



The Rebound Effect – A Blind Spot in Reduction Efforts

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In recent years, a commendable effort has been made to reduce the environmental footprint of laboratories.

This has notably involved conducting greenhouse gas (GHG) assessments and implementing various measures to limit emissions within laboratories.

In this context, several questions arise such as:

Can we improve efficiency—for example, by accelerating our codes and reducing energy consumption?

Can we simply reduce the level of activity—and therefore the budget—of our laboratories?

The answers to these questions are less straightforward than they may initially appear.

Rebound effect or the Jevons paradox

In 1865, the economist William Stanley Jevons observed that coal consumption in the United Kingdom increased following the introduction of a more efficient steam engine, (developed by James Watt).

The improvement in efficiency facilitated the widespread adoption of steam engines, which in turn led to an increase in overall coal consumption.

This phenomenon, now known as the **Jevons paradox**, illustrates how gains in efficiency can sometimes result in higher overall resource consumption rather than the expected reduction.

Modern version

The « Khazzoom-Brookes » postulate
(Saunders 1992)

In a disturbing assault on intuition and conventional wisdom, Khazzoom and Brookes have asserted that energy efficiency improvements might increase, rather than decrease energy consumption. If true, policies aimed at encouraging conservation could worsen rather than ameliorate global warming and would accelerate the need for offshore drilling rather than provide a substitute for it. More generally, this result would pit conservation against environmental goals, in direct contradiction to many countries' energy plans (which see conservation as an environmental solution).

Yet neoclassical growth theory confirms this possibility given certain fairly reasonable conditions—conditions that recent work by Hogan and Jorgenson indicates may hold in the U.S. economy. By no means proving the postulate, this analysis appears to make it much more difficult to dismiss.

In fact, the effect can be more dramatic than even Khazzoom and Brookes may appreciate. Energy efficiency gains can increase energy use even more directly by increasing the economic growth rate, not only by decreasing the effective cost of energy. Efficiency gains for other factors (capital and labor) can also increase energy use.

THE
COAL QUESTION;

AN INQUIRY
CONCERNING THE PROGRESS OF THE NATION,
AND THE
PROBABLE EXHAUSTION OF OUR COAL-MINES.

W. STANLEY JEVONS, M.A.

FELLOW OF UNIVERSITY COLLEGE, LONDON;
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SECOND EDITION, REVISED.

London:
MACMILLAN AND CO.

1866.

6B

Different types of rebound effects

1. Direct rebound effect (or price effect).

An increase in the energy efficiency of a product reduces its effective cost of use and can therefore lead to greater consumption of that product or the service it provides. For example, the lower cost of lighting resulting from efficiency improvements may encourage less careful use, such as leaving lights on unnecessarily. Similar effects can be observed with automobiles, where lower fuel consumption per kilometre may encourage increased travel, or with building insulation, where reduced heating requirements may lead occupants to maintain higher indoor temperatures.

