EEDAL'24

Behavioral Patterns in Home Energy Reports:

Seasonal and Regional Analysis in Japan's Varied Climates

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9th October 2024

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Background and Objectives

Home Energy Reports (HERs):

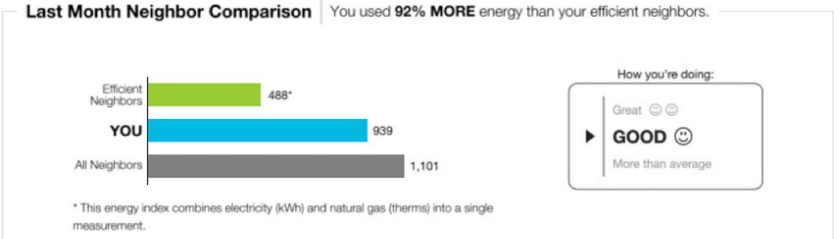
- Provide personalized feedback to households on their energy consumption.
- Include social comparisons and energy-saving tips.
- Reduce energy consumption by an average of 2%.

Knowledge Gap:

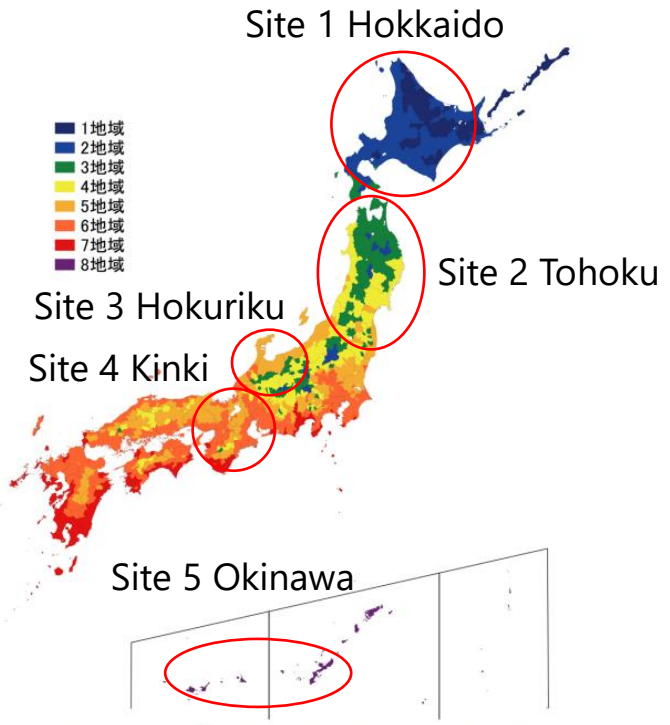
- How do the energy-saving impacts of HERs vary across regions, seasons, and heating systems in Japan?

Our Approach:

- Field Trial: Distributed HERs to 300,000 households across five diverse regions in Japan.
- Data Analysis: Assessed energy savings based on climate, season, and energy contract types.



Home Energy Reports (HERs)



Map of Japan with Heating Degree Days (HDD18) as an indicator

Source: https://www.mlit.go.jp/common/001627028.pdf

Example of the Home Energy Report used in this study

UtilityCo

Home Energy Report
July 20, 2018
Customer Number 100001
We are pleased to provide you with a report on your energy usage and tips for saving energy and money. Please use this report as a guide to try energy-saving actions that can reduce your household's utility bills and CO2 emissions.
http://www.utility.com

Neighbor comparison applying "social norms"

Last Month Neighbor Comparison

All Neighbors: Approximately 100 occupied, nearby homes that are similar to you. Efficient Neighbors: The most efficient 20 % from the "All Neighbors" group.

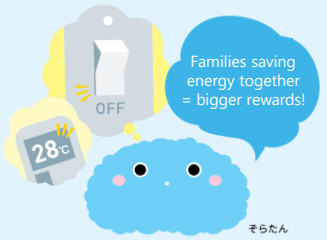
Great
GOOD
More than average

38 % MORE
than your efficient neighbors

Why not discuss energy savings?

Why not discuss energy saving at home this summer? You may notice unexpected waste in the discussion, such as discussing the temperature setting of the air-conditioner or setting a family rule to remember to switch off lights and equipment that are not in use.

