“Community Smart Grid: Integrating Renewable Energy with Green Technologies”

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Chiang Mai Rajabhat University, Thailand

adiCET

Outline

- Concept of Smart Grid
  - Class Questions
- Examples of Smart Grid Systems
  - Case Study – Jeju Island
- Community Smart Grid – RE & Green Technologies
  - Case Study: Chiang Mai World Green City
  - DC Microgrid
  - Integrating Energy Infrastructure with Green City Components
- Smart Homes
- Conclusion

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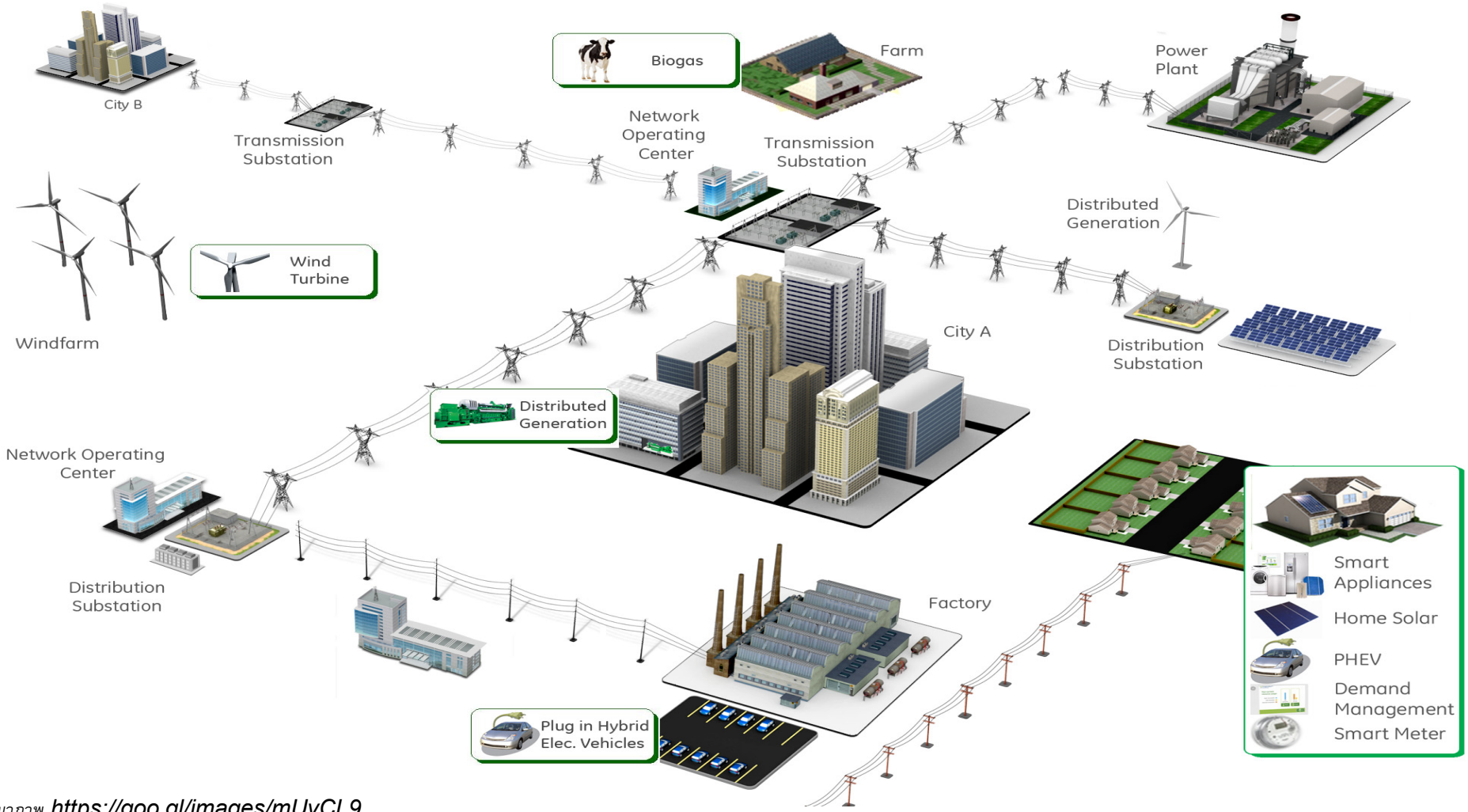
Class Questions

- What is a grid?
- What is a electrical grid?
- What is a smart grid?
- Why do we need smart grid?
- What are the component of smart grid?

- Distributed Generations
  - What are the generation profiles of renewable energy?
  - What are the load profiles for home, offices, factories, etc?
- What are the role of energy storage and EVs?

Smart Grid Example



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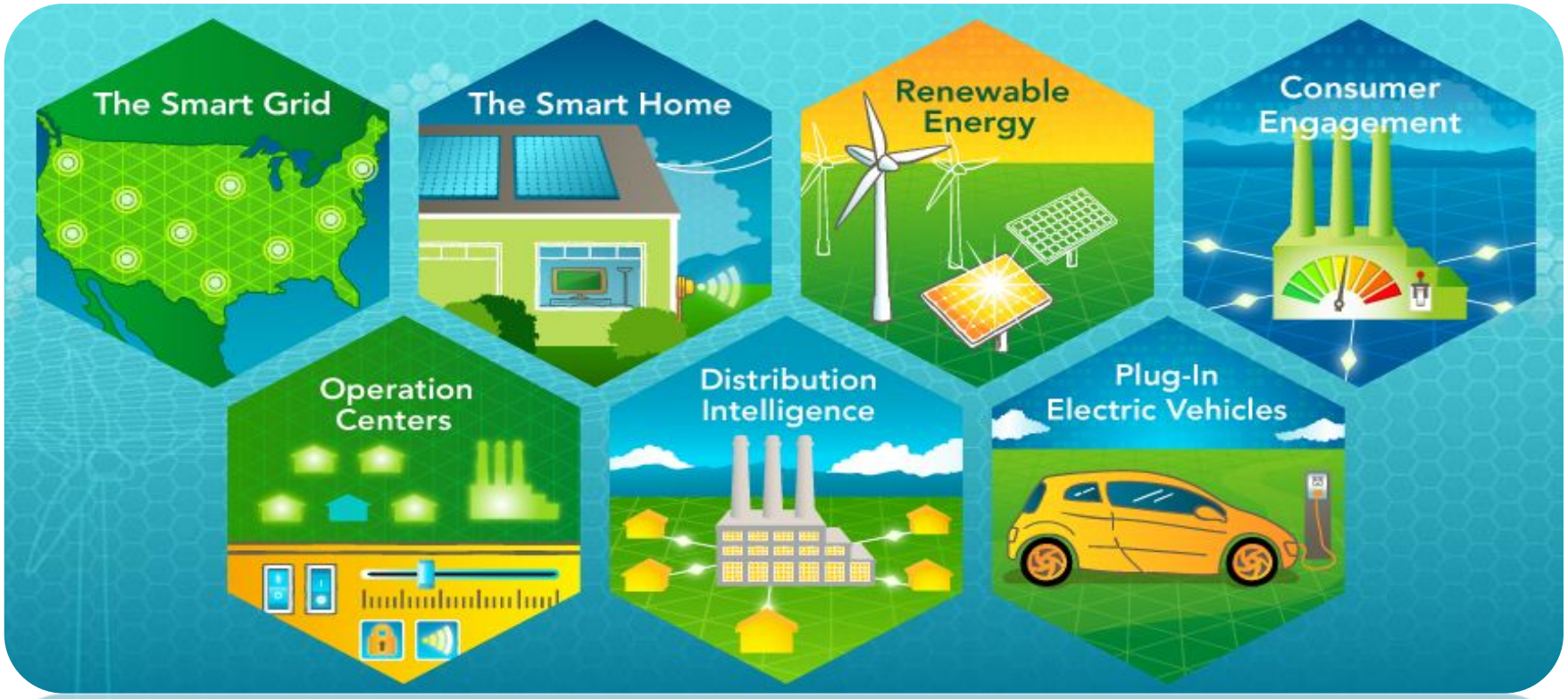
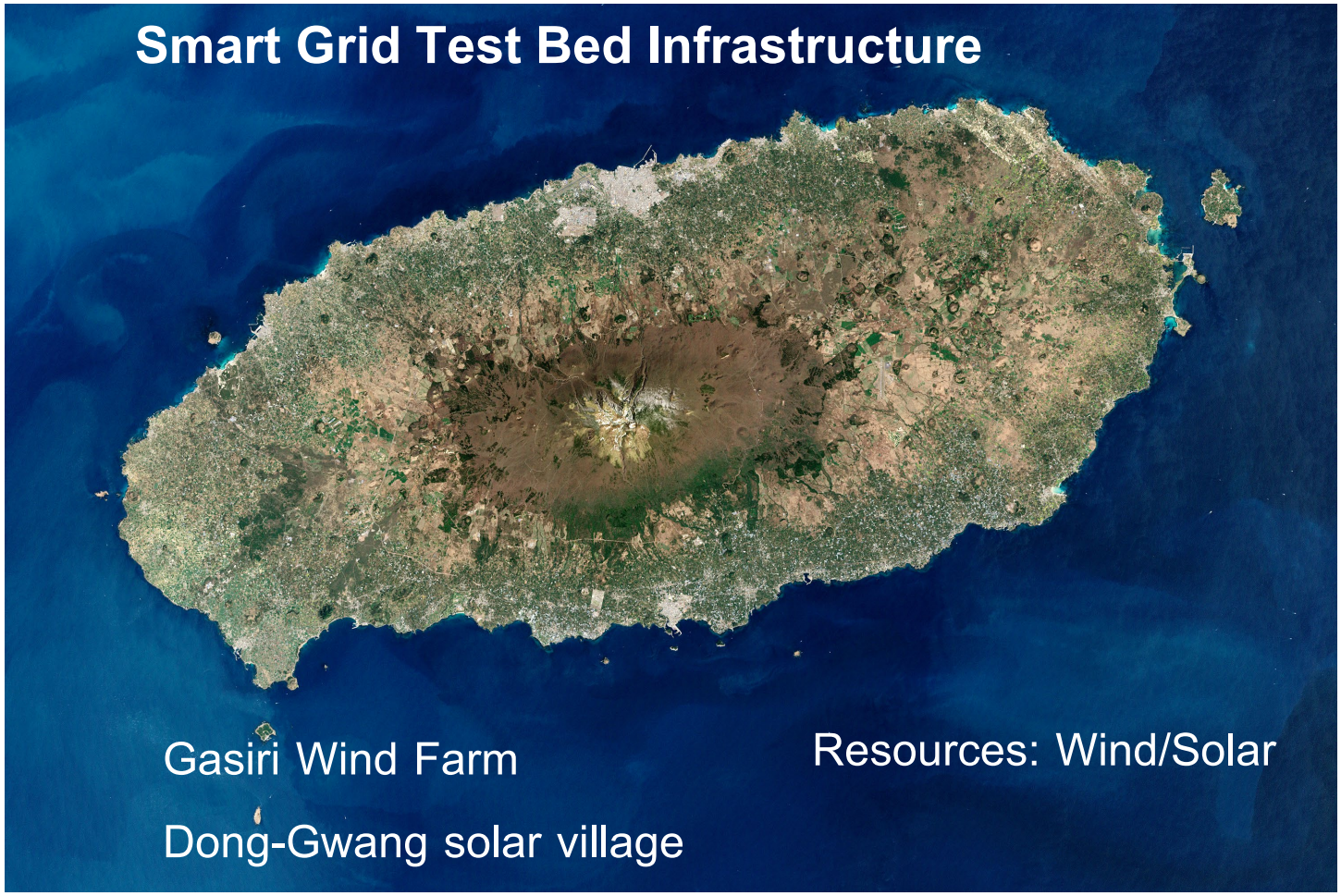
Smart Grid Component



US Department of Energy

EXAMPLES OF SMART GRID SYSTEMS
JEJU ISLAND, KOREA

Jeju Island



Gapado – Carbon Free Island

Population: 604,670

Area: 1,848 km^2

Adapt from Jeju Energy Corporation

Korea's Vision

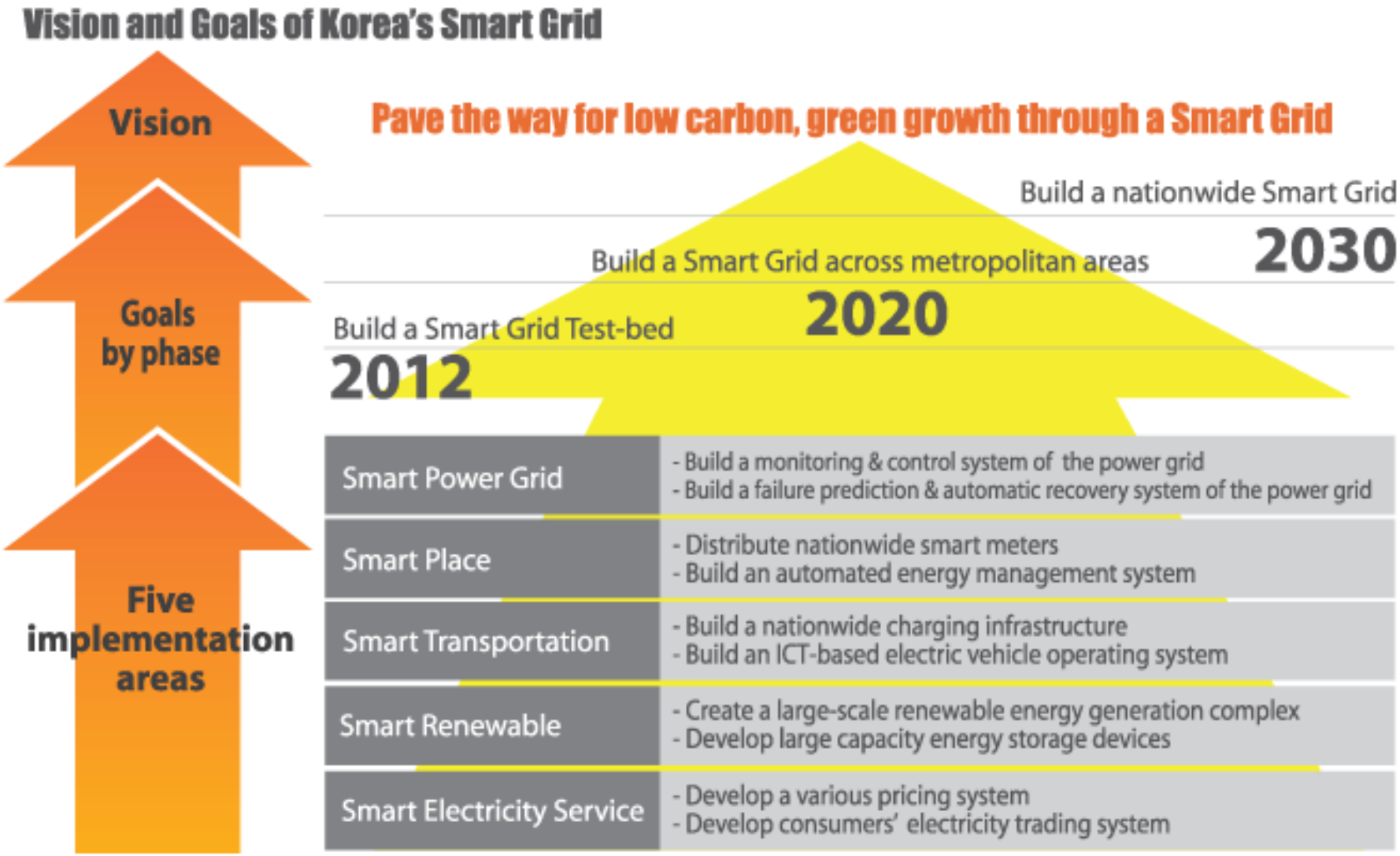
Build the world's best nationwide Smart Electricity Grid

→ Realize a low carbon, green growth society

Opportunity Elements

- **Highly Populated Land**
- **World's Best Broadband Internet Networks**
- **Single Power Transmission & Distribution Company**

Vision of Korea's Smart Grid



http://www.smartgrid.or.kr/10eng4-1.php

Alternative Energy No Fossil by 2030

Renewable Energy

- **100% Electricity usage by RE**
  - Development of 1GW Offshore wind business by 2019 → 15%
  - Development of 2 GW Offshore wind business by 2030 → 100%
    - Onshore 350 MW; Solar PV 100 MW, etc

Electrical Vehicle

- **100% Replacement of Fossil Fuel Cars to Electrical Vehicle by 2030**
  - Public by 2017 → 10% (29,000 vehicles)
  - Public transportation by 2020 →30% (94,000 vehicles)
  - Commercial Vehicles by 2030 → 100% (371,000 vehicles)

Smart Grid

- **Smart Grid City all around Jeju**
  - Smart Grid Pilot Project in 2014
  - Spread Smart Grid Business by 2017
  - Smart Grid City around all Jeju by 2020

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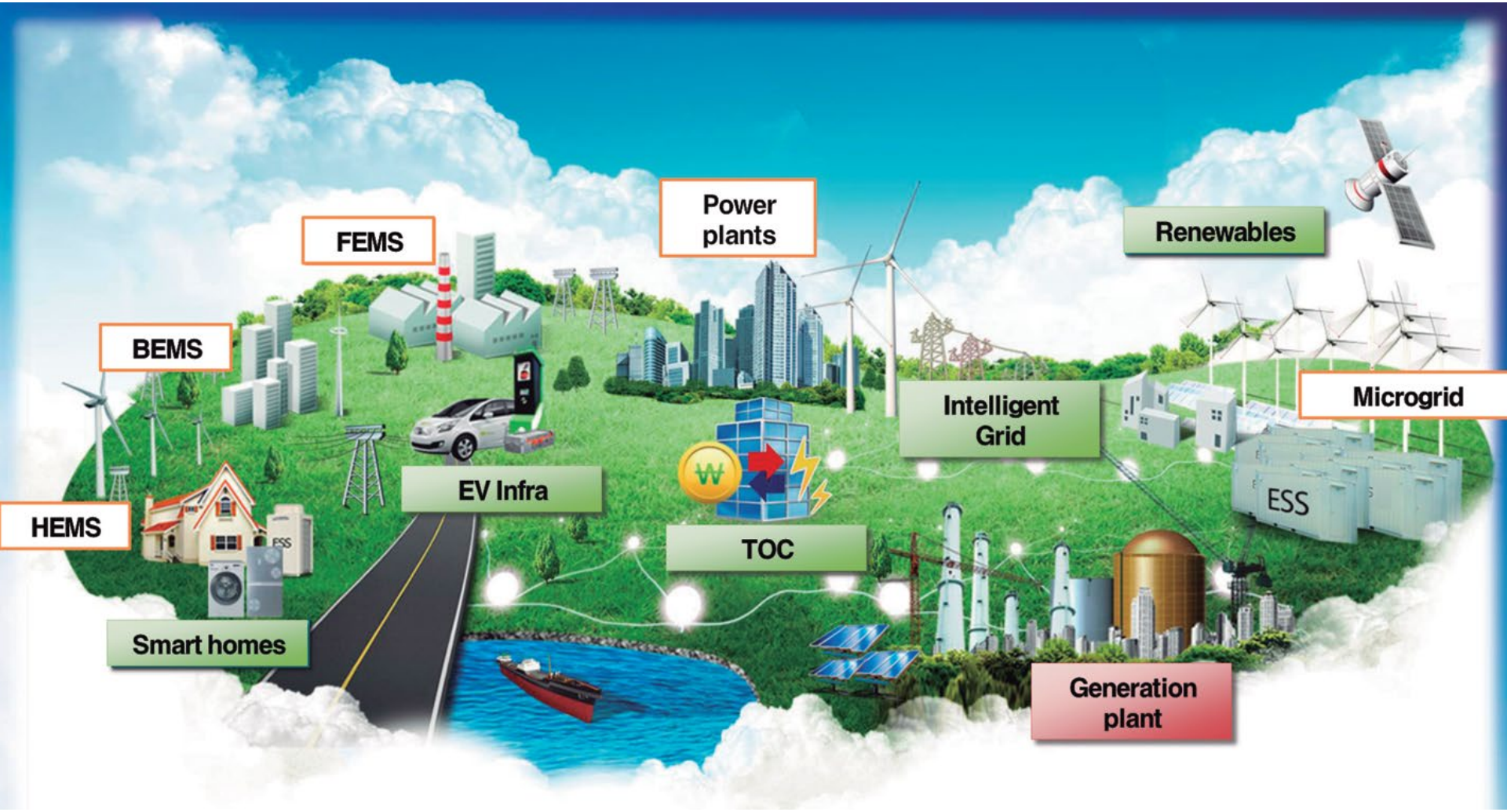
Vision of Jeju Smart City