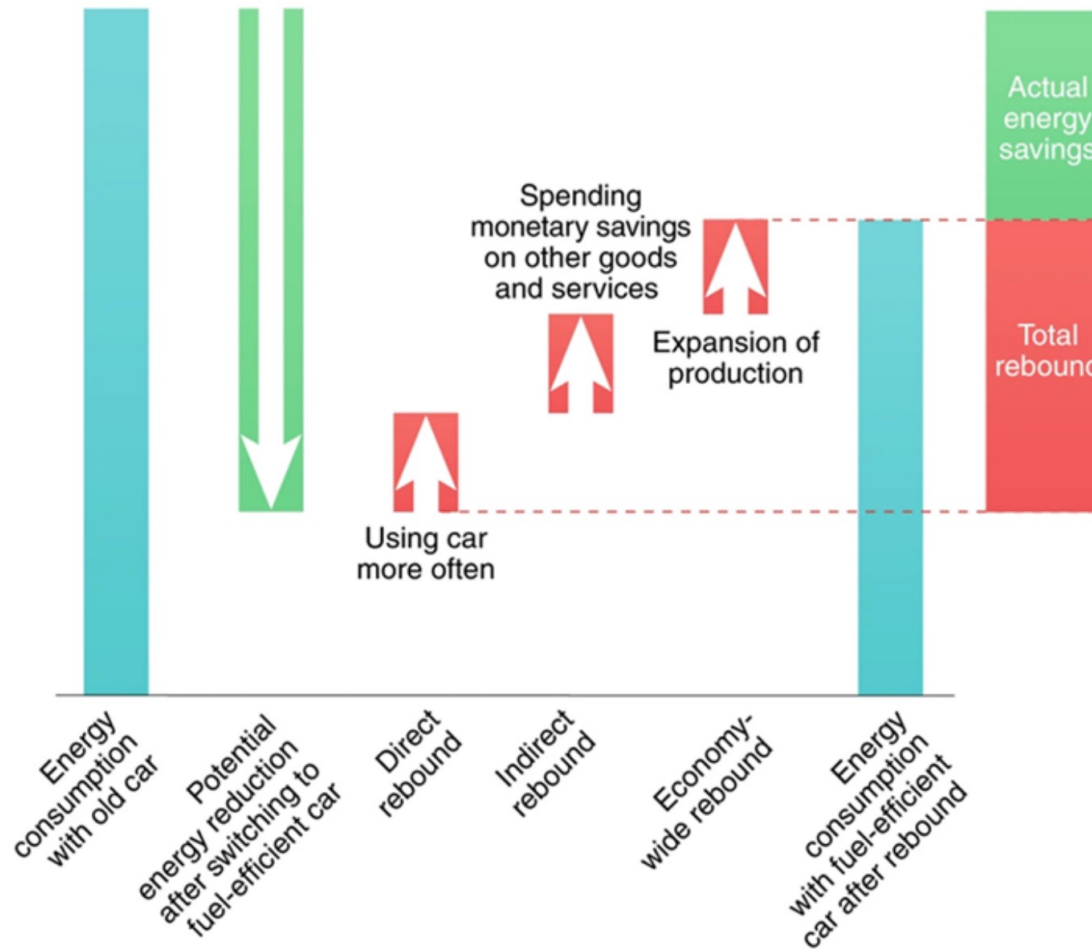
2. Indirect rebound effect (or income effect).

The financial savings generated by lower energy consumption—for transportation, heating, or electricity, for example—may be spent on other goods and services that themselves require energy. For instance, savings on household energy bills may be used to finance air travel.

3. Macroeconomic rebound effect.

This effect may arise through two main mechanisms. First, the reduction in overall energy demand resulting from efficiency improvements can lower energy prices, thereby stimulating energy-intensive sectors of the economy. Second, improvements in energy efficiency can contribute to economic growth, which in turn may increase energy consumption at the scale of the economy as a whole.

Illustration des différents types d'effet rebond provoqués par le passage d'une vieille voiture à une voiture peu consommatrice de carburant



Source Filippou Exadaktylos, Jeroen van den Bergh, « Energy-related behaviour and rebound when rationality, self-interest and willpower are limited », Nature Energy, 2021.

Comprendre l'effet rebond
PAR MARION COHEN ET ALAIN GRANDJEAN

Some examples of rebound effects

En Allemagne, les rénovations énergétiques des bâtiments n'ont pas fait baisser la consommation

Le Monde Octobre 2020

Comme expliquer une telle contre-performance ? La GdW souligne plusieurs causes. La première est le fameux « effet rebond » : dans des logements mieux isolés, avec des prix des énergies fossiles en baisse depuis 2013, les occupants ne sont pas incités à bouder leur confort. Au lieu de chauffer à 20 °C, ils préfèrent pousser à 22 °C. S'ajoute à cela que certaines rénovations sont parfois inefficaces.

