centre for sustainable energy

Energy consumer archetypes (domestic)

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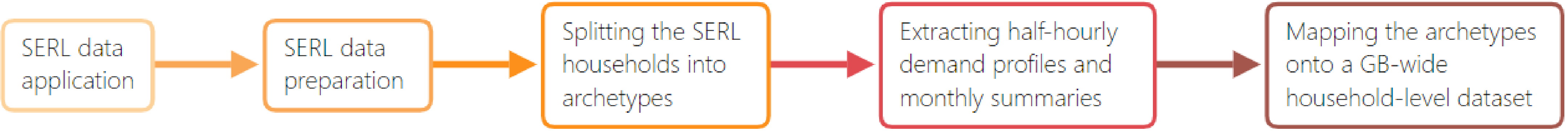
Method

Method overview

This is a brief outline of the method with further detail on each step in the following slides.

- The Smart Energy Research Lab (SERL) Observatory dataset contains half-hourly electricity and gas consumption data and contextual survey data for 13,000 GB households.
- We split these households into archetypes using the survey data. All households in the same group have the same answers for a selection of survey questions. These groups are the domestic archetypes.
- Half-hourly demand profiles were then extracted per archetype
- We classified every household in GB into one of the archetypes using a GB-wide household-level dataset (built from a variety of sources). This gave us the ability to output the geographic distribution of the archetypes and add more descriptive information to each archetype in different areas (e.g., proportion of home owners)



SERL data

- The UKRI Engineering and Physical Sciences Research Council (EPSRC) funded a five-year project to develop a Smart Energy Research Lab (SERL) Observatory to provide access to energy data for the UK research community
- The project was funded to run from August 2017 to August 2022 (with a no-cost extension granted until August 2023) and the SERL dataset has been available to researchers since August 2020. The project is a consortium of seven UK universities and the Energy Saving Trust.
- The SERL data contains the following information for 13,000 GB households:
  - Half-hourly electricity import, electricity export, and gas consumption data from smart meters running from Jan 2019 to late 2022 (although participants were recruited throughout the time period so 13,000 GB households was only reached from 2021 onwards)
  - Survey data on dwelling and household characteristics
- The SERL households are broadly representative of the GB population in terms of Index of Multiple Deprivation (IMD) quintile and region
- The SERL Observatory annual metered energy consumption is consistent with other national datasets such as NEED. This gives confidence that the SERL Observatory is representative of energy use in GB.

"Smart Energy Research Lab (SERL) Observatory DataElam, S., Webborn, E., McKenna, E., Oreszczyn, T., Anderson, B., Few, J., Pullinger, M., European Centre for Medium-Range Weather Forecasts, Ministry of Housing, Communities and Local Government, Royal Mail Group Limited. (2022). Smart Energy Research Lab Observatory Data, 2019-2021: Secure Access. [data collection]. 5th Edition. UK Data Service. SN: 8666, DOI: http://doi.org/10.5255/UKDA-SN-8666-5"

Limitations and drawbacks of the SERL data

Data access

- Access to household-level data is very secure with the application process taking approximately 3 months
  - See the SERL website for current access requirements: https://serl.ac.uk/researchers/
- Researchers working with the data must be Accredited Researchers (AR status is applied for through the ONS Research Accreditation Service and requires training)
- Analysis of the data must take place within the UK Data Service Secure Lab. Any outputs from this secure environment must pass through Statistical Disclosure Control (SDC), which can take 1 – 3 weeks and requires all underlying Ns to be greater than 10.

Data content

- Only includes households with a smart meter and there is bias in the smart meter rollout
- Does not include non-metered fuel consumption data
- Only one survey (on household and dwelling characteristics) conducted at the start of the participant’s involvement. Household and dwelling characteristics could change during the smart meter data collection time period.
- The data collection period partially overlaps with the COVID-19 lockdowns. This makes it a fantastic resource for studying demand pattern changes during societal changes, but it adds complications for studying “normal” demand patterns.

SERL data preparation

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Here we show the step-by-step process we went through to clean and prepare the SERL data for further analysis.

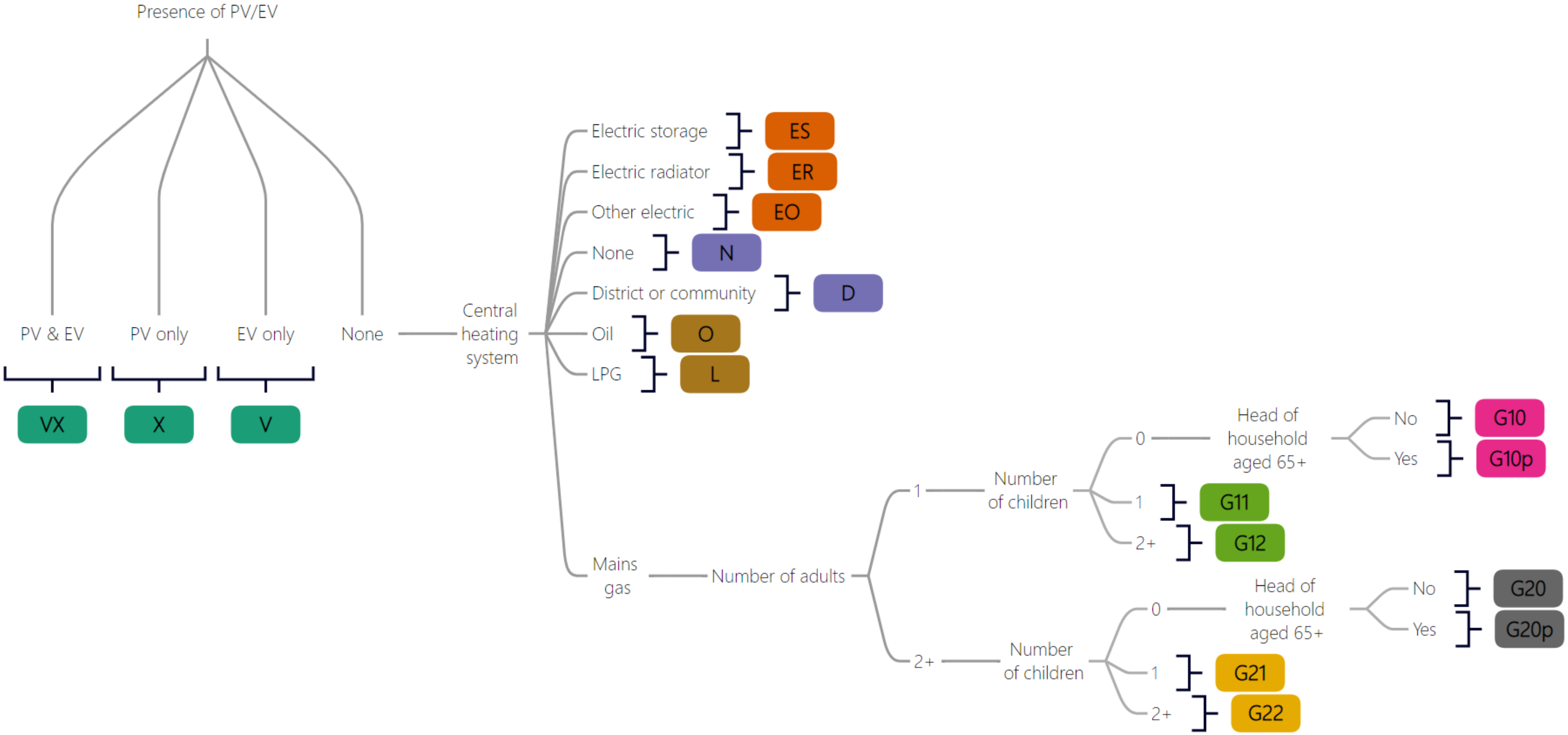
1. We wanted to maximise the number of households in our analysis, which meant we could only use smart meter data from 2021 onwards (the number of participating households increased from approximately 5000 to 13,000 at the end of 2020).
2. We also wanted to avoid a period of time where a COVID-19 national lockdown occurred. The last national lockdown ended in March 2021 with local lockdowns and other restrictions coming to an end in July 2021. For these reasons, we decided we would use smart meter data from July 2021 to June 2022 (inclusive). This would give us an entire year of energy consumption data, avoiding national lockdowns, and including the greatest number of households possible.
3. The SERL researchers had already attached a flag to each half-hourly smart meter reading to indicate whether the data was valid, missing, or likely to be an error. We filtered out any households with less than 75% of valid readings over the year long time period.
4. For the remaining households, we replaced invalid readings with the mean of valid readings from the same household, same month, and same type of day (either weekday or weekend).
5. We then applied a further filter to make sure we only kept households with data throughout the entire July 2021 – June 2022 time period (some households dropped out during the time period)
6. We were left with 8,671 households with valid smart meter data
7. We then joined the smart meter data to the survey data (on dwelling and household characteristics) and filtered out households with missing survey data, leaving 8,457 households.

Creating the domestic archetypes

- We split the 8,457 remaining SERL households (after data cleaning) into archetypes. The splitting was achieved using a selection of SERL survey variables.
- The variables used for archetype creation were selected based on the following requirements (the first three were identified during the **user needs assessment and stakeholder engagement process**):
  - The total number of archetypes should be around 15
  - The half-hourly demand profile shapes should be as distinct as possible. Note, we are talking about demand profile *shapes* (i.e., normalised demand profiles).
  - The SERL survey variables used for splitting need to have an exact (or similar) match with a variable in the GB-wide household-level dataset to enable us to calculate the geographic distribution of the archetypes
  - After splitting, the number of SERL households within an archetype needs to be greater than 10 (the N > 10 rule for statistical disclosure control)
- *Presence of an EV or PV* and the household's *type of central heating system* has the greatest influence on demand profile shape, which is why these variables were used first to split the SERL households. Further splitting was not possible, except for gas archetypes, due to the N > 10 rule.
- The gas archetypes were split further by *number of adults*, *number of children*, and *head of household aged 65+* because these variables had a strong influence on morning and evening demand peaks
- In total, 18 archetypes were created, and the full splitting structure can be seen visually in the next slide

It should be noted that we trialled another method for creating archetypes with the SERL data. We performed a cluster analysis using approximately 10 variables. These clusters had the benefit of containing more information but the drawback of being harder to define and less distinct from one another, and the mapping of every GB household onto an archetype would have been far less accurate.

Domestic archetype tree



The 18 domestic archetypes and the profiles that could be extracted for each archetype. The numbers in parentheses in the last three columns indicate the number of underlying SERL households behind each profile.

Archetype code	Presence of PV/EV	Central heating system	Number of adults	Number of children	Head of household aged 65+	Electricity import profiles	Electricity export profiles	Gas profiles
VX	EV and PV					Yes (59)	Yes (59)	Yes (38)
X	PV only					Yes (499)	Yes (501)	Yes (373)
V	EV only					Yes (255)	No	Yes (194)
ES	None	Electric storage				Yes (130)	No	No
ER	None	Electric radiators				Yes (164)	No	No
EO	None	Other electric				Yes (61)	No	No
N	None	None				Yes (194)	No	Yes (92)
D	None	District or community				Yes (80)	No	No
O	None	Oil				Yes (296)	No	No
L	None	LPG				No	No	No
G11	None	Mains gas	1 adult	1 child		Yes (87)	No	Yes (87)
G12	None	Mains gas	1 adult	2+ children		Yes (56)	No	Yes (56)
G21	None	Mains gas	2+ adults	1 child		Yes (434)	No	Yes (434)
G22	None	Mains gas	2+ adults	2+ children		Yes (529)	No	Yes (529)
G10	None	Mains gas	1 adult	0 children	No	Yes (583)	No	Yes (584)
G10p	None	Mains gas	1 adult	0 children	Yes	Yes (699)	No	Yes (699)
G20	None	Mains gas	2+ adults	0 children	No	Yes (1,621)	No	Yes (1,621)
G20p	None	Mains gas	2+ adults	0 children	Yes	Yes (1,221)	No	Yes (1,221)

Notes on the archetypes

- “Other electric” refers to electric central heating other than storage heaters and electric radiators (e.g., heat pumps)
- “LPG” refers to Liquified Petroleum Gas, tank and bottled. No electricity import, electricity export, or gas consumption profiles could be extracted for households using LPG for heating. This is because there was not enough information in the SERL data to completely isolate LPG households so the profiles would not have been entirely “LPG households”.
- Not having a gas profile does not necessarily mean that ALL households that fall into that archetype do not use gas (although it is more likely they don’t due to there being a central heating system that uses a different fuel). The reason for there not being a gas profile is that we were unable to extract the data from SERL due to there not being enough gas consuming households in those archetypes to pass the N > 10 statistical disclosure rule. Later, you will see that we add a *mains gas connection proportion* variable to our outputs to assist with understanding which households use mains gas and which households do not.
- Archetypes VX, X, and V will have a mixture of central heating types because they were created before the split by central heating type

Extracting half-hourly normalised demand profiles

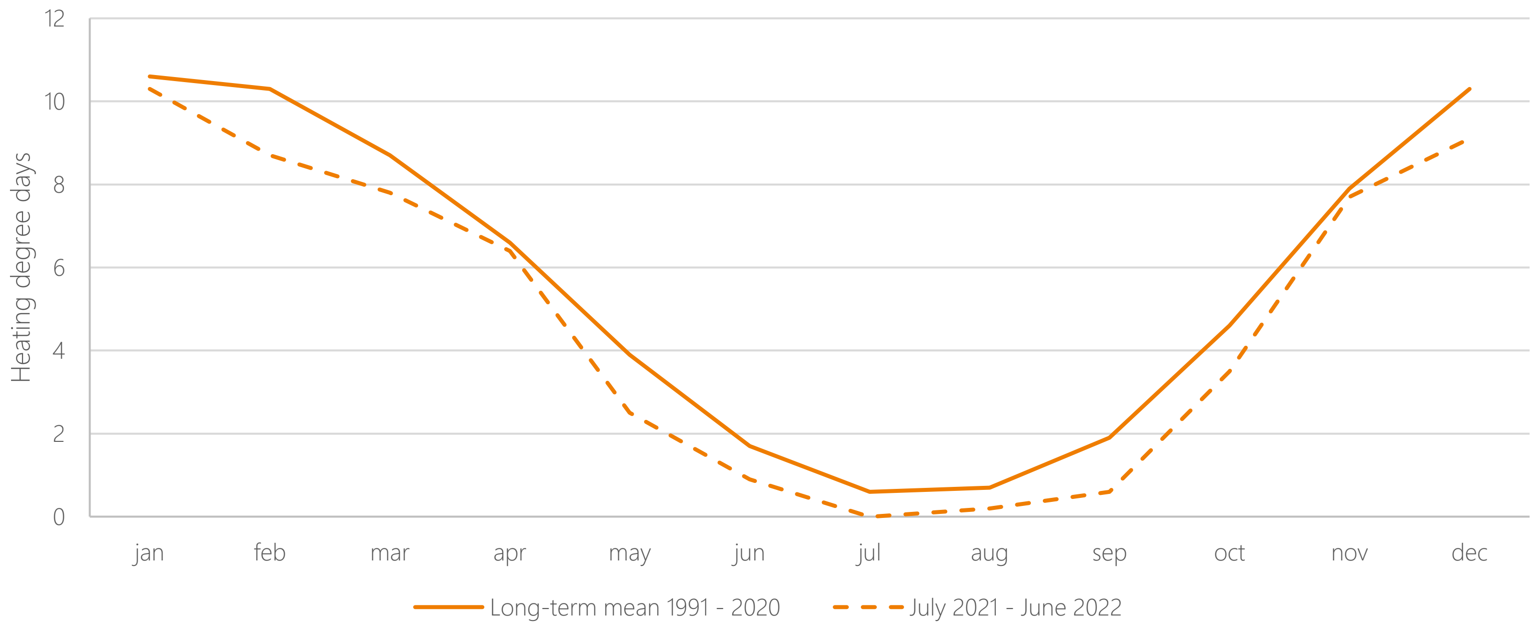
1. Each of the 8,457 SERL households had 17,520 half-hourly data points (units: Wh) for electricity import, gas, and electricity export (every half-hour for the time period July 2021 to June 2022). First, we normalised these profiles by dividing each data point by the annual sum. For example, each data point for an electricity import profile became the proportion of annual electricity import consumed within that single half-hour period.
2. We then determined which households could contribute to the three types of profile per archetype:
   a) For a household to contribute to the electricity import profile of an archetype, annual electricity import must be greater than 200 kWh
   b) For a household to contribute to the gas profile of an archetype, annual gas consumption must be greater than 200 kWh
   c) For a household to contribute to the electricity export profile of an archetype, annual electricity export must be greater than 100 kWh
3. For each archetype, this left the number of households given in parentheses in the last three columns of the table of archetypes. Note, a "No" in these columns may either indicate zero households or fewer than 10 (the N > 10 rule for statistical disclosure control).
4. For each SERL household and profile type, we grouped the data by calendar month, type of day, and half-hour period. The *type of day* was either a weekday (defined as Monday – Friday) or a weekend (Saturday – Sunday).
5. For each SERL household and profile type, we then took the mean of each group of data points (with the following dates not included in the averaging: all bank holidays between July 2021 and June 2022 plus 25/12/2021, 26/12/2021, and 01/01/2023)
6. For each archetype and profile type, the following were calculated using all the SERL households within the archetype for each calendar month, type of day, and half-hour period: mean, 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentile.
   a) So, for example, the mean gas consumption for archetype G1 on a March weekday between 07:30 and 08:00 was calculated by averaging over 13,432 data points = *number of weekday days in March 2022* (23) × *number of SERL households with a gas profile in archetype G10* (584)
   b) The percentiles were calculated by taking the mean of the 10 SERL households closest to the X^{th} percentile (this method was required due to statistical disclosure control restrictions).

Extracting monthly summaries

1. We used the same constraints imposed for half-hourly profiles to determine which households could contribute to the three types of monthly summary per archetype:
    a) For a household to contribute to the electricity import monthly of an archetype, annual electricity import must be greater than 200 kWh
    b) For a household to contribute to the gas monthly summary of an archetype, annual gas consumption must be greater than 200 kWh
    c) For a household to contribute to the electricity export monthly summary of an archetype, annual electricity export must be greater than 100 kWh
2. For each SERL household and profile type the following summaries were calculated: monthly total kWh, monthly half-hour peak Wh, and monthly half-hour minimum Wh
3. For each archetype and profile type, the following were calculated using all the SERL households within the archetype for each summary variable: mean, 10th, 25th, 50th, 75th, and 90th percentile.
    a) So, for example, the mean half-hour peak gas consumption for archetype G10 in March was calculated by averaging over all the "half-hour peak gas consumption in March" values for each SERL household in archetype G10 (584 households)
    b) The percentiles were calculated by taking the mean of the 10 SERL households closest to the Xth percentile (this method was required due to statistical disclosure control restrictions).

Heating degree days July 2021 – June 2022

- The domestic archetype half-hourly profiles and monthly summaries were derived from smart meter data from the time period July 2021 – June 2022 (to maximise the number of SERL households and to avoid the COVID lockdowns)
- From the graph below, we can see that the heating degree days for July 2021 – June 2022 was less than the 1991 – 2020 long-term mean for every month. The winter of 2021 – 2022 was quite mild compared to the average winter.
- The smart meter data in the outputs is NOT temperature-corrected, so care needs to be taken when using the outputs for peak demand estimates. A scaling factor could be used on the monthly summary outputs based on a heating degree day ratio.



