

Classifying household electricity use with smart meter data

How can data be used to target energy advice and services?

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CodeClan final project

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github.com/npscience/final_project_london_energy_weather_forecasting

How can energy supplier use smart meter data to improve services to domestic consumers?

Business problems:

- **Unpaid bills:** seasonal fluctuation → more people unable to afford winter bills
- **Spread out electricity usage:** balance load on national grid, use renewable sources
- **Reduce electricity usage:** from non-renewable sources, by inefficient electrical appliances, and/or where unaffordable for customers (fuel poverty)

We seek to understand:

- Which factors influence electricity use?
- How does electricity use vary across years, seasons, days? Is this predictable?
- How does electricity use vary between individual households? Is this predictable?

Approximately half of households in the UK (45% in England, 40% in Scotland) have an energy monitoring device, or electricity smart meter

English Housing Survey; Scottish House Condition Survey



UK Power Networks research data

- Smart meter readings (kWh) – half-hourly kWh measurements (Nov 2011 – Feb 2014)
- 5,567 households in London (balanced sample representative of Greater London population)
- Research purpose: understand impact of pricing tariffs on domestic electricity usage
- *Shared under CC-BY license*

1. data.london.gov.uk/dataset/smartmeter-energy-use-data-in-london-households
2. kaggle.com/datasets/emmanuelwerr/london-homes-energy-data
3. kaggle.com/datasets/emmanuelwerr/london-homes-energy-data

Secondary data:

Kaggle dataset: “London energy data”

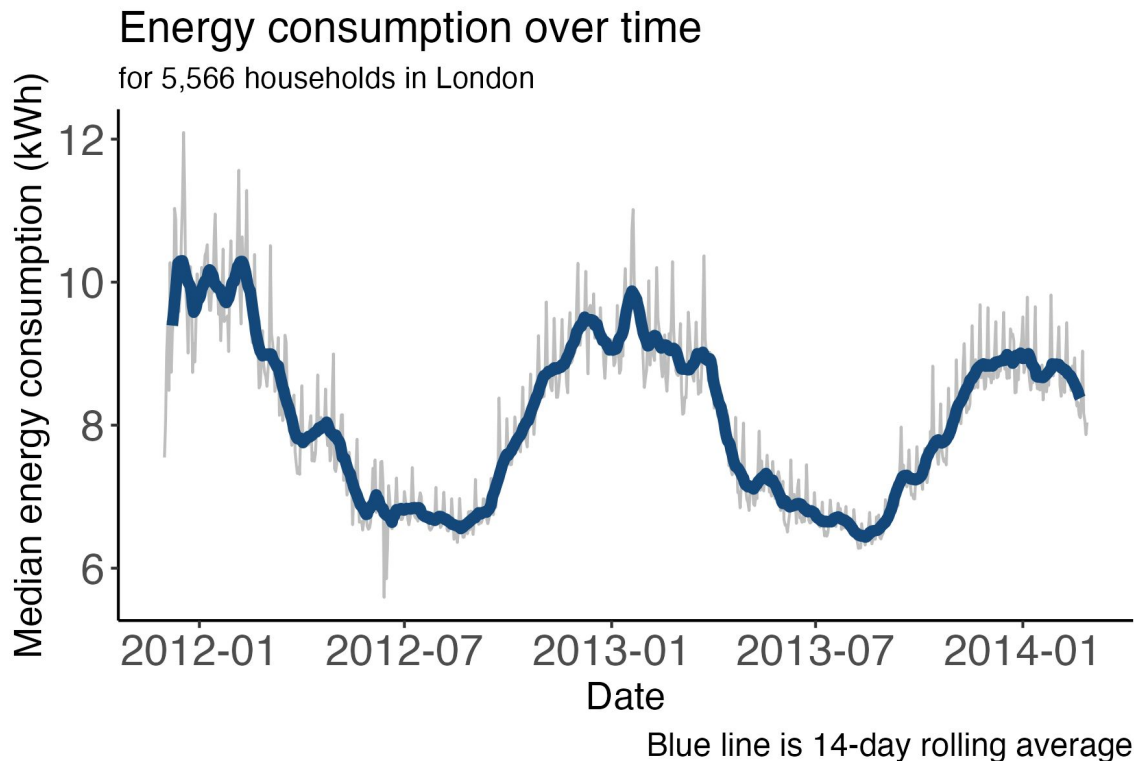
- Daily energy usage per household (summarised from UK Power Networks data)
- Not including pricing tariff groups – *confounding*

