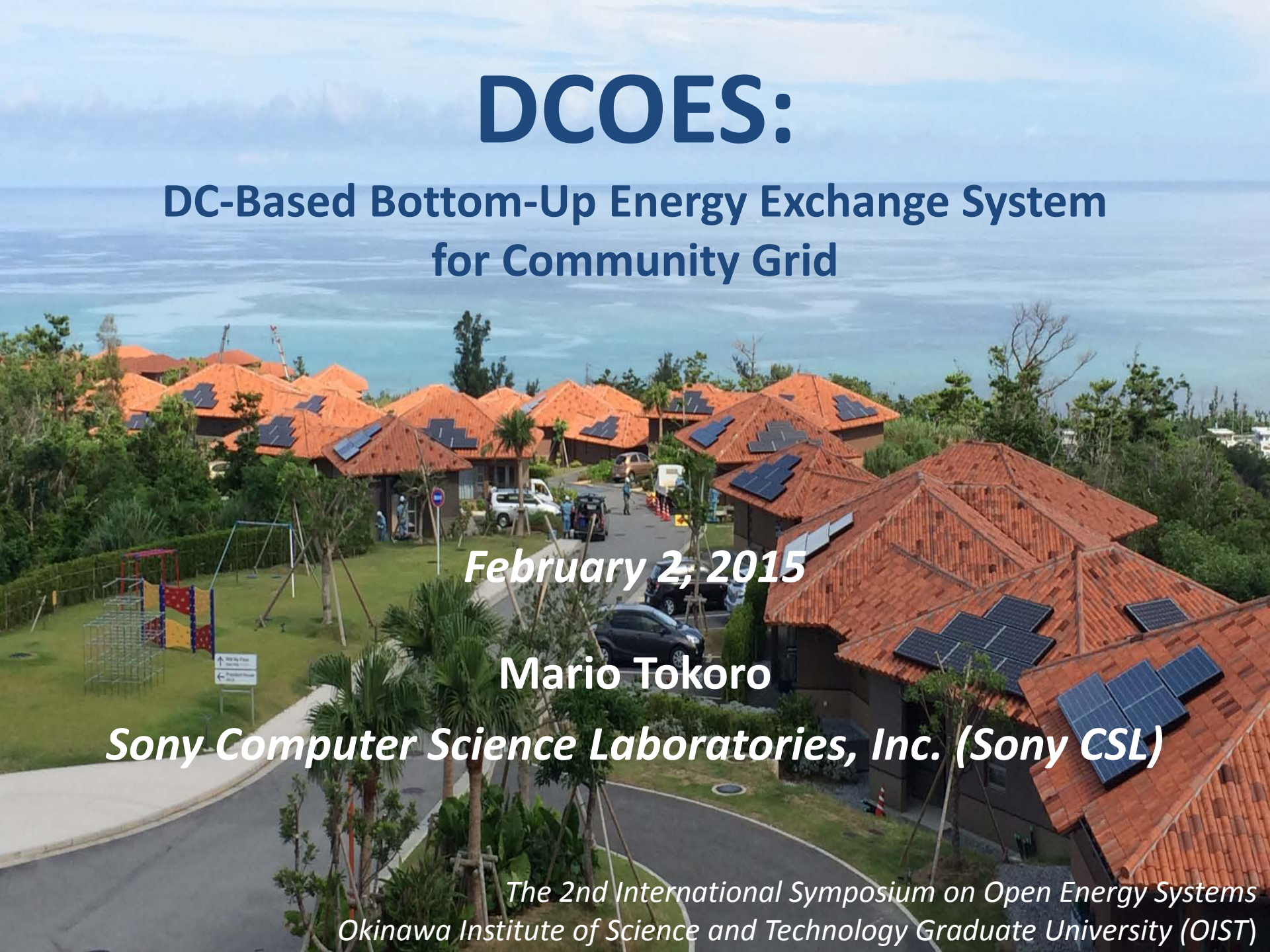
DCOES:

DC-Based Bottom-Up Energy Exchange System for Community Grid



February 2, 2015

Mario Tokoro

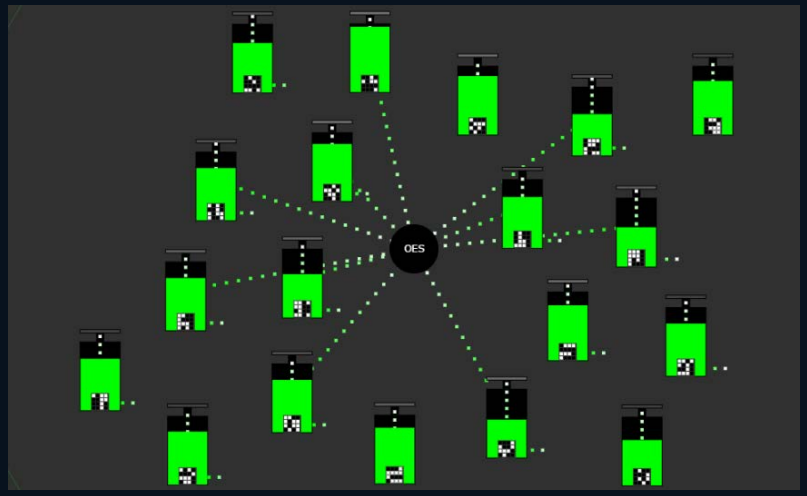
Sony Computer Science Laboratories, Inc. (Sony CSL)

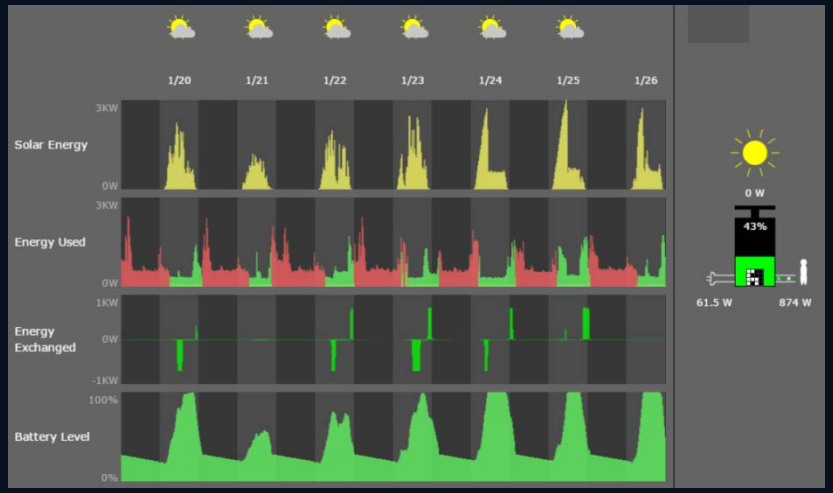
The 2nd International Symposium on Open Energy Systems
Okinawa Institute of Science and Technology Graduate University (OIST)

CURRENT OPERATION

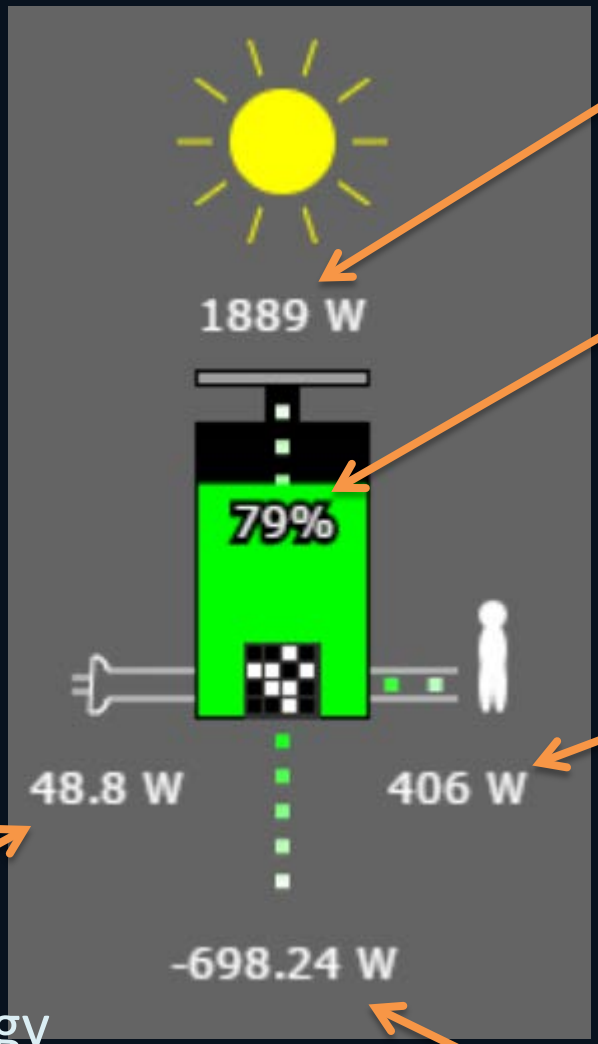
Monitoring Current Operation

- Live Video - 19 houses
- Live Video – Energy history of a house





Snap shot



Solar energy generation

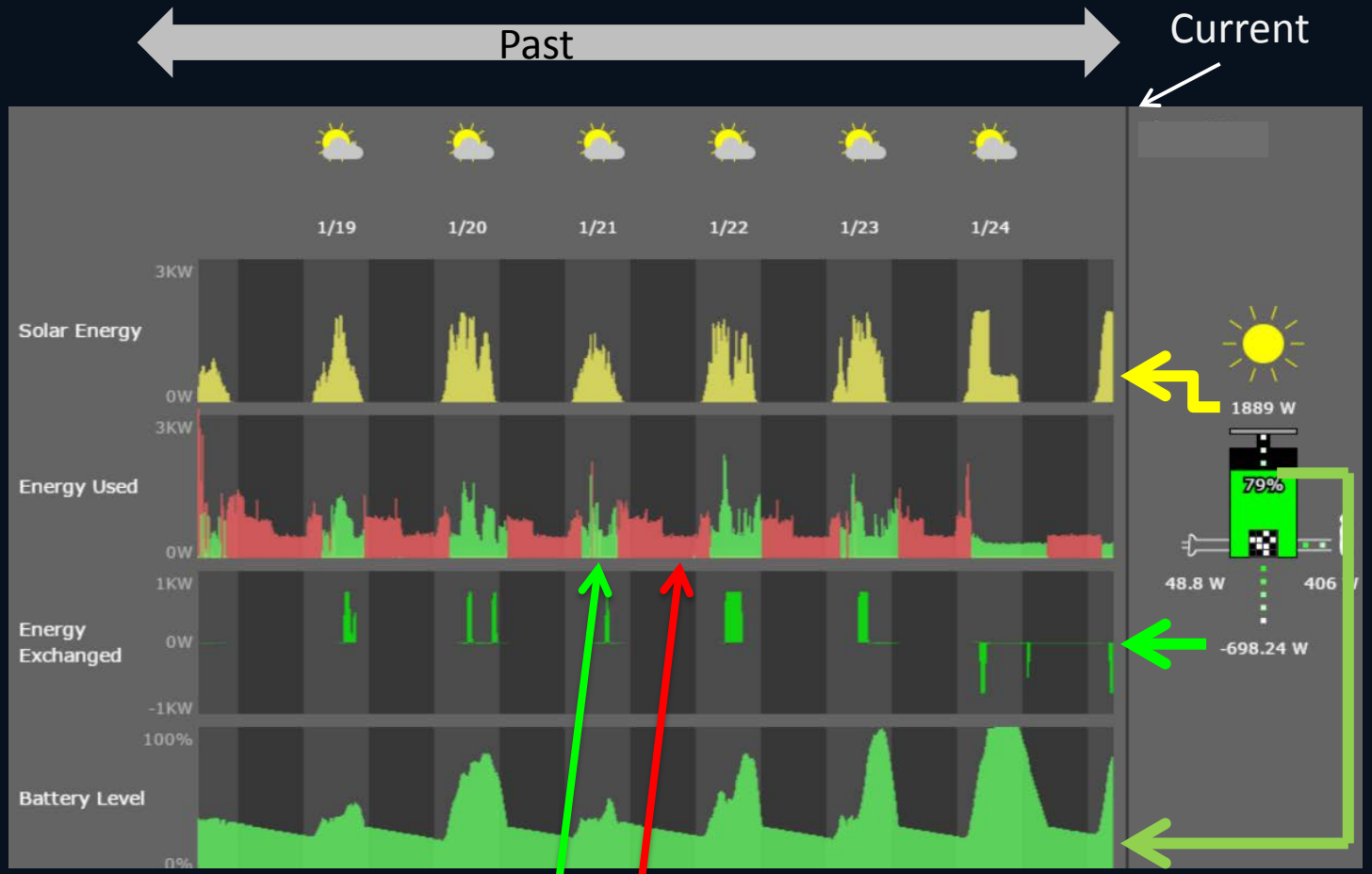
Battery level

Consumed energy
(for 100V appliances)

