JAPAN / CANADA RESULTS FORUM

SOLAR ENERGY MANAGEMENT SYSTEMS

FEBRUARY 19, 2019

NEDO

Oshawa
Prepare To Be Amazed

TABUCHI ELECTRIC

Oshawa PUC Energy Services

WELCOME

CONTEXT

INTERNATIONAL PARTNERSHIP

Demonstrate System Effectiveness

- Behind-the-meter generation
- Storage
- Back-up power
- Peak shift

Demonstrate Technology Benefits

- Grid optimization
- Greenhouse Gas reductions
- Homeowner resilience
- Development of energy prosumers

Define a Business Case

- Utility ownership model
- Software optimization

PRACTICAL IMPLEMENTATION

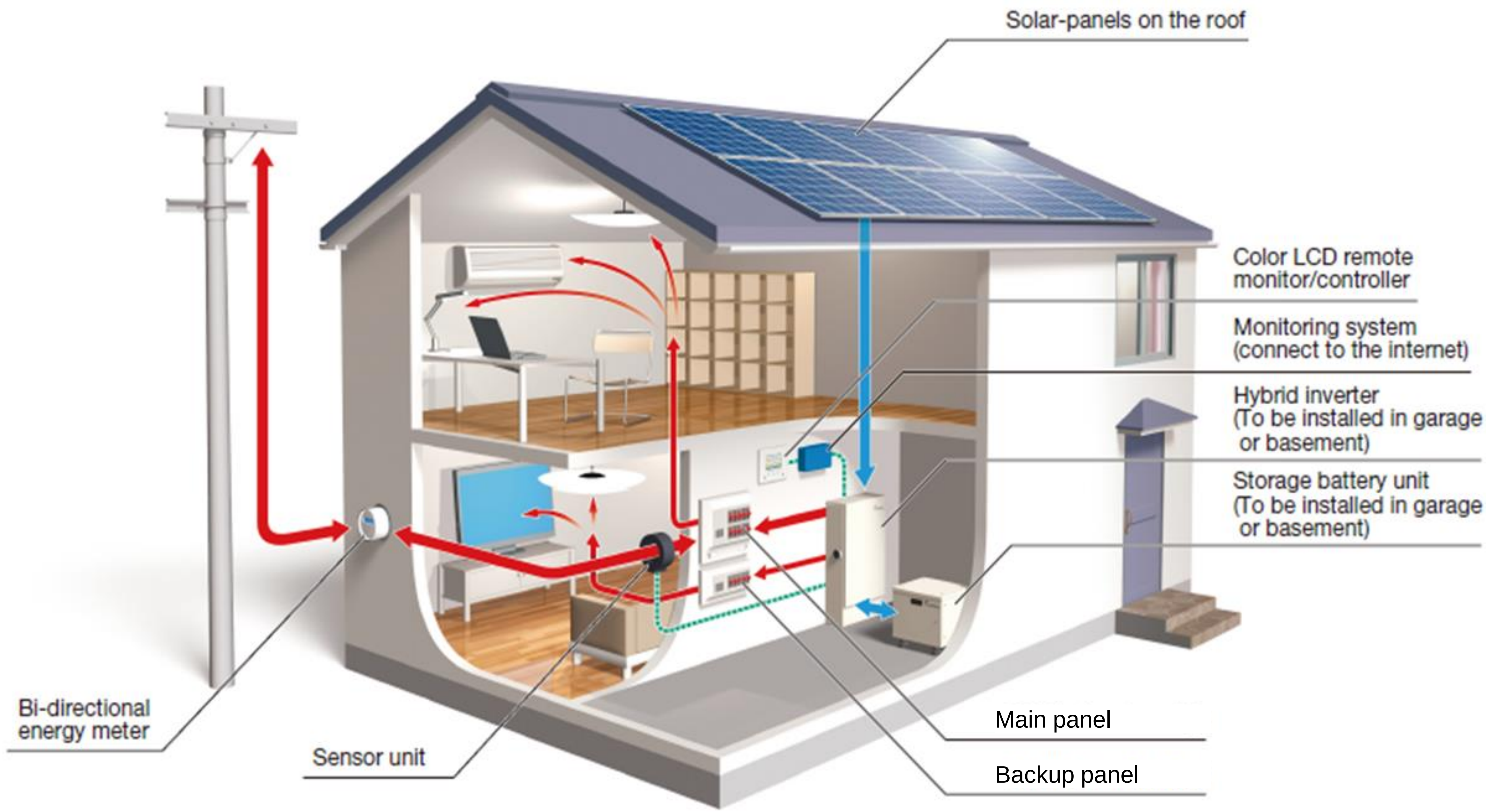
- 30 homes
- ~6-7 kW solar PV (roughly 20 panels)
- Tri-functioning inverter
- 10 kW Lithium-Ion battery
- Net metering contract – 10 ¢/kWh
- 5 years

TIMELINES

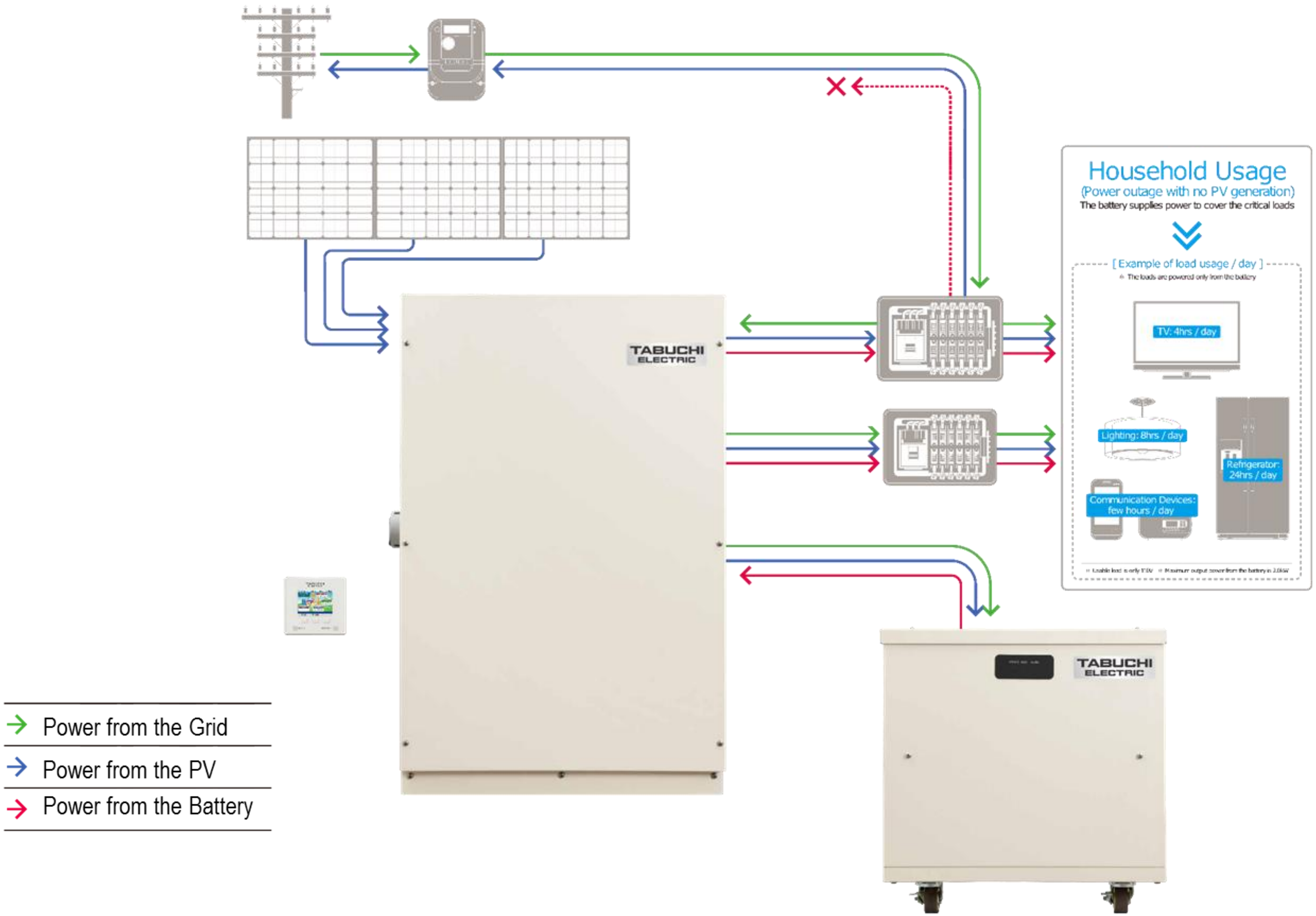
OBJECTIVE	MILESTONE ACHIEVED
Study and Implementation Technical diagrams and plans Financial simulations Contracts with 30 homes	March 2015
Demonstration and Evaluation Installations System tests Data sharing and analysis	February 2018
Publish Results Share with international community	Ongoing


TECHNOLOGY

INSTALLATION DIAGRAM



HYBRID SOLAR INVERTER & BATTERY SYSTEM



TABUCHI – LEADING TECHNOLOGY

- Different charge/discharge controls may be set for the three system operational modes.
- Residents on site can freely control the operational mode.

1. Max power export mode: priority on economic benefits

Power is charged and discharged at preset times. Charging may not occur during solar power generation as priority is placed on the export of photovoltaic power. Electric power is purchased for storage late at night at inexpensive rates and consumed at home during the day.

