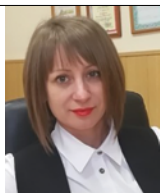


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The “rebound effect” of energy efficient actions to be performed as part of a major renovation of apartment buildings

Environmental safety and the rational use of natural resources are among pressing present-day problems. Energy efficiency improvement is an important constituent of energy policies in many countries. This article examines the impact of the “rebound effect” on improving the energy efficiency of environmental safety programs implemented at federal and municipal levels. There is still no consensus on how to take the “rebound effect” into account and whether it should be considered at all. Paradoxically, the “rebound effect” is the unintended side effect of energy efficiency activities. In this paper, different types of this effect are considered. The “direct assessment” method, based on the non-linear relationship between energy consumption and efficiency, is used to assess the “rebound effect” produced on individual household appliances. The factors hindering the implementation of energy efficiency activities are also identified. Having analyzed the impact of the effect on different sectors of economy, we can conclude that the most pronounced “rebound effect” is observed in the housing sector. Consequently, if we consider a major energy efficient renovation, we have to take account of the “rebound effect” caused by new energy saving activities.

Keywords: major renovation, housing stock, apartment buildings, energy efficiency, energy saving technologies, rebound effect

INTRODUCTION

The purpose of major renovations is to improve the quality and comfort of an apartment building, but only an energy efficient renovation allows to recoup the work performed and the services provided during a major renovation, since it saves energy costs [1–3].

Let's address the advantages of an energy efficient renovation. It encompasses the modernization of in-house engineering systems, improves the level of comfort in apartment buildings, reduces the consumption of energy resources, cuts per-apartment utility bills; raises the market value of premises.

Federal Law 185-FZ of July 21, 2007 “About the housing and utilities reform fund”, and Decree No. 183 issued by the Government of the Voronezh Region on

March 6, 2014 “On the approval of the regional program for the major renovation of common property in apartment buildings in the Voronezh region for 2014–2044”, the subprogram “Major renovation of common property in apartment buildings” were enacted to bring multi-family housing into proper technical and operational condition. The priority areas, covered by this municipal program, are provided in Fig. 1¹.

A major renovation cannot be done in all apartment buildings at the same time for objective reasons. The main criteria for the selection of apartment buildings to be renovated include the number of

¹ On approval of the regional program for the overhaul of common property in apartment buildings in the Voronezh Region for 2014–2044 (as amended on February 7, 2019) : Decree of the Government of the Voronezh Region dated March 6, 2014 No. 183. URL: <http://docs.cntd.ru/document/430639697>



Fig. 1. Implementation priorities of municipal policies set in subprogram “Major renovation of common property in apartment buildings”¹

years in operation, the physical deterioration of building elements, and the dates of the most recent major renovation [2, 3].

Despite the advantages of a major renovation, the so-called "rebound effect" may occur due to the irrational implementation of energy efficient activities in the process of renovation.

"The rebound effect" is the rise in consumption of energy and/or materials after the implementation of energy efficiency activities [4, 5].

MATERIALS AND METHODS

Energy efficiency policies, adopted by many countries as a way to reduce energy consumption and related negative effects, are aimed at avoiding or reducing the consumption of non-renewable energy sources.

The "rebound effect" paradox, resulting from the introduction of new energy-efficient technologies, reduces the cost of energy services, thereby increasing the demand for these services or goods (whose production is accompanied by energy consumption).

"The rebound effect" is a side effect of technologies aimed at increasing energy efficiency. It was first described in 1865 by William Stanley Jevons (the Jevons paradox). William Stanley Jevons has identified that the technological progress boosts the efficient use of a resource, thereby increasing its consumption (Fig. 2) [6, 7].

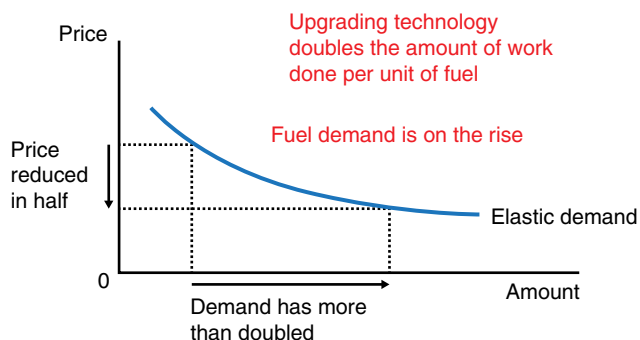


Fig. 2. The Jevons paradox [7]

Let's address the dispute on the importance of considering or ignoring the "rebound effect" when implementing energy efficiency programs. Firstly, let's identify the types of effects to be subdivided. In general, "the rebound effect" is divided into a direct rebound effect, an indirect effect, and a macroeconomic effect. The structure of the rebound effect is shown in Fig. 3 [8–10].

