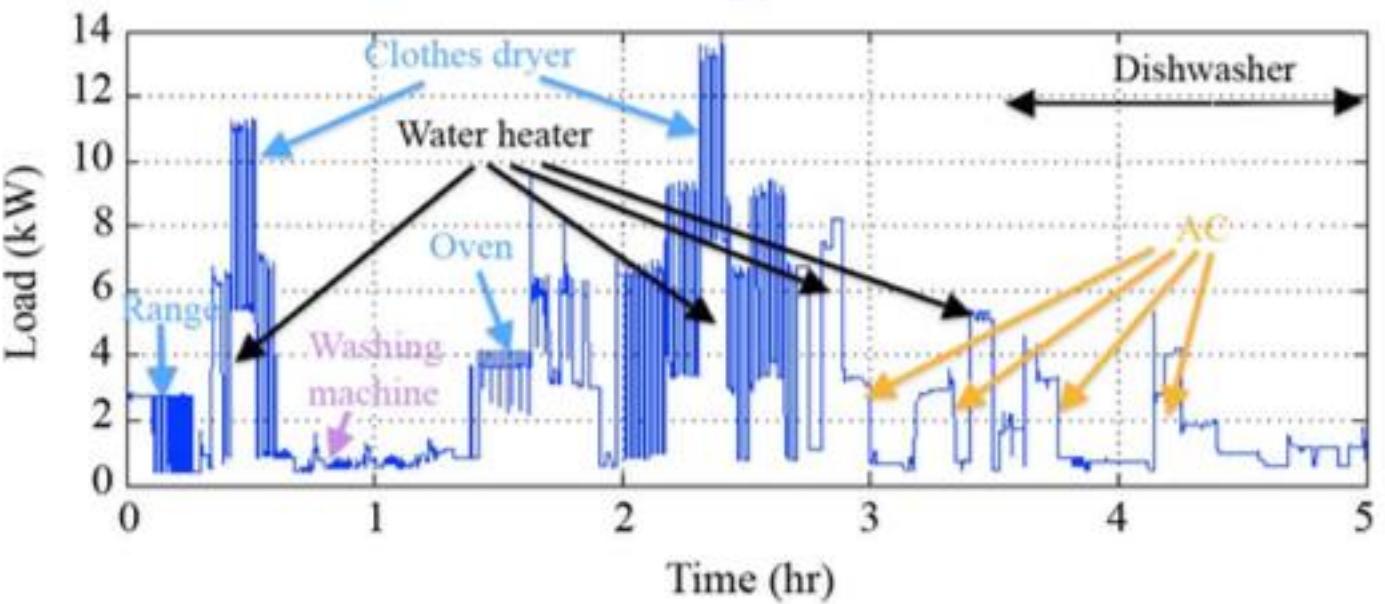
Measurements

House (100 m²)

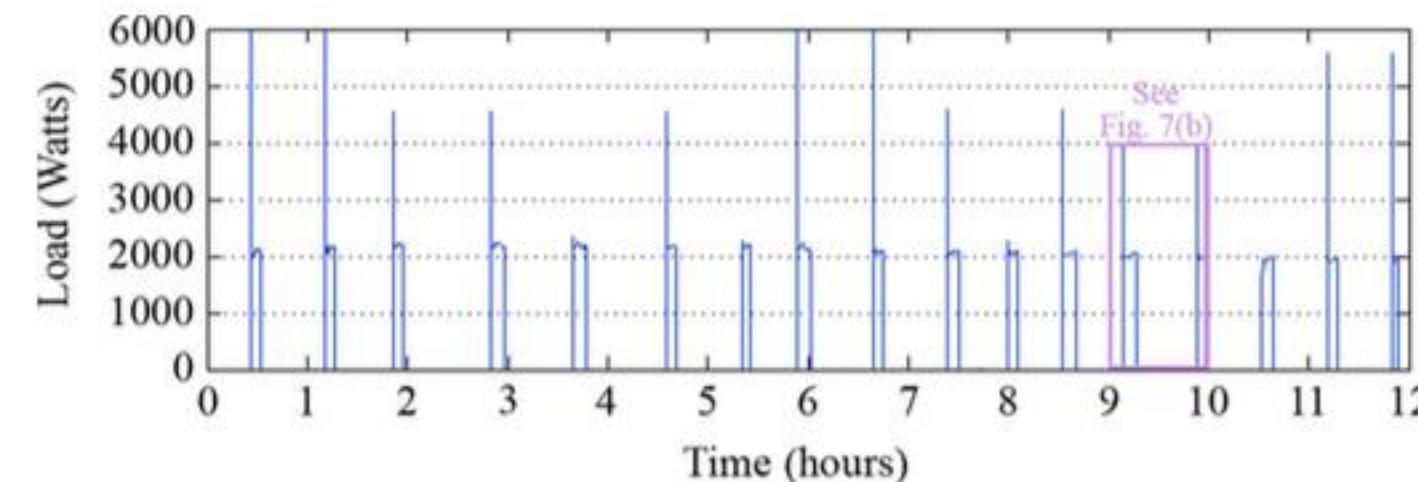
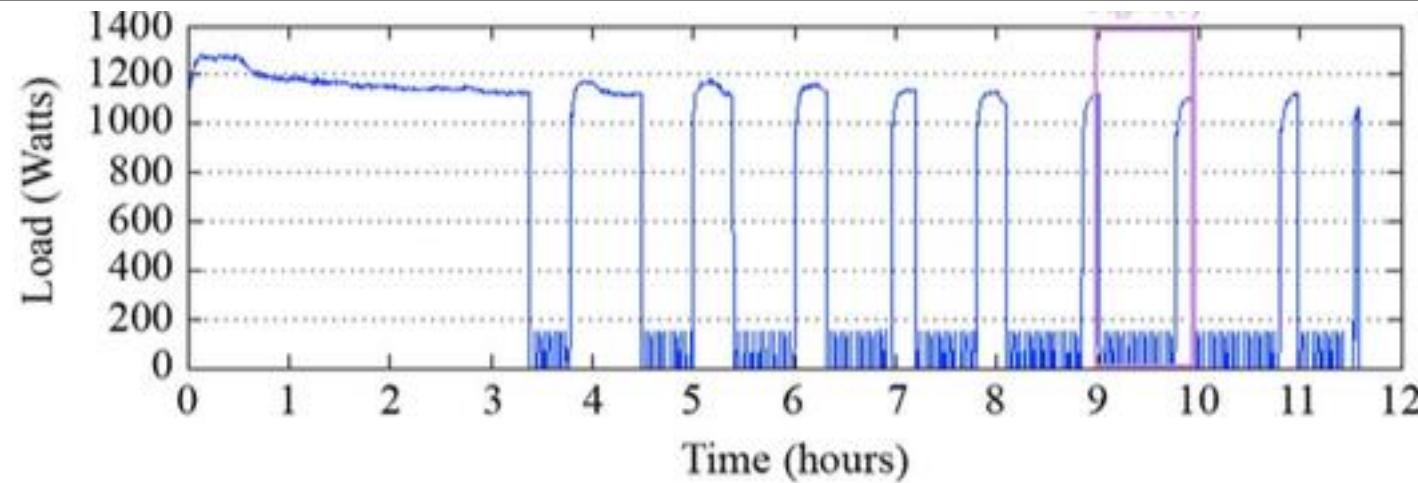


(a)

Townhouse (167 m²)