Utility-supplied energy

Exchanged energy

Historical Data

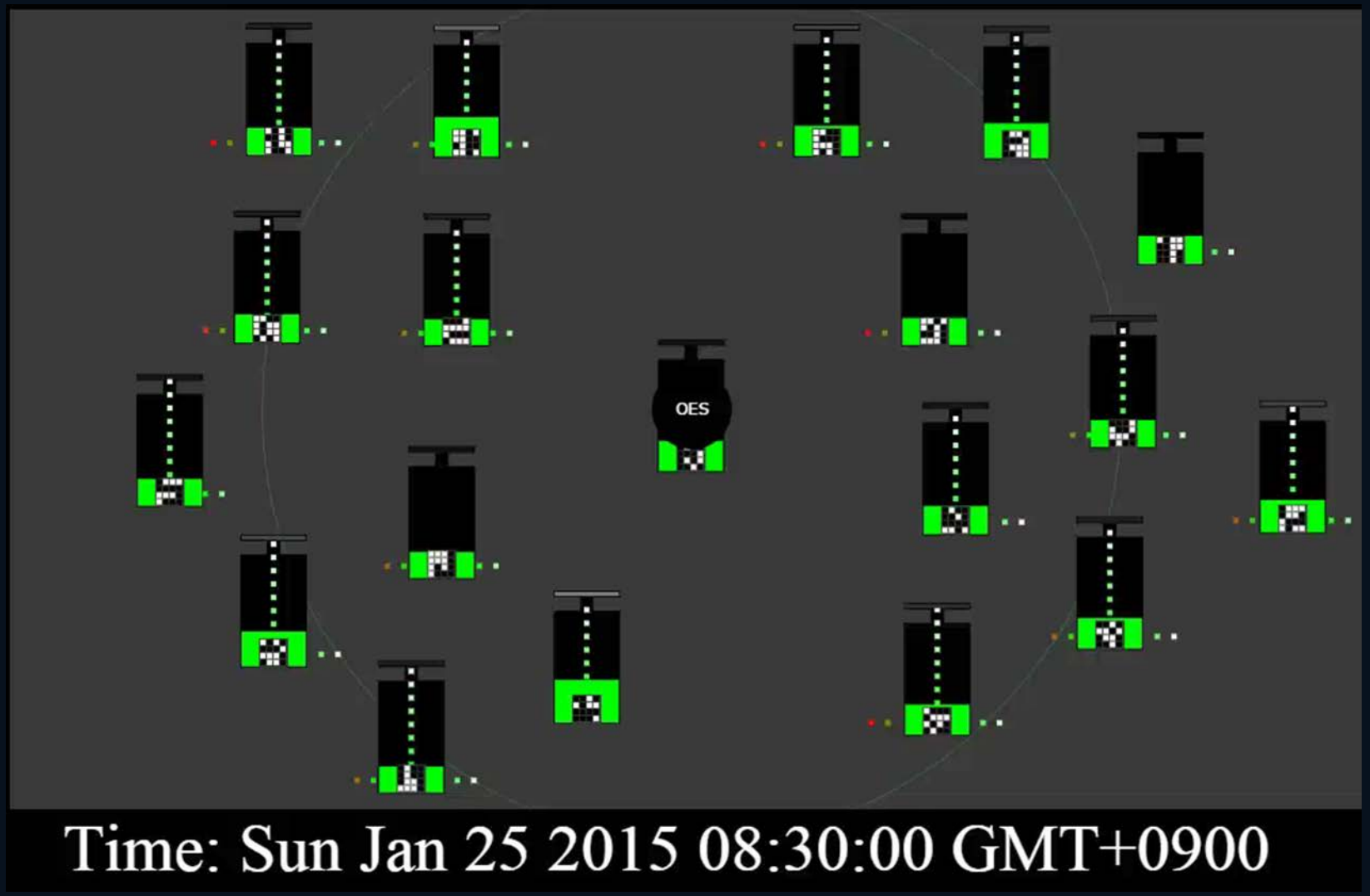


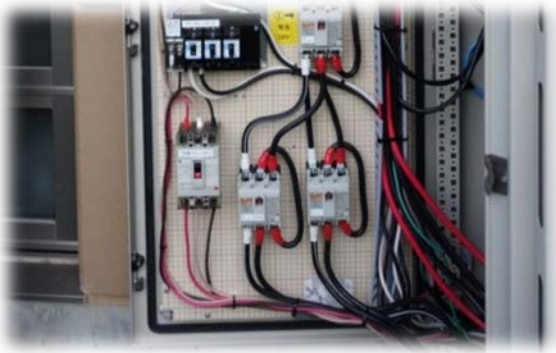
Energy consumed

Green: Renewable energy

Red: Utility-supplied energy

Example Daily Operation

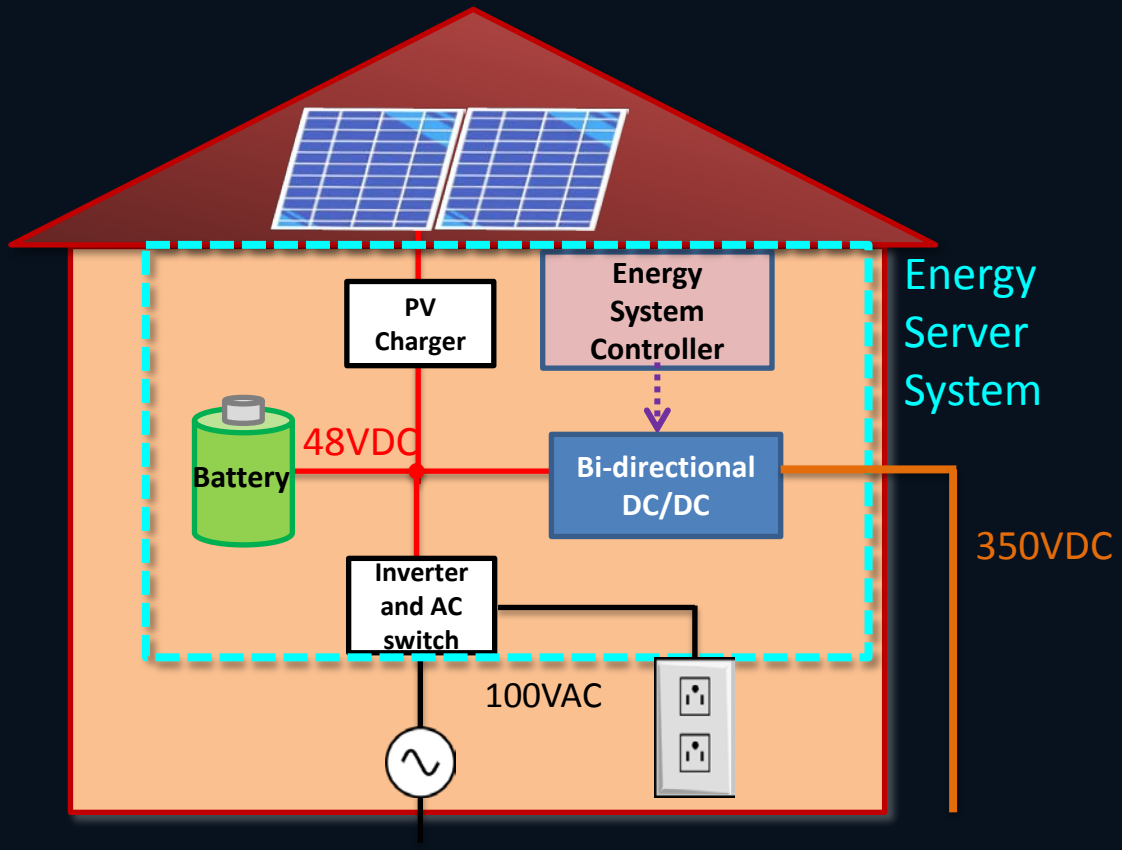




STRUCTURE OF DCOES

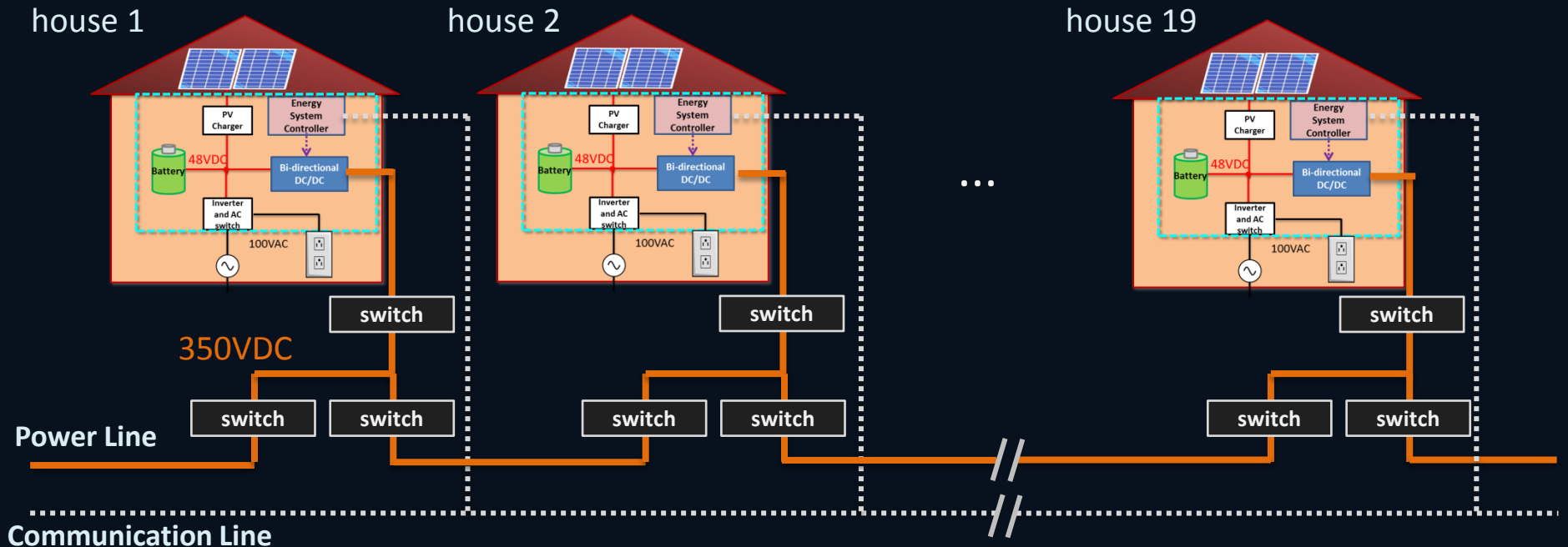
DCOES System Structure (1)

- Configuration of each house



DCOES System Structure (2)