Digest of UK Energy Statistics (DUKES): weather

Mean heating degree days 2002 to 2022 (DUKES 1.1.9)

https://www.gov.uk/government/statistics/weather-digest-of-united-kingdom-energy-statistics-dukes

GB-wide household level dataset

- This dataset is the result of joining datasets from multiple sources:
  - Ordnance Survey AddressBase
  - EPCs (contains EPC rating, heating fuel/system, recommended insulation etc)
  - Experian Household Directory
  - Experian Mosaic Grand Index
- Missing EPC data was imputed based on average (or modal for non-numeric) values for addresses in the same postcode with non-missing EPC data with the same built form, number of bedrooms, and building age. If this was not possible, then one (or more) of those variables were dropped until there was a non-missing EPC value found in the same postcode to impute from.
- Along with EPC data, an open dataset of solar PV installations was used to estimate whether a household had solar PV or not.
  - Link to the Nature paper: https://www.nature.com/articles/s41597-020-00739-0
  - Link to the open dataset: https://zenodo.org/record/4059881
- The variables *EV score*, *PV score*, and *fuel poverty score* will be explained in more detail in later slides

Table of all the variables in the GB-wide household level dataset (see bullets on the left for more detail)

Variable	Data source
UPRN	OS AddressBase, Experian Household Directory
Residential status (TRUE/FALSE)	OS AddressBase
Heating fuel/system	EPC
Rooftop solar PV (TRUE/FALSE)	EPC, open dataset of solar PV installations
Mains gas connection (TRUE/FALSE)	EPC, Experian Household Directory
Tenure	Experian Household Directory
Head of household age	Experian Household Directory
Household income	Experian Household Directory
Number of adults in the household	Experian Household Directory
Number of children in the household	Experian Household Directory
EV score	Experian Mosaic Grand Index
PV score	Experian Mosaic Grand Index
Fuel poverty score	Experian Mosaic Grand Index

Classifying every GB household into one of the archetypes

- Each household in the GB-wide household-level dataset was classified into one of the domestic archetypes using the logic shown in the table on the right
- The archetype household counts were then aggregated to the following levels:
  - Lower super output area (LSOA) using Census 2011 boundaries
  - Local authority level (LAD) using 2023 boundaries
  - All of GB
- For statistical disclosure control reasons, household counts below 5 and the total household count are both not shown in the LSOA and LAD outputs
- Note, there are 3 LSOAs with no UPRNs (implying no households). These LSOAs are therefore missing from the outputs, so the total number of LSOAs in the outputs is 41,726 rather than 41,729
  - S01010206, Petershill – 04, Glasgow City
  - S01010226, Sighthill – 02, Glasgow City
  - S01010227, Sighthill – 03, Glasgow City

Archetype code	Logic for mapping GB households onto the archetypes (evaluated in order)
X	If household has solar PV
ES	If household has electric storage heaters
ER	If household has electric radiators
EO	If household has electric heating but not electric storage heaters or radiators (e.g., heat pumps)
N	If household has no central heating (from EPC data)
D	If household is heated via district or community heat
O	If household has oil central heating
L	If household has LPG central heating
G11	If household has mains gas central heating, 1 adult, and 1 child
G12	If household has mains gas central heating, 1 adult, and 2+ children
G21	If household has mains gas central heating, 2+ adults, and 1 child
G22	If household has mains gas central heating, 2+ adults, and 2+ children
G10	If household has mains gas central heating, 1 adult, and the head of the household is not over 65
G10p	If household has mains gas central heating, 1 adult, and the head of the household is over 65
G20	If household has mains gas central heating, 2+ adults, and the head of the household is not over 65
G20p	If household has mains gas central heating, 2+ adults, and the head of the household is over 65
NA	If household meets none of the above conditions

Limitations of the household-level classification

- According to national statistics published by DESNZ[1], there are 1.2 million domestic solar PV installations as of March 2023. The classification of each GB household into an archetype resulted in 346,118 households being assigned archetype X. Therefore, archetype X is underrepresented and is roughly 25% of what it should be.
- We have no data on EV ownership at a household level so could not map archetype V and VX alongside the others. However, using a dataset from the Department of Transport and DVLA[3] we have calculated the number of licensed ultra-low emission vehicles at an LSOA level by fuel type (battery electric, plug-in hybrid electric, range extended electric) and keepership (private and company).
  - The data shows yearly counts for the last five years so also gives an indication of the EV growth rate by LSOA
  - In the raw data, "[c]" represents fewer than 5 vehicles (suppressed due to statistical disclosure control)
- EV numbers by LSOA could be used as an estimate for the number of households with an EV (the sum of archetypes VX and V). However, without data on EV ownership at a household level, it would be difficult to predict which households currently mapped to one of the other archetypes (X,…,G20p) would instead actually be assigned to VX or X.

1 https://www.gov.uk/government/statistics/solar-photovoltaics-deployment
2 https://www.ons.gov.uk/datasets/create
3 https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-files

Additional household-level variables

- The following additional variables were available for each household in the GB-wide dataset:
    - Mains gas connection
    - Tenure
    - Household income
    - EV score
    - PV score
    - Fuel poverty score
- Note, EV, PV, and fuel poverty score are not present in the data at a strictly household level. Each of the Experian Mosaic types (66 archetypes created from a cluster analysis of the UK population) are assigned an index (a number) to certain variables (e.g., Highest qualifications: GCSEs). The index is calculated by dividing the Mosaic type % by the UK %. A score above 100 represents greater than UK average prevalence/agreement with the statement. A score below 100 represents less than UK average prevalence/agreement with the statement. Each household in GB is then classified into one of the 66 Experian Mosaic types.
- The EV score is derived from the Experian Mosaic variable "Electric cars are the future of motor industry". This variable uses YouGov and TGI as the source.
- The PV score is derived from the Experian Mosaic variable "Consider getting solar panels on my home". This variable uses YouGov and TGI as the source.
- The fuel poverty score is derived from the Experian Mosaic variable "Fuel poverty". We do not know the source of this data (other than Experian).

The additional variables in the GB-wide dataset allowed us to calculate the following for each archetype for each LSOA, LAD, and all of GB:

- Mains gas connection proportion
- Home owner proportion
- Average (median) household income
- Average EV score
- Average PV score
- Average fuel poverty score

The additional variables were chosen to assist with modelling the following:

- Flexibility service engagement
- Vulnerable customers / ability to pay
- EV and PV take-up

These were identified as key use cases of the archetypes during the **user needs assessment and stakeholder engagement process**.

Using the Living Cost and Food Survey to estimate scheme eligibility

- We used the Living Cost and Food Survey[1] (LCF) to estimate the proportion of households within each domestic archetype that are eligible for each of the following:
  - Cold Weather Payment (https://www.gov.uk/cold-weather-payment/eligibility)
  - Energy Company Obligation (https://www.gov.uk/energy-company-obligation)
  - Winter Fuel Payment (https://www.gov.uk/winter-fuel-payment)
  - Warm Home Discount Scheme (https://www.gov.uk/the-warm-home-discount-scheme)
- First, we used the scheme eligibility criteria to establish which households in the LCF are eligible for each scheme. The schemes' criteria consider factors such as receiving specific benefits, meeting income thresholds, having a household representative above a certain age, having a certain EPC rating, maintaining a specific tenure, and having children below the age of five.
- Then, we classified each household in the LCF into one of the domestic archetypes. This allowed us to estimate the proportion of households within each domestic archetype that are eligible for each scheme. We also used the LCF to estimate the proportion of households within each domestic archetype that receive disability benefits.
- Note, households in the LCF could not be joined with archetypes VX, X, V, and N (due to a lack of data on low carbon technologies in the LCF) and archetypes ES/ER/EO could not be distinguished from each other.

1 Department for Environment, Food and Rural Affairs, Office for National Statistics. (2023). Living Costs and Food Survey, 2020-2021. [data collection]. 2nd Edition. UK Data Service. SN: 9022, DOI: http://doi.org/10.5255/UKDA-SN-9022-2

Outputs

Outputs overview

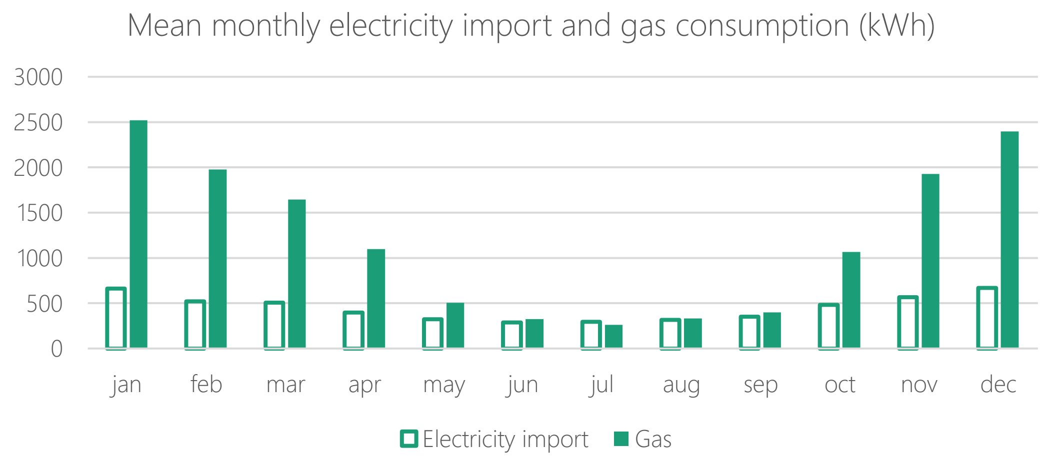
- The table on the right lists all the output files with a short description of each
- The slides to follow will showcase some of the outputs:
    - For each archetype in turn, annual energy consumption summaries* and half-hourly profiles
    - A comparison of half-hourly profiles across the different archetypes
    - An example showing the different percentiles (10th, 25th, 50th, 75th, and 90th) in a half-hourly profile
    - A comparison of annual energy consumption across the different archetypes
    - Overview of GB-wide household counts
    - Example scatter plot of the additional variables/metrics

File name	Description
archetype-summaries-all-gb.xlsx	Archetype household counts and other metrics for all of GB
archetype-summaries-by-lad23.xlsx	Archetype household counts and other metrics by local authority (2023 boundaries)
archetype-summaries-by-lsoa11.xlsx	Archetype household counts and other metrics by LSOA (Census 2011 boundaries)
electricity-export-normalised-hh-profiles.xlsx	Normalised half-hourly electricity export over the time period July 2021 – June 2022 split by archetype, month, and type of day
electricity-export-summaries-by-month.xlsx	Monthly summaries of electricity export (total, peak, and minimum) by archetype
electricity-import-normalised-hh-profiles.xlsx	Normalised half-hourly electricity import over the time period July 2021 – June 2022 split by archetype, month, and type of day
electricity-import-summaries-by-month.xlsx	Monthly summaries of electricity import (total, peak, and minimum) by archetype
gas-normalised-hh-profiles.xlsx	Normalised half-hourly gas consumption over the time period July 2021 – June 2022 split by archetype, month, and type of day
gas-summaries-by-month.xlsx	Monthly summaries of gas consumption (total, peak, and minimum) by archetype
number-of-evs-by-lsoa11.xlsx	Counts of licensed ultra-low emission vehicles at an LSOA level by fuel type (battery electric, plug-in hybrid electric, range extended electric) and keepership (private and company)
scheme-eligibility.xlsx	Estimates of the proportion of households within each domestic archetype that are eligible for each of the following schemes: Cold Weather Payment, Energy Company Obligation, Winter Fuel Payment, Warm Home Discount Scheme
colour-palette.xlsx	HEX and RGB values for the archetype colour palette

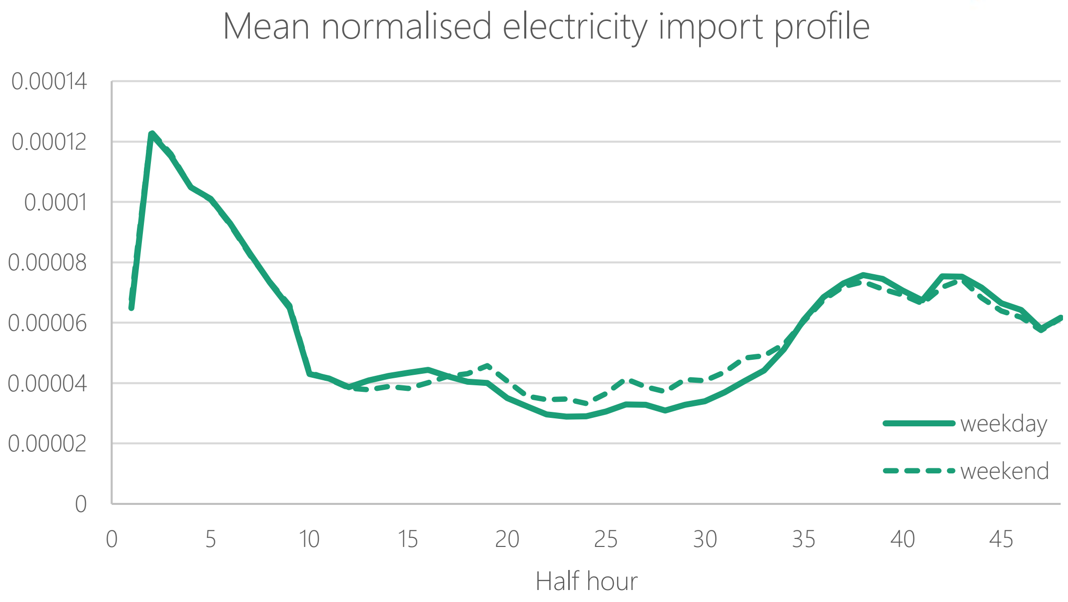
* For each archetype, we calculate the 90th percentile (out of all SERL households within the archetype) peak half-hourly consumption per month. "Peak" refers to the maximum value out of all 12 months in the year in the following slides showcasing each archetype.

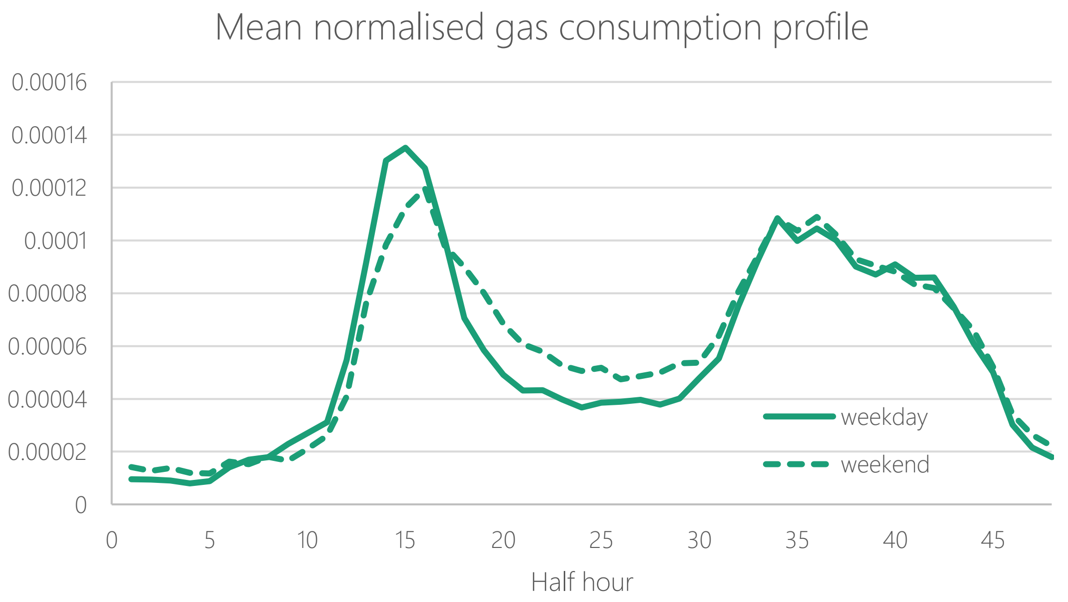
Archetype VX

Energy metric	Value
Mean annual electricity import	5,380 kWh
Mean annual gas consumption	14,440 kWh
Mean annual electricity export	1,630 kWh
Peak* half-hourly electricity import	5.5 kWh
Peak half-hourly gas consumption	14.4 kWh
Peak half-hourly electricity export	1.8 kWh



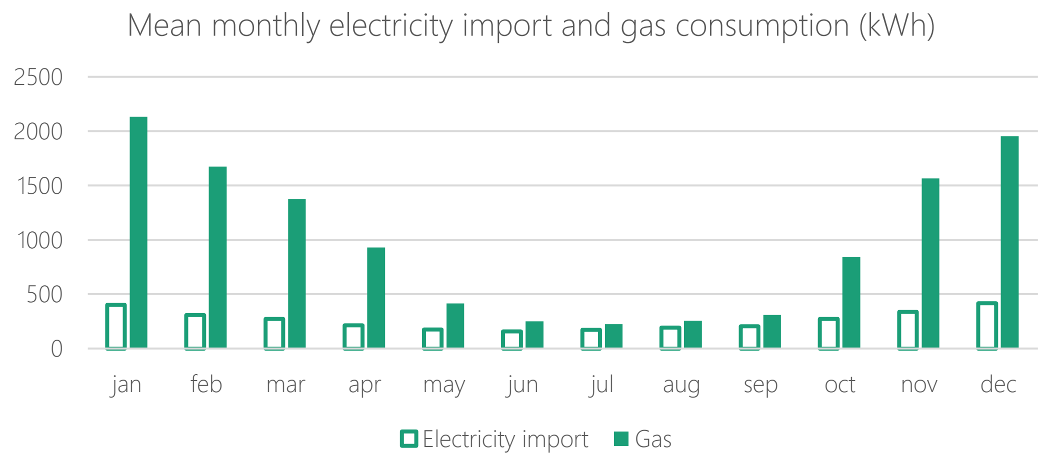
* See the "Outputs overview" slide for a definition of "Peak"

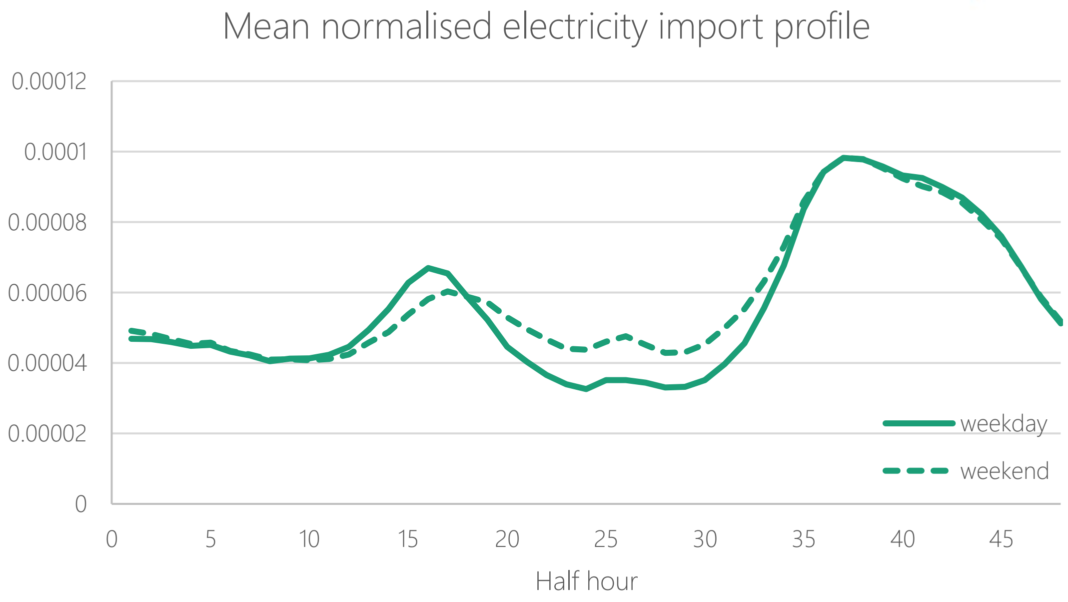


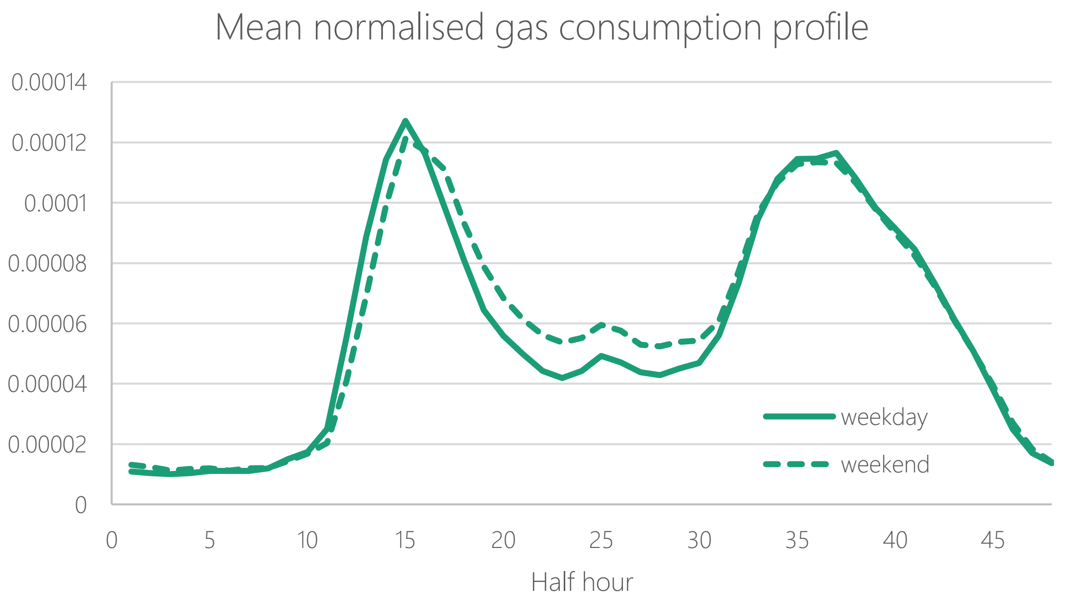


Archetype X

Energy metric	Value
Mean annual electricity import	3,130 kWh
Mean annual gas consumption	11,920 kWh
Mean annual electricity export	1,730 kWh
Peak* half-hourly electricity import	3.5 kWh
Peak half-hourly gas consumption	13.1 kWh
Peak half-hourly electricity export	1.6 kWh

