Title : Smart Energy Sharing and Management Devices for a Low-Carbon Society

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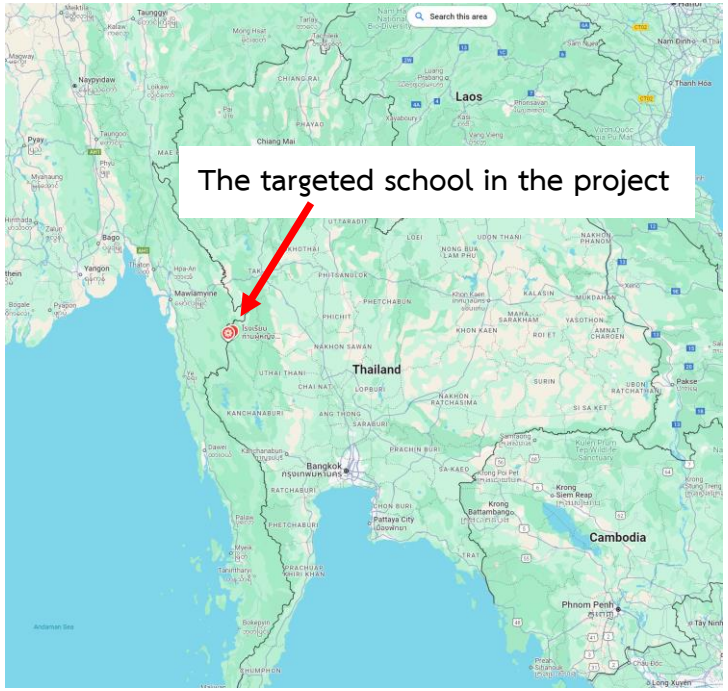
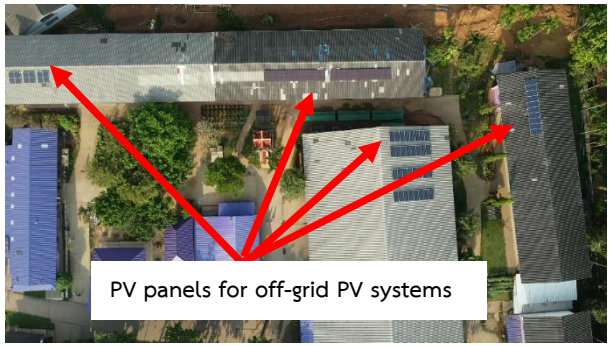
Institution : National Electronics and Computer Technology Center (NECTEC),
National Science and Technology Development Agency (NSTDA), Thailand

# Project Title: Smart Energy Sharing and Management Devices for a Low-Carbon Society

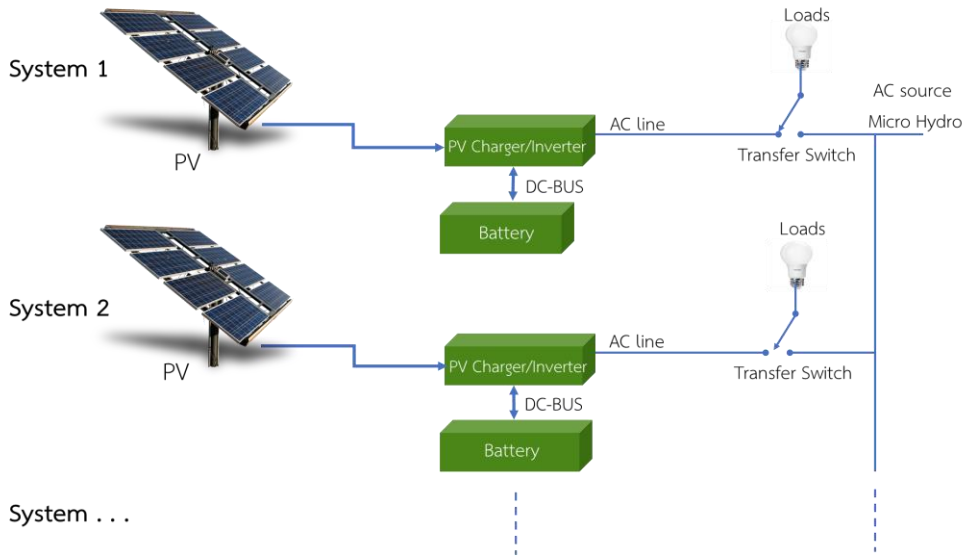
## Background :




Energy sources for the targeted school


Original electrical systems in the school




**Reserved forests:** public utilities, such as national grid, are not permitted.

However, people had already settled in before.