Kaggle dataset: “London weather data”

- Daily weather observations in London, 1978– 2021
- Source: European Climate Assessment & Dataset
- Includes temperature, hours of sunshine, cloud cover, radiation, amount of precipitation (including snow)

Kaggle datasets processed and shared to public domain (CC-0) by Emmanuel F Werr

Seasonal electricity usage

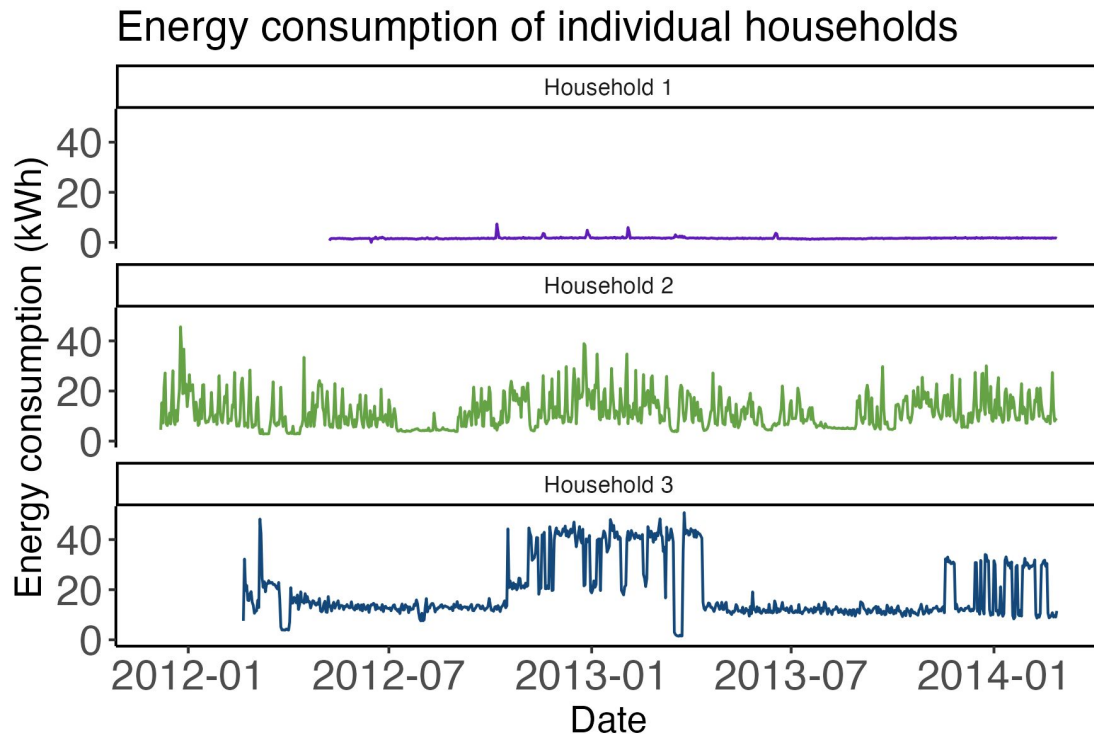


Median electricity usage 7-10 kWh/day, with **winter peaks**

- Typical household uses **75% energy** (all types) on heating the home
- **Electric storage heaters and portable heaters** are main heating method for minority and are **expensive** (electricity is more expensive than gas)