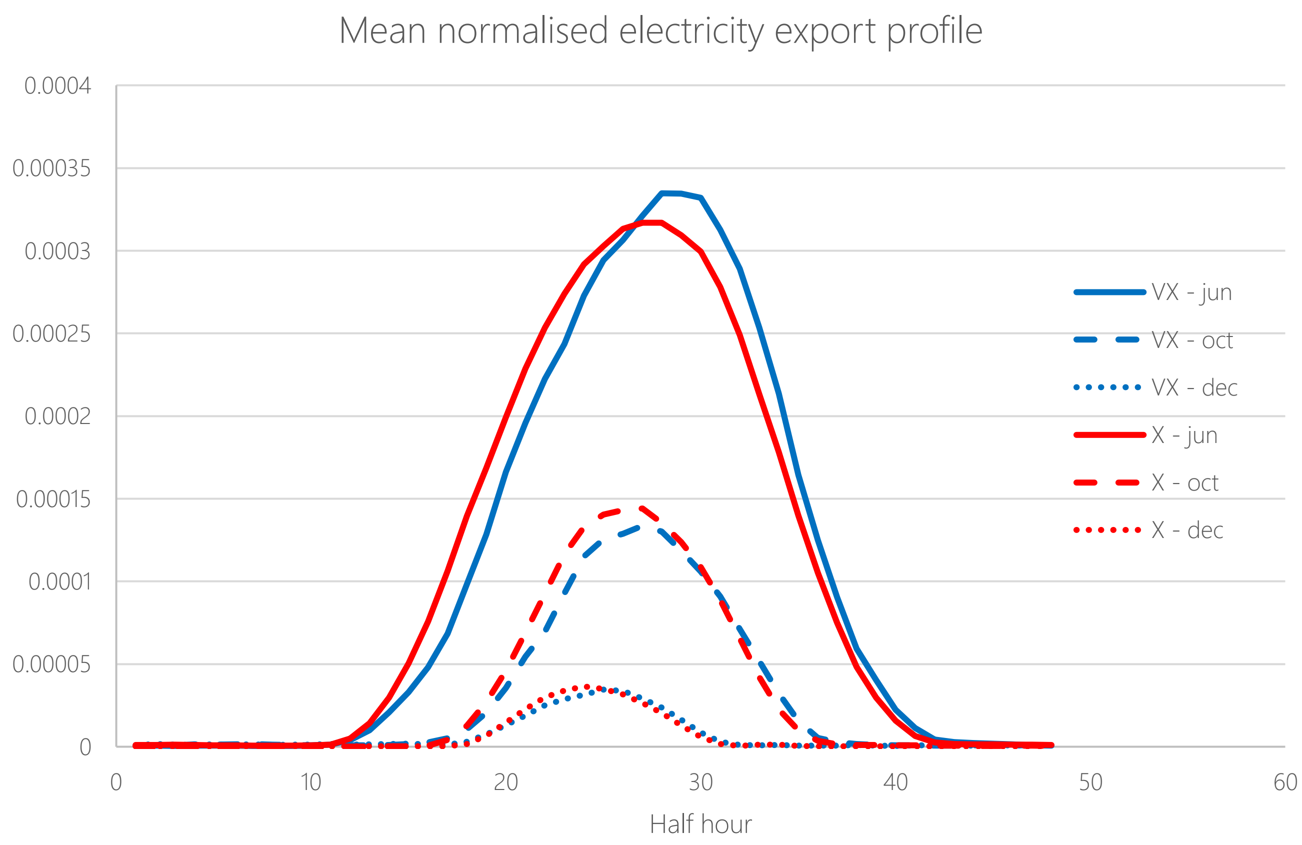


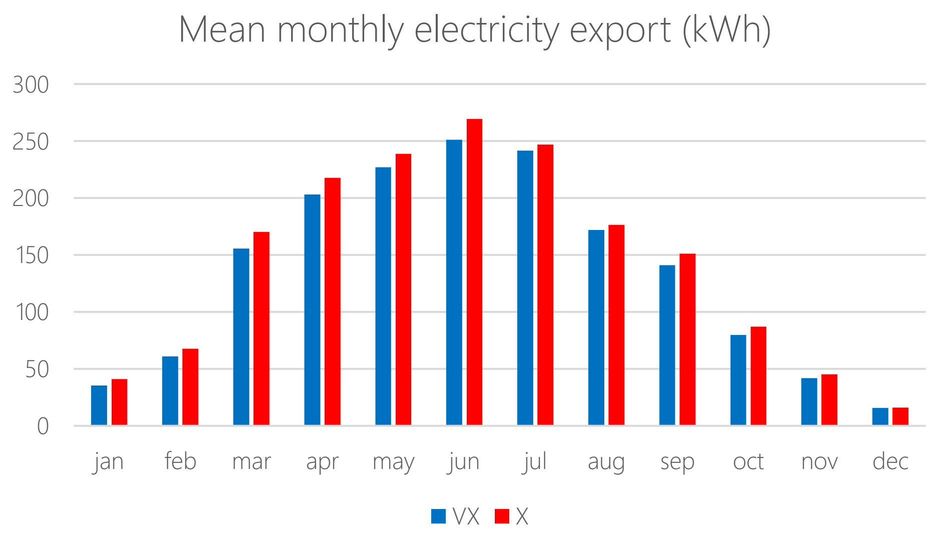




* See the "Outputs overview" slide for a definition of "Peak"

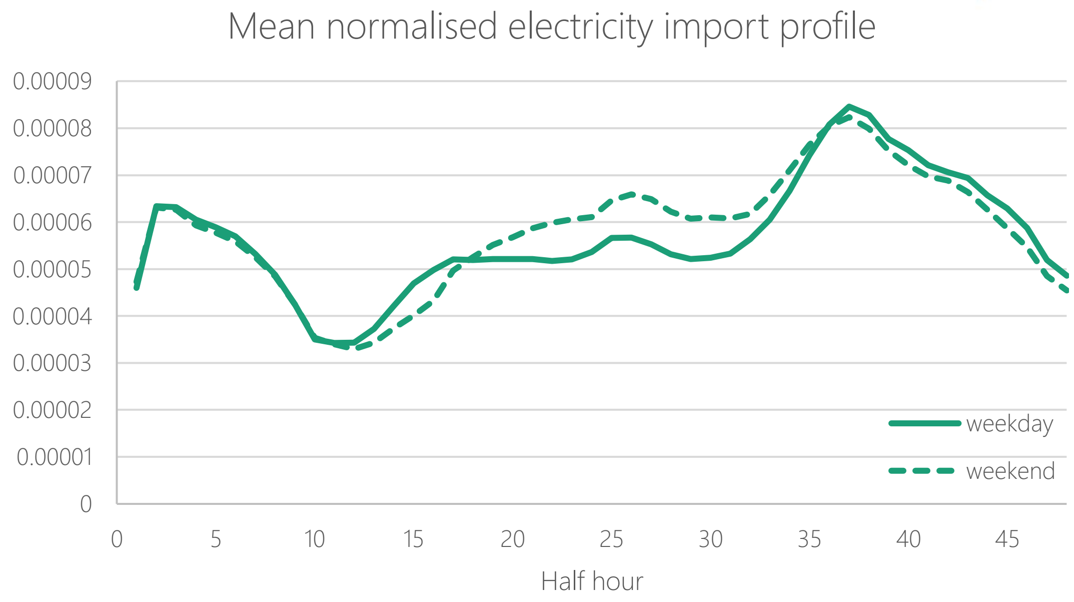
Archetypes VX and X (electricity export)

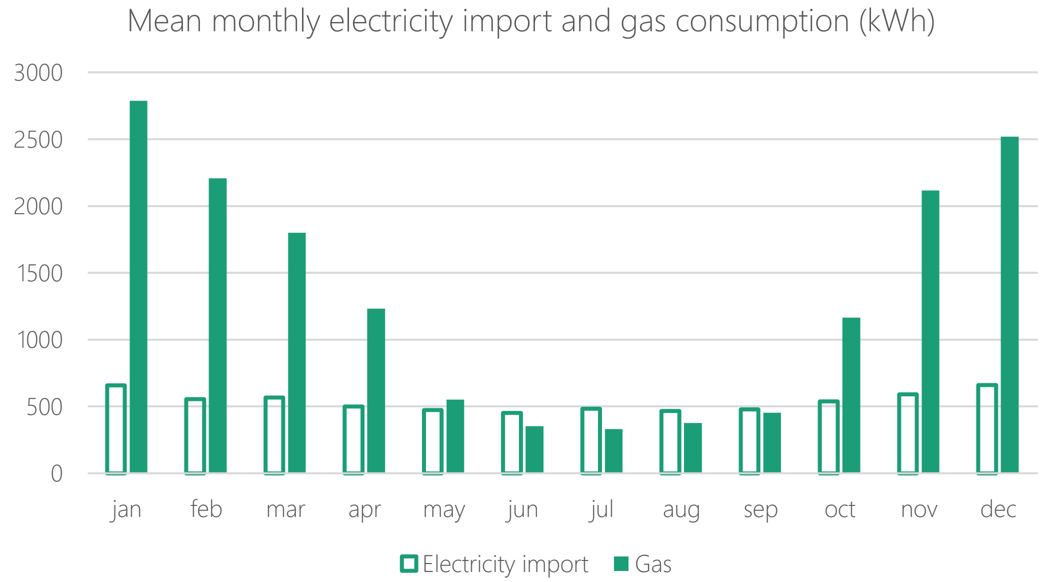


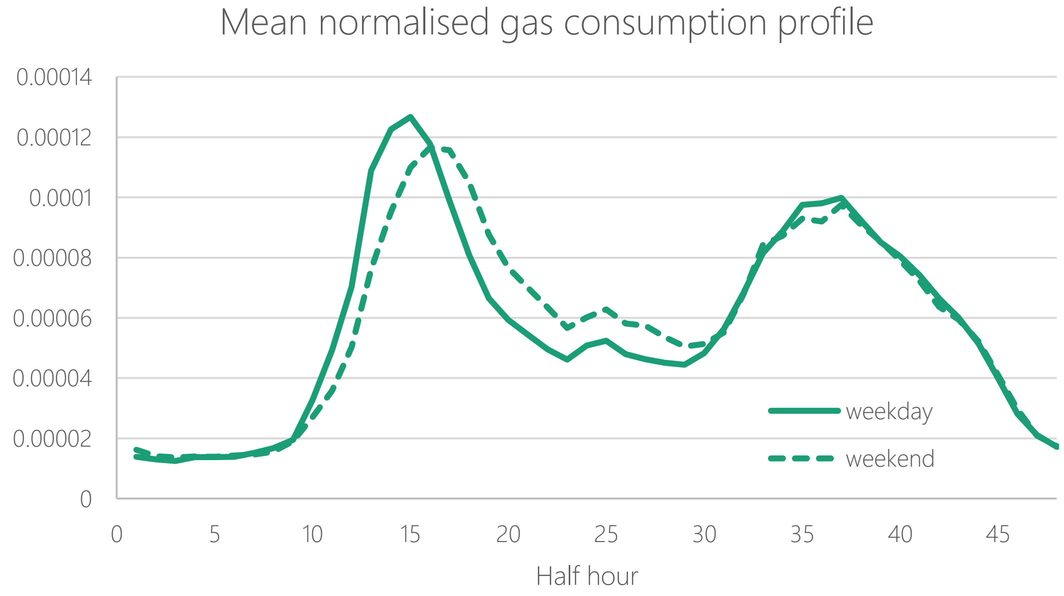


Archetype V

Energy metric	Value
Mean annual electricity import	6,420 kWh
Mean annual gas consumption	15,890 kWh
Peak* half-hourly electricity import	5.4 kWh
Peak half-hourly gas consumption	15.1 kWh



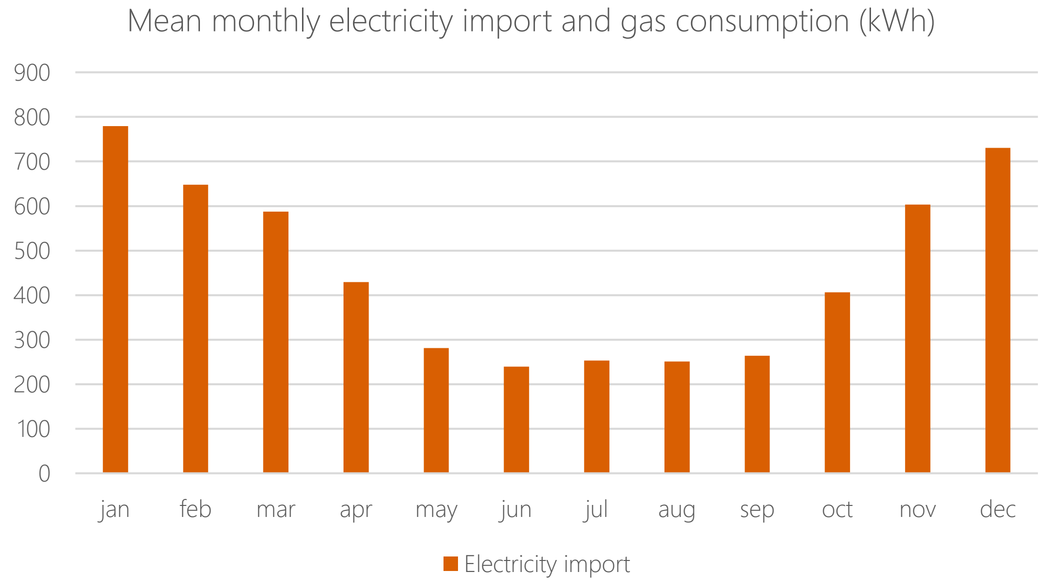


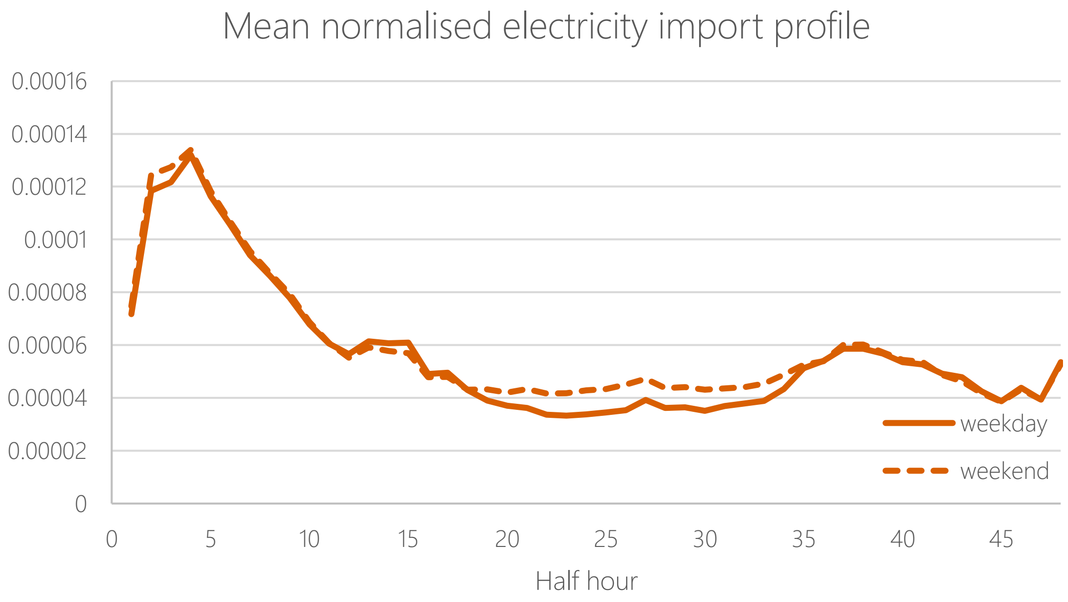


* See the "Outputs overview" slide for a definition of "Peak"

Archetype ES

Energy metric	Value
Mean annual electricity import	5,470 kWh
Mean annual gas consumption	NA
Peak* half-hourly electricity import	5.6 kWh
Peak half-hourly gas consumption	NA

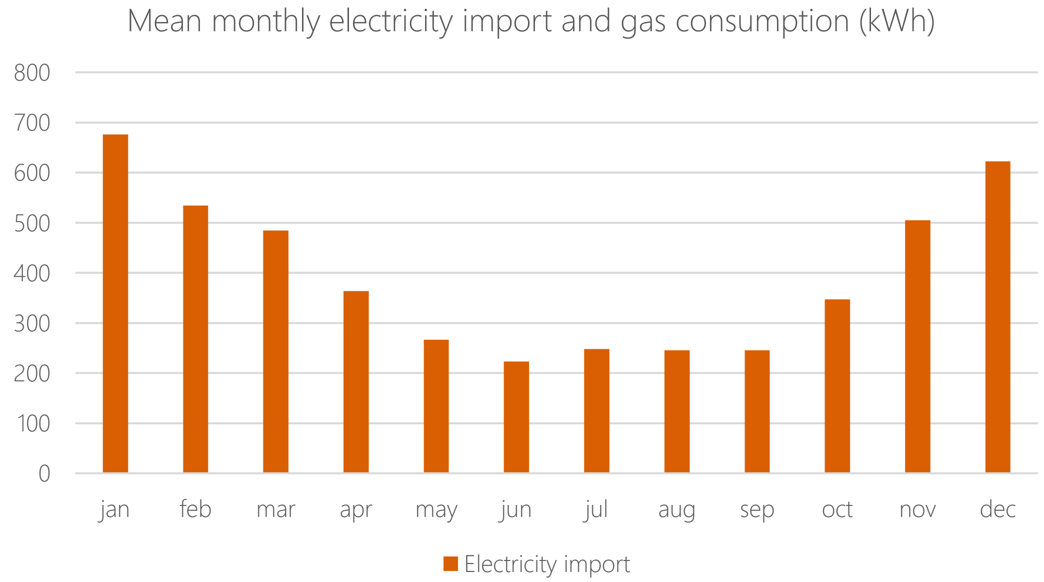


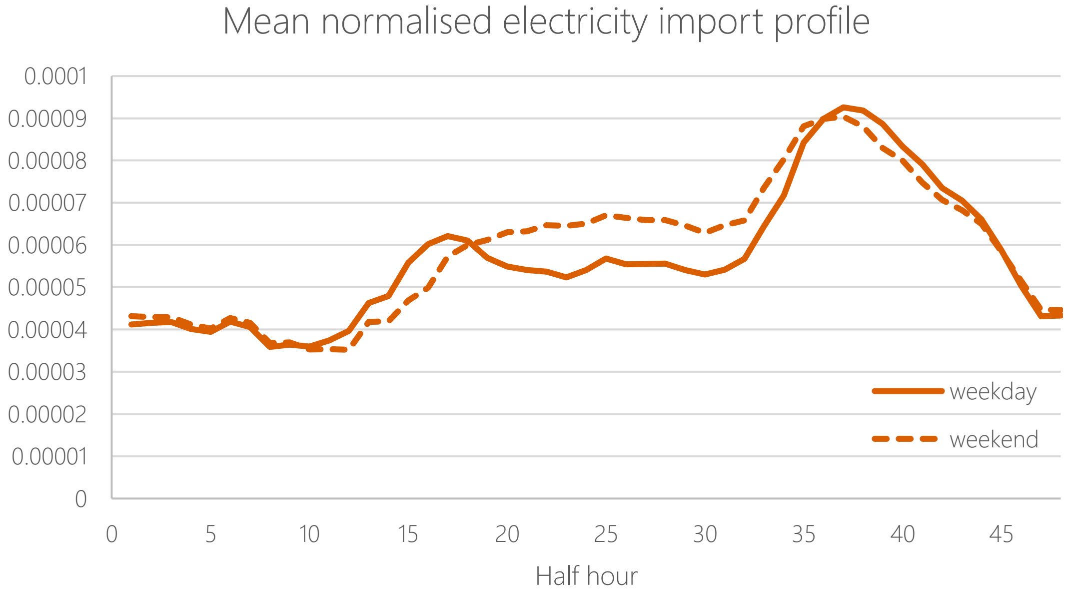


* See the "Outputs overview" slide for a definition of "Peak"

Archetype ER

Energy metric	Value
Mean annual electricity import	4,760 kWh
Mean annual gas consumption	NA
Peak* half-hourly electricity import	4.9 kWh
Peak half-hourly gas consumption	NA

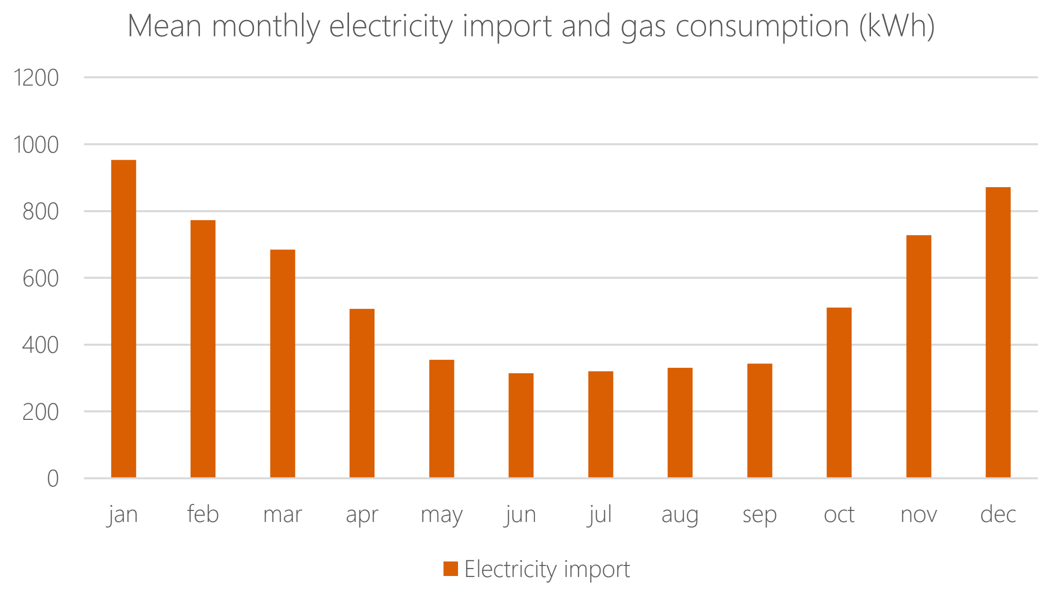


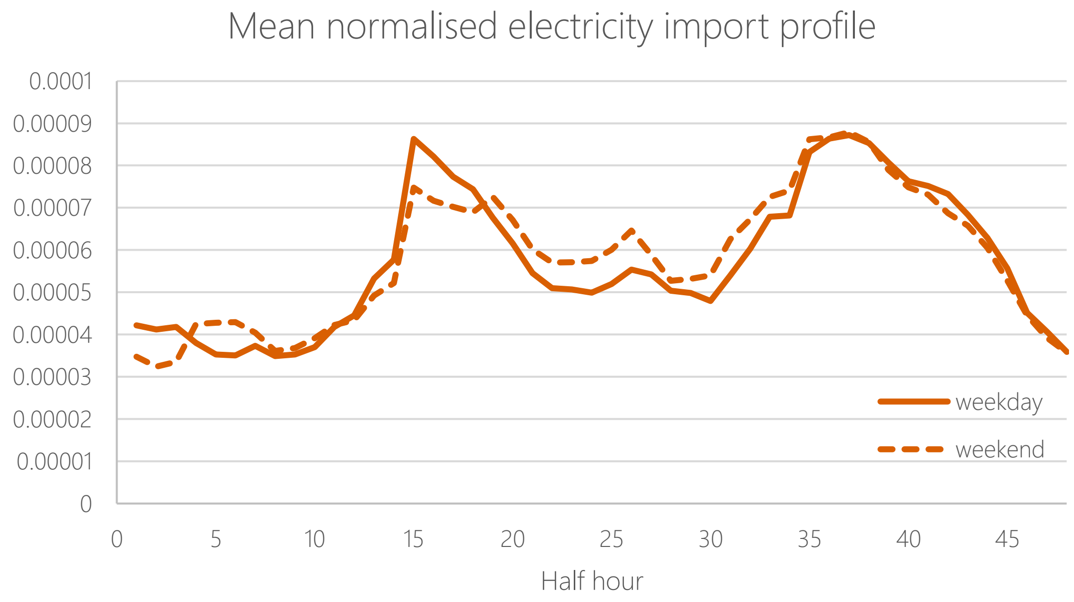


* See the "Outputs overview" slide for a definition of "Peak"

