

Spatial location of activities and energy consumption of households in France

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Summary

The design of policies and interventions aiming at the reduction of energy consumption requires a good understanding of the underlying social logics. In this perspective, this paper focuses on how the distribution of daily activities at home and away, in various locations, result into different levels of energy consumption in buildings and transportation.

This analysis is based on an ad hoc survey of 2000 French households in late 2013. The questionnaire was focused on daily activities, mobility and energy consumption. This core information was complemented with questions about values, residential location and equipment choices. Additional information was collected regarding building types, appliances and socio-demographics. We also did a socio-spatial description of the geographical areas, based on several databases from the French statistical office (INSEE).

Our initial analysis consists in clustering respondents based on their stated daily activities and values, in an attempt to qualify distinct lifestyles. Short- and long-term choices at the individual and household level were considered in this task. We then described how these lifestyles and how they deploy in space, imply the use of different types and levels of energy consumption.

Introduction

In response to the environmental need to reduce energy consumption, the underlying causes of this consumption are receiving increasing attention from researchers, industries and institutions. However, research on the causal role of households' energy consumption is often split between works on domestic consumption and those on transportation and mobility issues. In this article we would like to combine these two specialized areas by attempting (1) first to understand consumption by considering the services and activities that give way to it, and then (2) showing how these links are structured by individual lifestyles and regional characteristics.

Several types of factors are found in these works and combined to explain individuals' and households' energy use in the home. These include sociodemographic variables (income, age, gender, household size) (Roy, 2007), technical variables (surface area, building type, type of energy and heating system) (Sanquist and al., 2012; Cayla, 2011, Huebner, 2015), final activities (Hauser and al., 2012) and energy use awareness (savings and restrictions), and underlying attitudes, particularly as regards the environment (Moussaoui, 2007).

Regarding energy consumption generated by individual mobility, the causal factors were likewise numerous. Income (Devalière, 2007; Nicolas and al., 2012), household structure (Devalière, 2007, Pattaroni and al., 2009), residential/professional trajectories (Stock, 2006), life courses and residential location (Orfeuil and Polacchini, 1999; Raux and Traisnel, 2007;

Plateau, 2008) have all been highlighted. At the same time, other works emphasize the importance of vehicle features, such as the type of fuel, horsepower, speed and the number of cold starts (SOeS, 2008). Though distance is also analyzed, the mode of transport is also critical (car, boat, train, plane, etc.), and beyond, the preferences in terms of modes uses and even more broadly the abilities to move or motility (Kaufmann 2002).

It would be somewhat hasty to purport that there is no permeability between works on energy consumption in the home and those that address mobility-related energy consumption. Thus do we find works uniting the two, in order to produce a complete picture of energy consumption for macroeconomic purpose (Cayla, 2011), or around the question of social vulnerability (Jouffe & Massot, 2013; Leroux, 2011). The advantage of a joint approach that combines housing and mobility is the fact that it highlights compensation between sectors due to economic duress. This goal of understanding potential substitution dynamics in overall energy consumption is applicable for the entire population.

From these brief theoretical guidelines, it is important to recall that social and spatial dimensions are critical in the way we must link energy consumption in the home and through mobility. This is precisely the approach we defend in this article. Another lesson concerns the need to explore the activities that give rise to energy consumption. In this respect, the practice theory has made a decisive contribution to the analysis of the energy demand (see especially Warde, 2005 and Shove, 2005; 2010).

We propose to link domestic and mobility-related energy consumption mainly through the concept of lifestyle.

The concept of lifestyle has been studied in the sociology of energy for many years. As Maresca and Dujin (2014) point out, lifestyle is a fuzzy concept with complex origins, and can therefore be used to describe the state of technology, values and/or the use of specific practices at several levels: in a society as a whole, within social groups or among individuals.