**Renewable energy systems:**
Independent off-grid PV systems,
(inadequate and unstable) micro hydropower system

**Benefits:** Safe (low power, low voltage, 5kW/48Vdc, local people can take care of the systems

**Problems:** energy is not shared among the systems. High energy waste, low overall reliability, cost ineffective, etc.

The Proposed Solution: Energy Sharing...

# Project Title: Smart Energy Sharing and Management Devices for a Low-Carbon Society

We have completed the first version of the Energy Sharing Devices (**ESDs**) and Simple Energy Management Board (**EMB**) and have installed them for use in the school. Training sessions have also been conducted for the teachers.

**Acknowledgement:**

The current project is financially supported by The Power Development Fund Department, Office of the Energy Regulatory Commission (ERC) From Dec 2022 – Dec 2024

## The Next Targets Will Be:

**1. Data Collection**:

Gather utilization data of the **ESDs** for overall improvements.

**2. Propose A New Project**:

- To Promote the use of prototypes and improve prototypes:
  Improve packaging and adding IoT functions for mobile applications.
- Develop advanced Energy Management Board (EMB):
  communicate and control other devices, IoT, on-line control and monitoring

**3. Collaborate with Universities/Partners in Thailand and ASEAN countries**:

For further research, development, and student internships.

# The Proposed Method: Energy Sharing Devices (ESDs)

**Acknowledgement:**
The current project is financially supported by
The Power Development Fund Department,
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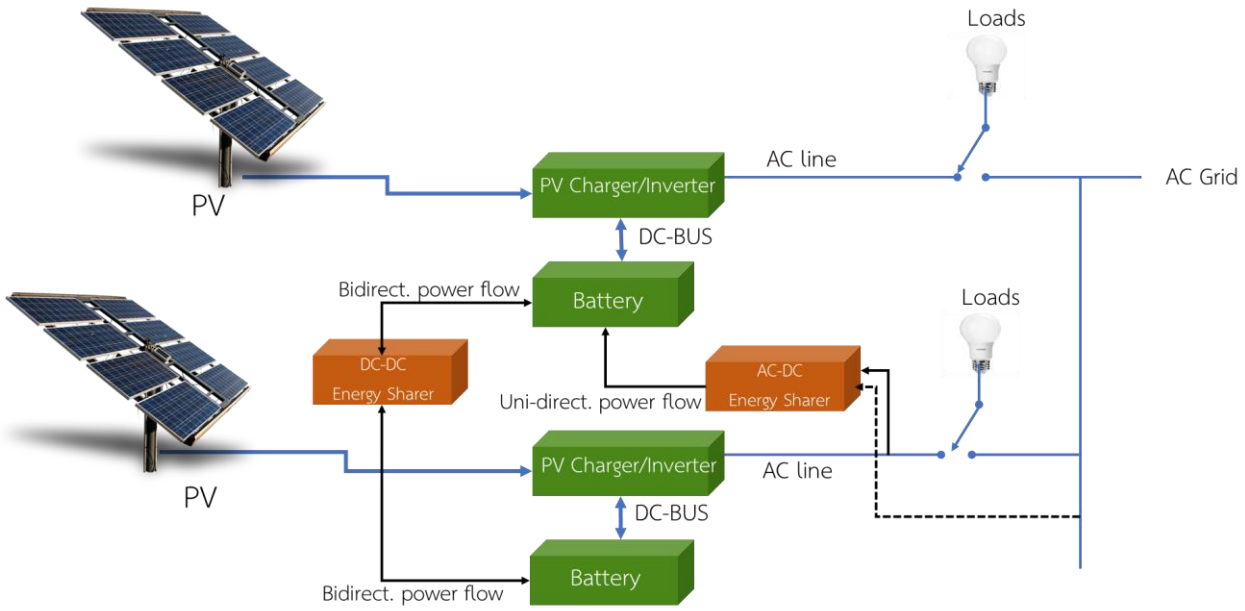



The proposed Method

In practice, we can select which devices to use; it is not necessary to use all of them.