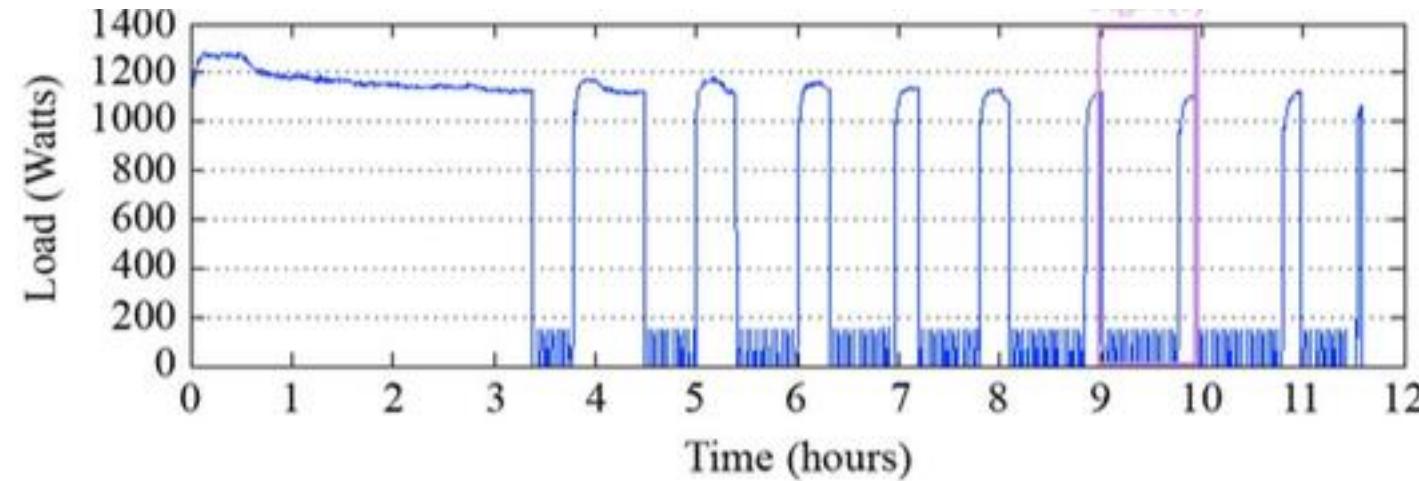


Appliance-level Load Profiles

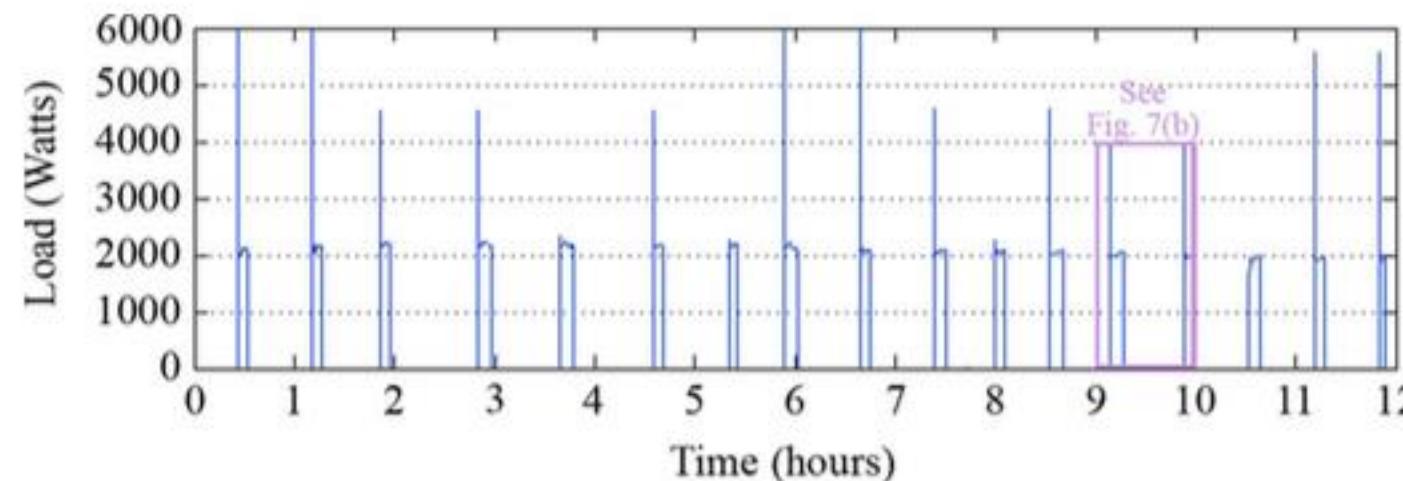


Appliance-level Load Profiles

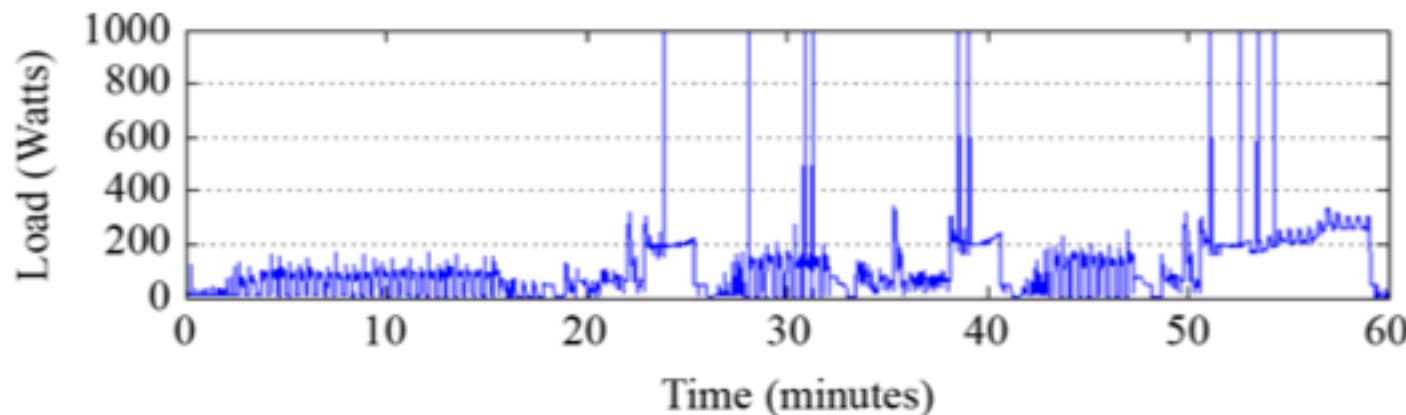
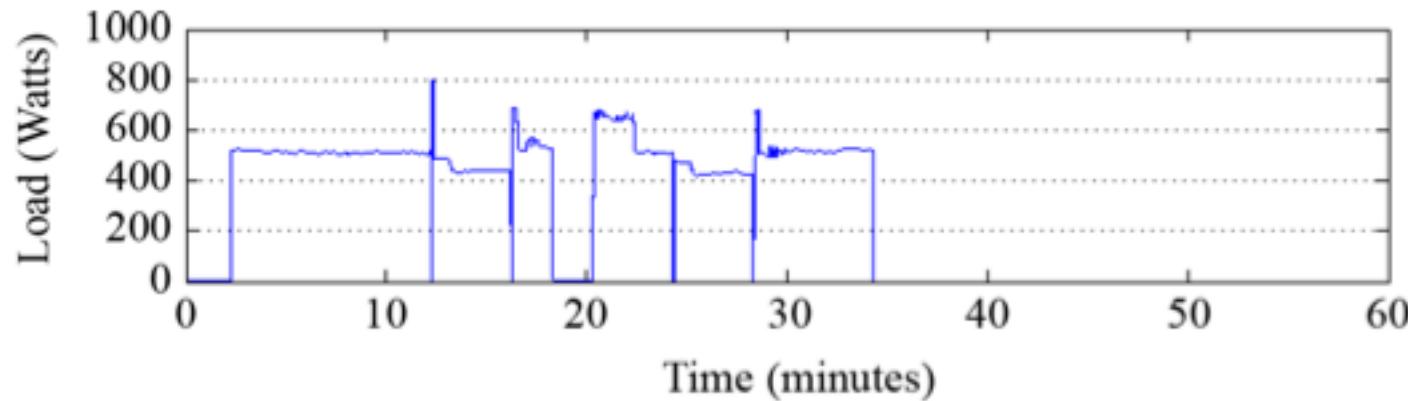
Window unit AC
(~1.2kW)



Central AC
(2-5kW)



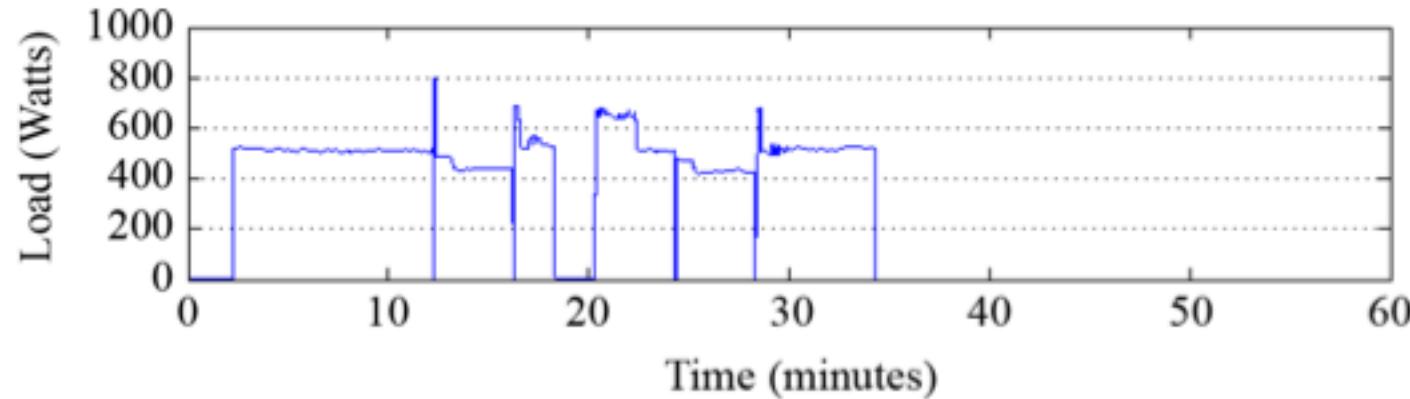
Appliance-level Load Profiles



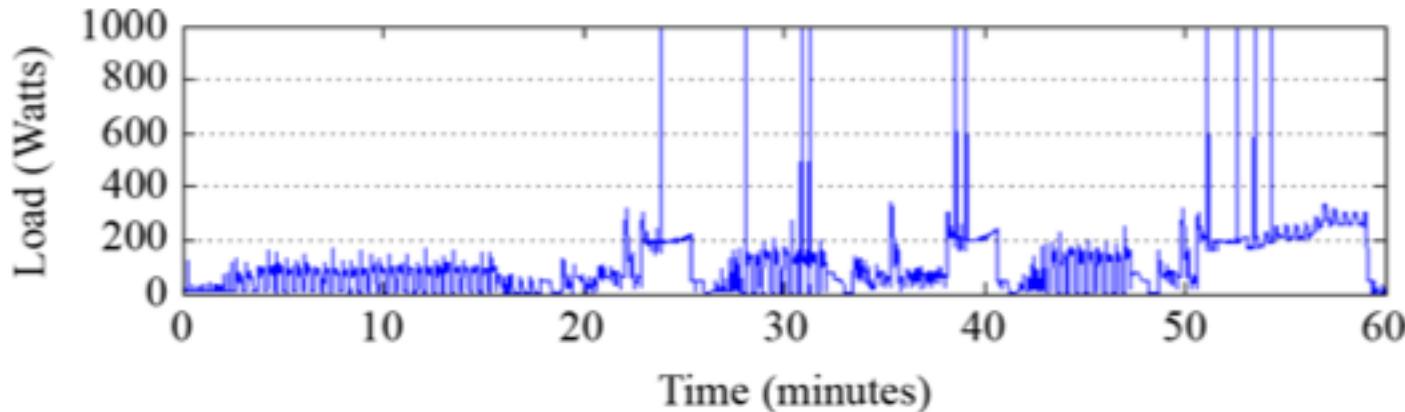
Appliance-level Load Profiles

Washing Machines

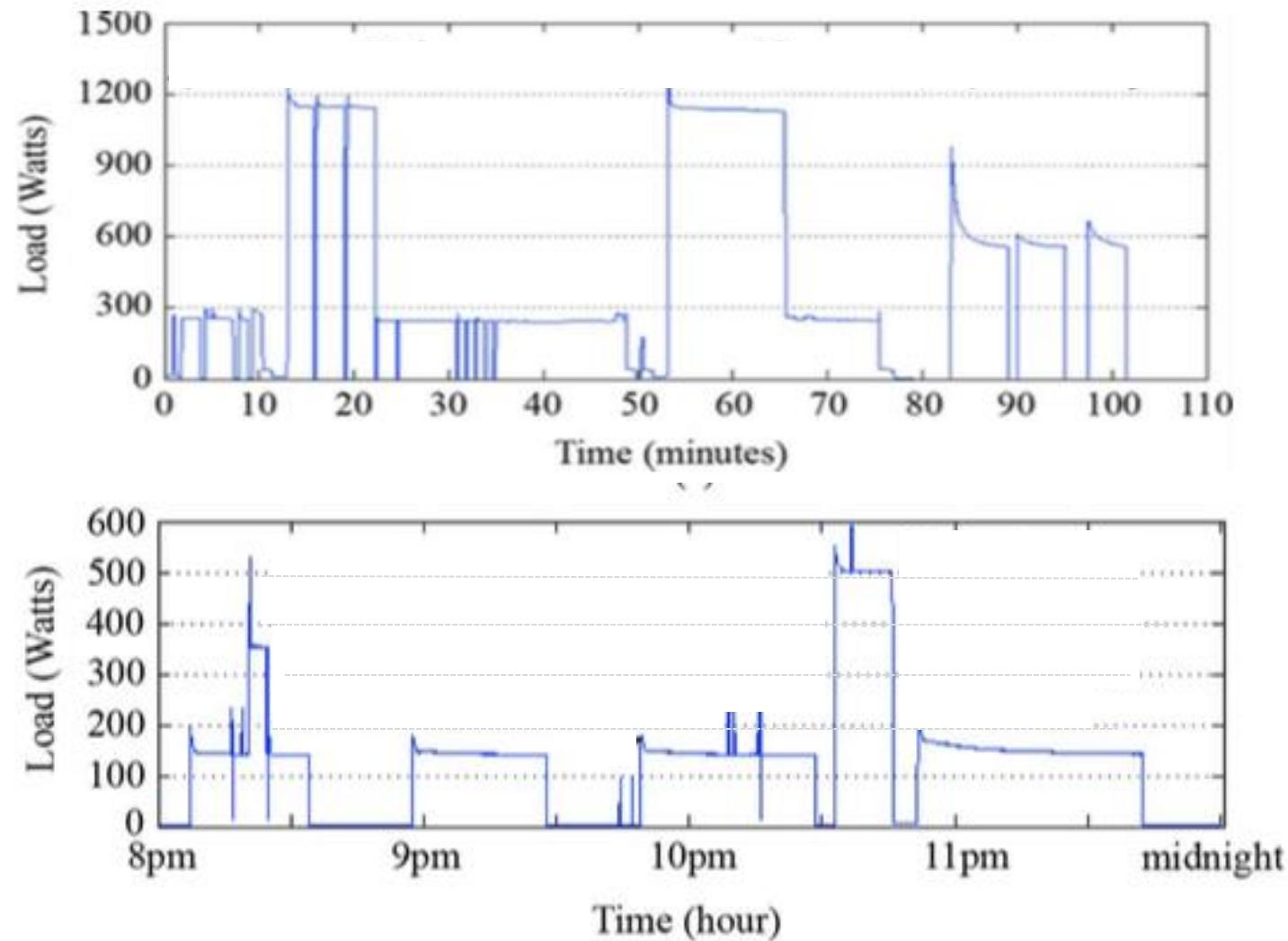
Top-load washer
(600W)



Front-load washer
(200W)

