# How much energy do we need to live decently?

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The authors are solely responsible for this work with no engagement from the institutions to which they belong.

# Table of Contents

# French context (2023)

- 12.1% of households were unable to heat their homes adequately (2022: 10.7%) - Eurostat
- 26% reported suffering from the cold (during the winter of 2022-2023), 42% of them for financial reasons
- 79% of households reported having limited their heating to avoid excessive energy bills
- 31% encountered difficulties paying certain natural gas or electricity bills (Le médiateur national de l'énergie, 2023)

**The tariff shield** (price cap on electricity and natural gas) (autumn 2021) expired

- on 1 February 2025 for electricity
- on 1 January 2025 for collective housing that signed high-price natural gas supply contracts before 30 June 2023
- For other natural gas-powered housing, it ended on 30 June 2023

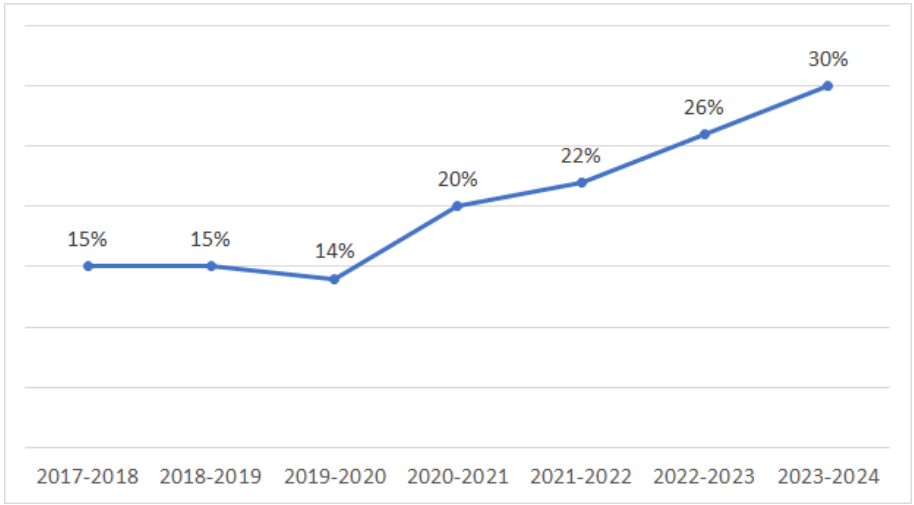
**Exceptional energy vouchers** for the most disadvantaged households
$\rightarrow$ A more difficult situation for the poorest households, particularly those living in poorly insulated housing.

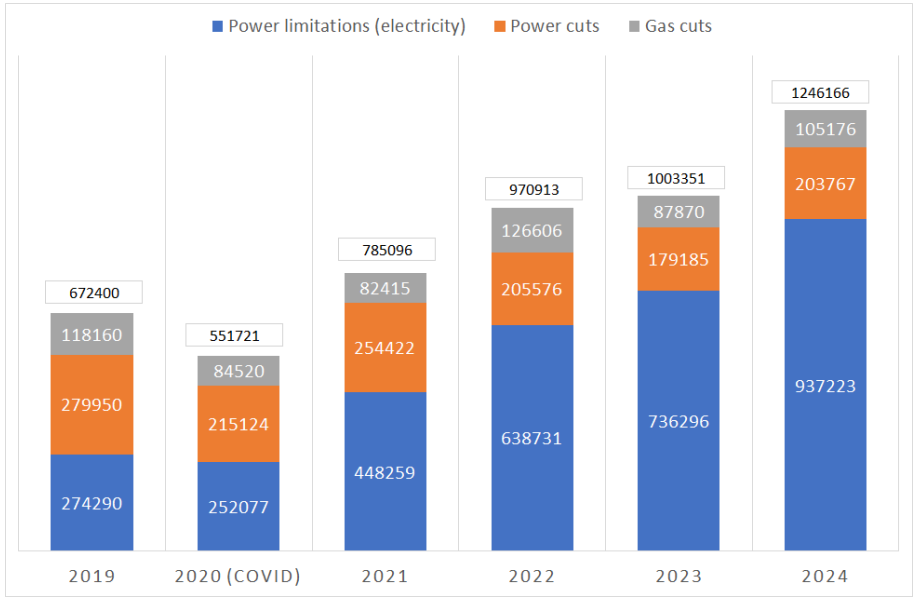
# French context (2024)

A milder winter in 2024 than in 2023 $\rightarrow$ fewer French households

- were unable to heat their homes properly (11.8%) – Eurostat
- had to limit heating in their homes (75%)
- had difficulty paying certain natural gas or electricity bills (28%) (Le médiateur national de l'énergie, 2023)

Too many households cut back on heating




**Note**: The graph on the left shows the percentage of French people (in mainland France) who reported suffering from the cold for at least 24 hours during the winter. The graph on the left shows the trend in energy arrears (natural gas and electricity) interventions. In 2024, more than 1.2 million interventions for unpaid bills were carried out at the request of electricity and natural gas suppliers. The majority of interventions concern electricity (in 2024, 1,140,990 interventions for electricity and 118,160 for natural gas).
(Le médiateur national de l'énergie, 2023)

# French context (2024)

At least 5.5 million French households received an energy voucher
The amount of this voucher depends on the composition of the household and its income

| Number of people living in the household | Reference tax income (€) per consumption unit (CU) | | | |
|---|---|---|---|---|
| | < 5,700 | [5,700 ; 6,800 [ | [6, 800 ; 7,850[ | [7,850 ; 11,000[ |
| 1 person (equivalent to 1 CU) | 194 | 146 | 98 | 48 |
| 2 people (1 CU + 0.5 CU) | 240 | 176 | 113 | 63 |
| 3 persons and more (1 CU + 0.5 CU + 0.3 CU for each additional person) | 277 | 202 | 126 | 76 |

Source: Service-public.fr

It does not take into account the energy levels required to live decently in one's home.

# Question

What is the minimum amount of energy a household (in France) needs to live comfortably (decently)?

# The objective and the energy services

To estimate **the energy levels needed to live decently in one's home**

- Energy services: not human needs, but need *satisfiers*
  - The term *satisfiers* refers to all objects, activities, and relationships that satisfy our basic needs (Kamenetzky, 1981 ; Max-Neef et al., 1991)
  - "*Basic needs then are always universal but their satisfiers are often relative.*" (Doyal and Gough, 1991)
  - "*we argue that energy services (ES) are vital "satisfiers" of human needs*" Brand-Correa and Steinberger (2017)
- Energy services = tools that meet everyday needs (lighting, cooking,...).
  - They are a prerequisite for many 'capabilities' essential to daily life (A. Sen and M. Nussbaum)
  - Energy is essential ("*is instrumentally important*") to well-being and quality of life (Day et al., 2016)
  - Relative to the individual, space and time
- These energy levels = material needs, basic needs which "*must be included as theoretical primitives because both the needs and the satisfiers of these needs are universal*" (Kemp-Benedict, 2013)

# Energy services and decent living conditions

Access to energy does not guarantee a decent standard of living

- Rao and Min (2018) define a (universal) set of material goods and conditions that households and societies need to ensure a decent life for all
- Rao and Baer (2012) develop a conceptual framework for quantifying the energy needs required to ensure a decent life for all
- Kikstra et al. (2021) provide estimates of energy requirements for a decent standard of living - DSL (regional)

# The importance/necessity of knowing these levels

- DLS can help establish "*Reference Budgets*" (or Standard Budget, or Minimum Income Standard)
  RB = an indicator of minimum income on which public policies to combat poverty are based
- Better targeting households likely to benefit from energy vouchers and better calibrating the amount of these vouchers
- A basis for insurance contracts against fuel poverty (Alasseur et al., 2022; Chaton and Guillerminet, 2023), and for fair differentiated pricing
- Minimum levels to quantify the concept of sobriety

# Reference budgets

*"A 'standard budget' is a list of goods and services that a family of a specified size and composition–and sometimes of a specified social class or occupational group–would need to live at a designated level of well-being, together with the estimated monthly or annual costs of those goods and services."* (Fisher, 2007)

Two approaches to calculating reference budgets (Preuße, 2012)

- Experts and/or representatives of the population jointly determine the goods and services needed and their quantity – the French National Observatory on Poverty and Social Exclusion (ONPES)[1] (Gilles et al., 2014)
- Based on statistical data obtained from national surveys ✓

ONPES (2015)

⇒ Estimates of reference budgets for effective participation in social life in France

⇒ For energy, per month: €78 for a single person, €105 for a couple without children, €116 for a single-parent family, €135 for a couple with two children

CNLE[2] (2022) – Lelièvre (2022)

⇒ Updating and expanding the ONPES study

⇒ Reference budgets for energy are no longer quantified (included in housing)

[1] Observatoire national de la pauvreté et de l'exclusion sociale

[2] Conseil national des politiques de lutte contre la pauvreté et de l'exclusion sociale

# No information· · ·

· · · on 'minimum' energy levels or associated costs

Chaton and Guillerminet (2023) – SRCV2019

Are the determinants of these levels (associated expenditure) similar to those of consumption in the residential sector?