Télétravail : l'ADEME étudie les effets rebonds induits par cette nouvelle pratique

<https://www.alterea.fr/le-lab/teletravail-ademe-etudie-effets-rebond-induits-nouvelle-pratique>

Tout d'abord, l'ADEME a établi que le bénéfice environnemental moyen lié à la réduction des déplacements domicile-travail est de **271 kgCO₂e annuels par jour de télétravail hebdomadaire**, ainsi télétravailler 4 jours par semaine permettrait de réduire son empreinte d'1 tCO₂e par an, soit 10% de l'empreinte annuelle d'un français (9,9 tCO₂e).

L'étude de l'ADEME fait état de 6 effets rebond directs :

- **Effet « Chaînes Modales »** : le trajet domicile-travail permet aussi de déposer les enfants à l'école et d'aller faire ses courses, ces trajets seront donc réalisés par ailleurs, menant à une augmentation de + 67,7 kgCO₂e/an/jour de TT hebdomadaire.
- **Effet « Nouvelles mobilités quotidiennes »** : le véhicule restant à la maison, il est utilisable par d'autres membres de la famille.
- **Effet « Relocalisation »** : le télétravail favorise l'éloignement des villes, dans des zones moins bien desservies en transports en commun obligeant l'utilisation de la voiture.
- **Effet « Logement »** : consommation énergétique personnelle du télétravailleur augmente, menant à +20,7 kgCO₂e/an/jour de TT hebdomadaire.
- **Effet « Bureau à la demande »** : le télétravail avec conservation d'un bureau classique permet de réduire de - 6,7 kgCO₂e/an/jour de TT hebdomadaire, alors qu'en appliquant le flex office cette réduction passe à -234 kgCO₂e/an/jour de TT hebdomadaire.
- **Effet « Visio conférence »** : le télétravail demande l'utilisation de visioconférence, pour 1 heure par jour c'est une augmentation de + 2,82 kgCO₂e/an/jour de TT hebdomadaire.

Estimating the strength of direct rebound effect

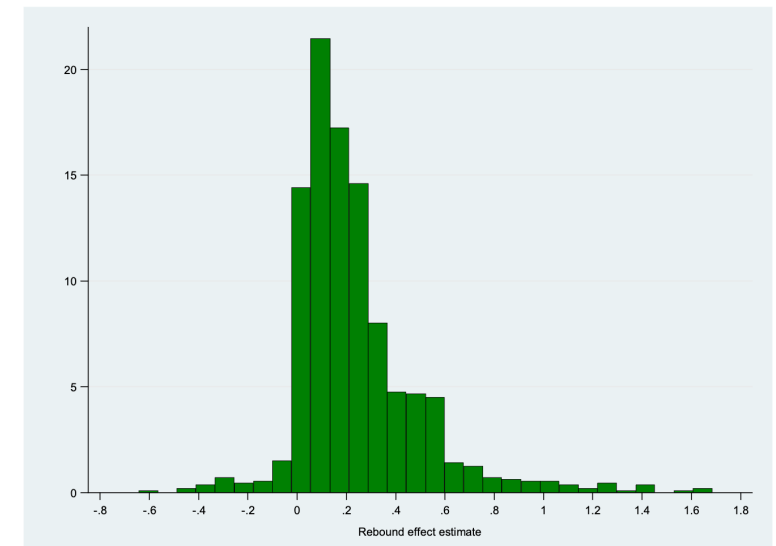
THE REBOUND EFFECT IN ROAD TRANSPORT: A META-ANALYSIS OF EMPIRICAL STUDIES -

ENVIRONMENT WORKING PAPER No. 113

By Alexandros Dimitropoulos (1), Walid Oueslati (1) and Christina Sintek (1)

The rebound effect is the phenomenon underlying the disproportionality between energy efficiency improvements and observed energy savings. This paper presents a meta-analysis of 76 primary studies and 1138 estimates of the direct rebound effect in road transport to synthesise past work and inform ongoing discussions about the determinants and magnitude of the rebound effect. The magnitude of rebound effect estimates varies with the time horizon considered. **On average, the direct rebound effect is around 12% in the short run and 32% in the long run.** Indirect and macroeconomic effects would come on top of these estimates. Heterogeneity in rebound effect estimates can mainly be explained by variation in the time horizon considered, the elasticity measure used and the econometric approach employed in primary studies, and by macro-level economic factors, such as real income and gasoline prices. In addition to identifying the factors responsible for the variation in rebound effect estimates, the meta-regression model developed in this paper can serve as a relevant tool to assist policy analysis in contexts where rebound effect estimates are missing.