## The proposed Energy Sharing Devices

Why ESDs?: Do not affect system operations or reduce key advantages, such as ease of maintenance, safe, availability of general parts on the market, and low cost.

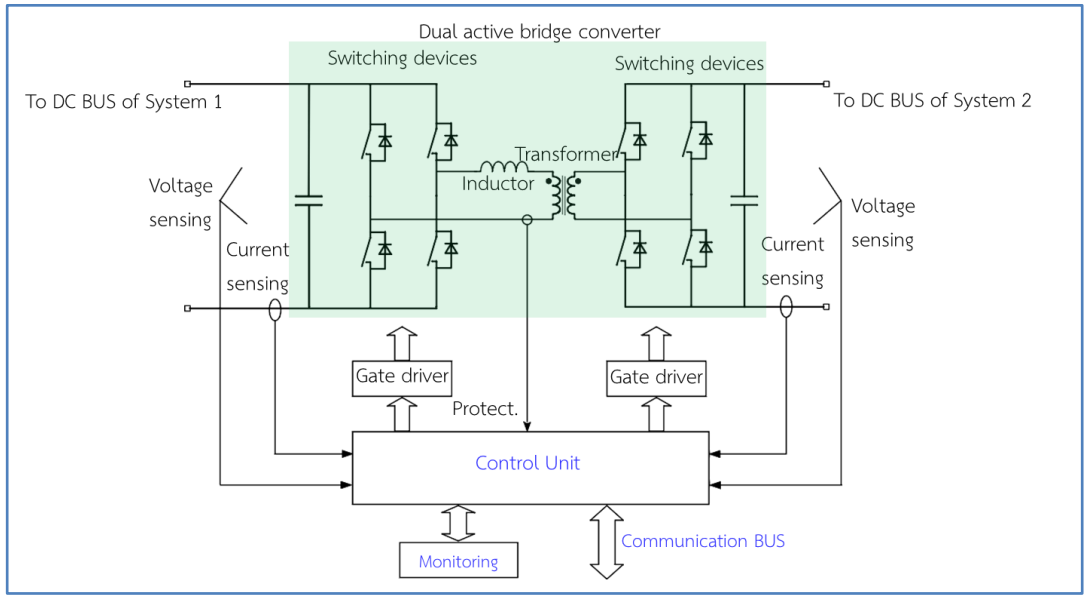
1. DC-to-DC type (Bidirectional power flow)

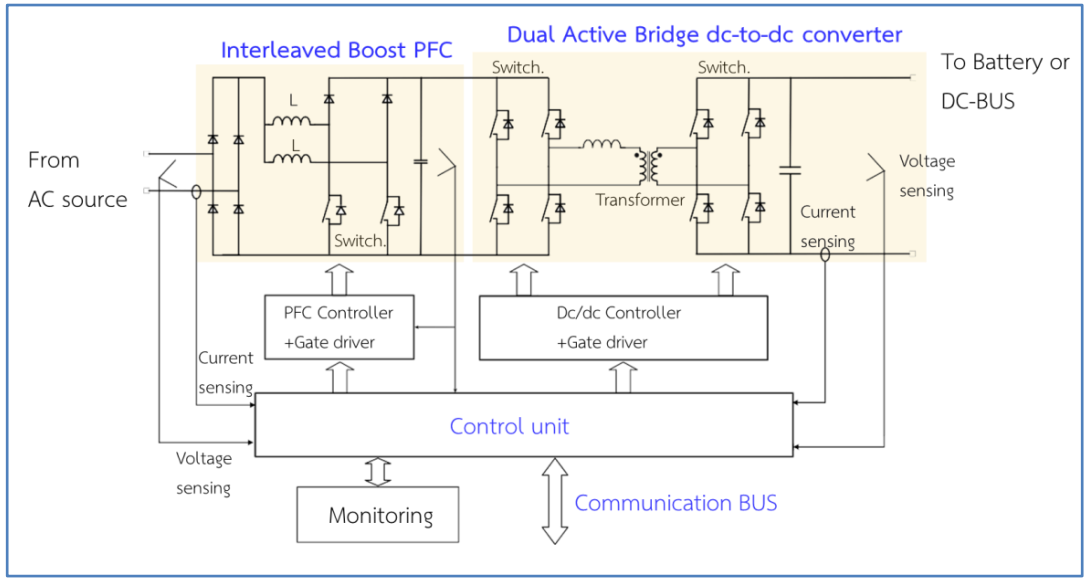
For sharing energy directly between battery modules when they are placed close together, the Dual Active Bridge (DAB) converter topology is used. This topology offers high efficiency, bidirectional power flow, galvanic isolation, and simple control.