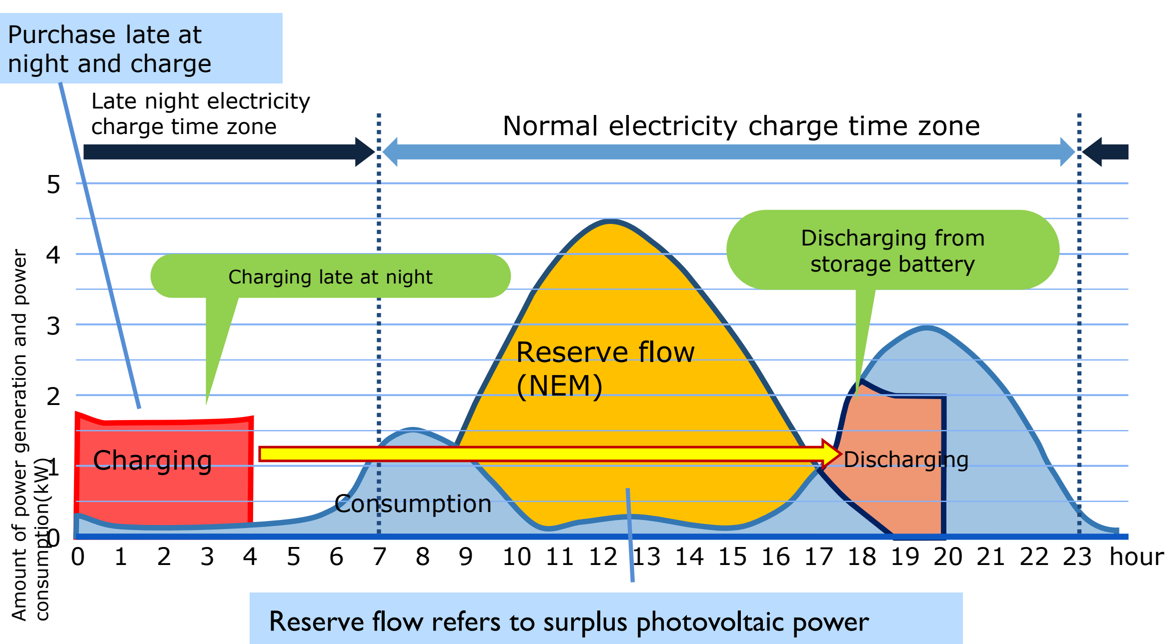
2. Economy mode: priority on self-consumption

Photovoltaic power is generated in the daytime and electricity is consumed during times when photovoltaic power is not generated, such as during the evening and nighttime. This mode aims to store photovoltaic power generated by the system, thereby reducing the amount of electricity purchased and improving the rate of electric power self-sufficiency.

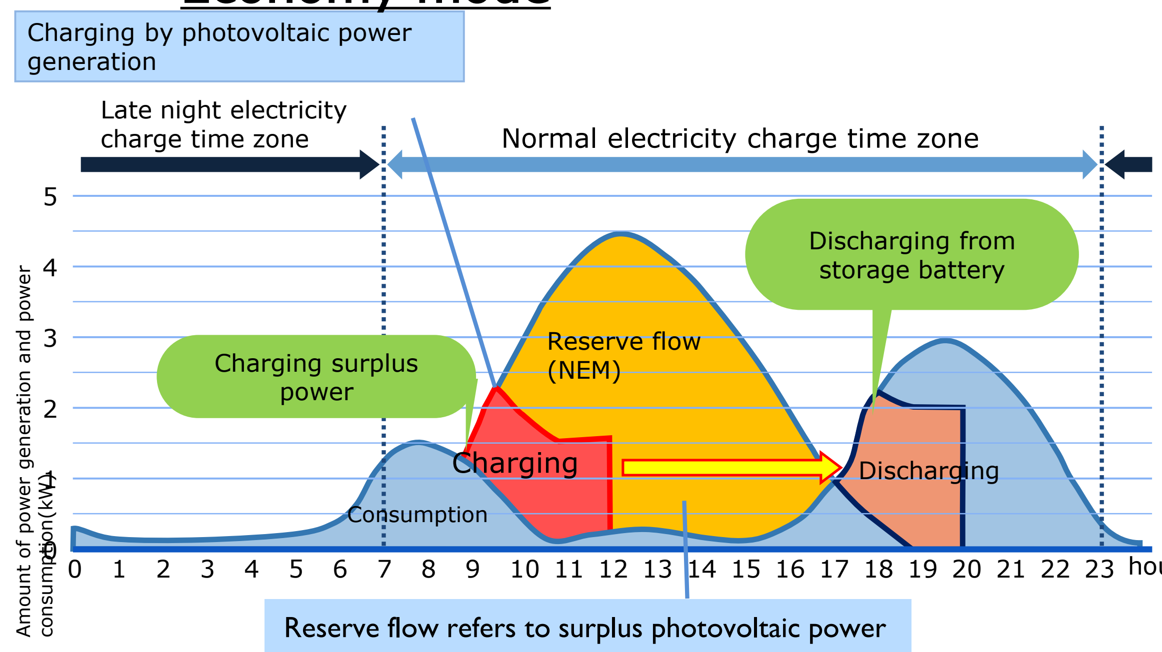
3. Home backup mode: standby for power outages

Storage batteries are kept fully charged in preparation for emergency disasters and power outages.