Figure 1. Distribution of estimates of the rebound effect



Estimating the strength of the economy-wide rebound effect

Difficult to estimate but several methods lead to > 50%

The majority of global energy scenarios anticipate a structural break in the relationship between energy consumption and gross domestic product (GDP), with several scenarios projecting absolute decoupling, where energy use falls while GDP continues to grow. However, there are few precedents for absolute decoupling, and current global trends are in the opposite direction. This paper explores one possible explanation for the historical close relationship between energy consumption and GDP, namely that the economy-wide rebound effects from improved energy efficiency are larger than is commonly assumed. We review the evidence on the size of economy-wide rebound effects and explore whether and how such effects are taken into account within the models used to produce global energy scenarios. We find the evidence base to be growing in size and quality, but remarkably diverse in terms of the methodologies employed, assumptions used, and rebound mechanisms included. **Despite this diversity, the results are broadly consistent and suggest that economy-wide rebound effects may erode more than half of the expected energy savings from improved energy efficiency. We also find that many of the mechanisms driving rebound effects are overlooked by integrated assessment and global energy models.** We therefore conclude that global energy scenarios may underestimate the future rate of growth of global energy demand.

Brockway + 2021

Renewable and sustainable energy review

Appendix B. Mechanisms contributing to economy-wide rebound effects

Category	Mechanism	Source
Direct rebound effect (partial equilibrium)	Income effect (consumers)	Changes in the consumption of the energy service, owing to the increase in real income stimulated by the energy efficiency improvement
	Substitution effect (consumers)	Changes in the consumption of the energy service, owing to a fall in its effective price relative to other commodities (holding utility constant)
	Output effect (producers)	Changes in the consumption of the energy service owing to the increase in output stimulated by the energy efficiency improvement
Indirect rebound effect (partial equilibrium)	Substitution effect (producers)	Changes in the consumption of the energy service, owing to a fall in its effective price relative to other inputs (holding output constant)
	Income effect (consumers)	Changes in the consumption of other commodities, owing to the increase in real income stimulated by the energy efficiency improvement
	Output effect (producers)	Changes in the consumption of other inputs owing to the increase in output stimulated by the energy efficiency improvement
Macroeconomic rebound effect (general equilibrium)	Substitution effect (producers)	Changes in the consumption of other inputs, owing to an increase in their effective price relative to the energy service (holding output constant)
	Energy market effect	Changes in energy consumption following changes in energy prices (leftward shift of the demand curve for energy)
	Composition effect	Changes in energy consumption following structural change in the economy - with energy-intensive sectors and goods benefiting more
	Growth effect	Changes in energy consumption following investment and increased output stimulated by the energy efficiency improvement
	Scale effect	Changes in energy consumption following reductions in the price of goods and services stimulated by increased output of those goods and services
	Labour supply effect	Changes in energy consumption following increases in real wages stimulated by the energy efficiency improvement
	Disinvestment effect	Changes in energy consumption following disinvestment in the energy supply sectors in response to lower energy prices

Sources: Own elaboration based upon [21,71,93].

Note: This list is not exhaustive, the mechanisms are not necessarily additive; and each mechanism may either increase or reduce economy-wide energy consumption depending upon the particular situation. The relative importance of these mechanisms will also vary from one context to another and from one type of energy efficiency improvement to another.