2. AC-to-DC type (Unidirectional power flow)

For sharing energy from an AC source, such as an AC grid or the AC output of a distant inverter, to charge a battery, interleaved boost converters are employed for Power Factor Correction (PFC), along with DAB for battery charging. This ESD type offers high efficiency, galvanic isolation, and easy control.

# The Proposed Method: Technologies for the Energy Sharing Devices




## 1. DC-to-DC Energy Sharing

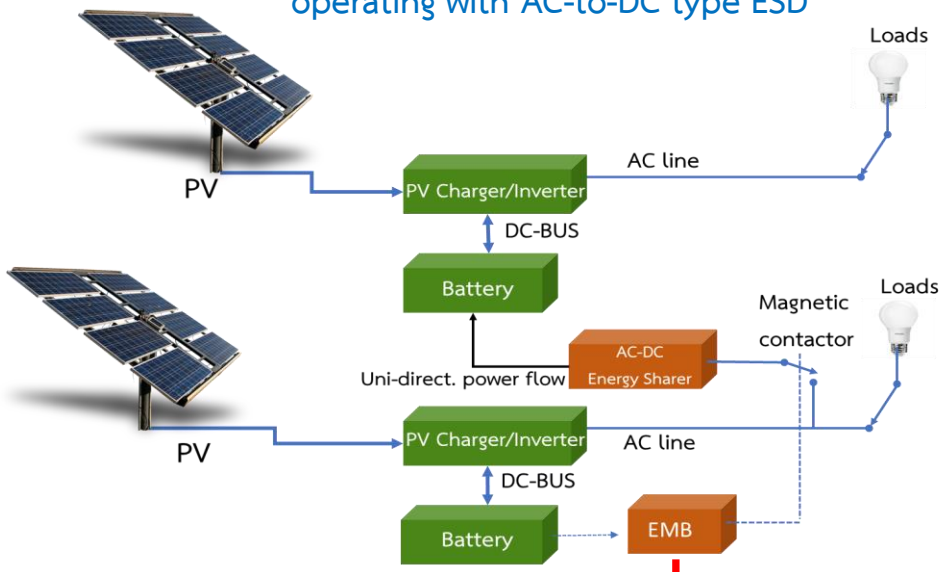
- Dual Active Bridge Converter (DAB)
- Control unit: Analog + Digital
- Communication BUS for communicate with BMS and others
- Monitoring/Control panel
- High frequency transformer for galvanic isolation

## 2. AC-to-DC Energy Sharing Device contains:

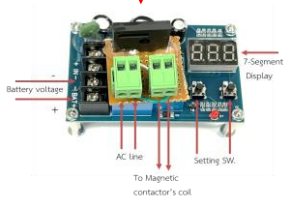
- Interleaved boost converter for PFC (Power Factor Correction)
- Dual Active Bridge Converter (DAB)
- Control unit: Analog + Digital + (Optional) Energy Management Board
- Communication BUS for communicate with BMS and others
- Monitoring/Control panel
- High frequency transformer for galvanic isolation