Max power export mode

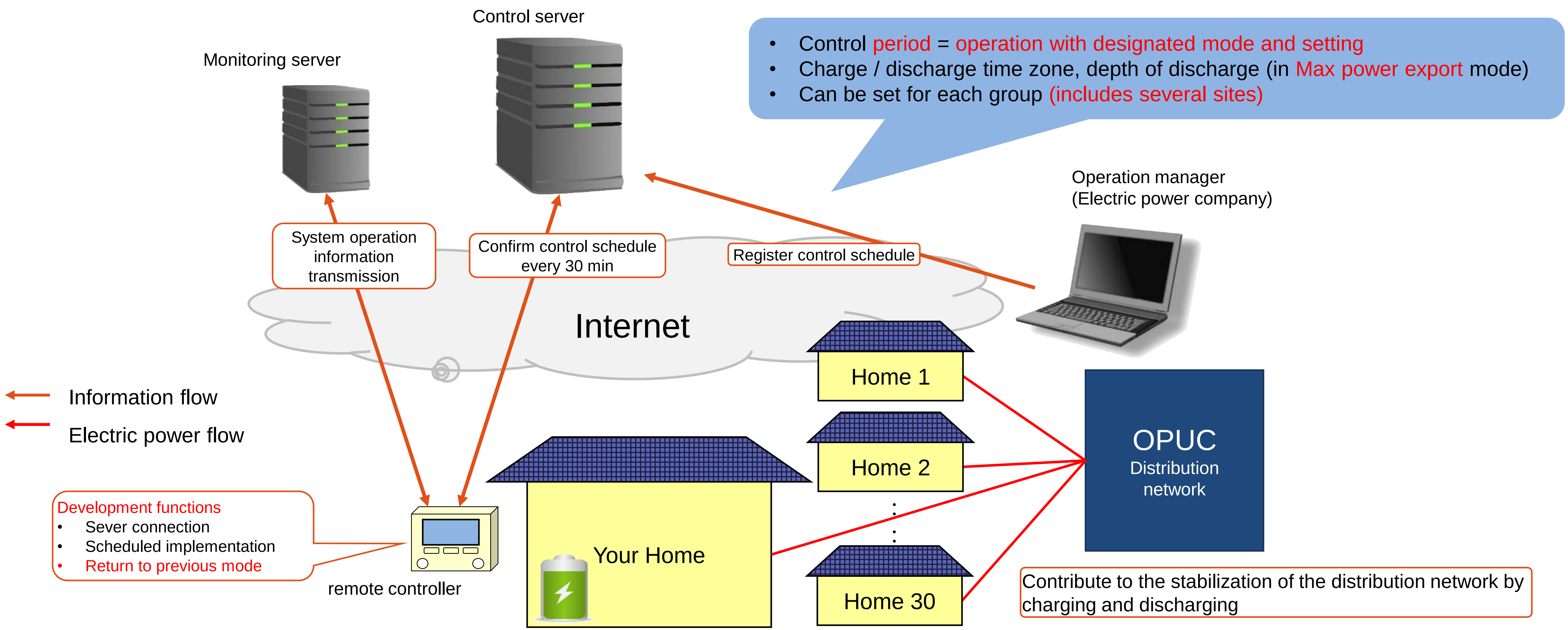


Economy mode

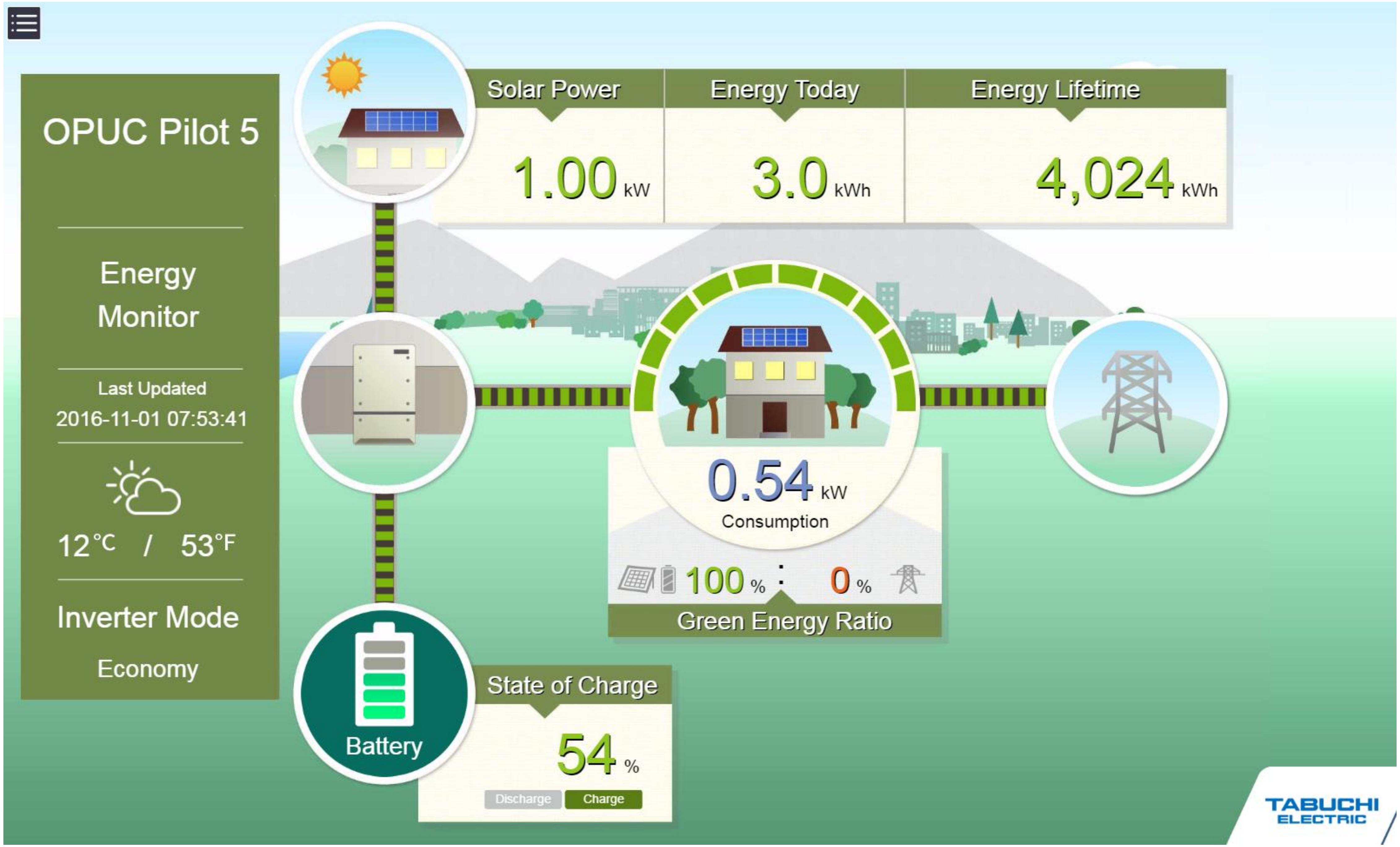


CENTRAL CONTROL FUNCTION

- Add server communication function to the remote controller and change operation mode from remote location via the internet
- Peak control can be realized with Max power export mode＋time setting
- Return to the previous operation which owner set with control completion



USER INTERFACE



GRID-FRIENDLY SOLAR + BATTERY STORAGE SYSTEM BRIDGES THE GAP

Benefits for the grid ⟷ Benefits for users

Grid	Users
▪ Handles the "duck curve" and voltage and frequency controls ▪ Balances solar integration ▪ Saves money through stabilization of the grid ▪ Optimizes major investments in upgrading grid infrastructure transmission/ distribution/substations ▪ Reacts to demand charges	▪ Uses battery for backup when power is out ▪ Contributes to safer communities and lowers business risks ▪ Minimizes "time of use" rates ▪ Eliminates demand charges ▪ Results in lower long-term electricity costs

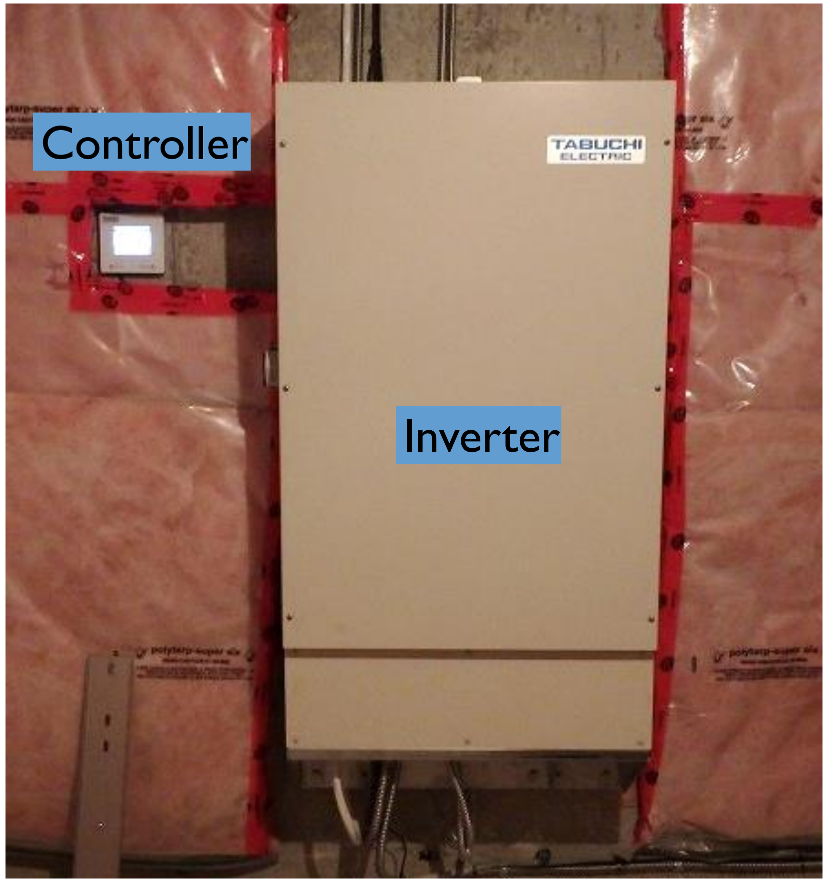
This system is the fastest and least expensive way to implement renewable energy portfolio standards and can be a win-win solution for utilities and users.

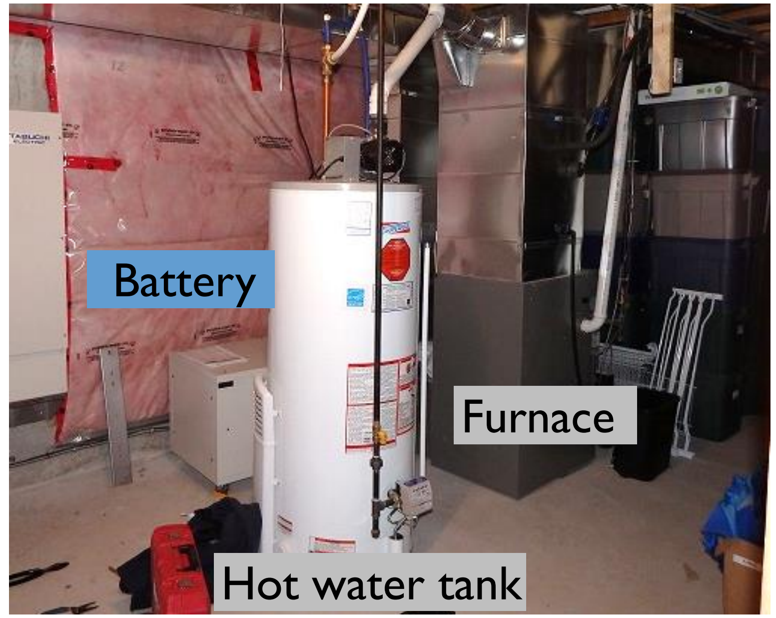
TABUCHI – LEADING TECHNOLOGY

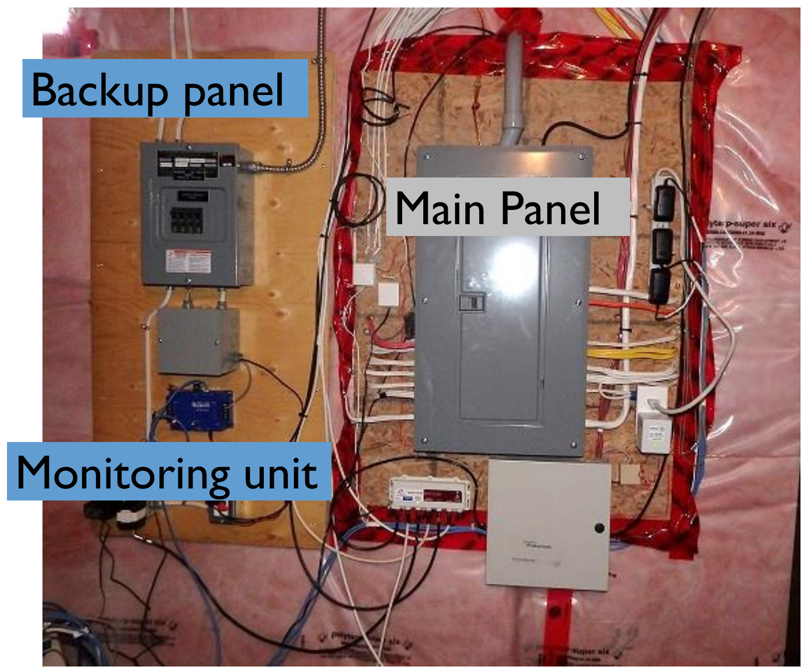
https://youtu.be/9sSfnIL6elc

RESULTS

30 INSTALLATIONS







All of units are installed in basement.

The location of the project's 30 home sites in the city of Oshawa.