Estimating the strength of the economy-wide rebound effect

Do Energy Efficiency Improvements Reduce Energy Use? Empirical. Evidence on the Economy-Wide Rebound Effect in Europe and the United States

Berner, A., Bruns, S., Moneta, A., Stern, D. 2022

Increasing energy efficiency is often considered to be one of the main ways of reducing [greenhouse gas emissions](#). However, efficiency gains that reduce the cost of energy services result in energy use rebounding and potential energy use savings being eaten up. Empirical research that quantifies the economy-wide rebound effect while taking the dynamic economic responses to energy efficiency improvements into account is limited. We use a Structural Factor-Augmented Vector Autoregressive model (S-FAVAR) that allows us to track how energy use changes in response to an energy efficiency improvement while accounting for a vast range of potential confounders. **We find economy-wide rebound effects of 78% to 101% after two years in France, Germany, Italy, the UK, and the US.** This implies that energy efficiency innovations alone may be of limited help in reducing future energy use and emphasizes the importance of tackling [carbon emissions](#) directly.

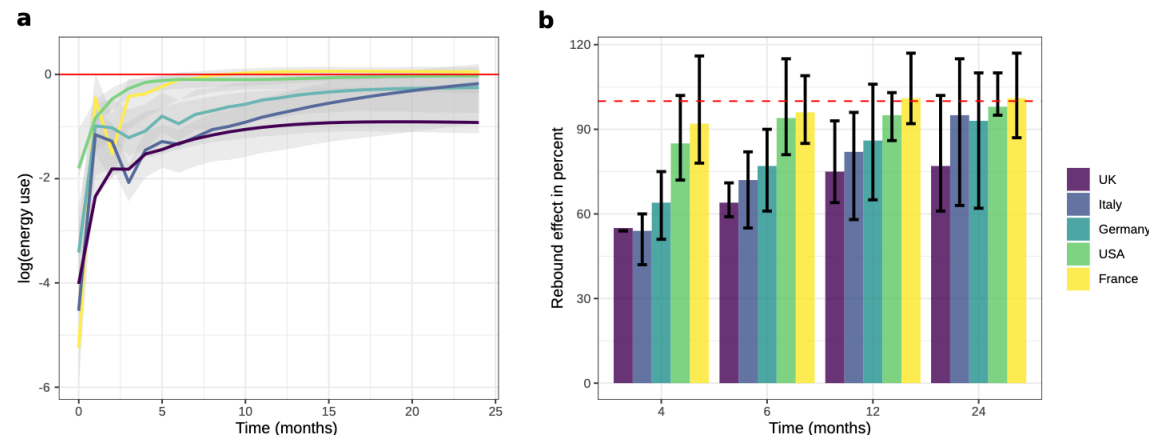


Figure 6: **Impulse response functions of energy use for an energy efficiency shock (a) and estimated rebound effects (b).** Shaded areas represent 90% confidence intervals in the left panel. Error bars represent 90% confidence intervals in the right panel. Confidence intervals based on wild bootstrapping.

How to deal with the rebound effect?

How to deal with the rebound effect? A policy-oriented approach

David Font Vivanco, René Kem, Ester van der Voet

Energy Policy 94 (2016) 114–125

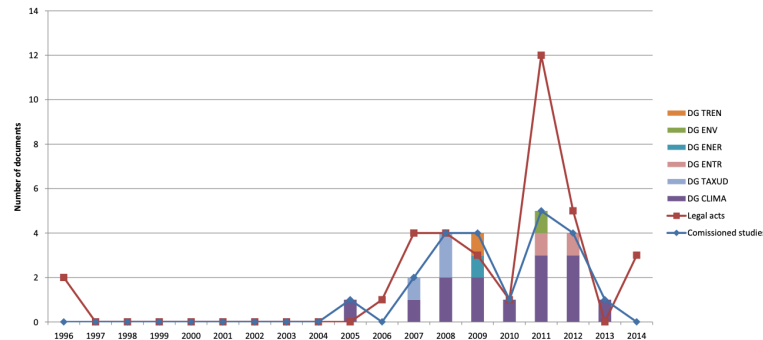


Fig. 1. Number of European Union legal acts and cooperative research studies commissioned by the European Commission in which the rebound effect is mentioned. Source: European Commission (2014b).

