Effect of Information Presentations on Consumer Emotions to Induce Power Saving Actions

Contents

筑波大学
University of Tsukuba

AIST
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Tomonori Nakayama[*1]
Hirotaka Osawa[*1]
Shinichiro Okushima[*1]
Hirohisa Aki[*2]

*1 University of Tsukuba
*2 National Institute of Advanced Industrial Science and Tehcnology

1. Background ~Power Saving~

Rolling blackout in around Tokyo

- After the 2011 Tohoku earthquake and Tsunami, there are several times of rolling blackout in around Tokyo.
- The summer in same year, people were forced saving electric power because of power supply shortage.
- However, the users accepted inconvenient for difficult situation in whole Japan.

If there are reasonable reasons,

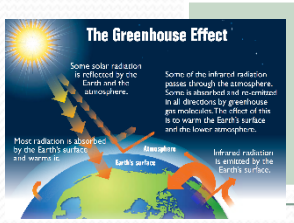
May electricity consumers save power positively without stress?

~Hypothesis~

What methods do induce Consumers' power saving actions?

INFORMATION

Pecuniary incentives

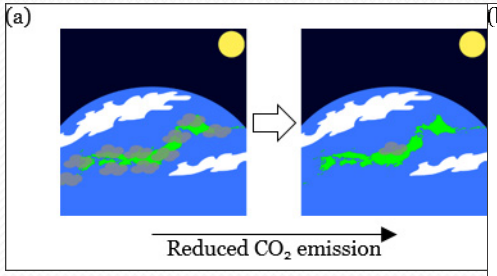


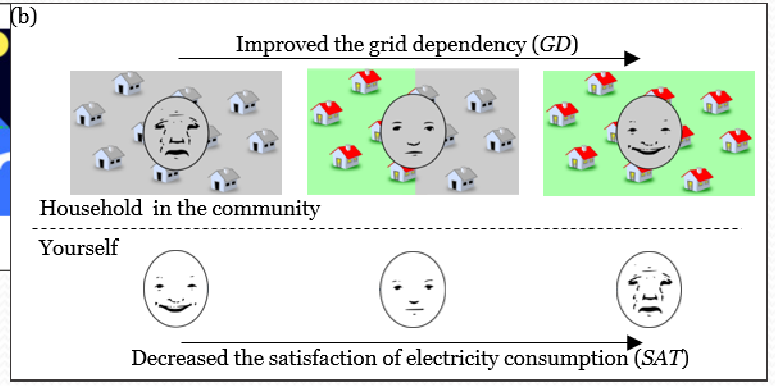
Global environmental concern (CO_2 emission)

Community environmental concern
(*GD*: Grid Dependency),
(*SAT*: Satisfaction with electricity consumption)

