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ENDOGENOUS ENERGY EFFICIENCY IMPROVEMENT OF LARGE-SCALE REFURBISHMENT IN THE SWISS RESIDENTIAL BUILDING STOCK

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Topic: Energy efficiency in buildings

Overview

In Switzerland, according to the Swiss Federal Office of Energy around 50% of primary energy consumption is attributable to buildings: 30% for heating, air-conditioning, and hot water, 14% for electricity and around 6% for construction and maintenance. Energy efficiency improvement is widely considered to be the most important aspect that will lead to the continuous transformation of the Swiss national energy system. A remarkable feature of the new energy system will be the gradual decarbonisation of the housing sector in Switzerland.

The goal of this paper is to endogenize the energy efficiency improvement and in addition introduce barriers to retrofit in the housing sector. With this purpose, we allocate the Swiss housing stock into energy classes and construction periods. The distribution of building stock shifts due to a transition matrix, which is based on the costs and benefits of a retrofit. In order to acquire genuine results and on a later stage incorporate the effects of barriers, we introduce a two steps model. The property owner first decides on doing the energy audit or not. Second, he makes the decision on doing the retrofit.

Method

The housing stock is grouped into seven energy classes that will follow Cantonal Energy Certificate for Buildings classification. Each energy class has fixed specific space heating demand in kWh per square meter.

Energy reference area:
The quantity of housing is measured by the total energy reference area in square meter i.e. the total heated surface. The energy reference area is represented by a three-dimensional matrix and is divided into energy classes, construction periods and property owner types. The energy reference area changes from one period to the next because of a proportion that is demolished, through new construction and through transfers between classes through retrofit with the help of a retrofit matrix.

The decision of retrofit:
In order to describe how property owners make a decision regarding retrofit, we introduce a two steps model:

- First step: Probability of being triggered.
  In the first step, the owner of the house is triggered (for example: by receiving a letter from the community, speaking with his/her spouse) and orders an energy audit.
- Second step: Decision on retrofit.
  Depending on the result of the energy audit, he decides on doing the retrofit or not.

The probability of doing the energy audit (Π). The first step:
The owner of the house takes the decision based on the current energy class of the house, the cost of heating and the awareness level (called "Information level"). The probability to do the audit increases when the energy class of the building is decreasing. The impact of energy price on the probability is represented through an elasticity function of the energy price change with respect to a reference price. Finally, the probability is also an increasing function of the information level (Inf: {1; 2; 3; 4}). For example, if the information level equals to '4', it might stem from a large-scale of the information campaign.

The indicator variable (Ω). The second step:
This decision is based on retrofit gain, that has to be positive and the largest for all possible energy classes. We have also defined four different property owner types, that have different discount rates. Taking into account discount rates of each group: {3%; 4%; 5%; 6%}, we compute the percentage of buildings that are retrofitted.

We get retrofit from EC to EC' if:
(i) The economic gain from EC to EC 0 is positive.
(ii) The retrofit gain is higher than any other retrofit, that can be done from EC.

Retrofit matrix:
The retrofit matrix is calculated by multiplying the probability of doing the audit by the indicator variable as well as by the energy reference area.

Results

Reference Scenario: In the reference scenario, the information level is equal to 1, in this section we perform several scenarios where we increase this information level. With the information level 4, the average energy consumption reaches 39 kWh per m 2 and CO 2 emissions decrease by 56% with respect to 2015 levels. In 2050, energy class A represents 58% of the Swiss building stock, but there are still very inefficient buildings. Indeed, buildings from category G to E account for 25% of the Swiss building stock.

Subsidy on retrofit: In this scenario, we assume that the government implements a subsidy on the retrofit cost concerning energy classes G and F. We perform several scenarios with a subsidy rate ranging from 10% to 40%. If the subsidy increases the retrofit of energy class G, it does not affect the renovation decision for energy class F whose share is unchanged within different scenarios. It is worth noting, that when the subsidy rate is above 20%, no more retrofit is implemented (i.e. the share of energy class G is unchanged in 2050), but it affects the energy class in which the retrofit is done (i.e. the share of energy class A is increasing and the share of energy class E is decreasing).

Tax on fossil energy: In this scenario, we assume that the government puts a tax on fossil energy ranging from 10% to 50%. the impact is rather limited in comparison to other economic instruments and does not impact significantly the retrofit decision.

Combining economic instruments: We perform a scenario where we combine all economic instruments: the information level is equal to 4 and the fossil fuel tax equals 50%. Energy classes A et B represent respectively 77% and 9% of the Swiss building stock. Classes G and F represent only 1% and 2% respectively.

Conclusions

In the reference scenario, in the whole period, the average retrofit share is equal to 0.6%. The average heating consumption in kWh per square meter decreases from 92 kWh to 53 kWh in 2050. CO2 emissions decrease by 36% from 2015 to 2050, representing an annual decline rate equal to 1.3%. In information level scenarios increasing the information level augments the probability of doing an audit but does not change the economic profitability of the retrofit decision. Therefore, we find that the marginal gain of the information level is decreasing with respect to the average retrofit rate. We can conclude that if we want to obtain more CO2 abatements, it is necessary to combine information level policy with economic instruments that will affect the economic profitability of the retrofit decision. In subsidy on retrofit scenario CO 2 emissions, the subsidy succeeds to increase significantly the CO2 abatement, but again we find that the marginal CO2 abatement is decreasing with the subsidy rate. In tax on fossil energy scenarios, the impact is limited if we compare it to other economic instruments. Also it does not impact considerably the retrofit decision. When combining all economic instruments, the average retrofit rate is equal to 1.9%. In 2050, the average energy consumption reaches 21 kWh per square meter and CO 2 emissions decrease by 86%.
We demonstrated a working model that allows us to test several scenarios. We show that if we want if we want to achieve a deep decarbonisation of building sector, we need to combine different economic instruments: information campaign, subsidy on retrofit and carbon tax.

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