Haas (1997); Guo et al. (2018); Lee and Song (2022)

Brounen et al. (2012) – a sample of over 300,000 Dutch households –

- ⇒ residential natural gas consumption: mainly determined by the structural characteristics of the dwelling
- ⇒ electricity consumption varies more directly according to household composition

Belaïd and Garcia (2016) – Phebus -
Five main attributes that encourage energy-saving behaviour
energy prices, household income, level of education, age of the head of household and EPC label

# Table of Contents

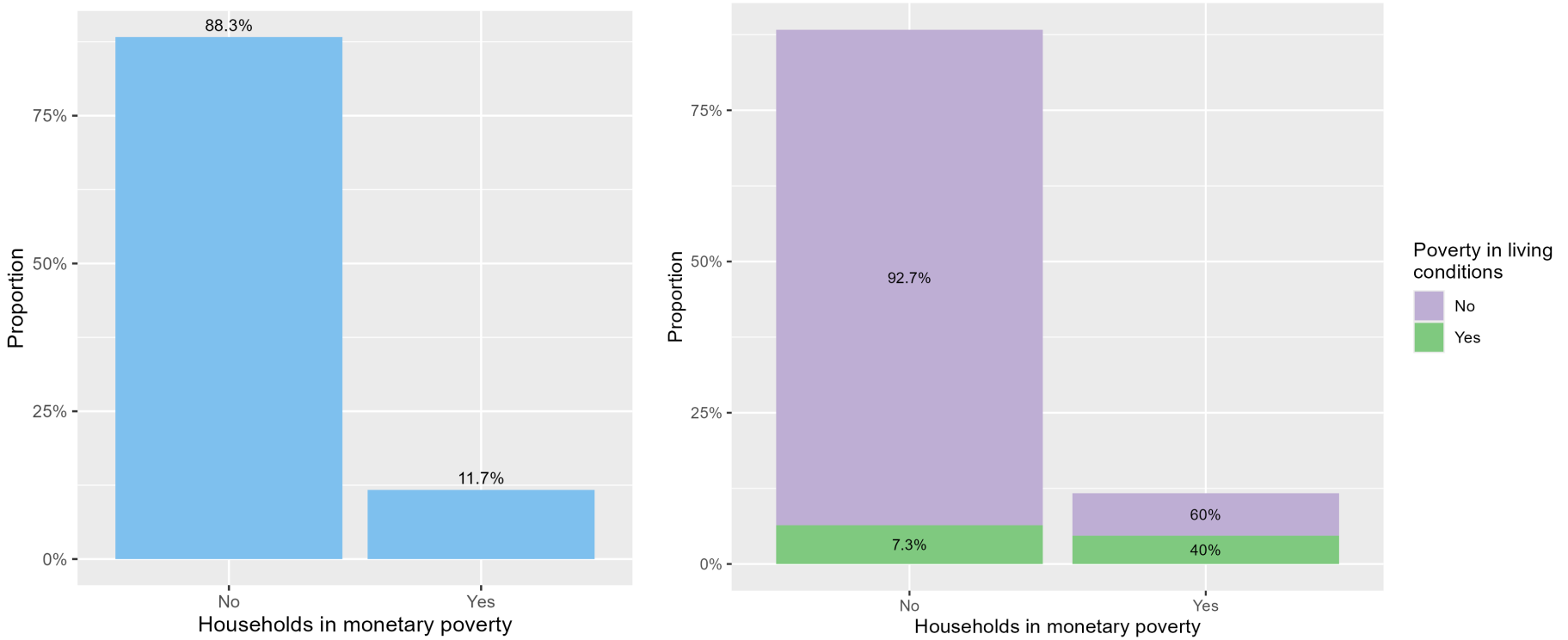
# SRCV survey

INSEE's **Statistics on Resources and Living Conditions (SRCV) survey**

- Data on income, financial situation, living conditions of households + housing characteristics and housing expenditure
  - ⇒ Including declarations of the annual amounts spent on electricity, natural gas and other end-use energy sources on heating or domestic hot water
- No information on the energy performance of households' dwellings
- The **2017** wave of the SRCV (SRCV2017).
  - ⇒ Allows comparison of the distribution of EPC scores obtained with the estimated condition of the housing stock based on the EPC score as of 1 January 2018 provided by Merly Alpa et al. (2020)[3]
- 11,068 households

[3] Le Saout et al. (2022) – Distinction between electricity and natural gas removed from 2020. Electricity, natural gas and heating bills included in the cost of housing since 2021.

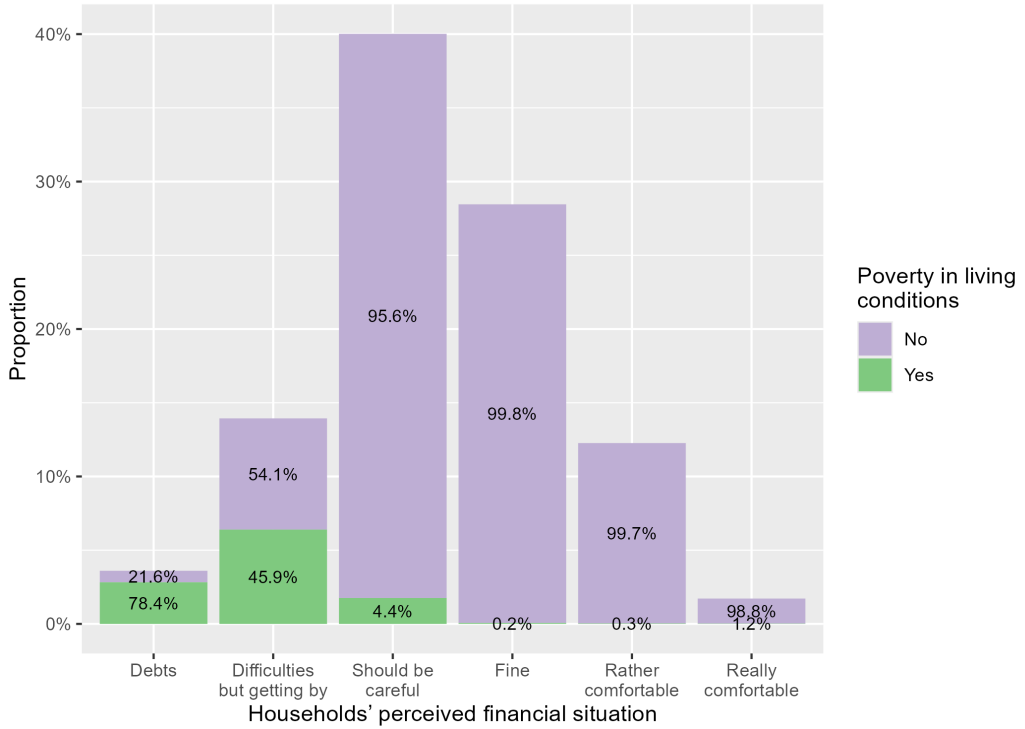
# Some statistics on poverty in France in 2017




The figure on the left shows the percentage of households in monetary poverty in 2017. The figure on the right compares income poverty and poverty in living conditions. Thus, 7.3% of households that are not poor in monetary terms are poor in terms of living standards.
Source: SRCV2017.

A household is exposed to the risk of monetary/income poverty if its standard of living is below the poverty threshold, set at 60% of the median standard of living.
A household is poor in living conditions according to the INSEE definition when it accumulates at least 8 deprivations or difficulties out of 27 relating to insufficient resources, late payments, consumption restrictions and housing difficulties

# Households' perceived financial situation and poverty in living conditions




Source: SRCV2017

*'Strained'* households: are not poor in terms of living conditions and report having difficulties but managing to get by (54.1%), or that everything is fine but they have to be careful (95.6%) = 4,232 households

# Energy performance Certificates, EPC

- **EPC**: Provides information on the energy performance of a dwelling by assessing its primary energy consumption and greenhouse gas emissions
- Collection of EPCs in mainland France carried out by **Ademe**[4]
- Changes to the method for calculating EPCs in 2021

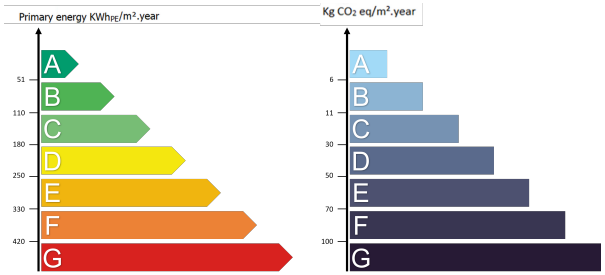



Figure: The EPC in 2017: two environmental labels

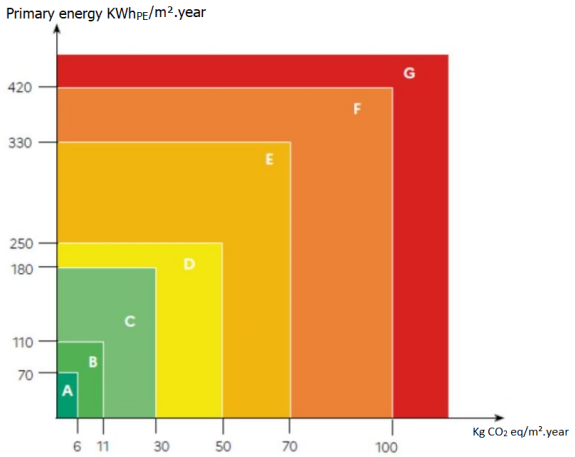



Figure: The EPC in 2022: 'double thresholds'

- Sample selected: EPCs issued in 2022 (908,007 dwellings)

[4] French Environment and Energy Management Agency

# Variables common to both databases

- Housing characteristics Appendix:
  1. Type of dwelling (flat or house)
  2. Surface area
  3. Zone d'études et d'aménagement du territoire (ZEAT)[5]
  4. Size of the urban unit
  5. (Date of construction)