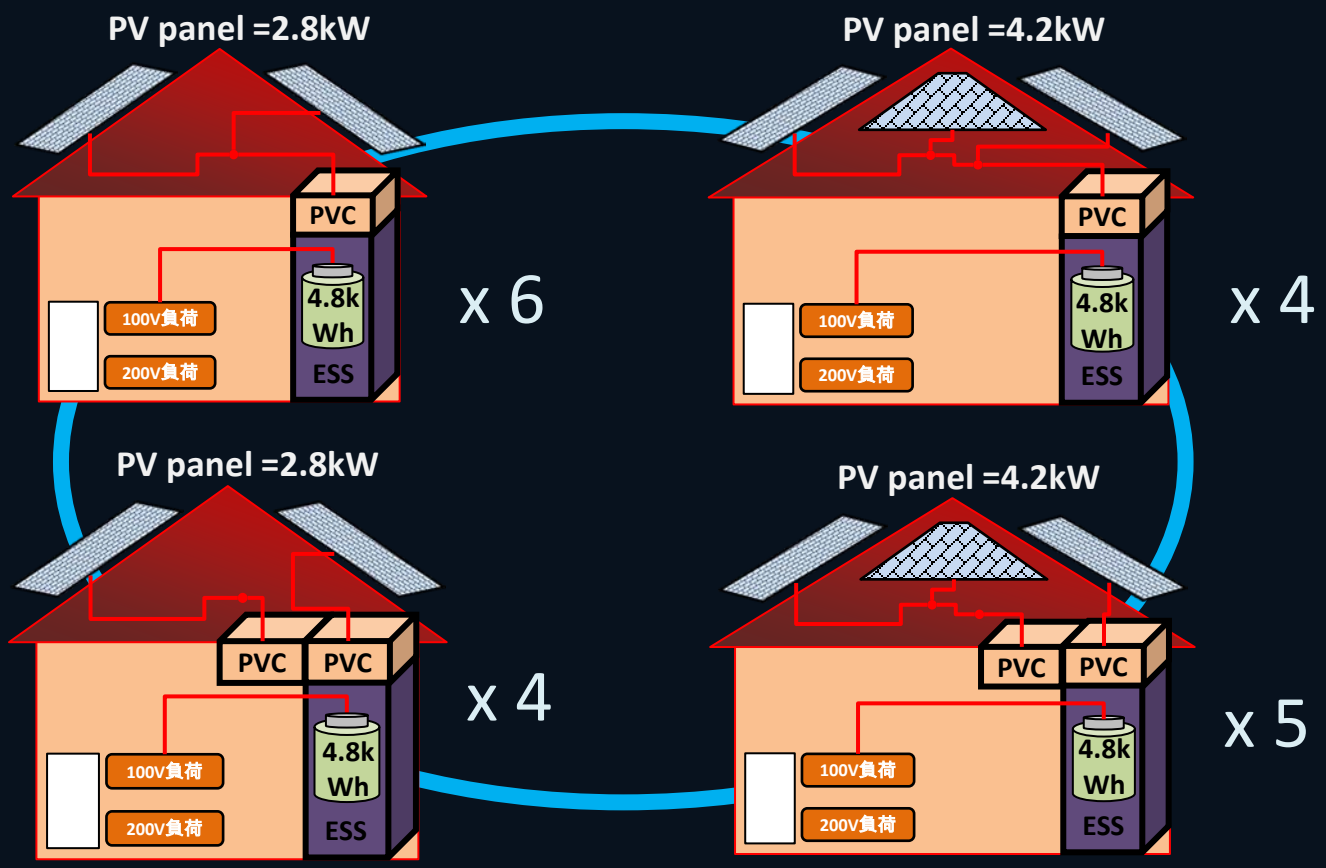
- 19 houses are connected



Real System Installation

Total 19 houses

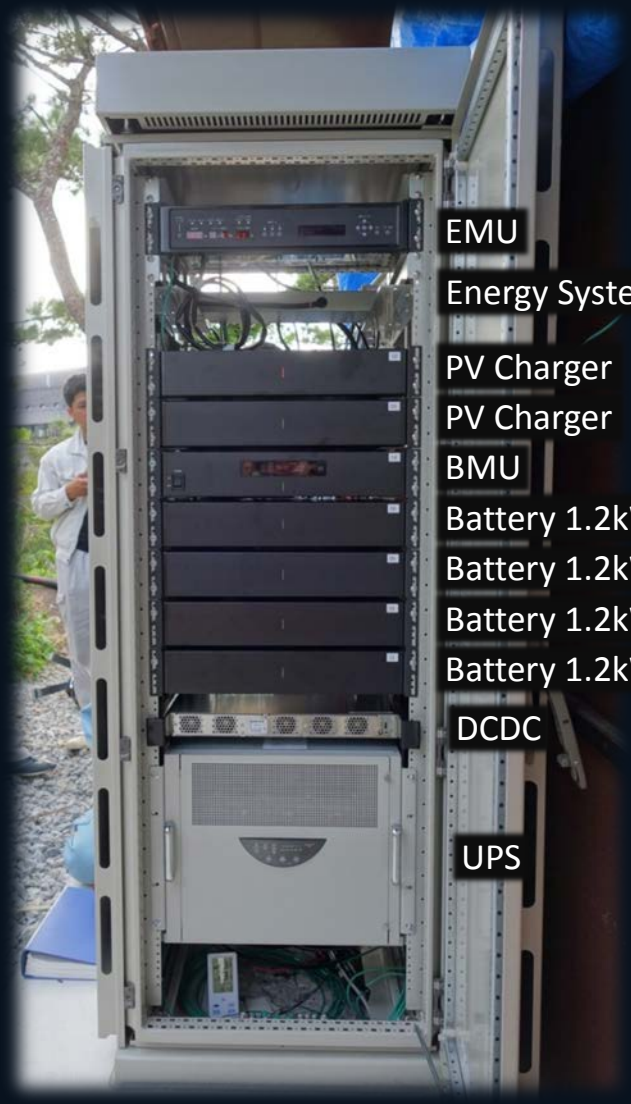
65.8kW PV panels, 90kWh Batteries



PV Panels

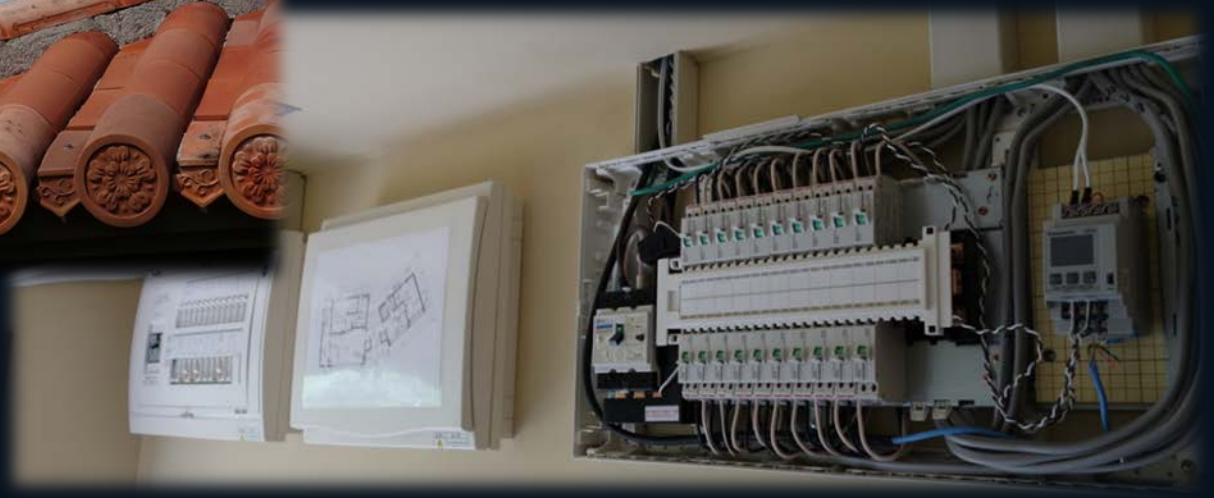
Energy Server System

- 48V energy server
- 350V Grid
- Energy exchange module, DCDC
- DC to AC conversion for appliances
- AC backup by utility company



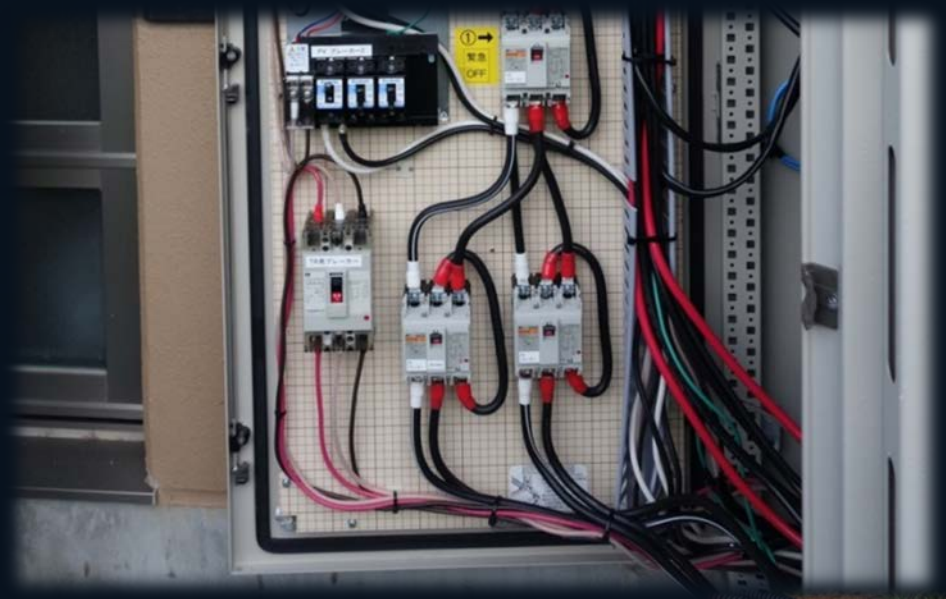
Weather Station and Distribution Board

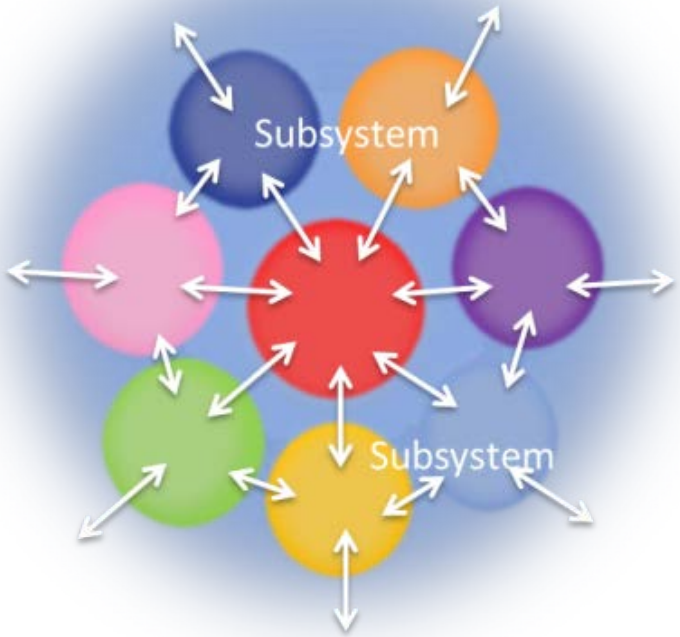
Weather Station



DCOES Distribution Board

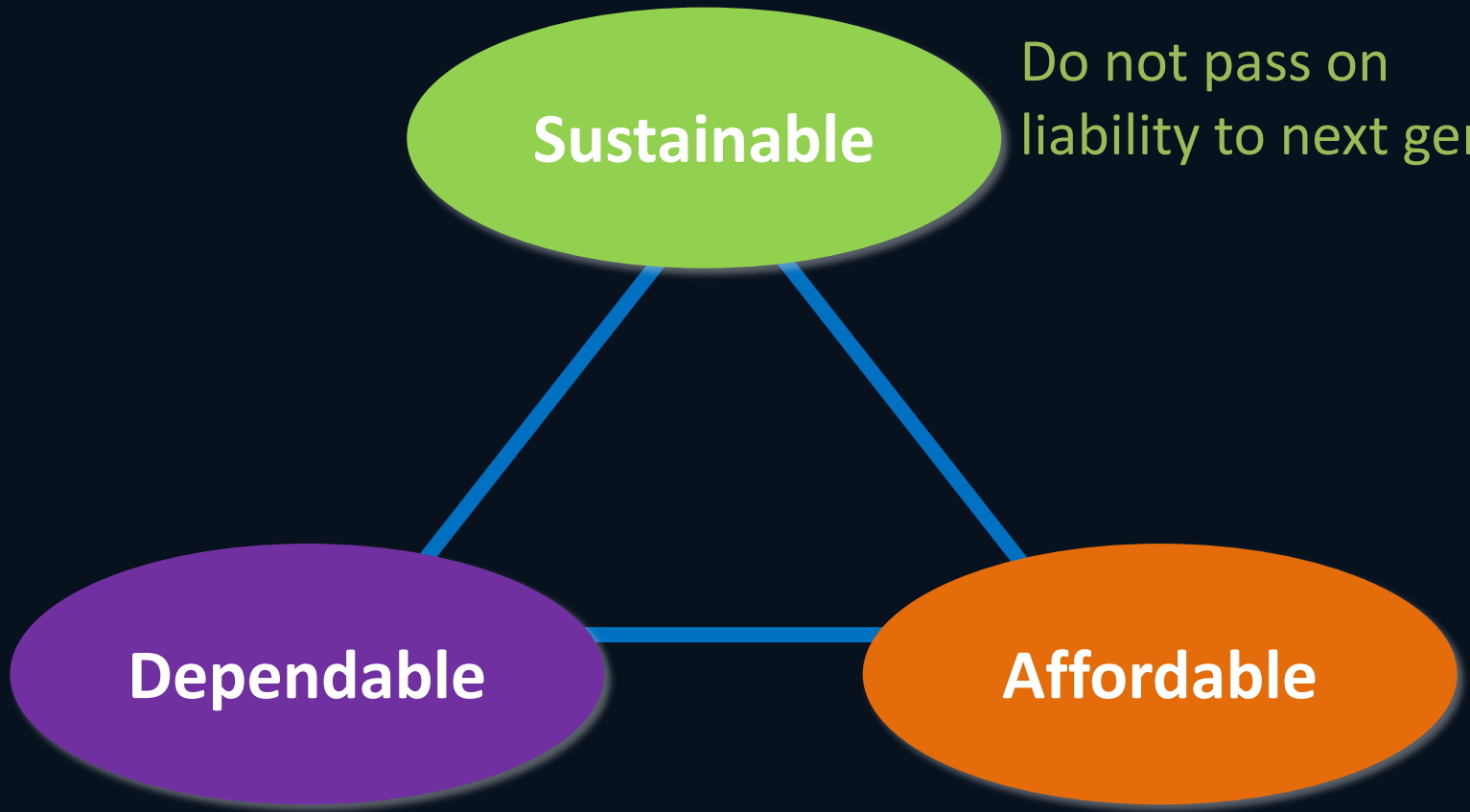
350VDC Grid Lines (Privately Owned)





CONCEPT AND THEORY

Our Project Goal



Our Approach

Do not pass on
liability to next generation
RENEWABLE ENERGY
as base energy source