電気料金シミュレーション 検索



Small Saving Tips

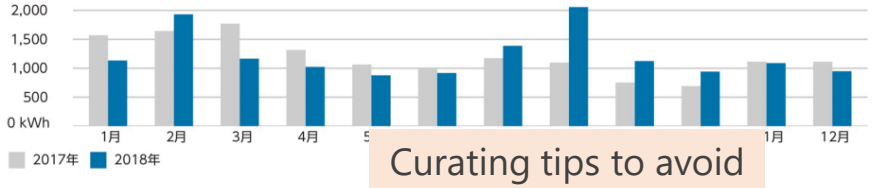
Remove anything covering the outdoor unit of the air conditioner
Save up to ￥1,000 per year

Replacing refrigerator door gaskets
Save up to ￥3,000 per year

See reverse side

Personal Tracker

Your 2018 usage is 2% above 2017



Curating tips to avoid "choice overload"

Saving Tip

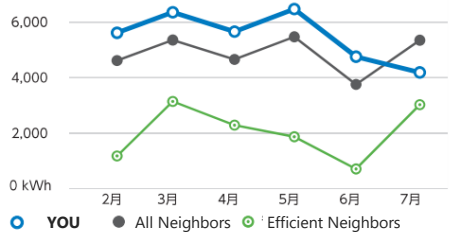
Don't overfill the refrigerator.

Refrigerators, often the most power-hungry appliance, run constantly to maintain temperature. Tips for efficient use can save electricity.

Don't overfill and don't block cold air vents. Also, don't leave doors open too long. Organize the refrigerator to reduce the time the door is open.

Save up to ￥1,000 per year

Last 6 Months Neighbor Trend



In the last 6 months, your usage exceeds neighbors by
￥384 MORE

Utility bill framing leveraging "loss aversion"

Contact Information

Utility Co. xx-xxxx-xxxx

本レポートの内容や、本事業に関する詳細やよくあるご質問については、特設サイト(https://j-nudge.jp/her)をご参照ください。本レポートの配送停止を希望される方は、大変お手数ですが、上記お問い合わせ先までご連絡ください。
※お客さまの電気機器の保有台数・種類、使用状況などは考慮しておりません。

そらたん 省エネ 検索
よくあるご質問
などは、こちらから！

Overview of Field Sites

- Residential customers from five energy companies were selected as field sites.
- Regions cover different climates, assessed by **Heating Degree Days (HDDs)** and **Cooling Degree Days (CDDs)** during the one-year baseline period.