PRESENTATION

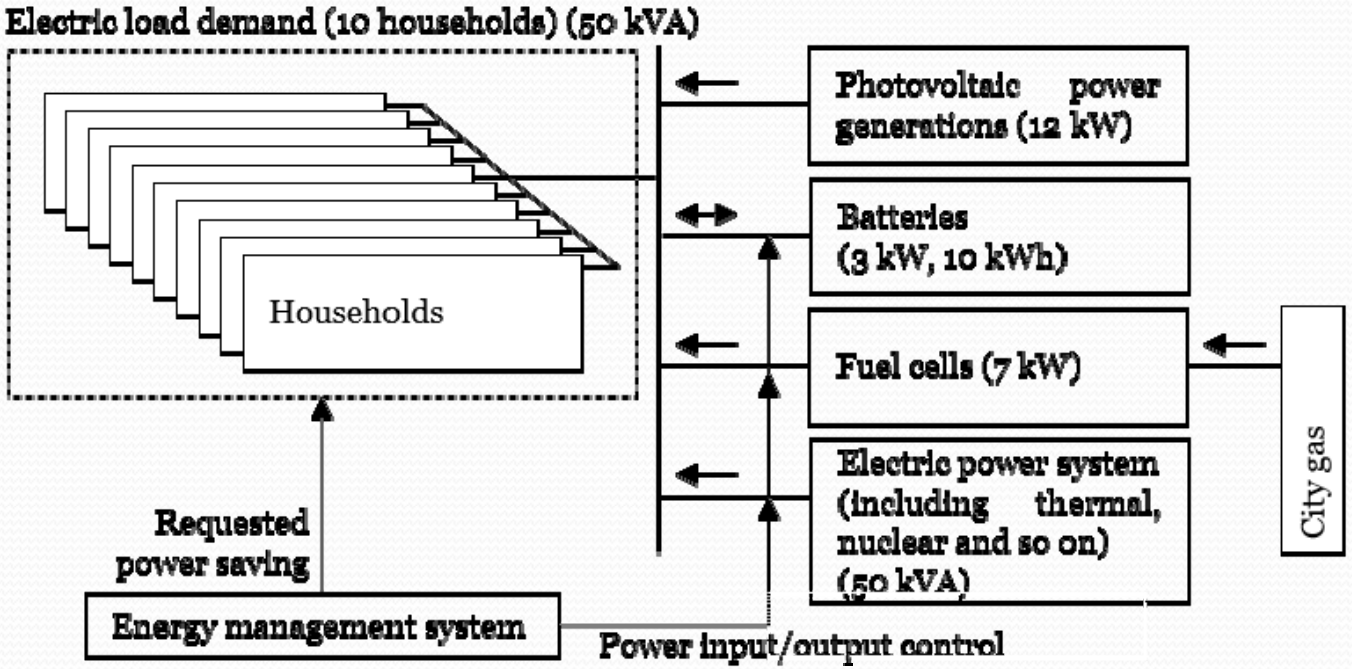
- Visualized
- Anthropomorphized
- Kantian-type moral motivation
  - If all the households would act as you do.





This study examined methods of presenting information related to requested power savings and their impact on consumers' power saving behaviors.