In this study, we use the notion of lifestyle at the individual level to describe the diversity of a given society at a given moment, without excluding structural differences between social groups - particularly those identified through socio-demographic variables. In this perspective "Lifestyle acts as a creative matrix of needs"; throughout their lives, individuals make choices for themselves and their family's (professional choices, residential location, activities, etc.). These choices have long-term consequences, i.e. several years, and therefore affect consumption patterns via choice of mobility equipment, residential context (Gram-Hanssen and al., 2004) and/or housing type (Herpin and Verger, 2008). Lifestyles are at the root of consumption patterns and configurations and are influenced by households' multiple anchors in the residential context (Sanquist and al., 2012). Research linking lifestyles and energy consumption include variables such as household makeup, equipment (appliances, cars, etc.) owned by the household, activities, schedules and beliefs that differentiate subgroups in societies (Lutzenhiser, 1993).

The second element that structures the relationship between consumption in the home and mobility patterns is the spatial environment of living. Thus, the density of a geographical region and inhabitants' location within them have a direct impact on energy consumption in terms of both mobility and housing. As Bouzouina and Nicolas (2009), Nicolas and al. (2012) and Desjardins and Mettetal (2013) point out, residential location influences the frequency (through car captivity), quality (depending on the material used) and intensity of people's travel. Thus, not all residential locations produce the same degree of pollution. Desjardins (2011) also highlights the importance of the transportation system and the distribution of services within cities. On the home front, residential location also plays a role in consumption, and notably the residential location within the larger urban framework (Cavalières and Hilal, 2012).

The aim of such a framework is to permits to test the following questions:

- Do high-consumption lifestyles exist both in the home and in terms of mobility?
- Do compensation phenomena exist? And
- Do the location the residence and of activities help in understanding how energy consumption is divided between housing and transportation?

I. Methodology

1.1 Data collected

This article is based on an analysis of a quantitative survey entitled "Lifestyle and Energy" (ad-hoc), conducted in late 2013. It was inspired by the former survey at the root of Cayla's work (2011). The novelty of survey is that it offers a parallel review of a wide range of activities both in and outside the home, and the equipment (form of housing, appliances, cars, etc.) and the energy consumption associated therewith. The intensity of these activities is measured in terms of frequency, on four (for leisure activities at home) or five levels (for regular activities outside the home), ranging from "every day" to "never." Activities at home were also qualified by duration.

Activities may take place 1) at home, 2) in the neighborhood, 3) outside the neighborhood but locally, or 4) further away. The activities include:

- Paid work and studies
- Domestic chores and shopping
- Meals and personal care
- Leisure activities (TV, gardening, sport, events, tourism...).
- Socializing (visiting, hosting, or going out with friends or relatives).

To explain the many ways in which energy is consumed, we must first calculate this consumption at home and in transports. This was done by aggregating and verifying the consistency of the information collected in the different parts of the survey. Consumption at home was first computed for the entire household by fuel type (from energy bills). It was then divided by individuals counted as decreasing consumer units. Mobility-related consumption was directly evaluated at the individual level, according to distance and transportation mode. To calculate vehicle emissions, we used the COPERT IV¹ method. The coefficients used for public transportation (train, plane, tram, subway, etc.) come from different scientific sources².

1.2 Typology of lifestyles

As we want to investigate the relationship between people's lifestyle and energy consumption, we had to identify a typical lifestyle for each respondent. An individual's lifestyle was defined as a combination of her/his activities and the values and motivations she/he expresses. In this conception, activities are the practical performance of a "lifestyle," whereas values reveal the meanings and intentions that contributed to this realization and/or the tensions that arise from it. Lifestyle refers to daily activities (which can be described as activities systems, including leisure activities and constraints in and outside the home, holidays and vacations) as well as dispositions (which can be described as systems of values, preferences and attitudes). The typology was built in two stages: first we used principal component analysis (PCA) to identify individuals' activity systems (i.e. leisure activities, obligatory activities and holidays/vacations) and their values systems, preferences and attitudes (using Schwartz's value variables and choice criteria for equipment/residential location). We then created dynamic clusters of individuals based on their position on factorial

¹ Computer Program to calculate Emission from Road Transport, <http://emisla.com/products/copert-4>

² Cayla (2011); CO₂ data for transportation services: methodological guide (2012)

axes relative to systems of activities and values/preferences. Six groups were thus built as follows:

- **Homebody workers:** Apart from work, the daily lives of these individuals are largely centered on their home and indoor activities. They have strong ties with family (meals, visits, etc.).
- **Peaceful nature-lovers:** These individuals seek green spaces, tranquility and proximity to nature. They want to be close to work and leisure amenities (sport, culture, arts, etc.), extol values of universalism, autonomy and kindness, and are generally attentive to their energy consumption. Their activities at home are fairly diverse. Those outside the home tend to be far away from the neighborhood of residence.
- **Homebody creatures of habit:** These individuals want to live city centers, preferably in a lively, friendly neighborhood. For them, housing size is critical (square footage, number of rooms, etc.). They extol values of security, conformity, tradition and benevolence. They do few activities outside the home (primarily food shopping and walks in the neighborhood). Those done in home center around meal preparation and cleaning. Holiday/vacation travel is infrequent.
- **Dynamic urbanophiles:** These individuals seek the proximity and density that city life offers. They also prefer housing lively neighborhood and place importance on the former's layout. They seek stimulation and partake in numerous outdoor activities in the neighborhood, including frequent visits to friends (important) locally but are willing to travel further if need be.
- **Career-oriented parents:** These individuals above all seek housing close to work and good schools/nurseries. They praise success and power and often travel for work. Their schedules are largely structured around work and childcare. Activities at home are usually done on weekends.
- **Community-oriented families:** These individuals' activities are mainly linked to an active social network including often receiving and visiting friends and relatives, and taking part into communities either through local associations or travelling far away for specific hobbies.

These lifestyles are neither entirely defined by nor independent from the socio-demographic structures. Among those links, workers are more often younger active lower income small households, creatures of habit are more likely to be older and retired, while parents and families tend to include more children.

1.3 Typology of territories

Based on the residential location indicated in the survey, we were able to directly link the data collected with outside French public statistical data, allowing for a description of the areas in question³. We then built a residential typology based on three complementary variables - type of agglomeration, distance from the center and at least half the proximity amenities nearby - using K-Means method. From this we created the following four groups:

- **Small town centers** are essentially centrally-located areas with good local amenities, close to the center of the agglomeration in cities of 2,000 to 20,000 or 20,000 to 100,000 inhabitants.
- **Big city centers** also have good local amenities and are close to urban centers, but of slightly larger cities (more than 100,000 inhabitants, or the greater Paris area).

³ Geographic location tables 2010; Permanent facilities basis 2010; Population census 2010; Household tax revenues 2010

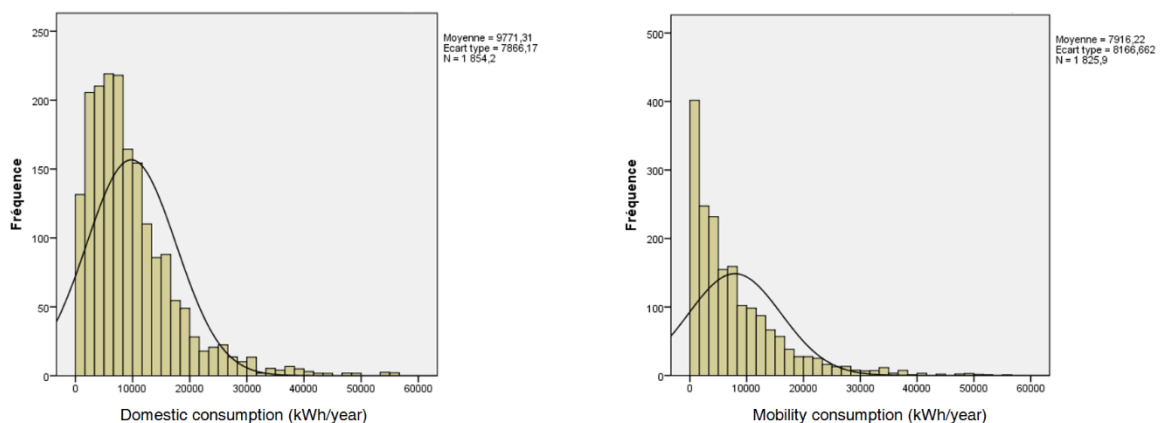
- **Poorly-equipped rural areas** have few local amenities and are far from the center of the nearest agglomeration (and, to a lesser extent small towns of 2,000 to 20,000 inhabitants).
- **Inner and Outer suburbs of large agglomerations** have rather good amenities and are far away from the center of agglomerations (generally greater than 100,000 inhabitants).