- Annual energy bills Appendix:
  1. *SRCV*: Declarations of annual amounts spent on electricity, natual gas and other expenses for heating and domestic hot water costs
  2. *EPC database*: Estimated costs for standard use of each energy consumed: cost of heating, cost of DHW and total cost for the five uses (DHW, heating, air conditioning, lighting, and auxiliaries)

  $\Rightarrow$ Comparable after adjusting for price changes between 2017 and 2022

**Objective**: to assign an EPC to each dwelling of SRCV households

[5] Survey zone and national planning

# Multinomial logistic regression model

$$\pi_i^{(d)} = \frac{\exp(\beta_0^{(d)} + \beta_1^{(d)} surface_i + \beta_2^{(d)} ZEAT_i + \beta_3^{(d)} urbanunit_i + \beta_4^{(d)} energybill_i)}{1 + \sum_{k=1}^{5} \exp(\beta_0^{(k)} + \beta_1^{(k)} surface_i + \beta_2^{(k)} ZEAT_i + \beta_3^{(k)} urbanunit_i + \beta_4^{(k)} energybill_i)}$$

$$\text{and} \quad \pi_i^{(0)} = 1 - \sum_{k=1}^{5} \pi_i^{(k)} \quad \text{for an EPC score A–B}$$

where $\pi_i^{(0)}$ the probability that the dwelling $i$ has an EPC rating of A–B (ref) and $\pi_i^{(d)}$ the probability that it has a rating of $d$ (d = 1 'C', 2 'D', 3 'E', 4 'F', 5 'G')

- **6 models** based on **energy consumption** and **type of housing** Le Saout et al. (2022)
  1. Flats - Electricity alone
  2. Flats - Natural gas
  3. Flats - Other energy source
  4. Houses - Electricity alone
  5. Houses - Natural gas
  6. Houses - Other energy source

Samples from the EPC database

- Training (80%) and testing (20%) based on Ademe's **EPC** data
- Performance rating of the six models: good, especially for all-electric homes (88% of EPC labels correctly predicted for flats and 93% for houses) Appendix

# Multinomial logistic regression model

- Use of the six models **to predict EPCs of primary residences in the SRCV database**
- Comparison of predictions with the distribution of EPCs labels produced by Merly-Alpa et al. (2020)
  - ⇒ Majority of E labels, more energy-intensive buildings and fewer low-energy homes

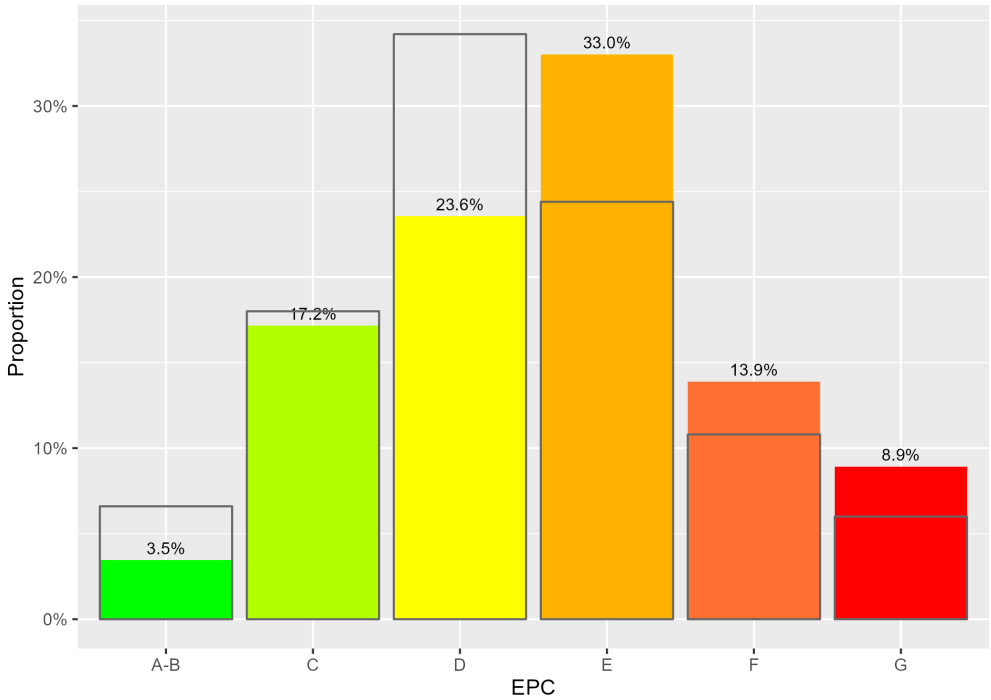



Figure: Distribution of EPC labels in SRCV and comparison with Merly-Alpa et al. (2020)

# Adjustment of predictions

- **Objective:** Obtain the same **distribution of EPCs by income quintiles as Merly-Alpa et al.**
  1. $n_{q,r}^{\text{model}} < n_{q,r}^{\text{Merly}}$: we assign an EPC rating of $r$ to households $n_{q,r}^{\text{model}}$ and complete with the other households in the quintile sorted in descending order of $\pi_i^{(r)}$.
  2. $n_{q,r}^{\text{model}} > n_{q,r}^{\text{Merly}}$: we sort the households $n_{q,r}^{\text{model}}$ in descending order of $\pi_i^{(r)}$ and assign an EPC rating of $r$ to the first $n_{q,r}^{\text{Merly}}$ of them.

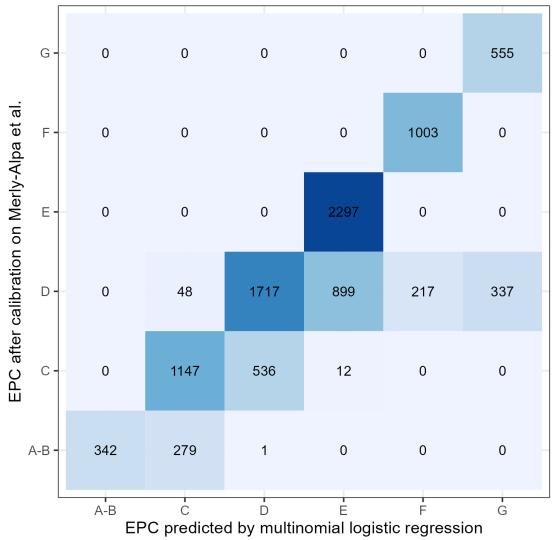



Figure: Prediction of EPCs before and after calibration on Merly-Alpa et al.

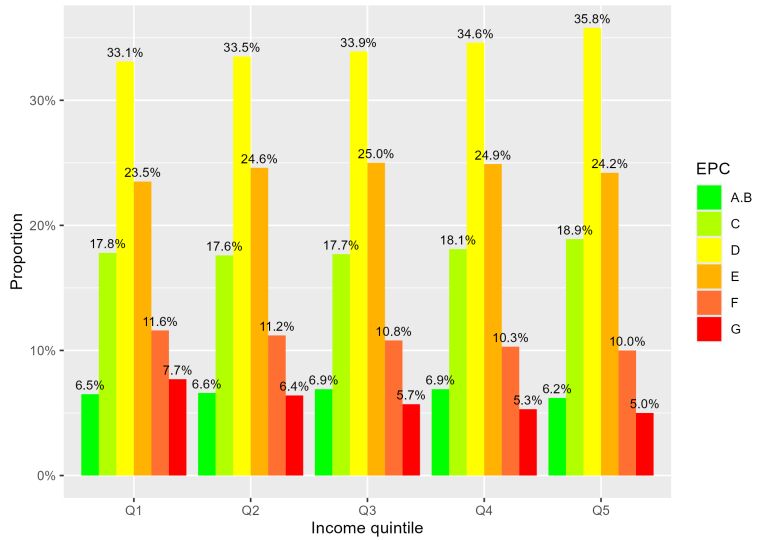



Figure: EPC labels by income quintile (after calibration)

Number of deviation labels

# Limitations of the methodology

1. Based on energy bills: calculated for standard usage in the Ademe's EPC database, 'actual' bills in SRCV
2. It is impossible to take into account the fact that households are restricting their spending
3. Lack of details in SRCV: on housing characteristics, energy expenditure, location
4. **Entirely based on the distribution of EPCs by income quintiles provided by Merly-Alpa et al.**

# Table of Contents

# Annual energy bills per $m^2$ according to EPC labels

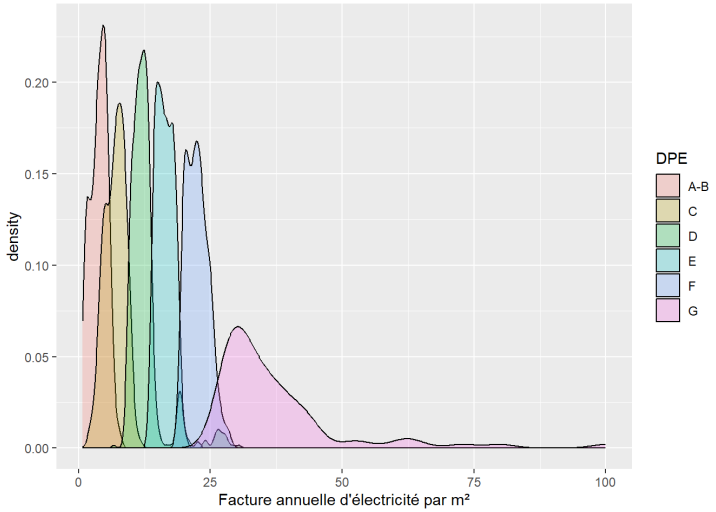



Figure: Annual electricity bills per $m^2$

| | Min | Q1 | Med | Mean | Q3 | Max |
|---|---|---|---|---|---|---|
| A-B | 0,74 | 2,55 | 3,95 | 3,81 | 5,00 | 7,79 |
| C | 1,48 | 5,33 | 7,06 | 6,88 | 8,37 | 12,0 |
| D | 6,67 | 10,8 | 12,0 | 12,6 | 13,2 | 30,4 |
| E | 13,3 | 15,0 | 16,3 | 16,4 | 17,8 | 22,7 |
| F | 19,2 | 20,8 | 22,4 | 22,5 | 24,0 | 28,6 |
| G | 27,3 | 29,4 | 33,3 | 38,4 | 39,4 | 125 |