Archetype EO

Energy metric	Value
Mean annual electricity import	6,690 kWh
Mean annual gas consumption	NA
Peak* half-hourly electricity import	5.6 kWh
Peak half-hourly gas consumption	NA

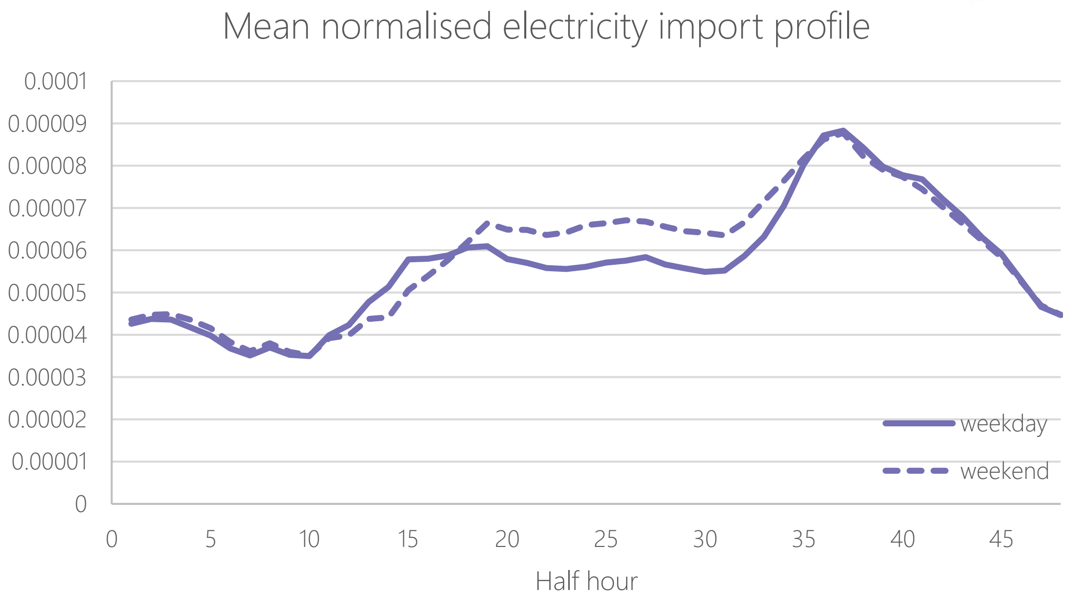


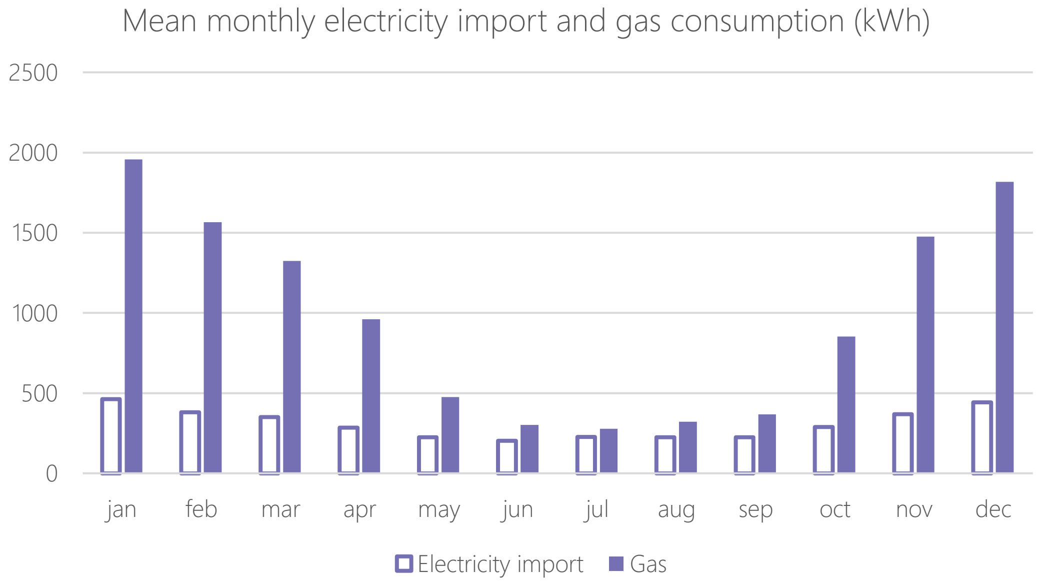


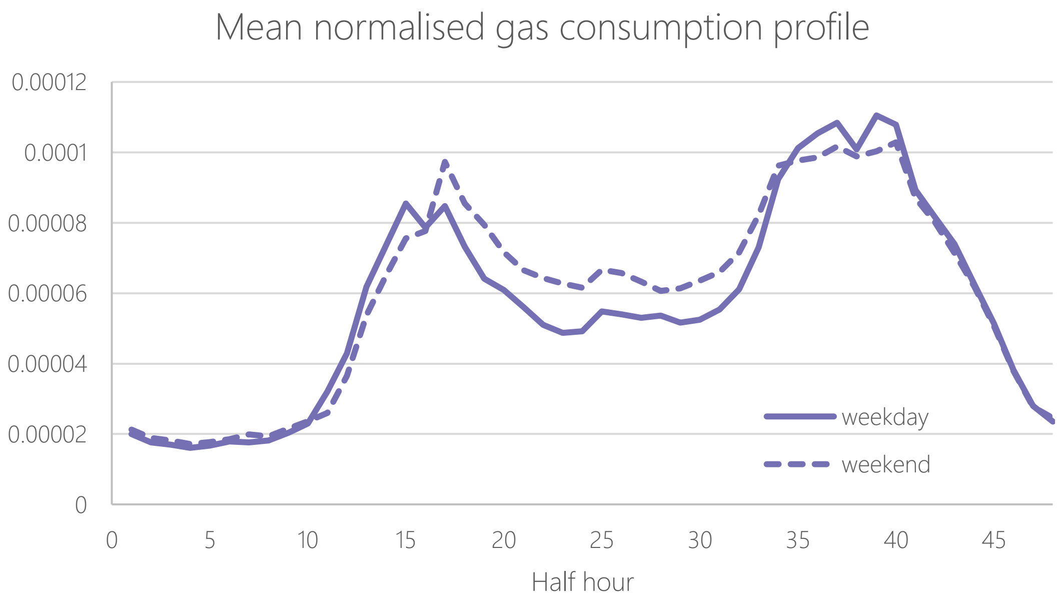
* See the "Outputs overview" slide for a definition of "Peak"

Archetype N

Energy metric	Value
Mean annual electricity import	3,680 kWh
Mean annual gas consumption	11,700 kWh
Peak* half-hourly electricity import	3.7 kWh
Peak half-hourly gas consumption	12.2 kWh



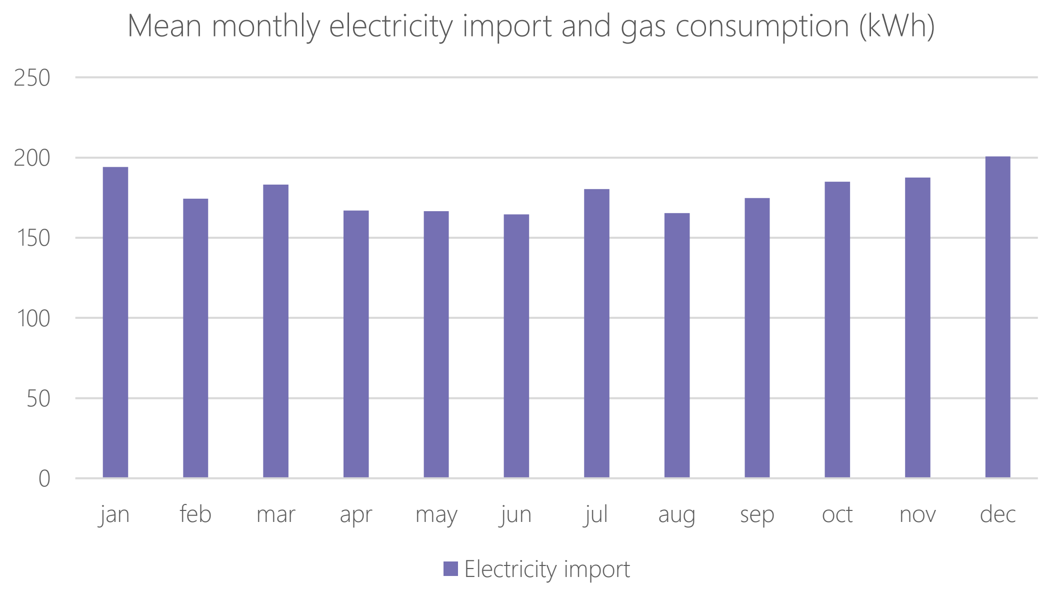


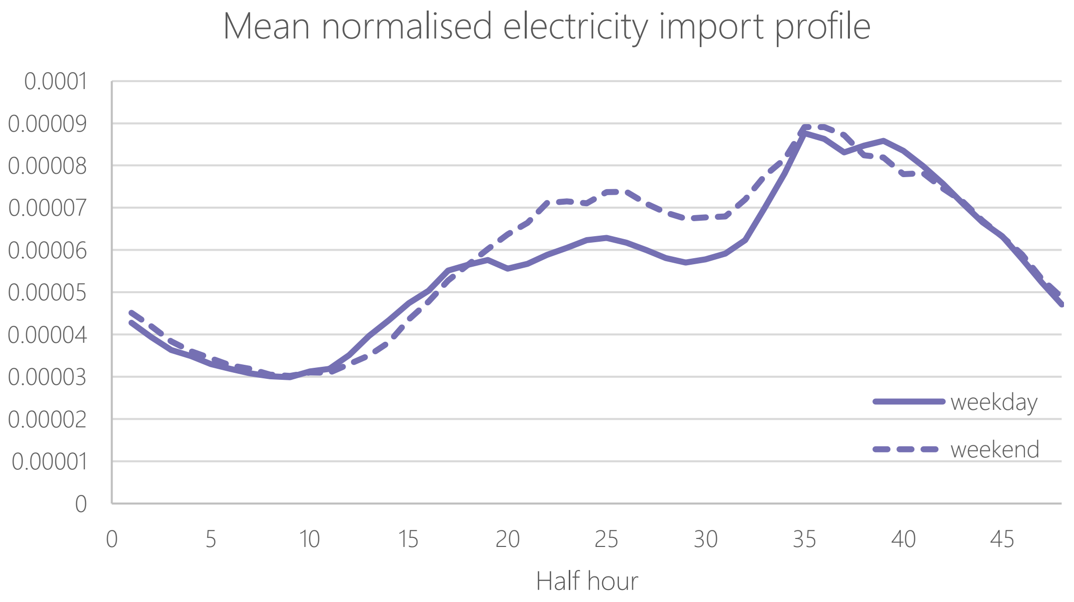


* See the "Outputs overview" slide for a definition of "Peak"

Archetype D

Energy metric	Value
Mean annual electricity import	2,140 kWh
Mean annual gas consumption	NA
Peak* half-hourly electricity import	2.1 kWh
Peak half-hourly gas consumption	NA

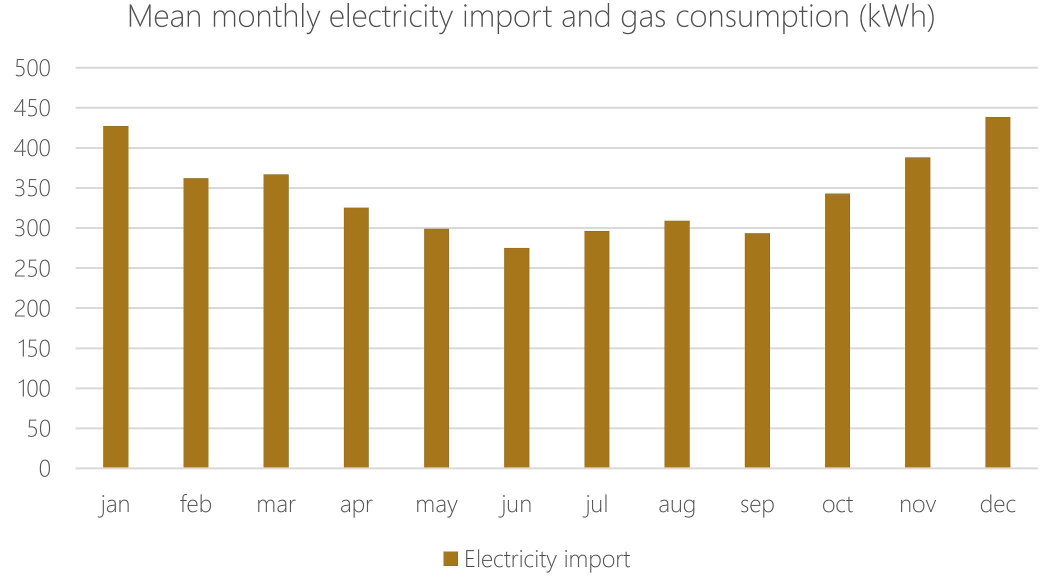


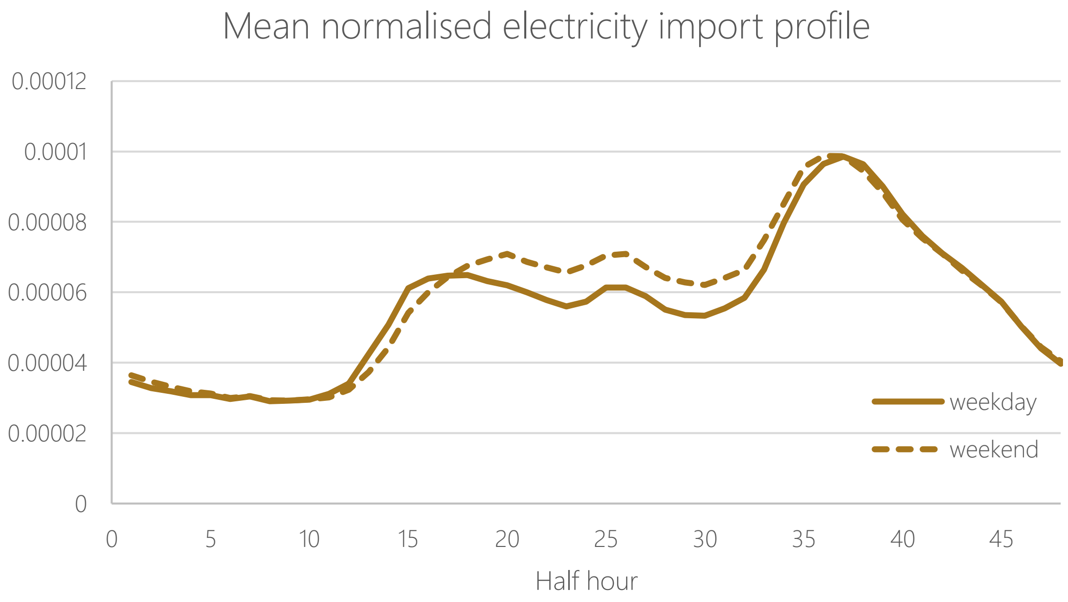


* See the "Outputs overview" slide for a definition of "Peak"

Archetype O

Energy metric	Value
Mean annual electricity import	4,130 kWh
Mean annual gas consumption	NA
Peak* half-hourly electricity import	3.6 kWh
Peak half-hourly gas consumption	NA

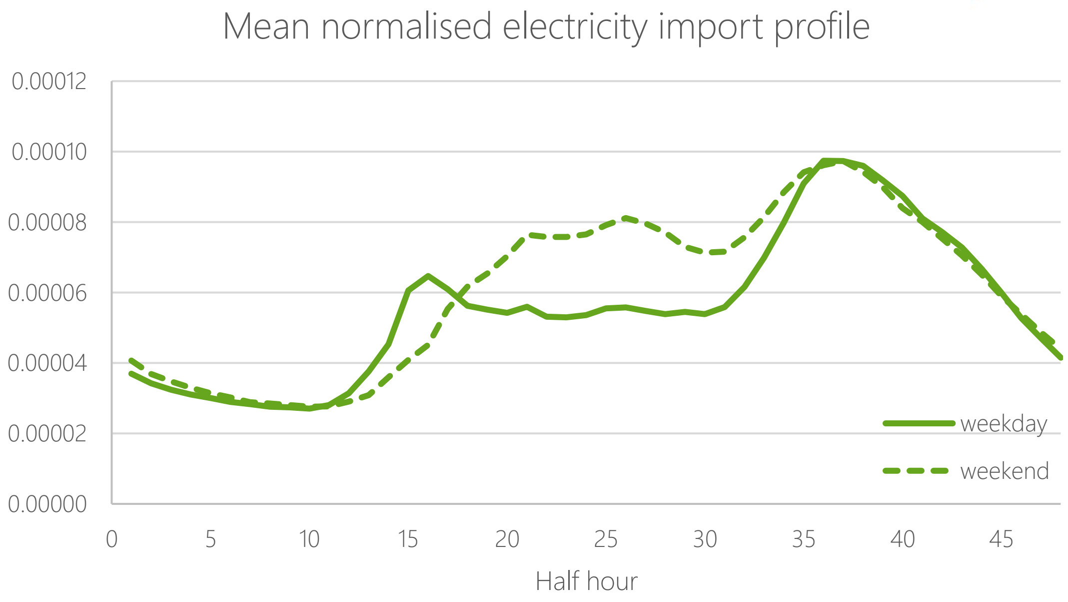


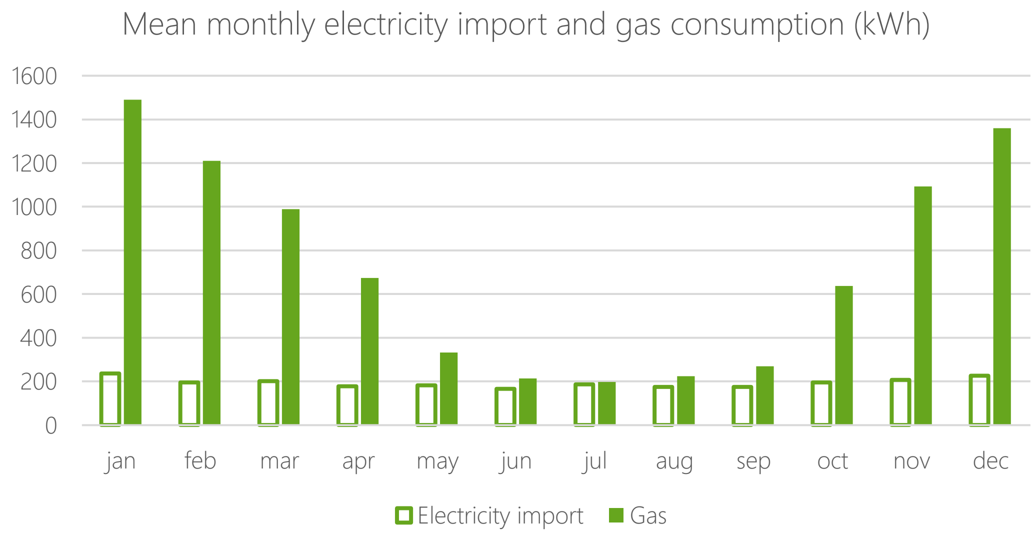


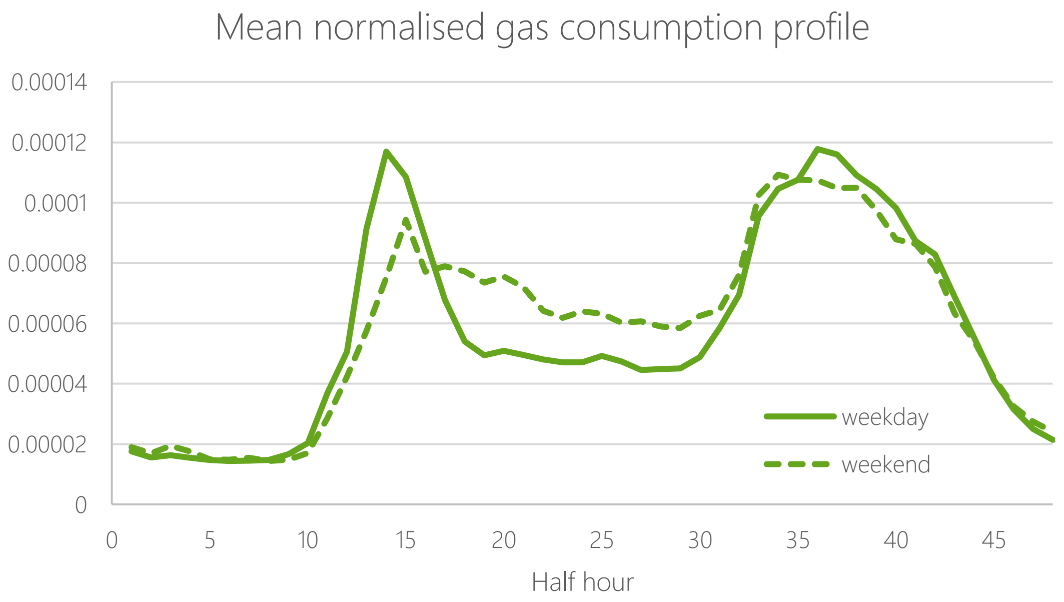
* See the "Outputs overview" slide for a definition of "Peak"