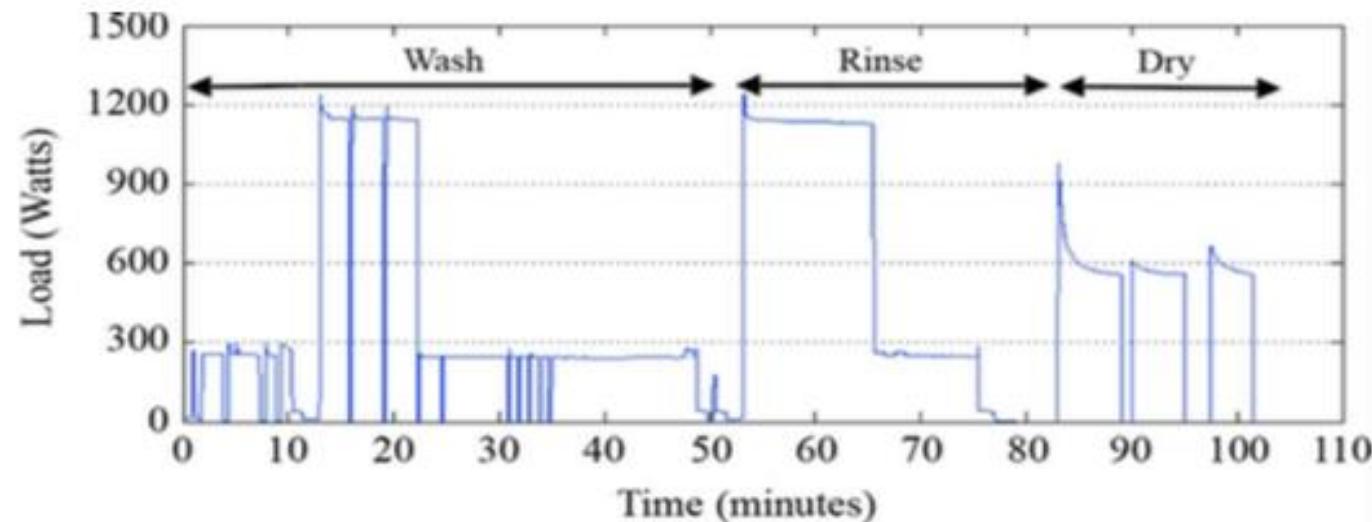


Appliance-level Load Profiles

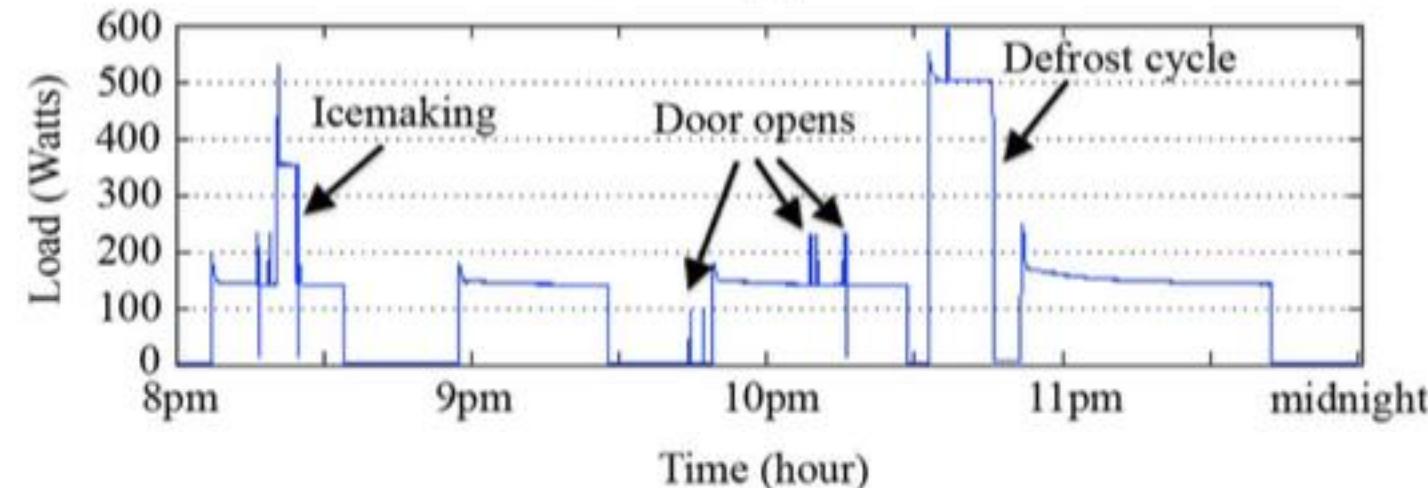


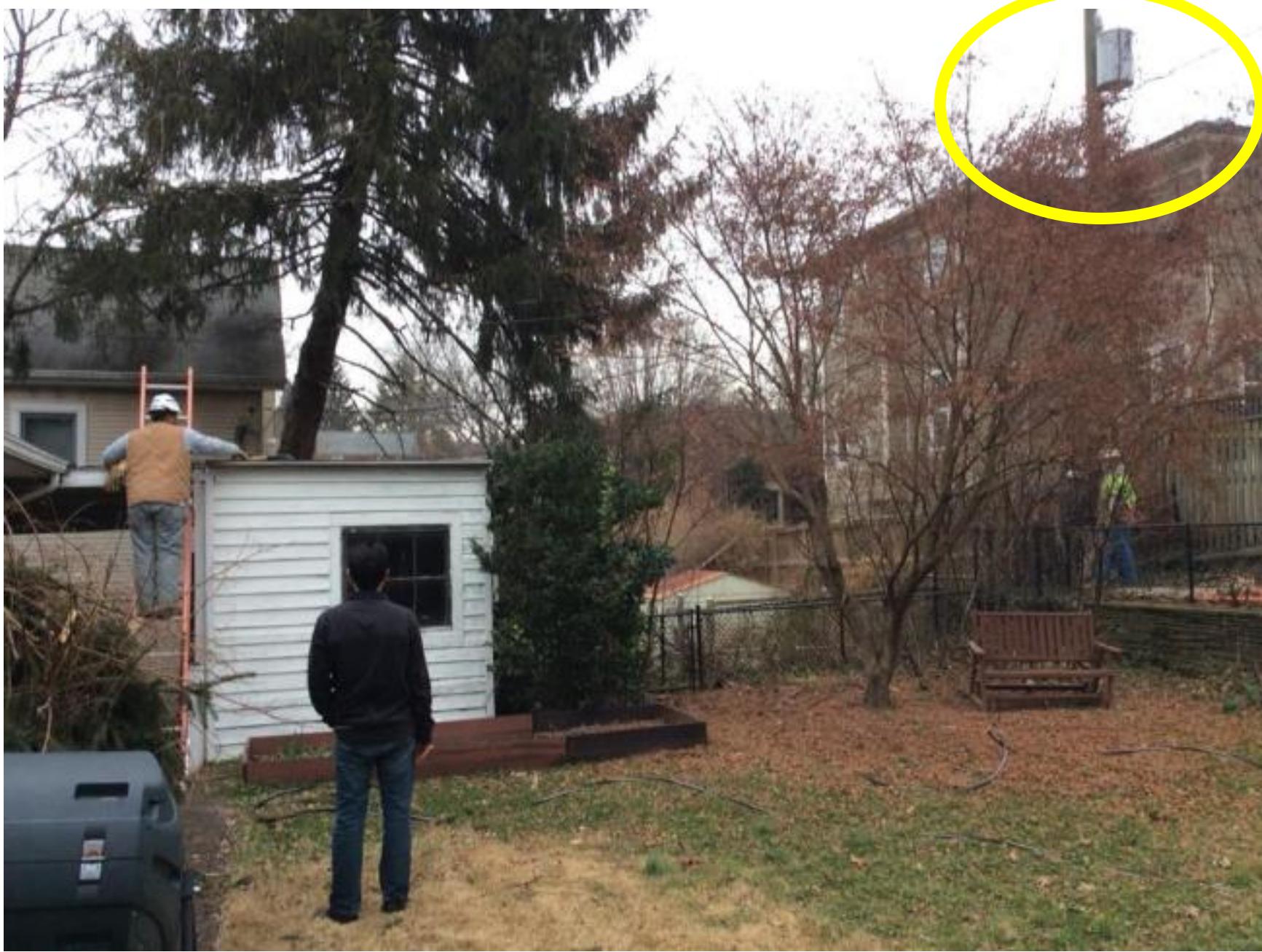
Appliance-level Load Profiles

Dishwasher
(~1 kW)

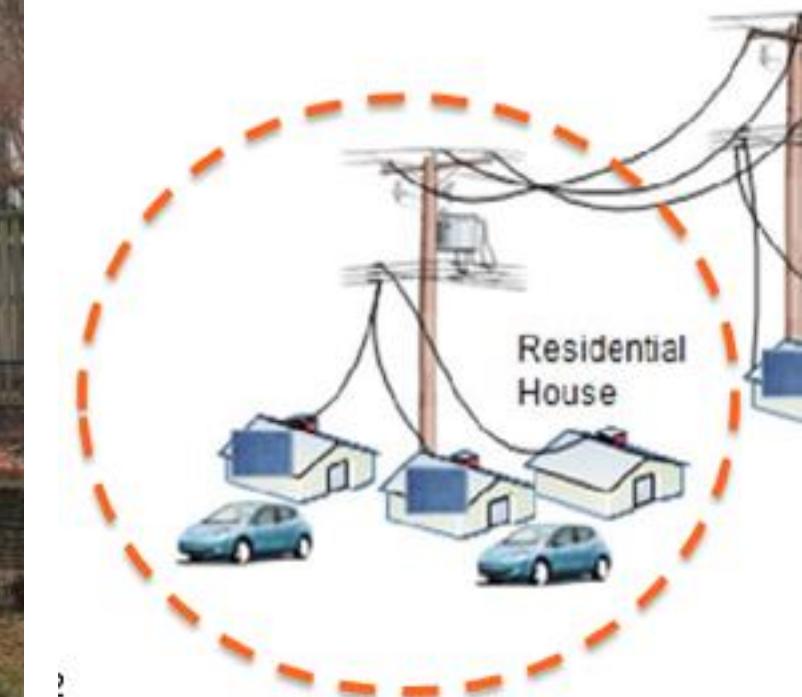


Refrigerator
(150-500W)





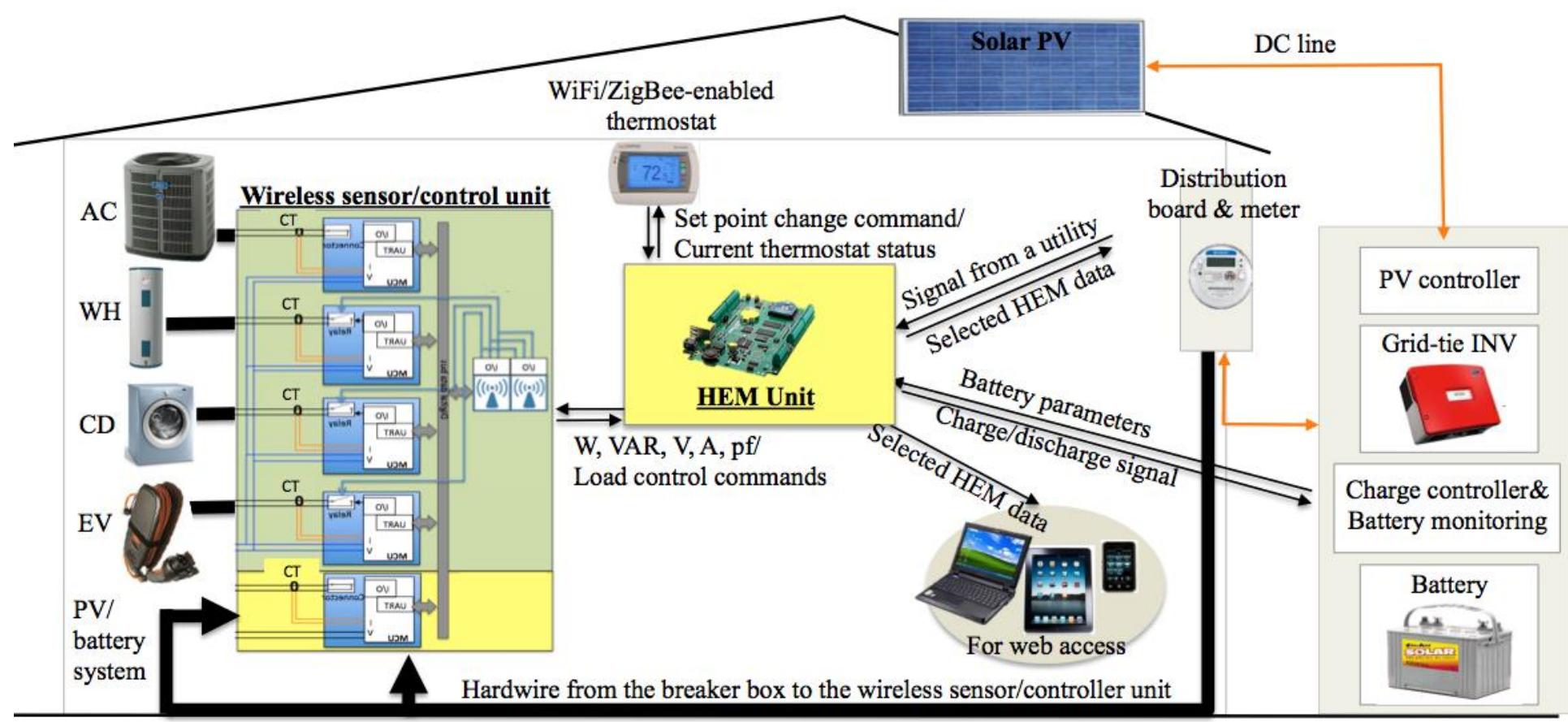
Distribution transformer:
25, 37.5, 50 and 100 kVA



Electric vehicle
(3.3-16.8 kW for level-2)



