Energy efficiency in dwellings: it works! Retrofitting represents ¾ of French dwellings space heating consumption 2006–2013 decrease

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Abstract

Since 2000, a significant and continuous decline in dwellings Space Heating (SH) consumption has been observed in several European countries; including France. The decrease is very fast (18 % between 2000 and 2015) and could suggest that its main cause is the change in households' behaviours. This assumption is reinforced by the important increase of retail energy prices that has been observed during the same period.

Obviously, another important cause explaining this fast decline is the improving energy efficiency of the housing stock due to the refurbishment of existing dwellings.

In order to check if the addition of retrofitting actions conducted by French households could explain the decrease of consumption by itself, an evaluation of cumulated savings due to the refurbishment of existing dwelling stock has been made.

Several national surveys exploring French housing retrofitting market have been conducted in France since 2006. Thanks to these surveys, a compilation of the retrofitting actions conducted between 2006 and 2013 has been built. During this period, the annual current flows were 3.66 million thermal insulation gestures and 1.125 million replacements of heating systems. Nearly 3 million housing per year (principal residences) was affected (10 % of the whole dwelling stock). Building insulation gestures were the majority of the retrofitting actions but the unitary efficiency (per gesture) was usually considered as low.

Three scenarios have been defined. We assume same annual number of retrofitting actions for the three scenarios. The differentiation between scenarios relies on the levels of "retrofitting intensity" (unitary energy savings per gesture): *pessimistic*, *neutral* and *optimistic*.

By 2013, the two realistic scenarios (*pessimistic* and *neutral*) give cumulated savings (2006–2013) close to the observed decline of the pre-2006 existing dwellings SH consumption. The *pessimistic* scenario is the only one stating lower savings (77 %) than the observed decrease.

This results are sufficiently robust as the statistical margin error is correct. They reinforce the hypothesis that the decline in SH consumption in dwellings is mainly due to the increase in energy efficiency of existing dwellings stock.

The 2013 French National Housing survey (Enquête Nationale Logement) is available since the beginning of 2017. Future analysis of the 2006 and 2013 editions will give precious information on the evolution of households' behaviours during the same period. Further work will investigate if it could explain the 23 % savings missing.

Introduction

In European countries, Space Heating (SH) is still the most important part of dwellings' energy consumption [CEREN, 2013] and bills [eceee, 2013]: for France, respectively 66 % and 55 % by 2012.

After a long flat period, space heating consumption of French dwellings has continuously decreased since 2000 (-18 % between 2000 and 2015, [CEREN, 2016]). During the same period, the number of dwellings (principal residences) have increased by

14 % and heated surfaces of residential sector by 16 %. The same observation is made for other European countries (ex: United Kingdom, [DECC, 2016]).

This paper gives elements in order to answer the question: "Is this decline due to changes in behaviours (less comfort) or to the improvement of energy efficiency of buildings' envelopes and space heating systems (refurbishment of existing dwellings)?"

Methodology

HOW MANY RETROFITTING ACTIONS PER YEAR?

Since 2006, several national surveys studying French dwelling retrofitting market have been conducted:

- Baromètre 10,000 ménages (TNS Sofres): this periodic survey is conducted by TNS Sofres for the National Agency for Environment and Energy Efficiency (ADEME). It is completely dedicated to energy efficiency in French dwellings and gives information on the retrofitting market (kind of actions, number, etc.), [ADEME, 2014].
- PHEBUS: in 2012/13, the Statistical Office (SOeS, Service de l'Observation et des Statistiques) of the French Ministry for Environment, Energy and Sea carried out a survey of the 28 million principal residences in France. This survey, PHEBUS, was in two parts – a face-to-face interview of residents (13,074 individuals) of 5,405 representative dwellings. It also included information on a sub-sample of 2,389 dwellings to give a picture of the energy performance of the principal residences, and on energy vulnerability by comparing income and the share of energy expenses, as well as the subjective satisfaction with the heating, [SOeS, 2016].
- Enquête Nationale Logements (ENL): this periodic survey on French housing stock and households is conducted by INSEE (National Institute for Statistical and Economic Studies). A large part of this survey is dedicated to energy in dwellings. The last ENL survey was conducted in 2013 (ENL 2013).