Archetype G11

Energy metric	Value
Mean annual electricity import	2,320 kWh
Mean annual gas consumption	8,690 kWh
Peak* half-hourly electricity import	3.1 kWh
Peak half-hourly gas consumption	12.2 kWh



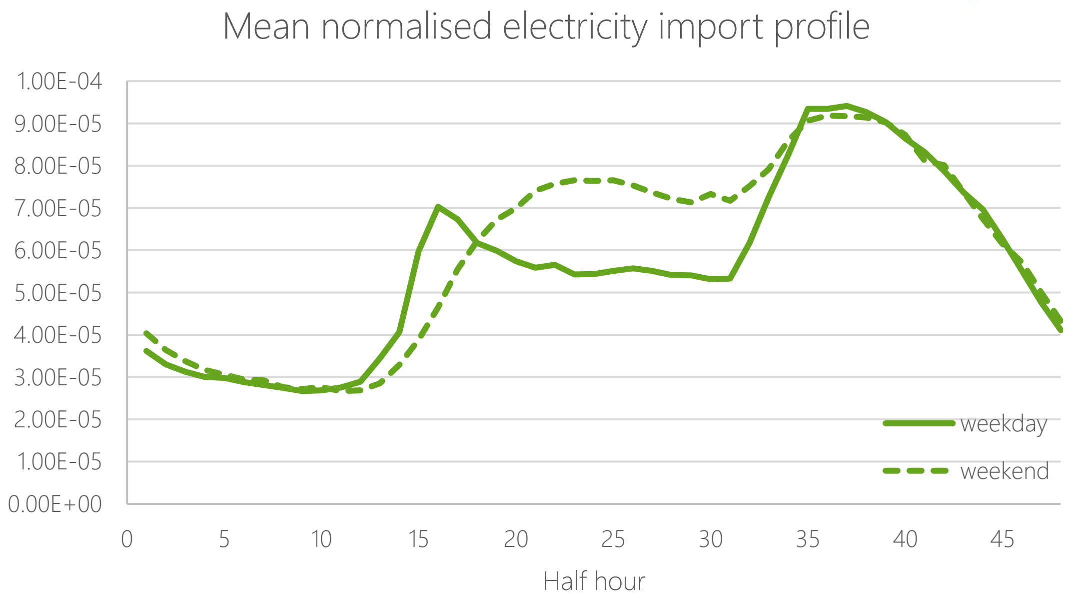


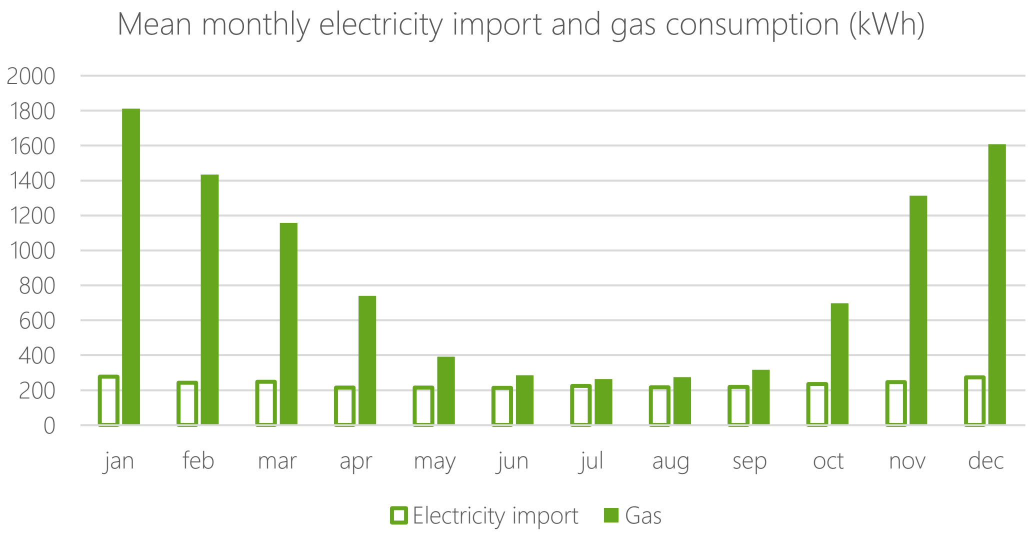


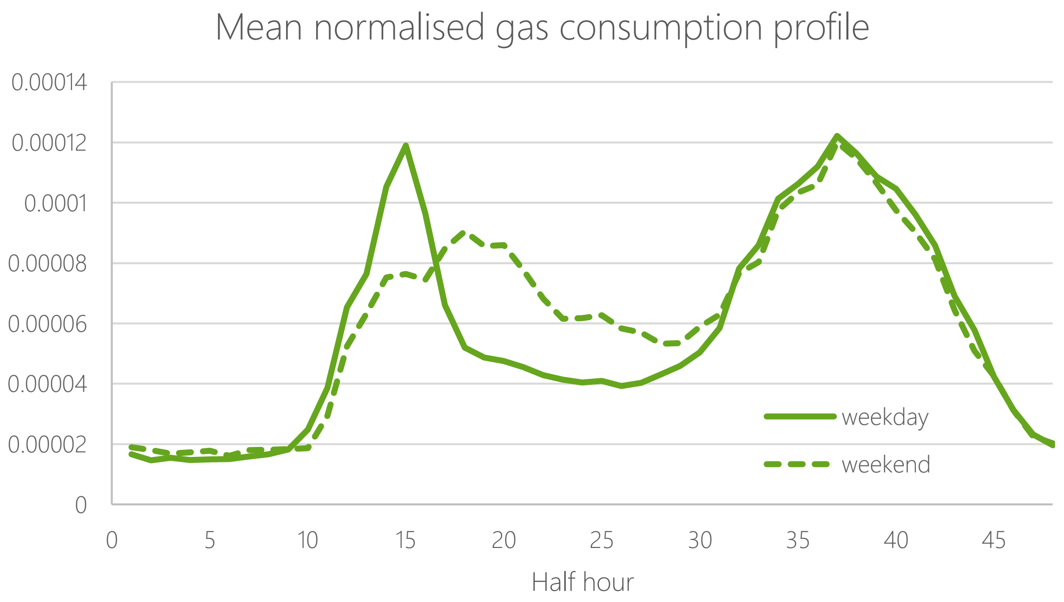
* See the "Outputs overview" slide for a definition of "Peak"

Archetype G12

Energy metric	Value
Mean annual electricity import	2,820 kWh
Mean annual gas consumption	10,290 kWh
Peak* half-hourly electricity import	3.2 kWh
Peak half-hourly gas consumption	13.6 kWh



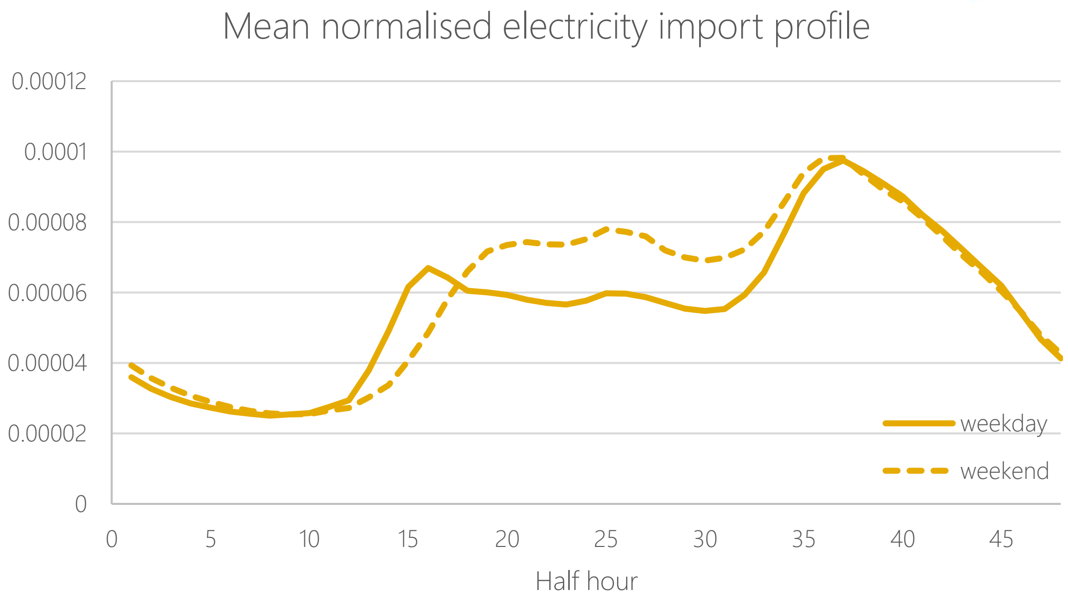


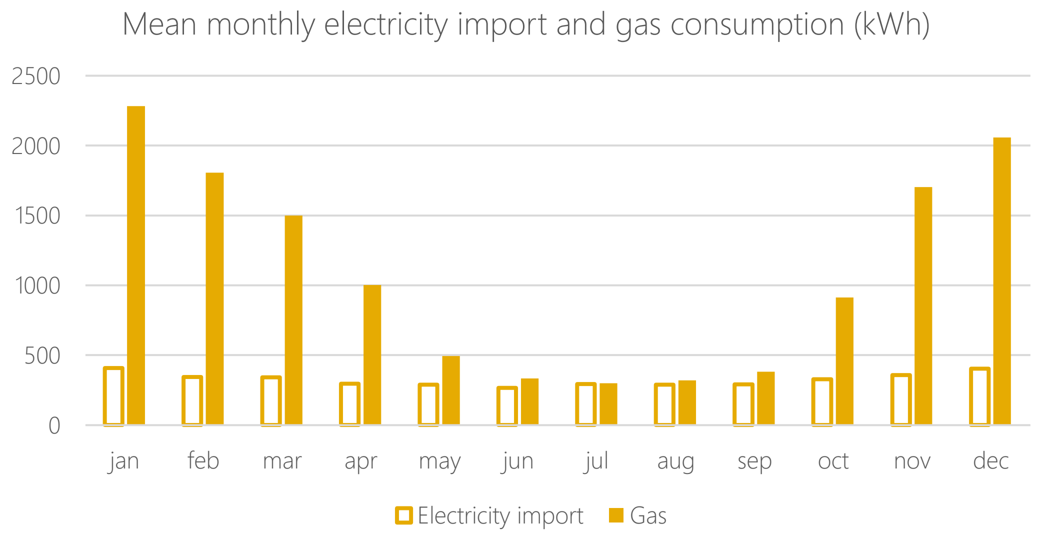


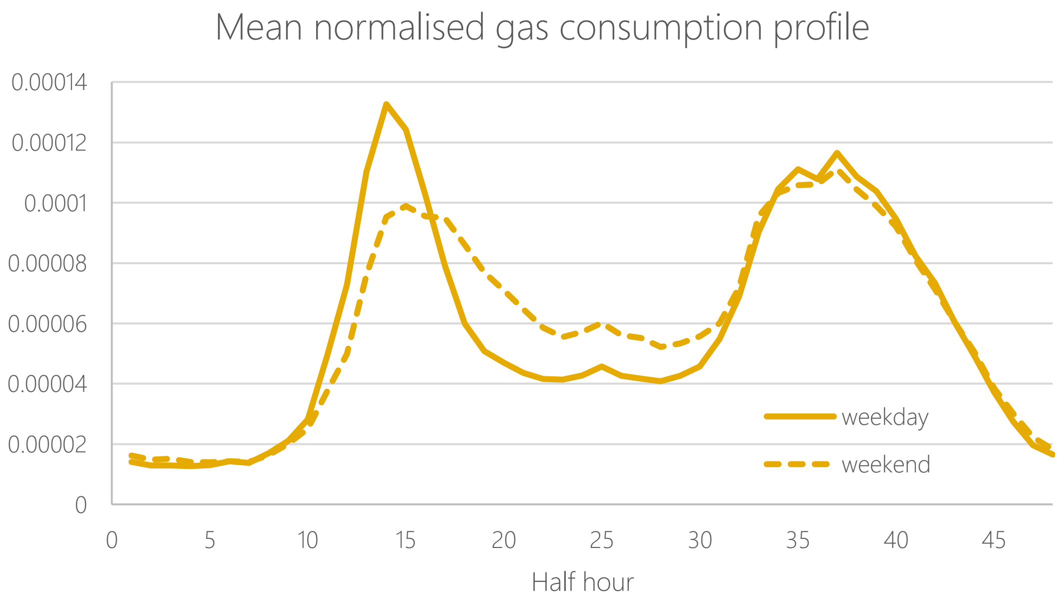
* See the "Outputs overview" slide for a definition of "Peak"

Archetype G21

Energy metric	Value
Mean annual electricity import	3,910 kWh
Mean annual gas consumption	13,090 kWh
Peak* half-hourly electricity import	3.6 kWh
Peak half-hourly gas consumption	13.7 kWh



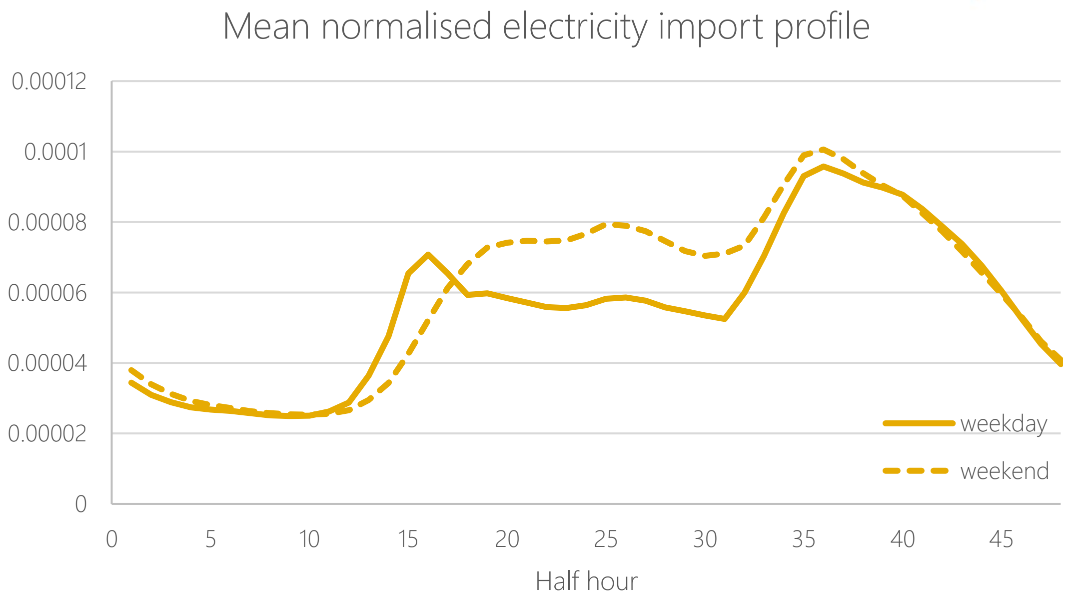


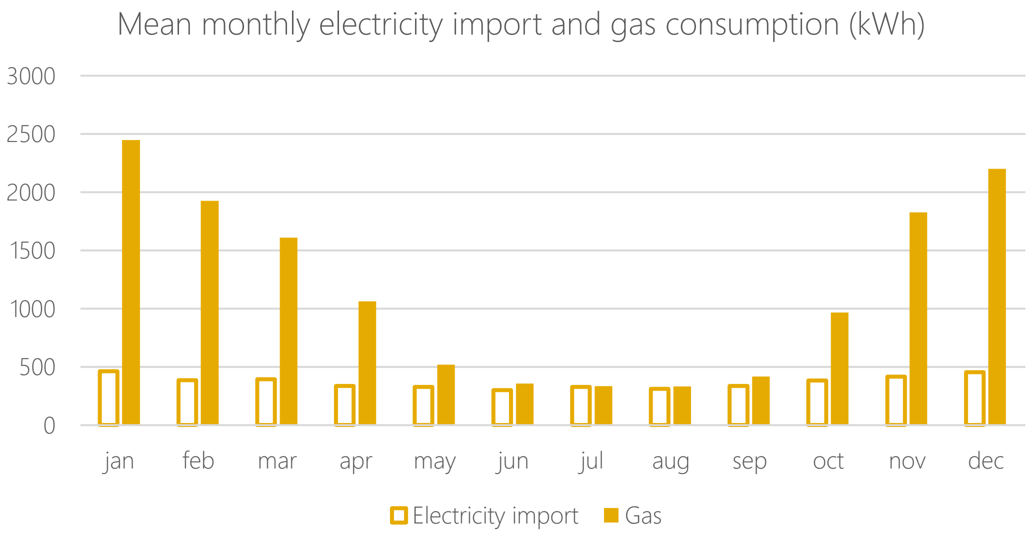


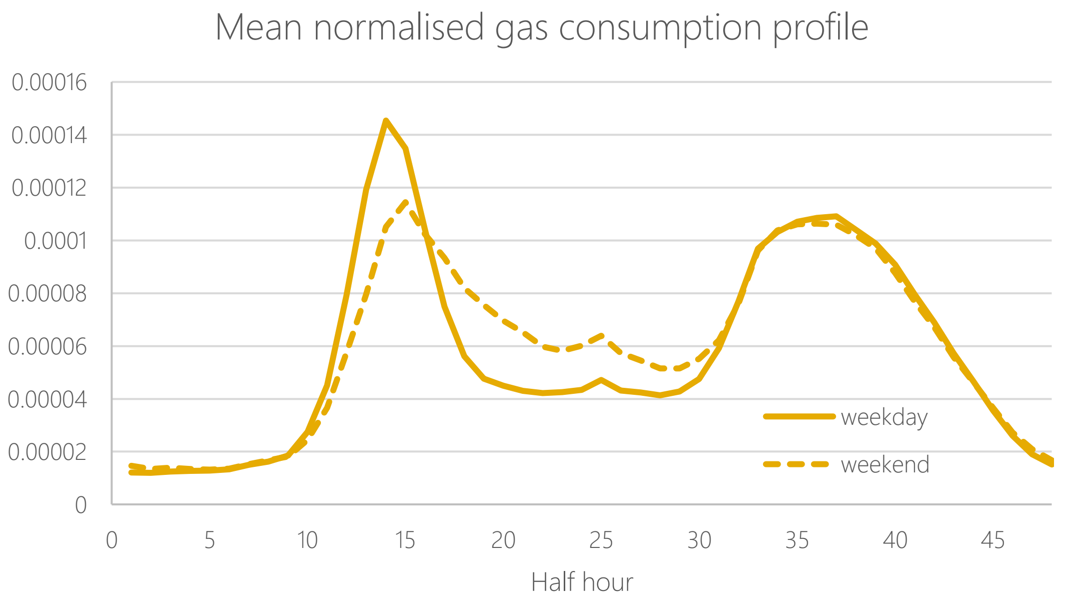
* See the "Outputs overview" slide for a definition of "Peak"

Archetype G22

Energy metric	Value
Mean annual electricity import	4,440 kWh
Mean annual gas consumption	14,000 kWh
Peak* half-hourly electricity import	3.8 kWh
Peak half-hourly gas consumption	14.2 kWh