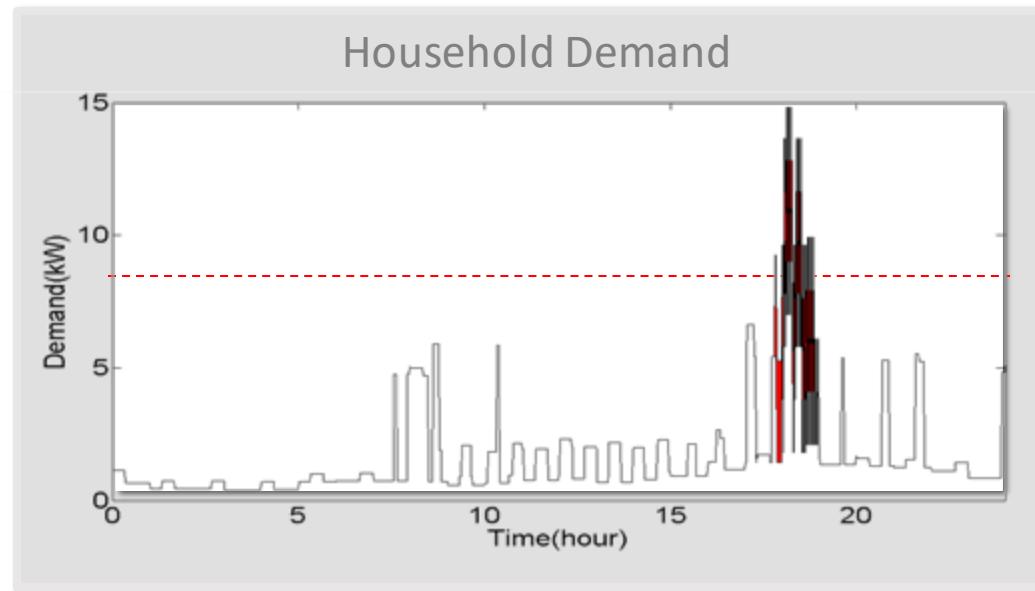
Home Energy Management (2011-2013)



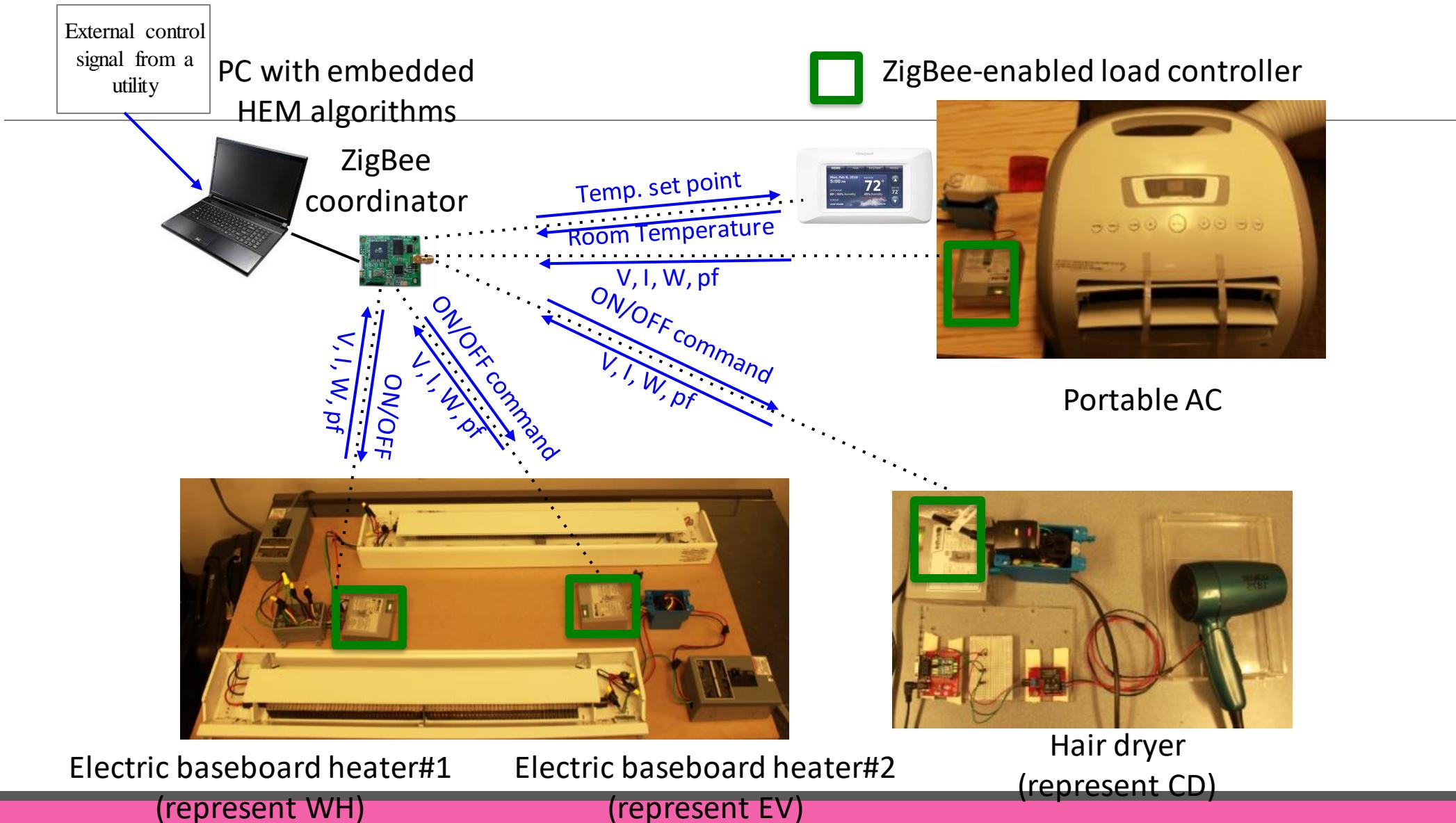
Algorithm Development

	PHEV 	Water heater 	HVAC 	Dryer 
Priority	1	2	3	4
Preference	Full by 8 pm	$\geq 100^{\circ} \text{ F}$	$< 82^{\circ} \text{ F}$	-

Before Demand Response



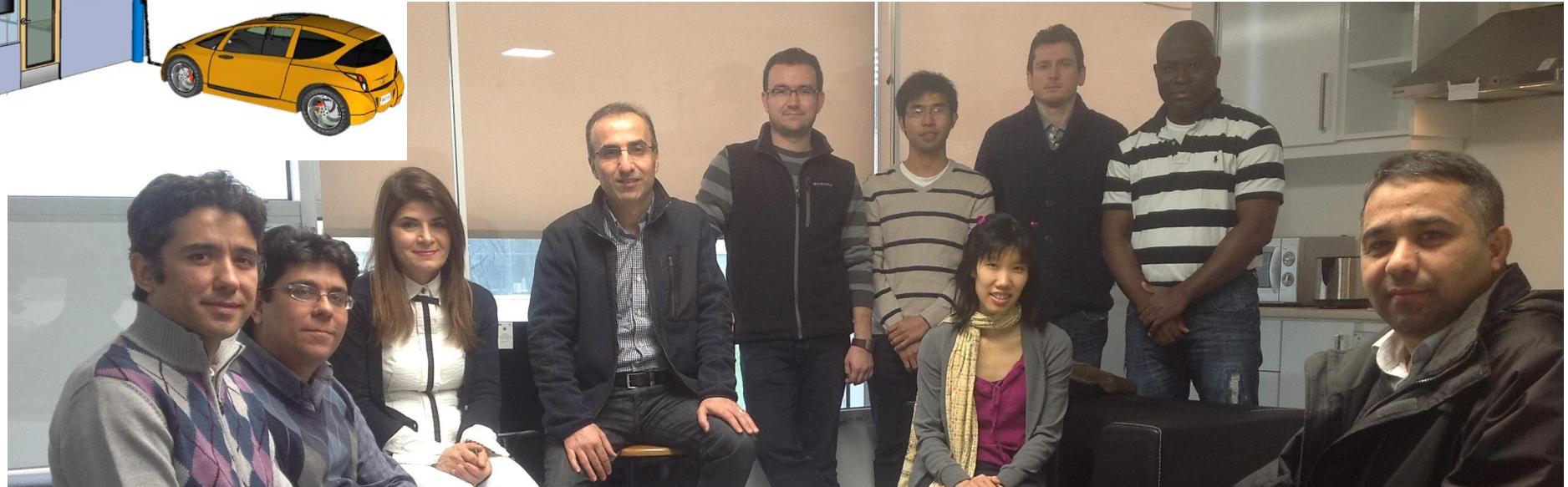
Hardware Development



Smart Home @ Yildiz Technical University, Turkey



VT's HEM Algorithm



Control Section



4Nok Smart Plug



EV Charger



Renewables



16 Kyocera panels @ 210W each
= 3.36kW

Batteries

22 kWh



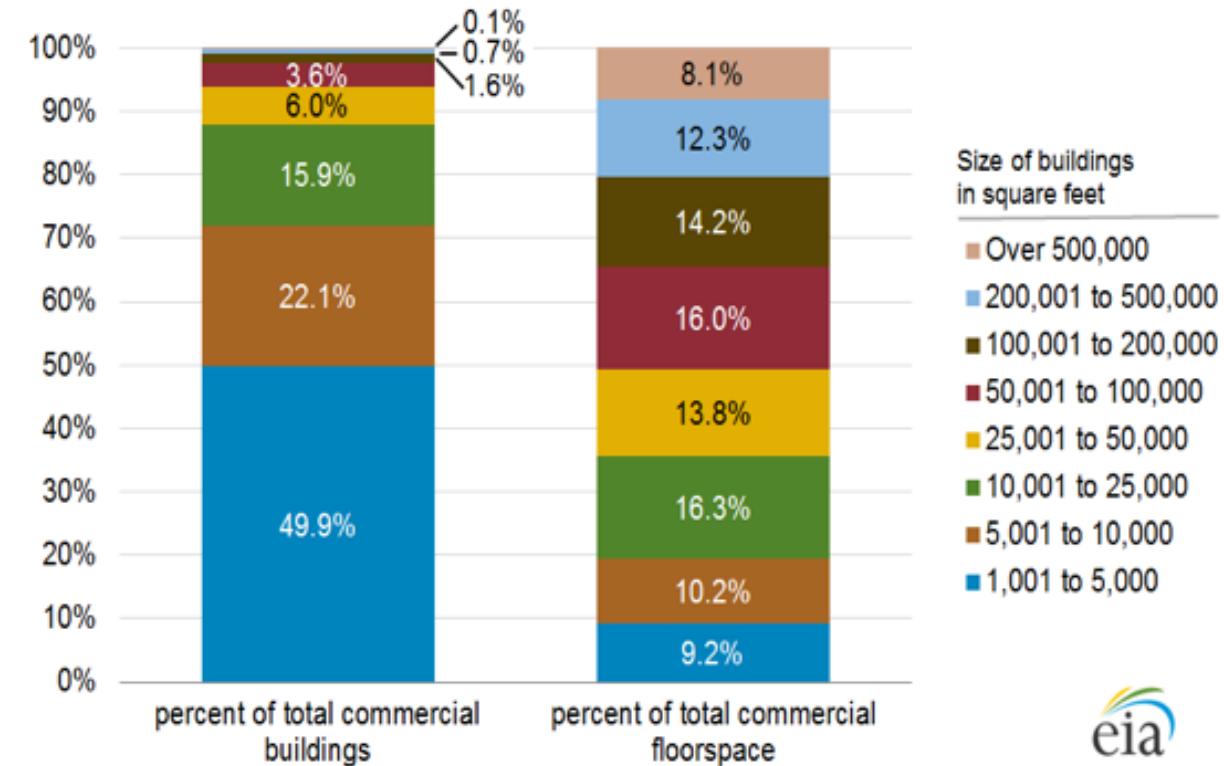
Programmable Source & Load



U.S. Commercial Buildings

Buildings consume over 40% of the total energy consumption in the U.S. Over 90% of the buildings in the U.S. are either small-sized (<5,000 square feet) or medium-sized (between 5,000 sqft and 50,000 sqft).

These buildings typically do not use Building Automation Systems (BAS) to monitor and control their building systems from a central location.



BEMOSS (2014-2017)



BEMOSS

BEMOSS is a Building Energy Management Open Source Software (**BEMOSS**) solution that is engineered to improve sensing and control of equipment in small- and medium-sized commercial buildings.

BEMOSS monitoring and control:

Three major loads in buildings

- HVAC
- Lighting loads
- Plug loads

BEMOSS value:

Improves energy efficiency and facilitates demand response implementation in buildings.

BEMOSS Advisory Committee

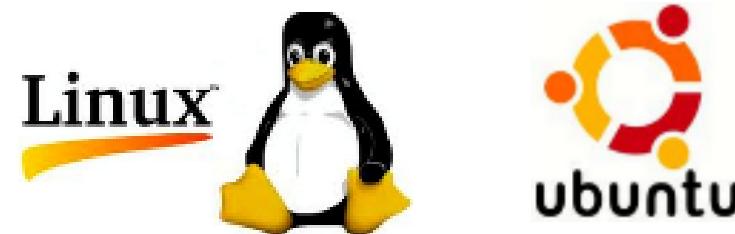
BEMOSS is developed in consultation with industry

BEMOSS advisory committee has representatives from 21 organizations:



Built upon Open-Source Software

VOLTTRON™ was used as a platform to host our BEMOSS solution.
It is open-source and not hardware specific.