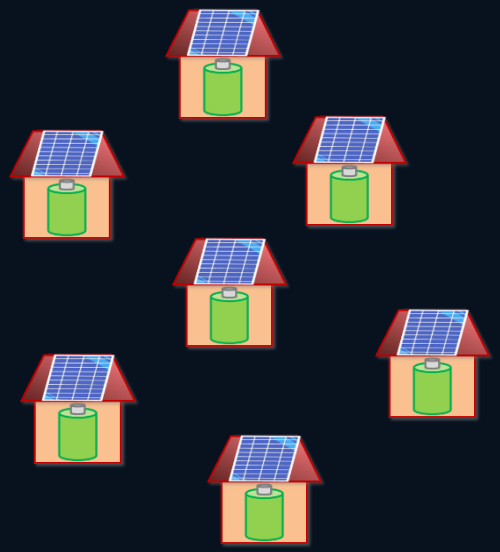
Community Grid

Keep risk manageable
BOTTOM-UP,
energy **EXCHANGE** system

Accessible to everyone on earth
Can start with
SMALL INVESTMENT

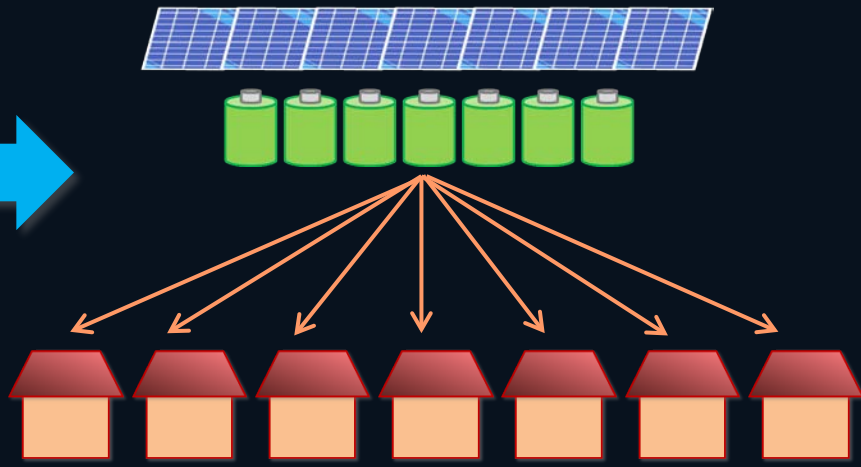
Topologies for Renewable Energy Systems

Distributed stand-alone system



vs

Centralized system



Bottom-up by individuals

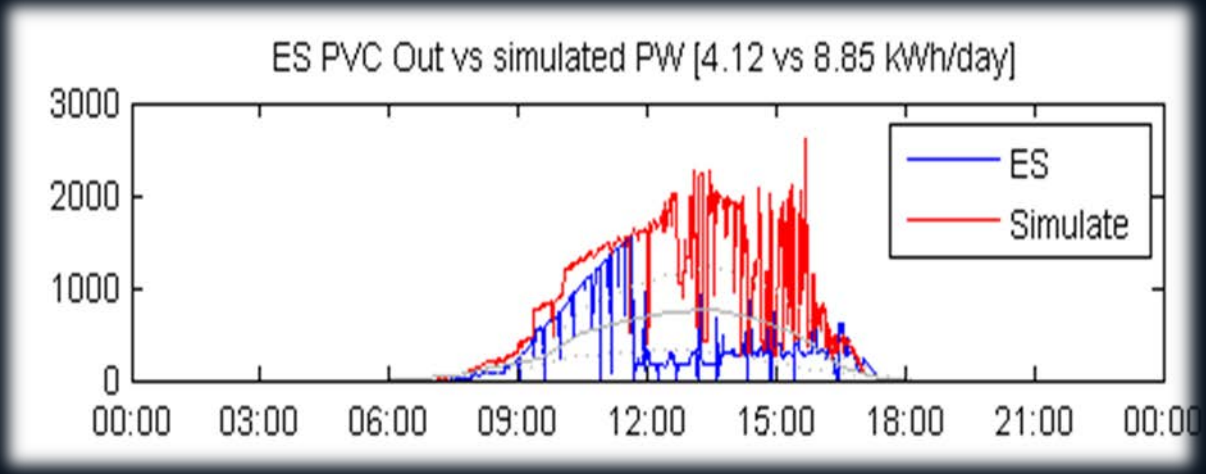
- May not be efficient overall
- Failures do not cause total system outages
- Low initial costs

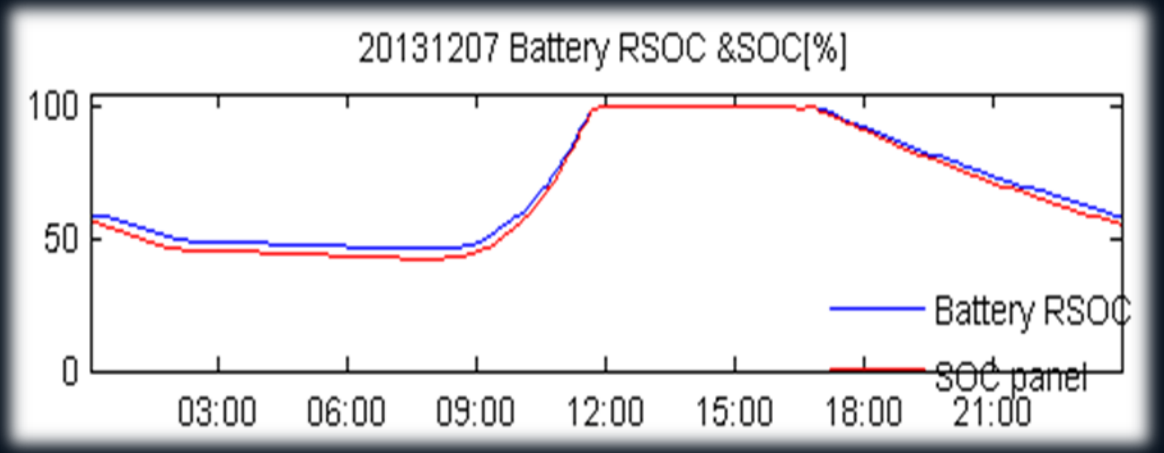
Top-down by a single entity

- Overall efficient for a predefined users and usage patterns
- Single failure may cause total system outage
- High initial costs

What Happens in Reality (1)

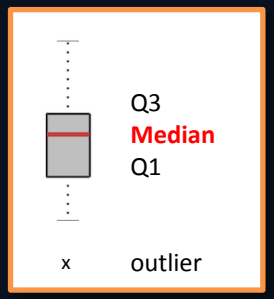
Batteries cannot take whole energy produced

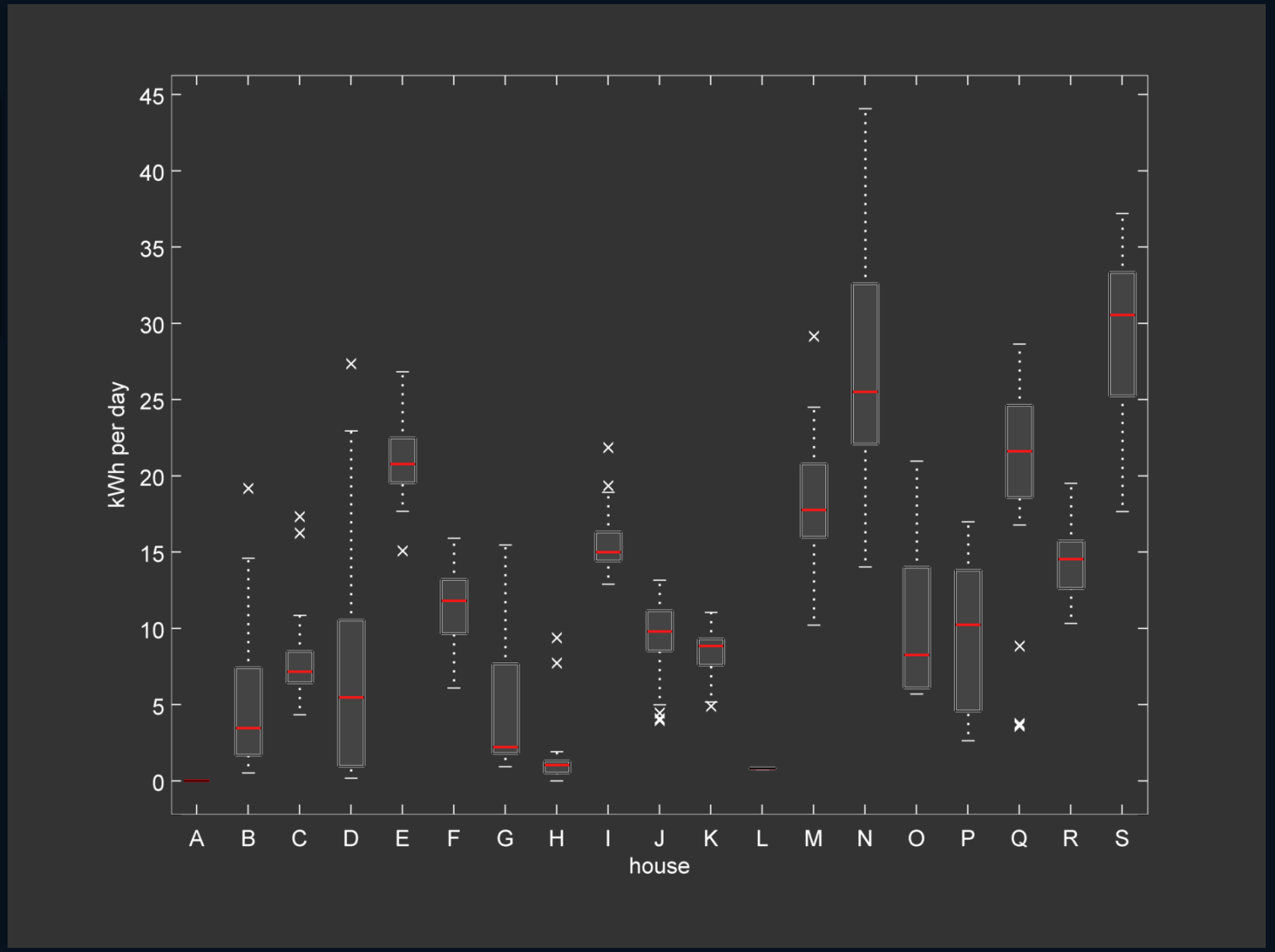




What Happens in Reality (2)