Thank to these surveys, we have rebuilt the annual numbers of retrofitting actions concerning the pre-2006 dwellings stock for the 2006-2013 period. Two kinds of actions are considered:

- Thermal insulation of existing dwelling envelope: roofs, lofts and ceilings; walls (internal and external insulation), floors, glazing.
- Renewal of space heating equipment (boilers, electric heaters, stoves, etc.) keeping (or not) the same space heating energy.

The annual number of actions have been evaluated in details. Numerous segments have been defined:

- Type of dwellings: private/public dwellings, individual and collective housing, age.
- Type of space heating energy before retrofitting.

Finally, we have established that during the 2006–2013 period, the annual current flow of the thermal insulation actions on existing dwellings was 3.66 million/year (75 % for individual housing). During the same period, more than 1.1 million of space heating systems have been renewed.

Globally, almost 4.8 million actions per year have been conducted and almost three million existing dwellings (10 % of the stock) have been annually refurbished (1.6 actions per dwelling on an average).

The detail of considered actions is given in Figure 3 for individual housing (public and private ones).

Double glazing represents almost 50 % of the total amount of actions dedicated to the envelope (thermal insulation). Unfortunately, it is one the actions giving the lowest energy savings.

WHAT SAVINGS PER RETROFITTING ACTION?

The speed of increase in energy efficiency depends on:

- The annual number of refurbishment actions,
- The type of considered dwellings (category, age?),
- The type of actions (insulation: which part of the envelope, space heating equipment: which energy?) and the "deepness" of the refurbishment (very efficient or light?).

National surveys help in establishing the number and kind of action but they do not give the amount of energy savings per action. In order to calculate the cumulated savings due to retrofitting, it is necessary to make assumptions on the potential savings per action.

For each category of retrofitting action, a fourth survey – OPEN – evaluates the % of actions distributed in three levels of efficiency. Unfortunately, the perimeter of OPEN survey is smaller than other surveys' one and data have to be adapted. The Figure 4 shows that only a few dwellings are refurbished with a high level of efficiency and that the proportion of high level actions is increasing very slowly [OPEN, 2012].

For each action and each type of dwelling (age, type, and space heating energy), three scenarios for unitary savings per action and per dwellings (combination of different actions) have been evaluated:

- *Optimistic* (theoretical savings based on the normative assumptions of French "White Certificates" scheme);
- *Neutral* (average value of existing French studies);
- *Pessimistic* (lowest value of existing studies).

Only neutral and pessimistic scenarios are considered as realistic ones.

The savings per action are defined as a % of the SH consumption of the dwelling before refurbishment. This pre-retrofitting consumption have been established with CEREN data [CEREN, 2013].

The Figure 5 gives our assumptions for dwellings' envelope insulation.

The estimated savings for some actions (lofts and roofs) could be considered as very low. It is partly due to the level of thermal insulation before retrofitting that is taken into account in order to evaluate realistic savings. Rebound effect and potential poor level of quality for retrofitting actions is also taken into account as these savings have to be realistic ones.

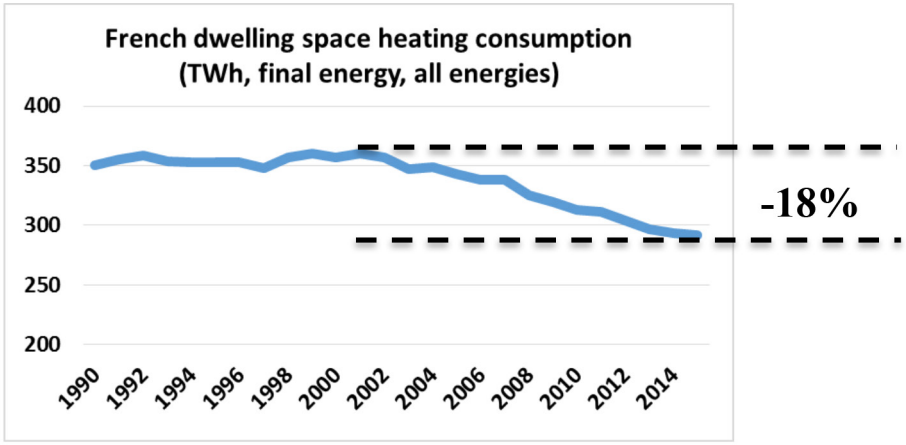

Figure 1. Evolution of space heating consumption – French dwellings (final energy, TWh climate adjusted, 2015, source: CEREN).