Other software used:



ZeroMQ sMAP

BEMOSS Interoperability

Communication Technologies

- Ethernet (IEEE 802.3)
- Serial Interface (RS-485)
- ZigBee (IEEE 802.15.4)
- WiFi (IEEE 802.11)



Data Exchange Protocols

- BACnet (IP and MS/TP)
- Modbus (RTU and TCP)
- Web (e.g., XML, JSON, RSS/Atom)
- ZigBee API
- Smart Energy (SE)
- OpenADR (Open Automated Demand Response)



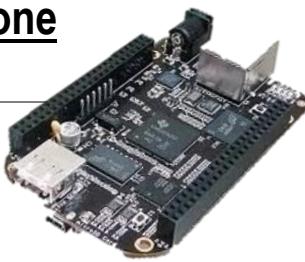
BEMOSS Plug & Play

BEMOSS automatically discovers new load controllers deployed in a building



BEMOSS on Various Embedded Devices

Beaglebone



CPU: 1GHz ARM Cortex-A8

RAM: 512MB

Price: \$55

Pandaboard



CPU: 1.2GHz Dual core ARM Cortex-A9

RAM: 1GB

Price: \$220

Odroid C3



CPU: 1.7GHz Quad core ARM Cortex

RAM: 2GB

Price: \$69

Raspberry Pi



CPU: 700 MHz ARM1176JZF-S

RAM: 256MB

Price: \$35

Raspberry Pi 2

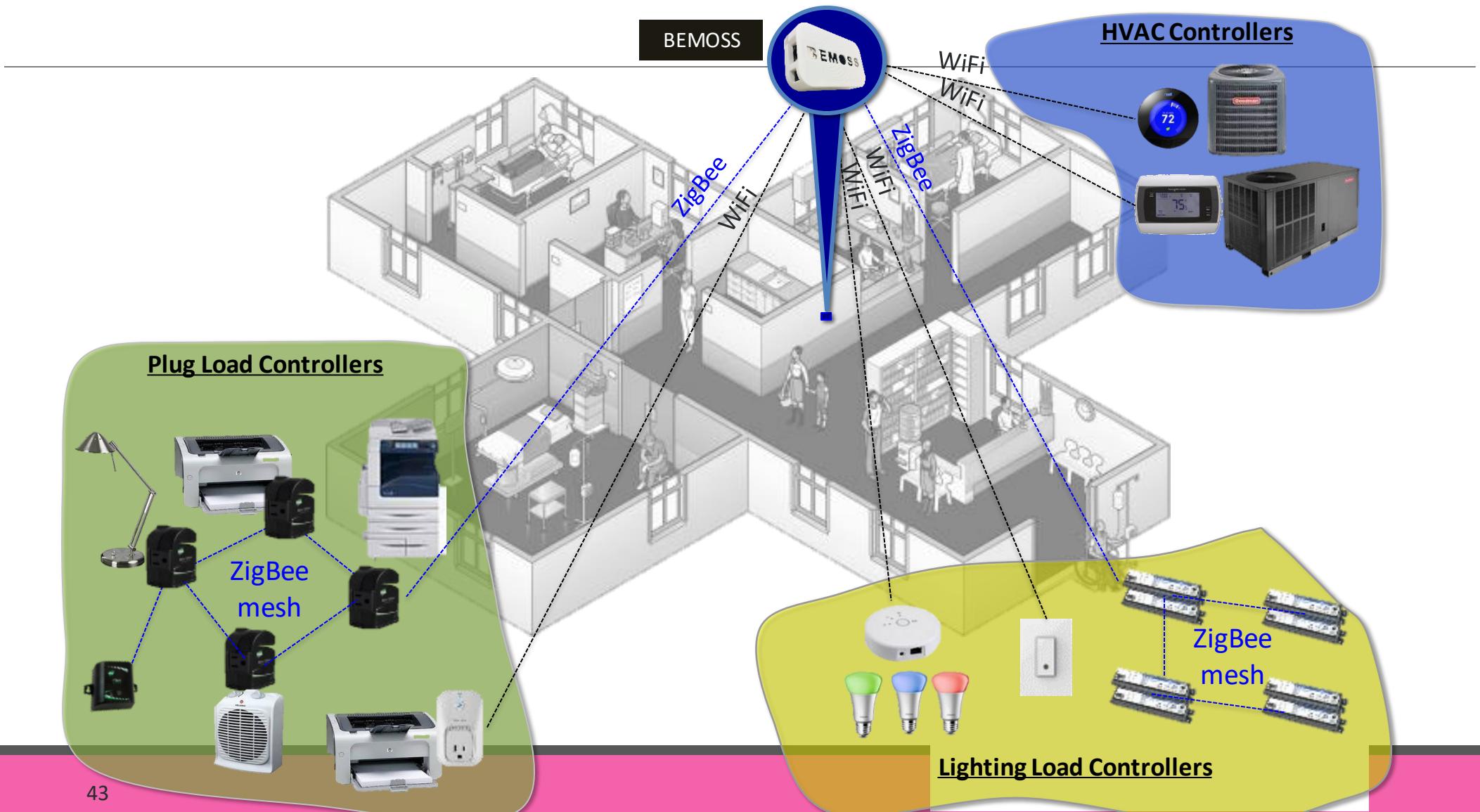


CPU: 900 MHz Quad core ARM Cortex A7

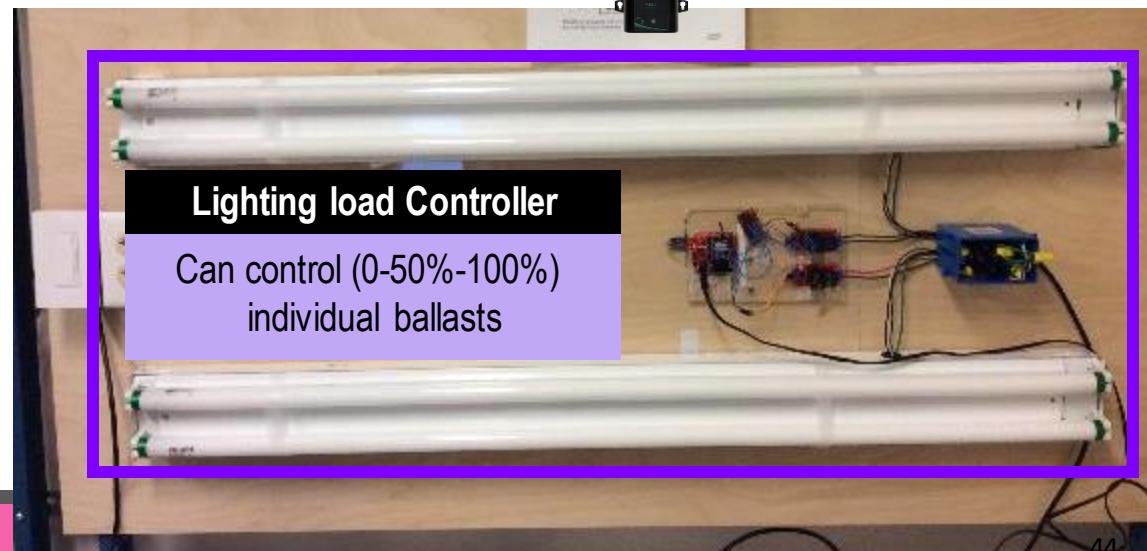
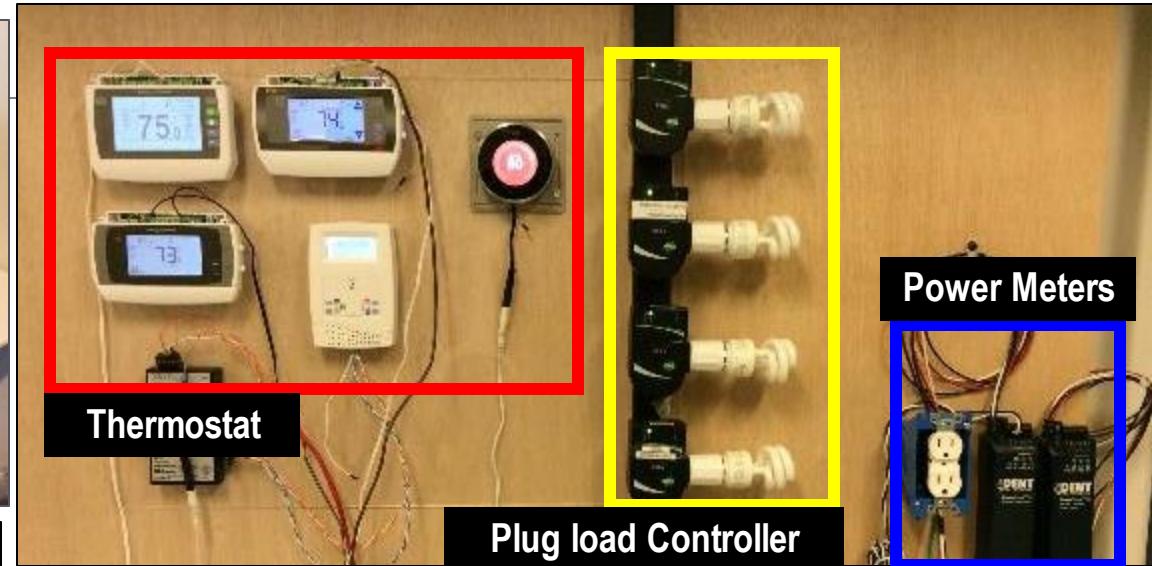
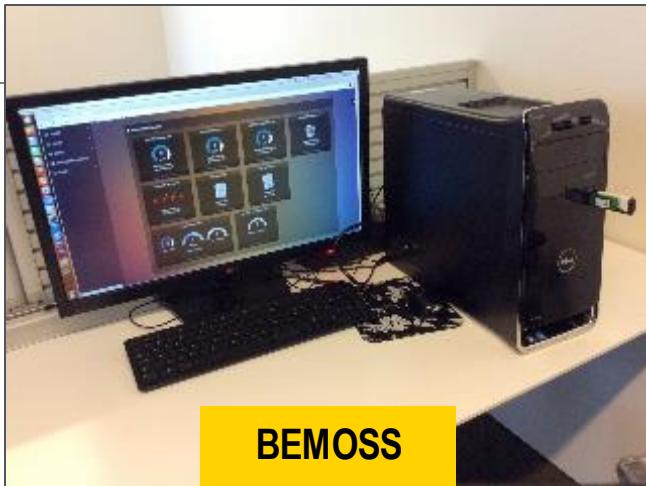
RAM: 1GB