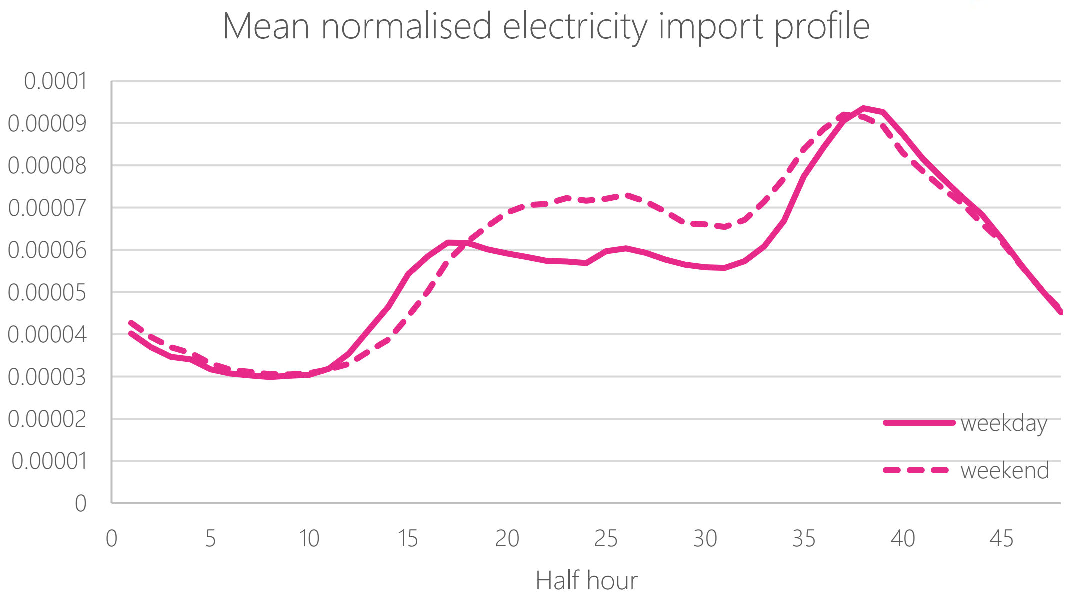


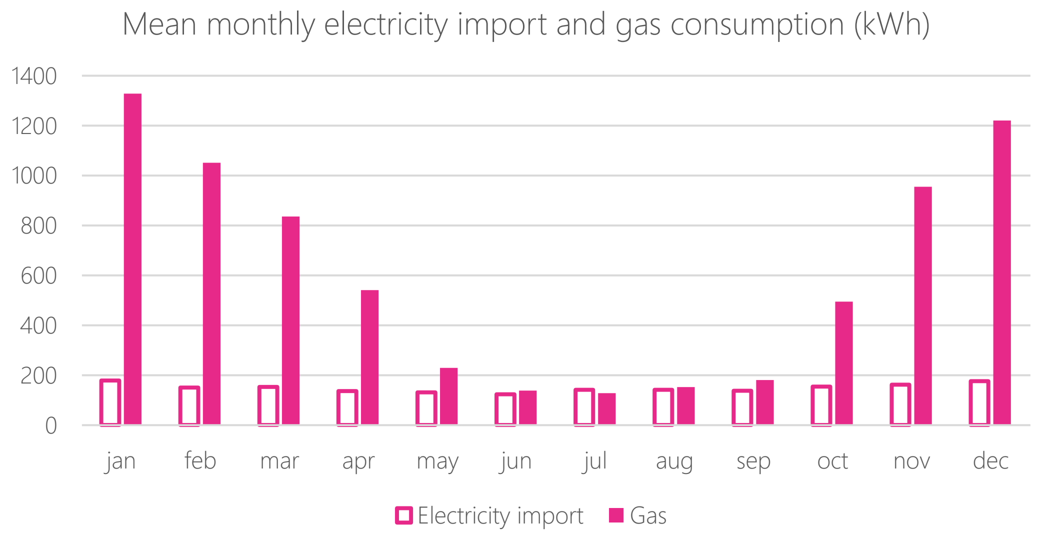


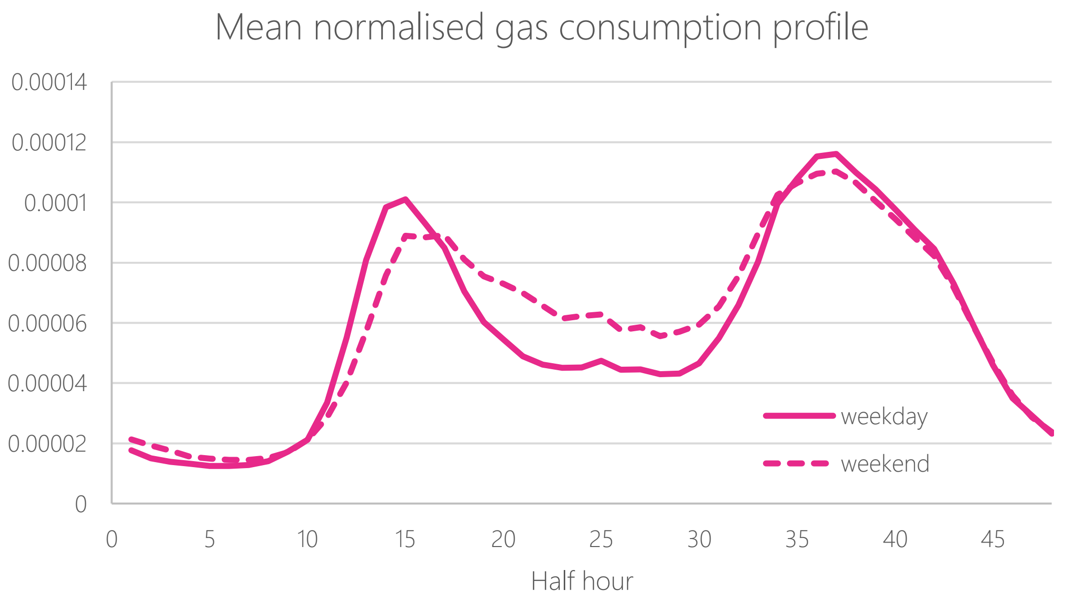
* See the "Outputs overview" slide for a definition of "Peak"

Archetype G10

Energy metric	Value
Mean annual electricity import	1,790 kWh
Mean annual gas consumption	7,260 kWh
Peak* half-hourly electricity import	2.5 kWh
Peak half-hourly gas consumption	11.2 kWh



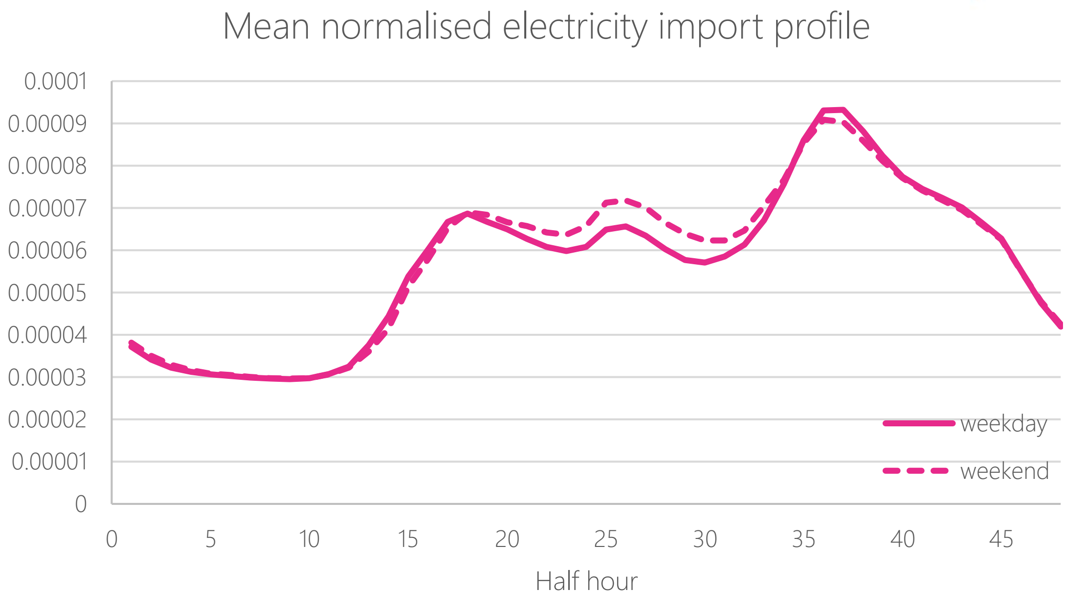


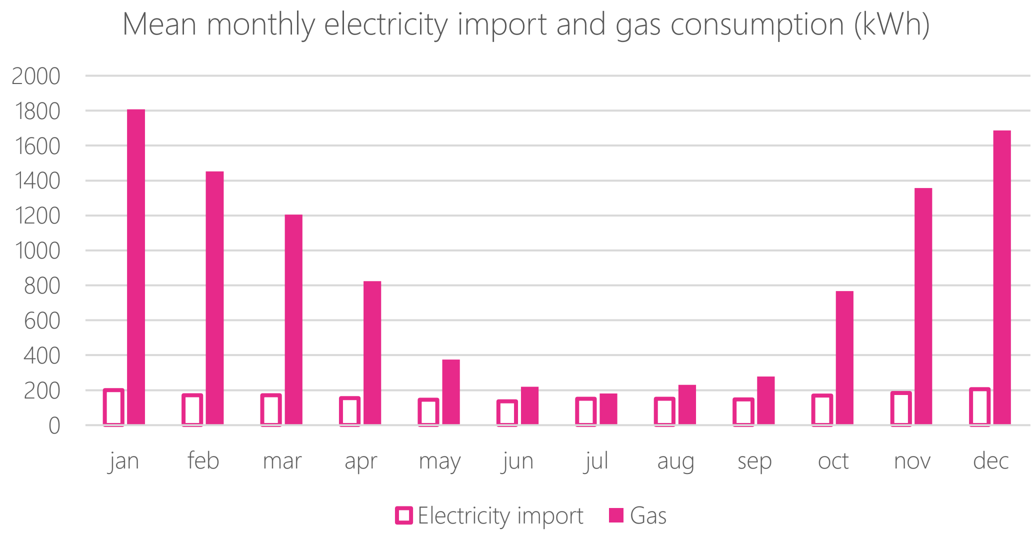


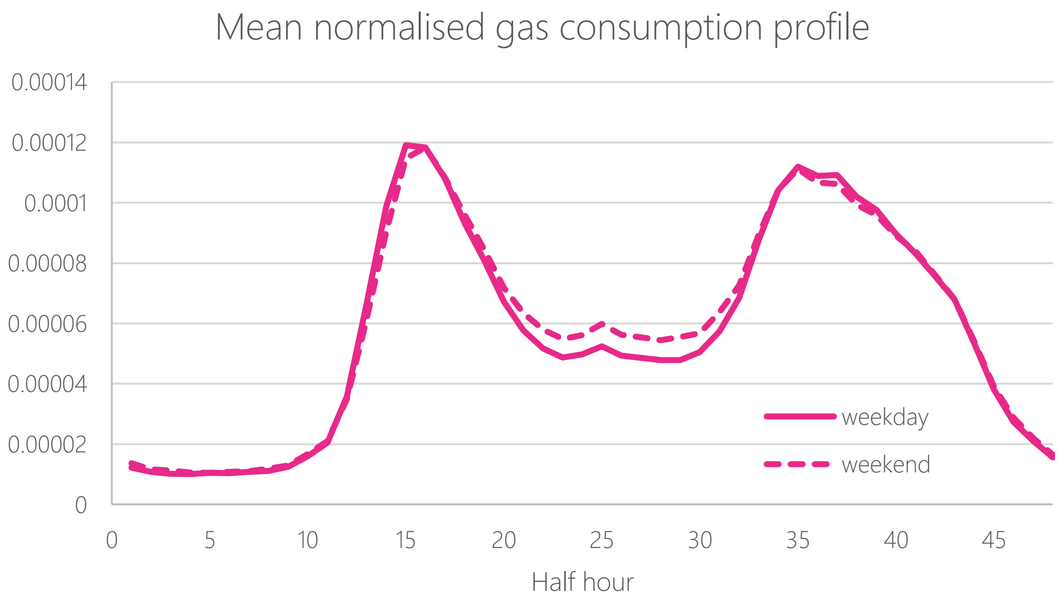
* See the "Outputs overview" slide for a definition of "Peak"

Archetype G10p

Energy metric	Value
Mean annual electricity import	1,980 kWh
Mean annual gas consumption	10,380 kWh
Peak* half-hourly electricity import	2.2 kWh
Peak half-hourly gas consumption	11.4 kWh



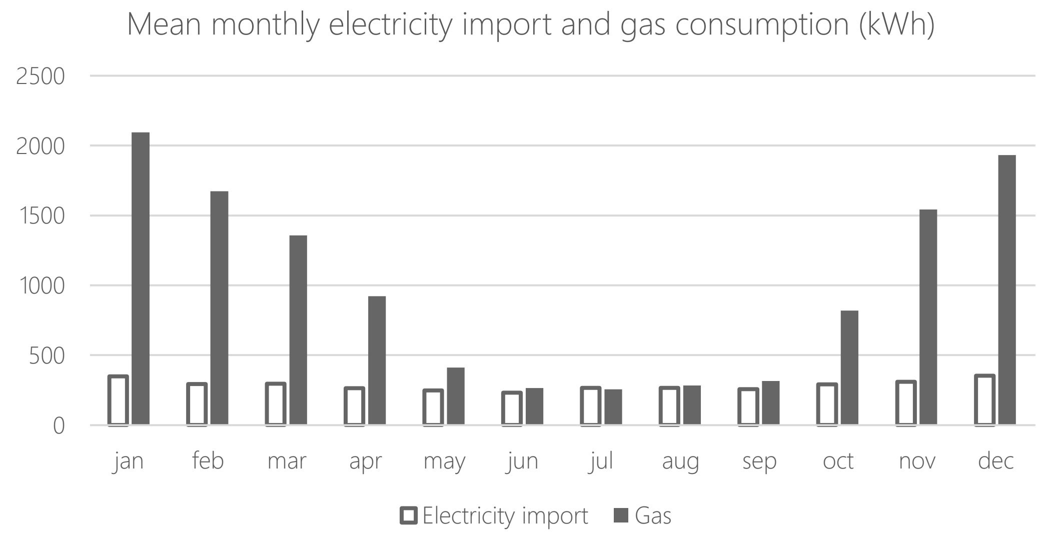


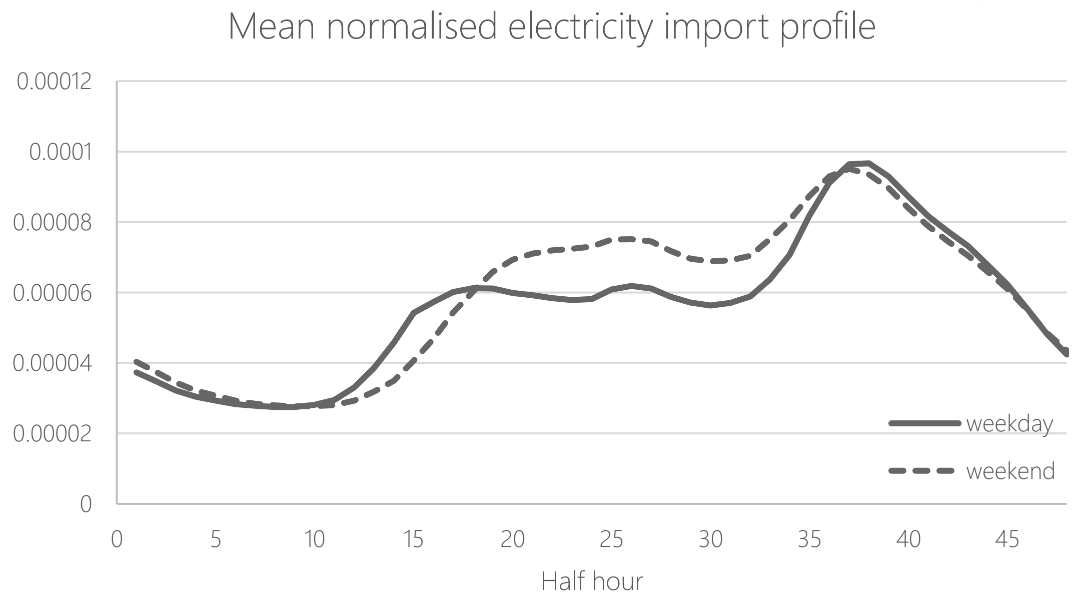


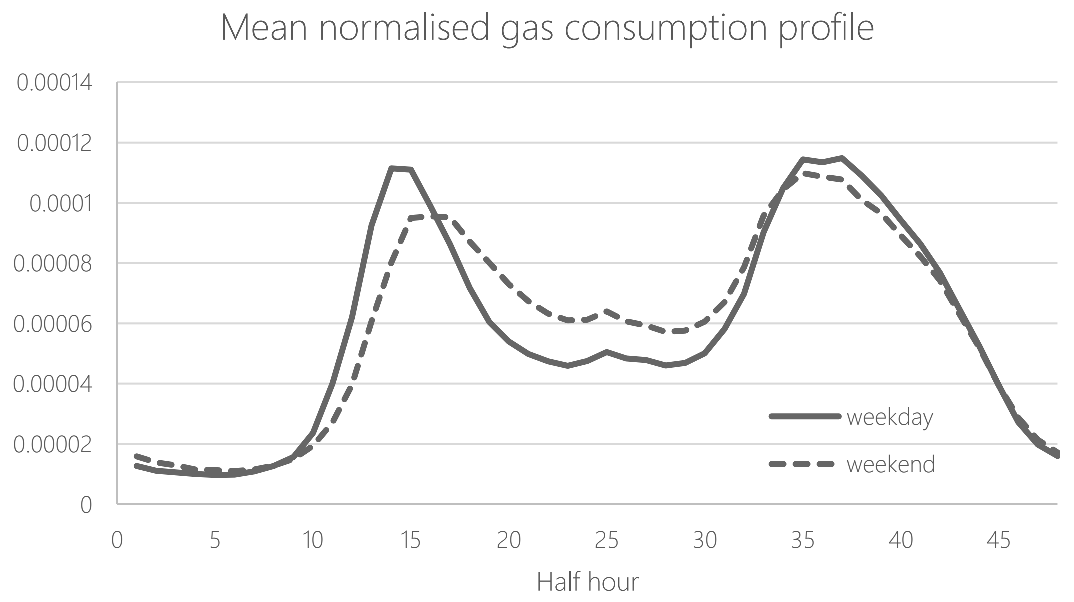
* See the "Outputs overview" slide for a definition of "Peak"

Archetype G20

Energy metric	Value
Mean annual electricity import	3,420 kWh
Mean annual gas consumption	11,870 kWh
Peak* half-hourly electricity import	3.2 kWh
Peak half-hourly gas consumption	13.1 kWh



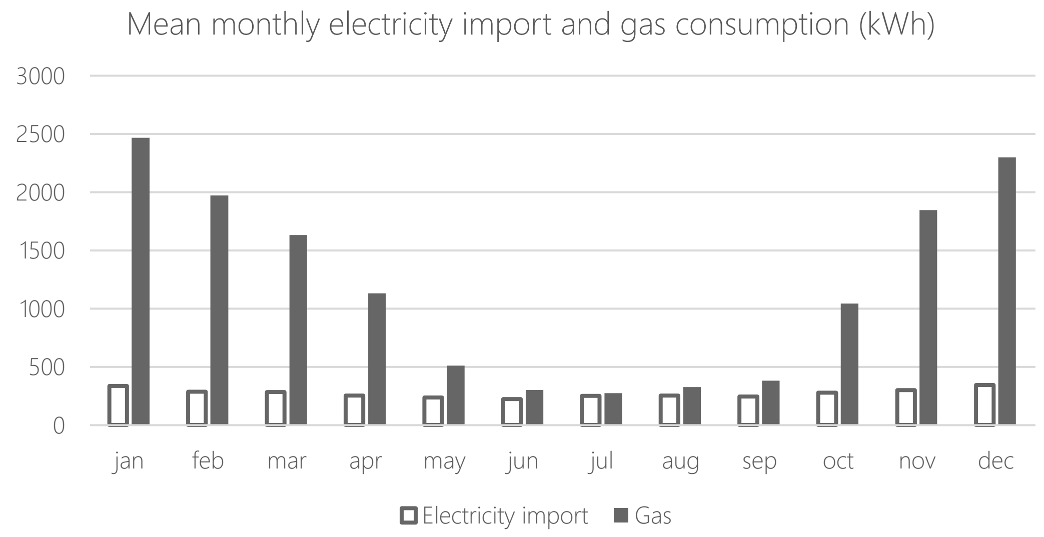


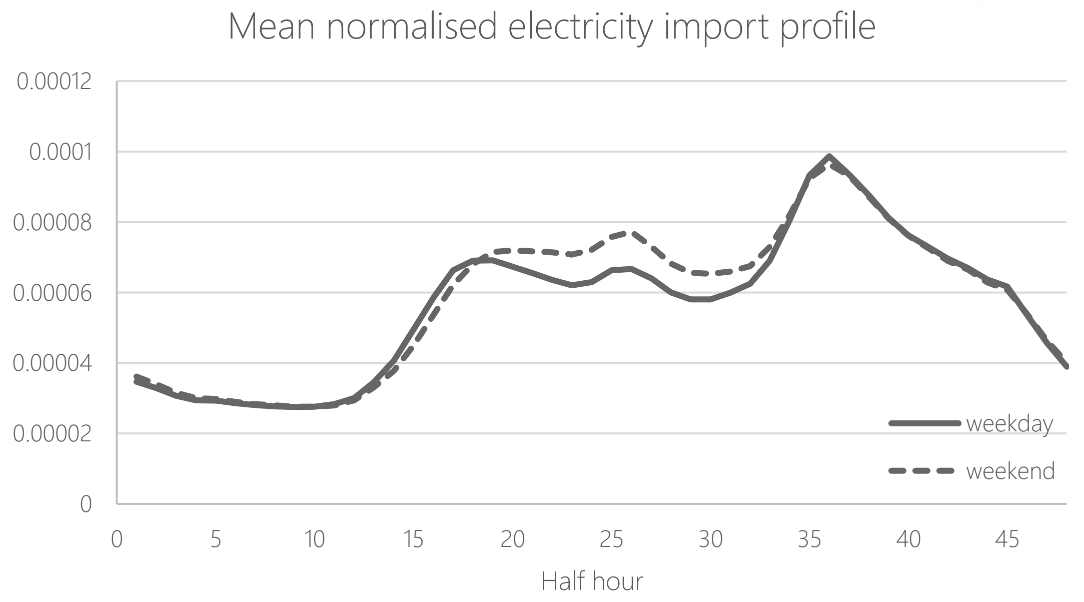


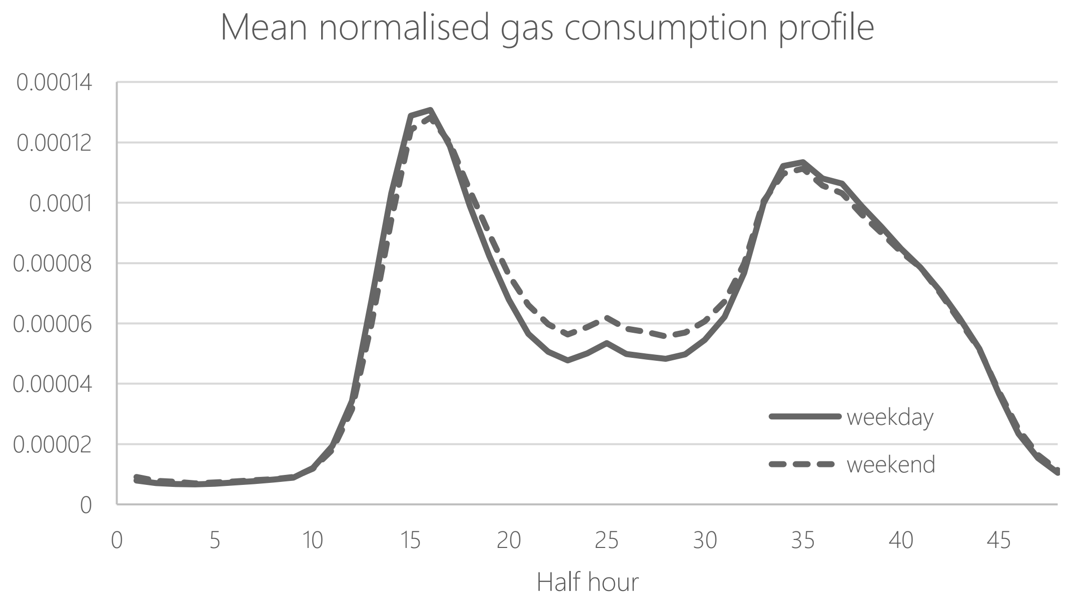
* See the "Outputs overview" slide for a definition of "Peak"