Table: Annual electricity bills per $m^2$

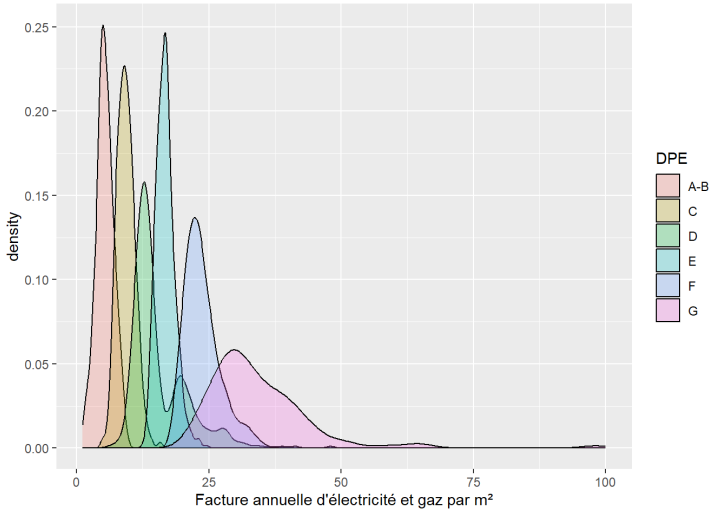



Figure: Annual electricity and gas bills per $m^2$

| | Min | Q1 | Med | Mean | Q3 | Max |
|---|---|---|---|---|---|---|
| A-B | 1,11 | 4,33 | 5,26 | 5,35 | 6,41 | 9,67 |
| C | 4,77 | 8,03 | 9,20 | 9,27 | 10,4 | 16,0 |
| D | 6,00 | 12,1 | 13,5 | 15,4 | 18,5 | 51,7 |
| E | 12,4 | 15,5 | 16,7 | 16,7 | 17,7 | 24,7 |
| F | 17,8 | 21,3 | 23,1 | 23,8 | 25,4 | 48,0 |
| G | 21,6 | 28,3 | 32,2 | 36,3 | 38,5 | 278 |

Table: Annual electricity and gas bills per $m^2$

# Method

- Linear regression model
  - ⇒ *Dependent* variable : **logarithm of annual energy bills**
  - ⇒ **Explanatory** variables:
    EPC, income quintile, type of housing, surface area and log(surface area), number of rooms, ZEAT, urban unit, date of construction, occupancy status, poverty in living conditions, type of household, number of working people, number of children, inactive people in the household, age, humidity, noise, difficult to heat, dark, freezer, washing machine, dishwasher, number of computers, number of televisions, gas cylinders, weight of electricity in the bill, EPC x income quintile, EPC x type of housing

- **4 model** depending on the energy consumed by the household:
  1. Electricity alone
  2. Electricity and natural gas
  3. Electricity and other energies for heating and DHW
  4. Electricity, natural gas and other end-use energy sources

# Results

| | All electric | Electricity & natural gas | Electricity & other | Electricity, natural gas & other |
|---|---|---|---|---|
| (Intercept) | 3.8700 *** | 4.3823 *** | 5.3106 *** | 4.6541 *** |
| EPC (ref: D) | | | | |
| EPC A–B | -0.8984 *** | -0.9513 *** | -0.9476 *** | -1.0683 *** |
| EPC C | -0.6565 *** | -0.4388 *** | -0.5912 *** | -0.5174 *** |
| EPC E | 0.3474 *** | 0.2995 *** | 0.3122 *** | 0.2553 *** |
| EPC F | 0.6823 *** | 0.6408 *** | 0.601 *** | 0.7413 *** |
| EPC G | 1.1146 *** | 0.8622 *** | 0.9941 *** | 1.0214 *** |
| Income quintile (ref: Q1) | | | | |
| Q2 | 0.1013 *** | 0.117 *** | 0.0852 * | 0.1676 *** |
| Q3 | 0.116 *** | 0.2405 *** | 0.2294 *** | 0.2747 *** |
| Q4 | 0.1768 *** | 0.2789 *** | 0.2958 *** | 0.3397 *** |
| Q5 | 0.2449 *** | 0.3184 *** | 0.3554 *** | 0.3368 *** |
| Type of accommodation (ref.: flat) | | | | |
| House | 0.0326 | 0.0927 *** | 0.2309 *** | -0.0344 |
| Surface | 0.0019 *** | 0.0008 *** | 0.002 *** | 0.0008 ** |
| log(Surface) | 0.6123 *** | 0.5221 *** | 0.2894 *** | 0.4566 *** |
| Date of construction (ref: after 1990) | | | | |
| Before 1949 | 0.0040 | 0.0332 *** | 0.0182 | 0.0420 *** |
| From 1949 to 1974 | -0.0316 | 0.0242 ** | -0.0054 | 0.0051 |
| From 1975 to 1981 | -0.0039 | 0.0092 | 0.0313 | 0.0172 |
| From 1982 to 1989 | -0.0033 | 0.0095 | -0.006 | 0.0015 |
| Type of household (ref: single person) | | | | |
| Single parent family | 0.0849 *** | -0.0016 | 0.0571 | -0.0025 |
| Couple without child | 0.0609 *** | 0.0291 *** | 0.0552 * | 0.0248 |
| Couple with at least one child | 0.0437 | 0.0070 | 0.0765 * | 0.0618 ** |
| Reference person's age | 0.0004 | 0.0012 *** | 0.0015 | 0.0017 *** |
| Difficult/expensive to heat (Yes) | 0.0657 *** | 0.0455 *** | 0.082 *** | 0.0574 *** |
| Dishwasher (Yes) | 0.0494 *** | 0.0126 | 0.0739 *** | 0.0411 *** |
| Gas bottle (Yes) | - | -0.0441 *** | - | -0.0401 *** |
| Electricity weight (ref: minus 30%) | | | | |
| Between 30 and 50% | - | -0.0384 *** | -0.0831 *** | -0.059 *** |
| Between 50 and 75% | - | -0.0652 *** | -0.2122 *** | -0.0575 *** |
| Greater than 75% | - | -0.0317 ** | -0.2049 *** | 0.0062 |
| ... | ... | ... | ... | ... |
| **Number of observations** | **1,934** | **3,922** | **814** | **1,774** |
| **Adjusted $R^2$** | **0.897** | **0.877** | **0.792** | **0.757** |

# Results: Importance of the EPC rating on energy bills

- Energy bills always depend heavily on the characteristics of the dwelling (**EPC label, surface area**) and **household income**.
- The importance of location varies according to the estimates and the alternatives
  - ZEAT almost never significant
  - Electricity and electricity + natural gas bills are lower in large urban areas than in rural municipalities.
  - Living in Paris rather than in a rural commune reduces electricity bills by 11%, all other things being equal
- Household characteristics had little impact, although:
  - Electricity bills are 9% higher for single-parent families and 6% higher for couples without children than for single people
  - Electricity and other energy bills are 8% and 6% higher for a couple with and without children, respectively, than for a single person
- Energy bills 3-4% higher for homes built before 1945 **if natural gas is used**
- Energy bills decrease when the proportion of electricity expenditure increases

# Table of Contents

# Assumptions, methodology and model

1. *'Strained households'*: households that only have the financial capacity to consume the essential goods basket
   - In **SRCV**: defined via the **household's perception of their financial situation** and the **poverty in living conditions** indicator
     ⇒ Households that responded that they are "struggling but are getting by", or "that things are okay but they should be careful" but are not poor in terms of living conditions
   - 4 232 ménages

2. **Determination of minimum energy levels**
   - Assumptions about the price of energy used
     ⇒ Regulated tariffs for natural gas and electricity
     ⇒ Choice of option and power subscribed according to surface area and types of energy
   - Allows you to calculate the amount of electricity and natural gas consumed

3. A linear regression model for *strained household*
   - *Dependent* variable: **logarithm of the annual quantity of energy consumed**
   - 2 models: (1) Dwellings entirely electric (2) Electricity and natural gas