# The Proposed Method: Configuration and Improvement

## Proposed simple energy management board for operating with AC-to-DC type ESD

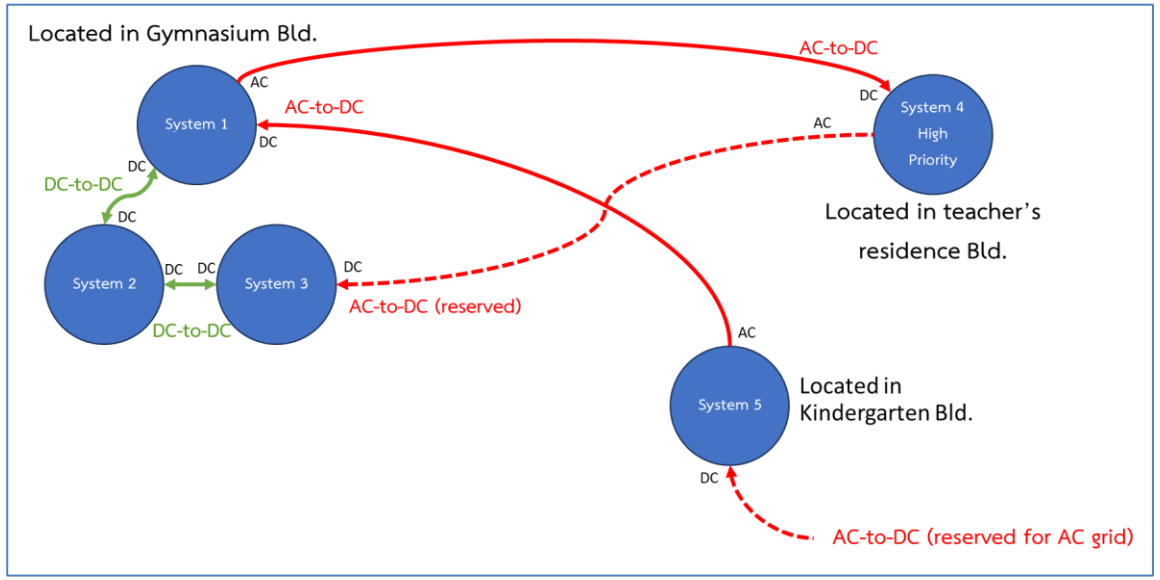



Simple Energy Management Board (EMB)

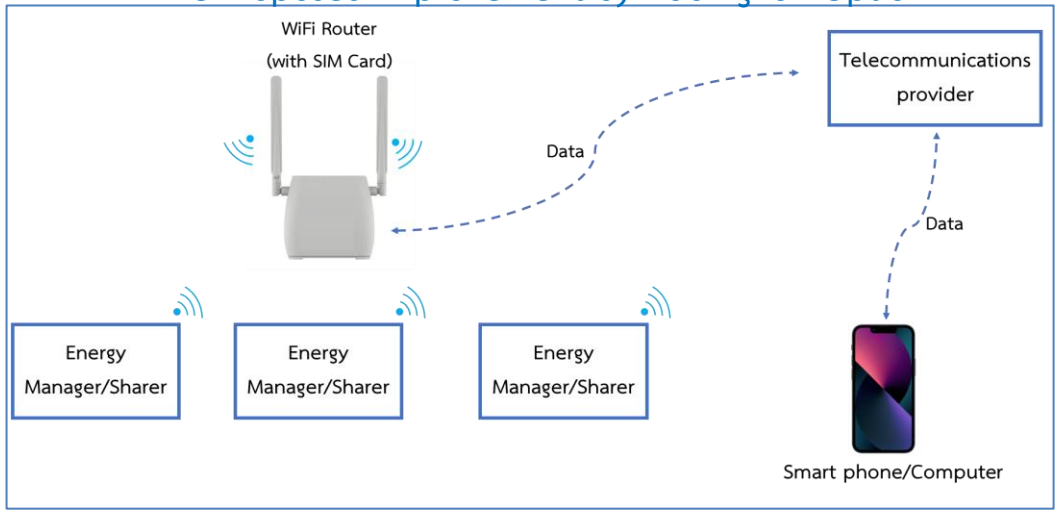



EMB must be used with either the AC-to-DC ESD or an AC-to-DC charger available on the market. However, AC-to-DC ESD can be used independently.