Archetype G20p

Energy metric	Value
Mean annual electricity import	3,290 kWh
Mean annual gas consumption	14,180 kWh
Peak* half-hourly electricity import	2.8 kWh
Peak half-hourly gas consumption	13.4 kWh

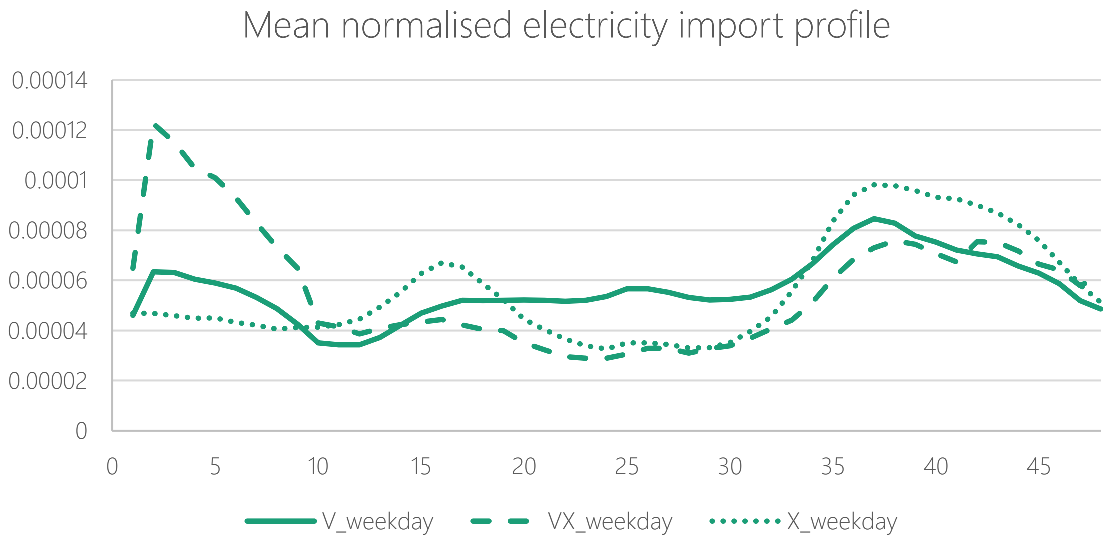


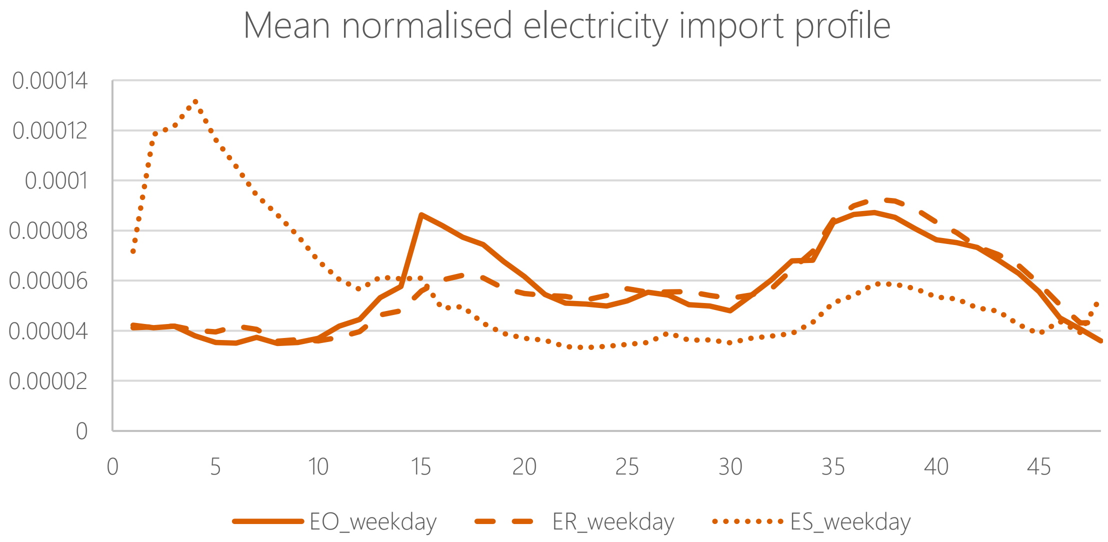


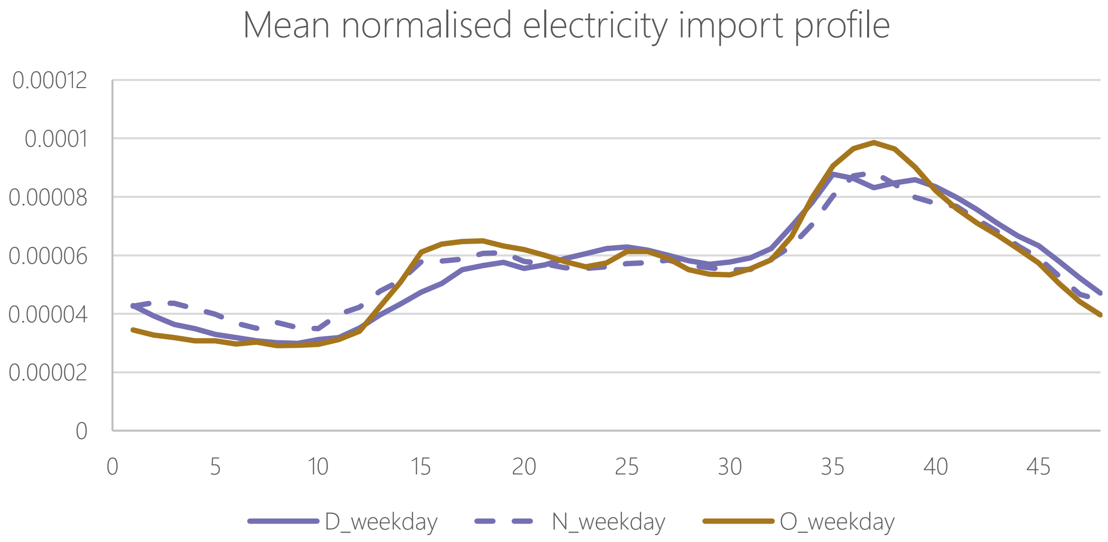


* See the "Outputs overview" slide for a definition of "Peak"

Comparing electricity import profiles

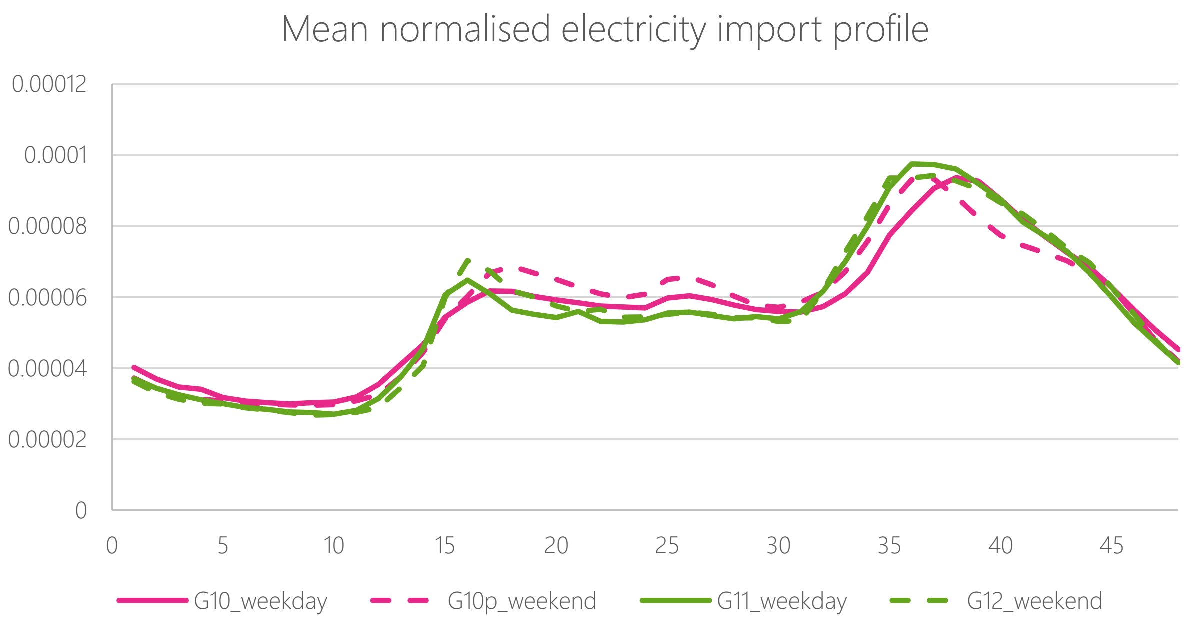


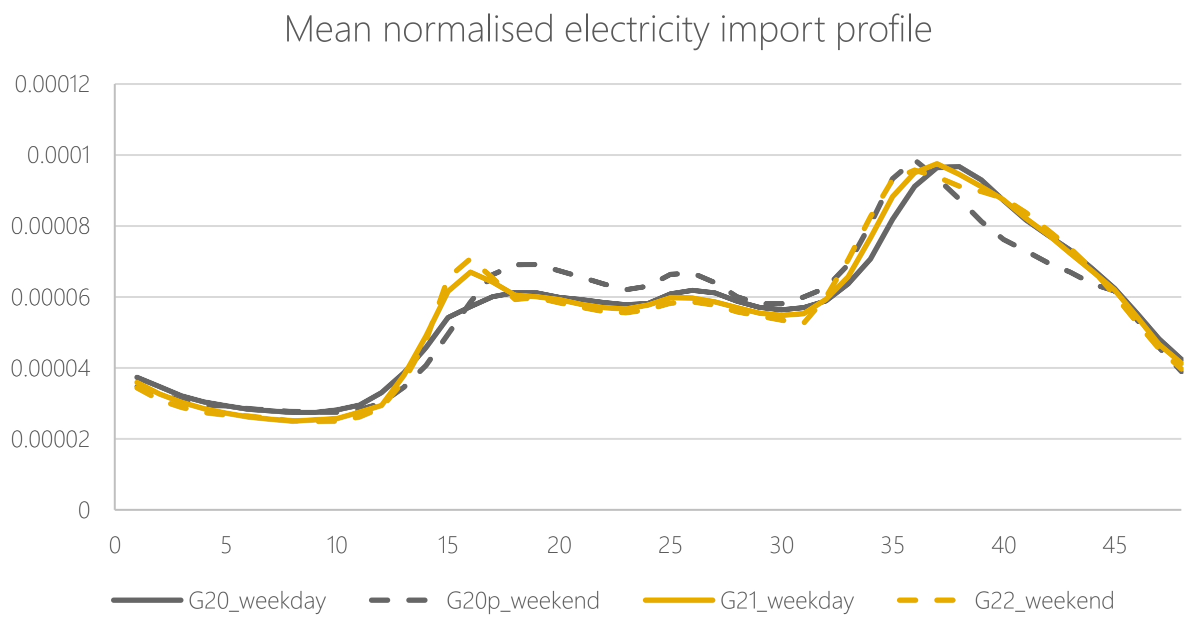




- VX has a large peak in the early hours of the morning due to EV charging. This peak is present, but less pronounced for V. VX and X have minimum electricity import in the middle of the day, due to using solar PV generated electricity during those times.
- ES has a similar peak to VX in the early hours of the morning (charging the storage heaters), but it occurs slightly later. EO has a similar shape to ER but with a more pronounced morning peak (equal to its evening peak).
- D, N, and O all have similar profiles, but the morning and evening ramps in O are slightly steeper

Comparing electricity import profiles

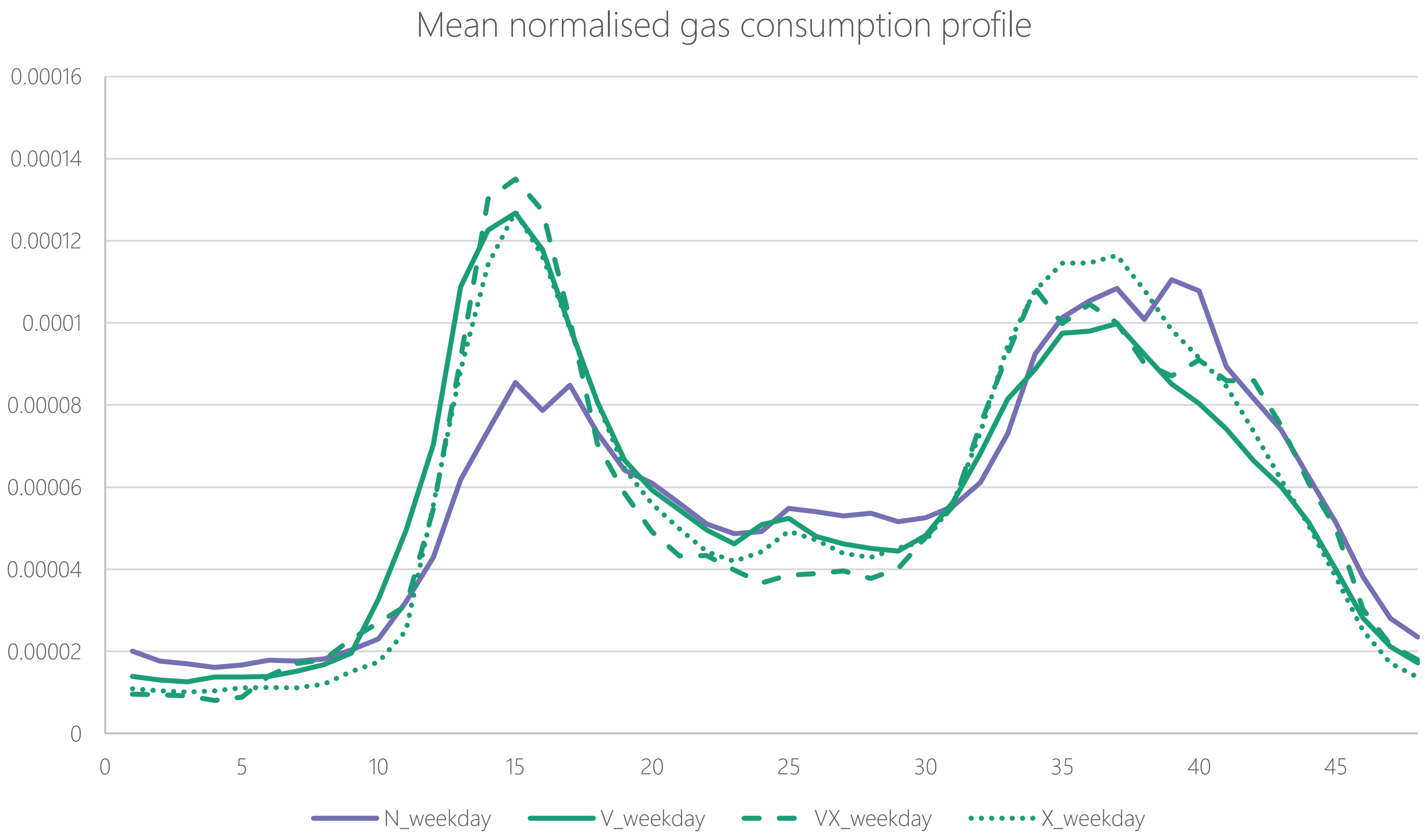




- The morning peaks of G11 and G12 are earlier than G10 and G10p and the morning ramps are steeper
- A higher proportion of consumption occurs during work hours for G10p compared to G10, G11, and G12
- G10 has the latest evening peak compared to G10p, G11, and G12

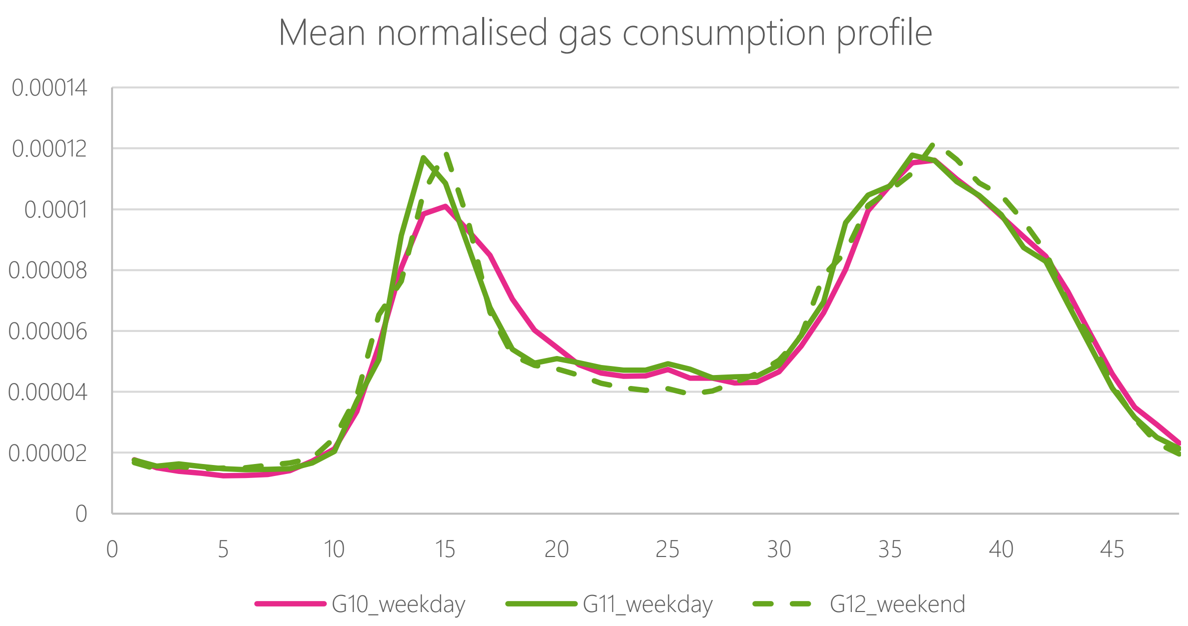
- The morning peaks of G21 and G22 are earlier than G20 and G20p and the morning ramps are steeper
- A higher proportion of consumption occurs during work hours for G20p compared to G20, G21, and G22
- G20 has the latest evening peak compared to G20p, G21, and G22

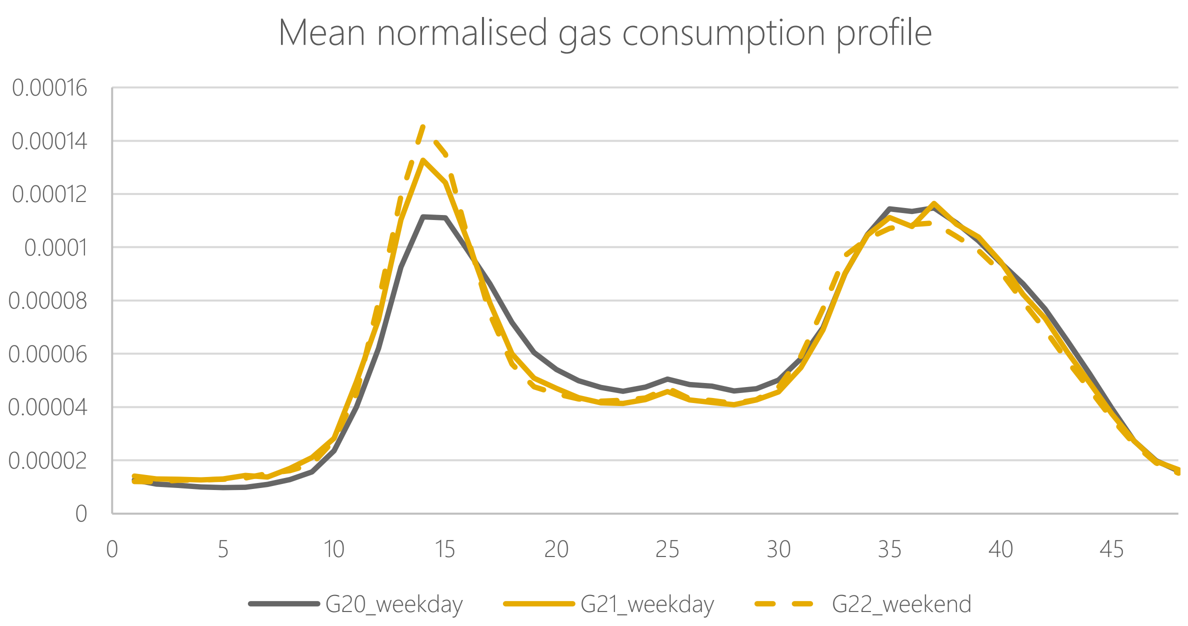
Comparing gas consumption profiles



- VX, V, and X all have similar profiles. VX has a slightly higher evening peak.
- N has a much lower morning peak than the other three archetypes but a similar evening peak