Price: \$35

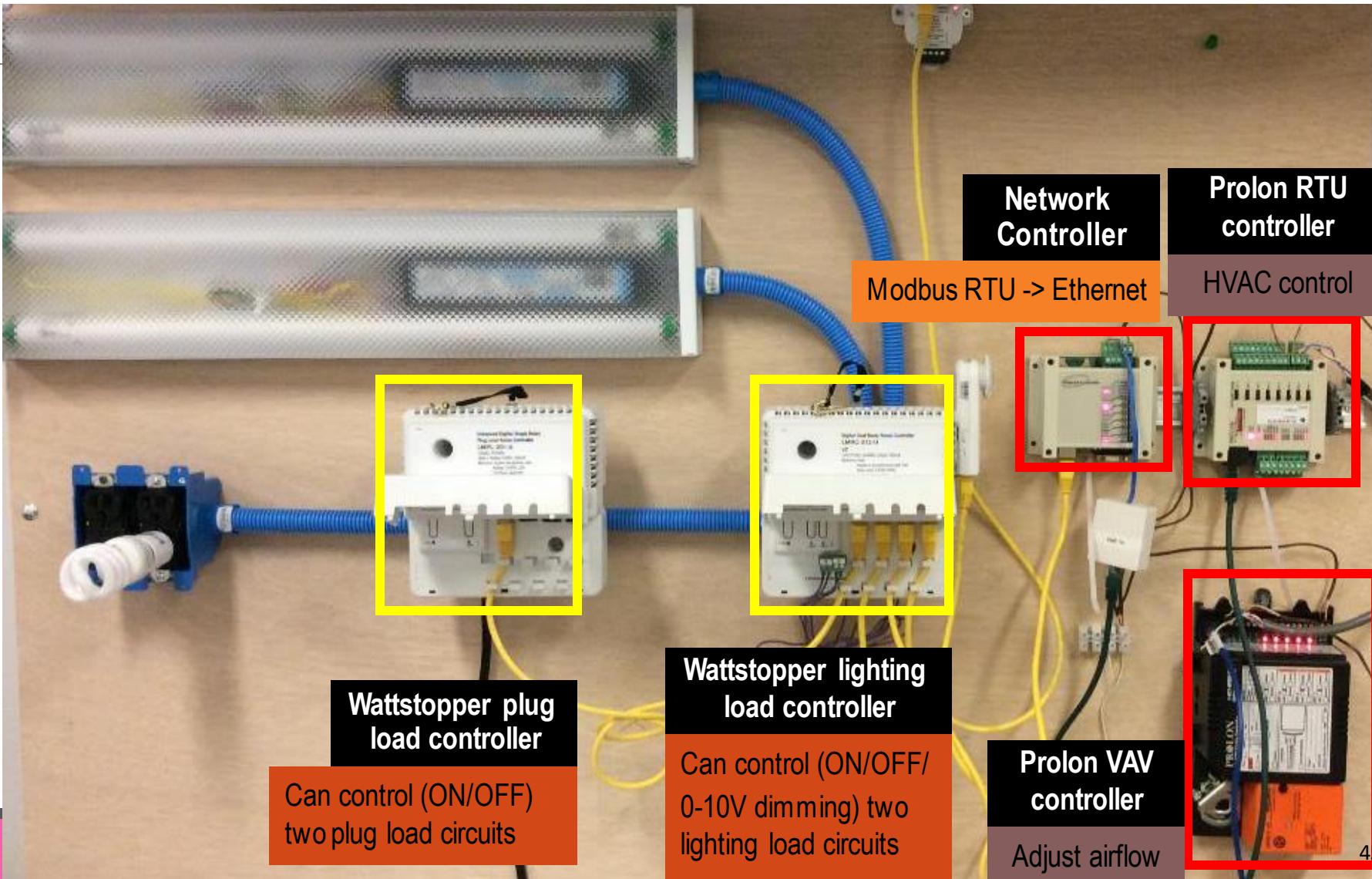
BEMOSS Solutions for Small Buildings



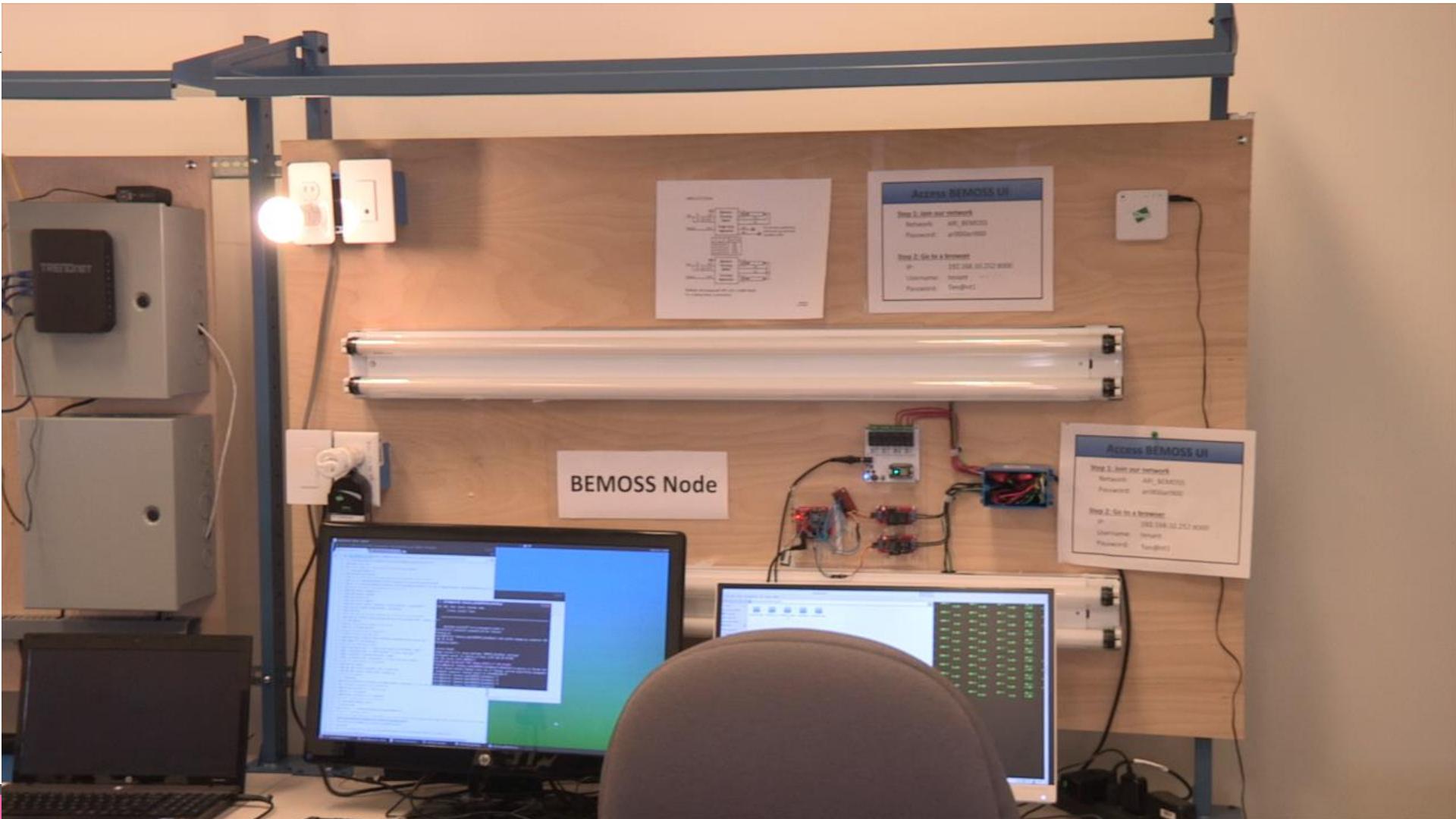
Lab Setup 1



Lab Setup 2



Lab Overview

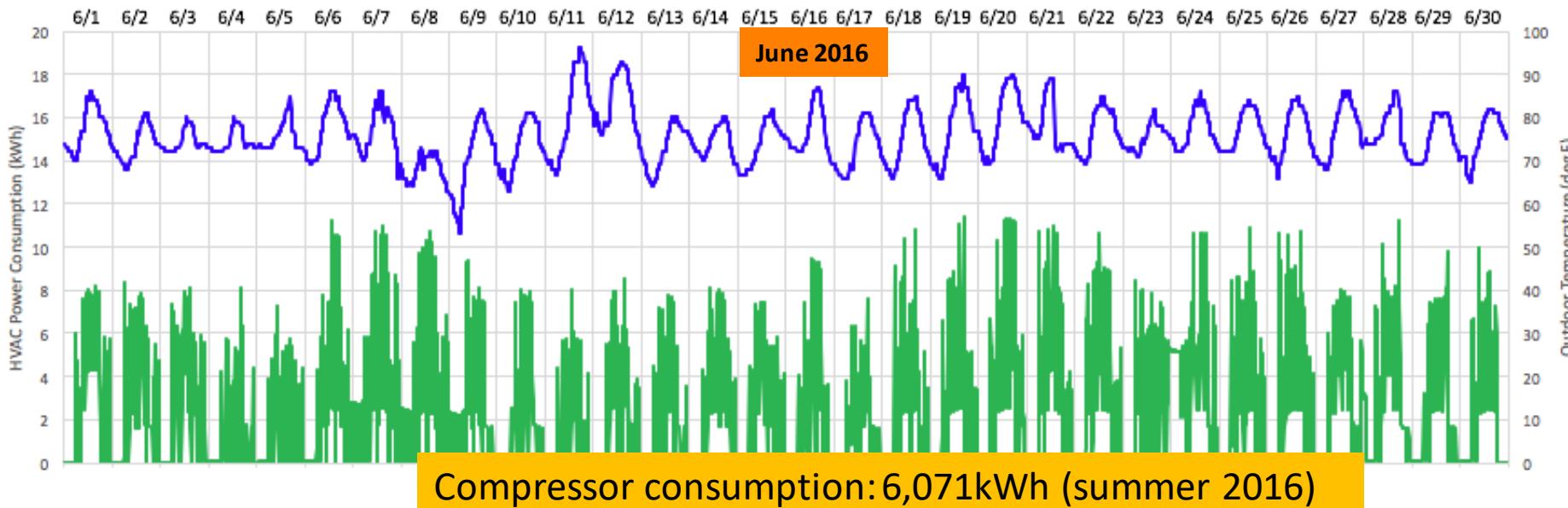
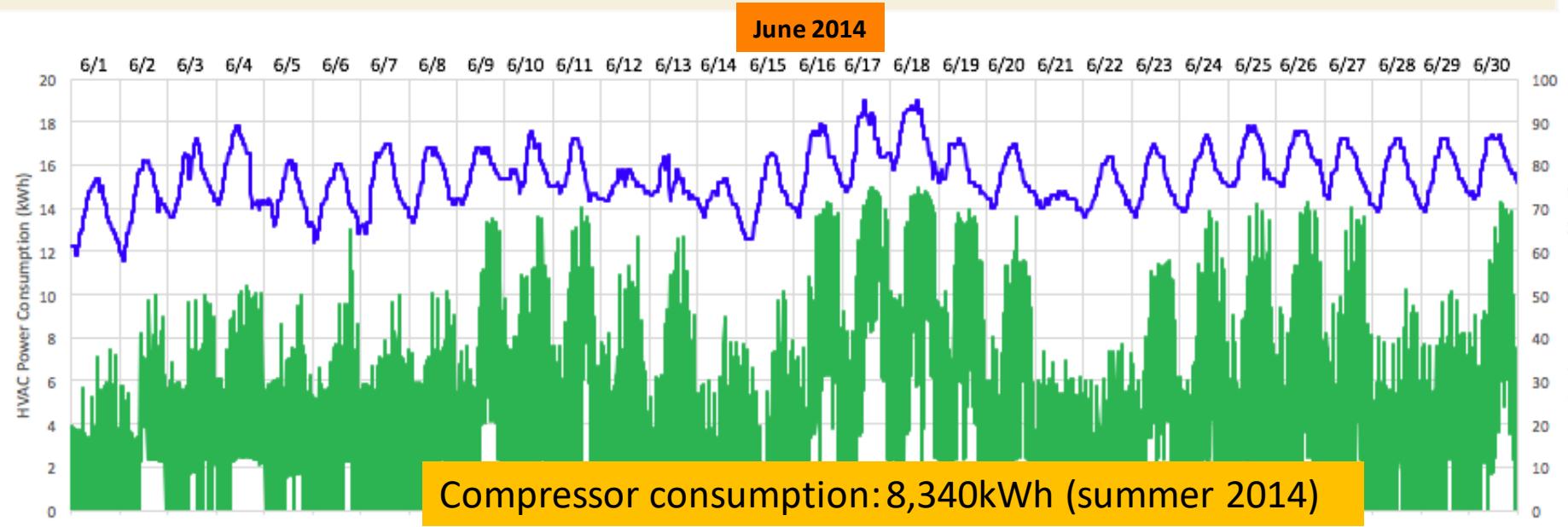


Building 1: VT Alexandria

1021 Prince St.,
Alexandria, VA 22314



27% Energy Savings before/after BEMOSS





SBIR/STTR

SMALL BUSINESS INNOVATION RESEARCH
SMALL BUSINESS TECHNOLOGY TRANSFER

Transitioning from a Research Project to a Small Business (2017-2019)

BEMOSS

Node1 : Der1

Power

INCIDENT	DC	AC
35361.2 W	5140.15 W	4958.0 W

Efficiency

PANEL	
14.54 %	96.46 %

Voltage

DC	AC
357.7 V	212.3 V

Current

DC	AC
14.37 A	23.51 A

Energy

TOTAL	
6.52 MV	14.03 %

Irradiance

ARRAY	HORIZONTAL
865.0 W/m ²	W/m ²

Temperature

AMBIENT	MODULE
84.0 °F	93.0 °F

Wind Velocity

0.0 m/s	10105.01 lbs
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Smart inverter control