## Electrical System Configuration Using ESDs at The School




## The Proposed Improvement by Adding IoT Option



# Testing and Specifications of ESDs

| Item | DC-to-DC type | AC-to-DC type |
|---|---|---|
| **Rated Power** | **3 kW, Bidirectional** | **3 kW, Unidirectional** |
| Power converter topology | Dual Active Bridge (DAB) | DAB, 2-phase Interleaved PFC boost converter |
| Switching frequency | 50 kHz | 50 kHz |
| **Isolation transformer** | **Ferrite, 3 kV Hi-pot test** | **Ferrite, 3 kV Hi-pot test** |
| **Electrical standard (passed)** | **IEC 60950-1 (Hi-pot), IEC 61000-6-1 ( Surge and EFT)** | **IEC 60950-1 (Hi-pot, Electric strength, Touch current and protective conductor current), IEC 61000-6-1 (Surge and EFT)** |
| **Input voltage** | **30 – 70 Vdc (Nominal 48V)** | **85 – 265 Vac (Nominal 220V)** |
| **Output voltage** | **30 – 70 Vdc (Nominal 48V)** | **30 – 70 Vdc (Nominal 48V)** |
| **Battery** | **Lead-acid, Li-ion** | **Lead-acid, Li-ion** |
| Cooling | Fan (Automatic) | Fan (Automatic) |
| Field test | Currently being used at the school | Currently being used at the school |