CUSTOMER CHOICES

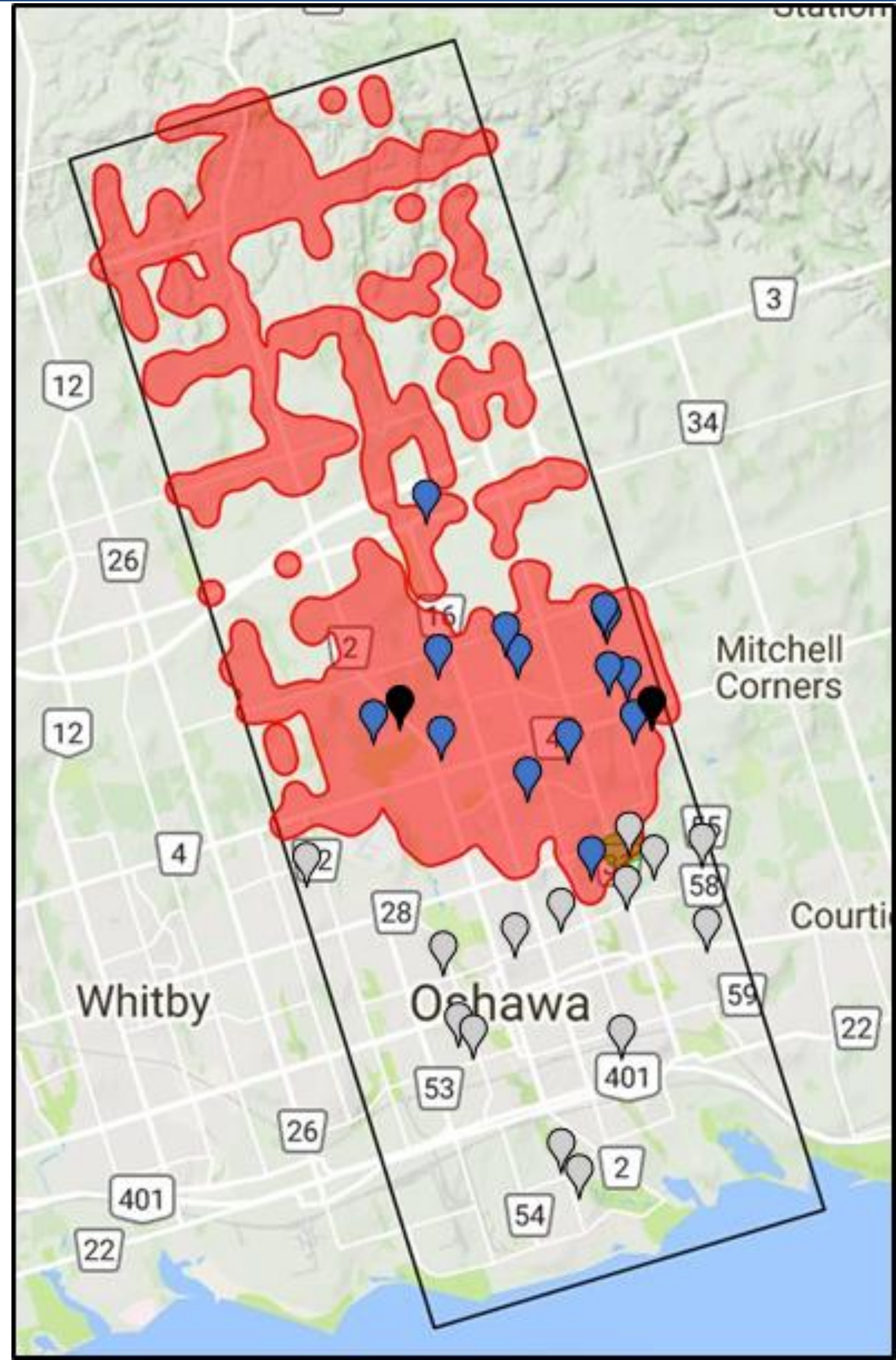
1. Monitoring / internet (30)
2. Furnace (21)
3. Hot Water (19)
4. Refrigerator (9)
5. Smoke detector (6)
6. Freezer (4)
7. Television (4)
8. Boiler (2)
9. Fan (2)
10. Telephone (1)

OUTAGE PERFORMANCE – STAND-ALONE MODE

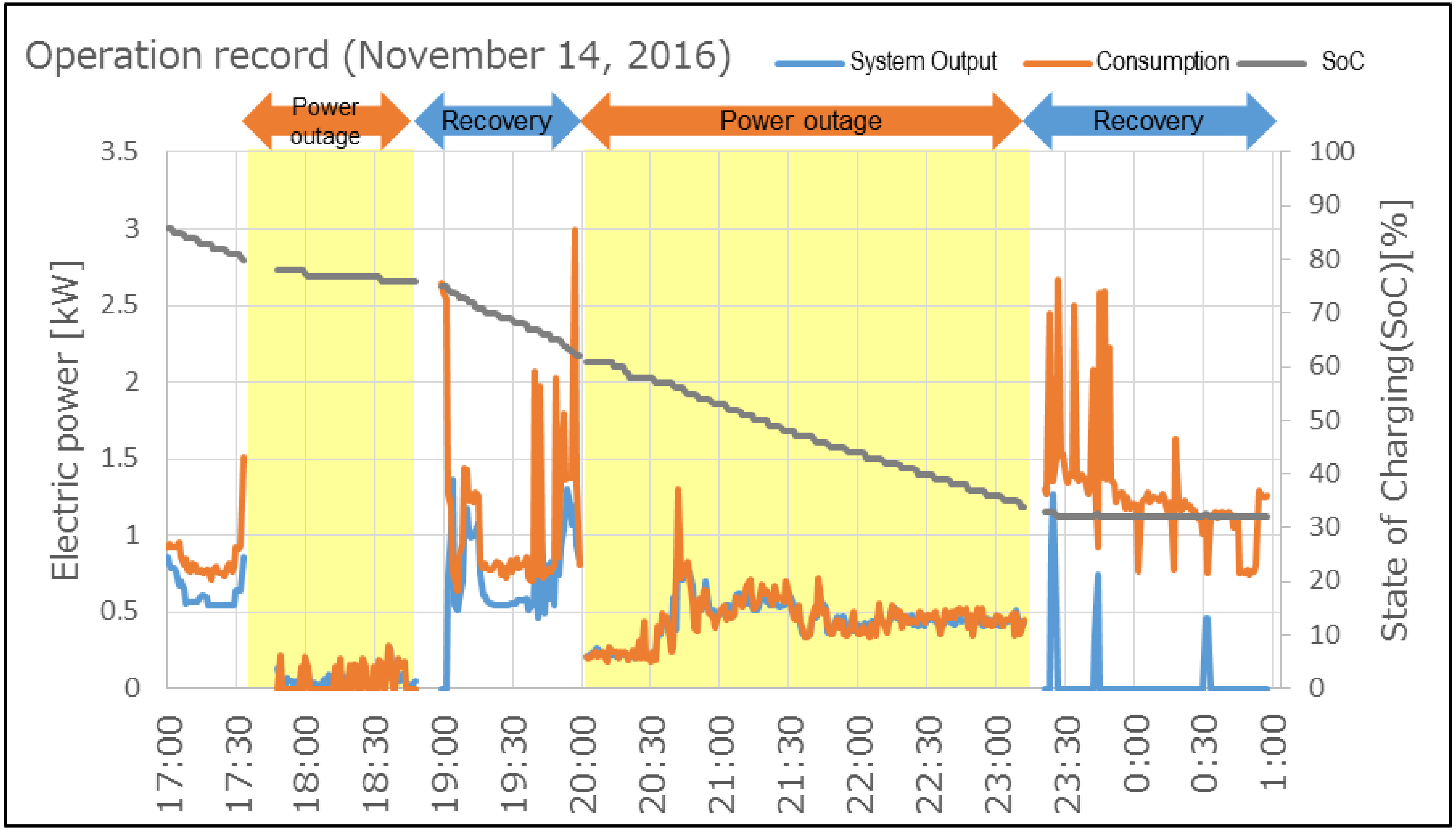
CASE STUDY

November 14, 2016, a power outage occurred in the northern part of Oshawa due to equipment failure (transformer burnout in substation).

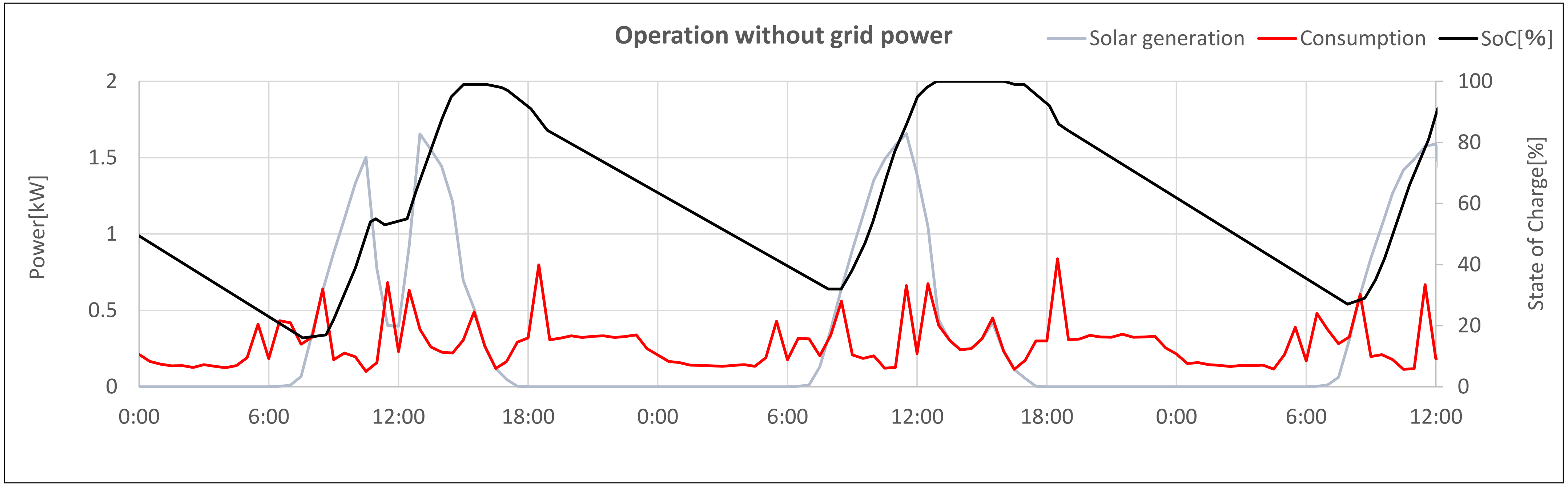
Stand-alone operation was activated for ~3 hours at 14 sites out of the area where power outage occurred, and electric power was supplied during the power outage.