# Results

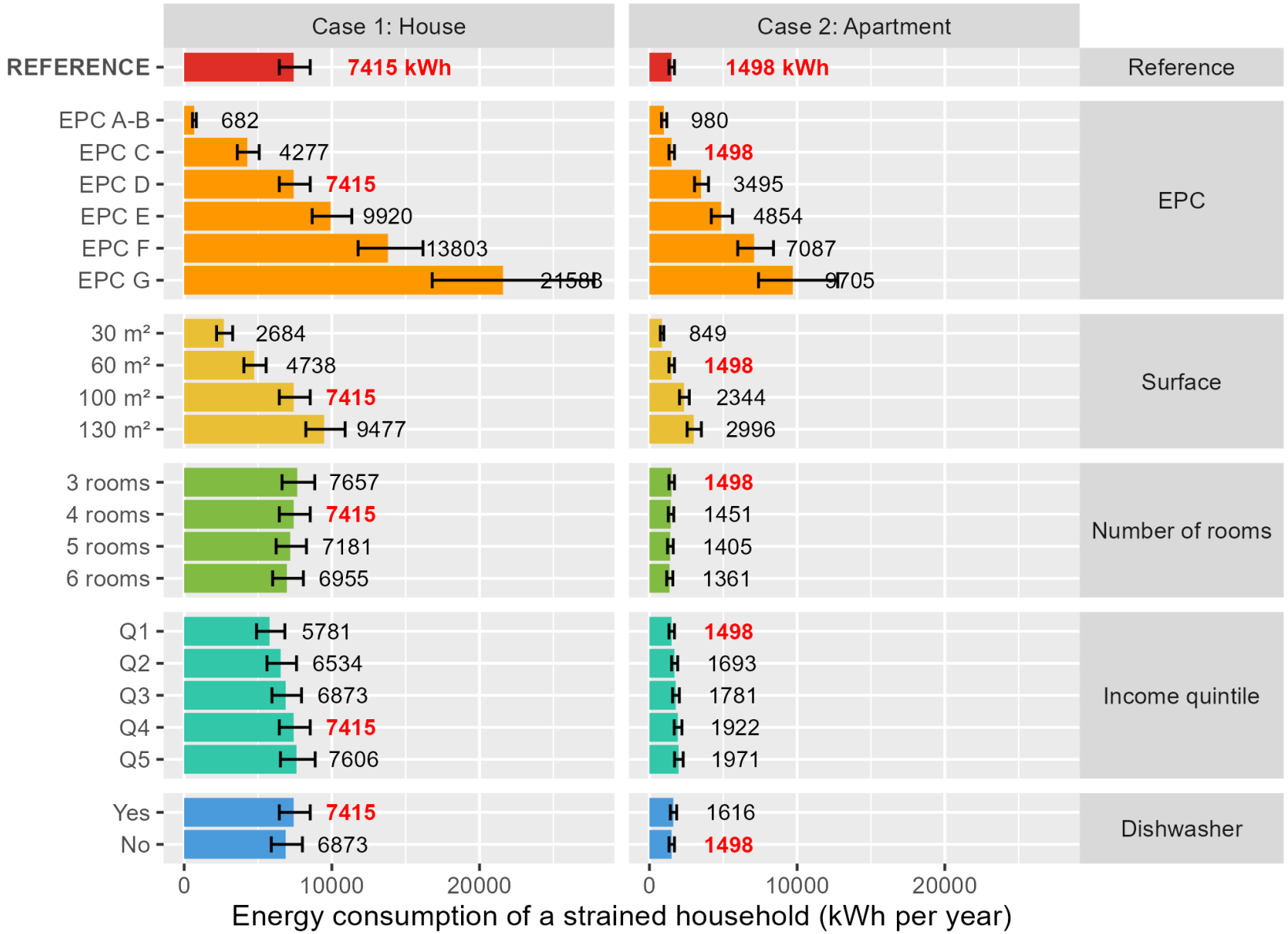
| | **All electric** | **Electricity & natural gas** |
|---|---|---|
| (Intercept) | 4.9796 *** | 6.8991 *** |
| EPC (ref : D) | | |
| EPC A-B | -1.2716 *** | -1.462 *** |
| EPC C | -0.8471 *** | -0.6234 *** |
| EPC E | 0.3284 *** | 0.2157 *** |
| EPC F | 0.7069 *** | 0.6671 *** |
| EPC G | 1.0213 *** | 0.9114 *** |
| Type of accommodation (ref.: flat) | | |
| House | 0.1064 * | 0.1653 *** |
| EPC x Type de logement | | |
| EPC A-B x House | -1.1154 *** | 0.2527 *** |
| EPC C x House | 0.2969 *** | 0.0803 ** |
| EPC E x House | -0.0374 | -0.0805 ** |
| EPC F x House | -0.0856 | -0.1908 *** |
| EPC G x House | 0.0473 | -0.0634 |
| Surface | 0.0016 | 0.0008 |
| log(Surface) | 0.7495 *** | 0.5513 *** |
| Number of rooms | -0.0321 ** | 0.006 |
| Date of construction (ref: after 1990) | | |
| Before 1949 | 0.0244 | 0.0457 ** |
| Housing occupancy status (Tenant or sub-tenant) | 0.049 | -0.0352 * |
| Type of household (ref: single person) | | |
| Couple without child | 0.0923 ** | 0.0491 ** |
| Number of children | 0.0179 | 0.0238 * |
| Difficult/expensive to heat (Yes) | 0.0398 | 0.0624 *** |
| Dishwasher (Yes) | 0.076 ** | 0.0337 ** |
| Number of televisions | 0.0058 | 0.0197 ** |
| Income quintile (ref: Q1) | | |
| Q2 | 0.1224 *** | 0.0412 ** |
| Q3 | 0.173 *** | 0.1575 *** |
| Q4 | 0.249 *** | 0.2257 *** |
| Q5 | 0.2743 *** | 0.2403 *** |
| Electricity weight | - | -0.0234 *** |
| $(\text{Electricity weight})^2$ | - | 0.0001 *** |
| ... | ... | ... |
| **Number of observations** | **819** | **1 764** |

# Results

- Adjusted $R^2$: 0.84 for "all electric", 0.88 for "electricity and natural gas"
- Few significant variables:
  - **Minimum amount of energy almost entirely explained by EPC**
  - **Type of housing and surface area** are also significant
  - Minimum energy requirement increases with **income quintile**
  - 'Low' impact of household composition
- To facilitate interpretation: **2 reference situations** (arbitrary choices)
  1. A **working couple with two children**, **homeowners**, belonging to the **4$^{th}$ income quintile**, living in a **house** of **100 m²** with 4 rooms, with a **EPC D** energy rating, in a rural municipality in the Paris Basin
  2. A **single working individual**, in the **1$^{st}$ income quintile**, renting a three-room, **60 m² flat** with a **EPC rating of C** in **Paris**

  $\Rightarrow$ Then study of variations in the decent level of energy when one of the characteristics is modified

# All electric



# Results - All electric: Realistic?

*Comparison with consumption provided by certain energy suppliers*

- According to EDF solution solaire, the average consumption of
  - one personne living in an all-electric flat (heating, hot water and cooking) measuring 30 $m^2$ is **3,600 kWh per year**
  - a family of four living in an all-electric house (heating, hot water and cooking) measuring 100 $m^2$ is **14,100 kWh/y**

- Estimates of decent energy levels:
  - 30 $m^2$ flat occupied by one person: between 660 and 6,500 kWh per year, according to the EPC (3,300 for an EPC rating of E).
  - 100 $m^2$ house occupied by a family of four: between 682 and 2,158.8 kWh per year, according to EPC (1,380 for an EPC rating of F)

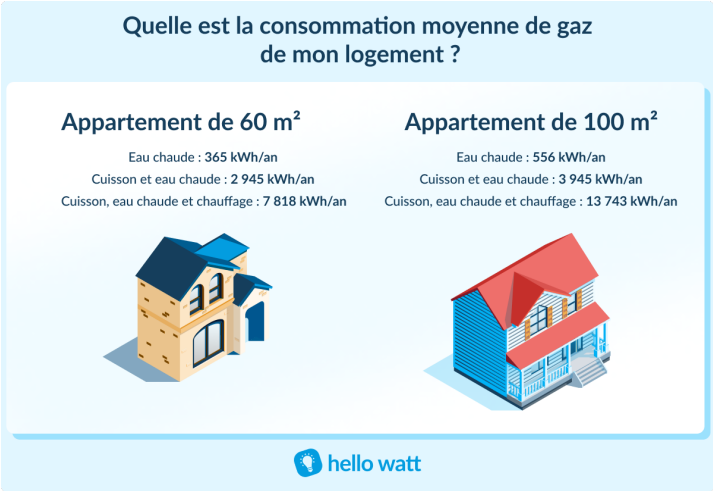
- Average consumption indicated by energy suppliers in the upper range of estimates, because:
  1. Not specific to the EPC
  2. For a given EPC: consumption of households not in fuel poverty $\geq$ the minimum level

# Results - Electricity and natural gas


Figure: Estimation de la quantité annuelle d'énergie consommée par un ménage juste

# Results - Electricity and natural gas: Realistic?

- Commission pour la Régulation de l'Énergie (CRE): Average gas consumption per household between 11,000 and 12,000 kWh per year in France
- Hello watt:




- Estimates of decent gas levels *(for natural gas consumption equal to 69% of electricity + gas consumption)* :
  - 60 $m^2$ flat: between 931 and 9,995 kWh per year, according to the EPC
  - 100 $m^2$ house: between 2,906 and 22,740 kWh per year, according to the EPC
- **Limitations of results:** In the case of joint bills, the distinction between the amount of electricity and natural gas consumed is estimated and not given

# And how much is that in euros? (in 2017)

## All electric: Appendix

1. Case study **house**:
   - Reference: €1,217
   - According to the EPC: between €260 (EPC A–B) and €3,121 (EPC G)
   - Depending on the surface area: €827 for 60 $m^2$, €1,513 for 130 $m^2$
2. Case study **flat**:
   - Reference: €322
   - According to the EPC: between €229 (EPC A–B) and €1,454 (EPC G)
   - Depending on the surface area: €200 for 30 $m^2$, €473 for 100 $m^2$