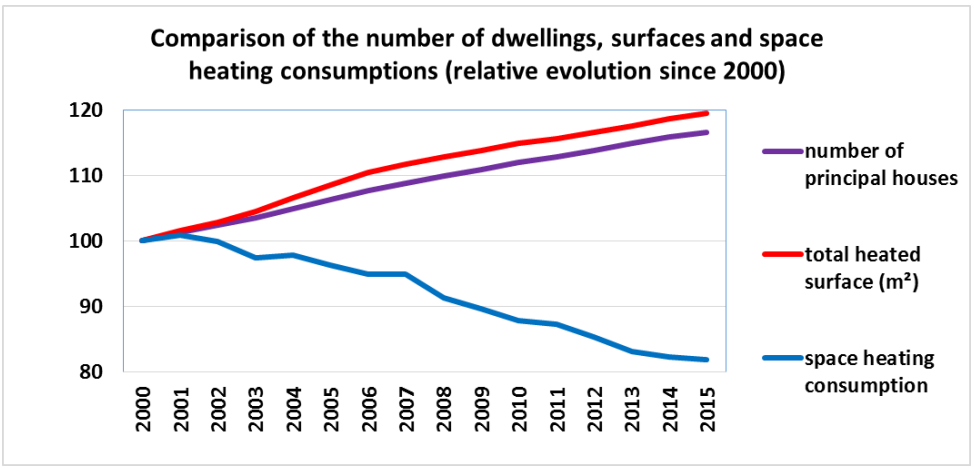

Figure 2. Relative evolutions of space heating consumption, number of principal residences and total heated surfaces in French dwellings (final energy, TWh climate adjusted, 2015, source: CEREN).

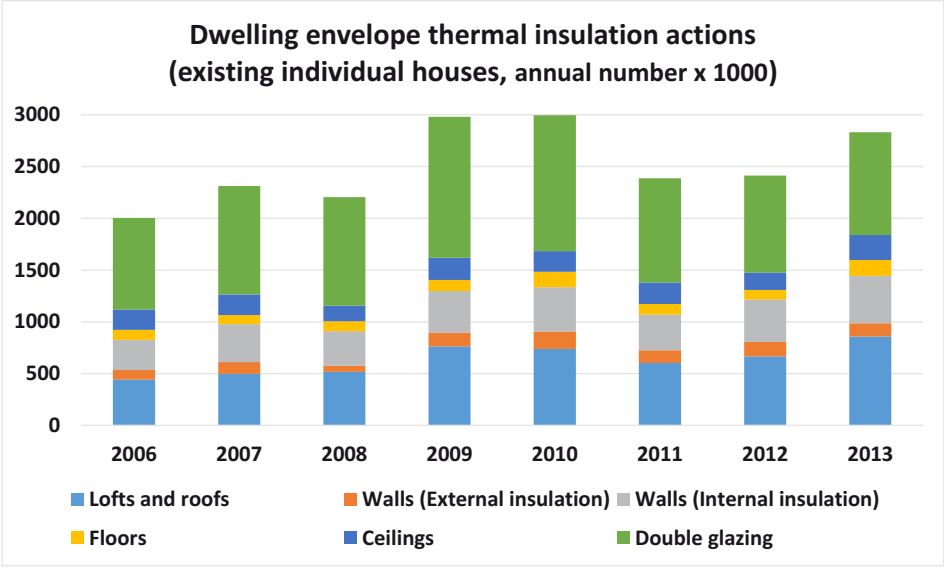

Figure 3. Estimated number of annual retrofitting actions (thermal insulation) for individual housing (authors' calculation).

WHAT SAVINGS AND ENERGY CONSUMPTION DECLINE HAVE TO BE COMPARED?

The surveys giving the number and details of retrofitting actions (TNS, PHEBUS, ENL) were not available before 2006. Consequently, the analysis has been conducted on the dwelling stock between 2006 and 2013.