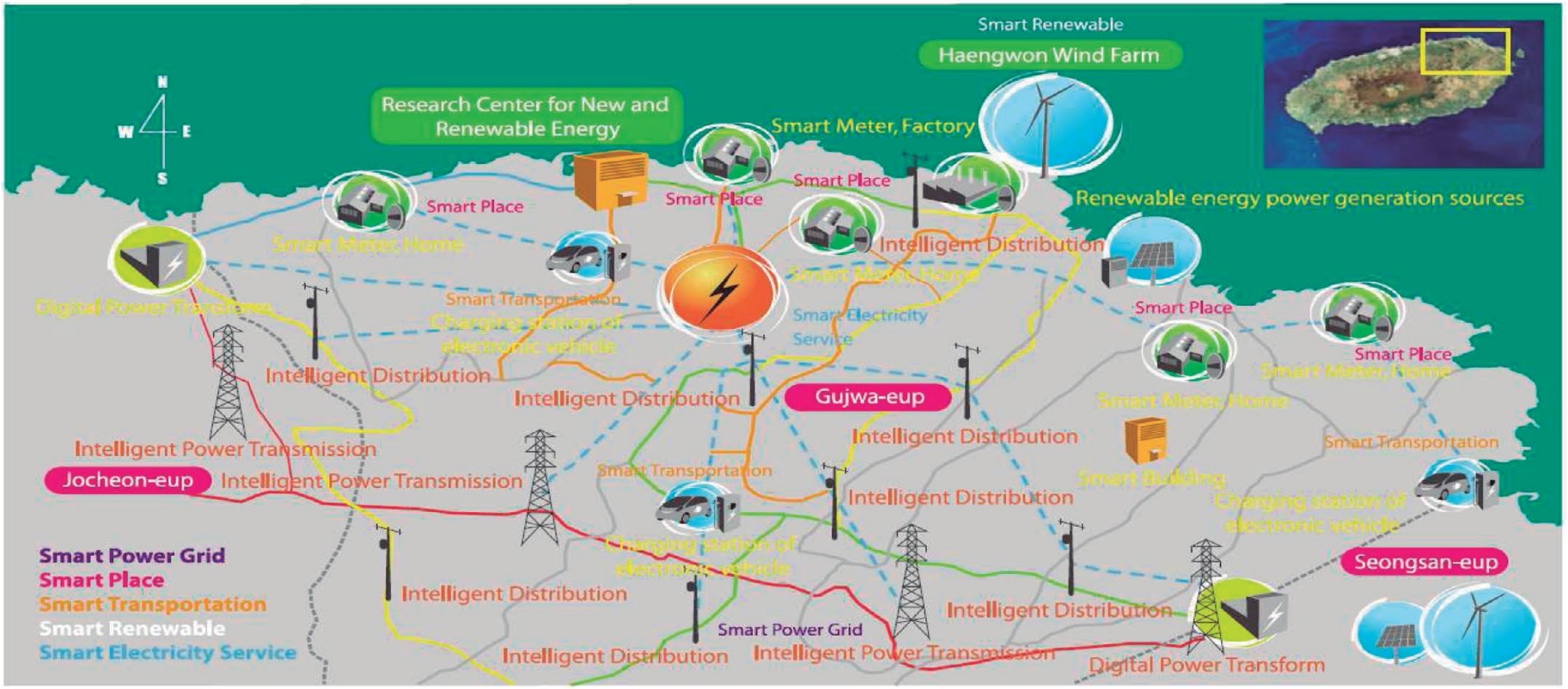


Jeju Smart Grid Test-Bed

- **1st Stage – Test-bed Infrastructure (Dec 2009– May 2011)**
  - Energy Monitoring Service (200 house/buildings)
  - Energy Efficiency Service (+800 house/buildings)

- **2nd Stage – Operation (June 2011 – May 2013)**
  - Real-time Pricing, DR, Power Trading, etc. (+Buildings/Industrial Plants)
  - Business Model Implementation (Smart Grid City)
- Area: 186 km^2 (1/10 of Jeju)
- Population: 15,500 (6,250 Homes)

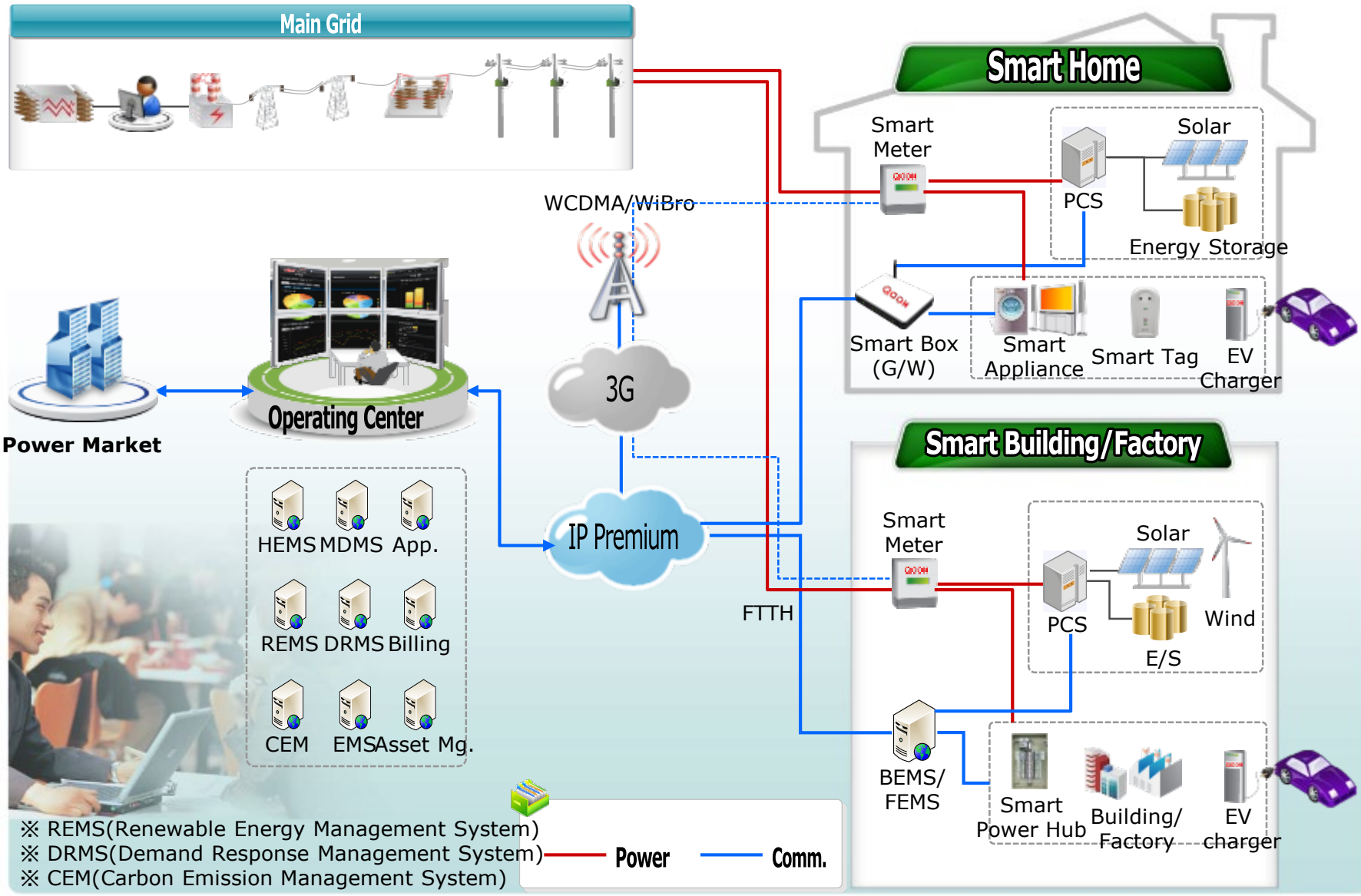
**Budget 230M US$** (Government 70M US$, Private Sector 160 M US$)



Implementation Directions by Phase	First Stage (2010~2012) 'Construction and operation of the Smart Grid Test-bed' (Technical validation)	Second Stage (2012~2020) 'Expansion into metropolitan areas' (Intelligent consumers)	Third Stage (2021~2030) 'Completion of a nationwide power grid' (Intelligent power grid)
Smart Power Grid	- Real-time power grid monitoring - Digital power transmission - Operate optimal distribution system	- Predict possible failures in power grids - Connect the power system with that of other countries - Connect the power delivery system with distributed generation and power storage devices	- Self-recovery of power grids - Operate an integrated energy Smart Grid
Smart Consumer	- Power management of intelligent homes - Various choices for consumers including rates	- Smart power management of buildings/factories - Encourage consumers' power production	- Zero energy homes/buildings
Smart Transportation	- Build & test electric vehicle charging facilities - Operate electric vehicles as a pilot project	- Expand electric vehicle charging facilities across the nation - Effective maintenance and management of electric vehicles	- Make the presence of charging facilities commonly available - Diversify charging methods - Utilize portable power storage devices
Smart Renewable	- Operate microgrids by connecting distributed generation, power storage devices and electric vehicles - Expanded utilization of power storage devices and distributed generation	- Optimal operation of the power system with microgrids - Expand the application of power storage devices	- Make renewable energy universally available
Smart Electricity Service	- Consumers' choice of electricity rates - Consumers' selling of renewable energy	- Promote transactions of electrical power derivatives - Implement real-time pricing system nationwide - Emergence of voluntary market participants	- Promote various types of electrical power transactions - Promote convergence for the market of electricity-based sectors - Lead the power market in Northeast Asia

http://www.smartgrid.or.kr/10eng4-1.php

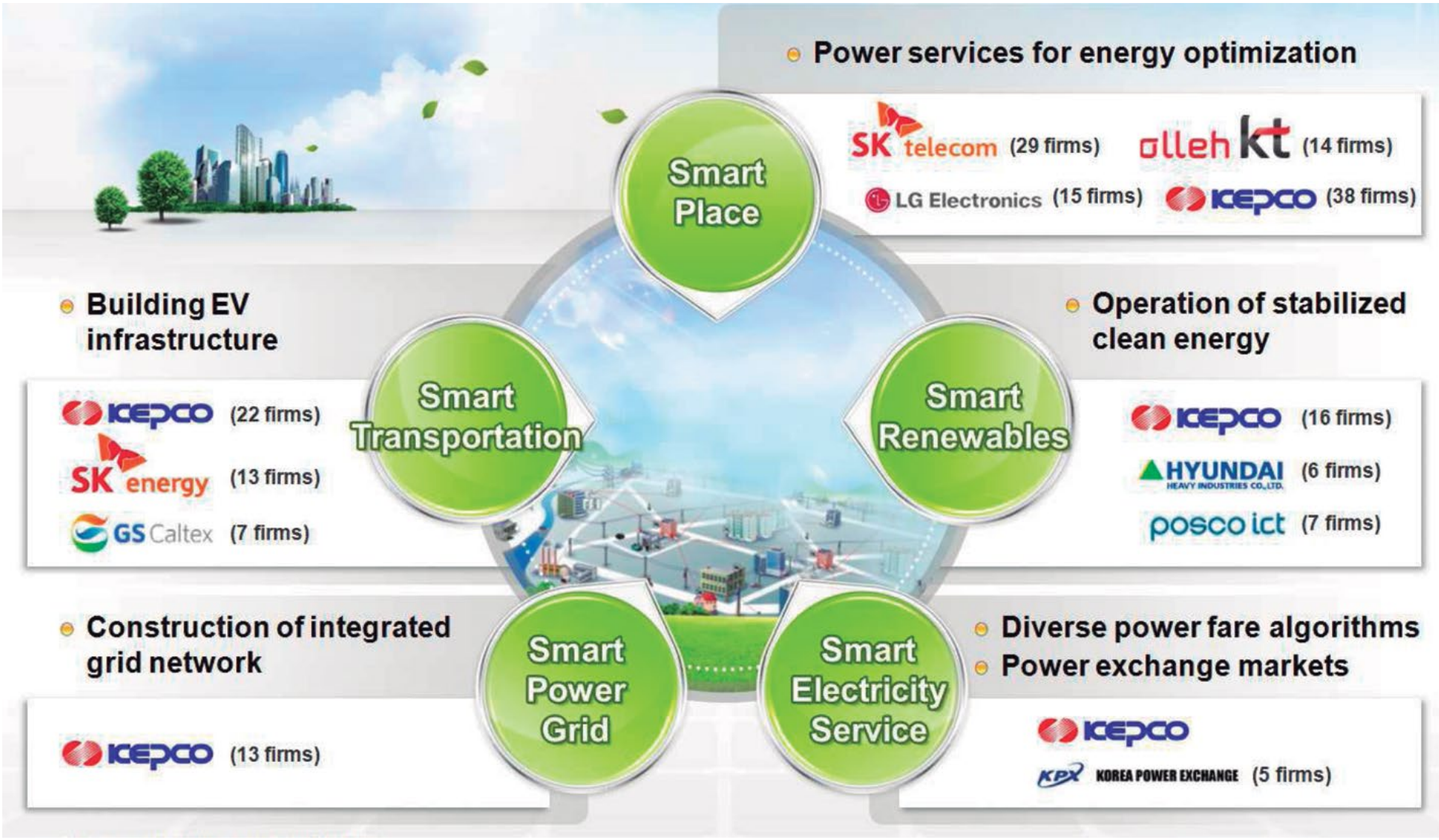
Field trial in Jeju Island



What we have done?
Technology Verification

AMI	• Smart Metering • Measured Data Management	
EMS	• Energy Monitoring & Control • Energy Usage Optimization	
EVCI	• Normal Charging & Quick Charging • Communications	
Interconnection	• Renewables (Wind Power, PV etc.) • Microgrids	
ESS	• Renewable Power Output Smoothing • Peak Shaving & Load Leveling	
Intelligent Device	• Electronic Sensors and IED • Intelligent T&D Devices	
DR	• Reliability Based DR • Market Based DR	

5 Areas of the Jeju Test-Bed



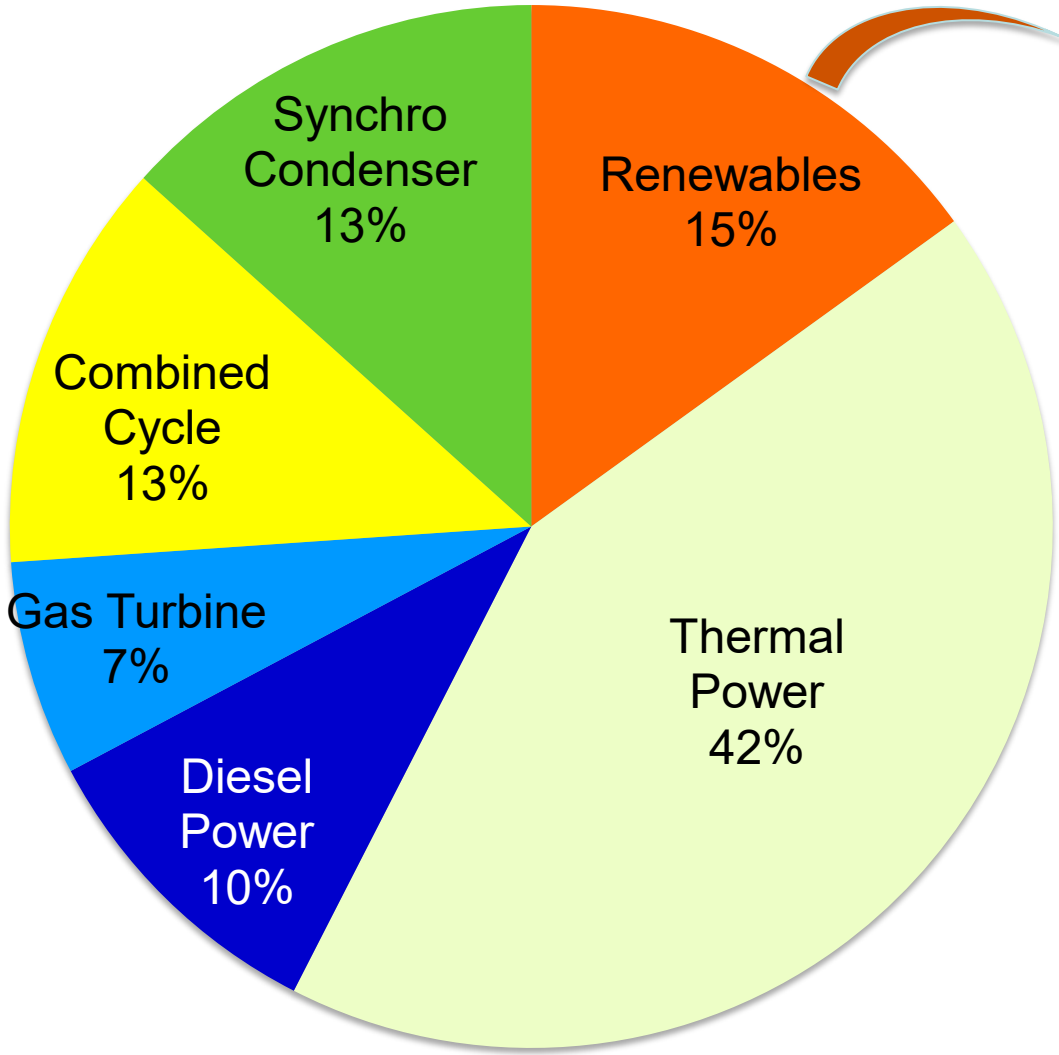
Smart Power Grid

Smart Renewables

Smart Renewables is new technology that
improve the quality of power from renewable energy sources and
it realizes stable interconnection of distributed resources with power grid

Showcase – New & Renewable Energy

Current Generating Plant in Jeju



Wind = 112.2 MW
PV = 9.6 MW
Small Hydro, LFG, etc = 2.66 MW
Total = 124.41 MW

Total Capacity = 822.2 MW

Energy Storage System

Renewables Power Output Smoothing

Peak Shaving & Load Leveling


HYOSUNG
KEPCO

Smart Transportation

Smart Transportation is to build infrastructure
for electric vehicle which is the next generation transportation


충전방식을 선택해 주세요.
DC 차데모
CARD
EMERGENCY
EV
CHARGING
☎ 032-590-3682


EV


7880


CHARGING STATION
kepco
Smart Grid Informatio
CHARGING STAND


CHARGING ST
전기자동차충전기
(Electric Vehicle Charger)
규 격
(Specification)
급속충전기
(Quick Charger)
완속충전기
(Normal Charger)
입력전압 (Input Power)
3Ø, 380Vac
1Ø, 220Vac
출력용량 (Output Capacity)
50kW
7.7kW
출력전압 (Output Voltage)
직류 (DC) 50V~400V
1Ø, 220Vac
충전시간 (Charging Time)
20~30분 (min)
약 5시간 (About 5 hours)
kepco
Smart Transportation Consortium

Smart Home


HAN
Home Area Network
지능형 가전
Smart Appliance
지능형 분전반
Smart Panel
스마트미터
Smart Meter
지능형 스위치
Smart Switch
지능형 콘센트
Smart Socket
전력정보표시장치


에너지 사용 현황
STOR A


Smart Grid
Back
Home Energy Consumption
Refrigerator Energy Consumption
RTP Level
Price Per Time
General Operation
DR-based Operation
OK


2019년 09월 24일 PM 01:27
1.7 kWh
79 원
PM 01:27
모드실행
48 원/kW
495.3 kWh
32,091 원


스마트콘센트(Smart Tag)
전력사용량과 대기전력 관리가 가능한 콘센트.
The Smart Tag is abale to manage the amount of
eletric power used and standby power.
kepco SMART PLACE CONSORTIUM

Access Control

Quarantine

VPN

Meter data Management System

Outage Management System

Operation Server Farm

TOC

Display for management

L3 switch

FEB

RTP Signal

IPS

Analysis of Client's Demand Pattern

In order to verify the Smart Place, first of all analyze the client's energy consuming pattern by each time zone.