## Electricity and natural gas: Appendix

1. Case study **house**:
   - Reference: €1,529
   - According to the EPC: between €605 (EPC A–B) and €3,173 (EPC G)
   - Depending on the surface area: €1,166 for 60 $m^2$, €1,768 for 130 $m^2$
2. Case study **flat**:
   - Reference: €464
   - According to the EPC: between €278 (EPC A–B) and €1,535 (EPC G)
   - Depending on the surface area: €326 for 30 $m^2$, €703 for 100 $m^2$

# Table of Contents

# Conclusion

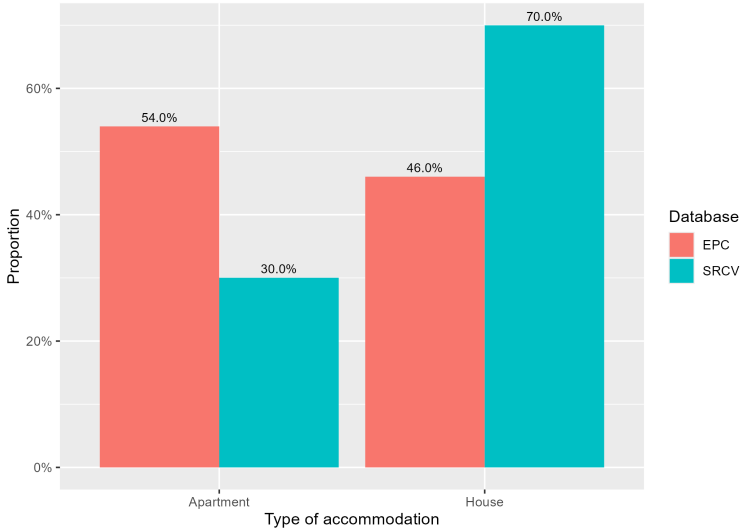
- The minimum energy levels required for decent living vary greatly depending on the characteristics of the dwelling: **EPC and surface area**
- The amount of the energy voucher is low compared to the cost of minimum energy levels, e.g.:
  - 30 m2 flat (all electric) occupied by one person: between 660 and 6,500 kWh per year : [€298; €1,446] ( HP/HC option - 60/40 - incl. subscription = €168)
  - Energy voucher: [€48;€184]
- Households living in energy-inefficient housing (especially if EPC score has no impact on rent) are 'disadvantaged' $\rightarrow$ energy retrofit
- **Lack of** consistent data to determine these essential levels, which are important for many public policies: energy voucher, energy renovation,...)
- **Extensions**: determine the minimum quantity of other essential goods and/or the cost of the essential basket specific to each household

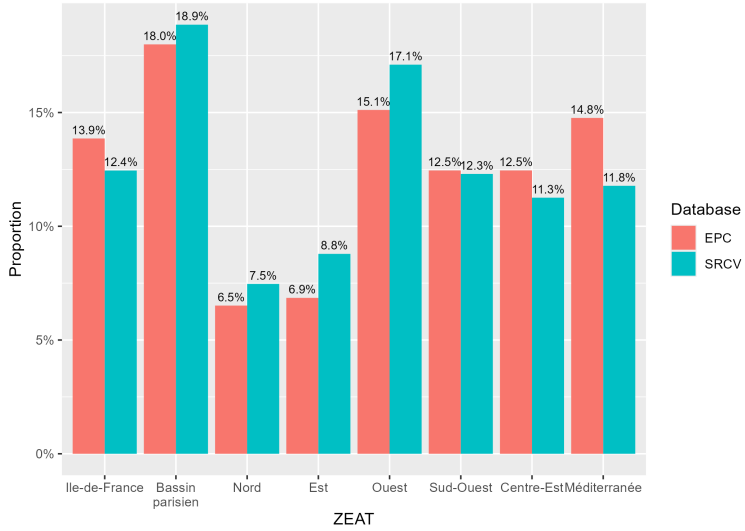
Working paper: How much energy do we need to live decently?

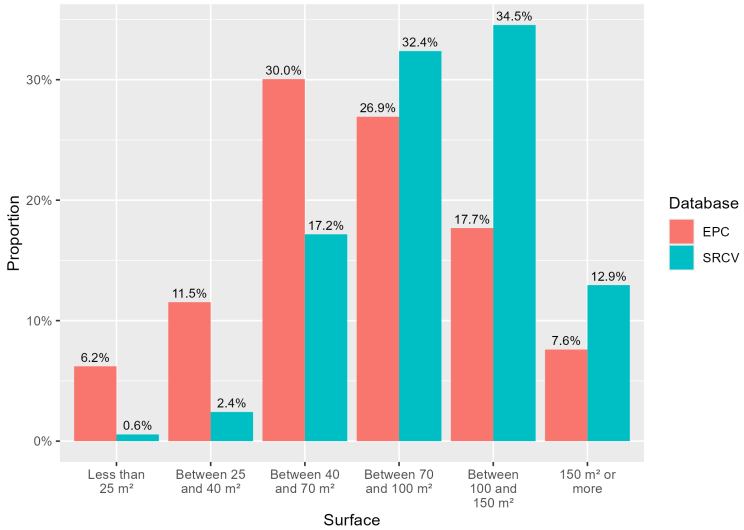
BEEPP project - ANR-24-CE26-5324

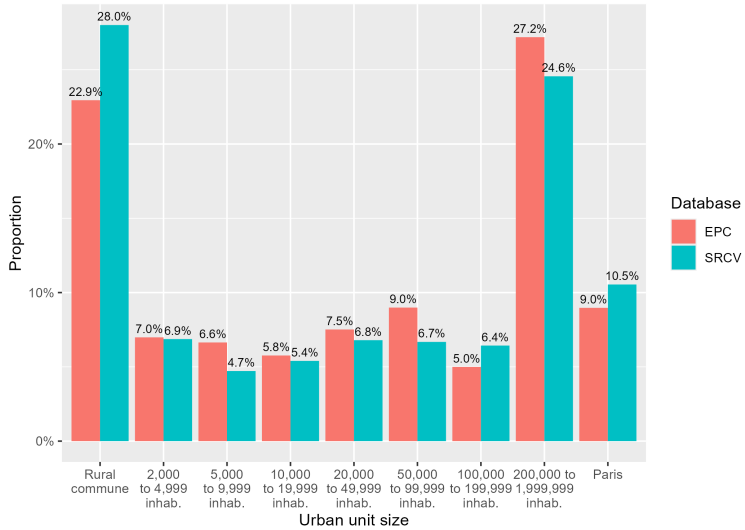
# Appendix

# Distribution of common variables




Back

# Distribution of annual energy bills

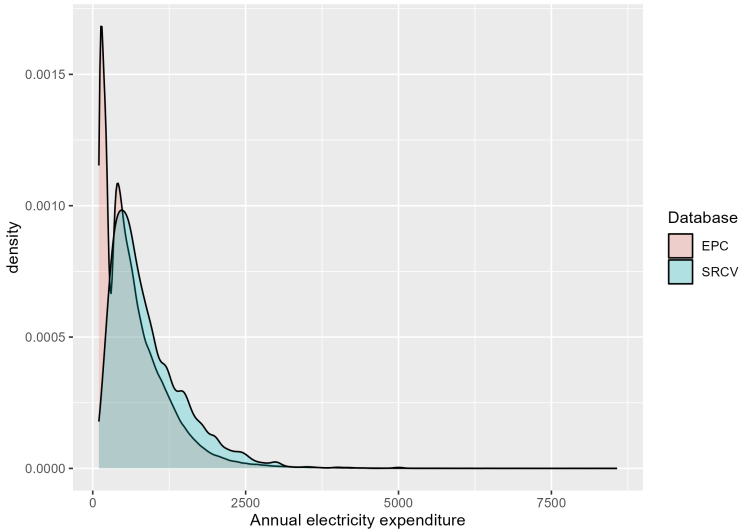



Figure: Annual electricity expenditure

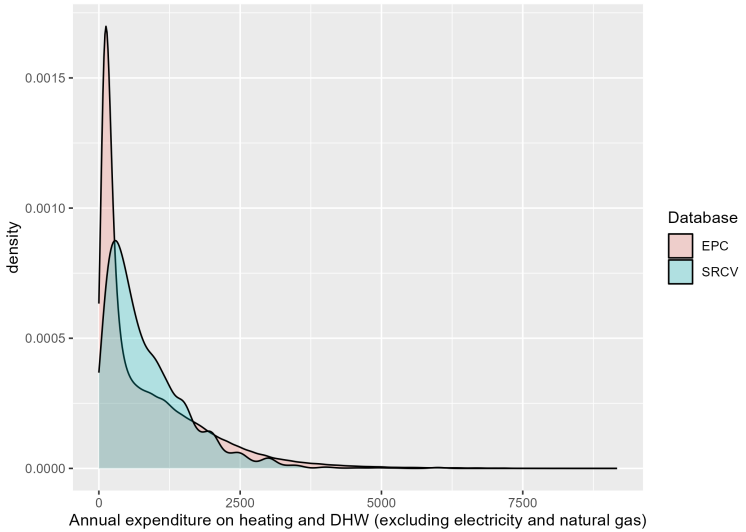



Figure: Other energy bill

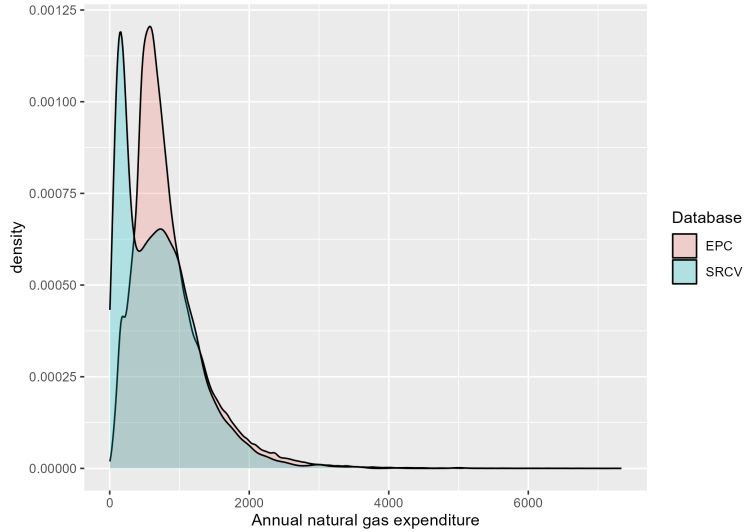



Figure: Annual natural gas expenditure

Back

# Samples from the EPC database

| | Sample | Number of homes |
|---|---|---|
| (a) | Flats – All electric | 311,986 |
| (b) | Houses – All electric | 145,787 |
| (c) | Flats – Electricity & natural gas | 141,292 |
| (d) | Houses – Electricity & natural gas | 123,564 |
| (e) | Flats – Electricity and other end-use energy sources | 36,875 |
| (f) | Houses – Electricity & other end-use energy sources | 148,503 |