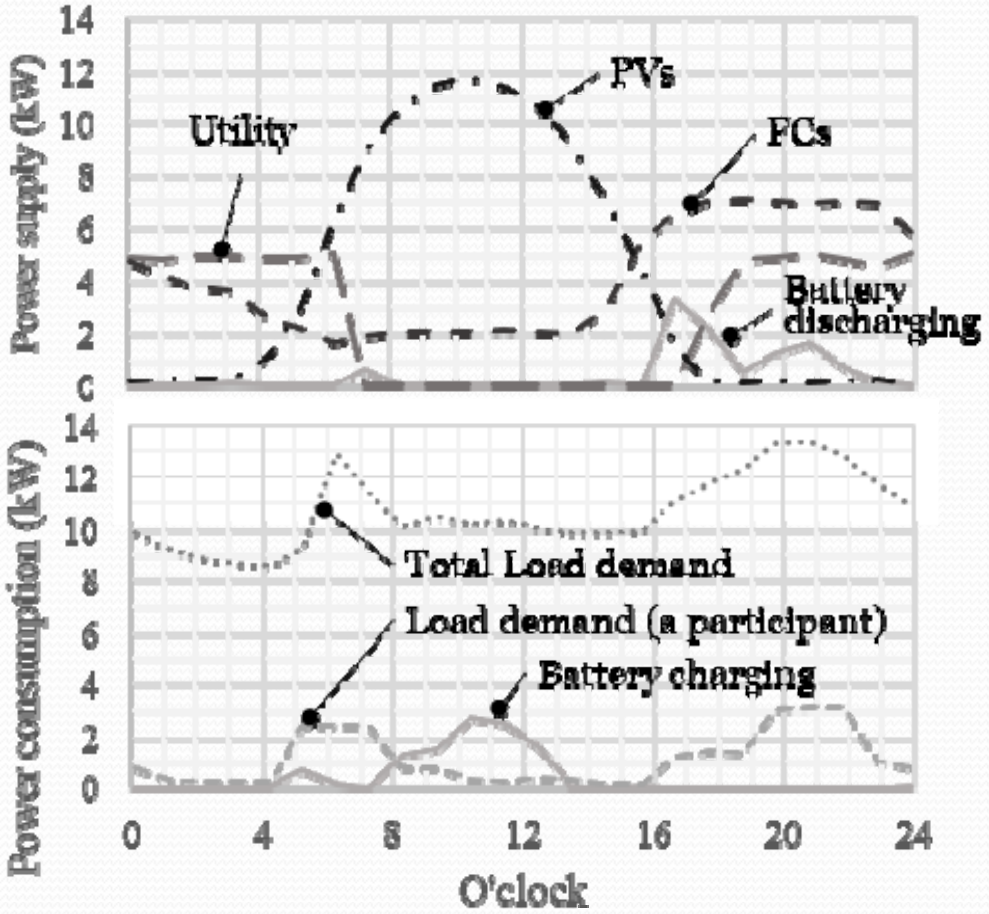
3. System Configuration ~System Model~



ASSUMPTION

- Microgrid connected commercial grid (Utility) which includes thermal, nuclear
- Including several Photovoltaic power generation (PVs), batteries, fuel cells (FCs), 10 households electric demand

3. System Configuration ~Supply and Demand~



ASSUMPTION

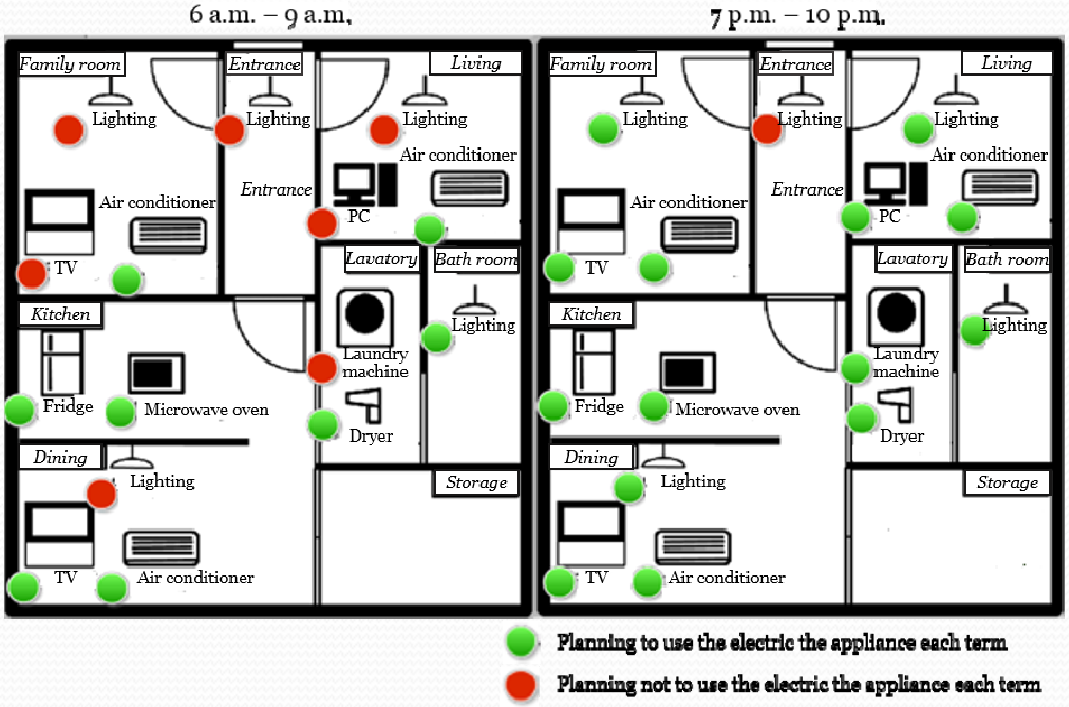
- The power supplies and demands such as the PVs, batteries, FCs, and utility will be operated above figure.