Fire wall

HAN

EMS

Switch

PLC

RF

Smart meter

Sensor

Water meter

TRS, Wibro

KEPCO Network

VPN

VPN agent
Data colecting

VPN agent
Data colecting

Building

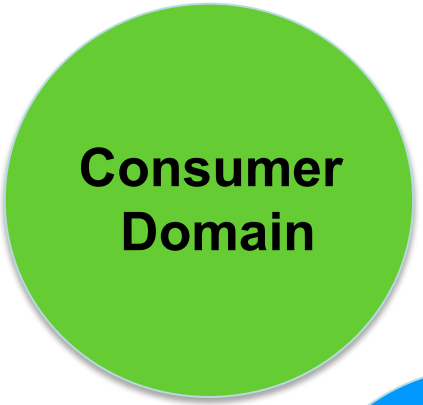
IHD

Smart meter

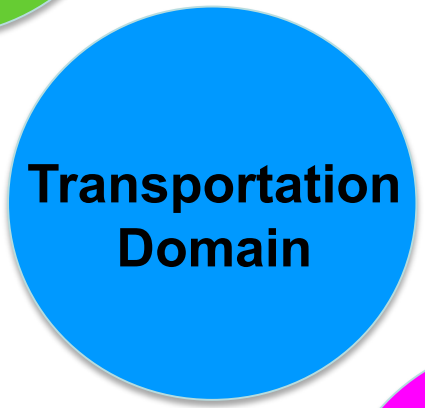
Water meter

Business Model Verification

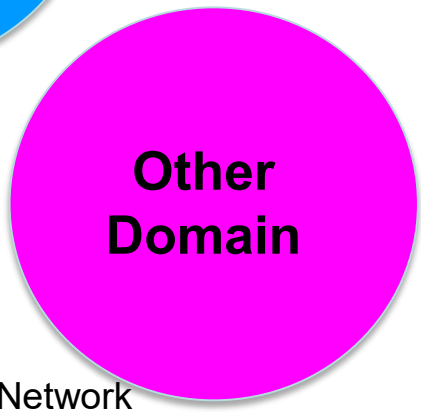
9 Business Models developed and verified



- Electric Retail Service
- Demand Response
- Retail Market Service
- Virtual Power Plant Service



- EV Charging Service
- Mobile Charging Service
- EV Rental Service



- Energy Usage Consulting Service
- Load Leveling & Quality Improvement

From: International Smart Grid Action Network

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Conclusion - Driving Force

- Strong Policy for Smart Grid with Challenging Road Map
- International Smart Grid Action Network (ISGAN)
- Korean Smart Grid Association (KSGA)
- Smart Grid → Business
- 150 Companies
  - Electricity, heavy electric machines, IT, electronics, automobile, energy storage devices
  - Korean Electric Power Corporation
  - Samsung, LG, Hyundai, LS, SK Telecom, Korea Hydro & Nuclear Power, etc.

COMMUNITY SMART GRID

CASE STUDY:

CHIANG MAI WORLD GREEN CITY
CHIANG MAI, THAILAND

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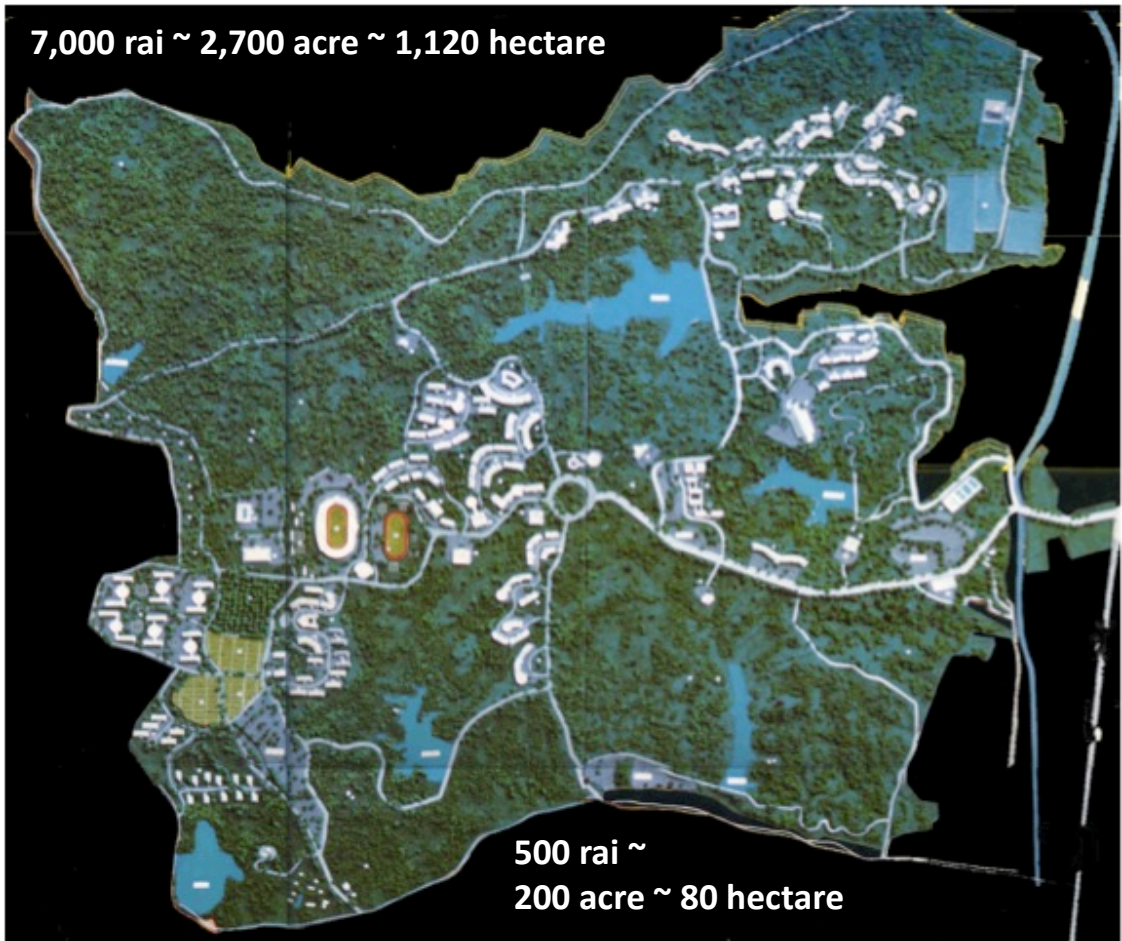
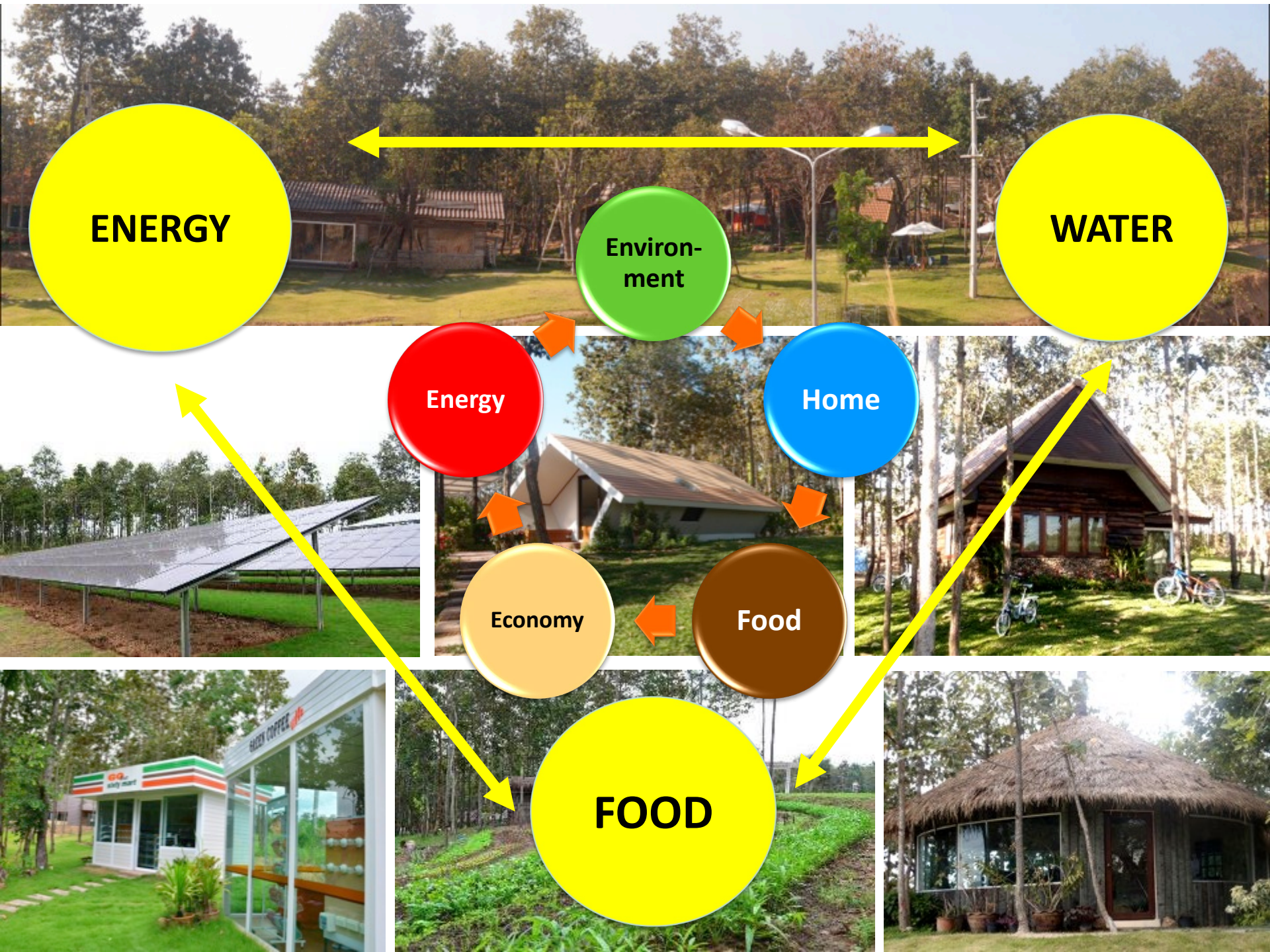
Chiang Mai Rajabhat University, Thailand

Asian Development College for Community Economy and Technology
Maerim Campus, Chiang Mai, Thailand
- 30 km from Chiang Mai City
- 1 hr flight from Bangkok



adiCET, CMRU

- Academic – R&D – Training institution for the well-being of the community by using green technologies.
- adiCET campus is on Chiang Mai World Green City (CMGC).
- Smart Community – Model Community uses 100% renewable energy.


ENERGY
Environ-
ment
WATER
Energy
Home
Economy
Food
FOOD

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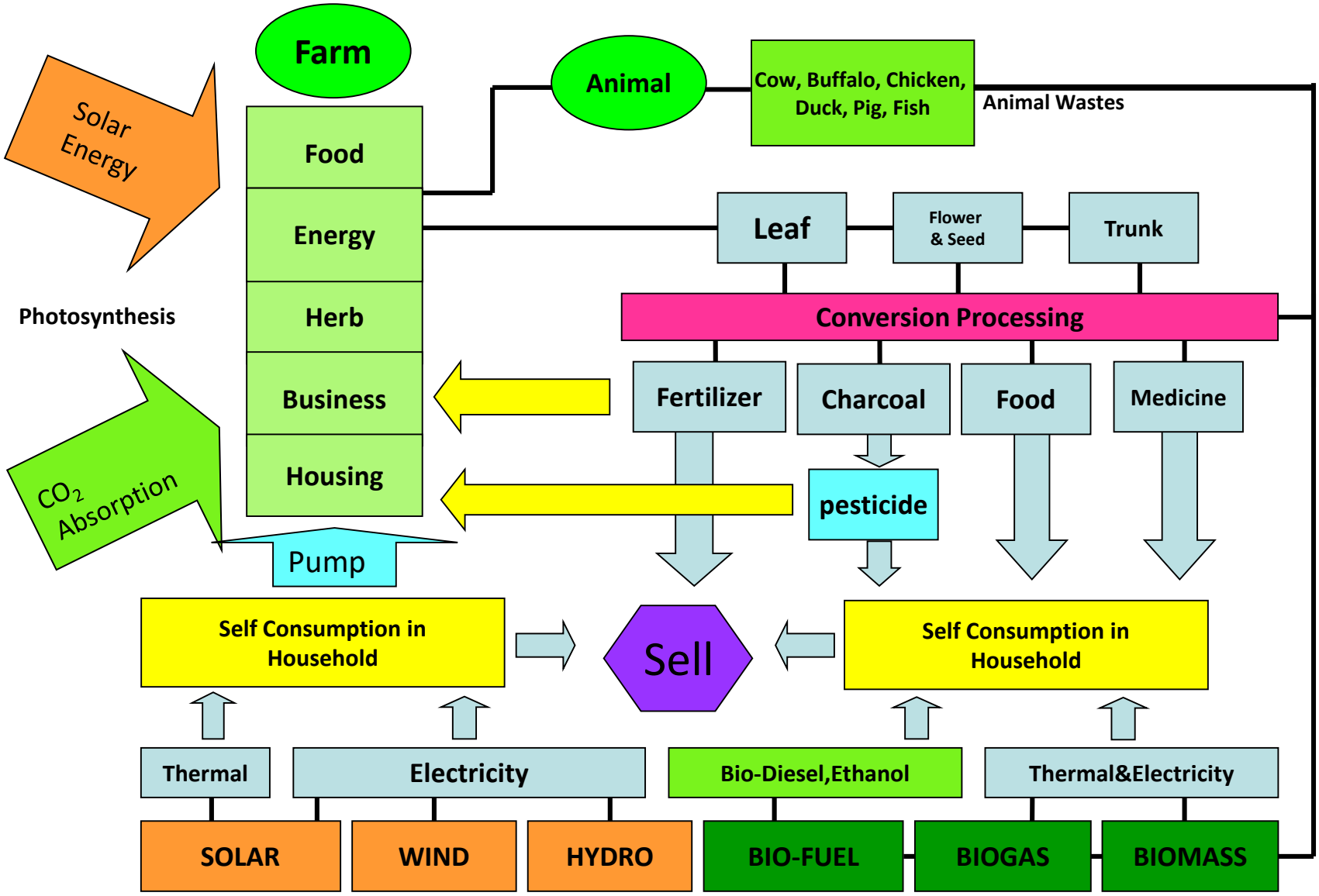
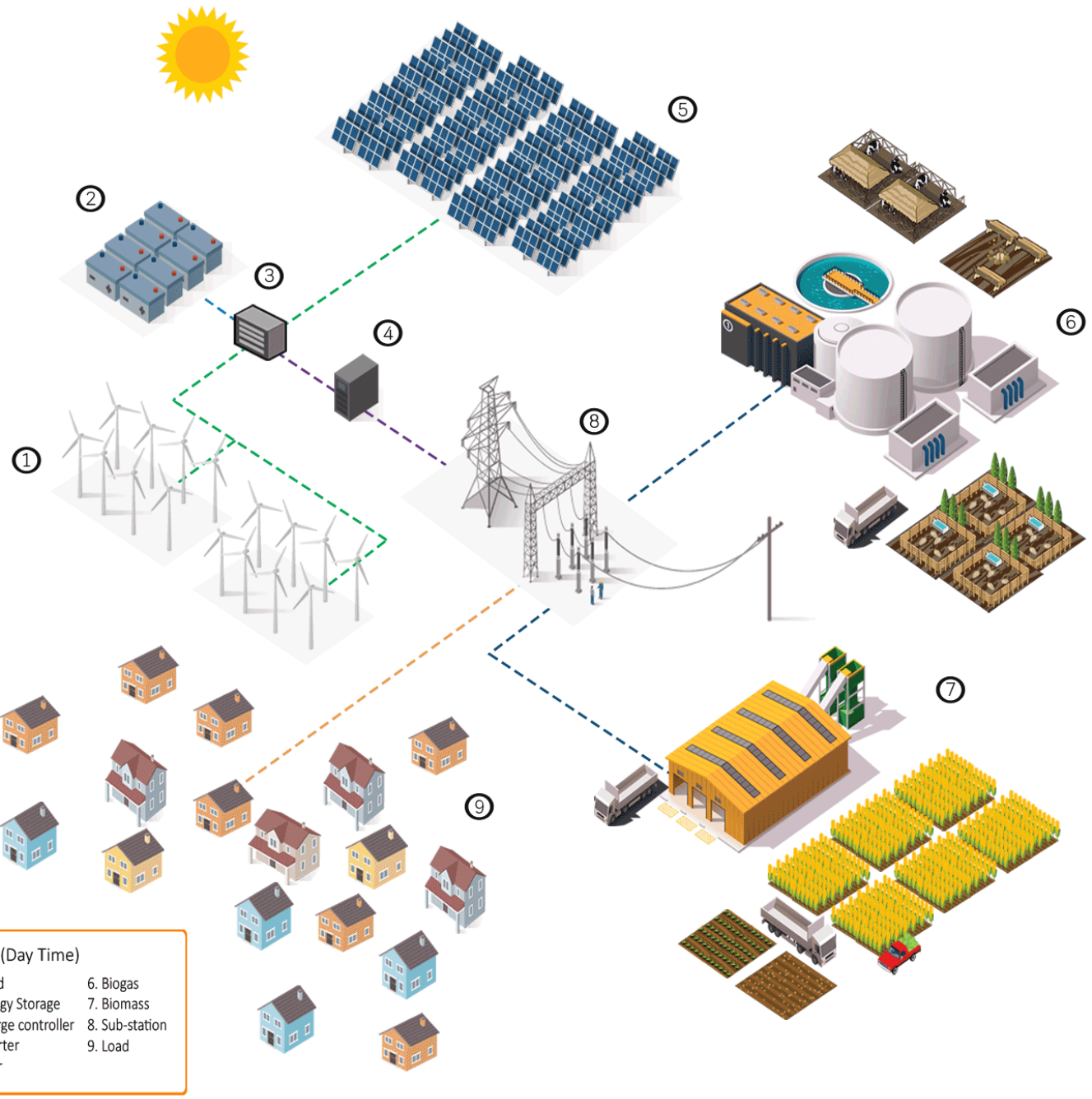
Research Concept: Sufficiency Economy → Bioenergy Cycle