**Source**: Ademe, EPC Existing homes (from July 2021)

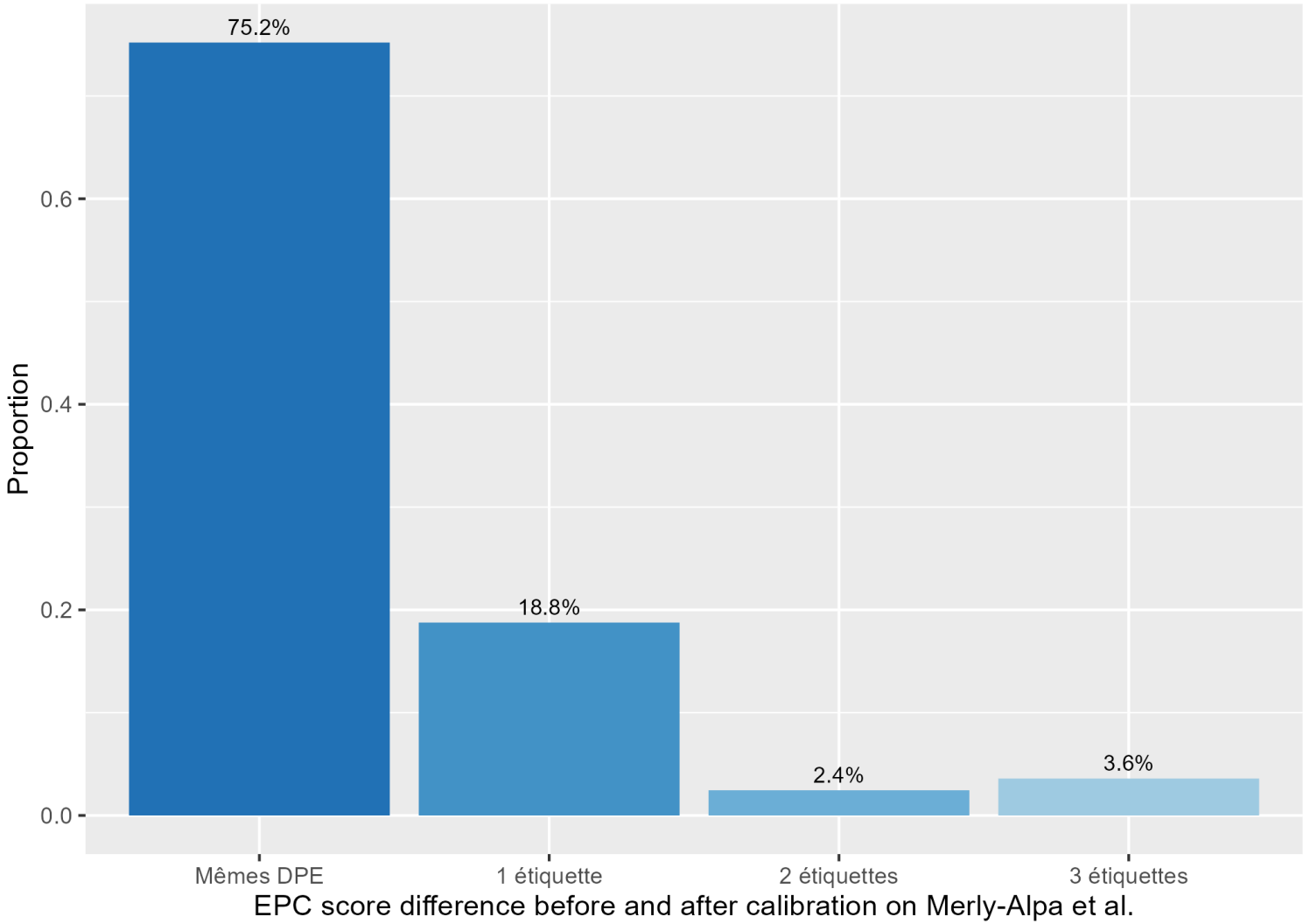
Go back

# Accuracy of the six models on the test sample

| Model | Accuracy (exact) | Accuracy (+/- 1 label) |
|---|---|---|
| Flats – All electric | 0.88 | 0.998 |
| Houses – All electric | 0.93 | 0.999 |
| Flats – Electricity & natural gas | 0.69 | 0.994 |
| Houses – Electricity & natural gas | 0.85 | 0.999 |
| Flats – Electricity & other end-use energy sources | 0.75 | 0.985 |
| Houses – Electricity & other end-use energy sources | 0.68 | 0.961 |