DETAILED ANALYSIS OF OUTAGE PERFORMANCE



CLIMATE RESILIENCE (JAPAN TRIAL)



<table>
<tr><td rowspan="2">Backup load</td><td colspan="24">Time</td></tr>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td></tr>
<tr><td>Refrigerator</td><td colspan="24">Always ON</td></tr>
<tr><td>Electric kettle</td><td colspan="8">keep</td><td>boil</td><td colspan="9">keep</td><td>boil</td><td colspan="5">keep</td></tr>
<tr><td>Rice cooker</td><td></td><td></td><td></td><td></td><td></td><td>cook</td><td colspan="8">keep</td><td></td><td>boil</td><td colspan="4">keep</td><td></td><td></td><td></td><td></td></tr>
<tr><td>LED lighting</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">ON</td><td></td><td colspan="2">ON</td><td></td><td></td><td></td><td></td><td colspan="7">ON</td></tr>
<tr><td>Air conditioner</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">ON</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Electric fan</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">ON</td><td></td><td></td><td></td><td></td><td colspan="7">ON</td><td></td></tr>
<tr><td>LCD TV</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">ON</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">ON</td><td></td></tr>
<tr><td>Phone charging</td><td colspan="5">Charge</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Notebook PC</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">ON</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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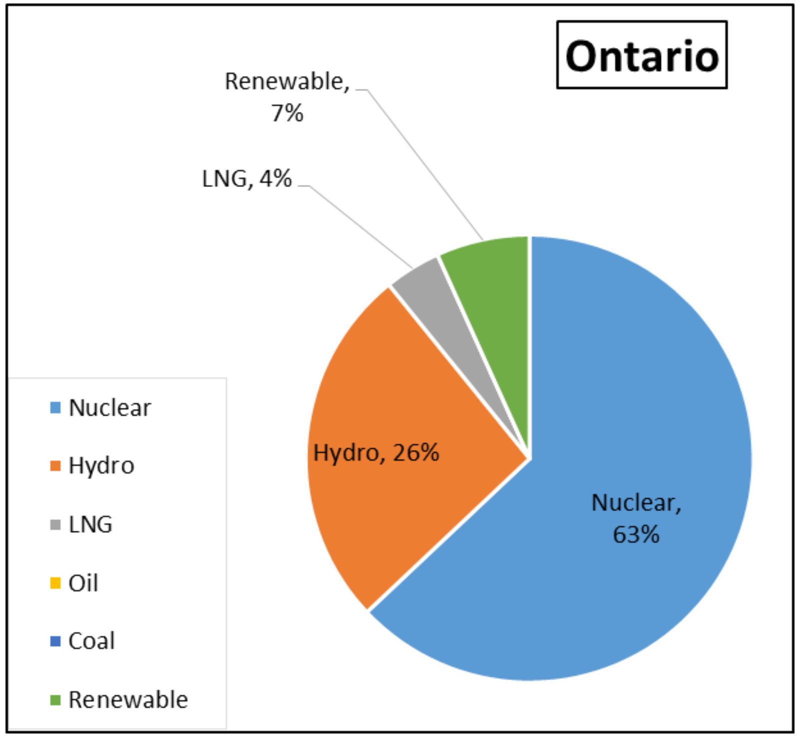
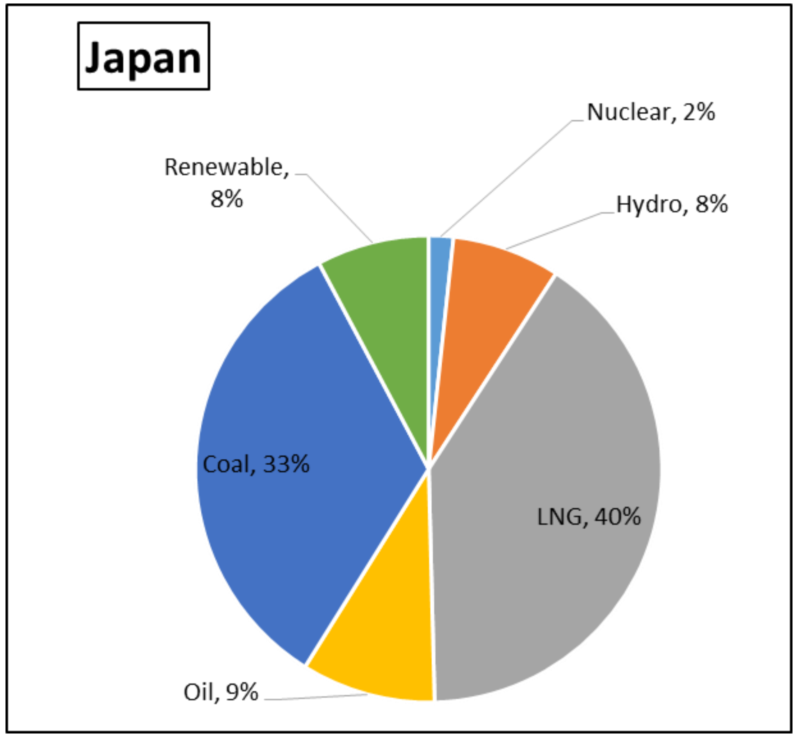
AVERAGE SOLAR GENERATION – 6.28 MWh IN 2017



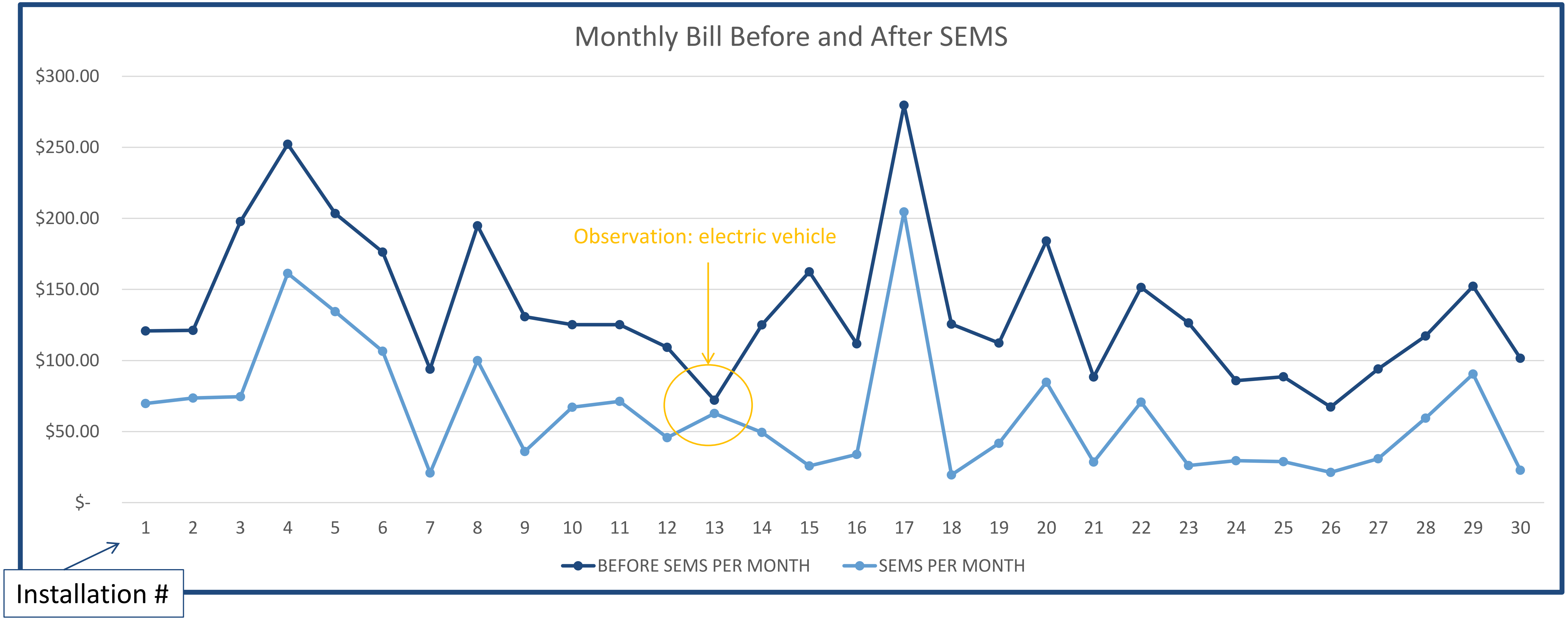
- GHG coefficiency : -17.96gCO_2/kWh
- GHG reduced : 3.38tCO_2(Ontario)



- GHG coefficiency : -533.5gCO_2/kWh
- GHG reduced : 100.57tCO_2(Japan)

GHG coefficiency depends on ratio of power generation sources.