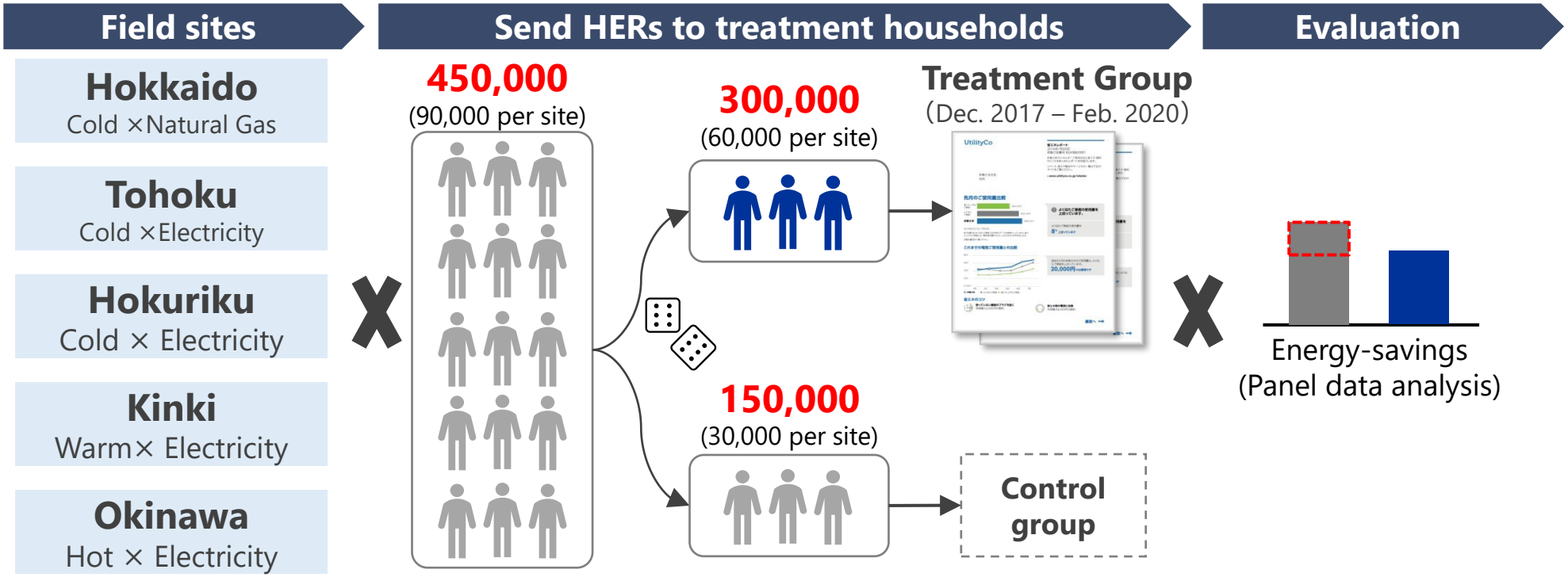
Overview of Field Sites

Site Number	1	2	3	4	5
Region	Hokkaido	Tohoku	Hokuriku	Kinki	Okinawa
Utility company	Hokkaido Gas	Tohoku EPCO	Hokuriku EPCO	Kansai EPCO	Okinawa EPCO
Degree days(DDs)					
Heating DDs	3,486	2,304	2,043	1,506	92
Cooling DDs	18	61	177	352	736
Target segment					
Energy type	Natural Gas	Electricity	Electricity	Electricity	Electricity
Contract type	HWH or FFH[*1]	TOU[*2]	TOU or STD[*3]	STD	STD
Housing type	Unspecified	Detached house	Detached house	Unspecified	Unspecified
Sample size					
Treatment	60,000	60,000	60,000	60,000	60,000
Control	30,000	30,000	30,000	30,000	30,000

*1 HWH: Hot-Water Heater, FFH: Forced Flue Heater, *2 TOU: Time-of-Use, *3 STD: Standard metered Rate

Randomized Controlled Trial (RCT)

- **RCT Design**: RCT with 90,000 households: 60,000 in the treatment group, 30,000 in control. Households were selected based on energy type, contract type, and housing.
- **Opt-out Process**: Pre-notification letters sent in November 2017 with project details and opt-out instructions. Opt-out households stopped receiving HERs.
- **Analysis**: Treatment effects estimated for the entire treatment group, including opt-outs; households with incomplete data (e.g., move-outs) were excluded.



Estimation of the Energy-Saving Impact of HERs

- **ATE (Average Treatment Effect):** Represents the **average energy savings** in MJ for all households in the treatment group.
- Estimated using a Difference-in-Differences (DiD) approach.
- Regression analysis calculates the average energy-saving effect by comparing pre- and post-treatment energy usage between treatment and control groups

Average daily energy usage for household i

$$daily\_usage_{it} = \alpha + \beta Treat_i \cdot mm_t + \gamma(AvgUse_i + AvgUseWin_i + AvgUseSum_i)mm_t + \varepsilon_{it}$$

Average Treatment Effect: The change in daily average energy consumption due to the intervention.