W. Rakwichian

Goal

“Smart Grid Infrastructure for Green City Development”



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Chiang Mai World Green City: Real Living Learning Park

Renewable Energy & Green Technologies

Energy

1. PV 25.5 kW DC Microgrid
2. PV 25 kW AC Microgrid
3. PV 702 kW Community Solar farm
4. PV Rooftop 3.5 kW
   Grid Connected
5. PV Bus stop 2.64 kW
   Stand Alone & EV & Charging Station
6. PV Pumping 3 kW
   Stand Alone
7. Biodiesel Generation 40 kW
8. Biomass Gasifier 20 kW
9. Charcoal/ Energy Efficient Stove
10. Biogas Fix Dome 16 m^3
    (~1.5 kW)
11. Biogas Fix Dome 1 m^3 x2
12. Biogas Generator 5 kW

Construction/Building

1. Road from waste plastic bag
2. Energy efficient house EPS x1
3. Energy efficient conference room x3
4. Energy efficient classroom x2
5. Low cost house x2
6. Coffee Shop
7. Minimart
8. Restaurant
9. Residential housing x 16
10. DC Smart Home

Green Business

1. Green Coffee Shop
2. Restaurant
3. Minimart
4. Bilingual Eco-education Learning

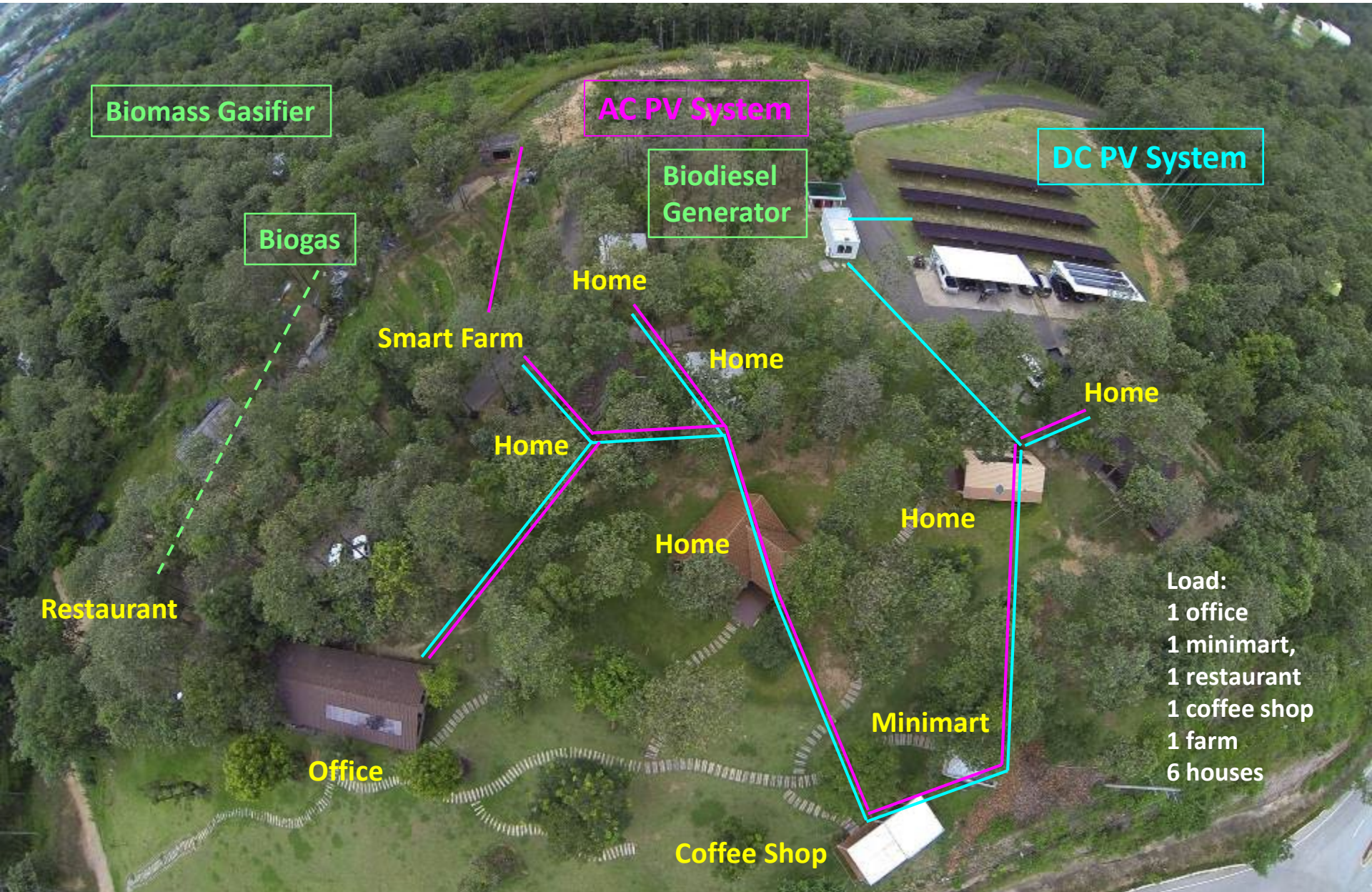
Agriculture

1. Smart Farm
2. Low Carbon Agriculture
3. Smart Watering System
4. Organic fertilizer from biogas system
5. Energy Crop

Environment

1. Green City Carbon Footprint Calculation
2. Biomass waste management
3. Water management
4. Forest Conservation and land management

Smart Community – DC Smart Grid




Biodiesel Generator
40 kW
PV DC Microgrid
25.5 kW
Biomass Gasifier
20 kW
PV AC Microgrid
25 kW

Off-grid: PV DC Microgrid Battery Bank (~100 kWh)
Backup power/ Power Control and Stability

On-grid: PV AC Microgrid Battery Bank (~100 kWh)
Backup power/ Power Control and Stability

Biomass Gasifier

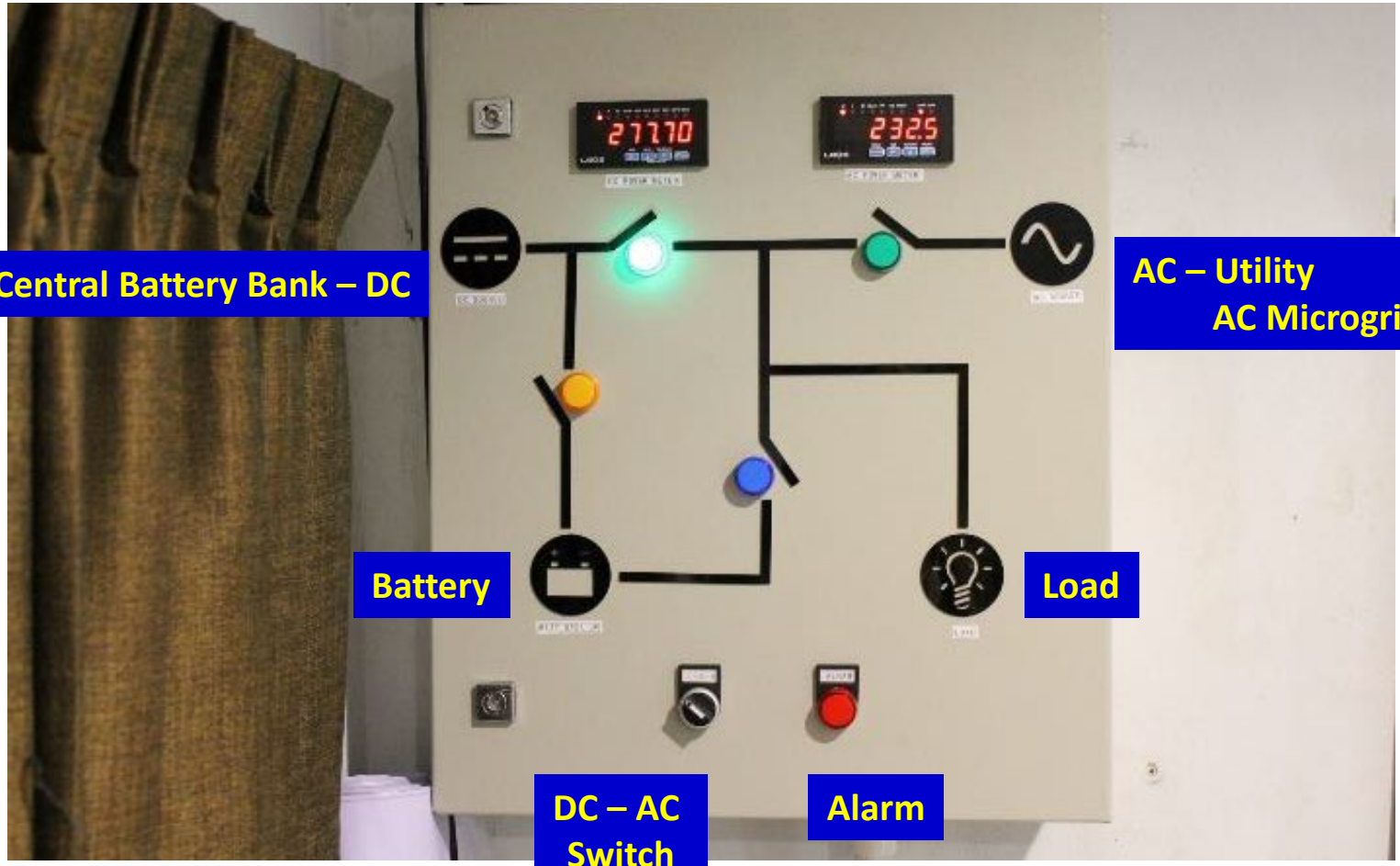
Biomass Gasifier: electricity for base load
Biochar/Charcoal: food, heat, soil conditioner

Energy from waste agriculture products
“Solve open field burning”

D. Kantayos – Intern
W. Photacharoen - Researcher


Diesel Generator 40 kW
Backup Power

Power Supply Controller



DC Smart Plug

Online Function

Web and Application

- Controls
- Monitors
- Program

Measurement Function

- Power consumption
- Behavior

Safety

Smart Function

- Smart Connection
- Smart Data Collection
- Energy saving


Expanded Polystyrene Foam


Reuse material house


ZONE
B


Zone C: Green Exhibition

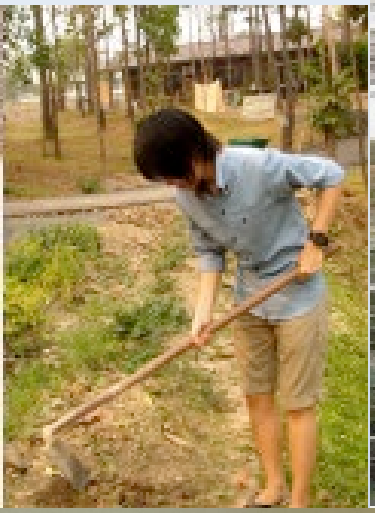

Tissue Culture Lab


Office

Community Business

Community Kitchen

Dr. N. Tantranont



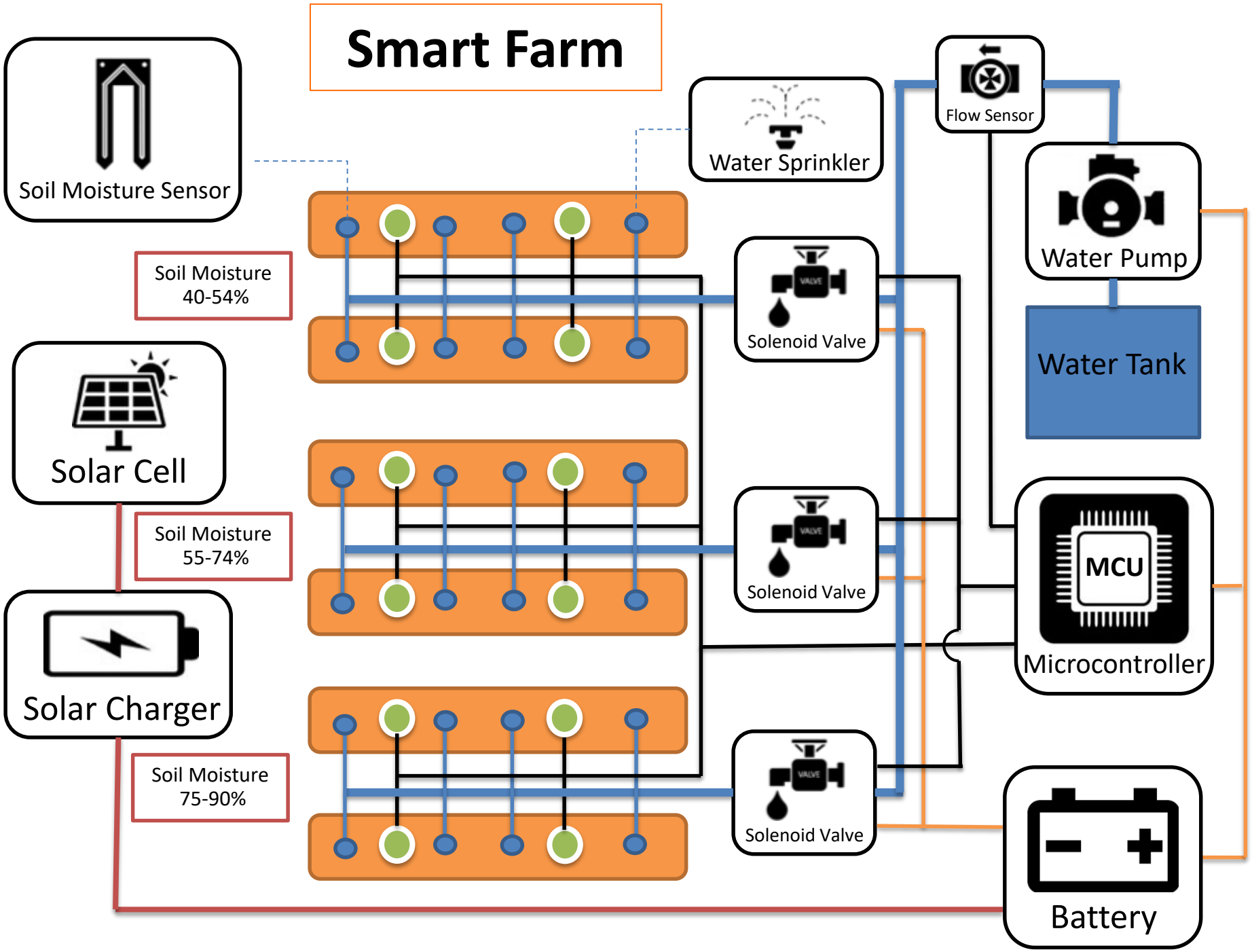





Community Biogas

K. Chuamuangpan – Intern
T. Takam – Intern
T. Seethong – Intern
C. Kongudomsap – Researcher


Smart Farm
PV Water Pumping
Moisture Sensor


Smart Farm
Soil Moisture Sensor
Water Sprinkler
Flow Sensor
Water Pump
Water Tank
Soil Moisture
40-54%
Solenoid Valve
Solar Cell
Soil Moisture
55-74%
Solenoid Valve
MCU
Microcontroller
Solar Charger
Soil Moisture
75-90%
Solenoid Valve
Battery