II. Presentation of the results

2.1 Domestic and mobility-related consumption

Domestic and mobility-related consumption levels show great inter-individual variability. The relative standard deviation was 80.5% for domestic consumption and 103.2% for mobility-related consumption. Consumption distributions also show heavy tails, with few very high consumption cases. For the rest of the analyses we excluded individuals whose consumption exceeded an average of more than four times the standard deviation.

Figure 1: Domestic and mobility-related energy consumption



In the next paragraphs we explore this diversity of energy consumption, the links between the amounts consumed at home and for mobility, and how energy in these two areas jointly support distinct lifestyles with specific spatial deployment.

2.2 Segmentation by lifestyle and residential location: analyzing domestic and mobility-related consumption

We have compared the average domestic and mobility-related consumption for each lifestyle group. It emerged that the career-oriented parents are characterized by stronger levels of consumption for mobility. The differences between the two types of consumption was particularly marked for peaceful nature-lovers and domestic creatures of habit, groups wherein domestic consumption was especially strong.

Finally, we noted that homebody workers and domestic creatures of habit tend to have low energy consumption compared to the other groups.

Figure 2: Domestic and mobility-related consumption levels by lifestyle

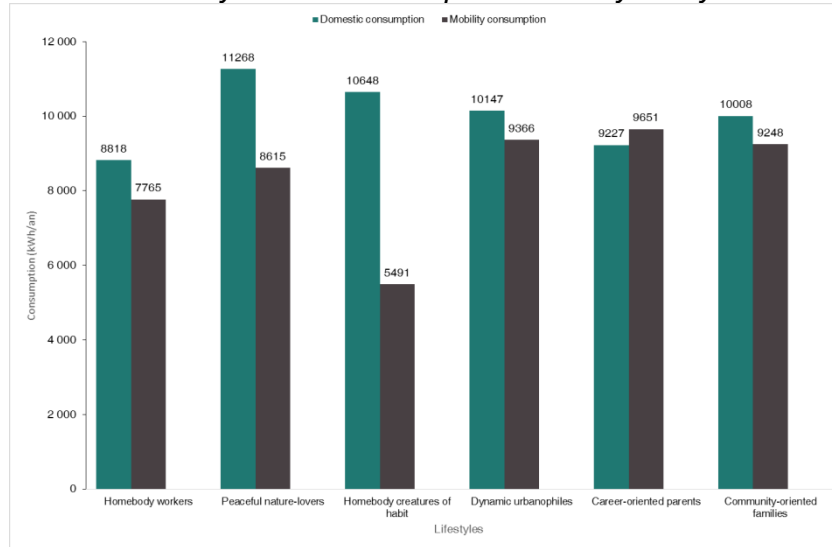
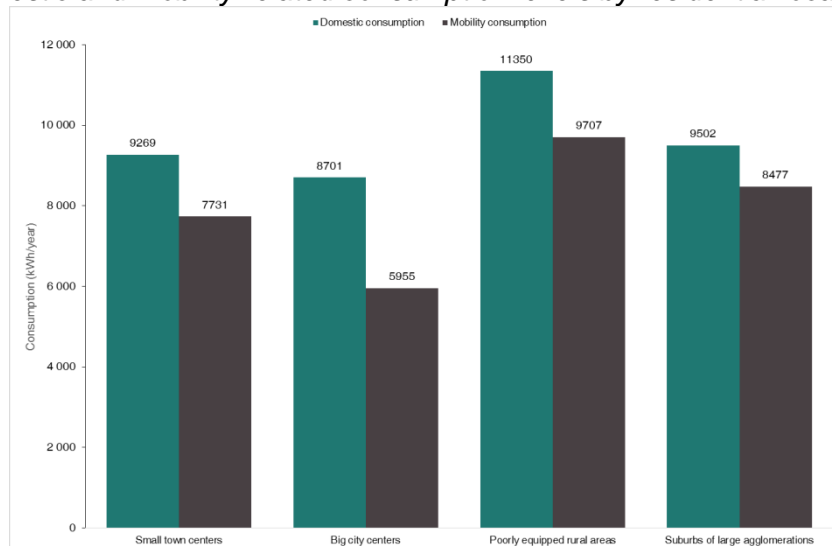
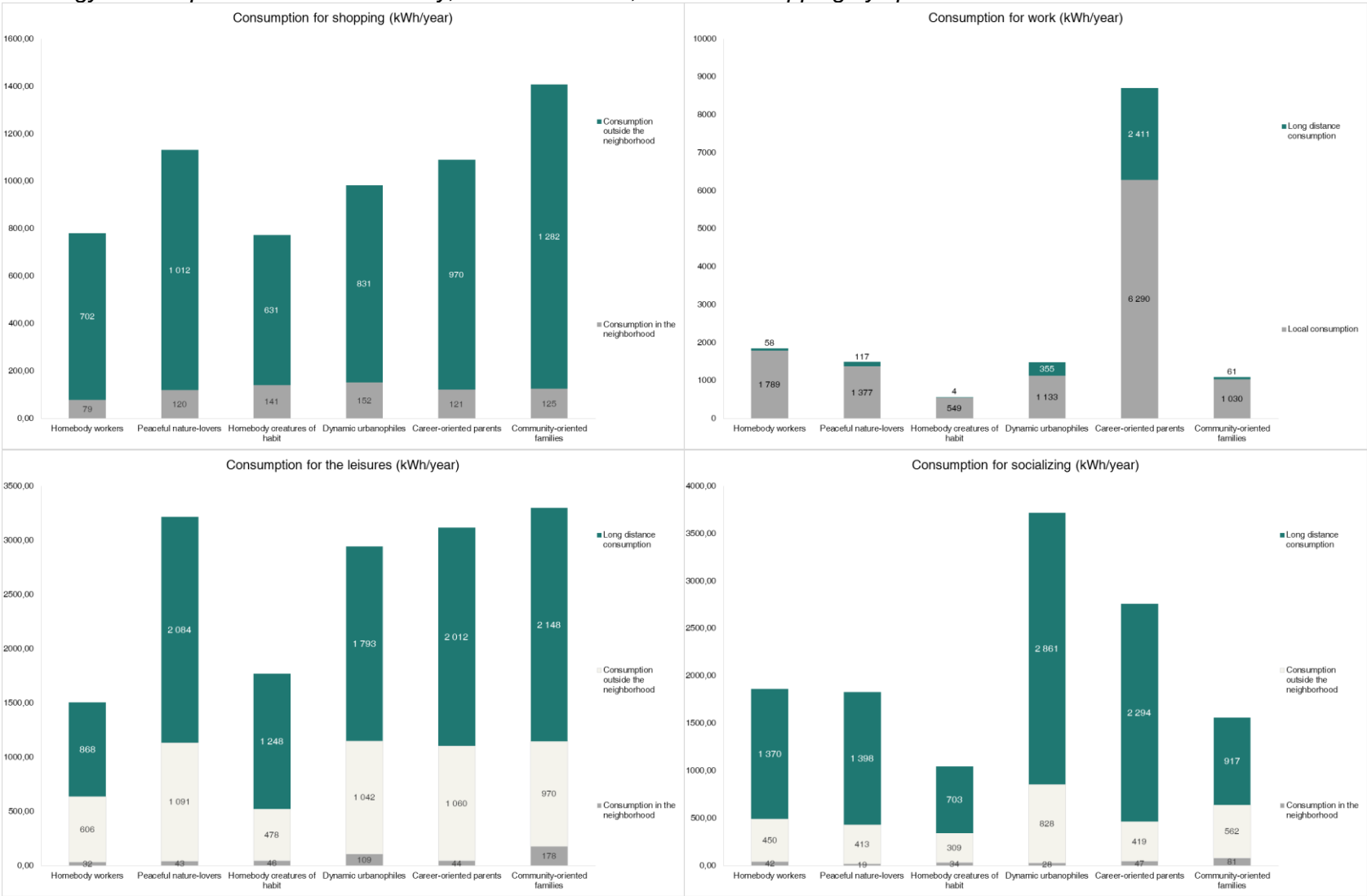