English Housing Survey

Households behave differently

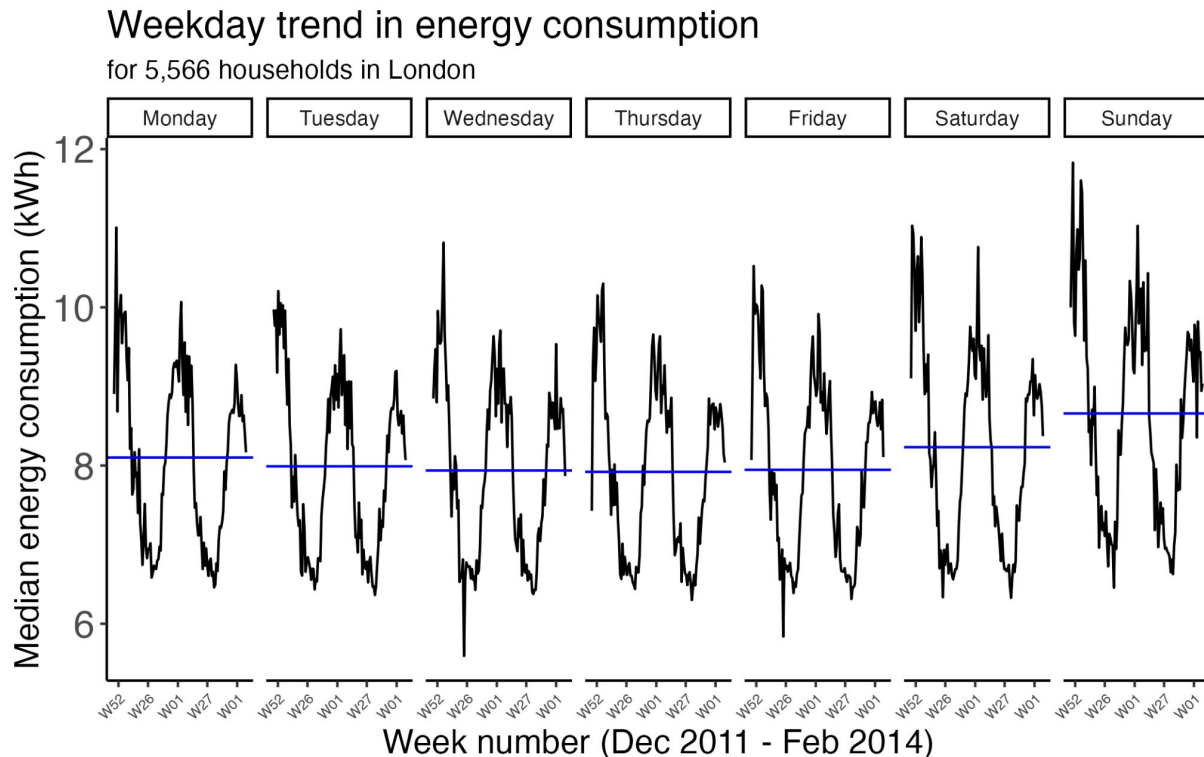


Identify types of households

by K-means clustering

1. Find features that summarise household energy use
 2. Select variables to cluster households by
 3. Prepare data (e.g. scale)
 4. Optimise for k in k-means clustering
 5. Interpret and visualise results
-

Seasonal and weekday trends

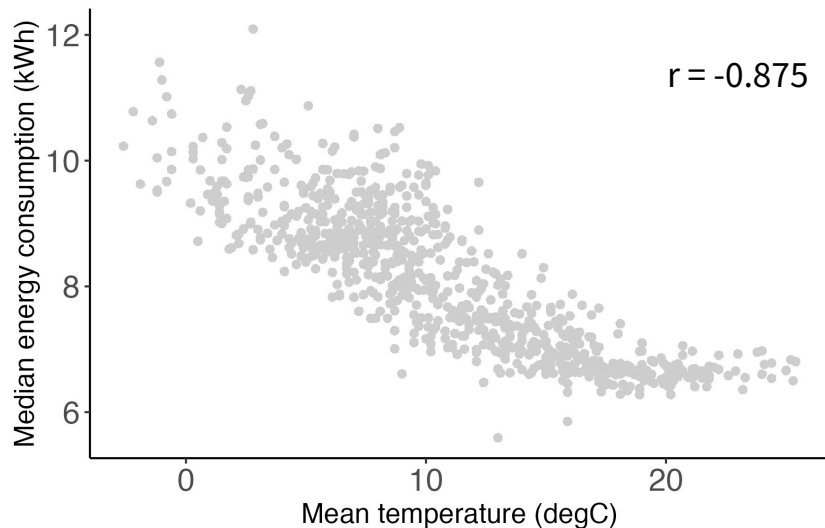


(Winter peaks)