Waste Plastic Road

W. Lakas – PhD

Solar Bus Stop
EV Charging Station

T. Jaorum - Intern
W. Luangpraditkul - Researcher

Independent Learning

Learning Media

Website of Community Smart Grid

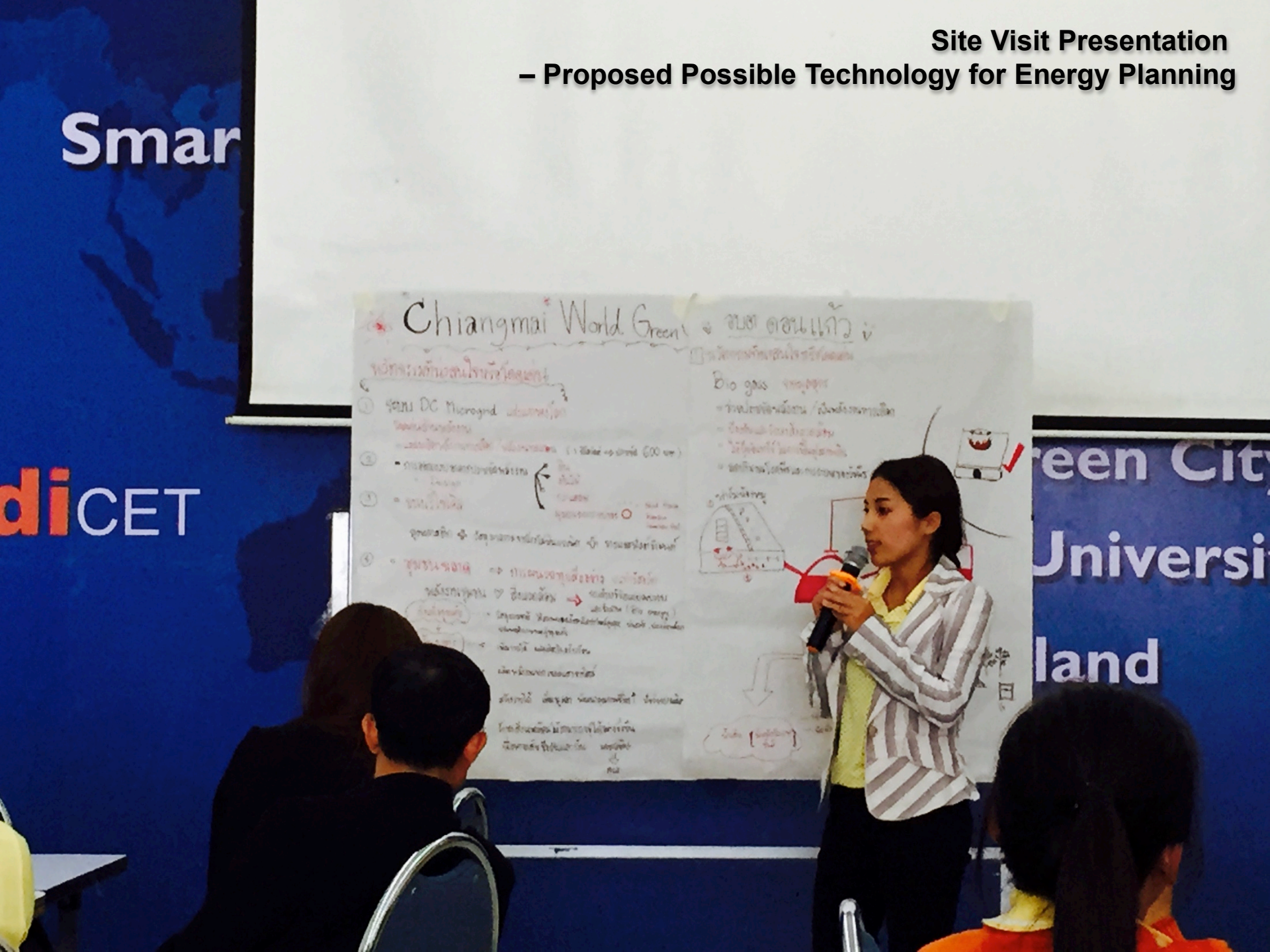
Thai/ English/ Chinese

Cr. Beni Sugiarto

P. Tanomkiet - Intern

Workshops

Site Visit Presentation
– Proposed Possible Technology for Energy Planning



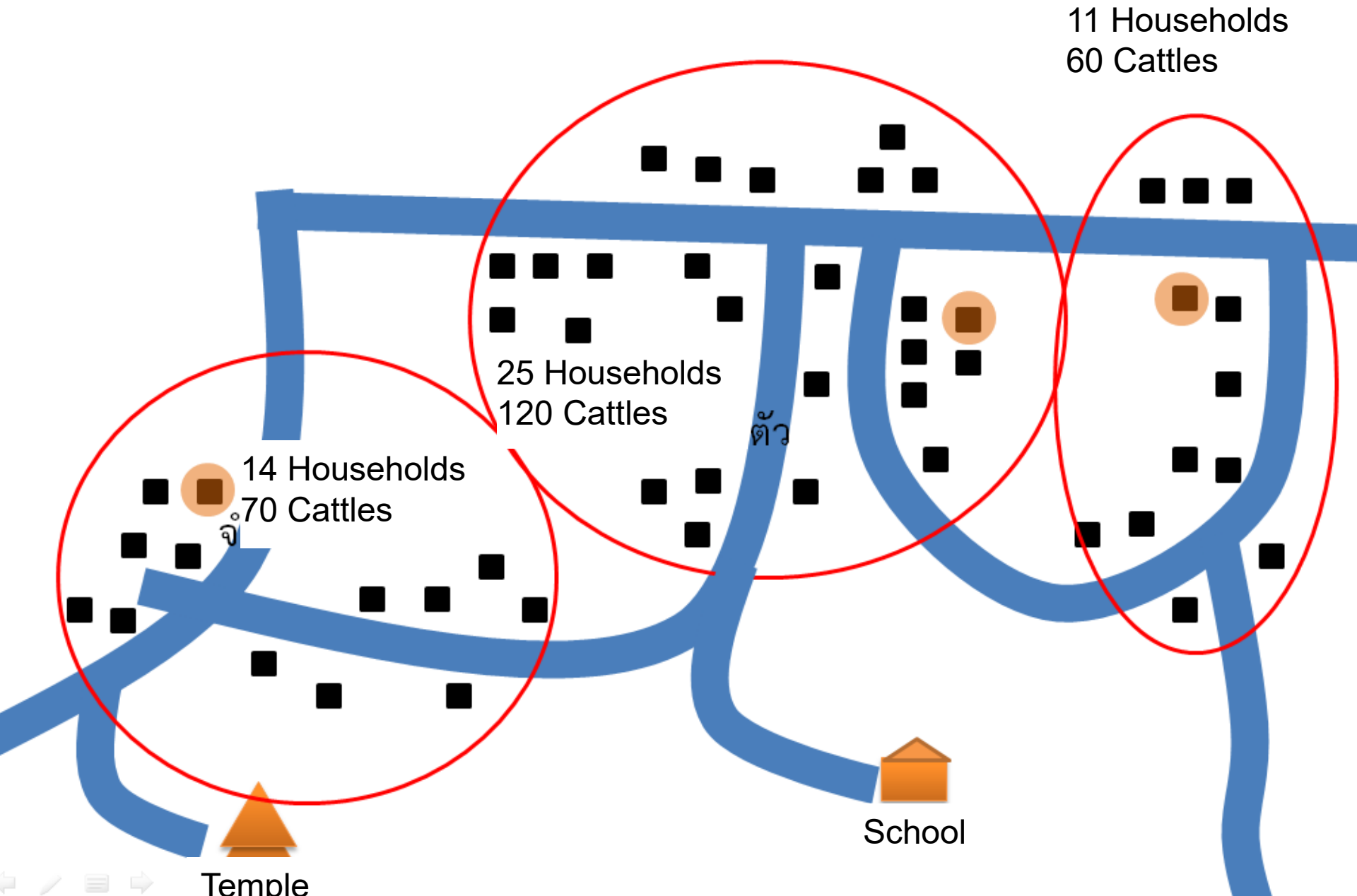
Prae Municipality

adiCET

Community Power Learning/Training Cente

Mae-Ta Energy Planning Meeting

Community Biogas System Map




MATEX

Sharp Asian Solution Installation - 100 kW Rooftop PV

on 14 Public Buildings, 4 Water Pumping Station

Summary – adiCET

- Concept: Renewable Energy and Green Technology for Local Community
  - Integrate with Community Resources - Ways of Living
  - Sufficiency Economy + Green Technologies (RE & EE)
  - Smart Grid as Infrastructure for Green Community Development

- Smart Community
  - Living/ learning/training center for student, researchers, and general public
  - Projects focus on appropriate technology and methods to solve real green city problems
  - Train problem solving skills relating to RE & Green Technology for local issues

DC MICROGRID

CASE STUDY:

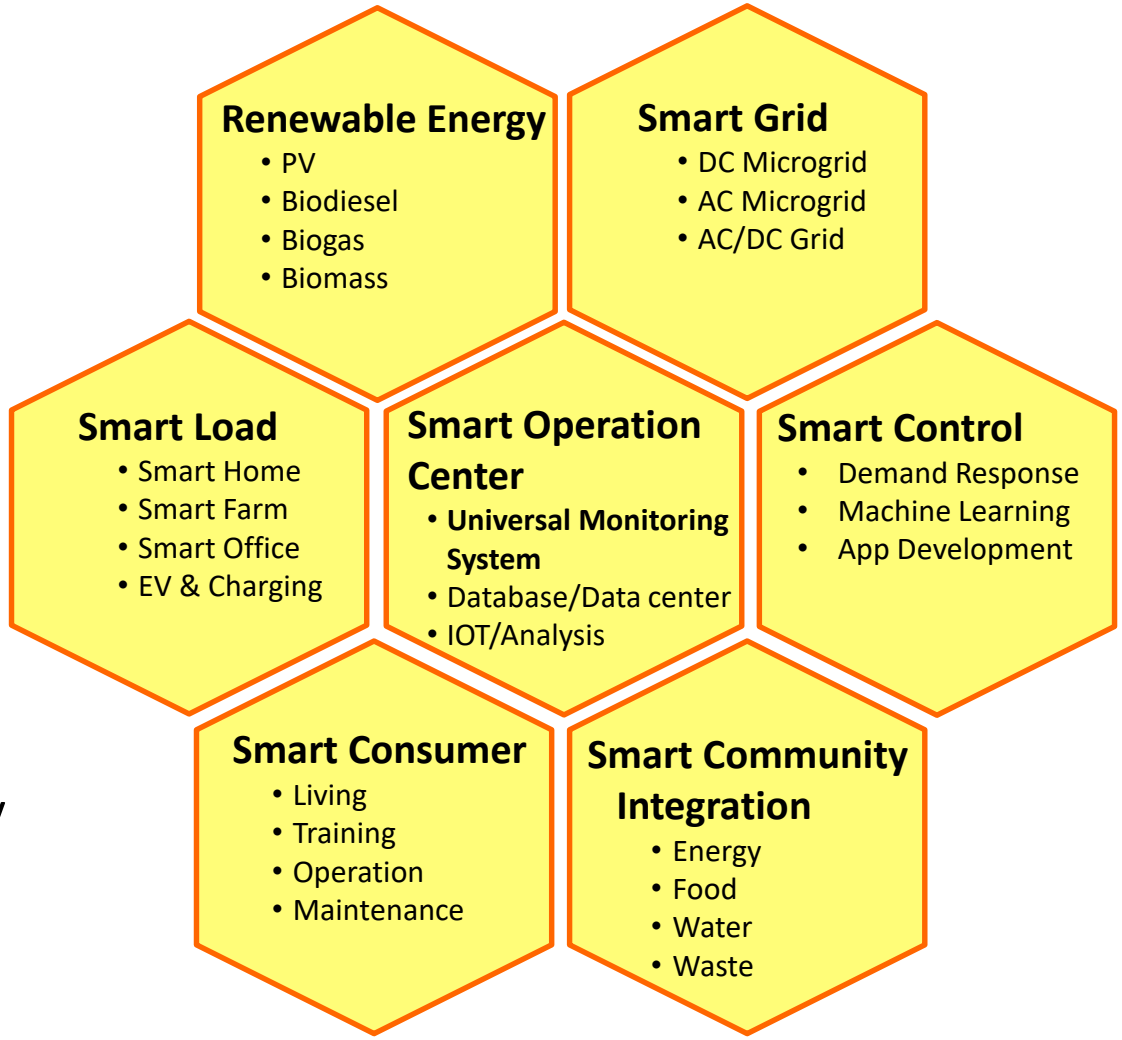
SMART COMMUNITY, CWGC
CHIANG MAI, THAILAND

adiCET Smart Grid Component

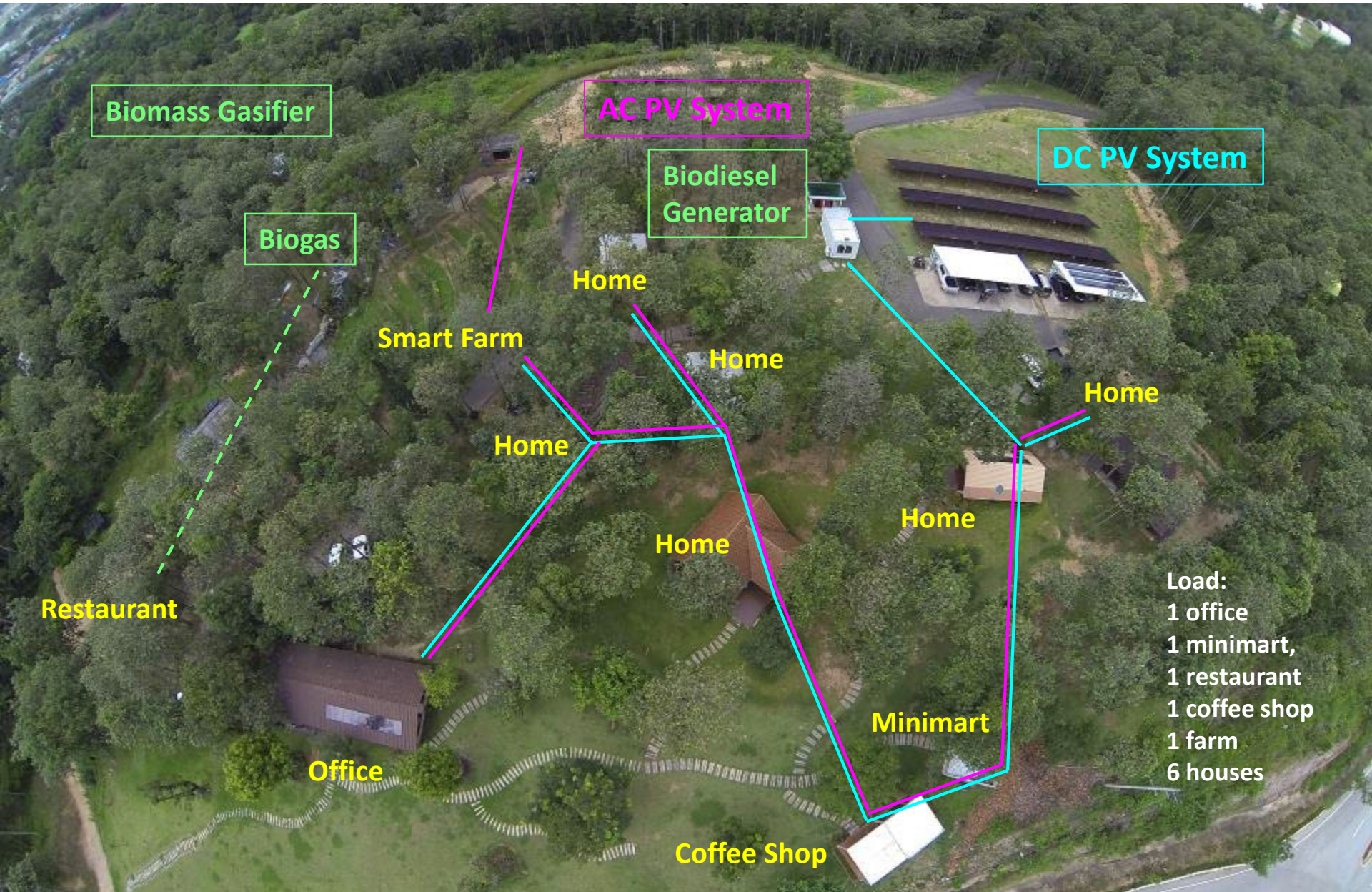
Technology

IT

Community



Smart Community – DC Smart Grid



Scope of DC Community

- Living Laboratory for community transition from AC → AC/DC → DC Community
- Evaluate Low Cost - Low Voltage DC Community Power System at the Smart Community
  - Phase 1: Lightings 24 VDC/ 1 House 240 VDC
  - Phase 2: Household Appliances 260-297 VDC
- Modify/Testing Household Appliances for DC & AC usage
  - Lighting, Refrigerator, Air Conditioner, Water Heater, Television, Computer, Rice Cooker, Microwave, Washing Machine
- Evaluate appliances during operation, stability and safety
  - Full DC
  - Full AC
  - Mixed DC & AC

2nd Phase DC Microgrid

Mode	Central Battery Voltage Stage	Usage
Full	297 – 260 VDC	DC use directly from Central Battery bank
Battery Boosting	260 – 250 VDC	DC from Battery bank (260 VDC) & Booster (54 VDC)
Biodiesel Generator Start	250 – 242 VDC	Generator - Charge Battery Bank - Charge Booster Batteries If ran out of fuel, AC from Utility will convert to DC
Battery dead	Below 242 VDC	Automatically switch to AC

Note: Voltage range depends on Charger Specification, battery voltage range and electrical load device requirements.