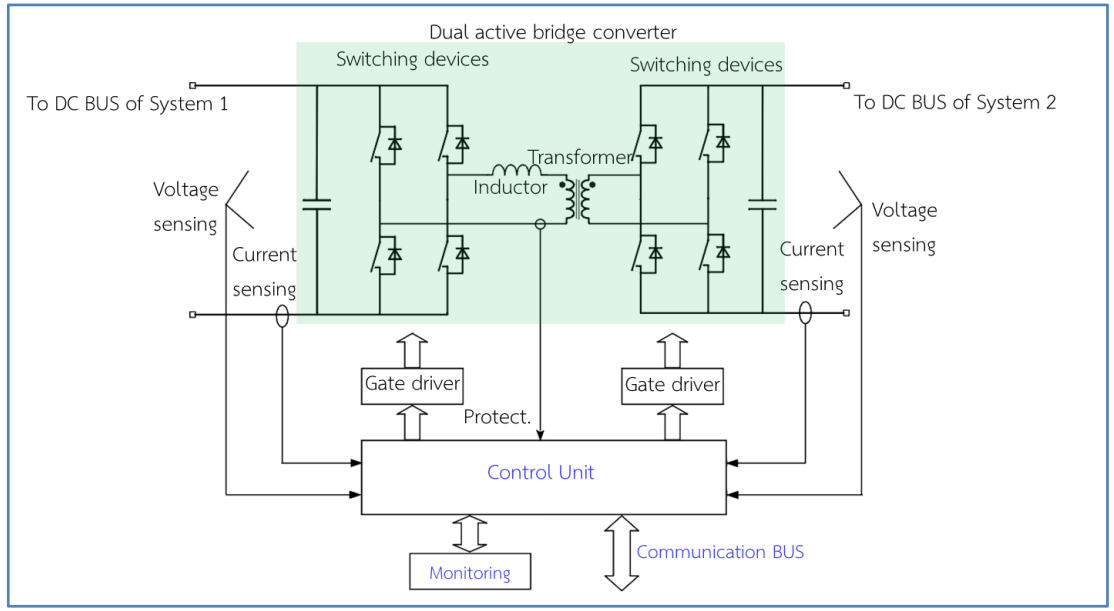
DC-to-DC ESD


DC-to-DC ESD

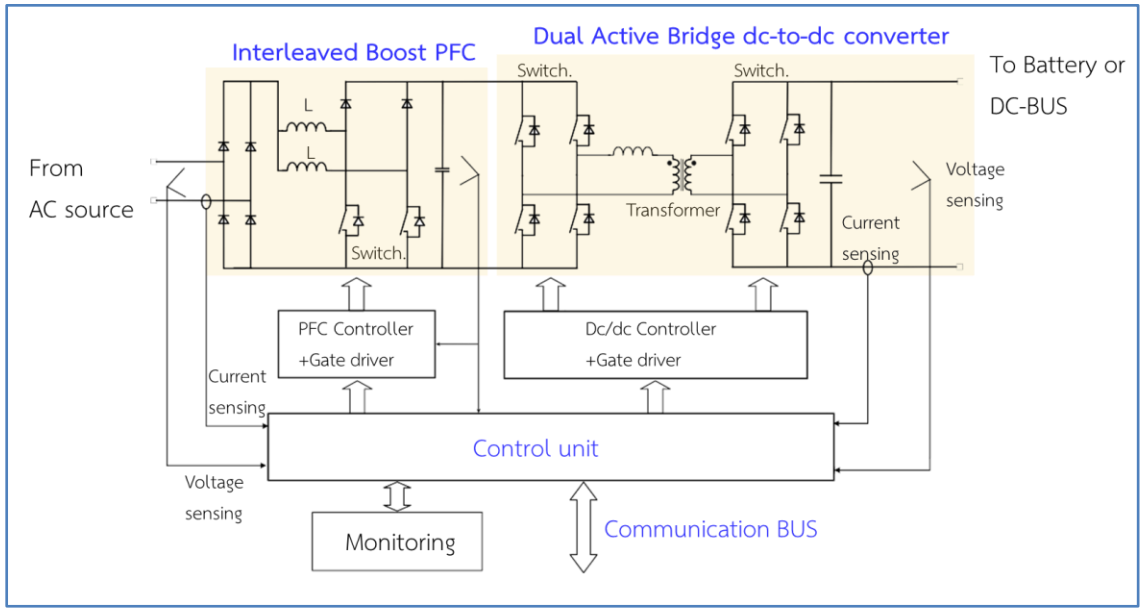
# Impact

## 1. Scientific and technological:

The proposed power conversion converter and energy management/balancing methods in this project would be the research topics for technical papers or patents. Moreover, the topologies proposed in this project have potential to apply to others application such as **EV chargers**, renewable energy, etc.




**DC-to-DC ESD**




**AC-to-DC ESD**

## 2. Societal:

This project would improve the quality of life in the communities. The current ESDs are improving the quality of learning and life at the targeted school, which has over 60 teachers and 900 students.

# Impact

## 3. Impact on the efficiency of energy utilization (Environment and Economic impact)

Electrical Parameters of the Off-Grid PV Systems in The School

| | PV (kW) | Average PVgen/Day (kWh) | Daily Load Demand (kWh) total(day/night) | Battery Capacity | Daytime un-storable Power (kWh) | Energy Waste (+) /Lack (-) |
|---|---|---|---|---|---|---|
| System 1 | 6.27 | 31.35 | 24 (14.4/9.6) | 5.12 kWh 51.2V 100A Li-ion | 11.83 | 7.35 |
| System 2 | 3.3 | 16.5 | 31.2 (18.72/12.48) | 9.6 kWh 48V 200A Lead-Acid | -7.34 | -14.7 |
| System 3 | 6.93 | 34.65 | 25.2 (15.12/10.08) | 14.4 kWh 48V 300A Lead-Acid | 5.13 | 9.45 |
| System 4 | 4.98 | 24.9 | 33.6 (20.16/13.44) | 5.12 kWh 51.2V 100A Li-ion | -0.38 | -8.7 |
| System 5 | 6.6 | 33 | 24 (14.4/9.6) | 5.12kWh 51.2V 100A Li-ion | 13.48 | 9 |
| Total | 28.08 | 140.4 | 138 | 39.38 kWh | 22.72 | 2.4 |

**Energy Waste** = 7.35 + 9.45 + 9 = **25.8 kWh/Day**

**Energy saving/Year** = 25.8 x 365 = **9,417 kWh** or **47,085 Baht** (1,414.55 USD) /Year

**The un-storable energy** = 11.83+5.13+13.48 = **30.44 kWh**

The un-storable energy that we can share = 7.34+0.38 = **7.72 kWh/Day** or 7.72 x 365 = **2,817.8 kWh/Year** or **14,089 Baht** (422.67 USD)/Year

The payback time would be 1 – 2 years!