Table 1

Policy pathways for rebound mitigation according to the type of instrument and general strategy.

Type of policy pathway	Rebound mitigation strategy		
	Increased environmental efficiency – “consuming more efficiently”	Consumption shifting – “consuming differently”	Downsize consumption – “consuming less”
Policy design	Recognition in policy design		
	Broader definitions and toolkit		
	Benchmarking tools		
Sustainable consumption and behaviour		Consumption information	
		Identity signalling	
		Standardisation	
Innovation			Autonomous frugal behaviour
	Targeted eco-innovation		
Environmental economic policy	Energy/carbon tax		
	Bonus-malus schemes		
	Cap and trade schemes		
New business models	Rebates and subsidies		
	Product service systems		

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Recognition in policy design

the United Kingdom (UK) Department of Energy and Climate Change decided to take into account the direct rebound effect when estimating the potential energy savings from domestic insulation and other measures. Concretely, such energy savings are reduced by 15% to account for the “comfort taking” effect (that is, the increase in internal temperature as a response to energy efficiency improvements). Another example is the Ireland's “National Energy Efficiency Action Plan 2014” ([DCENR, 2014](#)), which assumes a high rebound effect of 70% associated with the “comfort taking” effect in low-income households when calculating the outcomes of energy saving measures. Outside Europe, the U.S. Department of Energy includes a 10% rebound effect from car standards into its energy forecasting according to the [IRGC \(2013\)](#). By acknowledging the energy and broader environmental savings that are lost due to the rebound effect, its recognition can aid in achieving environmental goals from policy measures, either by allocating extra resources or by fostering different technologies with lower associated rebounds (e.g., technologies with smaller changes in their total cost of ownership [TCO]). Empirical evidence supporting the effectiveness of this pathway, however, is not currently available. The potential disadvantages of this pathway include the expenditure of additional public resources dedicated to the calculation of rebound effects and the achievement of more ambitious objectives.

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Broader definitions and toolkit

By defining the rebound effect in a way that broader effects can be included, for example through the environmental rebound effect' concept ([Font Vivanco et al., 2014a](#)), trade-offs can be considered in the policy design and additional resources can be allocated to mitigate unwanted effects. Moreover, the academic literature offers a panoply of methods to estimate the rebound effect, some being relatively complex and opaque, as is often the case with macroeconomic models ([Sorrell, 2007](#)). This makes communication and public engagement challenging and could deter policymakers from addressing the rebound effect. There is thus a need for relatively simple, transparent and ready-to-use tools to estimate rebound effects from policies. One example of such a tool is that developed by the UK [Department of Energy and Climate Change \(2014\)](#), which estimates the direct rebound effect or “comfort taking” effect from relevant energy-saving policies in its policy evaluation.