REAL POWER CONTROL

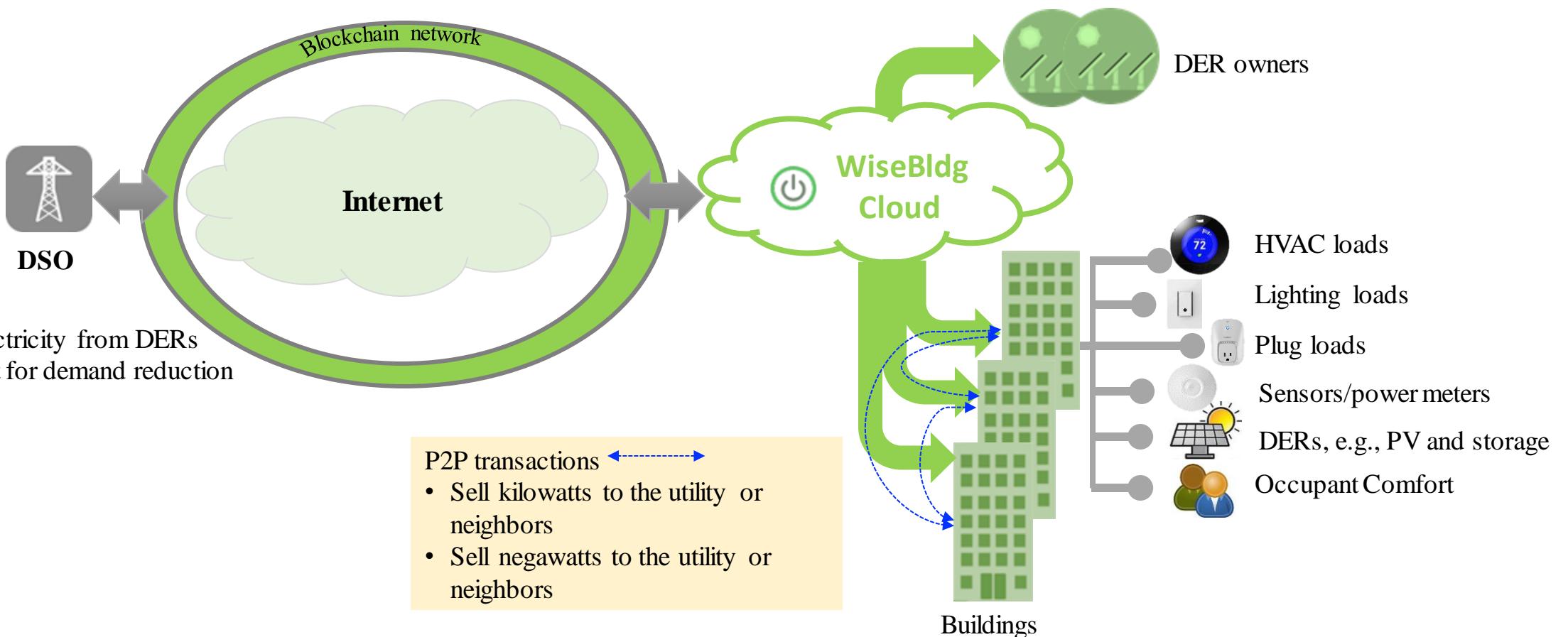
Power limit Value: **100.**

POWER FACTOR

Power factor limit: **100.**



Blockchain P2P trading (2018-2019)



CU Smart Campus Project (2020+)

Project Building Blocks:

1) Prosumer energy trading using blockchain technology

Research components:

(Blockchain)

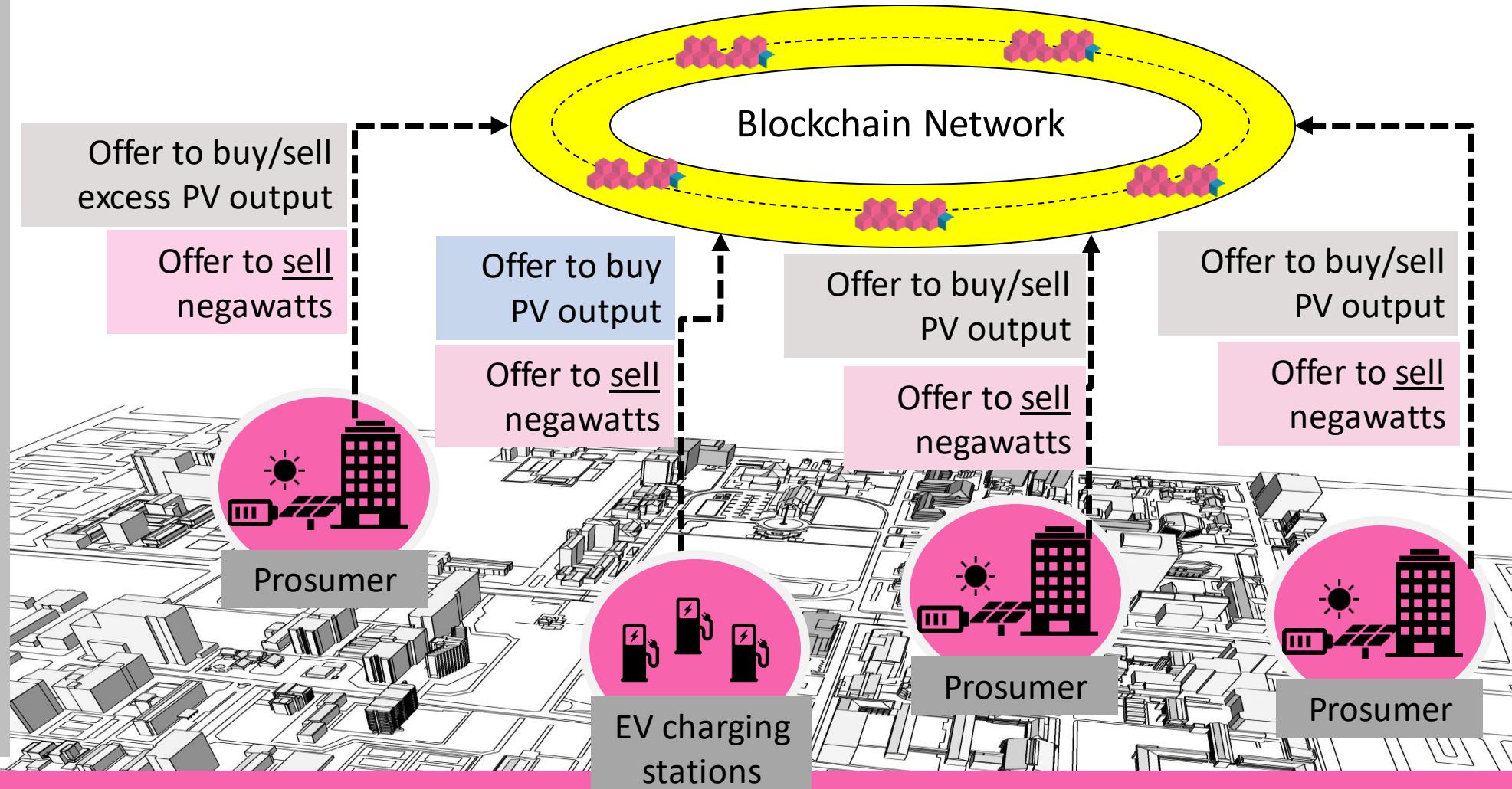
- Smart contract for excess PV output trading
- Smart contract for negawatt trading

Hardware requirements:

- Solar PVs
- Battery storage units
- EV charging stations

Software requirements:

- Open source blockchain platform





Project Building Blocks:

2) Smart building operation with ability to participate in a local electricity market and perform demand response

Research components:

(Building)

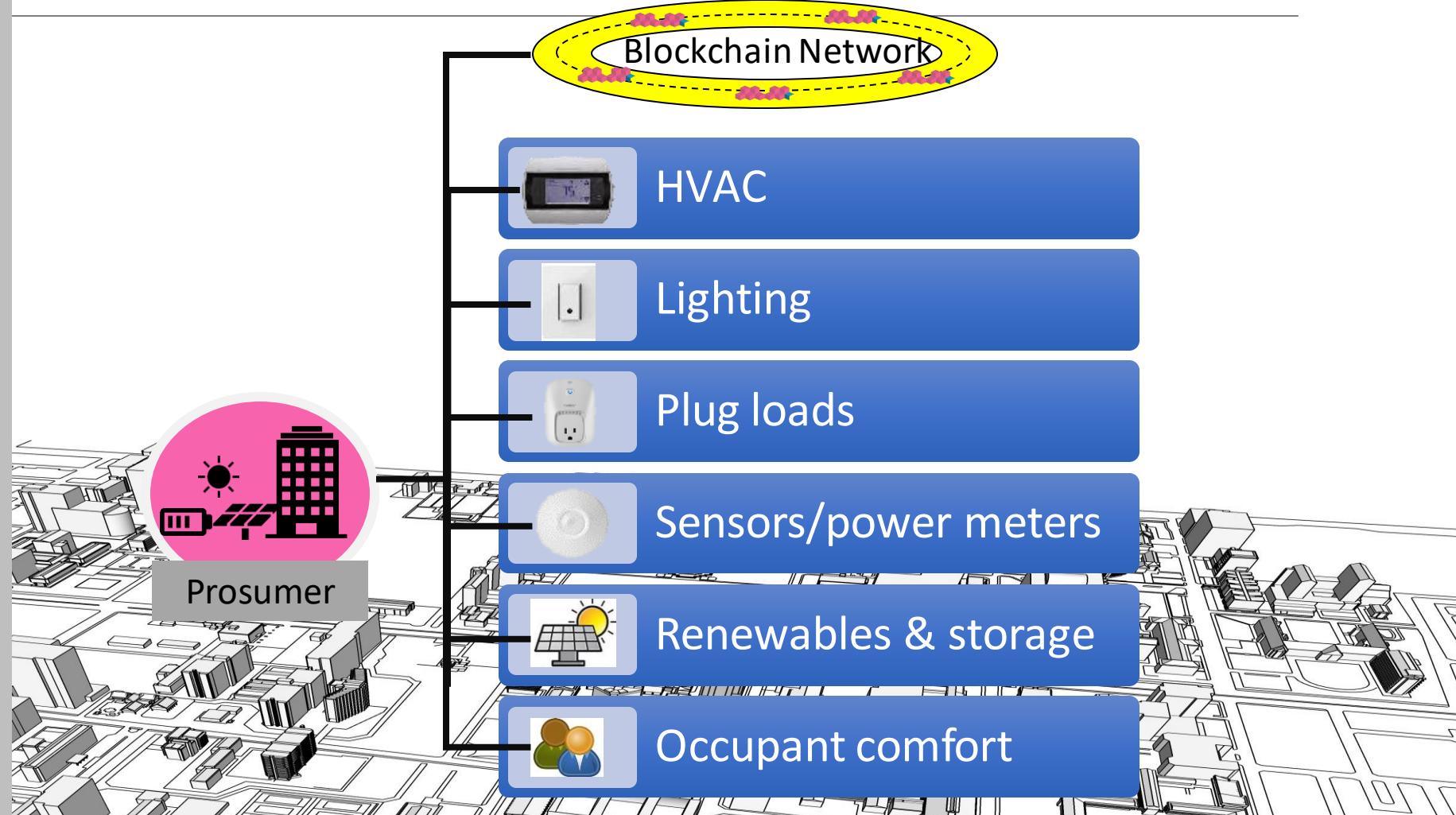
- Algorithm to bid into a local electricity market (e.g., game theory, double auction mechanism based on selected attributes)
- Algorithm to perform demand reduction for negawatt trading
- Machine learning-based algorithms to forecast:
 - ✓ Building-level load
 - ✓ PV output