The Figure 6 summarizes the evolution of Space Heating consumption of French dwellings during this period:

- The dark line represents the evolution of the whole dwelling stock energy consumption, including pre-2006 dwellings and new dwellings constructed between 2006 and 2013.
- New dwellings participate to the improvement of dwelling stock efficiency. Their energy consumption is limited but still existing: in order to consider the energy consumption of pre-2006 dwellings (light blue), it is necessary to subtract new dwellings consumption to whole consumption (orange blocks).
- The red dotted line gives the level of energy consumption of the whole stock considering that new dwellings (2006-2013) do not consume less than 2006 existing dwellings. The deep blue blocks show the cumulated savings due to energy efficiency of new dwellings between 2006 and 2013.

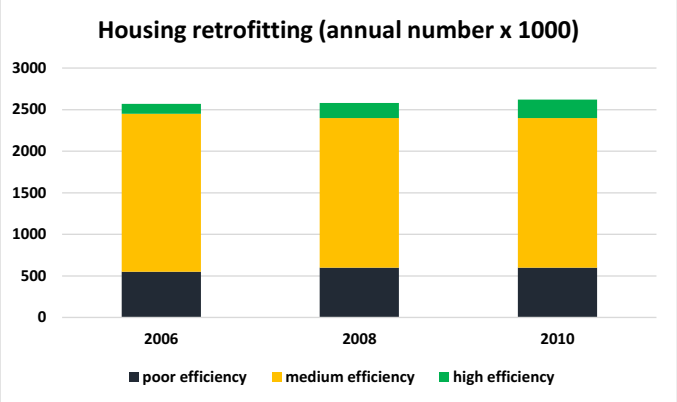

Figure 4. Housing retrofitting: annual number per level of efficiency [OPEN, 2012].

- Finally, the green blocks (very small) show the savings due to the existing dwellings leaving the stock (demolition, other utilization).

The savings on the pre-2006 dwelling stock is the difference between the light blue blocks and the "business as usual consumption" (without savings due to new and demolished dwellings). They are significantly higher than the savings due to the energy efficiency of new dwellings on the same period.

These current savings on the existing stock (pre-2006) have to be compared to the cumulated savings due to the retrofitting actions on the pre-2006 dwelling stock between 2006 and 2013.

Results

The (two) realistic scenarios give savings close to observed decline in pre-2006 dwelling stock SH consumption. The *pessimistic* scenario is the only one giving lower savings than the observed decrease. The *neutral* one is the closest to reality but it overestimates decrease (+16 %), giving no place for the potential impact of the behavioural changes. These results confirm that the *optimistic* scenario is unrealistic, as it gives savings 71 % higher than the observed decrease.

Figure 7 compares energy savings on pre-2006 dwellings (three scenarios: red, yellow and green lines) to current decrease of SH consumption in pre-2006 dwellings (light blue). The dark dotted line shows SH consumption decline for the whole dwelling stock (pre-2006 and new 2006–2013 dwellings). Avoided consumption due to demolition are deducted (green blocks) but very small. As new buildings consume (a little) energy for space heating, the decline is smaller than for pre-2016 dwelling stock only.

Conclusion

These results show that the 2006–2013 observed decrease in space heating energy consumption and the possible savings due to energy efficiency have the same order of magnitude. We have partly taken into account inhabitants' behaviour through rebound effect in the "pessimistic" scenario, but this study does not prove that there is not "daily behaviour effect" in the observed decrease in consumption.