FINANCIAL BENEFIT

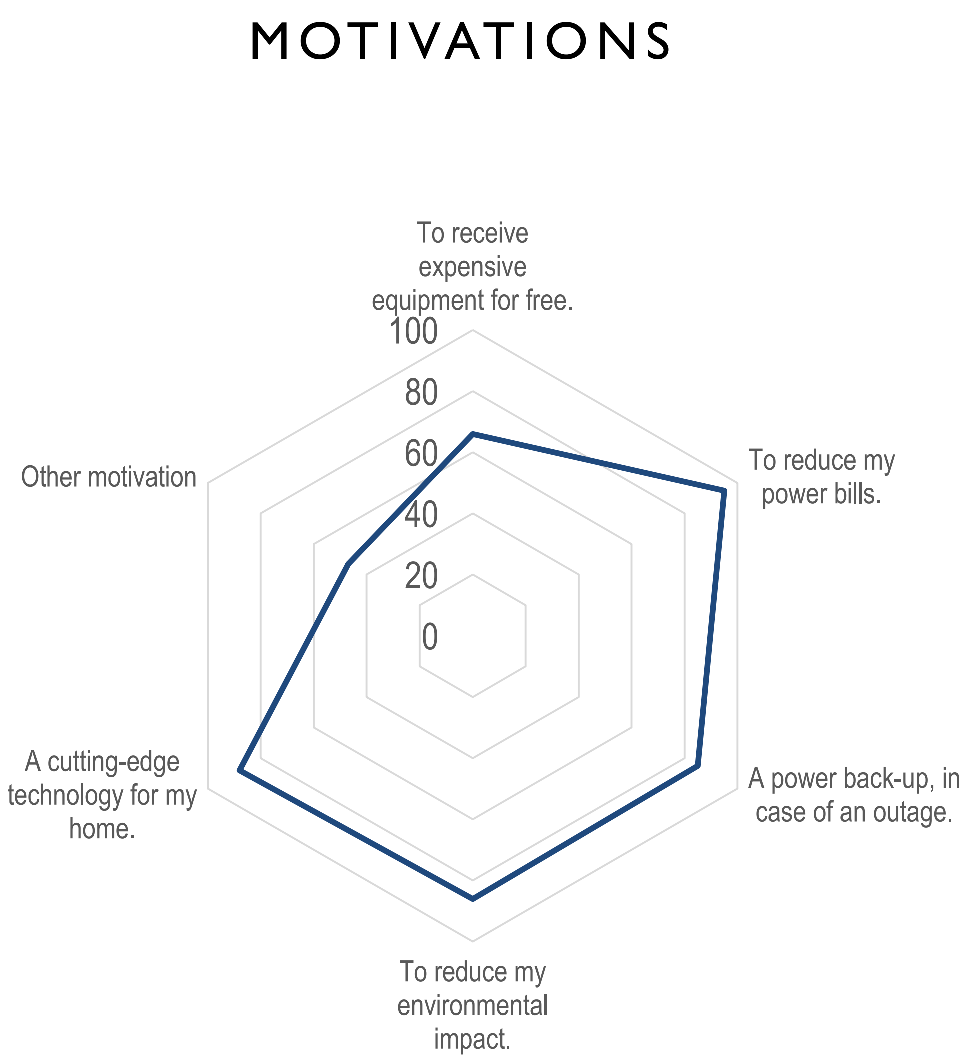


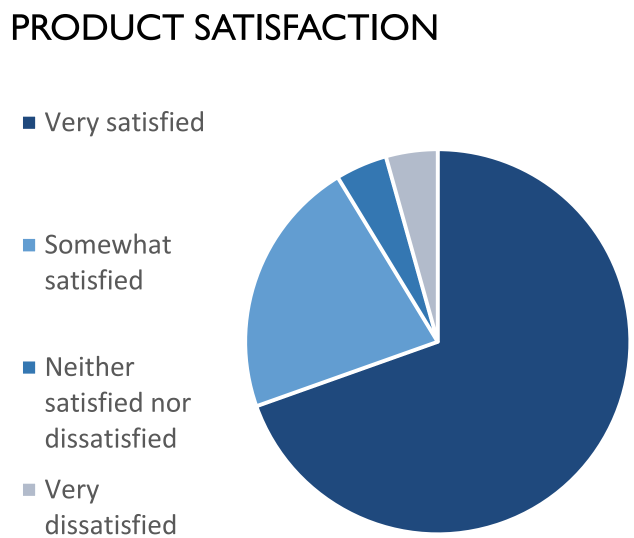
Average saving per month: $63.07*

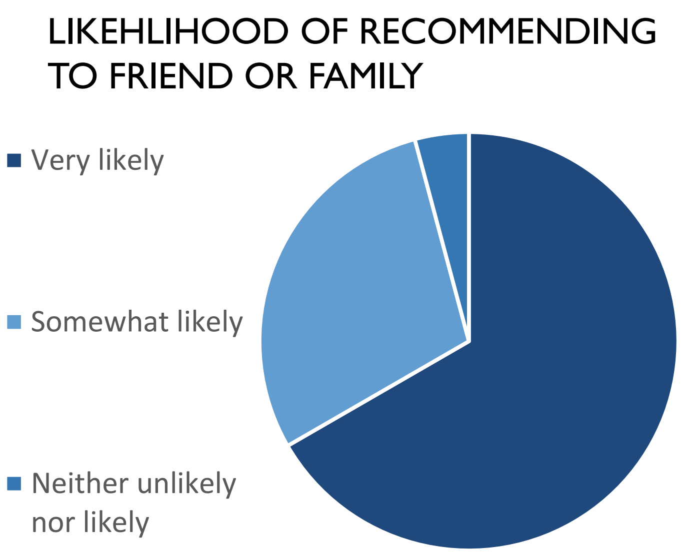
Averages calculated by averaging data for 24 months pre-install and approximately 24 months post install.

*Note that customers changed from Time-of-Use rates to tiered RPP rates, which may account for a portion of savings.

CUSTOMER EXPECTATIONS







CUSTOMER FEEDBACK

"Our family has become more interested in saving energy."

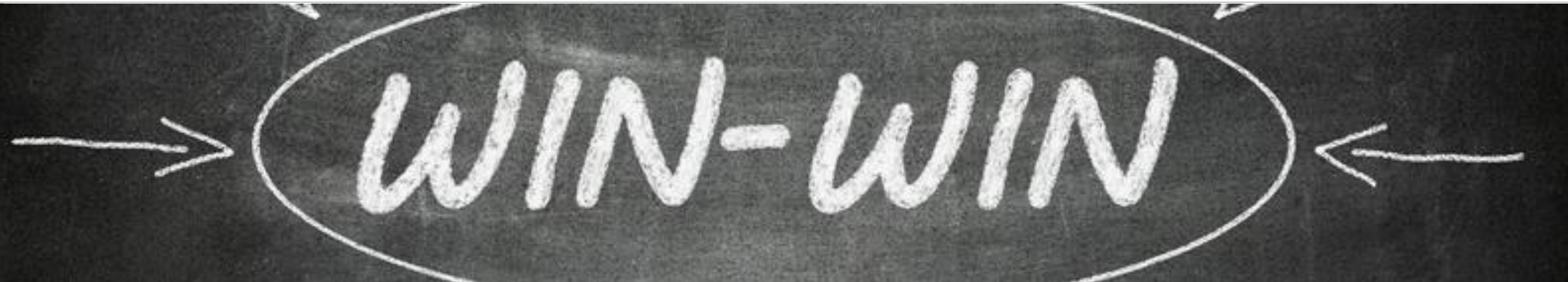
"We can understand the amount of energy we use. We are reducing the number of appliances that waste energy."

"We paid the minimal rate for our electric bill in April. That is effective for a family with kids and a 3,000 sq. ft. home."

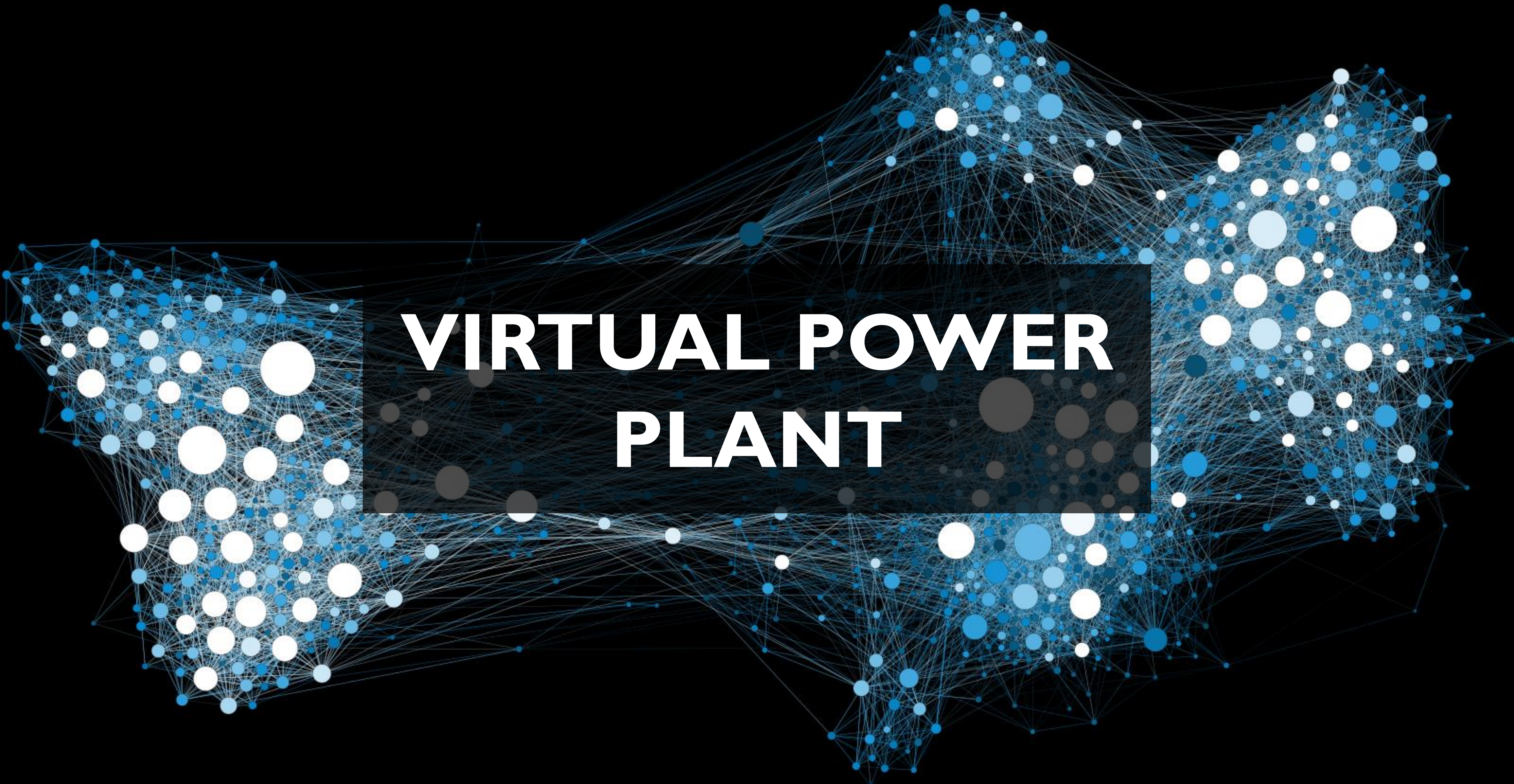
"If you energy use increases, my husband calls me and asks what we're doing!"