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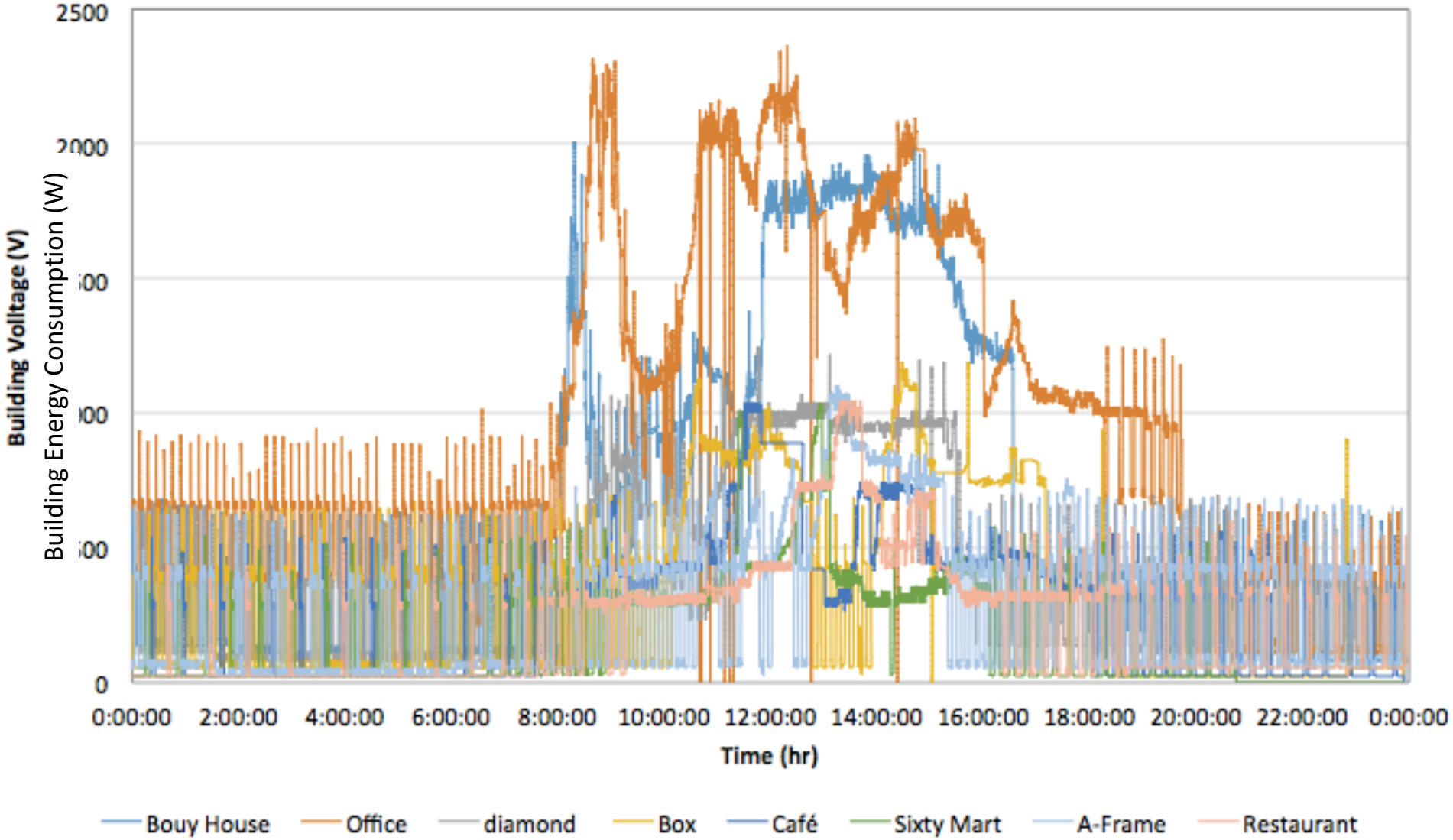
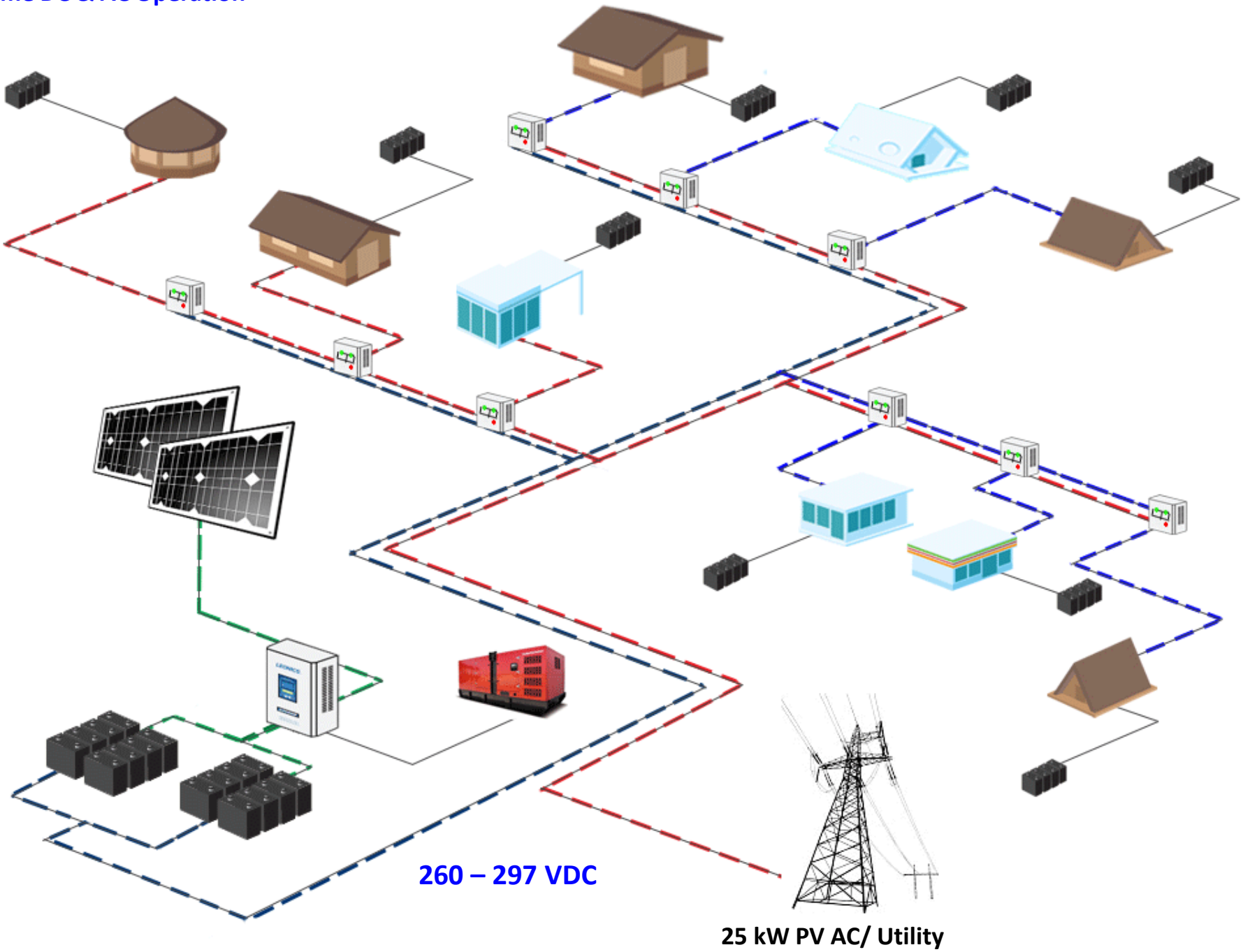
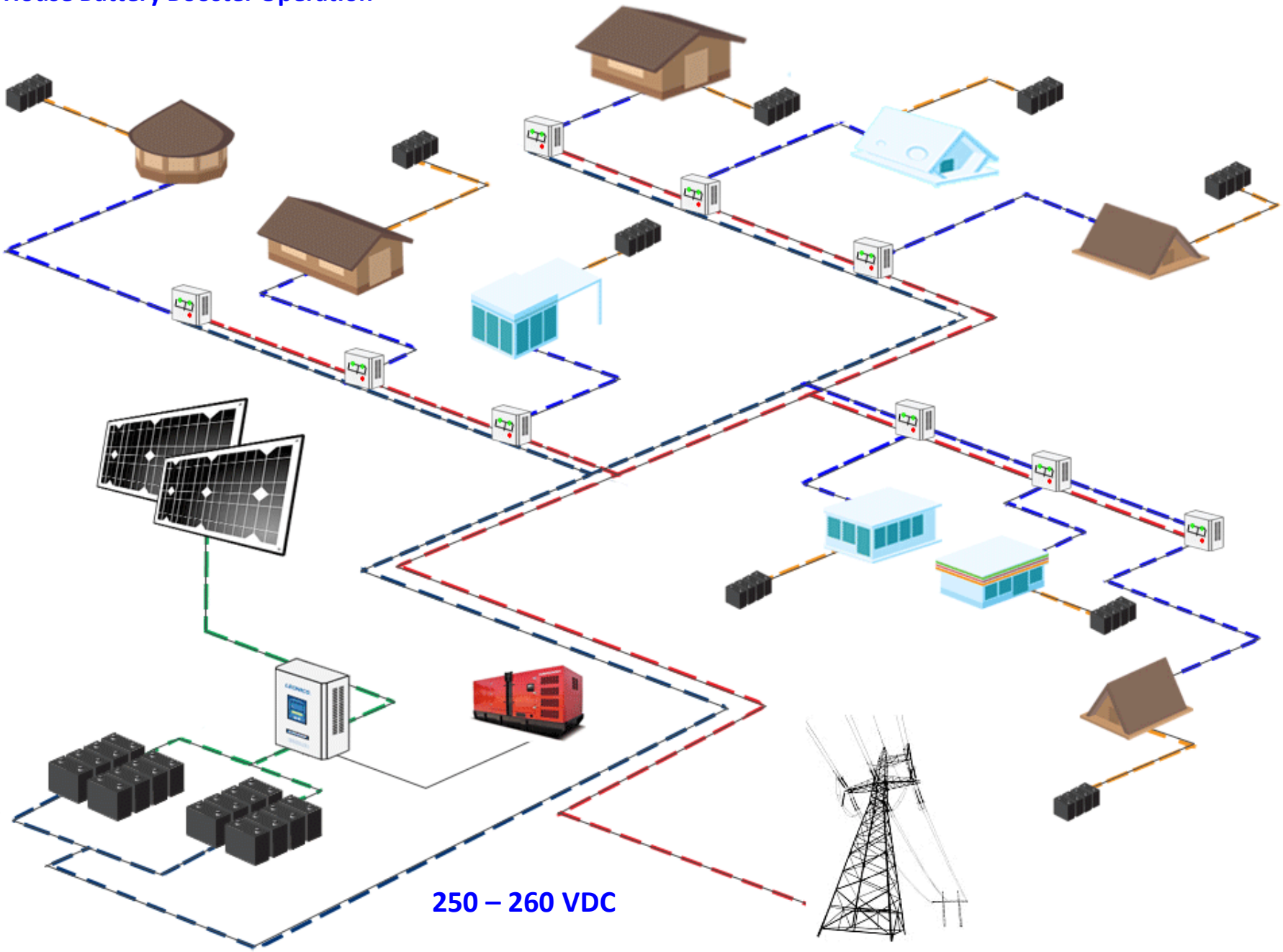
Phase 2:
Building Power Consumption



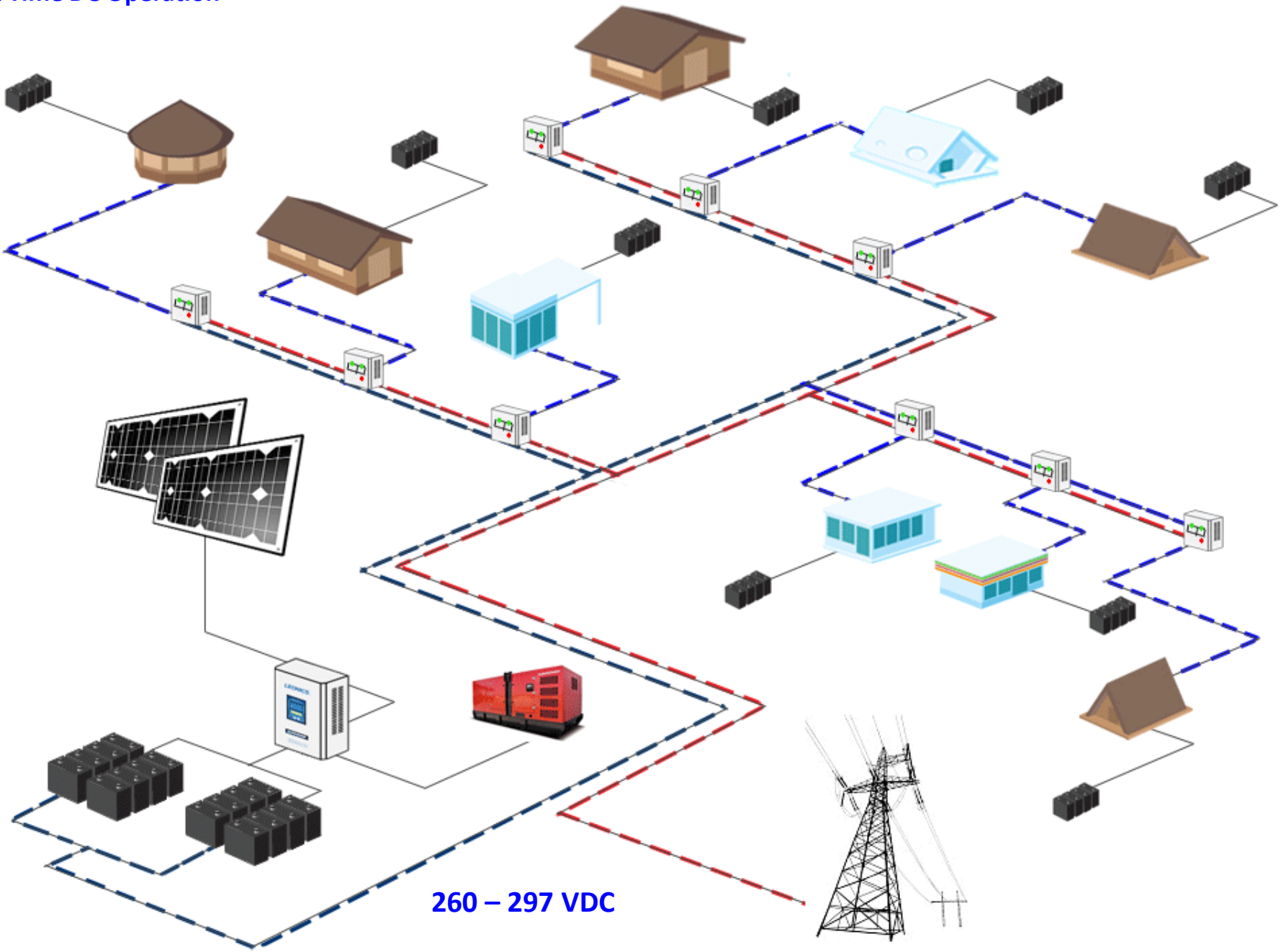
Daytime DC & AC Operation



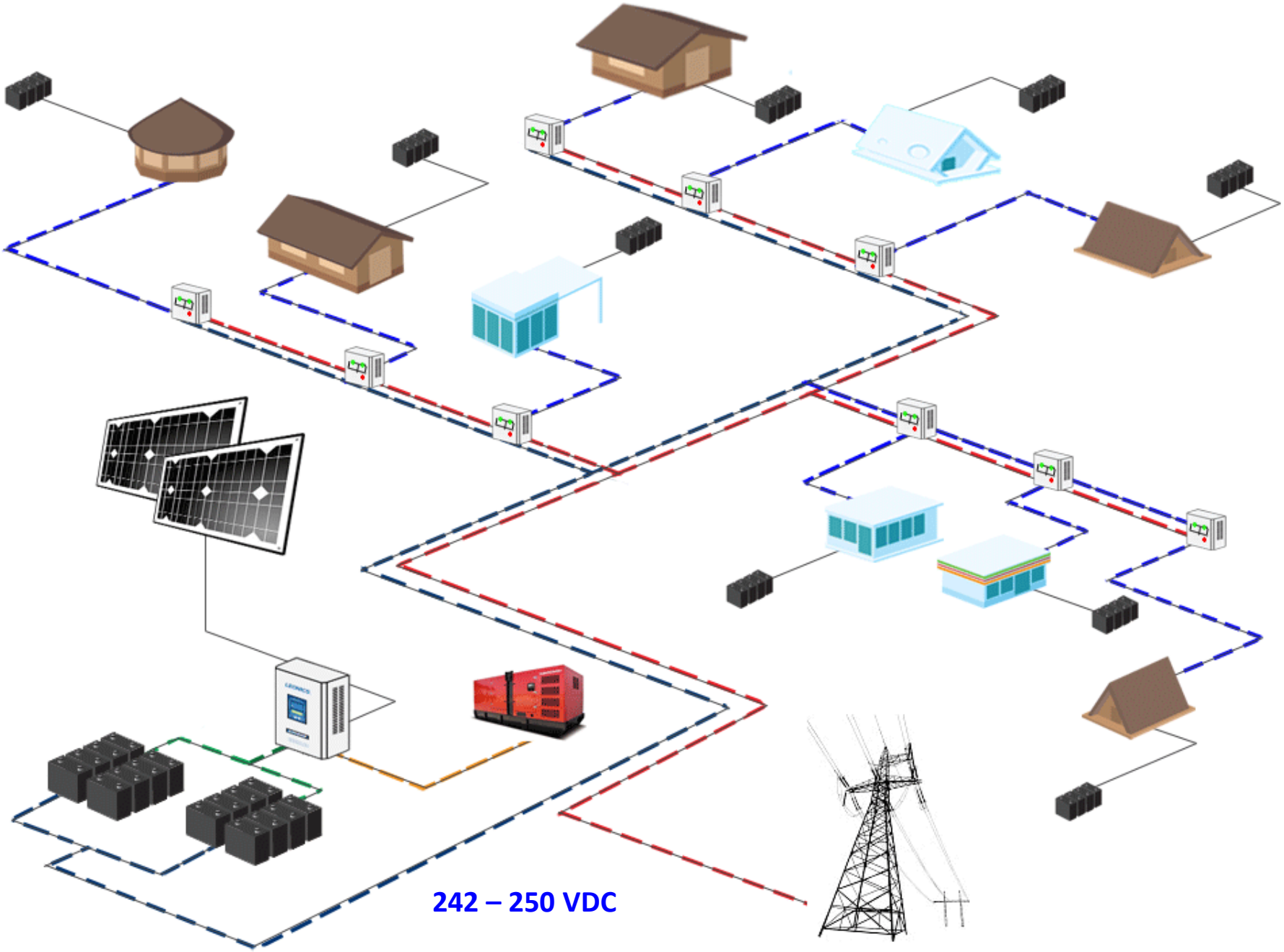
PV & House Battery Booster Operation



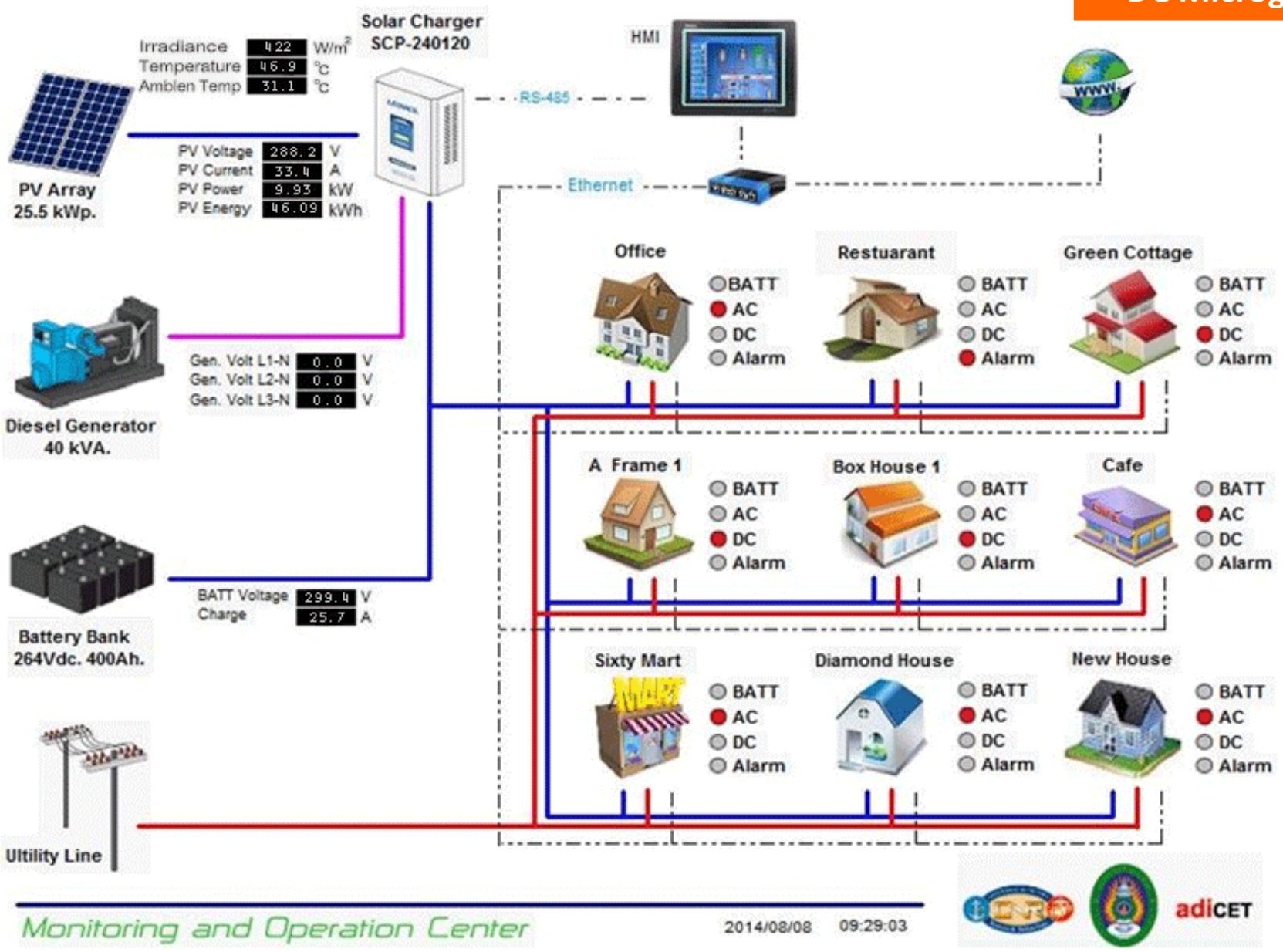
Night Time DC Operation



Night Diesel Generator DC



Monitoring DC Microgrid



Load Test: Modify Each Appliance

- LED lightings
- Refrigerator
- Water Heater
- Television
- Air Conditioner 9,000 btu
- Air Conditioner 13,000 btu
- Air Conditioner 18,000 btu