~Prices / Specifications of Each Device~

Category	Item		Value
Electric power system	Price [a]	(8 a.m. – 10 p.m.) (22 p.m. – 8 a.m.)	P_{e1} 32 yen/kWh P_{e2} 18 yen/kWh
	CO_2 emission intensity	(8 a.m. – 10 p.m.) (22 p.m. – 8 a.m.)	C_{e1} 356 CO_2-g/kWh C_{e2} 267 CO_2-g/kWh
	Maximum power	(each household) (total)	5 kVA 50 kVA
City gas	Price [a]		P_g 24.9 yen/kWh (140 yen/Nm^3)
	Higher heating value (HHV)		45 MJ/ Nm^3
	CO_2 emission intensity		183.2 CO_2-g/kWh (2291 CO_2-g/Nm^3)
FCs	Total rated power		7 kW
	Efficiency	(electricity) (heat)	0.45 0.35
	CO_2 emission intensity (electricity)		C_{FC} 407 CO_2-g/kWh
Battery	Total storage capacity		10 kWh
	Total rated power		3 kW
	Charge / discharge efficiency		0.9 / 0.9
PVs	Total rated power		12 kW
	CO_2 emission intensity		0 CO_2-g/kWh

- The saving money, CO2 emission, *GD*, *SAT* and so on were calculated according to above prices and specifications.