The "rebound effect" is determined by the formula [9]:

$$R = 1 - \left(\frac{\Delta E_a}{\Delta E_e} \right),$$

where ΔE_a is the actual change in the energy resource consumption after the implementation of energy efficiency improvements; ΔE_e is the estimated change in the energy resource consumption after the implementation of energy efficiency improvements.

The following conditions determine the "rebound effect":

- if $\Delta E_a = \Delta E_e \rightarrow R = 0$, then there is no rebound effect, as the actual result coincides with the anticipated one;
- if $\Delta E_a < \Delta E_e \rightarrow R > 0$, the rebound effect manifests itself;
- if $\Delta E_a < \Delta E_e \rightarrow R < 0$, the actual effect exceeds the anticipated one;
- if $\Delta E_a < \Delta E_e \rightarrow R \geq 0$, the rebound effect emerges.

The intensity of the "rebound effect" depends on many factors. For example, it ranges from 0 % to 60 % for the residential housing sector. This effect is triggered by various energy-related services (residential lighting, space heating, air conditioning, dishwashers and washing machines, refrigerators) [6, 7, 11].

RESULTS

The "direct estimate" method can be used to evaluate the rebound effect of individual appliances. This method employs the non-linear relationship between the energy used and the resulting efficiency. In the linear relationship, energy consumption is usually assumed to be negligible and the efficiency of a household appliance is high. However, in reality, the relationship is non-linear. Consequently, the gap between linear and non-linear relationships represents the rebound effect. It can be concluded that the concavity in the nonlinear relationship is the value of the rebound effect (Fig. 4) [7].