Figure 3: Domestic and mobility-related consumption levels by residential location



The same analysis by residential area-type highlights differences in overall consumption (both domestic and mobility-related). Thus people who live in large city centers seems to have lower overall consumption levels than those in small city centers, suburbs of large agglomerations and poorly-equipped rural areas respectively.

Figure 4: Energy consumption linked to sociability, leisure activities, work and shopping by spatial scale



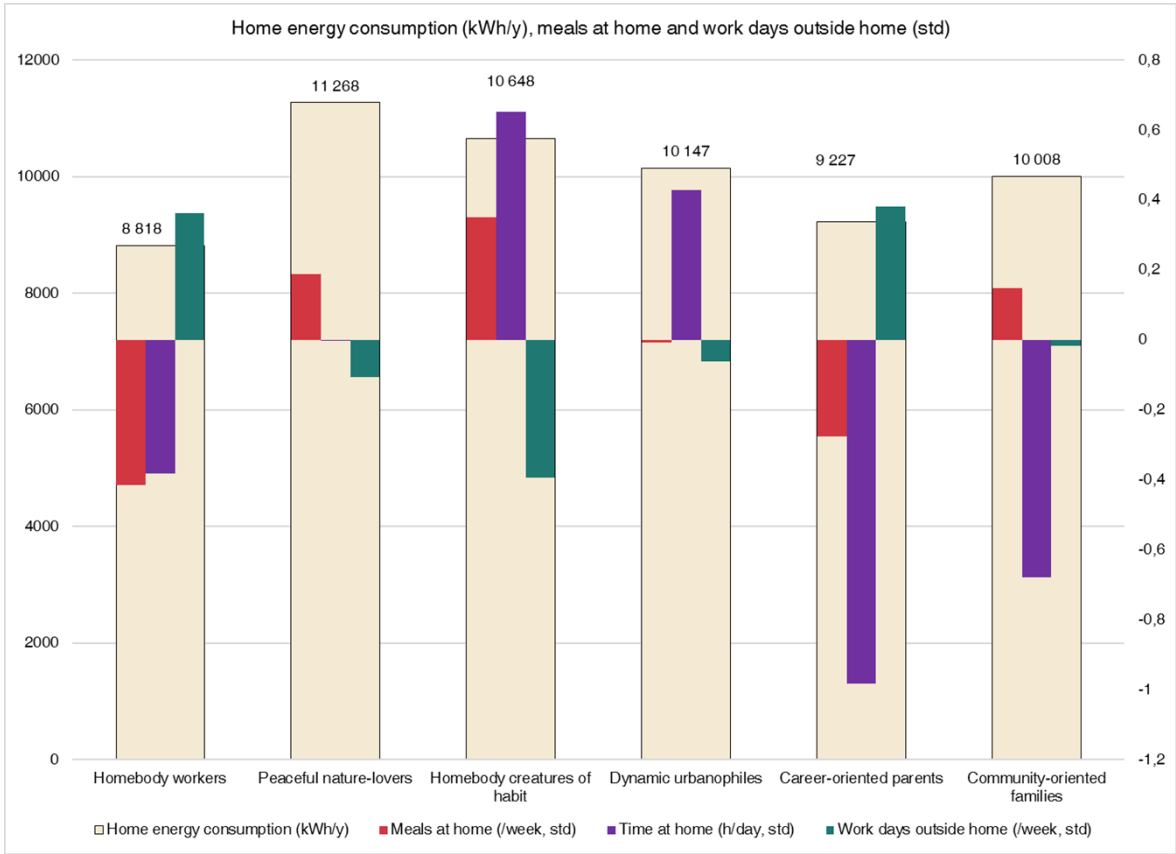
2.2 Daily activities and their spatial scale

As explained in the theoretical section, energy consumption can only be understood if we look more closely at the activities that give rise to it (at home, in the neighborhood, outside the neighborhood or far away). We focused on four types of activities: paid work, shopping, leisure activities and socializing.