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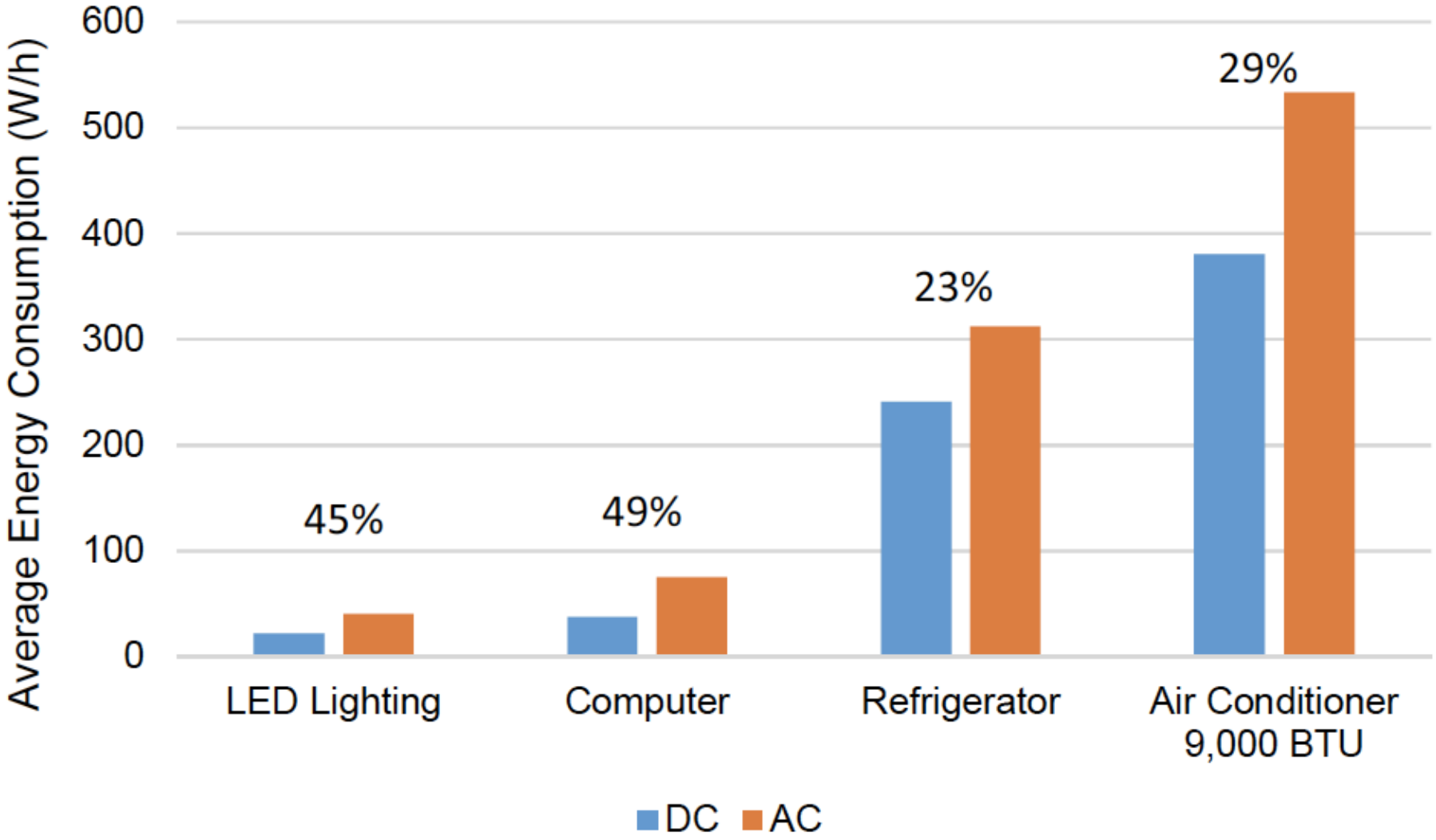
DC vs. AC

Energy Consumption Comparison



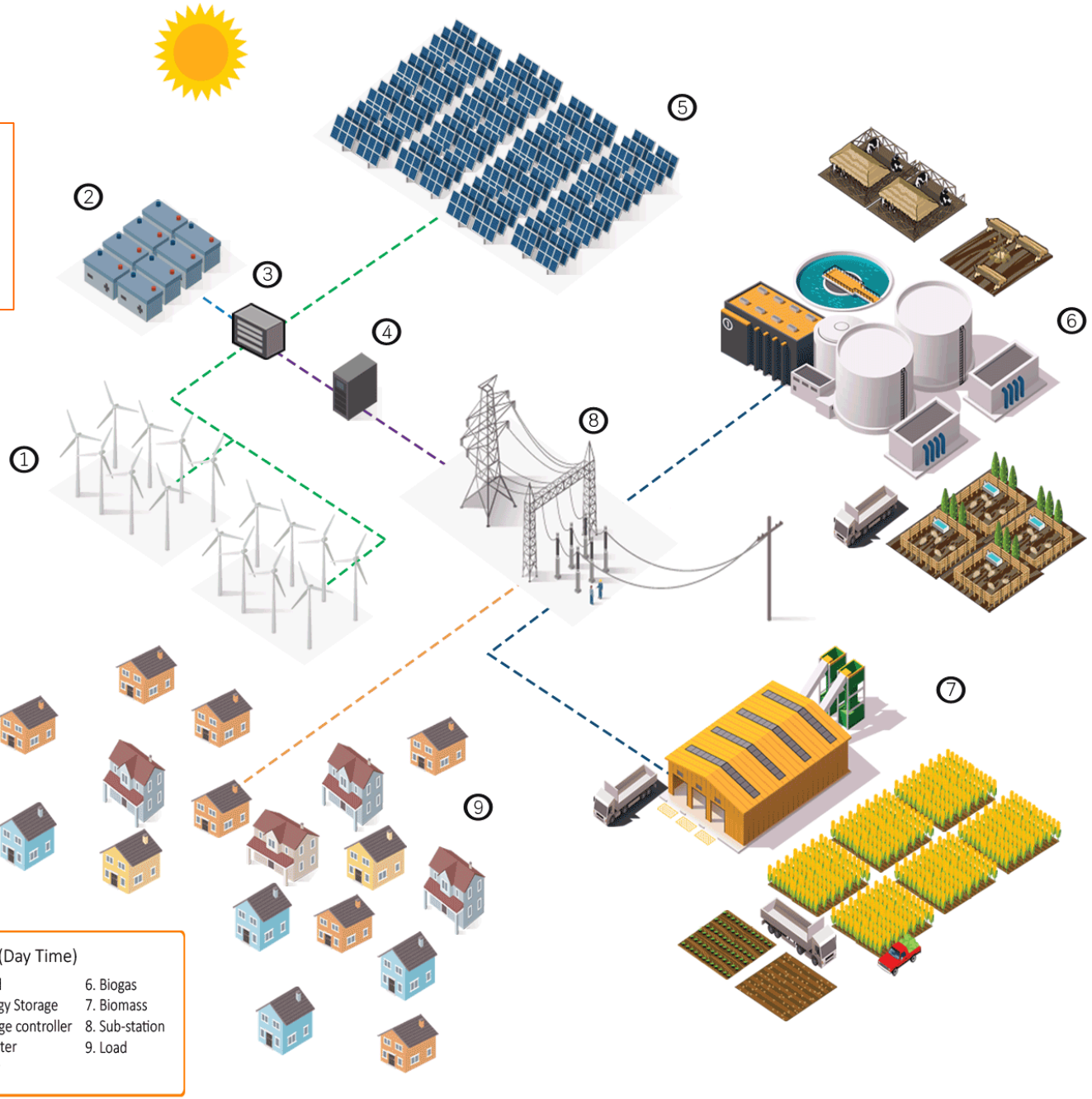
Issues to Overcome

- System Issues
  - Stability/Durability of components of the power supply when switching between DC and AC (capacitor, PLC)
  - The online connectivity with university network
  - Integrating Distributed Generations (voltage range - Diesel Generator)
- Nature Issues
  - During the rain, the voltage fluctuates from the utility line which cause the Hybrid Microgrid system to be disrupted.
  - Animals
- Human Issues

Goal

Demo-Site for

Energy Hybrid Systems
Community Smart Grid



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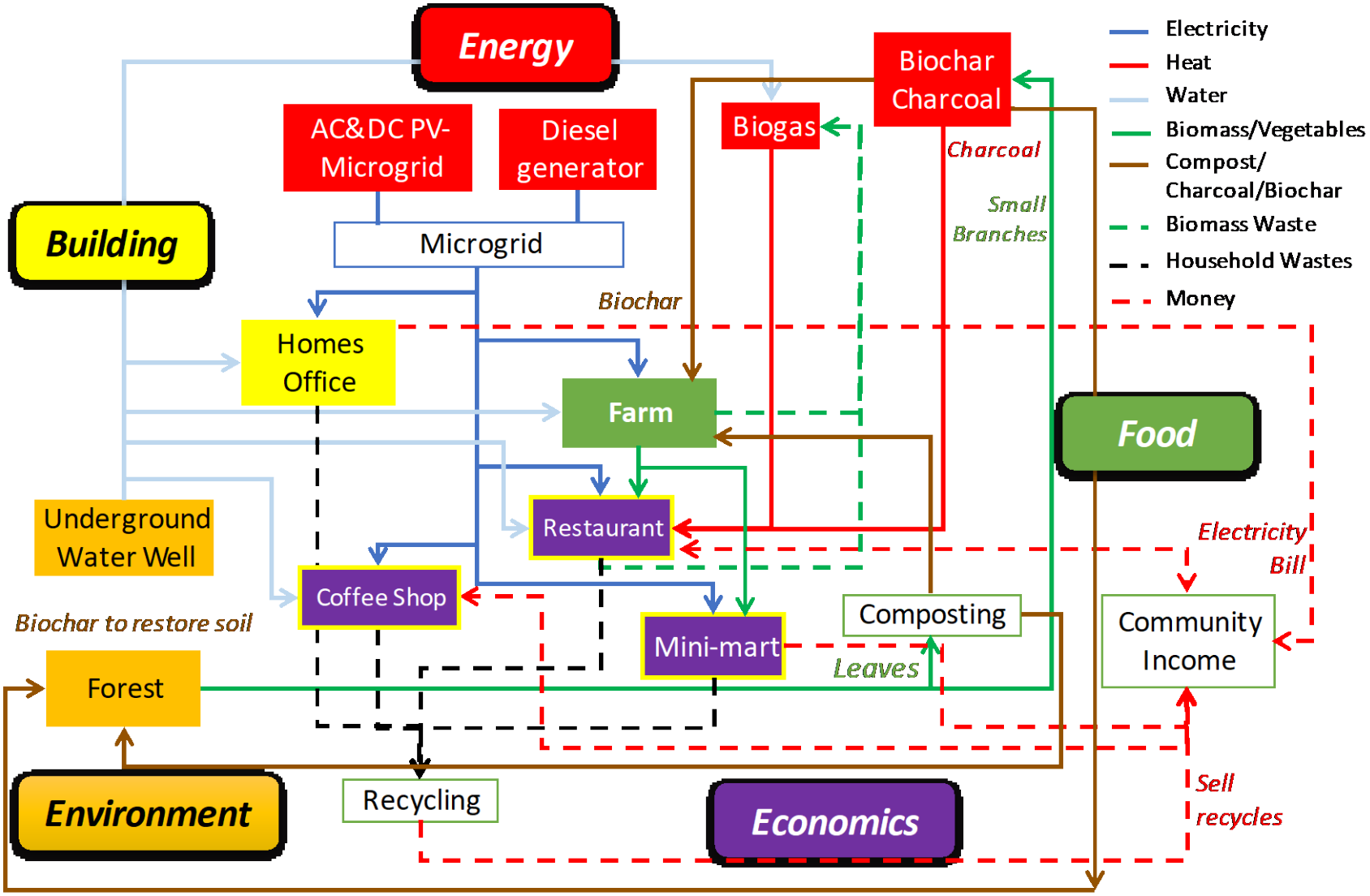
Goal: Realtime - Smart Community Monitoring



2017 Approved Project for Energy Conservation Fund, Ministry of Energy, Thailand

Smart Community Database

Environmental

Recycle waste (kg)
Organic waste (kg)
Hazardous waste (kg)
The frequency of dumping waste (time)
Date/time

Food

Vegetable production (Kg)
Using fertilizer (Kg)
Another material in cultivation (Kg)
Consumption and sale of vegetable (Kg)
Date/Time

Energy

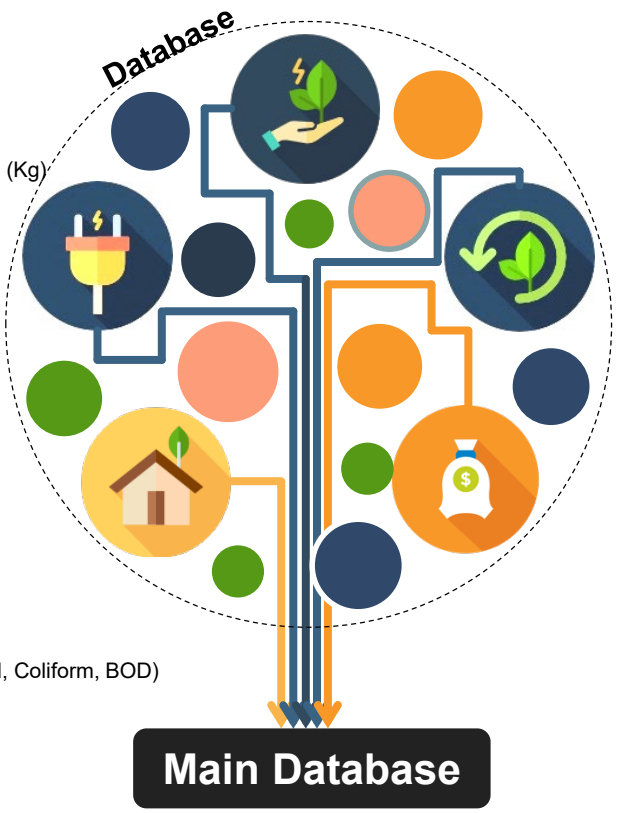
Production (kwh)
Consumption (kw)
Raw material of biogas and charcoal production (kg)
Biogas and charcoal yield/consumption (kg)
Fuel consumption in transportation (L)
Date/time

Economic

Expenses (Baht)
Income (Baht)
Date/Time

Building

Indoor/Outdoor temperature (° C) and humidity (%)
Outdoor solar intensity (W/m2) and wind velocity (m/s)
Water consumption (L) / Water flow rate average (L/min) and quality (Nephelometric Turbidity Units, pH, Coliform, BOD)
Particulate in the air (PM)
The frequency of using water (Time)
Date/Time



Instruments for Data Collection

Energy

- Power meter
- Flow meter
- Weighing Scale
- GPS

Food

- Temp. sensor
- Humidity sensor
- Waste weighing scale
- Water meter

- Water flow meter
- Moisture sensor
- Weighing scale

Building

Environment

- Weighing scale
- Weather station
- Wind sensor

Economy

- Ledger

THE START OF SMART GRID…..

START WITH SMART HOME

Class Questions

- What is a smart home?
- What functions do you want your smart home to have?

- What are the groups of the functions?
- How can smart home support smart grid?

Group 1

1. Control for irrigation the land by app and sensors
2. Control the light time outside automatically
3. Charging the Electric car and motorcycles
4. Safe house by alarm System + Camera
5. Wifi Communication for manage household appliances like TV, air conditioner, plug, heating water, cleaning, machine, playing music
6. Make smart light flash when the package is on the way
7. Smart Parking of the car, washing cloths,
8. Preparing coffee by boiler, video, phone, computer printer, telephone
9. Audio and video application, internet
10. Fire detector/ Car lock

Group 2

- Light turn on/off
- Appliances turn on/off in home
- Cooking food by facial expression
- Security System (Alarm go out locked)
- Energy Management
- Energy/other appliances- communication
- Waste collection/ Holidays, kids programs, etc.
- Communicate Scheduled programs
- Waste bin signals to collector

Group 3

a) A home equipped with lighting, heating, and other systems and can be controlled by smart phones and computers to provide inhabitants with monitoring and control over the building functions

b) Monitoring and controlling triggered events
   i) Lighting, ii) Blinds, Doors
   iii) HVAC/Air Conditioning
   iv) Security
   v) Feeding pets & watering plants
   vi) Home Energy Meters
   vii) Entertainment
   viii) Preparing foods

Group 4

1. Notice alarm for organizing our daily schedule
2. Setting condition for our mood booster
3. Spray different smell of perfumes
4. Draining system for collecting rainfall
5. Automatically feed pets
6. Scanning health with medical report
7. Checking our daily needs storage
8. Controls shelter to make the temperature
9. Safety thief system (Sent the stranger picture when we are not in home/ automatically locking the doors and windows)
10. Leaving message for guests when we are not at home
11. Giving the news today
12. Automatically turn on vacuum machine when the smart home detects dirty and cutting grass machines
13. Turning on the electricity breaker when fire alarm on.