3. System Configuration
~Consumption of Each Appliance~



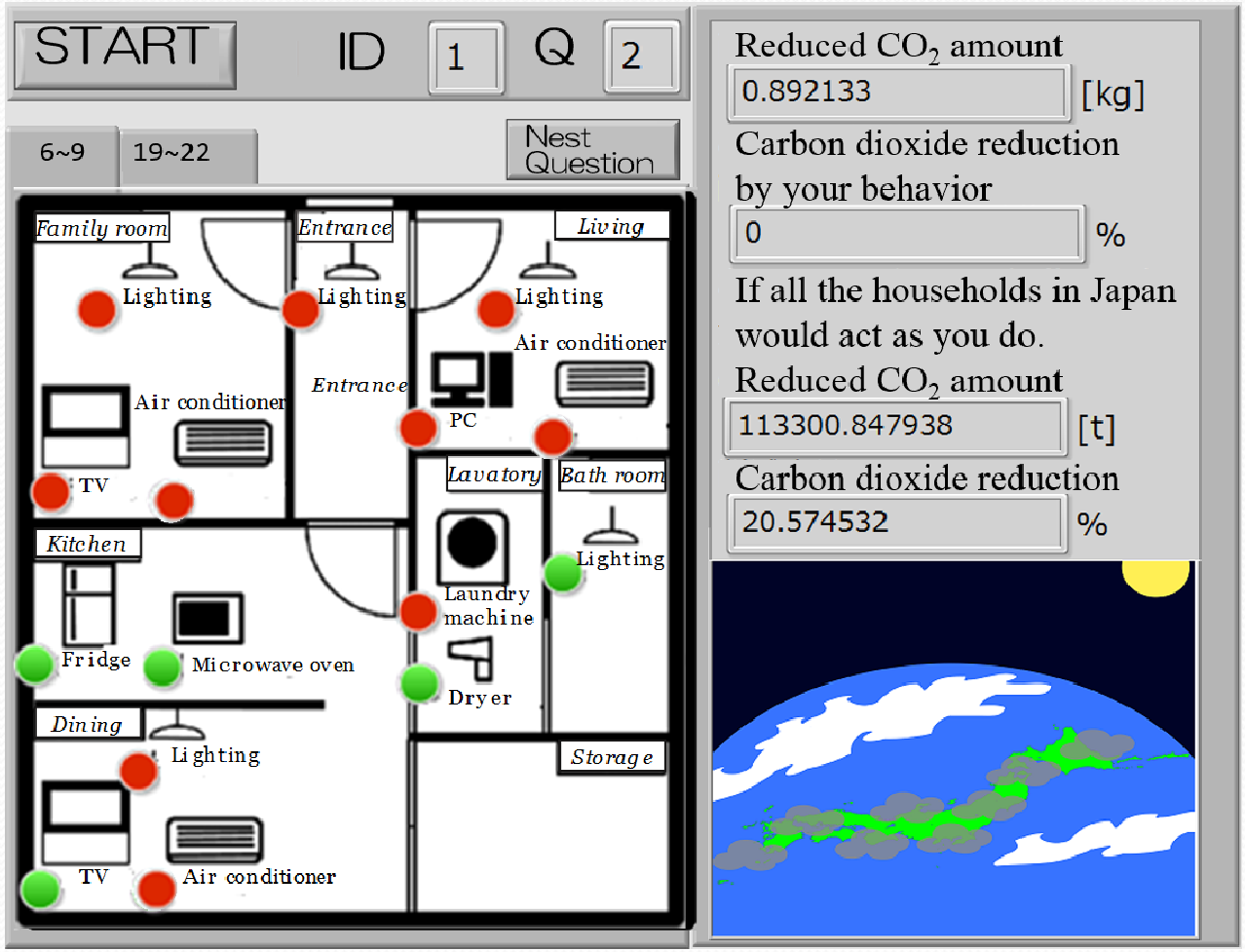
ASSUMPTION

- Each participant has several appliances.
- Using the appliances are planned on each term.
- Consumption of each appliance when the one is worked is shown below.

Appliance	Consumption Electric Energy for 3 hours
Dryer [a]	0.12 kWh
Microwave oven [a]	0.13 kWh
Air conditioner at family room and living	0.47 kWh
Air conditioner at dinning	0.87 kWh
Fridge	0.06 kWh
PC	0.2 kWh
TV	0.095 kWh
Lighting	0.03 W
Laundry machine	0.3 kWh

4. Experimental Method 8

~Developed HAI Interface~



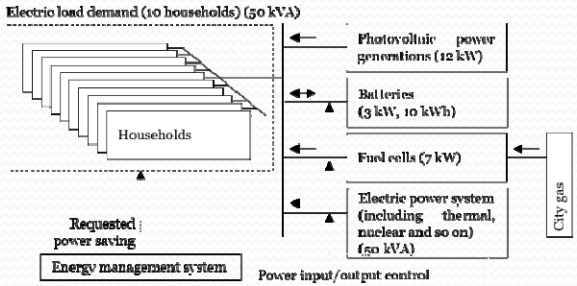
- An example of the interface in the experiment.
- The participants responded according to the feedback shown in Human-Agent Interaction (HAI) interface.

~Playing a Roll as Resident in Microgrid~

Each participant in the experiment answered questions related to the amount of electric power consumption saved by them in morning from 6 to 9 am (3 hours) and the night from 7 to 10 pm (3 hours) (the time periods of a day is easy to image the themselves home life), while viewing the feedback of the interfaces.

The participants read a roll–playing scenario which explains a roll–playing situation, as shown below.

EXPERIMENTAL SCENARIO



- You stay in an island involved the small–scale power grid.
- You live in a house which has room layout structure.
- You have some electric appliances.
- Today is a weekday.
- You go out to work in a weekday (being out 9 from a.m. to 7 p/m.).
- Optimized power operation plan.
- You plan some electric appliances according to "load demand (a participant),".
- You can change the plan of your electric appliances usage (ON or OFF) from 6 a.m. to 9 a.m. and from 7 p.m. to 10 p.m.
- Your pecuniary incentives, CO2 emission, and the number of *GD* of the small–scale power grid will be changed depend on your power saving behaviors.