The type of activities and their location involve very different levels of consumption depending on the individual's lifestyle. Regarding work, career-oriented parents - who make frequent business trips and long-distance commute - differ greatly from the individuals in the other groups. Homebody workers are not at all affected by these forms of work-related high mobility. At the same time, telecommuting is more frequent among career-oriented parents, showing a link between this way to avoid commuting and long commuting distance.

Working outside also affects the number of meals consumed at home and overall domestic energy consumption as can be seen on figure 5. As a result career oriented parents and workers have a lower consumption compared to habitual homebodies among which more people are retired and have most of their meals at home, whether during the week or the weekend. The time spent at home per day also depends on the rate of active people in the group but not only. Homebody workers spend more time at home than career oriented parents, for the same paid work rate, while urbanophiles spend the same time at home as habitual homebodies in spite of a higher employment rate.

Figure 5: Domestic energy consumption, work and meals

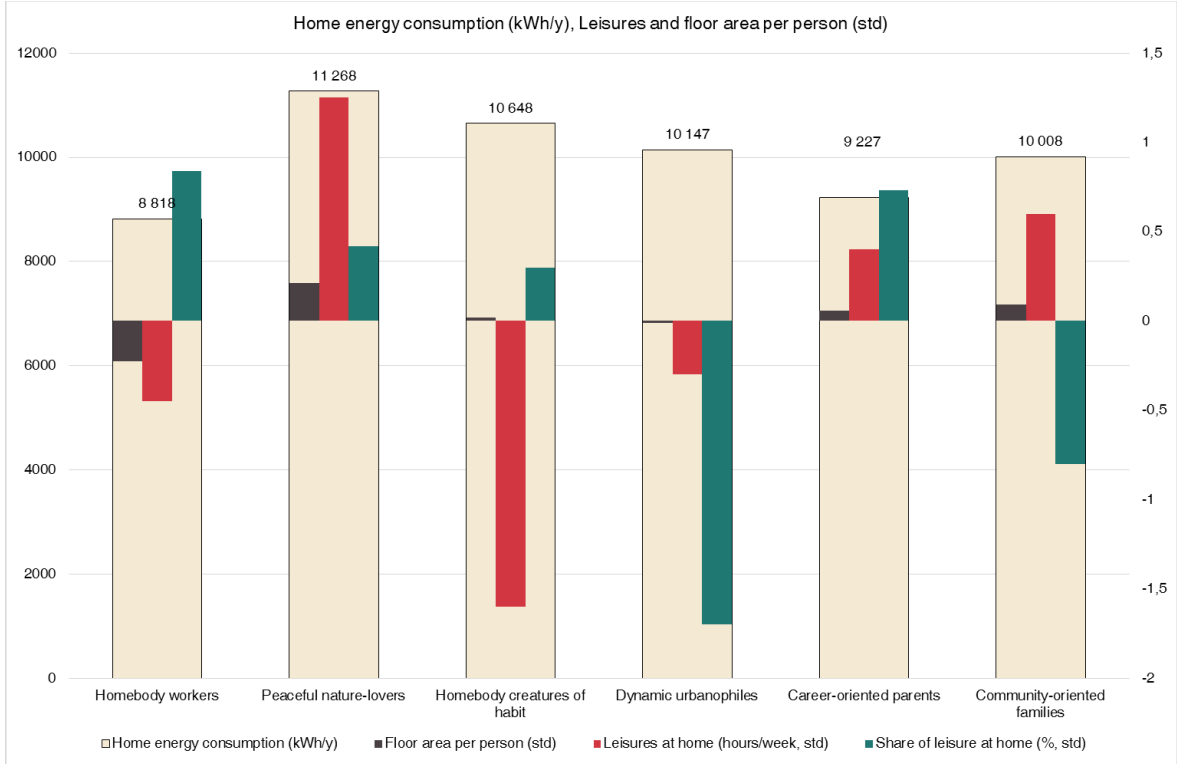


For shopping, the proportion of energy used for shopping outside the neighborhood is high overall. Dynamic urbanophiles and domestic creatures of habit tend to shop locally, but at greater frequency, in relation with the shorter distances between dwelling locations and available shopping areas for these groups. Community-oriented families' extremely high consumption levels for shopping can be attributed to more distant shopping areas and more systematic use of the car. Online shopping is more frequent among career-oriented parents

and community-oriented families. This practice could be motivated by the time constraint linked to parenting in these two groups. It can also be related to the distant location of the shopping places. Thus, for community-oriented families, buying practices are strong at all spatial scales (from online shopping to shopping outside the neighborhood).

With regard to leisure activities, we noted that the proportion of leisure activities done in the neighborhood for dynamic urbanophiles and community-oriented families did not mean fewer leisure activities outside the neighborhood or far away. However, the frequency of leisure activities at home are proportionally lower for these two groups (figure 6), in spite of average and high total durations for these domestic activities. The peaceful nature-lovers' living environment, though more green and spacious than those of the other groups, did not translate into fewer long-distance leisure activities. However, at home they do take advantage of the large floor area and outside space offered by their remote location, as they declare long durations of domestic leisure, including gardening. Generally a relation was observed between larger floor area and longer leisure time at home. Comparatively, homebody workers spend most of their leisure activities at home, mainly TV and video games, in spite of much smaller floor area, both aspects being constrained by their lower income. On the contrary, creatures of habit declare a very short time for domestic leisure compared to their floor area, but in this case it's related to very few leisure activities in general whether inside or outside.