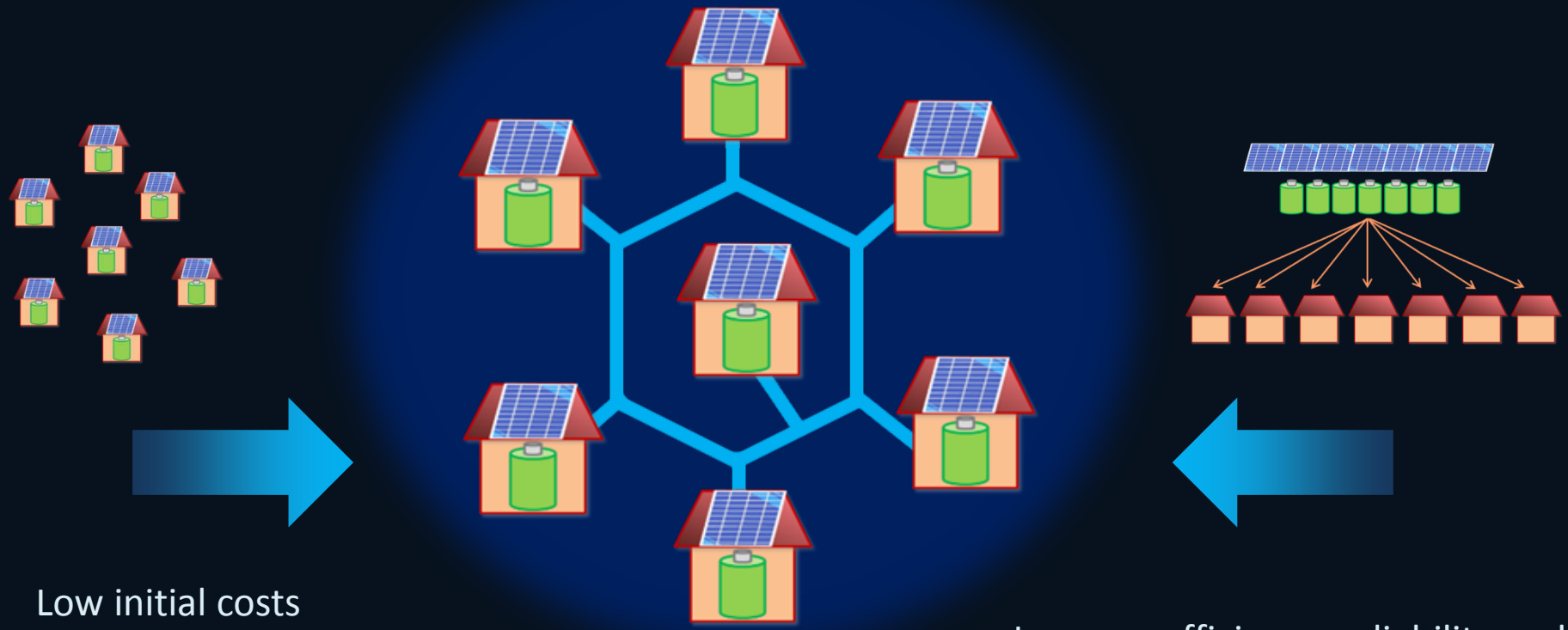
Variety in usage pattern





DCOES: Distributed System with Energy Exchange

DCOES

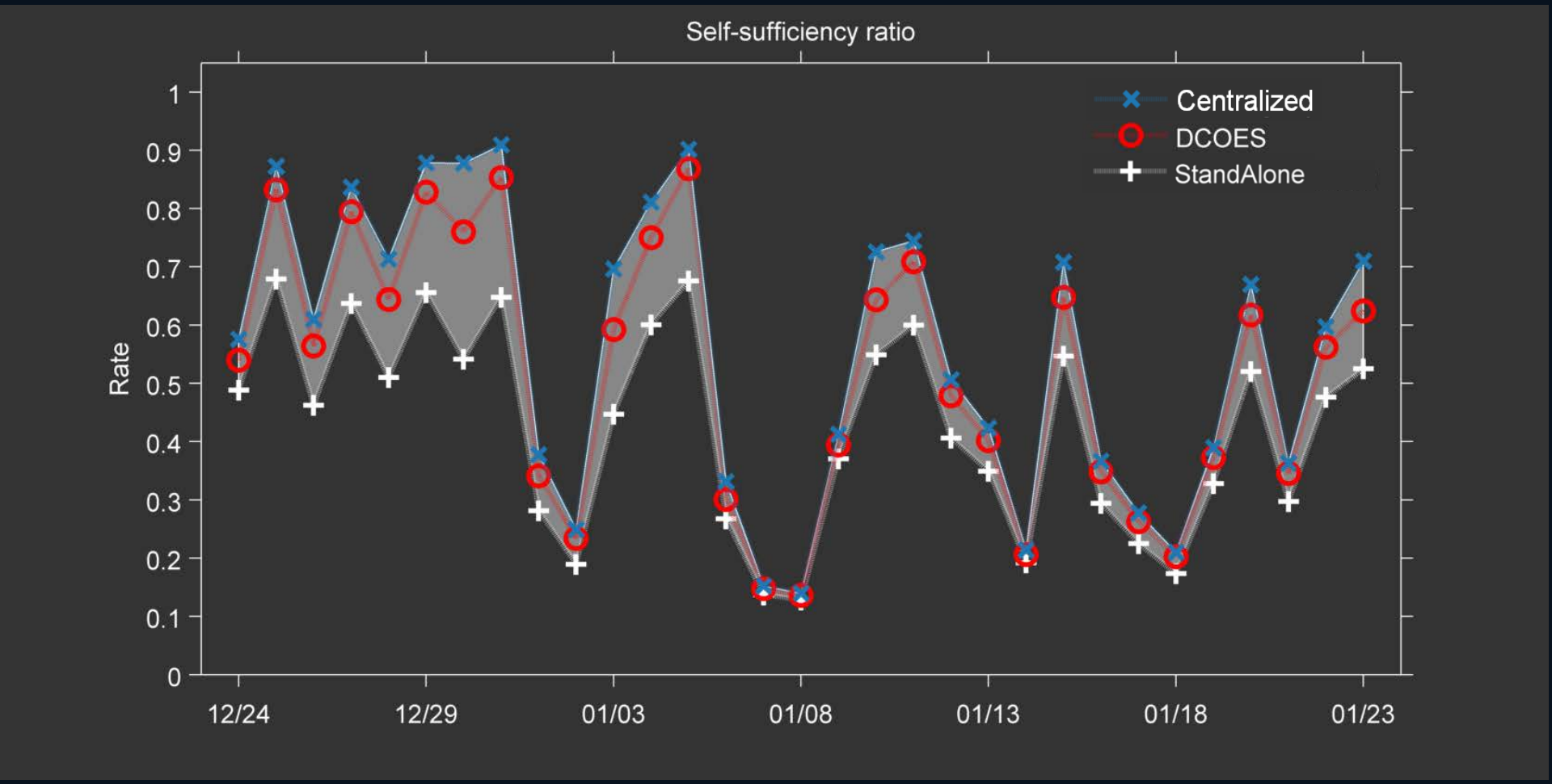


- Low initial costs
- Flexible in size and variety
- Keep independence from grid

- Improve efficiency, reliability and dependability

Self-Sufficiency Ratio

Winter: Real OIST Data: 2014/12/24- 2015/1/23 : 31 days of 19 houses consumptions



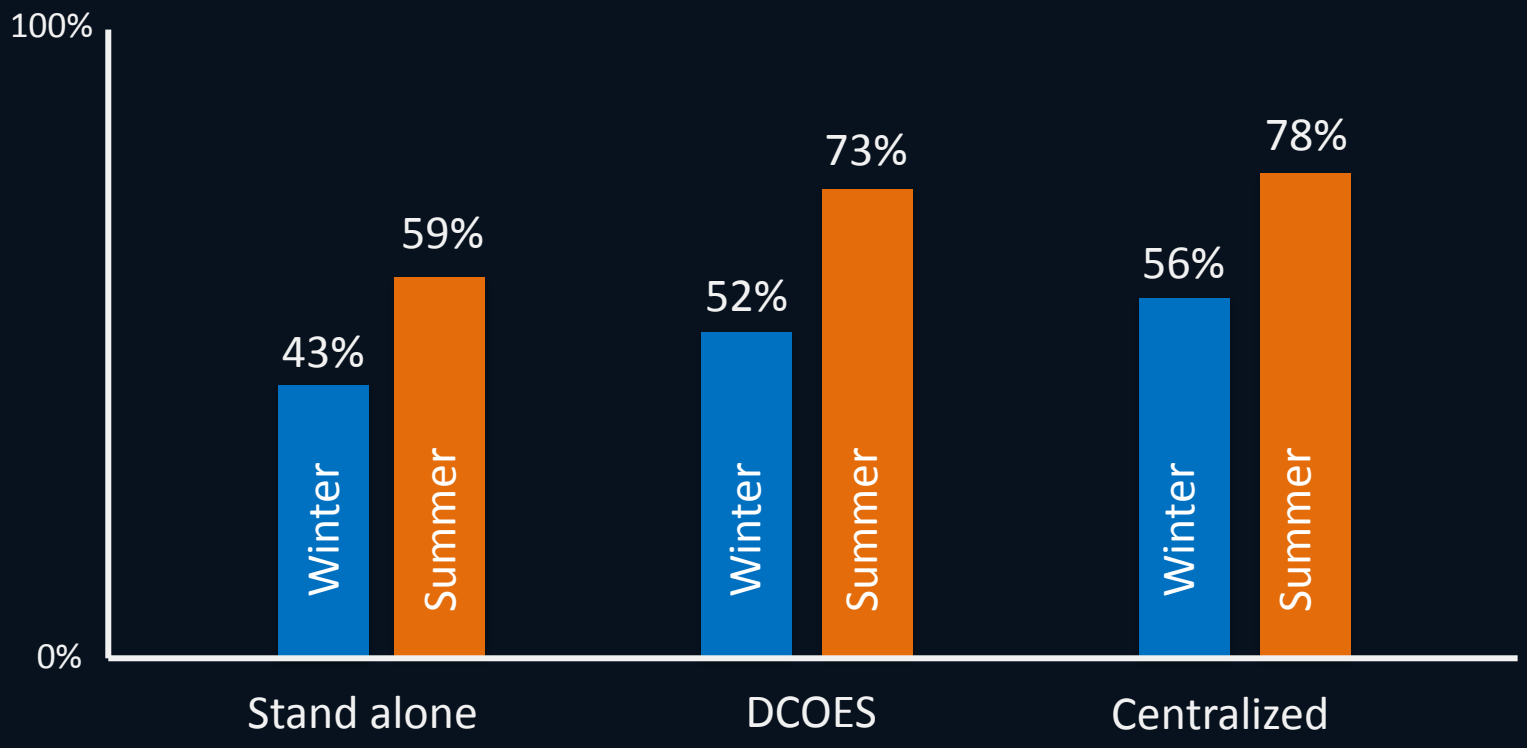
Self-sufficiency ratio =

$(Energy_{consumption} - Energy_{shortage}) / Energy_{consumption}$

Performance Estimation
(Current OIST configuration)

Winter: Real OIST Data
Date : 2014/12/24- 2015/1/23 : 31 days
19 houses consumptions.

Summer: Estimation by simulation
Date : 2014/7/16- 2014/8/15 : 31 days
19 houses expected consumptions.

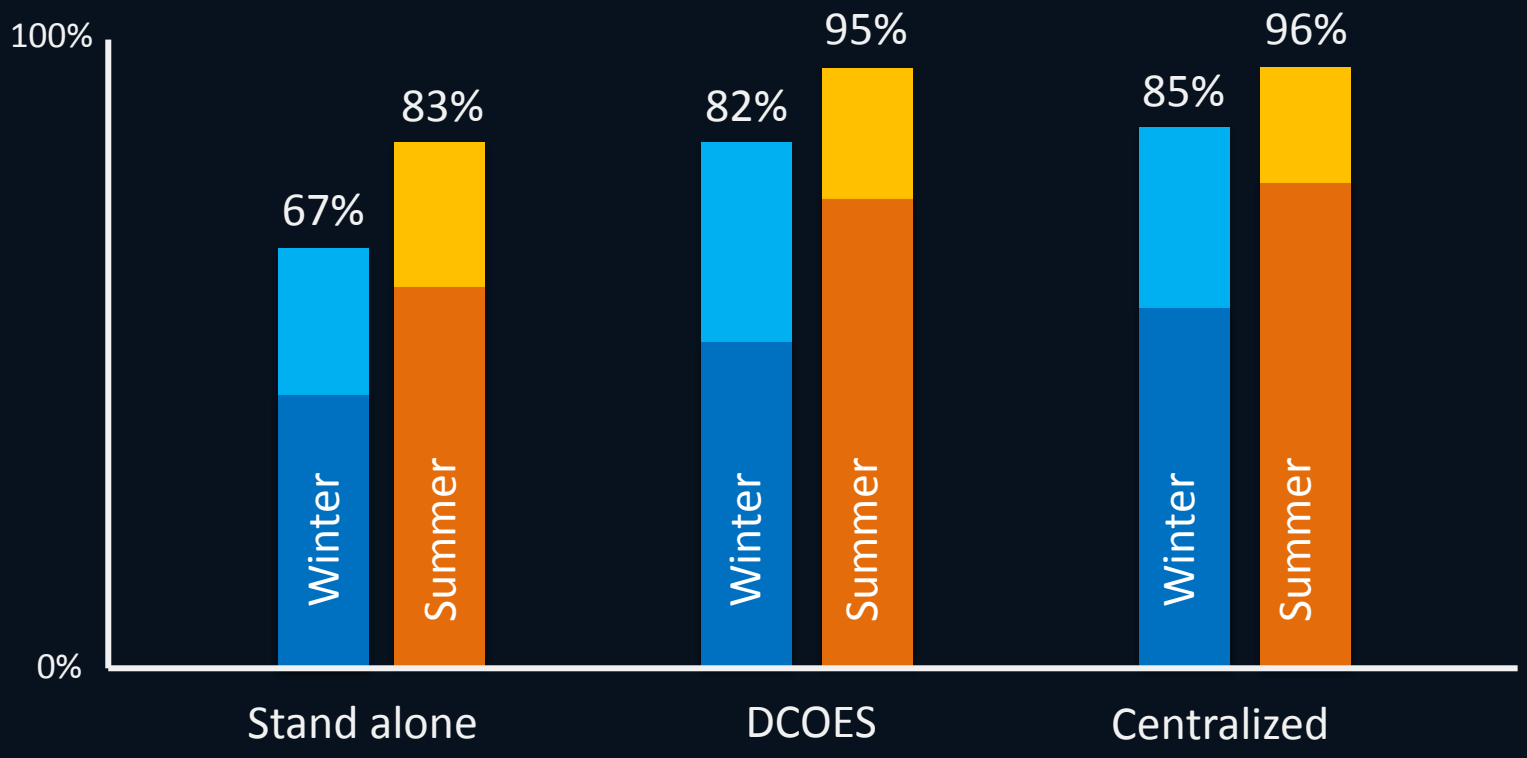


Self-sufficiency ratio = $(Energy_{consumption} - Energy_{shortage}) / Energy_{consumption}$

Performance Estimation
(Solar x2, Battery x2)

Winter: Real OIST Data
Date : 2014/12/24- 2015/1/23 : 31 days
19 houses consumptions.