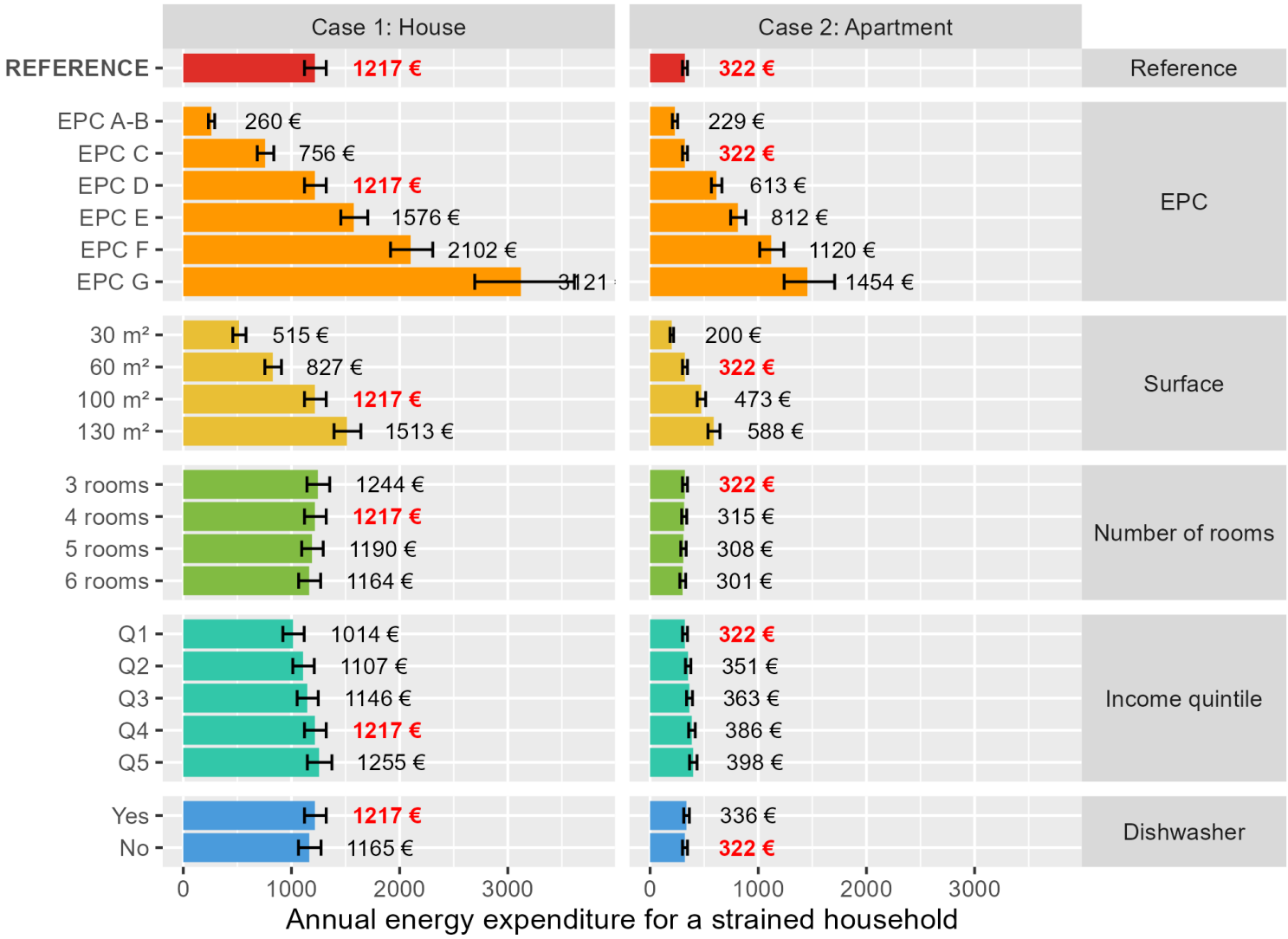
Go back

# Number of deviation labels




Go back

# Estimated annual energy bill for a strained household - All electric

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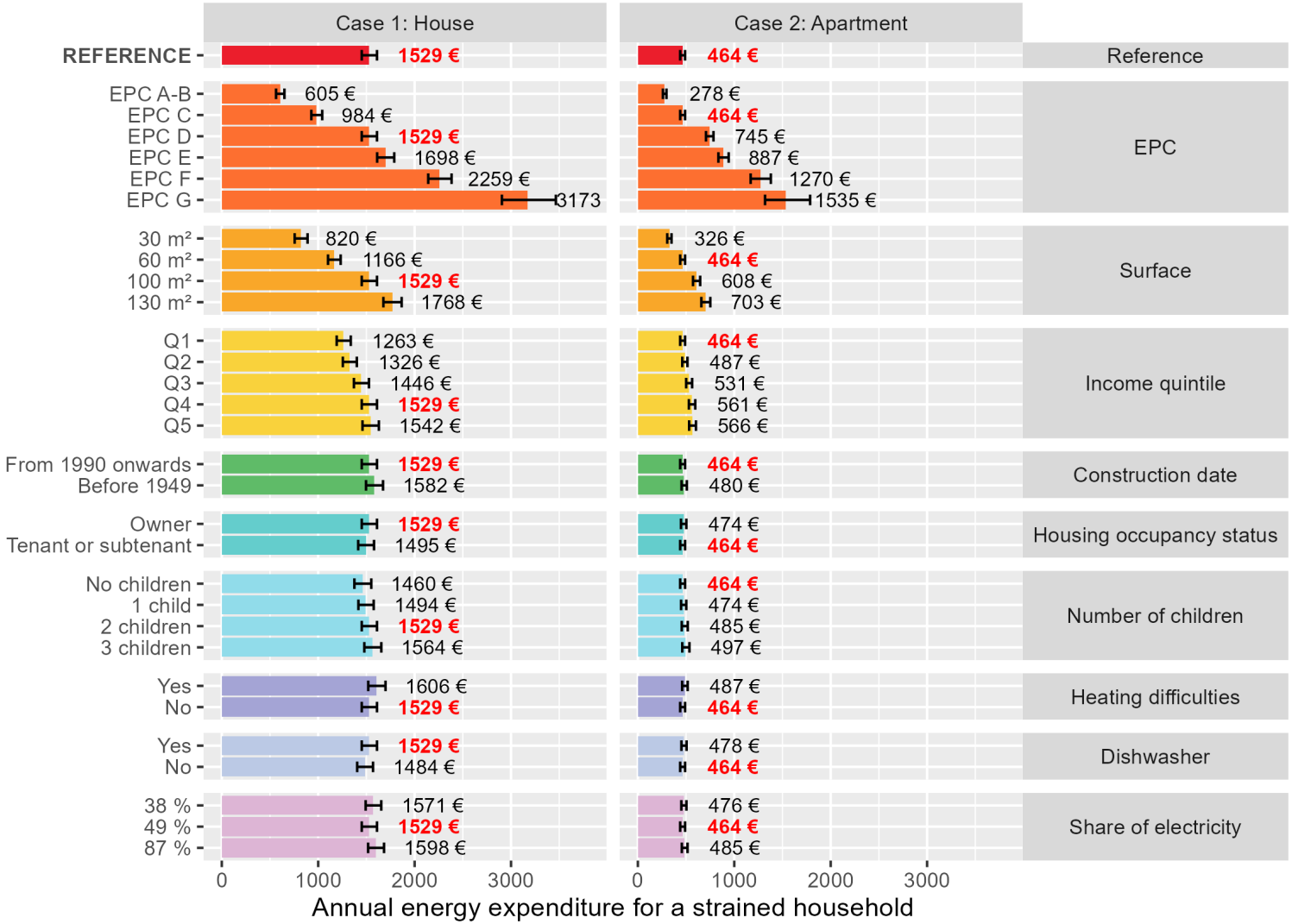
# Estimated annual energy bill for a strained household - Electricity and natural gas

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# Matrices of transition expenditure from one EPC to another (2017)

**House – All electric**

| Q1 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -58% | | | | |
| D | -72% | -34% | | | |
| E | -81% | -53% | -29% | | |
| F | -86% | -66% | -49% | -28% | |
| G | -91% | -78% | -67% | -54% | -35% |

| Q2 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -66% | | | | |
| D | -77% | -34% | | | |
| E | -84% | -53% | -29% | | |
| F | -89% | -66% | -49% | -28% | |
| G | -93% | -78% | -67% | -54% | -35% |

| Q3 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -65% | | | | |
| D | -77% | -34% | | | |
| E | -83% | -53% | -29% | | |
| F | -87% | -62% | -43% | -19% | |
| G | -91% | -74% | -60% | -44% | -30% |

| Q4 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -67% | | | | |
| D | -78% | -34% | | | |
| E | -82% | -46% | -18% | | |
| F | -87% | -61% | -42% | -29% | |
| G | -93% | -78% | -67% | -60% | -44% |

| Q5 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -71% | | | | |
| D | -81% | -34% | | | |
| E | -84% | -45% | -16% | | |
| F | -88% | -59% | -38% | -26% | |
| G | -92% | -71% | -56% | -48% | -29% |

# Matrices of transition expenditure from one EPC to another (2017)

**House - electricity and natural gas**

| Q1 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -39% | | | | |
| D | -58% | -32% | | | |
| E | -69% | -49% | -26% | | |
| F | -77% | -62% | -44% | -25% | |
| G | -82% | -71% | -58% | -43% | -24% |

| Q2 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -41% | | | | |
| D | -62% | -35% | | | |
| E | -69% | -47% | -18% | | |
| F | -76% | -60% | -38% | -25% | |
| G | -81% | -68% | -50% | -39% | -19% |

| Q3 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -36% | | | | |
| D | -61% | -38% | | | |
| E | -64% | -43% | -7% | | |
| F | -73% | -58% | -31% | -26% | |
| G | -83% | -74% | -58% | -54% | -38% |

| Q5 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -43% | | | | |
| D | -61% | -32% | | | |
| E | -63% | -35% | -5% | | |
| F | -72% | -51% | -28% | -25% | |
| G | -81% | -66% | -51% | -49% | -32% |

| Q5 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -43% | | | | |
| D | -61% | -32% | | | |
| E | -63% | -35% | -5% | | |
| F | -72% | -51% | -28% | -25% | |
| G | -81% | -66% | -51% | -49% | -32% |

# Matrices of transition expenditure from one EPC to another (2017)

**House – electricity and an other energy**

| Q1-Q2 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -60% | | | | |
| D | -78% | -45% | | | |
| E | -84% | -59% | -27% | | |
| F | -88% | -70% | -45% | -25% | |
| G | -92% | -80% | -63% | -49% | -33% |

| Q3 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -60% | | | | |
| D | -78% | -45% | | | |
| E | -80% | -49% | -8% | | |
| F | -85% | -62% | -32% | -26% | |
| G | -92% | -80% | -63% | -60% | -46% |

| Q4 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -60% | | | | |
| D | -78% | -45% | | | |
| E | -79% | -47% | -4% | | |
| F | -84% | -60% | -27% | -24% | |
| G | -86% | -65% | -36% | -34% | -12% |

| Q5 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -68% | | | | |
| D | -78% | -30% | | | |
| E | -79% | -32% | -3% | | |
| F | -84% | -48% | -26% | -24% | |
| G | -89% | -65% | -49% | -47% | -31% |

| Q1-Q2 | A-B |
|---|---|
| C | -30% |
| D | -61% |
| E | -72% |
| F | -79% |
| G | -86% |

| Q3 | A-B |
|---|---|
| C | -30% |
| D | -61% |
| E | -64% |
| F | -74% |
| G | -86% |

| Q4 | A-B |
|---|---|
| C | -30% |
| D | -61% |
| E | -63% |
| F | -72% |
| G | -75% |

| Q5 | A-B |
|---|---|
| C | -44% |
| D | -61% |
| E | -62% |
| F | -71% |
| G | -80% |

# Matrices of transition expenditure from one EPC to another (2017)

**House – electricity,natural gas and other energy**

| Q1 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -42% | | | | |
| D | -66% | -40% | | | |
| E | -73% | -54% | -23% | | |
| F | -79% | -64% | -39% | -21% | |
| G | -88% | -79% | -64% | -54% | -41% |

| Q2 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -42% | | | | |
| D | -66% | -40% | | | |
| E | -69% | -46% | -10% | | |
| F | -76% | -59% | -31% | -23% | |
| G | -86% | -76% | -60% | -56% | -42% |

| Q3 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -42% | | | | |
| D | -66% | -40% | | | |
| E | -66% | -42% | -2% | | |
| F | -74% | -55% | -24% | -22% | |
| G | -85% | -74% | -56% | -55% | -42% |

| Q4 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -42% | | | | |
| D | -66% | -40% | | | |
| E | -65% | -40% | 1% | | |
| F | -74% | -55% | -24% | -25% | |
| G | -84% | -72% | -54% | -54% | -39% |

| Q5 | A-B | C | D | E | F |
|---|---|---|---|---|---|
| C | -42% | | | | |
| D | -66% | -40% | | | |
| E | -66% | -41% | -1% | | |
| F | -74% | -55% | -25% | -24% | |
| G | -84% | -73% | -55% | -54% | -40% |