Figure 6: Domestic energy consumption and leisure activities at home



Finally, concerning sociability, we again note that high consumption in the neighborhood is not always indicative of lower consumption outside or far away from it, as evidenced by dynamic urbanophiles. Note that career-oriented parents' long-distance consumption is mainly linked to family visits. Community-oriented families and peaceful nature-lovers often invite friends and family to their homes. In the second case, this domestic activity is associated with an intense social life outside, including visits and taking part into associations, in the neighborhood or further.

Conclusion

The analyses conducted in this work highlight the importance of breaking down energy consumption depending on the activity that demands it, allowing us to reconcile what goes on in the home and what happens outside of it in a single approach. This article is therefore in line with works that advocate a joint approach to domestic and mobility-related consumption. We interpreted people's many and diverse activities at the individual level, which led to the construction of a lifestyle variable which formalize the unity between activities and logics of action.

A nested spatial approach to the locations of activities, housing, neighborhood, outside the neighborhood and far away was also a way to discuss potential cumulative and/or compensatory phenomenon in individuals' consumption.

In many cases mobility consumption tends to be homogeneous across the distinct spatial scales. Thus, urbanophiles' mobility consumption for sociability is very strong in each spatial perimeter: in the neighborhood, outside, and at long distance. This also is true of community-oriented families for leisure activities. However, in both cases, at-home consumption for these reasons is lower, which reveals a compensation mechanism between what takes place in and outside home. On the contrary, dynamic urbanophiles' intensive leisure in the neighborhood is associated a high energy consumption home.

The reduction of mobility demand expected from the development of telecommuting and online shopping could produce disappointing results given we currently observe these practices are currently associated with, and may make possible, very energy intensive lifestyles. Thus, career-oriented parents, who consume more than any other group for work in the neighborhood, outside the neighborhood and far away, are also those who telecommute the most. The logic is similar for community-oriented families and their buying practices. (Viry and al., 2015)

Finally, energy consumption does not necessarily increase with the intensity of the activities. For instance, the long durations of watching TV in the homebody workers lifestyle do not rely on energy consuming infrastructures since they live in small flats. This type of observations highlights the indirect link between activities and energy. As a result it is necessary to describe how lifestyle rely on specific infrastructures that will in turn shape energy consumptions.

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