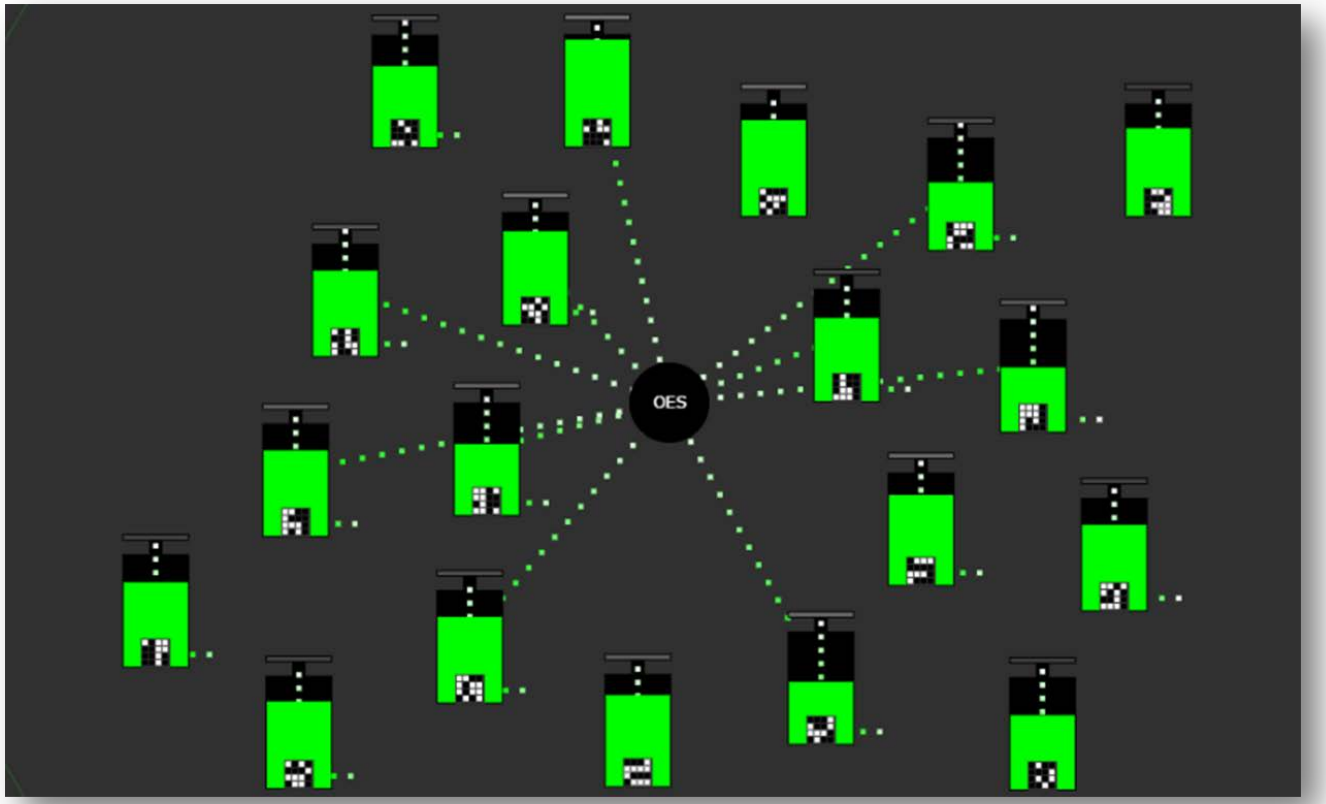
Summer: Estimation by simulation
Date : 2014/7/16- 2014/8/15 : 31 days
19 houses expected consumptions.



Self-sufficiency ratio = $(Energy_{consumption} - Energy_{shortage}) / Energy_{consumption}$

Comparison and Summary

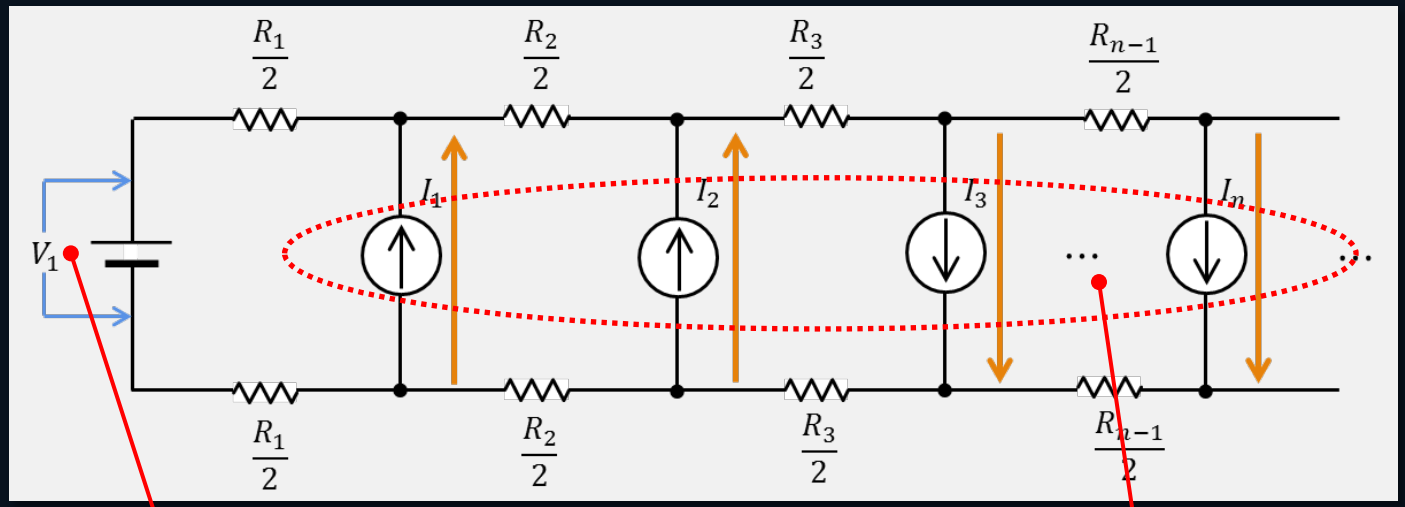
	Stand alone	DCOES	Centralized
Cost	***Low***	***Low*** *initial cost (exch. networks)*	***High*** *initial cost (dist. networks)*
Flexibility	***High***	***High***	***Low***
Efficiency	***Low***	***High***	***High***
Dependability	*Individual*	***High***	***Low***



HOW DO WE EXCHANGE ENERGY?

(1) Mechanism

1 Voltage Source and n Current Sources



Voltage source keeps the grid voltage at 350V

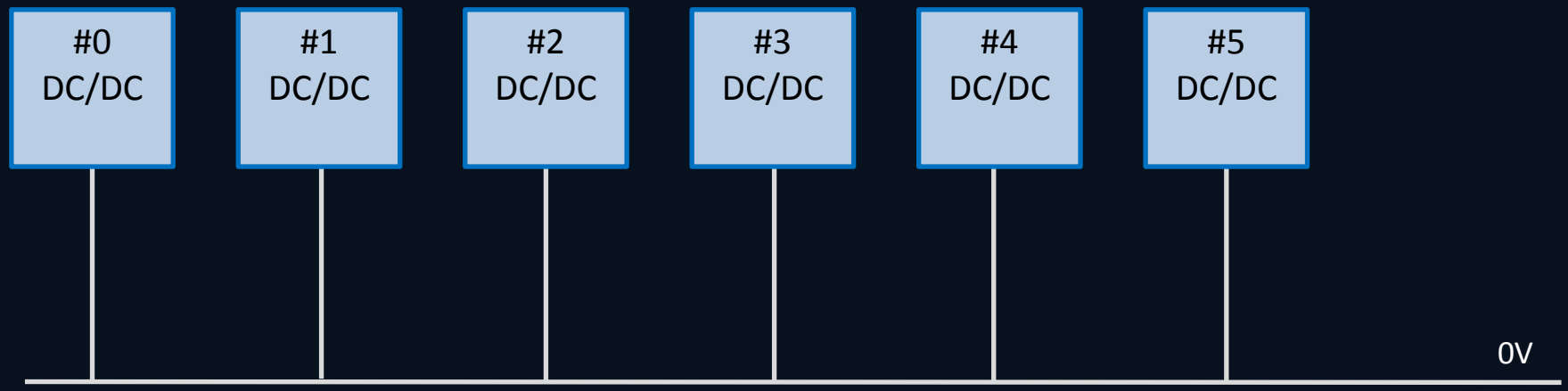
Current sources set desired current

With Durable and Flexible Distributed Control

n-to-n Energy Exchange

DC/DC converter can have 3 modes:

- Waiting (stop)
- Constant Voltage mode (CV)
- Constant Current mode (CC)



n-to-n Energy Exchange

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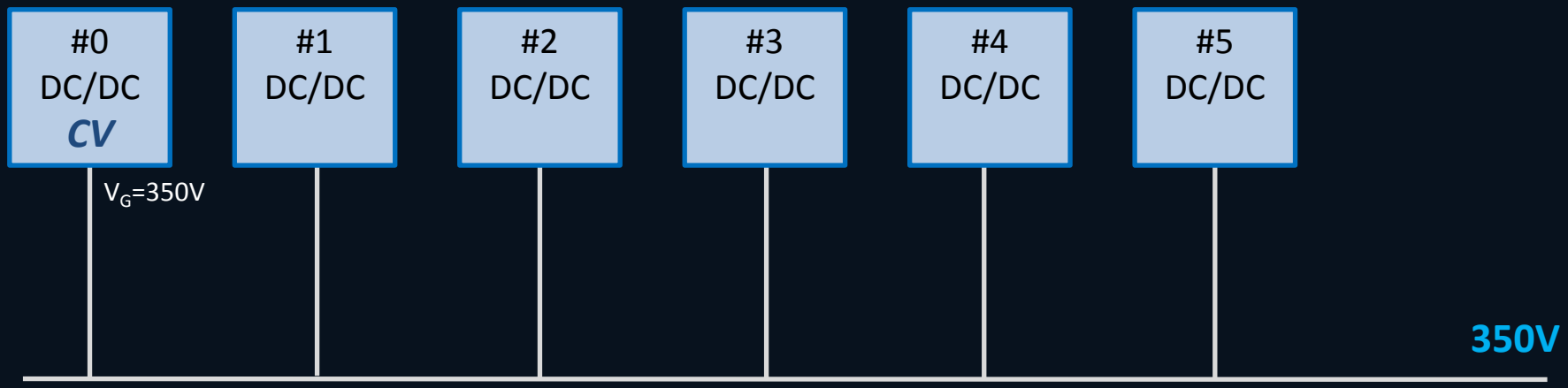
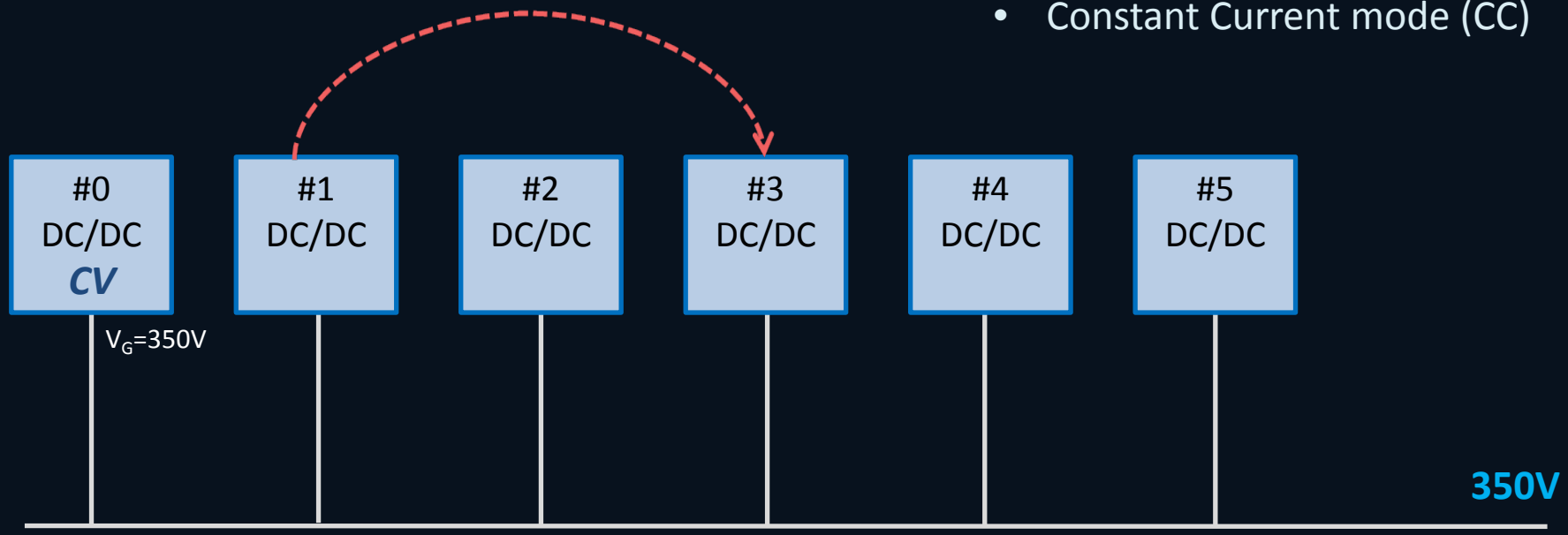