*** Assumption

- DOD of the battery is 100%
- Power conversion loss is negligible.
- The electricity price/kWh is 5 Baht (0.15 USD)
- Daytime load demand is 60% of daily load demand.
- The costs of the DC-to-DC and AC-to-DC ESDs are 15,000 Baht (450 USD) and 20,000 Baht (600 USD), respectively.

# Impact

4. Collaborative:

1

2

3

1. Assoc. Prof. Sakda Somkun, Naresuan University, Thailand: **Power Electronics**
2. Dr. Suparak Srita, Rajamangala University of Technology Lanna, Thailand: **Power Electronics**
3. Assist. Prof. Kenichiro Sano, Institute of Science Tokyo: **Power Electronics**
4. We are looking for an IoT company or **IoT research team**.

(5) Members from Japan and **ASEAN** countries are very welcome to join!

# Output/Outcome

1. Scientific

- 1 Petty Patent:

  Title: Charger/Power supply with energy management for improving efficiency

  Application no.: 2101005892, Application date:25/08/2021, Publication date: 25/12/2023,

  Filing date: 22/02/2024

- 1 Pending Patent:

  Title: Controller Unit for Dual Active Bridge Converter, Application no.: 2201005409,

  Application date:26/08/2022

- Field prototypes (in use) => **Will be upgraded to commercial or public prototypes in the new project.**

  3-kW DC-to-DC Energy Sharing Device installed at the school,

  3-kW AC-to-DC Energy Sharing Device installed at the school

  Energy Management Board?

2. Societal

- The use of ESDs or EMB in targeted communities or schools aims to enhance the quality of life and learning. Their first versions are already in use and contributing to these goals.

# Output/Outcome

## 3. Collaborative

- Assoc. Prof. Sakda Somkun and team– Naresuan University, Thailand

  *Contributions: Technical papers, internship students, co-researchers*

- Dr. Suparak Srita – Rajamangala University of Technology Lanna, Thailand

  *Contributions: Technical papers, co-researcher*

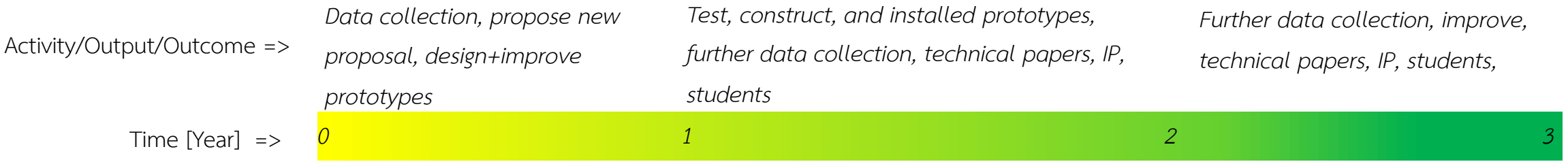
- Assist. Kenichiro Sano – Institute of Science, Tokyo

  *Contributions: Technical papers, co-researcher*

- We are looking for an IoT company or IoT research team to develop IoT functionalities.

- **Members from Japan and ASEAN countries are welcome to join!**

  *Contributions: Technical papers, exchange students, co-researchers, pilot-user communities, …*



# Conclusion

1. Targets
    - Collect data for next version ESDs and EMB
    - Strengthen collaborations with partners for R&D activities
    - Proposing new projects on improving prototypes and promote the use of prototypes
2. Method (idea)
    - Utilizing power conversion and IoT technologies to improve energy efficiency for (off-grid) power systems.
3. Scientific and societal impact
    - Holding **1 pending patent**, **1 petty patent**, and **2 field prototypes**. Potential for further technical publications (patents/papers).
    - **Improving the quality of life and learning** within communities and schools.
    - The proposed technologies are versatile, can be applied for variety applications such as **EV chargers** and **renewable energy**.


Thank you
For Your Kind Attention!