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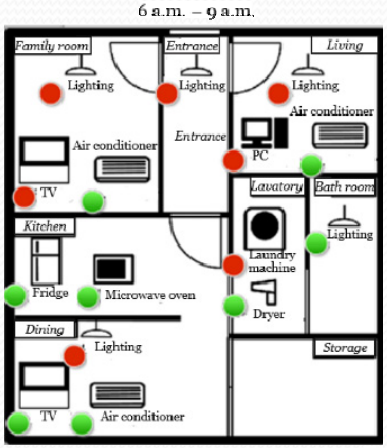

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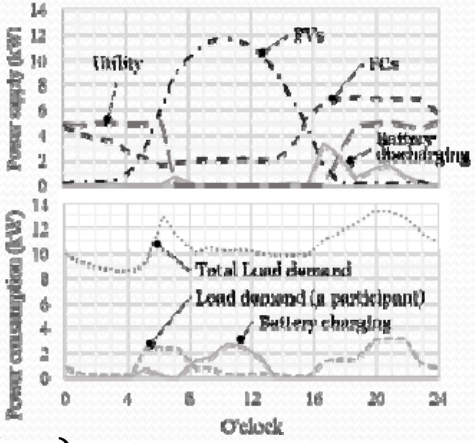

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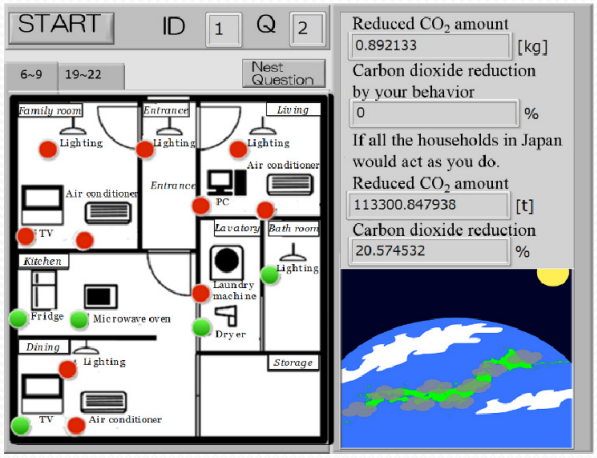
~Feedbacks~

The experiment involved nine feedback conditions in random order as used by past researches. It displayed numbers and/or visuals changes in real time when the participants turned on/off the appliance switch.



FEEDBACKS

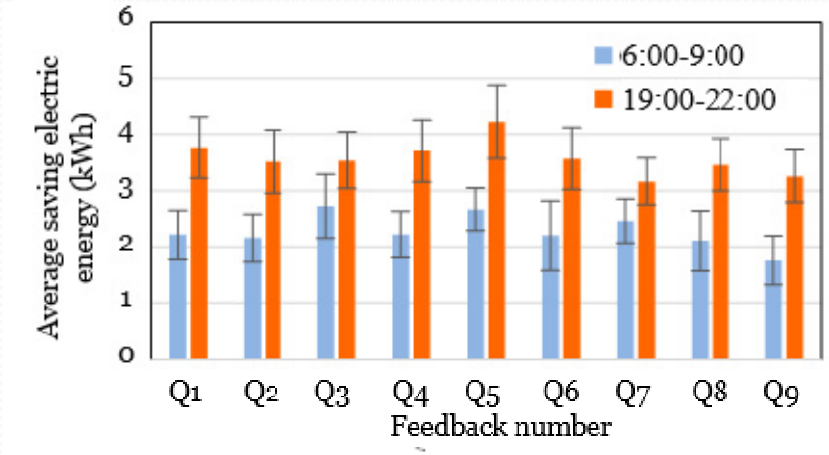
- Q1 Feedback as numeral pecuniary incentives.
- Q2 Feedback as a global effect with the number of CO2 emissions and rates caused by each participant's behavior.
- Q3 Visual feedback as a global effect with the number of CO2 emissions and rates.
- Q4 Feedback as a global effect with the number of CO2 emissions and rates if all the individuals in society act (Kantian-type moral motivation) in a manner similar to each participant.
- Q5 Visual feedback as a global effect with the number of CO2 emissions and rates if all the people in society would act in a manner similar to the participants.
- Q6 Feedback as the number of *GD* on the island increased.
- Q7 Feedback as the number of *GD* on the island increased if all the people in the society would act in a manner similar to the participants.
- Q8 Anthropomorphized feedback as the number of *GD* on the island increased.
- Q9 Anthropomorphized feedback as the number of *GD* on the island increased if all the people in the society would act would act in a manner similar to the participants.