dummy variable indicating the assignment status to the treatment group

average daily energy consumption for household i during the baseline period

dummy variable representing the month of the year after the treatment

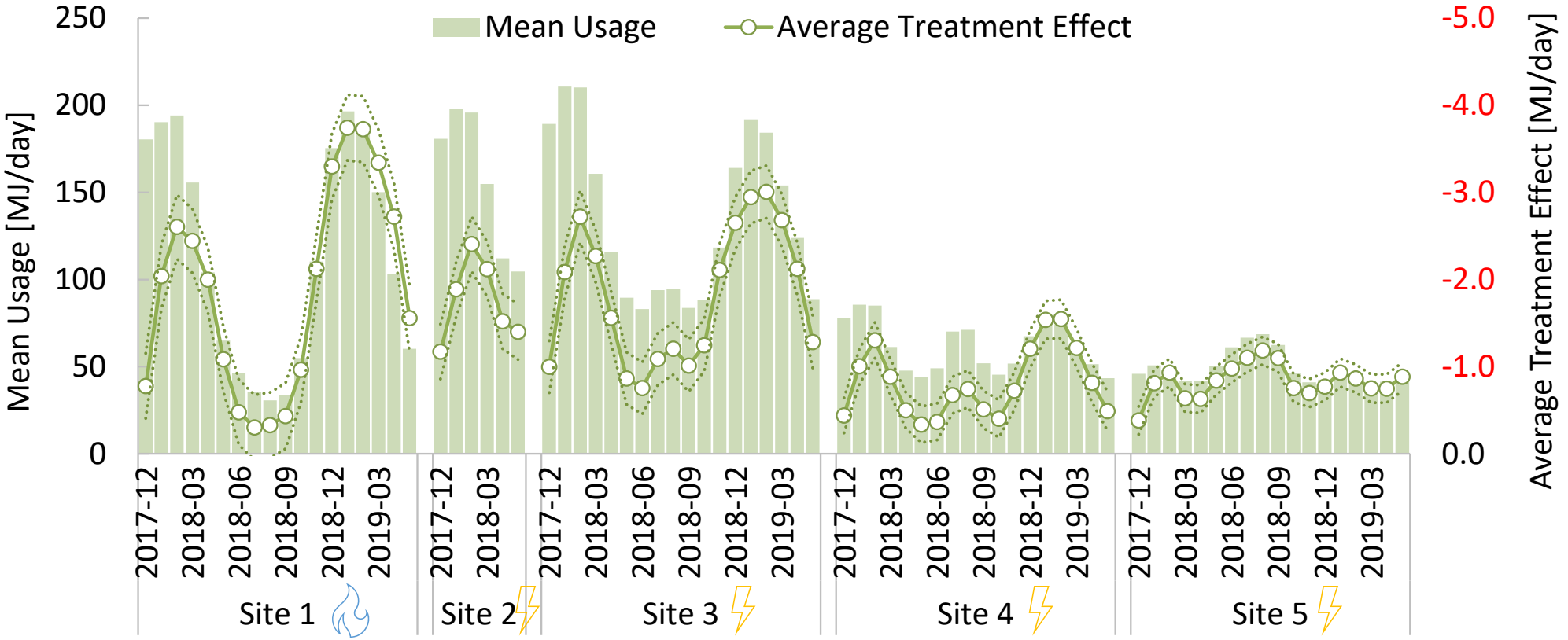
Hereby

- $daily\_usage_{it}$: average daily energy usage for household i [MJ/day]
- β: average treatment effect (ATE), quantifying the change in energy consumption due to the distribution of HERs [MJ/day]
- $Treat_i$: dummy variable indicating the assignment status to the treatment group [unitless]
- mm_t: dummy variable representing the month of the year after the treatment [unitless]
- $AvgUse_i$: average daily energy consumption for household i during the baseline period (one year) [MJ/day]
- $AvgUseWin_i$:average daily energy consumption for household i specifically during the winter months (December to March) [MJ/day]
- $AvgUse\mathrm{Sum}_i$: average daily energy consumption for household i during the summer months (June to September)) [MJ/day]
- ε_{it}:error term, capturing the unexplained variability in energy consumption

Equations for estimating the monthly ATE

Regional and Seasonal Variations of Energy-Saving Effects

- Statistically significant absolute energy reductions [MJ/day] were observed in nearly all months across all five sites.
- **Average Treatment Effect (ATE):**
  - Stronger in **colder regions** (Sites 1–3).
  - More pronounced in **winter** and **summer**, when energy consumption increase.