ENGAGEMENT

- ✓84% reported they gained knowledge of energy landscape
- ✓58% reported that they actively changed their energy efficiency behaviours
- ✓92% satisfied with carbon reductions achieved by system
- ✓Rating of system performance during outage – 4.23/5



VIRTUAL POWER PLANT

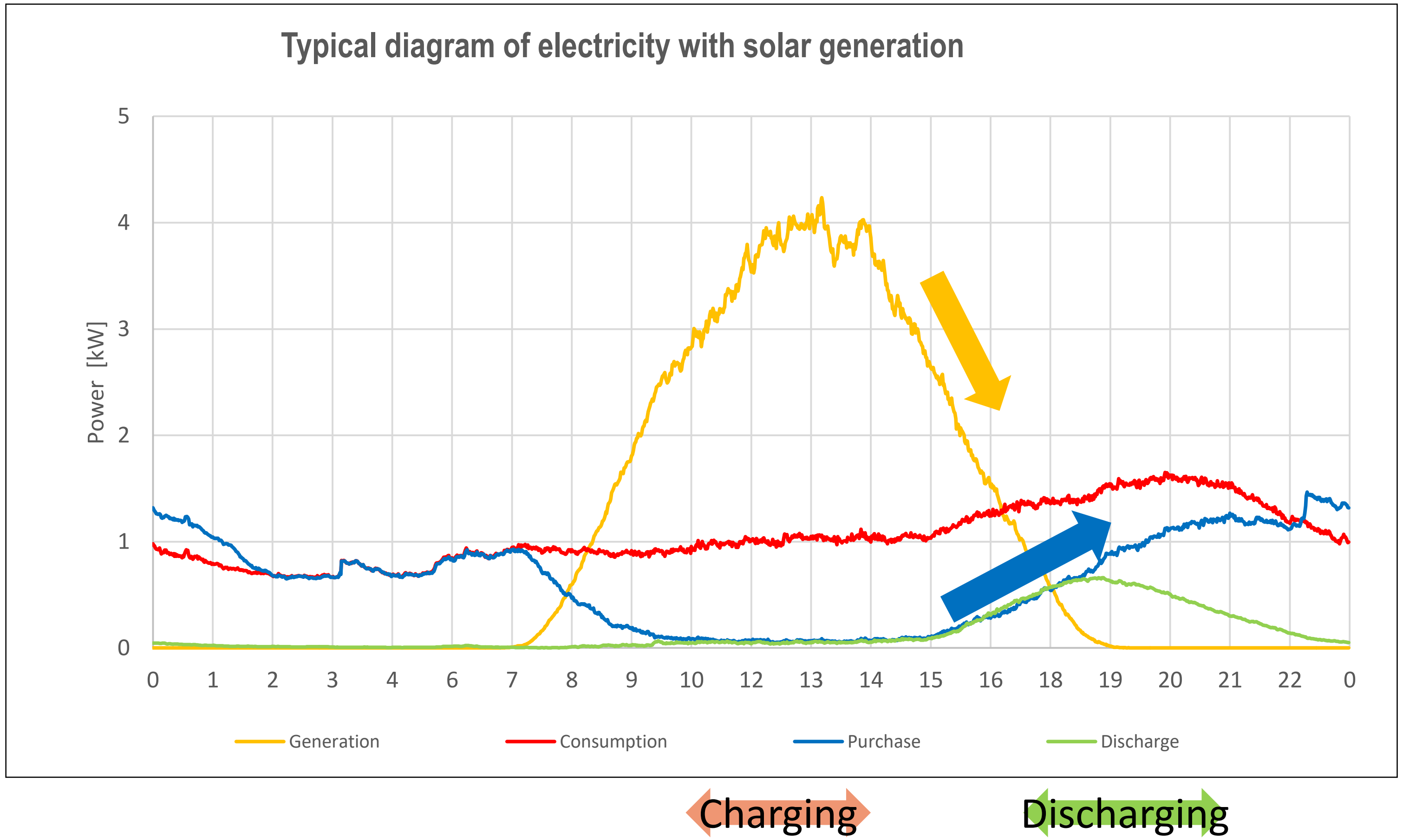


The plan

In many home, generation decreasing & consuming increasing in evening.
It will cause of heavy load on distribution line

When system discharge battery power in evening, load balance will be mild on distribution line.
It is the peak-shift effect.

Control setting
Mode: Max Power Export
Charging : 10am-2pm
Discharging : 5pm-9pm

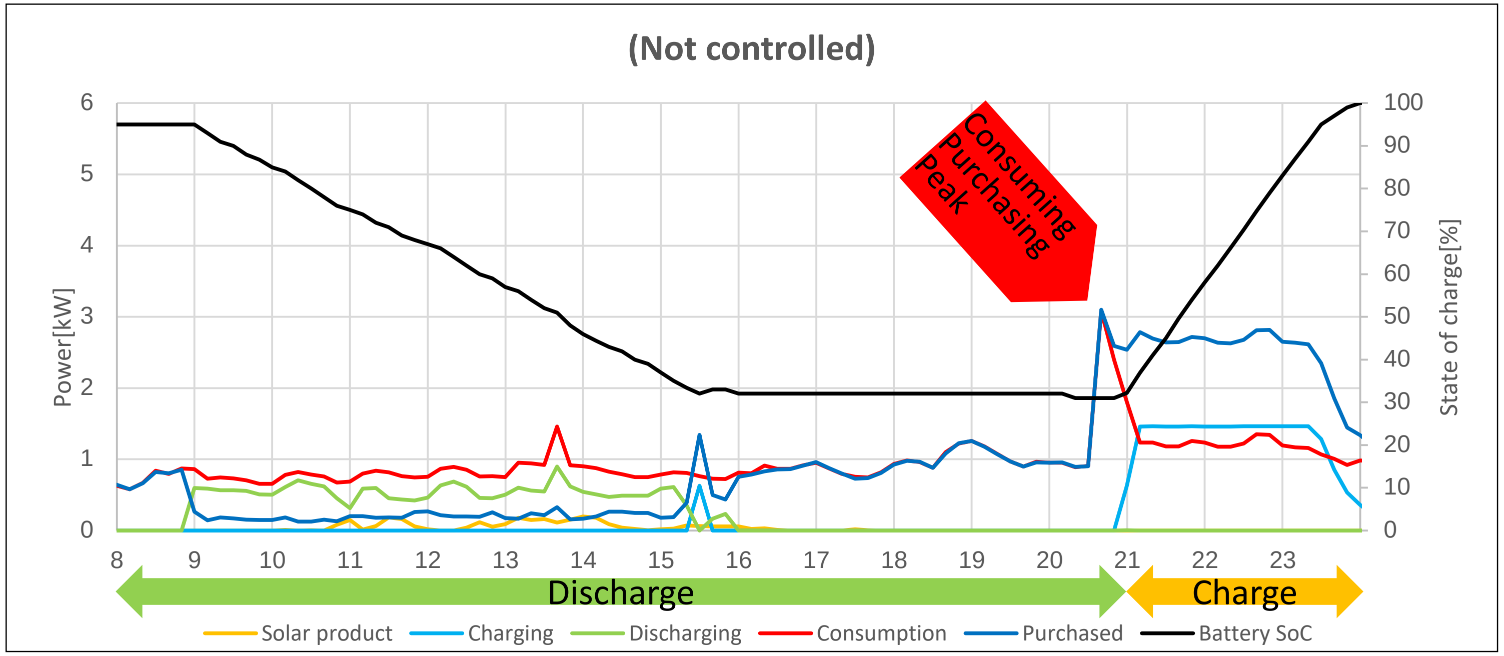


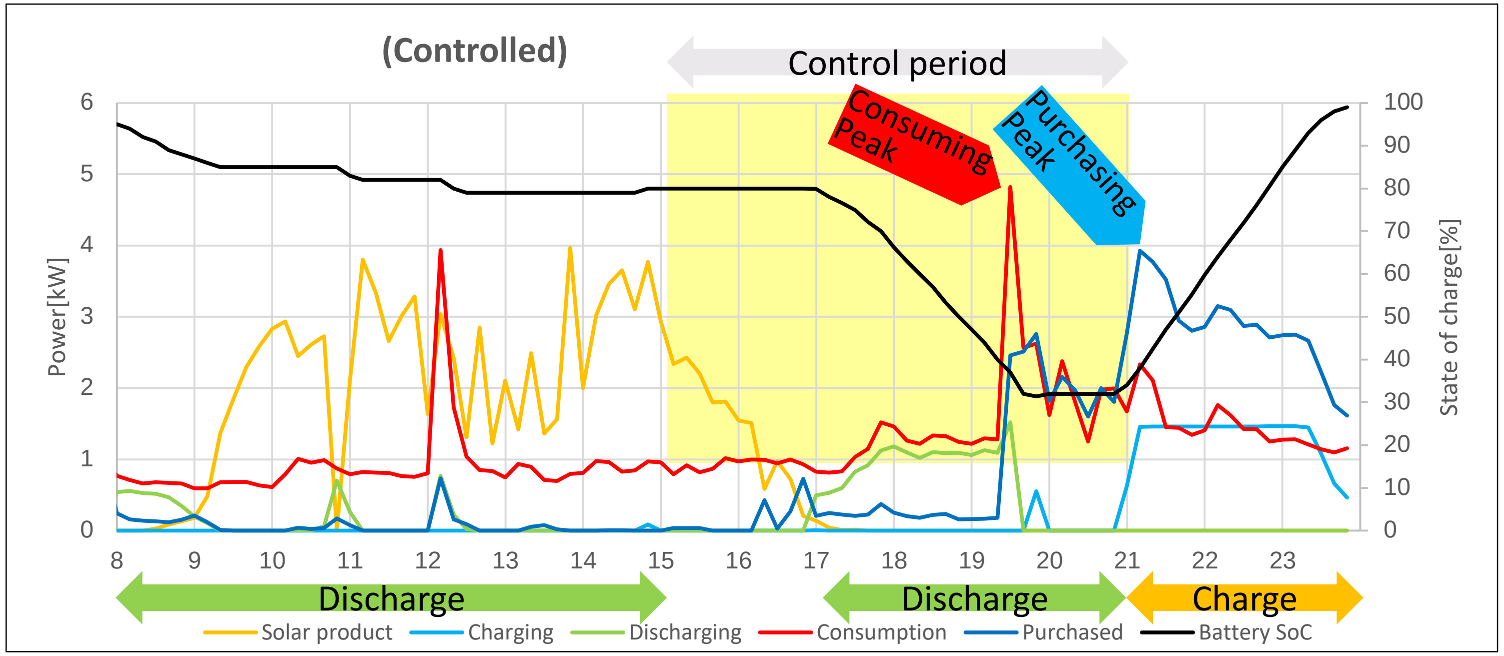
Charging in daytime, Discharging in evening

The result

- The system operated according to scenario and the peak had shifted.