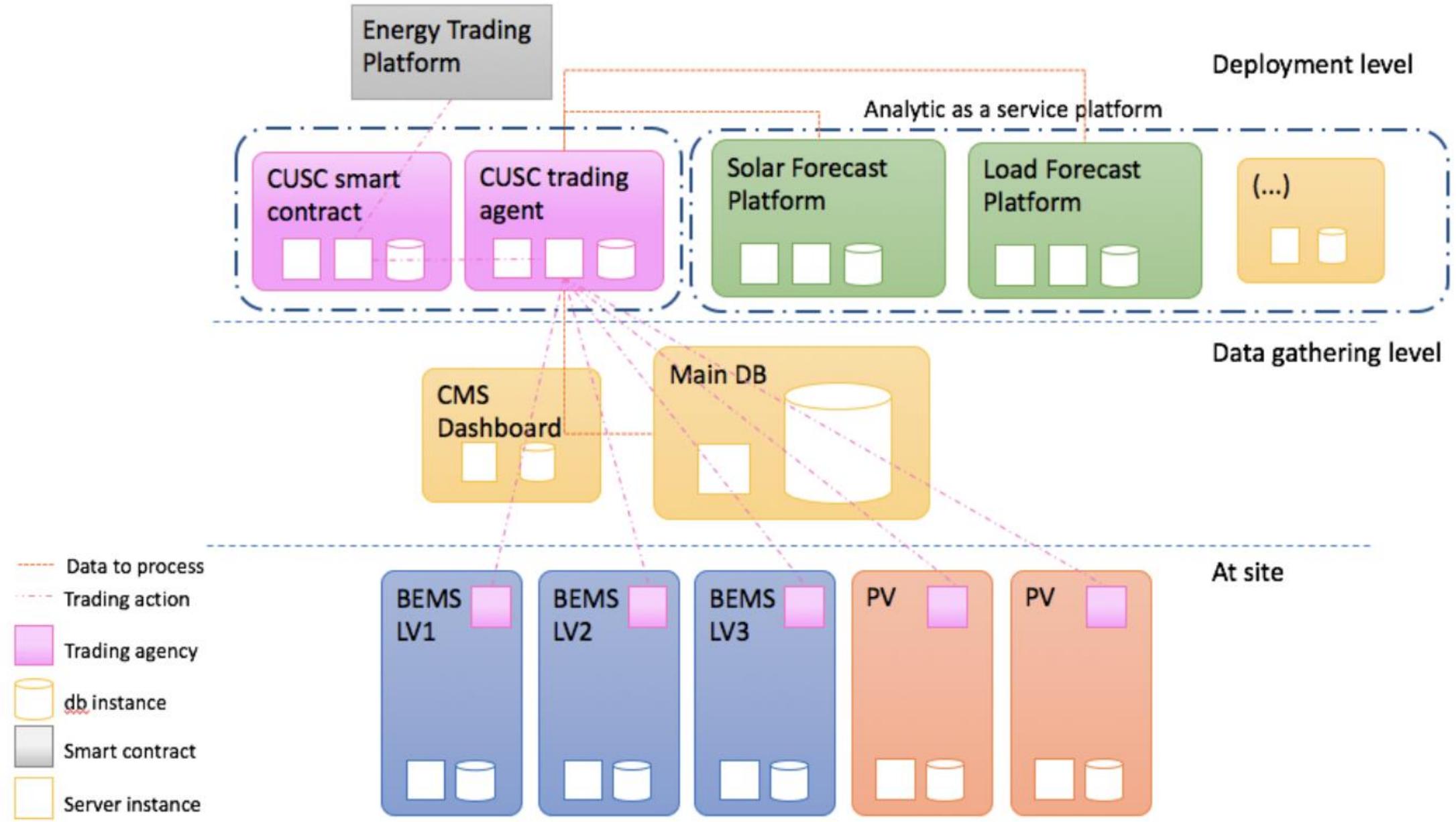
Hardware requirements:

- Meters, HVAC, lighting, plug load controllers

Software requirements:

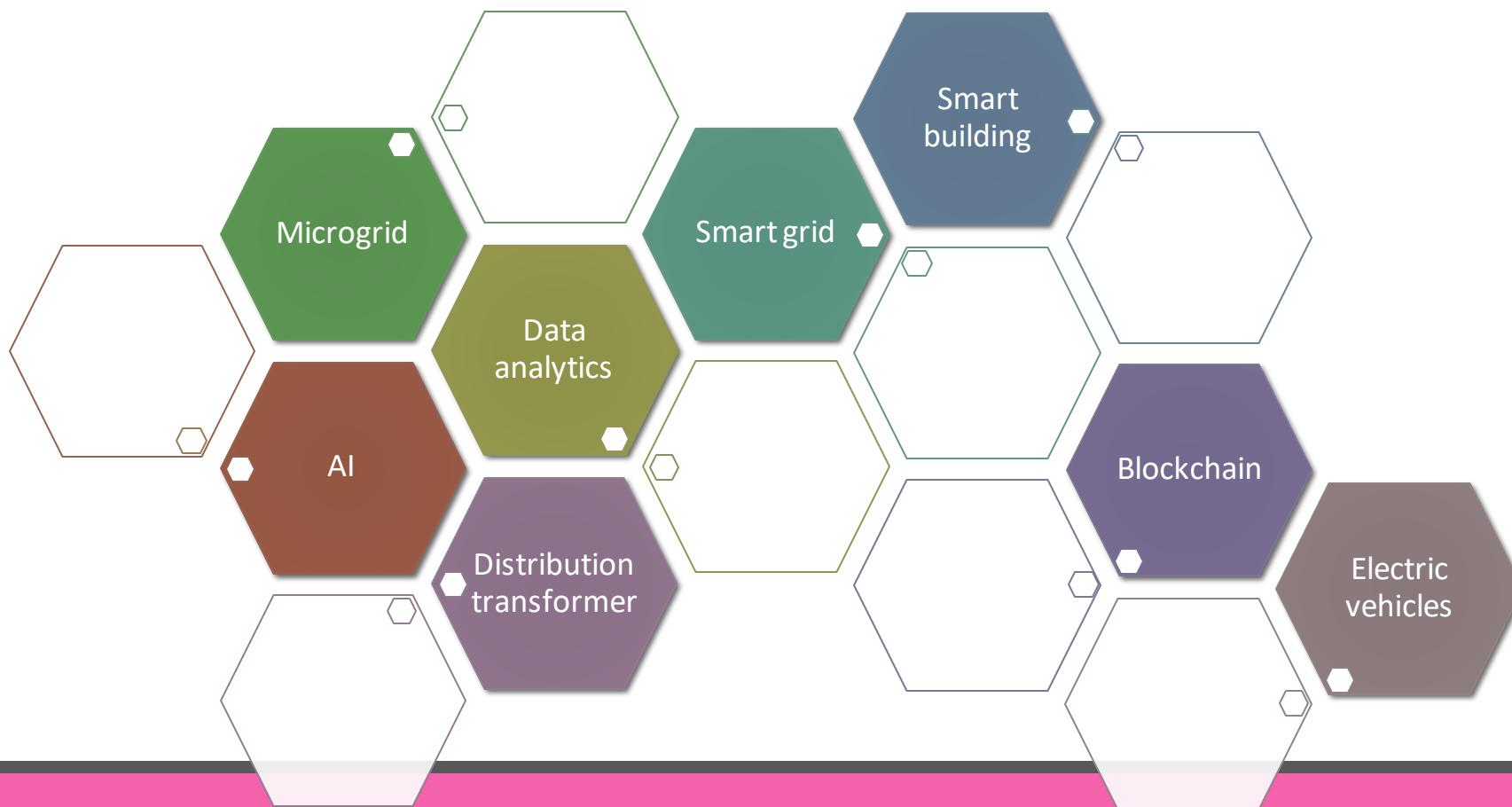
- Open source platform for BEM



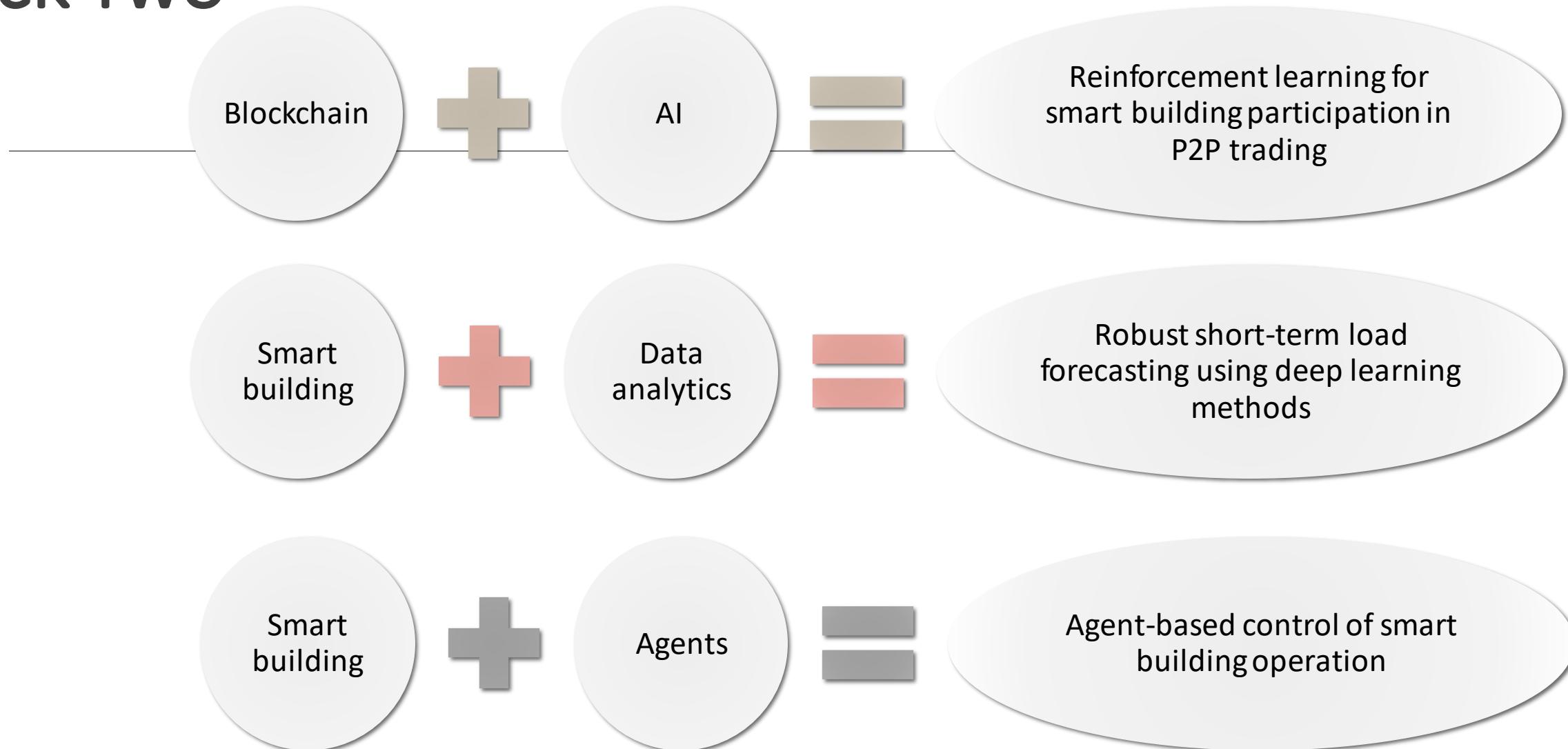


Takeaways 1

- How to come up with a research idea for your MS/PhD topic.

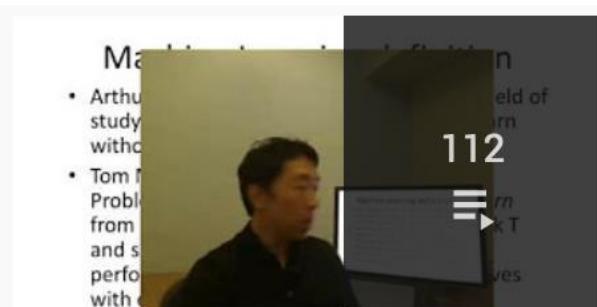


Pick Two



Takeaway 2

- Read a lot, study a lot.... OFFLINE and ONLINE!!



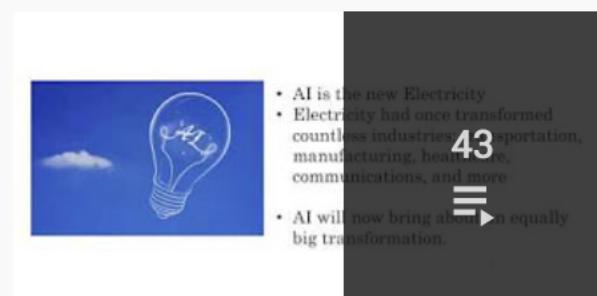
Machine Learning – Andrew Ng, Stanford University [FULL COURSE]

Artificial Intelligence - All in One

Lecture 1.1 – Introduction What Is Machine Learning – [Machine Learning | Andrew Ng] • 7:15

Lecture 1.2 – Introduction Supervised Learning – [Machine Learning | Andrew Ng] • 12:30

[VIEW FULL PLAYLIST](#)

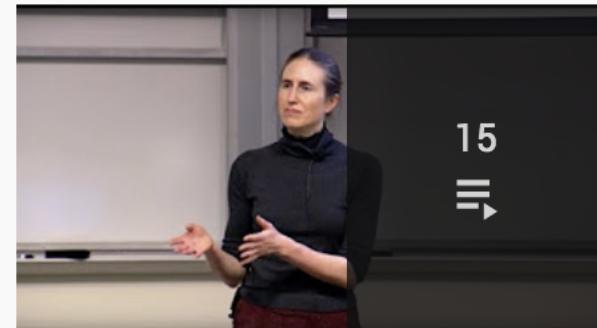


Neural Networks and Deep Learning (Course 1 of the Deep Learning Specialization)

Deeplearning.ai

Welcome (C1W1L01) • 5:32

What is a Neural Network? (C1W1L02) • 7:17



CS234: Reinforcement Learning | Winter 2019

stanfordonline

Stanford CS234: Reinforcement Learning | Winter 2019 | Lecture 1 - Introduction • 1:05:54

Stanford CS234: Reinforcement Learning | Winter 2019 | Lecture 2 - Given a Model of the Wo... • 1:13:36

[VIEW FULL PLAYLIST](#)

Takeaway 3

- Don't forget to take care of yourself



Thank you and Good Luck!!

manisa.pip@chula.ac.th