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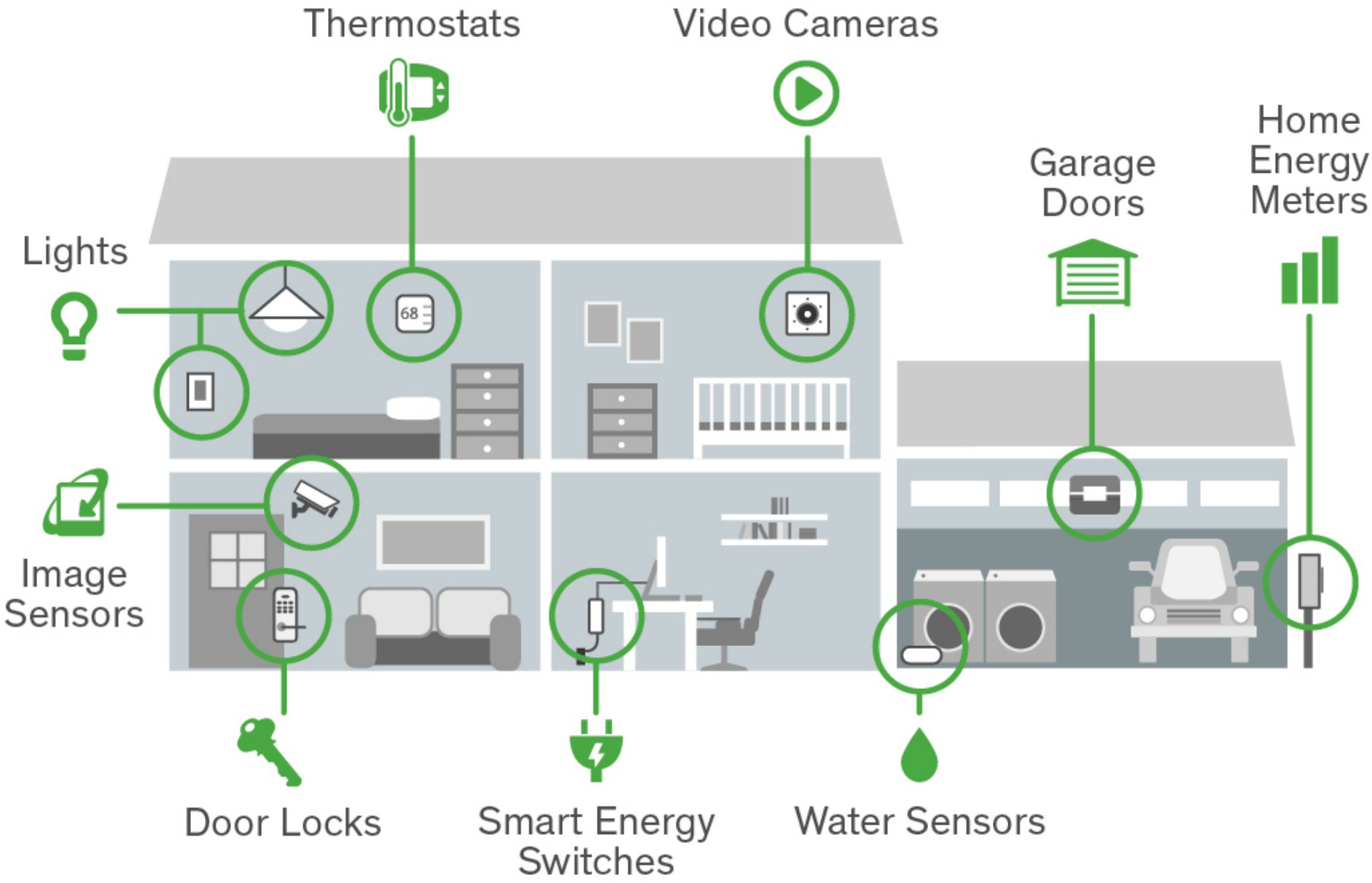
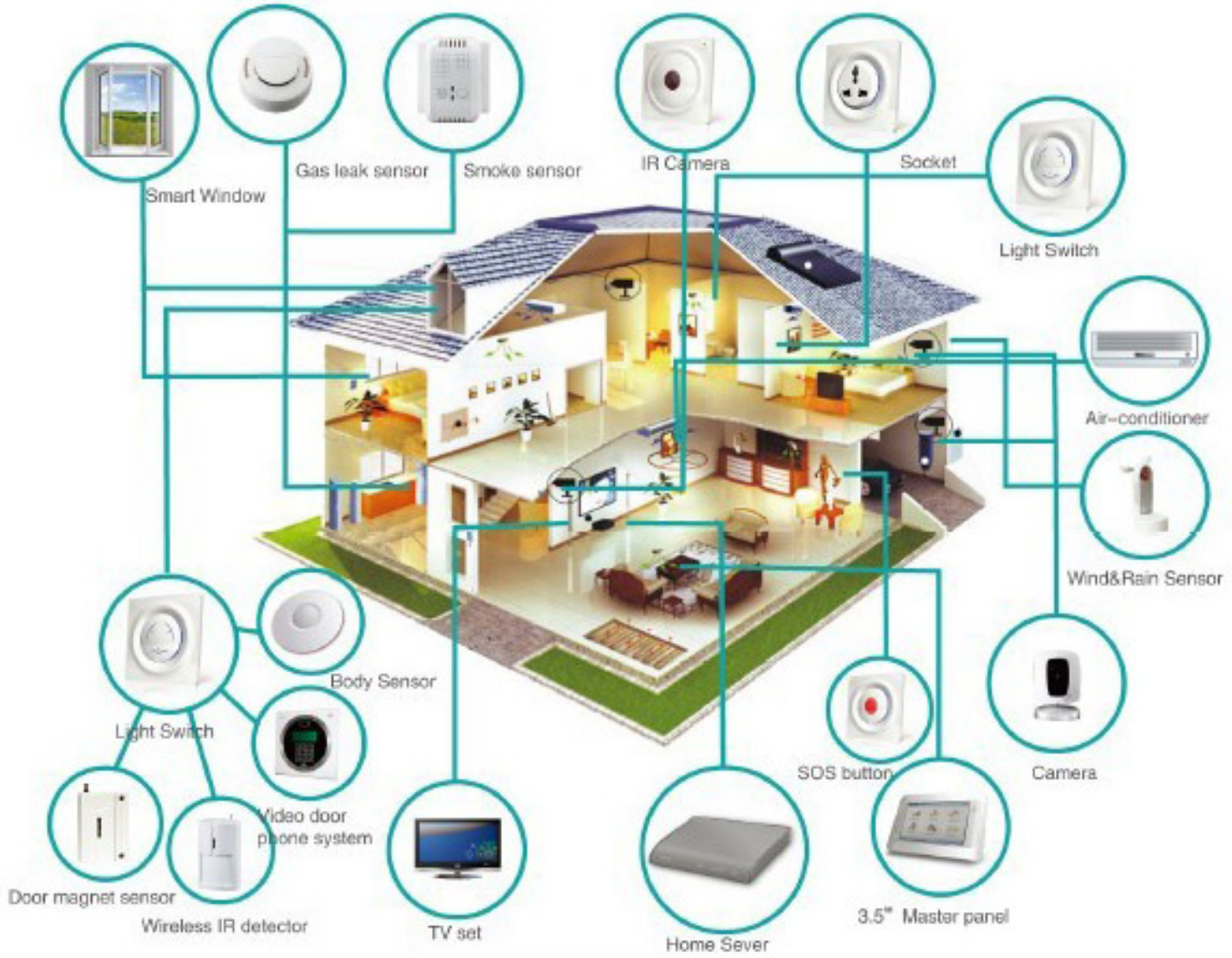
Smart Home

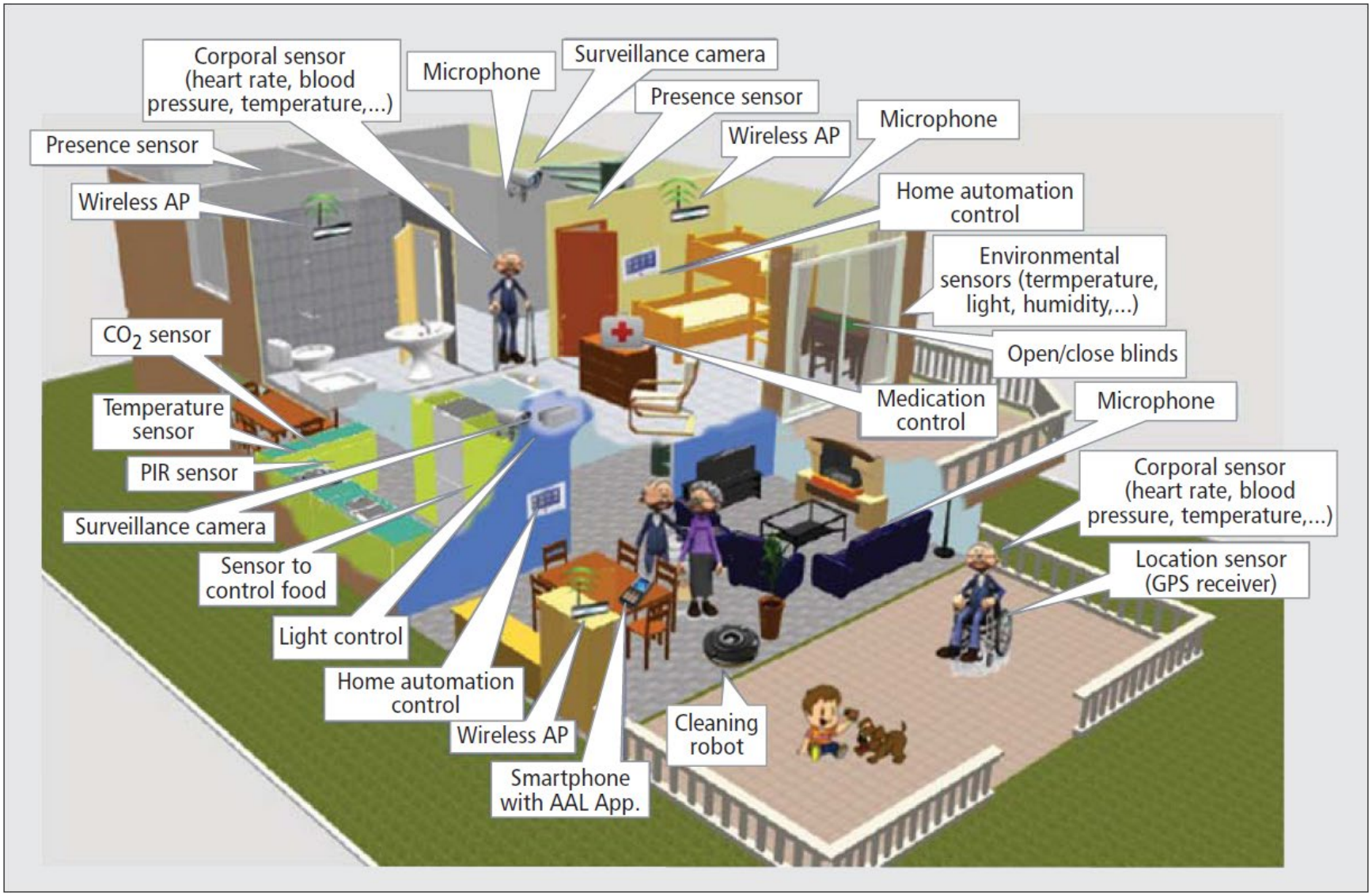


Smart Home



http://smarthomeenergy.co.uk/what-smart-home

Sensors/Automation



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Samsung Smart Home

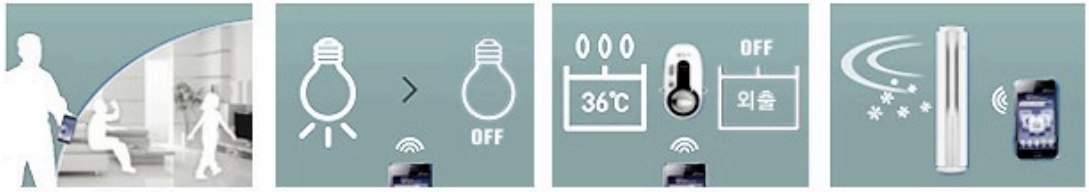
Samsung Smart Home

Samsung Smart Home Function

Visitor Identification

" Hello~" " Who is it " " Oh~ my sweetie! " " Welcome in "

Monitoring and control



" Are the children alright? " Oh, I think I left the veranda light on. The boiler temperature is too high~ I will turn the air conditioner on for a while

Intrusion Detection

(Buglar Intrusion Detection) (Emerency alarm, IP camera activated) (Resident notification via video)

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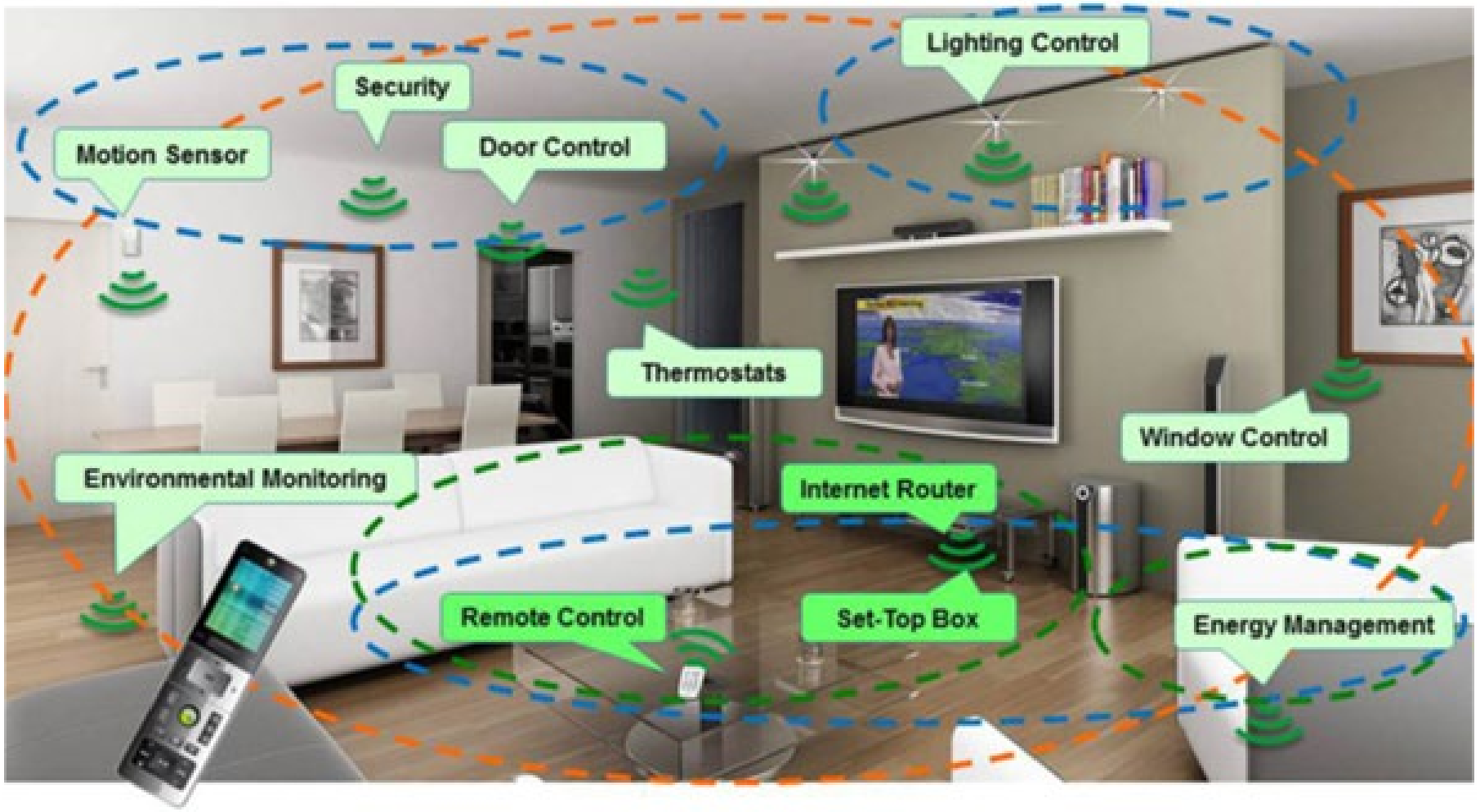
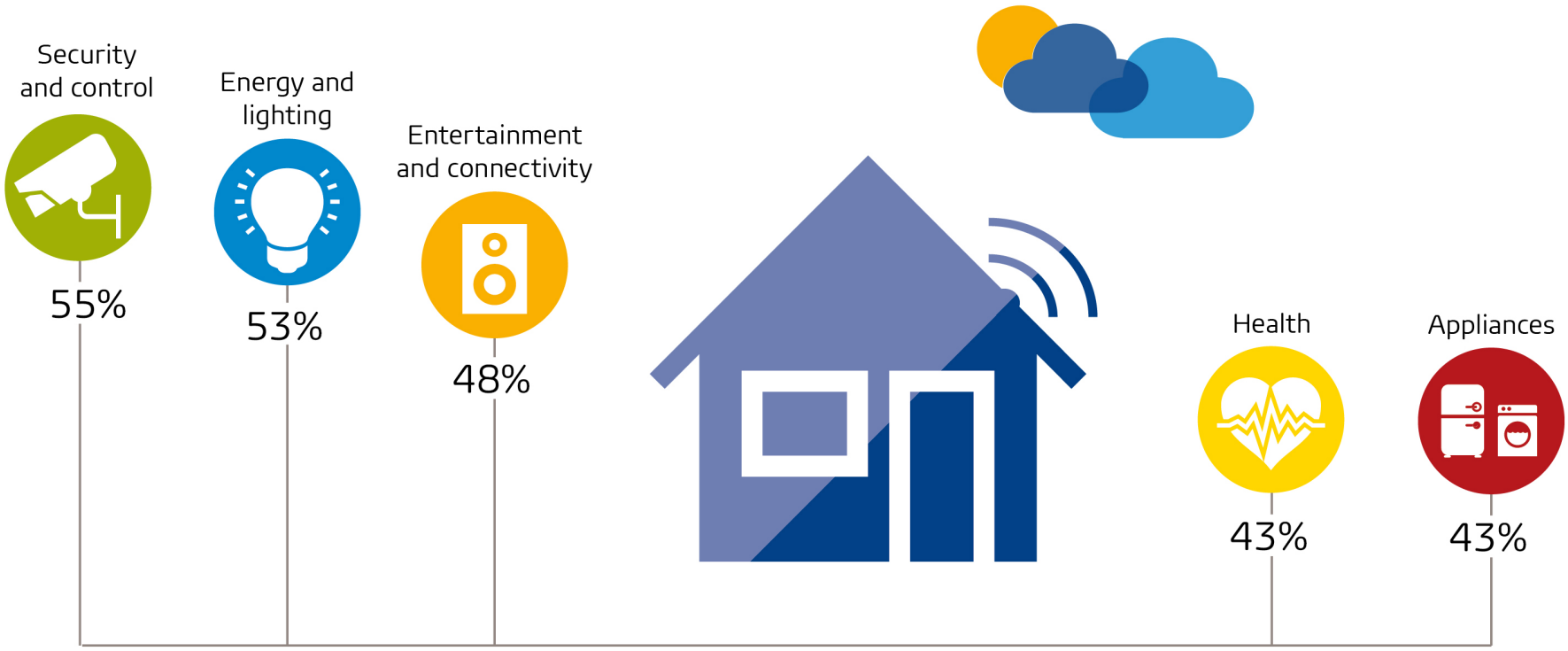
Smart Home Examples



https://www.wirelessdesignmag.com/blog/2012/09/new-smart-home-really-smart-home

Grouping Smart Home Functions

MOST APPEALING SMART HOME SERVICES AND SOLUTIONS ACCORDING TO CONSUMERS



Source: GfK smart home study 2015, +7000 consumers surveyed in September and October 2015 in Brazil, China, Germany, Japan, South Korea, UK and US (China and Japan data not included in this graphic)

https://blog.gfk.com/2015/11/unlocking-the-smart-home-opportunity/

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What we have discussed…

- Concept of Smart Grid
- Learn from Examples of Smart Grid Systems
  - Case Study – Jeju Island
  - Business oriented
- Learn from Demonstration Sites
  - Case Study: Chiang Mai World Green City
  - Community Smart Grid (DC&AC) – RE & Green Technologies
  - Integrating Energy Infrastructure with Green City Components
- Smart Home Functions

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Conclusion 1

- Smart Grid: - Efficient use of power by IT communications
  - Balance: Supply – Demand
  - Monitor – Control – Optimize
- Jeju Island
  - Strong Policy
  - Collaboration with Private Sectors
  - Business Oriented
- Smart Community
  - Living/ learning/training center for student, researchers, and general public
  - Appropriate technology and methods to solve real green city problems
  - Train problem solving skills - RE & Green Technology for local issues
  - Integrate with Community Resources - Ways of Living
  - Sufficiency Economy + Green Technologies (RE & EE)
  - Smart Grid as Infrastructure for Green Community Development

Conclusion 2

- Obstacles ???
  - Renewable Energy Deployment (Investment, Market, Policy)
  - Poor grid infrastructure/ Lack Feeder (Utility, Policy)
  - Lack policy/ Lack understanding – Integrated way forward
  - Market driven?

- Do you think smart grid is possible?

- Moving Forward
  - Appropriate Technology; Monitoring/Optimization
  - Integration with Social Development and Green Economic Development
  - Create awareness/ Share best practices/ Demonstrations Sites/ Community Implementation
  - Training General Public; Private Sectors; Policy Maker

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Acknowledgments

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- APEC Secretariat
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