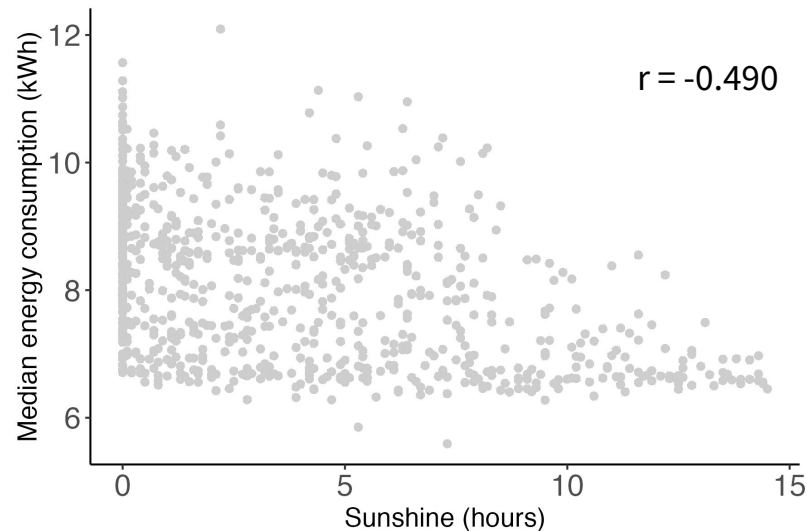
Energy consumption
is typically **higher on
weekend** days