Set the Grid to 350V by CV mode (#0)

n-to-n Energy Exchange

DC/DC converter can have 3 modes:

- Waiting (stop)
- Constant Voltage mode (CV)
- Constant Current mode (CC)



Set the Grid to 350V by CV mode (#0)

Deal 1: Send energy from #1 -> #3

n-to-n Energy Exchange

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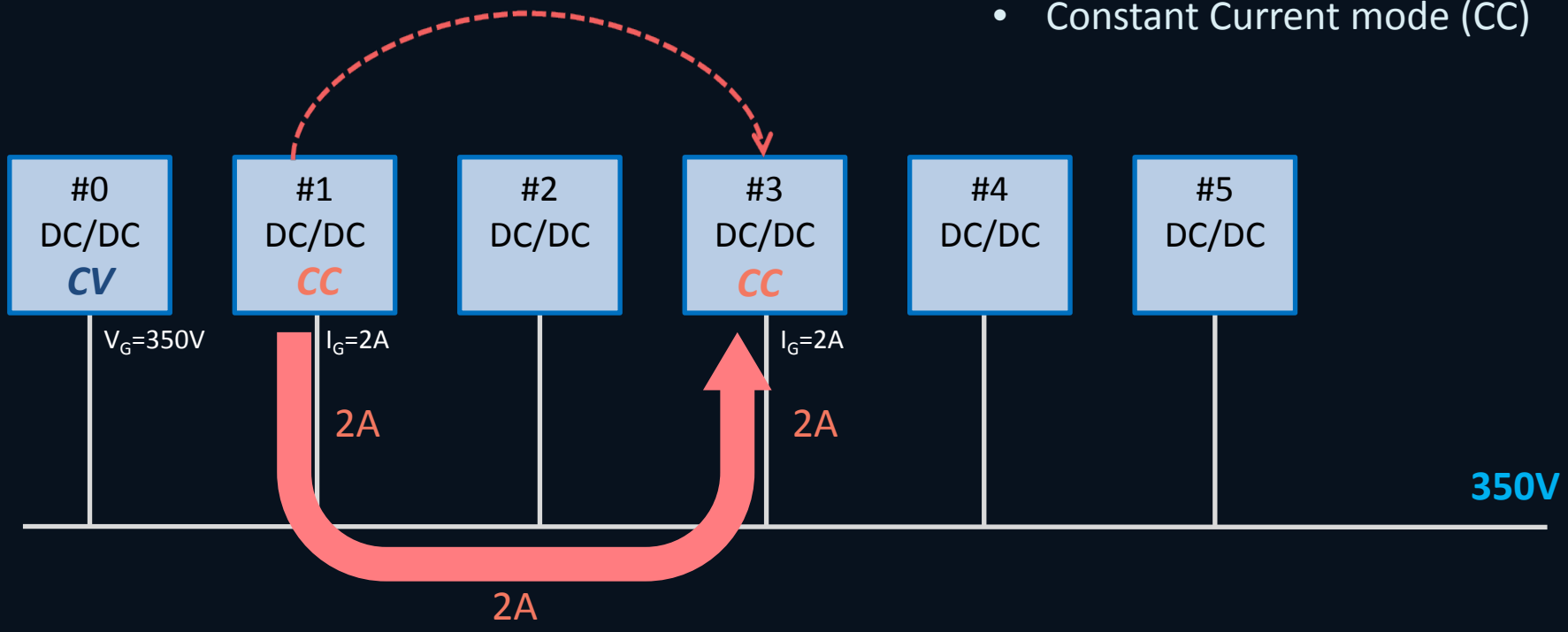

Set the Grid to 350V by CV mode (#0)

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n-to-n Energy Exchange

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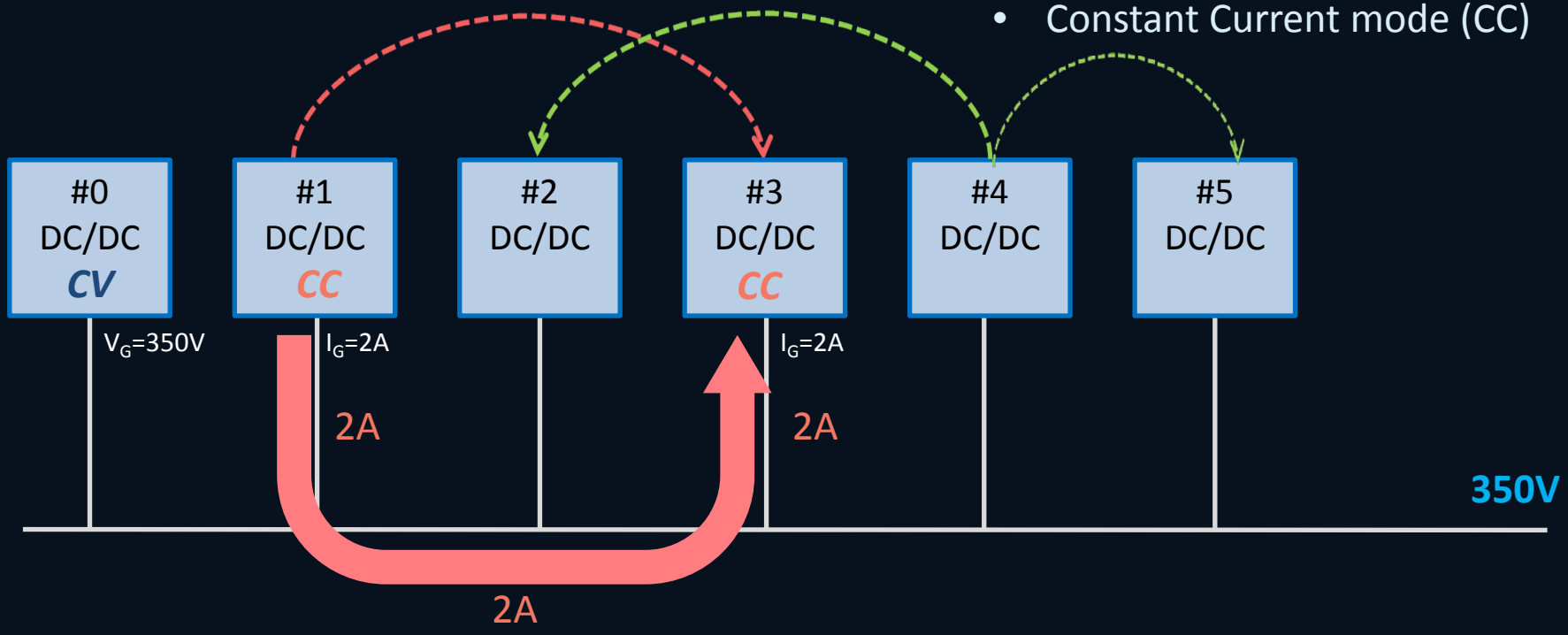


Set the Grid to 350V by CV mode (#0)

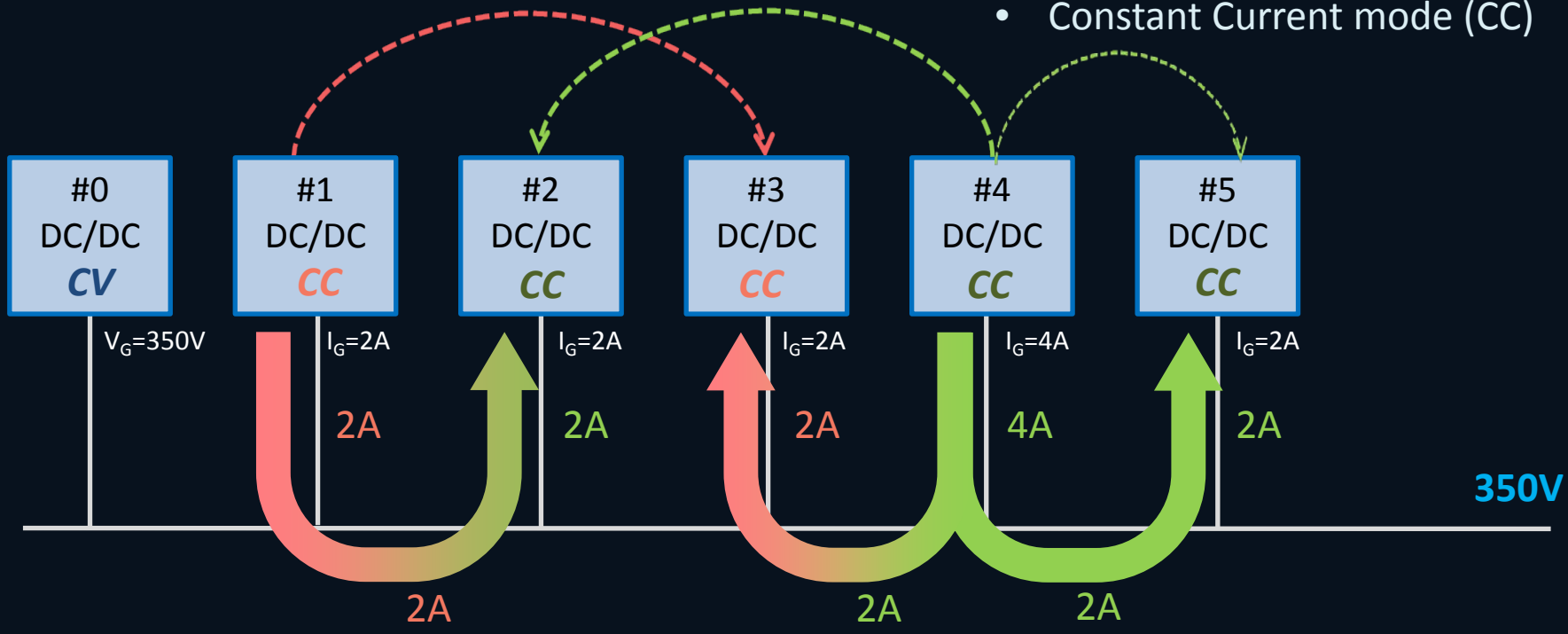
Deal 1: Send energy from #1 -> #3

Deal 2: Send energy from #4 -> #2, #5

n-to-n Energy Exchange

DC/DC converter can have 3 modes:

- Waiting (stop)
- Constant Voltage mode (CV)
- Constant Current mode (CC)



Set the Grid to 350V by CV mode (#0)