4. Experimental Method ~Summary of Feedbacks~

	Information type		
	Pecuniary incentives	Global environmental concern	Community environmental concern
Q1	O		
Q2		O	
Q3		O	
Q4		O	
Q5		O	
Q6			O
Q7			O
Q8			O
Q9			O

	Presentation method			
	Numeral	Visualized	Anthropomorphized	Kantian-type of moral motivation
Q1	O			
Q2	O			
Q3	O	O		
Q4	O			O
Q5	O	O		O
Q6	O			
Q7	O			O
Q8	O		O	
Q9	O		O	O

~Power Saving Behaviors Result~



- The evaluation involved 20 participants with ages ranging between 22-25 years old.
- The results were significant, or marginally significant using t-test calculations.
- This indicated that Q5 and Q3 that strongly induced power-saving actions.

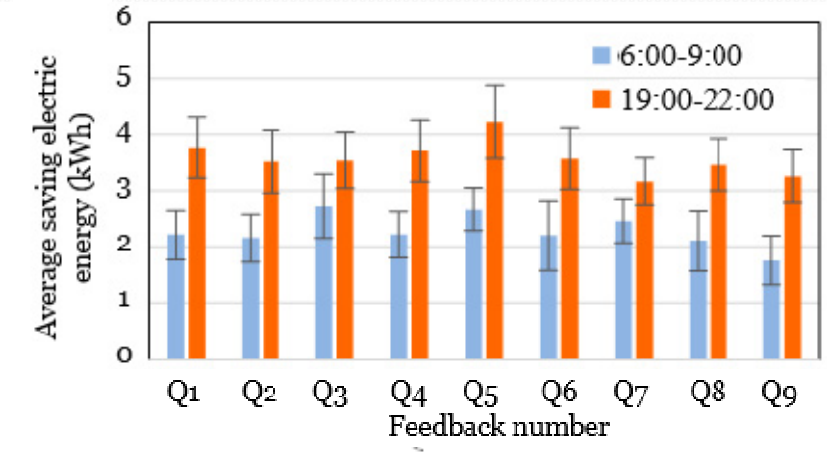
Morning

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Q1	-								
Q2		-	S		MS				
Q3			-					S	S
Q4				-					
Q5					-				S
Q6						-			
Q7							-		S
Q8								-	
Q9									-

Night

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Q1	-								
Q2		-			S				
Q3			-		S				
Q4				-	MS		MS		S
Q5					-	MS	S	S	S
Q6						-			
Q7							-		
Q8								-	
Q9									-

~Power Saving Behaviors Result~



- This indicated that Q5 and Q3 that included visualized information strongly induced power-saving actions.
- Moreover, the difference between Q3 and Q5 corresponded to a Kantian-type moral motivation, and Q5 that include visualized information with Kantian-type moral motivation was observed as most effective in inducing power-saving actions.