Weather trends

Median energy consumption by daily temperature
for 5,566 households in London

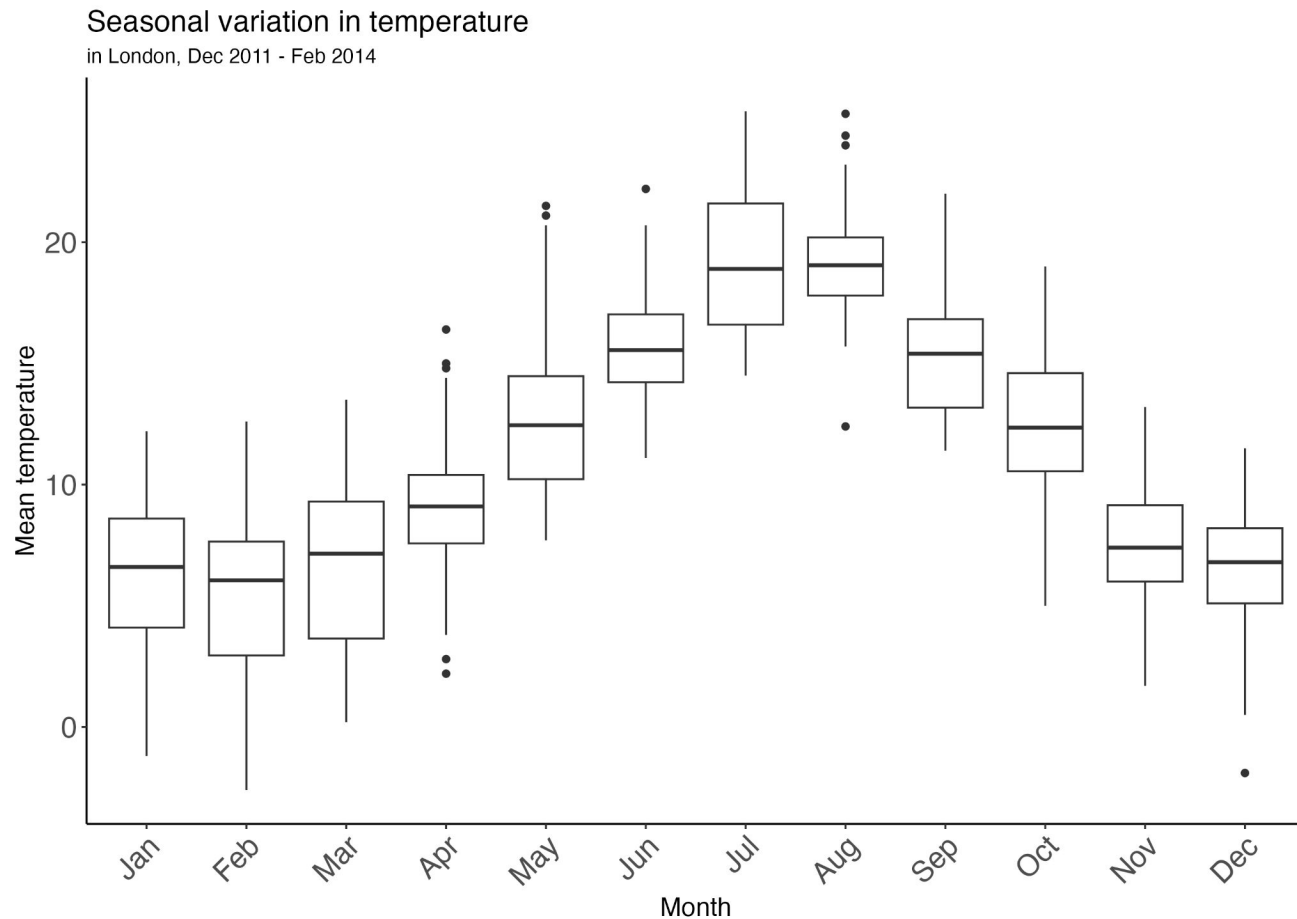


Median energy consumption by hours of sunshine
for 5,566 households in London



Unknown solar panel users

Month/season and weather variables are not independent

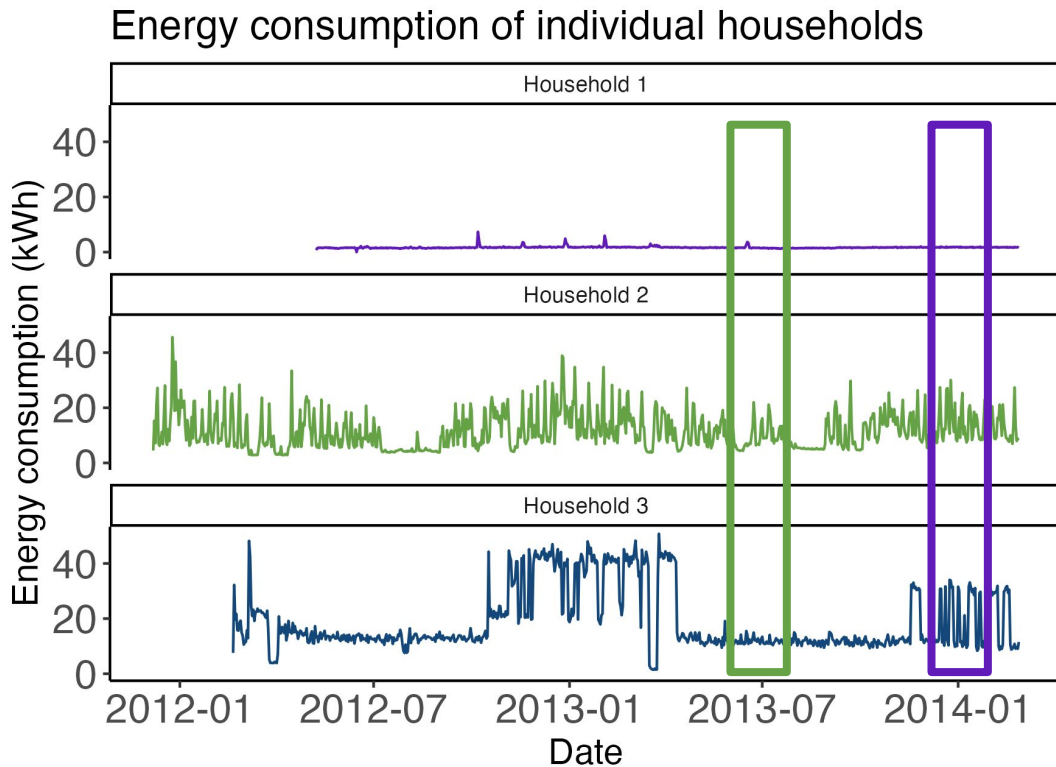


Model features

One row per household with summary statistics:

1. Mean daily energy consumption in Winter
- 2-3. Summer \rightarrow Winter: change in mean kWh and variability (sd)
- 4-5. Weekend: change in mean kWh, Summer and Winter separately

Data from 5,078 households* in Summer and Winter 2013 (*with at least 45 days' recorded energy data per season)

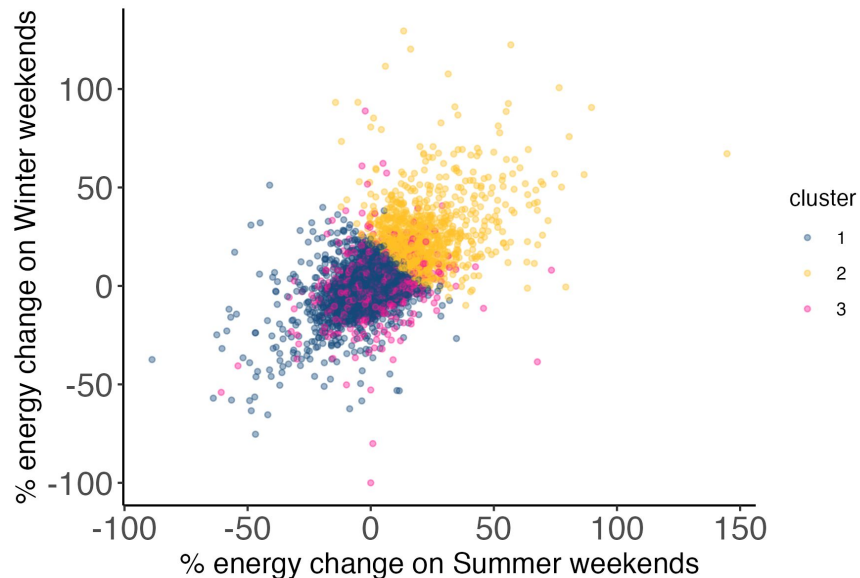


Three types of household

K = 3 optimal

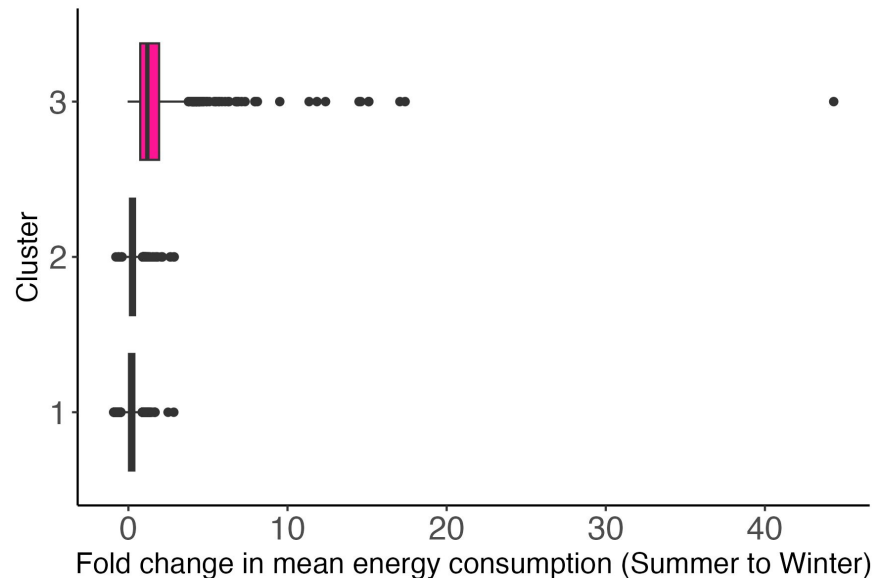
Change in energy usage: weekend effect

for 5,078 households in London, Summer/Winter 2013 (with $k = 3$)