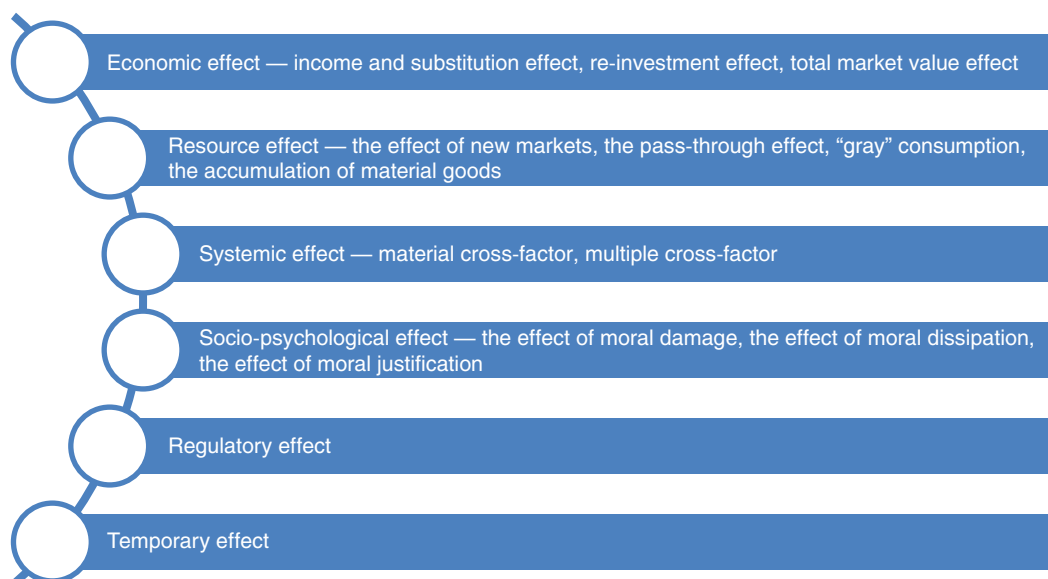


Fig. 3. The structure of the rebound effect

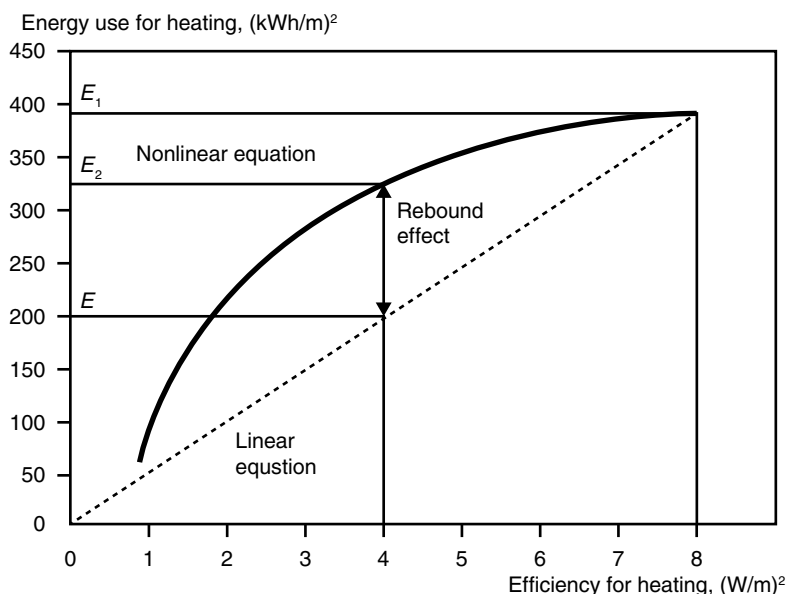


Fig. 4. The rebound effect in the non-linear relationship between the energy used for heating and the heating efficiency [8]: E_1 — actual energy consumption before efficiency improvements; E_2 — actual energy consumption after efficiency improvements; E — anticipated energy consumption after efficiency improvements

The table shows the approximate intensity of direct effects for different residential energy services [12, 13].

The intensity range of the direct rebound effect, %

Types of energy services	The intensity range
Lighting	5...12
Heating	2...60
Air conditioning	0...50
Other energy services	0...49

The table shows that lighting has the smallest “rebound effect”, while heating and air conditioning show higher “rebound effect” values.

The author [8] proposed to divide the main methods, used to reduce the impact of the rebound effect, into six groups. The author consolidated information campaigns, educational activities, and changes in consumer habits into the first group (26 %). The second group encompasses the impact on program design (23 %); the third group has fiscal activities (19 %); the fourth group contains stimulation (13 %), the fifth group has standardization (8 %); and the sixth group sets consumption limits and rationalizes consumption (8 %). This breakdown encompasses 97 % of activities, thus, minimizing “the rebound effect”. The remaining three per cent are insignificant.

DISCUSSION

The analysis of “the rebound effect” performed for different industries in several countries generated different results. The comparison was made for several categories: the economy as a whole, the housing sector, and the industry. As for the economy as a whole,

the rebound effect in the energy sector of China was 53.2 %, in the UK — 37.0 %; as for the housing sector, in China the rebound effect reached 71.5 %, in the UK — 34.0 %; as for the industry, China — 39.0 %, India — 80.0 %, USA — 24.0 %. It is noteworthy that the rebound effect depends on the national economy [14, 15]. Energy efficiency strategies do not always lead to energy savings. The cost and the return on investments are the obstacles. When starting energy efficient activities, a consumer expects that the investment in their launch will recoup in 2–3 years; however, this is not always feasible. Moreover, “the invisibility” of energy consumption is an obstacle. In most cases, it is difficult to determine how much energy each device consumes in a house. We get to know the ultimate power consumption figures for all electrical devices every month. Consequently, consumers do not care about electricity costs.

CONCLUSIONS

“The rebound effect” manifests itself in such spheres of economy as household power consumption, the residential sector, the construction and maintenance of buildings and structures, transport, industrial production, and the IT infrastructure.

The number of studies focused on this topic grows every year. It is noteworthy that the international community has developed an understanding of the need to consider the “rebound effect” when implementing energy efficient activities. Energy efficiency strategies need to consider lifestyles and changes in consumer behavior patterns as a matter of priority.

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«Эффект отскока» при внедрении энергоэффективных мероприятий при капитальном ремонте многоквартирных домов

Одной из актуальных проблем является экологическая безопасность и рациональное расходование природных ресурсов. Повышение энергоэффективности является важной частью энергетической политики многих стран. В данной статье рассматривается влияние «эффекта отскока» на реализацию программ по повышению энергоэффективности. По-прежнему нет единого мнения как учитывать «эффект отскока» и нужно ли вообще учитывать его. Как не парадоксально, «эффект отскока» является непреднамеренным побочным эффектом при внедрении энергоэффективных мероприятий. В данной работе рассмотрены виды эффекта. Для оценки «эффекта отскока» для отдельных бытовых приборов рассмотрен метод — «прямой оценки», который основывается на нелинейной зависимости между используемой энергией и эффективностью. Также были обозначены факторы, препятствующие внедрению энергоэффективных мероприятий. Анализируя влияние эффекта в разных сферах экономики, можно сделать вывод, что больше всего «эффект отскока» наблюдается в жилищном секторе. Следовательно, если рассматривать проведение энергоэффективного капитального ремонта, то перед нами стоит задача учитывать «эффект отскока» при внедрении энергосберегающих мероприятий при проведении энергоэффективного капитального ремонта.

Ключевые слова: капитальный ремонт, жилищный фонд, многоквартирные дома, энергоэффективность, энергосберегающие технологии, эффект отскока

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