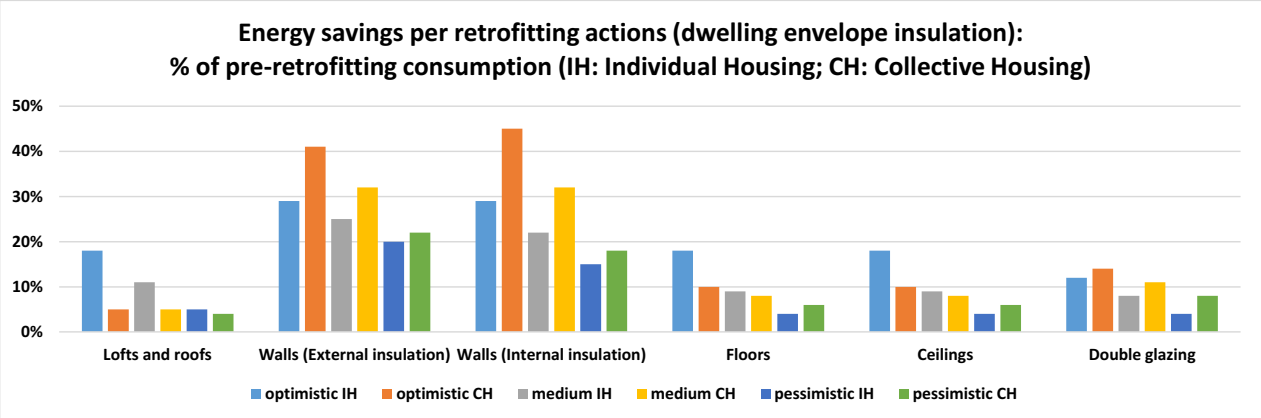

Figure 5. % of the energy consumption decline per retrofitting action (Assumptions per scenario and for dwelling envelope insulation).

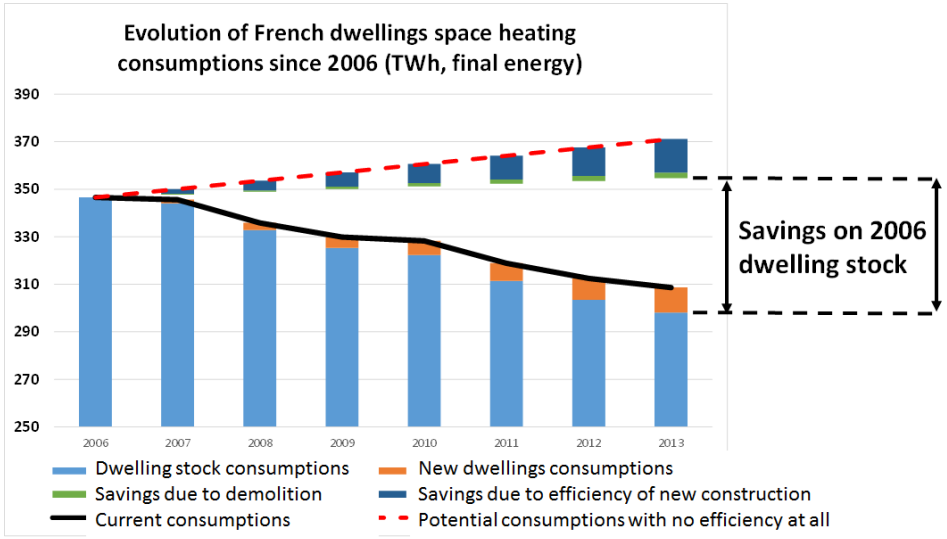

Figure 6. Energy savings due to the existing and new dwellings (2006–2013).

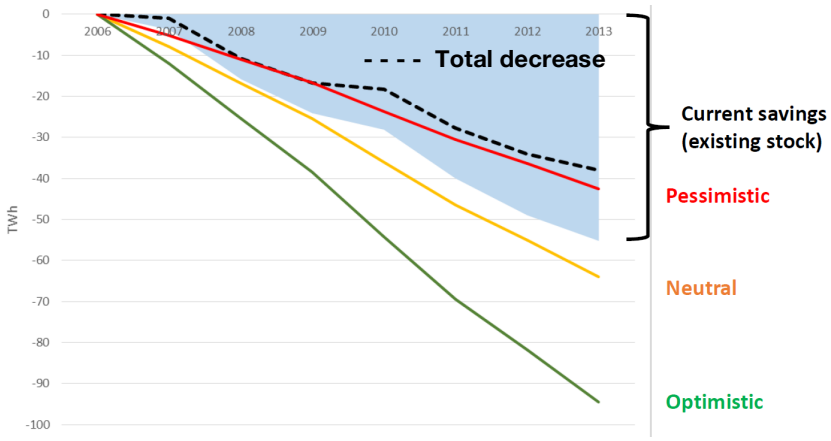

Figure 7. Decrease in the space heating energy consumption (whole existing stock) and retrospective scenarios savings (TWh, final energy).

Further works are needed in order to analyse evolution of inhabitants on the same period. The 2013 French National Housing survey (Enquête Nationale Logement) is available since the beginning of 2017. Future analysis of the 2006 and 2013 editions will give precious information on the evolution of households' behaviour during the studied period in order to study if "energy behaviour" had a minor or major impact on the decrease of space heating consumption in existing dwellings.

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