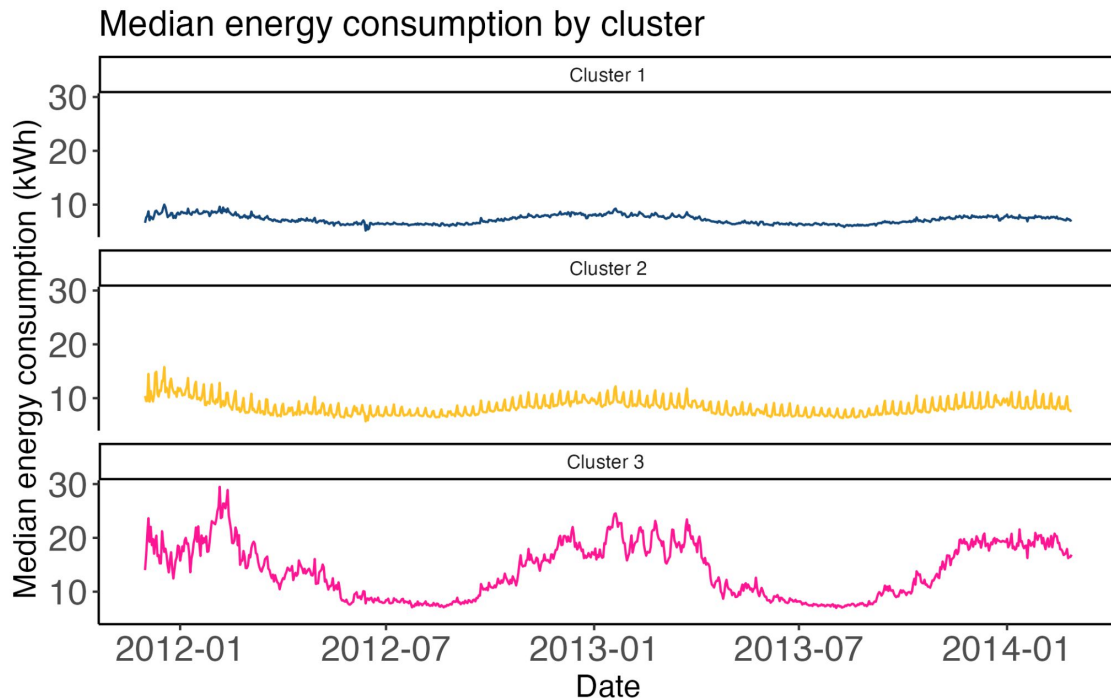


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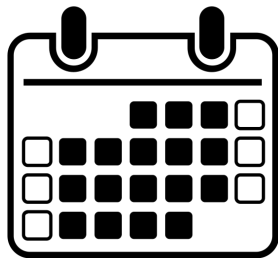


Cluster 1: largest group (3,151 (62%) households) – low electricity users, small seasonal fluctuations

Cluster 2: second-largest group (1,117 (22%) households) – similar to cluster 1 except ***use more energy at weekends***

Cluster 3: smallest group (810 (16%) households) – ***use more energy during winter***

Target advice and services



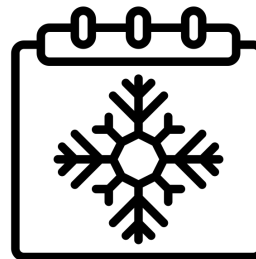
Created by Rohit Arun Rao
from Noun Project

Weekend users: average usage overall with higher use over the weekend (22% households in cluster 2)

May include: working adults, families

Recommend:

- Encourage use of appliances during off-peak times (cheaper pricing)



Created by J703
from Noun Project

Winter users: higher-than-average consumption overall, especially during Winter (16% households in cluster 3)

May include: non-working adults, people with higher heating needs and/or less energy-efficient homes

Recommend:

- Support to improving energy efficiency at home
- Prepare for winter energy bills

High
priority

Next steps

Improve model

- Add explanatory variables: within-season weather*, pricing tariff groups*
- Try different clustering method, e.g. DB-SCAN

Additional analyses

- Probabilistic forecasting to predict future electricity usage
- Analyse within-day energy usage
- Enrich with information on solar panels, gas consumption
- Develop predictive model (classify households)
- Compare to other means of customer segmentation

Continuous updates

- Productionise model
- Pipeline to add/update customer data, regenerate models to classify households

Summary

- Smart meter data is an important resource in efforts to support energy services
- We can use clustering to identify households by seasonal and weekly trends in energy consumption
- Enriching data could produce more individualised and meaningful insights

Thank you
Any questions?