- In order to operate effectively, we need to consider the stability of the Internet communication environment, the time setting for surely suppressing the peak band, and increased consumption after the controlled period should be considered.



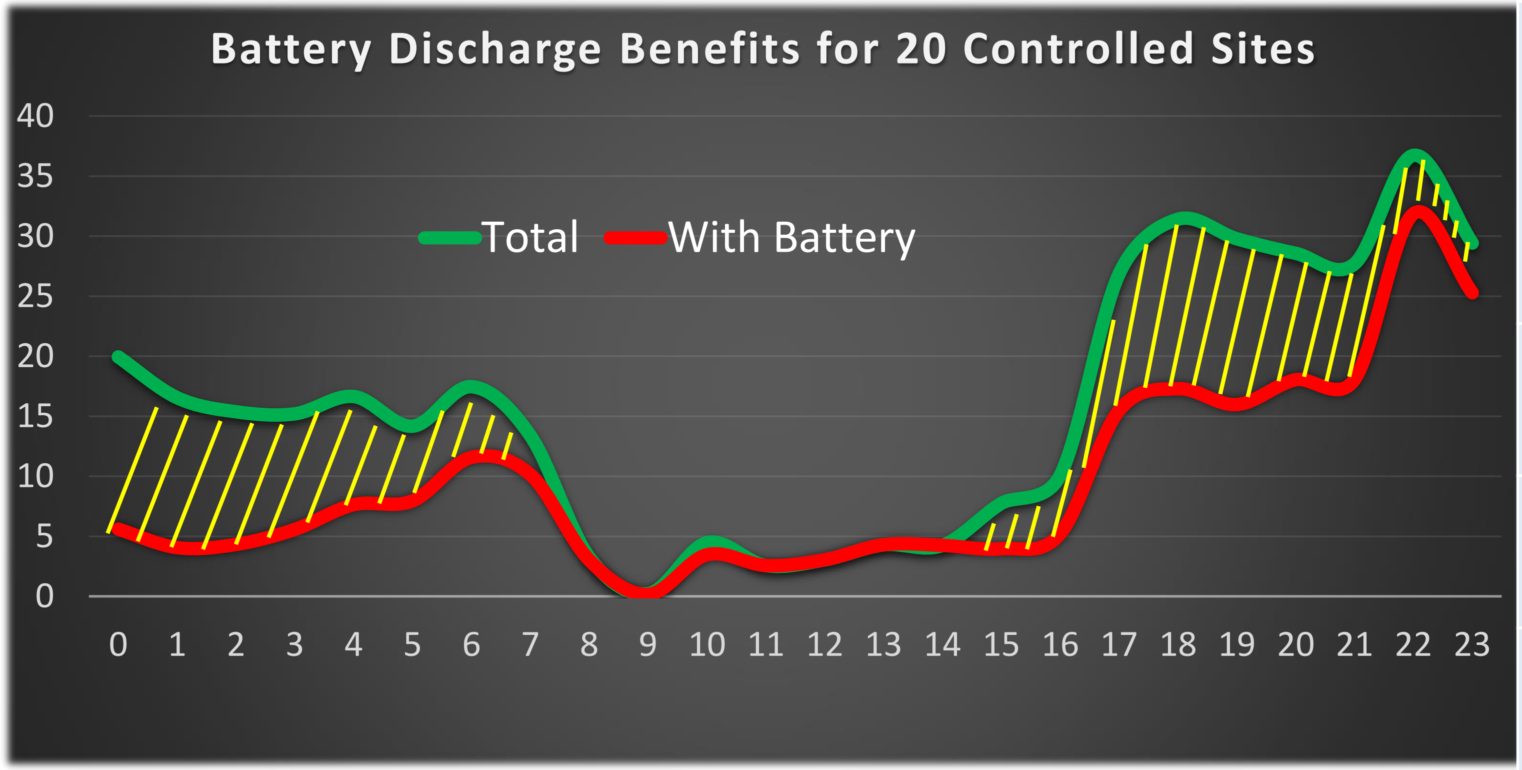


ADDITIONAL 30 TRIALS AT VARIOUS SITES

Goal – To minimize two-way energy flow under 3 battery modes:

- Economy – Reduces consumption from the grid and maximizes the use of PV power
- Home Back-up – Battery remains fully charged in case of power outage
- Max Power – Reduction of electricity cost by charging and discharging

BATTERY DISCHARGE FOR 20 SITES



# of Sites	Peak Shaving (MW)	DR ESTIMATE
20	0.15	Actual
100	0.75	Proj.
5000	37.58	Proj.
20,000	150.31	Proj.

BUSINESS CASE

THE SCOPE AND PROPOSAL FOR THE OSHAWA NEDO PROJECT

Technical Aspect

1. To verify the storage system will increase grid stability.
2. To verify that Solar systems with Battery will make effective use of existing grid resources, will reduce electricity rates.
3. Solar system with Battery **will provide customers with a safer, more stable lifestyle,** peace of mind by knowing they are prepared for future power outages



Business Aspect

1. To define the business model where utilities benefit from increasing distributed Solar generation and enable use of storage on the grid.
2. To verify the effectiveness of this model where the Utility owns the entire system and enters into a PPA or leases to the resident.
3. To implement software to optimize battery and grid usage for a better ROI.

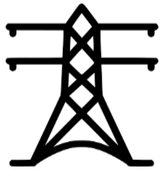
BENEFIT FROM INCREASING DISTRIBUTED SOLAR GENERATION

Promote Renewable Energy

- RPS
- State government and Utility need to promote Renewable at BTM (Behind the Meter)

Stabilize the grid

- Peak demand management /demand response
- Frequency and Voltage stabilization



Cost Reduction

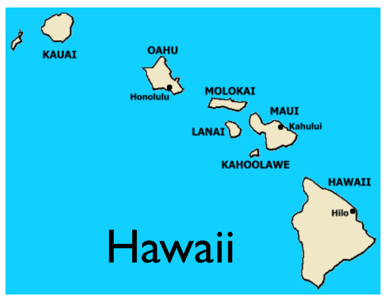
- Non Wired Alternative and does not require T/D investment
- Supplemental Charge for ancillary service through battery

UTILITY MODEL (IPP OWN, OR UTILITY OWN)

What We Had Proven in Canada

California and other States

Utility Own the Assets → Electricity Bill

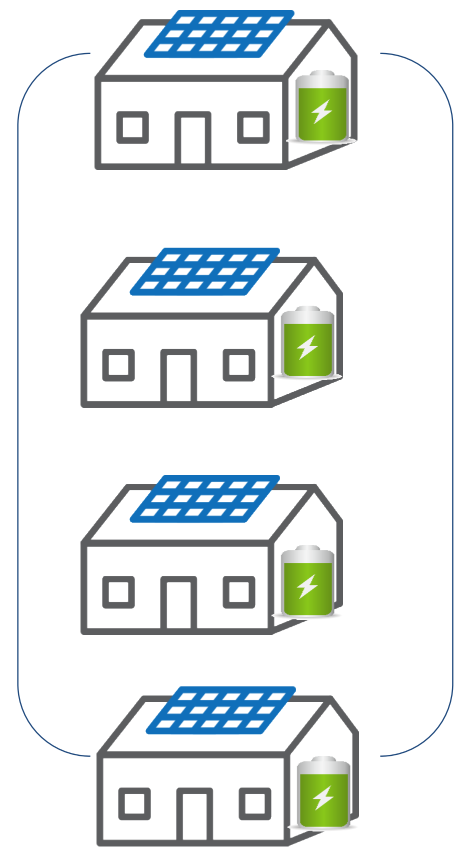


(Utility cannot own the assets at customer site)

IPP Own the Assets → PPA → Utility Buy Electricity from IPP → Electricity Bill

New Companies

IPP -> New Utility → Electricity Bill or lease or PPA



IT HAS BEEN HAPPENING WITH UTILITIES

Natural disasters

Reduce or eliminate risks associated with blackouts

Use microgrids as an emergency power source

Rate Structure/
Tariff Hike

The lowering of NEM or eliminated

TOU Peak Period are shifting to later in the day

Demand Charges
Additional monthly fees

- **Our energy management system and new business model can serve all Solar + Storage market**

LESSONS + FEEDBACK

PEER INDUSTRY REVIEW

AWARD WINNING PROJECT

QUEST 2017

- Runner-up – Smart Energy Communities Award

EDA 2017

- Winner – Environmental Excellence Award

ISGAN 2019

- Nominated – International Smart Grid Association Award of Excellence

LESSONS LEARNED

- Insurance challenges for emerging technologies
- Customer service standards for premium technologies
- Protection of assets from wildlife – a must!
- Effects of pricing variability on business case development
- Prosumer behaviour – thirst for tailoring and options
- Technological advances – leaps and bounds since 2014

MANUFACTURER LESSONS LEARNED

Flexible operational modes

Greater user awareness of solar and grid power

Demonstration of total energy management

Benefits for both the utility and its consumers (more solar installations)

Stabilization of grid at feeder level

CONCLUSION

- Solar + battery storage systems can be a win-win solution for everybody if managed properly.
- New technical and financial solutions should be implemented instead of using the augmentation approach of traditional grid infrastructure

THE LATEST MODEL

THANK YOU

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