Deal 1: Send energy from #1 -> #3

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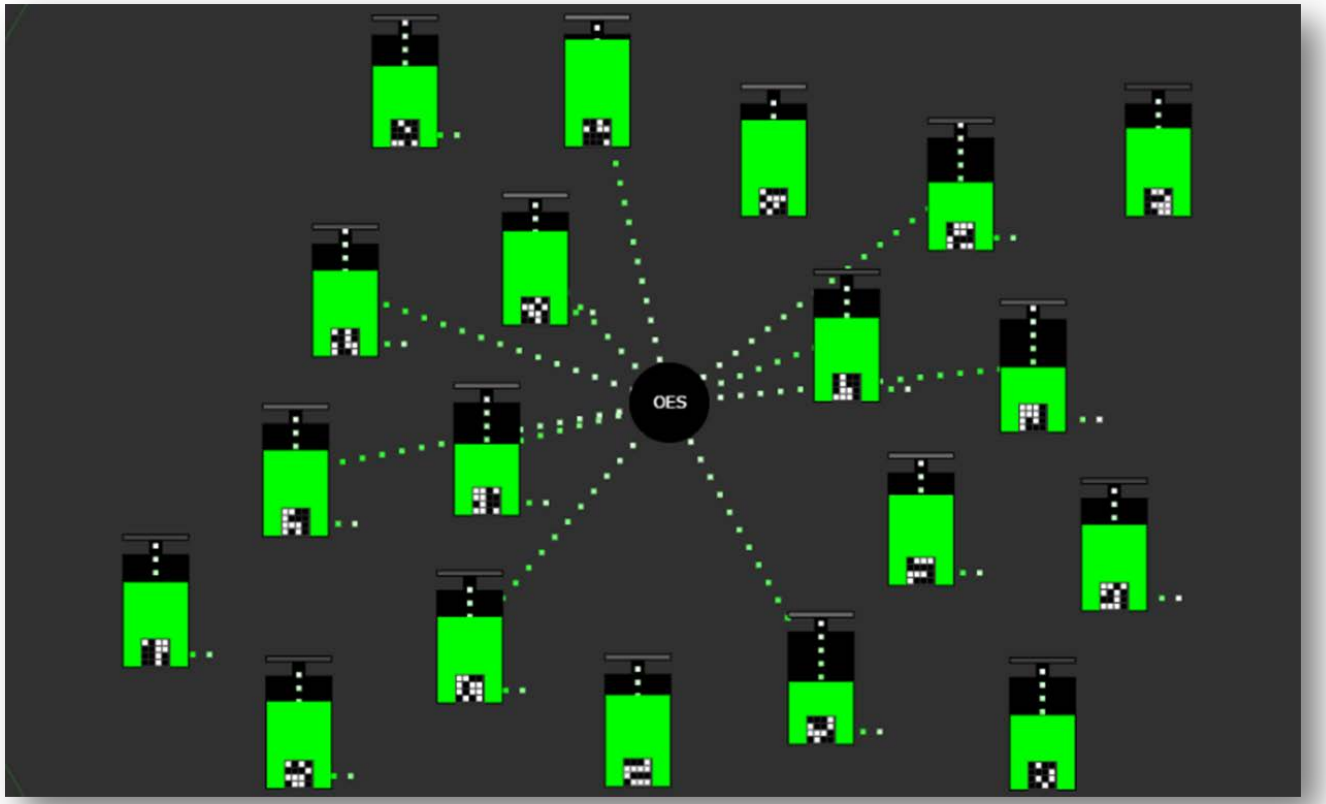
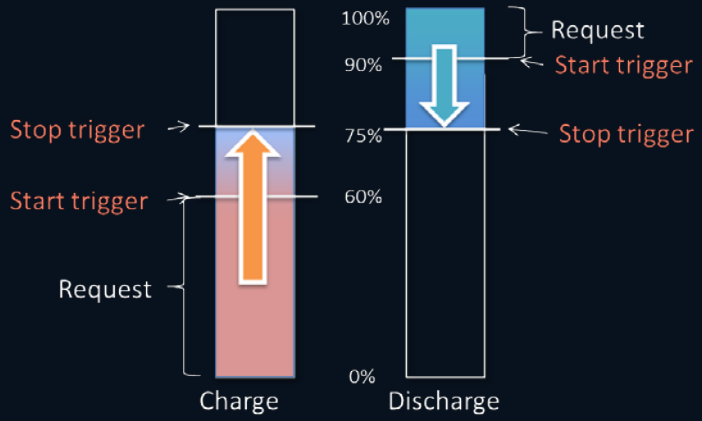
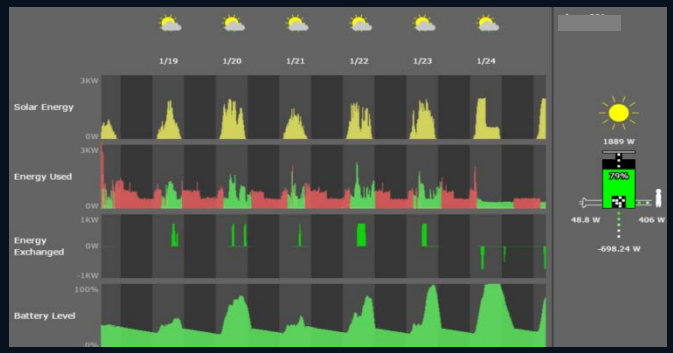


HOW DO WE EXCHANGE ENERGY?

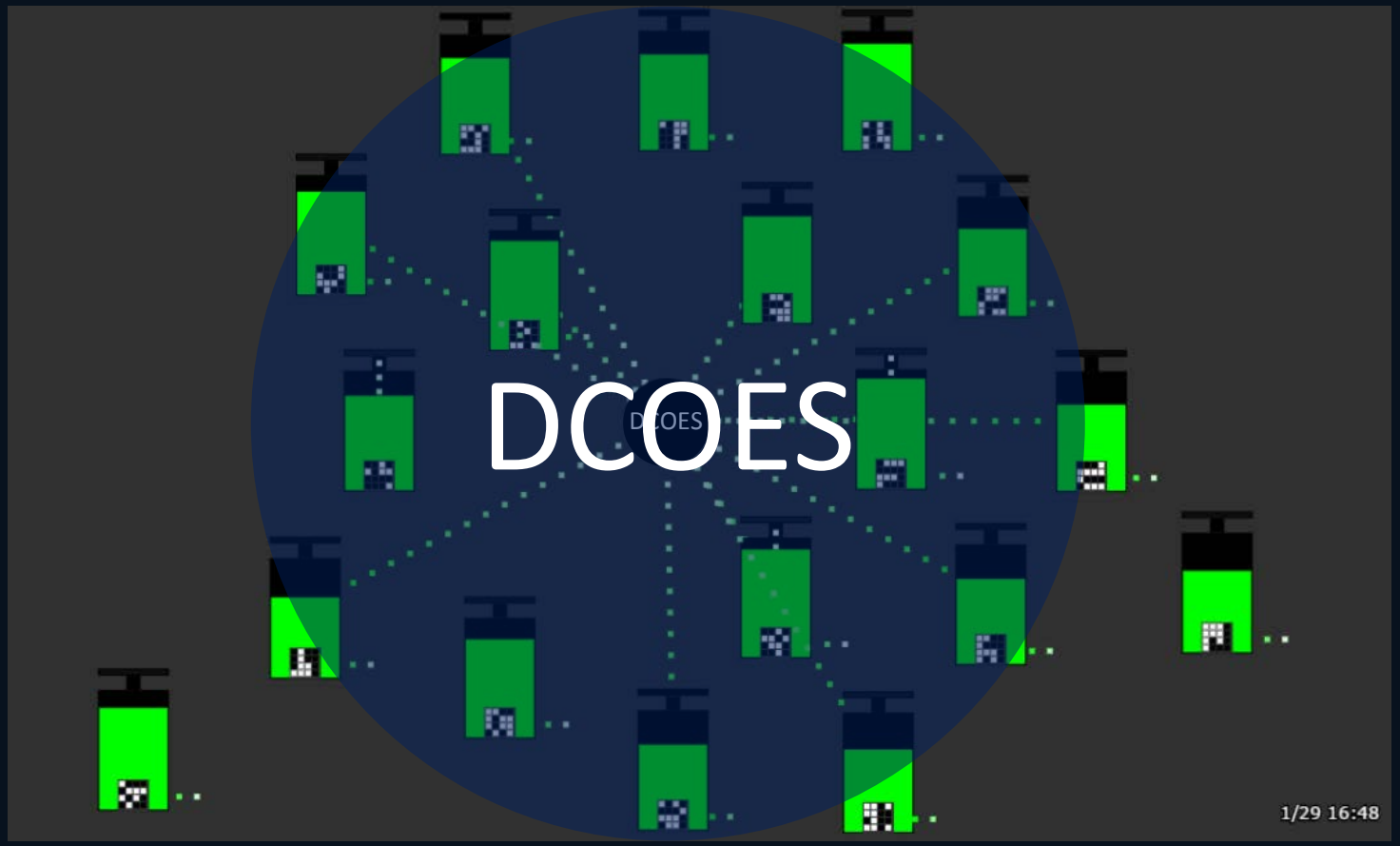
(2) Policy

- Capacity available for giving/ capacity request for receiving
- Prediction based on past usage pattern
- Weather forecast for generation and consumption
- Demand-response





- Virtual Energy Provider



DCOES PROJECT

DCOES Project

Research Consortium for
“Subtropical and Island Energy Infrastructure Technology Research Subsidy Program”

- **Mar. 2013 – Mar. 2015 (optionally 2-year extension)**
- **Supported by Okinawa Prefectural Government**
- **Solutions and new business for energy issues in Okinawa, island countries and the world**

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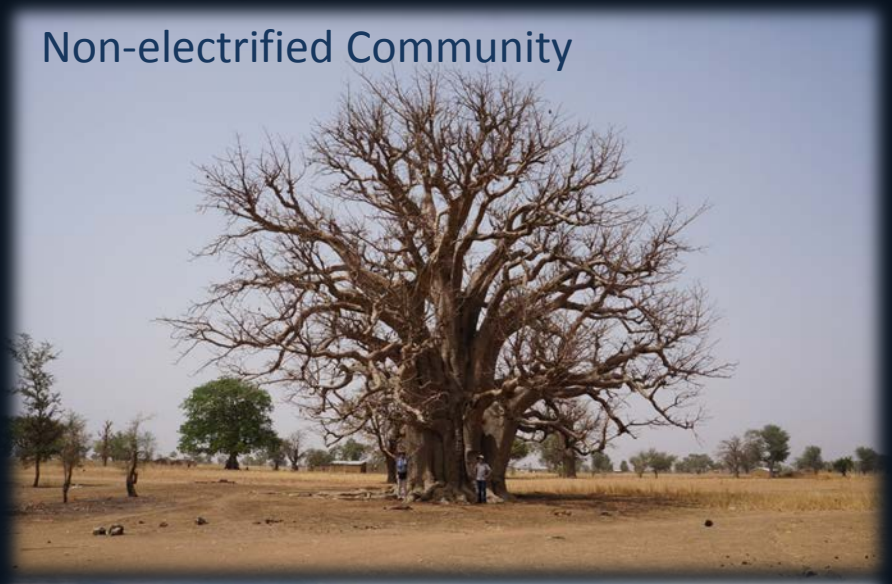
Sony Energy Device
Sony Business Solutions

FUTURE PLANS

Future Plan (1)

Small Rural Community

Non-electrified Community

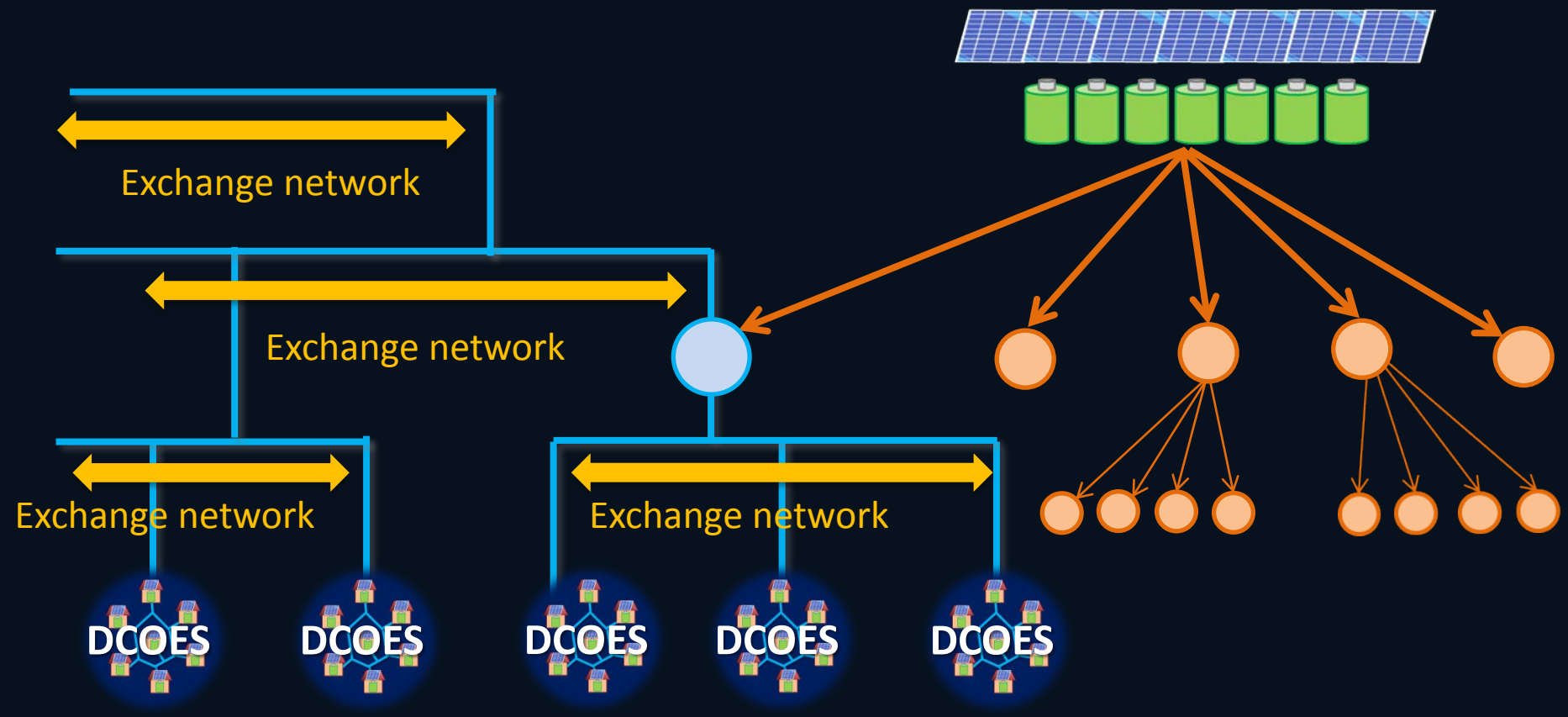


Small Island

Big Island

Future Plan (2)

- Hierarchical and Hybrid installation

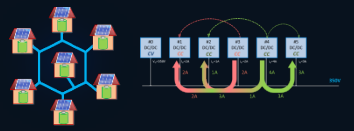


Future Plan (3)

- DC Houses
  - DC Air conditioner (collaboration with Daikin)
  - LED lights
  - DC Appliances
    - Needs standardization of home DC appliances

Conclusion

- DCOES: DC-based, bottom-up, energy exchange scheme
- Proven with real implementation and exploitation at OIST campus
- DCOES as a Community Grid for everyone




Thank You!