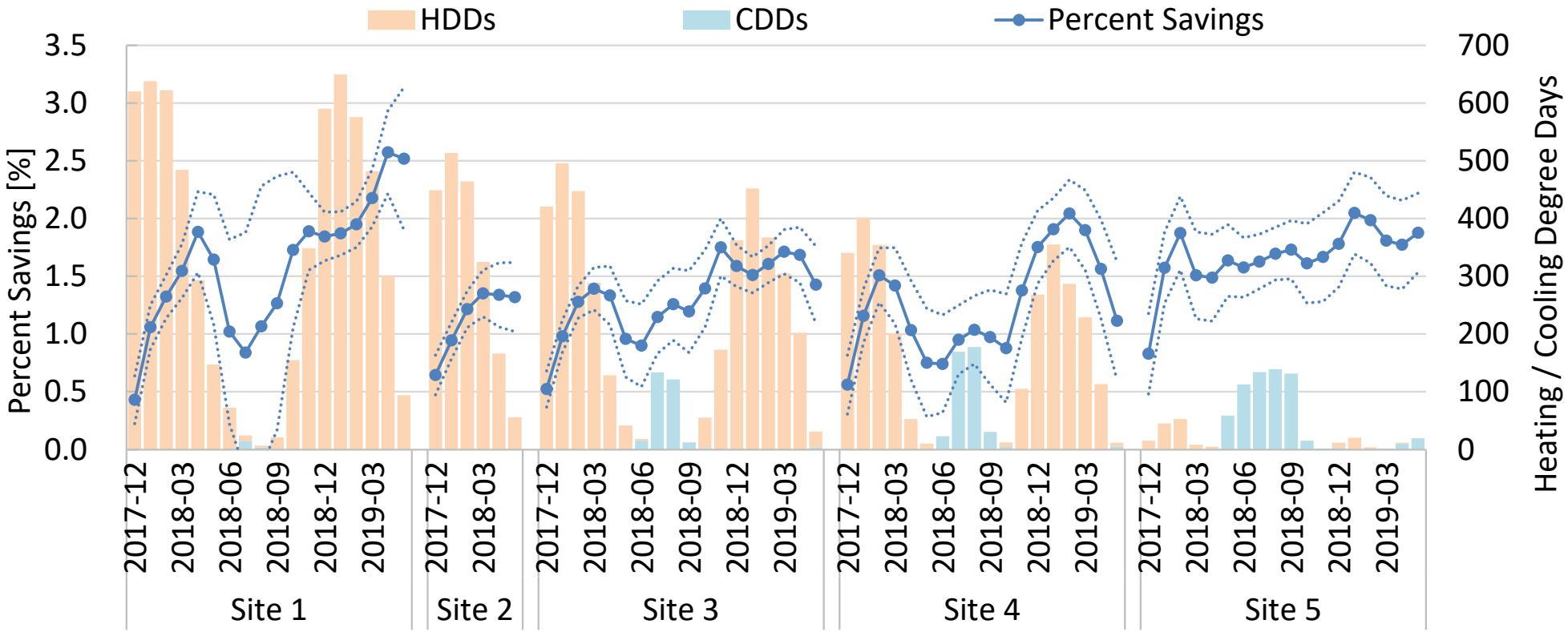


Monthly Mean Energy Usage and ATE for Each Site

Note: The upper and lower dotted lines show the 95% confidence interval.

Monthly Percent Savings and Heating/Cooling Degree Days

- Monthly percent savings [%] ranged from approximately **1.0% to 2.5%**.
  - Despite fluctuations across all regions, continuous intervention resulted in sustained effects up to **18 months**.
- Energy savings were **particularly higher during the heating season**.
  - During **mid-season periods**, higher savings were observed when heating demand decreased.



Monthly Percent Savings and Heating/Cooling Degree Days

Note: Percent Savings = average treatment effect / (average energy consumption of the treatment group - average treatment effect)

(1) Subgroup Settings by Contract Type for Site 3

- To examine how water/space heating systems impact energy savings from HERs by analyzing different contract types and winter usage levels.
- Subgroup by Contract Type:
  - **Time-of-Use (TOU):** Own **electric water/space heaters** using nighttime electricity.
  - **Standard (STD)**: Use gas or kerosine water heater without electricity discounts.
- Subgroup by Winter Energy Usage:
  - High winter baseline: **Primarily electric heater**.
  - Low winter baseline : Likely using non-electric heater (e.g., gas, kerosene).