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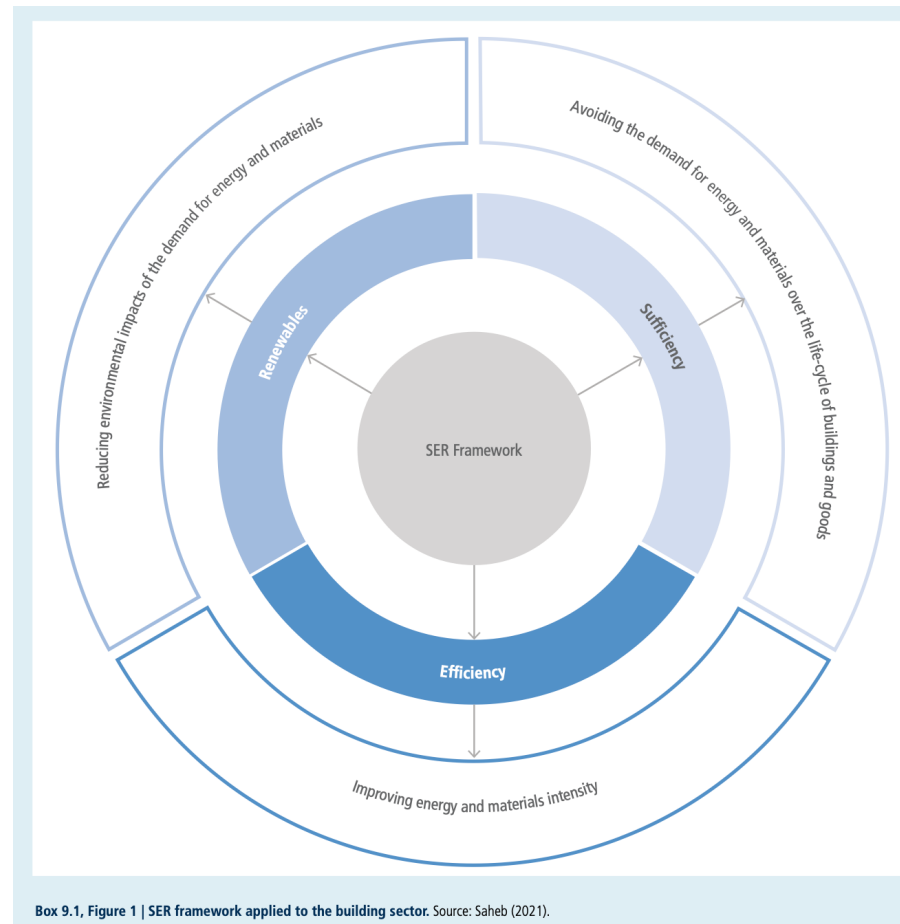
Energy Policy 94 (2016) 114–125

Autonomous frugal behaviour

Autonomous frugal behaviour is based on the principle of sufficiency, which relies upon the notions of restraint and moderation of individual consumption (Princen, 2005). Sufficiency behaviour is based on two concepts: (1) it presupposes purchasing power, so that essential consumption (e.g., food or heating) is still possible after downsizing consumption and (2) it is driven by environmental motivation (Alcott, 2008). Sufficiency can be achieved by reducing one's purchasing power, for instance, by means of working or earning less (ibid). Such measures, often proposed within the 'degrowth' movement (Martínez-Alier et al., 2010), can notably reduce rebound effects by limiting one's real income and thus the impact of re-spending effects. The effectiveness of sufficiency measures in terms of reducing environmental burdens from consumption, as well as of social benefits, has been demonstrated in the context of the reduction of working hours in developed countries (Hayden and Shandra, 2009; Knight et al., 2013; Rosnick and Weisbrot, 2007). While being a simple and effective way to mitigate the rebound effect, one of the principal barriers to the adoption of sufficiency-based strategies is its social acceptance, mainly because of the "consumption lock-in" phenomenon and various consumption habits that are difficult to overcome (Sorrell, 2010). To increase its social acceptance, it will likely require "collectively agreed objectives, priorities, procedures and constraints that are institutionalised through government action" (Sorrell, 2010: 1794). Additionally, these strategies are not immune to new rebound effects, as the decrease in demand for some products can lower their price and induce extra demand (Alcott, 2008).

Sufficiency, Efficiency, Renewable (SER)

Efficiency is not enough, it must be combined with « sufficiency »



And in our laboratories?

A fundamental question: what is the right strategy?

The easiest (only?) way to *significantly* reduce emission is to reduce expenditures

Reducing expenditures and more importantly emissions is important for exemplarity

...But reducing expenditures does not make the money disappear... **This is indirect rebound effect at the scale of the society.**

If the research budget is kept constant: a key question is how the money is employed

⇒ One obvious way to spend money without increasing carbon budget is human resources

If the research budget is decreased then a central question is STILL how the money is employed (carbon intensity of research not particularly high)

And in our laboratories?

Gaining efficiency in our practice is likely not a solution **unless specific actions** are taken

Rebound effect should be limited not only for our own usage but also for the global economy that will benefit of these improvements

Generally speaking, a somewhat holistic approach must be developed.

The rebound effects, economy-wide, must be accounted for in any reduction policy.