Comparing gas consumption profiles

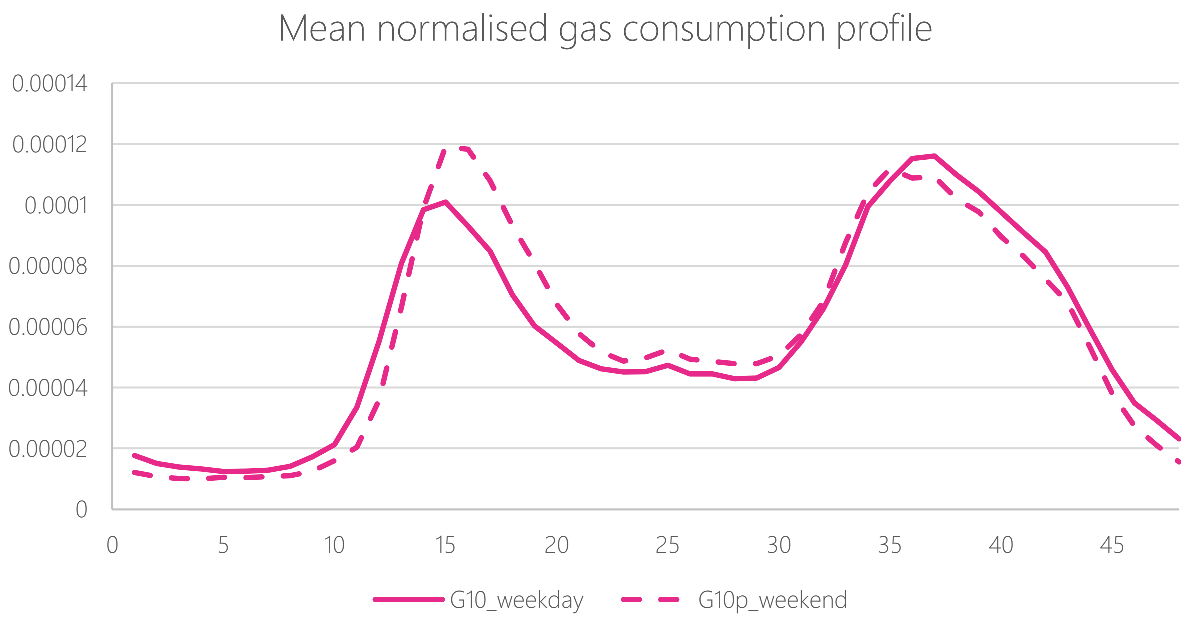


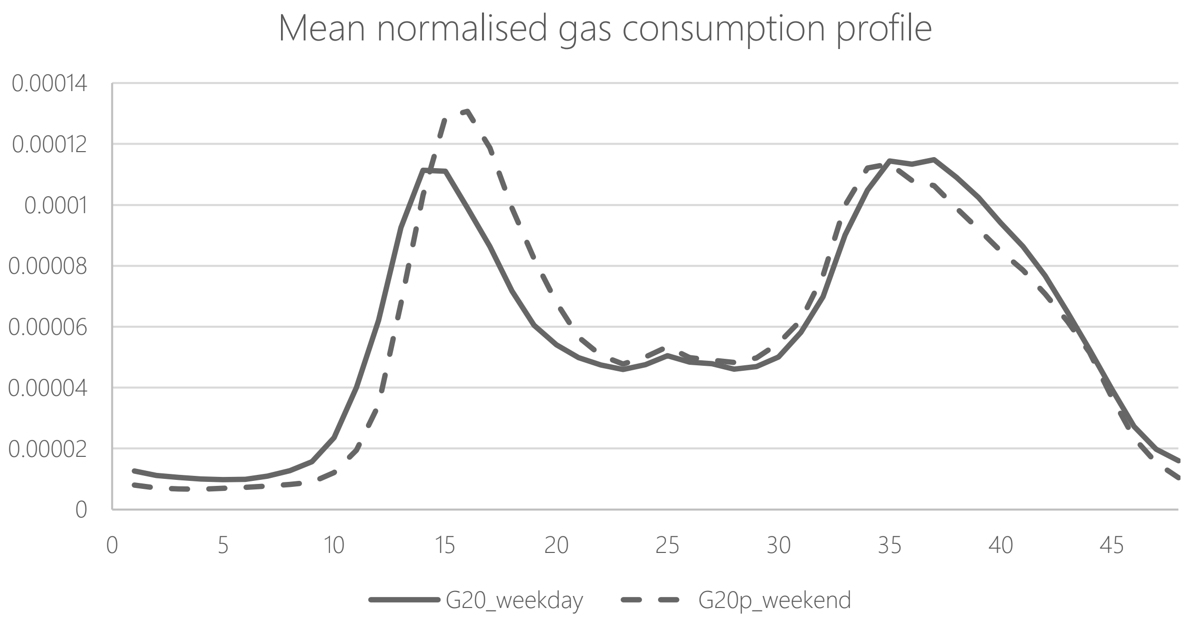


- The morning peaks of G11 and G12 are higher than G10
- The evening peak shape is quite similar across G10, G11, and G12

- The morning peak of G22 is higher than G21, which is higher than G20
- The evening peak shape is quite similar across G20, G21, and G22

Comparing gas consumption profiles

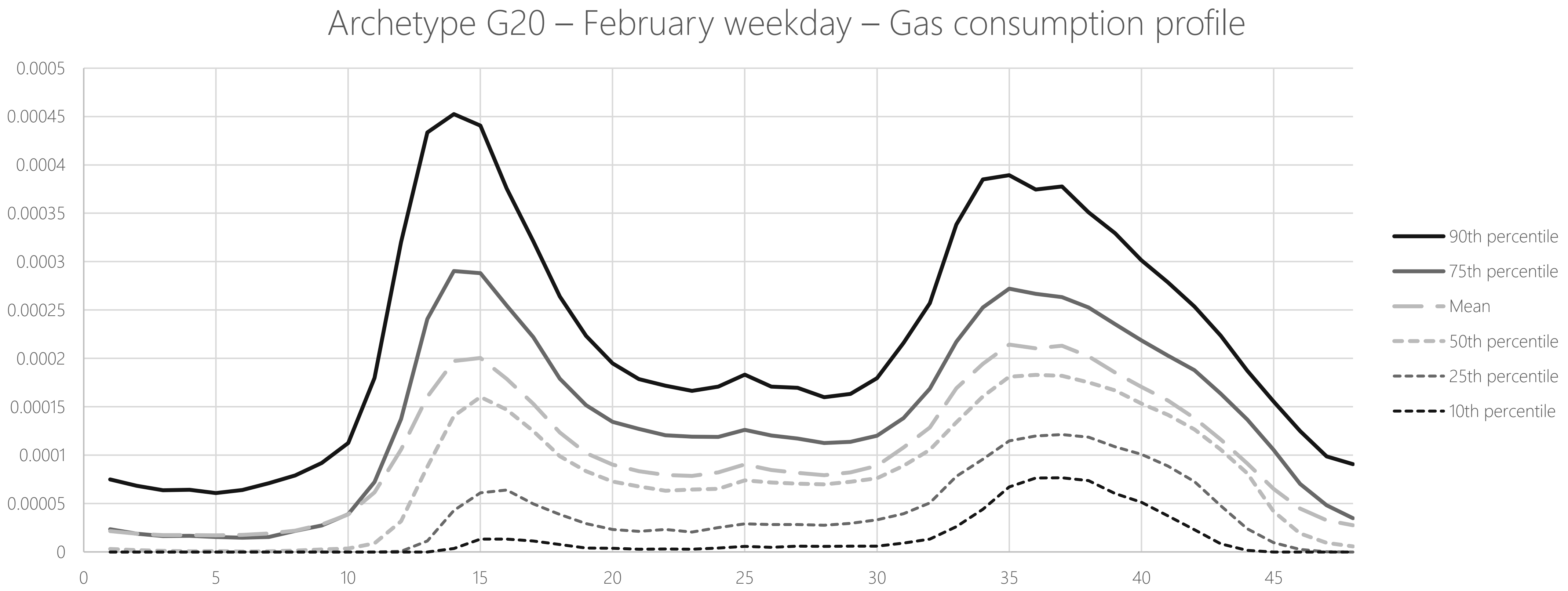




- The morning peak of G10p is higher than G10 and slightly later.
- The evening peak of G10p is earlier than G10 and there is slightly less consumption in the late evening

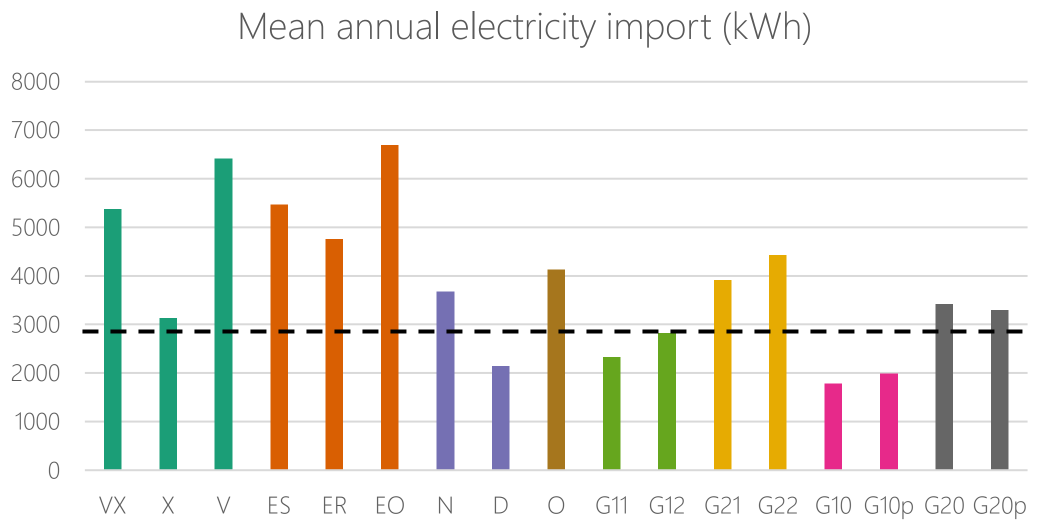
- The morning peak of G20p is higher than G20 and slightly later.
- The evening peak of G20p is earlier than G20 and there is slightly less consumption in the late evening

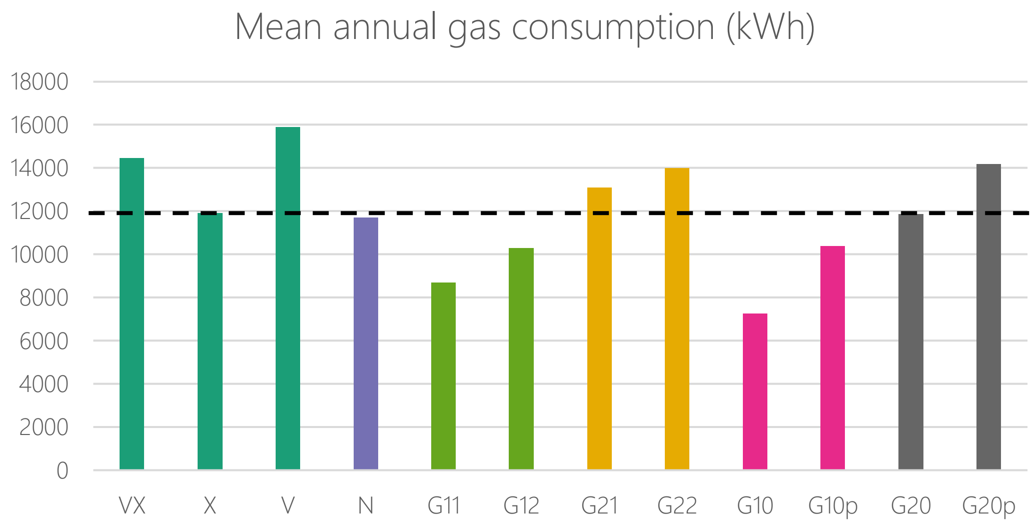
Comparing different percentiles (example)



- The mean gas consumption is higher than the median gas consumption (this is very common with energy demand)
- There is barely a morning peak in the 10th percentile curve. During the evening peak, the 10th percentile is between 5 and 10 times smaller than the 90th percentile curve

Comparing annual consumption





- Ofgem estimates the typical household in Britain uses 2,900 kWh of electricity and 12,000 kWh of gas in a year (shown as a black dashed line on the graphs)
- Unsurprisingly, the archetypes with the highest annual electricity import are EO, V, ES, VX, and ER (in that descending order). These archetypes either own EVs or use electricity as their main heating fuel. The archetype with the lowest annual electricity import is G10 and the next highest is D (probably due to the types and size of dwellings with district heating compared to the GB average).
- Archetypes V and VX have the highest annual gas consumption. Owners of EV are perhaps, on average, more likely to live in dwellings with a larger floor area. Archetypes G10 and G11 have the lowest gas consumption.
- Gas and electricity consumption generally increases in archetypes with a greater household size. Gas consumption increases in archetypes where the head of the household is aged 65+.

GB-wide domestic archetypes household counts

Archetype code	Household count	Household proportion
X	346,118	0.01
ES	1,229,044	0.04
ER	297,540	0.01
EO	303,167	0.01
N	913,506	0.03
D	736,610	0.03
O	1,099,135	0.04
L	212,865	0.01
G11	929,928	0.03
G12	773,631	0.03
G21	2,233,011	0.08
G22	3,139,014	0.11
G10	3,725,553	0.13
G10p	2,912,430	0.10
G20	5,064,209	0.18
G20p	3,148,571	0.11
NA	1,227,427	0.04
	28,291,759	1.00

Geographic distribution of archetype G20p (at LSOA11 level, zoomed in). The darker shades represent higher household counts.

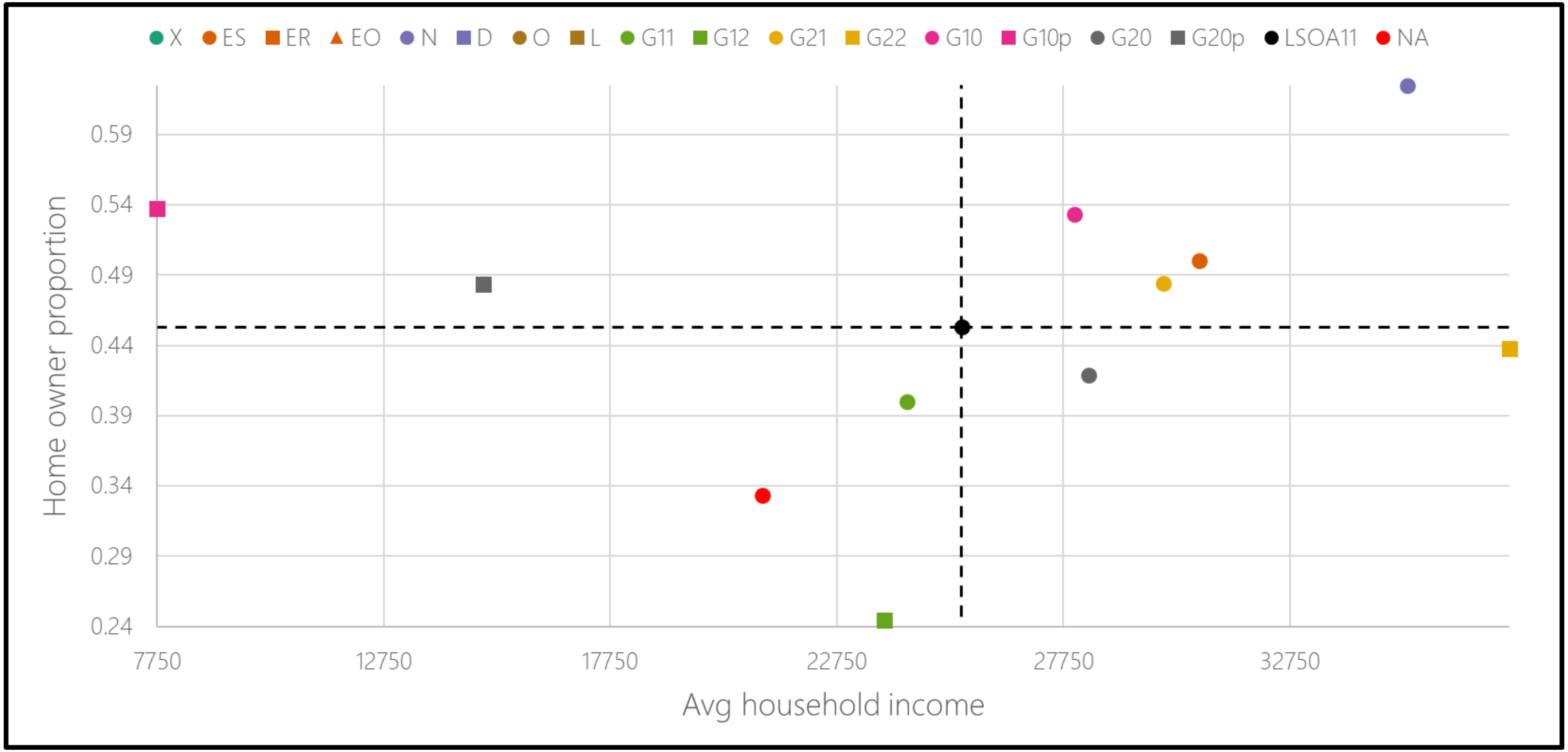
Scatter plot of additional variables

- As discussed in slide 18, for each LSOA11, local authority, and all of GB we calculated these 6 variables for each archetype
  - Mains gas connection proportion
  - Home owner proportion
  - Average (median) household income
  - Average EV score
  - Average PV score
  - Average fuel poverty score
- We also calculated the LSOA, local authority, and GB average for each variable (denoted by the black dot and dashed lines in the scatter plots)
- On the right is a count of households in each archetype for LSOA11 E01000046 and on the next slide is a scatter plot showing home owner proportion against average household income (as an example)

LSOA11: E01000046

Archetype code	Household count
ES	22
N	16
G11	30
G12	45
G21	62
G22	128
G10	90
G10p	54
G20	136
G20p	60
NA	15

LSOA11: E01000046. Home owner proportion against average household income (as an example).



Time evolution, updates, and use cases of the domestic archetypes

Evolution of the archetypes (in modelled time)

- During a modelled time period, a household within the model should switch to a different archetype if the following occurs:
  - They acquire an EV or install PV (or, less likely, get rid of either)
  - They change central heating system
  - The household size changes, they have children, or someone becomes 65+ in the household (only for gas archetypes)
- Shown below are a suggestion of variables from the outputs that could be used to help determine EV and PV take up per LSOA (and therefore archetype switching to VX, X, or V

Predicting EV take-up per LSOA

- Numbers of EVs by LSOA (also growth of EVs over the last five years)
- EV score for each archetype
- Avg household income
- Home ownership proportion

Predicting PV take-up per LSOA

- PV score for each archetype
- Avg household income
- Home ownership proportion

Updating the archetypes

Minor updates / maintenance

- A fresh classification of all GB households into one of the archetypes could occur annually based on the Experian Household Directory annual data refresh
- Minor additions could be made using the existing SERL data. Here are a few examples:
  - Inclusion of bank holiday demand profiles
  - The energy consumption behaviour of archetypes in historic extreme weather conditions
- If data about EV and PV installations becomes accessible at a household level, then households could be mapped to archetypes VX and V alongside all the other archetypes

Major updates

The domestic energy landscape will likely look quite different in a few years' time. It is very probable that more households will have PV installed and/or own an EV. At the moment, the archetypes with PV and EV are very broadly defined (VX – “EV & PV”, X – “PV only”, and V – “EV only”). In the future, as more and more households fall into those archetypes, they should be made more specific (e.g., PV with 1 child). This might be achievable if there is a successor research programme to SERL.

Joining with Demand Flexibility Service (DFS) data

- The DFS social research evaluation has created a dataset of 23,717 households, which combines:
  - variables that have been used to split the domestic archetypes (presence of PV, EV, central heating type, number of children and number of adults aged 65+ in the household),
  - location data, and
  - variables related to demand shifting (motivations, shifting strategies used, challenges experienced, likelihood to participate in future DFS type offers)
- 18,530 households have consented to their anonymised DFS evaluation data being made available for future research. Once this anonymised dataset is published, it could be possible to create a flexibility predictor for the domestic archetypes.