Subgroups Based on Contract Type and Winter Baseline for Site 3

CONTRACT TYPE	WINTER BASELINE	MAIN SPACE HEATER	WATER HEATER
TOU	Low	Gas or kerosine	**Electric**
STD	Low	Gas or kerosine	Gas or kerosine
TOU	High	**Electric thermal storage heating systems**	**Electric**
STD	High	**Other electric heaters**	Gas or kerosine

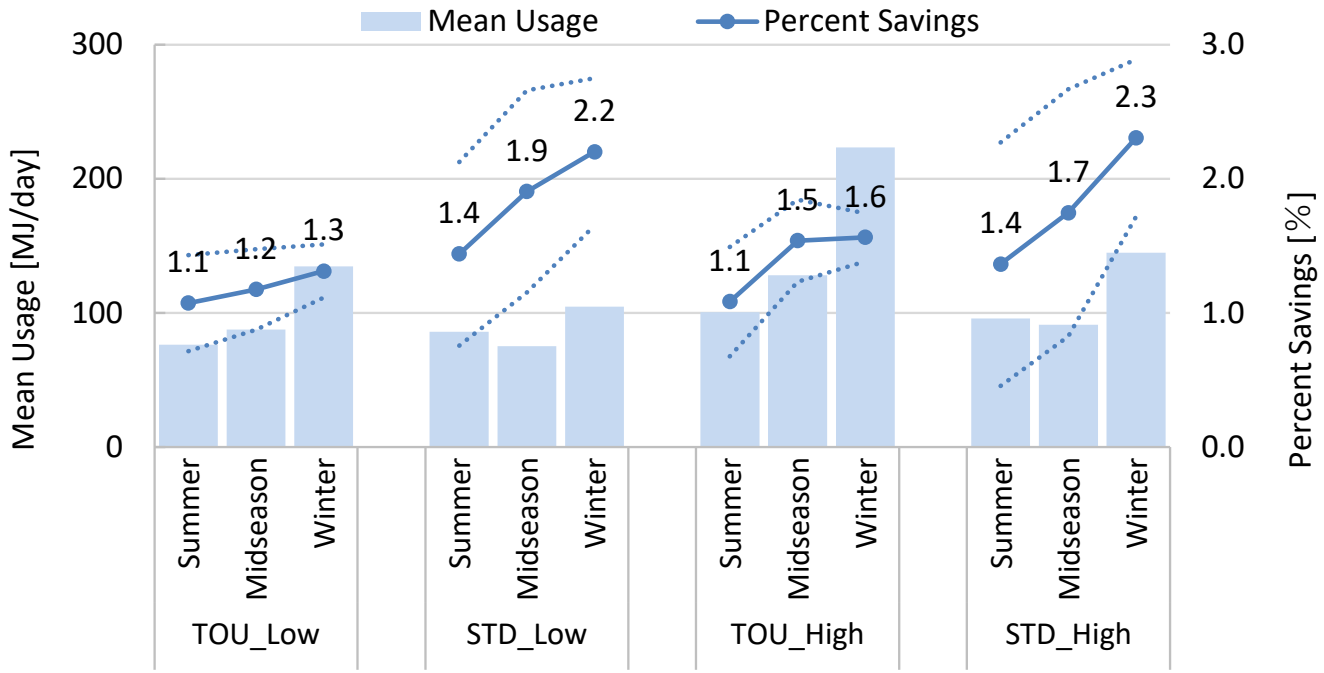
The difference is electric water heater

The difference is electric water AND storage space heater

Note: The top 50% of winter baseline consumption is considered High and the bottom 50% is considered Low

(2) Subgroup Analysis Results

- **Low winter usage**: TOU households (with electric water heaters) had consistently lower reduction rates across all seasons compared to STD households (using gas/kerosene).
- **High winter usage**: TOU households (using electric thermal water / storage space heaters) showed lower reduction rates, especially in winter, compared to STD households.
- Households with electric thermal storage systems (TOU) had lower HER effectiveness, likely due to limited daily control or lack of the knowledge to make efficient setting.



Seasonal Energy Consumption and Percent Savings by Contract Type and Winter Baseline in Site 3

Conclusion

- **Field experiment**: 300,000 households across 5 regions in Japan received HERs.
- **Energy-saving effects**: Verified through a randomized controlled trial (RCT) with statistical reliability from the first month at all sites.
- **Monthly energy savings**: Ranged from **1.0% to 2.5%** over 18 months.
    - Applied to **natural gas** in Site 1 and **electricity** in Sites 2–5.
    - Significant reductions were observed for both energy types.
- **Seasonal trend**: Higher energy savings were observed during the **heating season**.
- **Contract type analysis**: Lower savings for households using **electric thermal storage** systems for water and space heating.