	Information type		
	Pecuniary incentives	Global environmental concern	Community environmental concern
Q1	O		
Q2		O	
Q3		O	
Q4		O	
Q5		O	
Q6			O
Q7			O
Q8			O
Q9			O

	Presentation method			
	Numeral	Visualized	Anthropomorphized	Kantian-type of moral motivation
Q1	O			
Q2	O			
Q3	O	O		
Q4	O			O
Q5	O	O		O
Q6	O			
Q7	O			O
Q8	O		O	
Q9	O		O	O

- Anthropomorphized information could not strongly induce power-saving actions when compared with the other methods of presentation information in this experiment.
- This result did not affect inducing power saving behavior because Q8 and Q9 included the GD and SAT, which were mutually canceled out.

~Each Participant Preference~

	Saving Electric Energy (kWh)								
Participant	***Q1***	***Q2***	***Q3***	***Q4***	***Q5***	***Q6***	***Q7***	***Q8***	***Q9***
A	1.80	1.43	**3.26**	1.74	2.63	0.47	1.47	1.46	0.10
B	2.77	2.56	**3.39**	2.56	2.77	2.77	3.03	2.77	2.77
C	3.18	3.17	3.17	3.18	3.15	**5.78**	3.17	3.18	3.20
D	2.83	2.77	5.43	2.59	**5.45**	2.81	2.83	2.81	0.97
E	0.68	0.07	0.07	0.68	0.64	0.66	**1.84**	0.64	0.64
F	3.19	3.19	2.82	3.19	3.40	**6.02**	3.40	3.19	3.09
G	3.03	**3.40**	3.06	3.01	3.04	0.07	**3.40**	3.37	3.39
H	3.35	2.76	2.75	1.67	2.79	**3.02**	2.78	2.76	2.75
I	3.02	3.04	3.02	3.04	3.04	**3.43**	3.04	1.62	0.24
J	2.15	2.73	**3.66**	**3.66**	1.67	2.15	2.46	3.65	**3.66**
K	0.57	**0.95**	0.56	0.54	0.56	0.51	0.53	0.17	0.53
L	3.78	3.57	**6.01**	0.07	3.37	4.10	3.84	3.79	0.55
M	2.62	3.14	2.26	**3.52**	2.84	0.09	2.24	0.07	2.24
N	**3.58**	0.88	0.37	3.43	3.52	2.70	2.82	0.07	0.12
O	3.05	**3.06**	2.76	2.99	3.00	2.78	2.82	2.78	2.81
P	2.94	2.94	**5.35**	2.94	2.97	2.93	4.92	5.14	2.72
Q	0.22	0.22	0.24	**0.25**	0.19	0.22	0.19	0.22	0.24
R	0.07	1.90	2.13	**3.08**	3.01	2.15	2.13	0.09	0.22
S	2.25	2.22	2.29	2.25	2.20	2.57	2.07	**2.62**	2.23
T	0.21	0.09	**3.04**	0.07	2.81	0.07	0.06	**3.04**	2.80
Average	2.26	2.21	**2.78**	2.22	2.65	2.27	2.45	2.17	1.76
Median	2.80	2.75	**2.92**	2.77	2.90	2.64	2.80	2.77	2.24
Number of largest saving energy	1	3	**6**	5	1	4	2	2	1

- The experimental results with respect to the electric energy saved by each participant.
- The total amount of saved electric energy increased due to visualization.
- Furthermore, there are preference information presentation of each participant .

~Summary~

- This study examined methods of inducing power-saving action by using several ways of presenting information.

- The study involved conducting an experiment with respect to participants' power-saving behavior given changes in the presentation of information pertaining to pecuniary incentives, CO_2 emissions as global environmental concern, a grid dependency as community environmental concerns, visualized or anthropomorphized feedback, and Kantian-type moral motivation.

- The experimental results and results of t-test indicated that the most effective presentation of information involved the visualized information with respect to CO_2 emissions with Kantian-type moral motivation.

- Future work includes an experiment using an interface that does not display simultaneously conflicting information such as the degree of grid dependency and the satisfaction with electricity consumption.

Thank you for your kind attention.