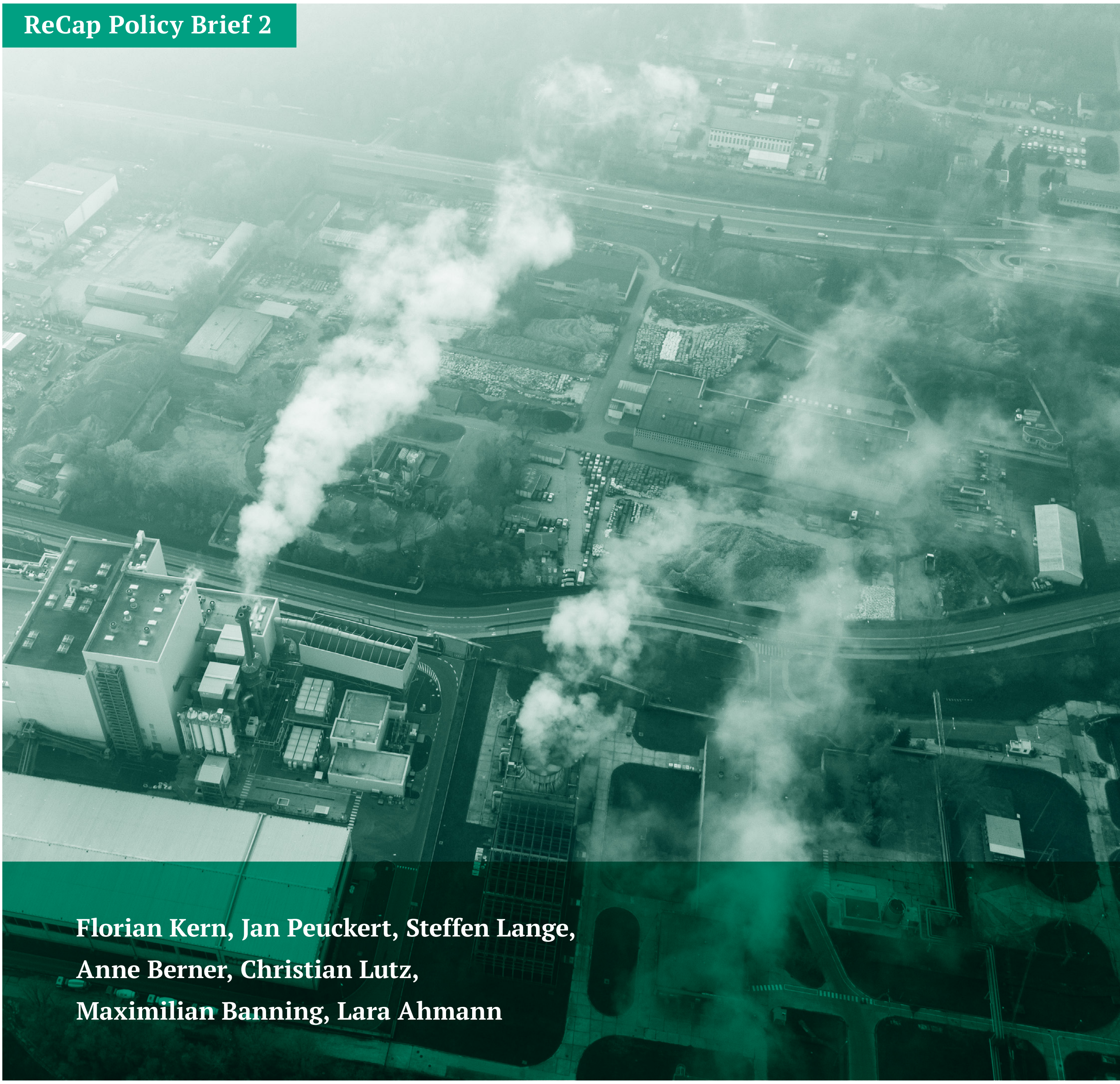
Energy efficiency policy must address rebound effects in order to achieve climate goals

ReCap Policy Brief 2



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ReCap Capping Macro Rebounds

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Energy efficiency policy must address rebound effects in order to achieve climate goals

Germany has committed itself to significantly reducing greenhouse gas emissions: to a 55 percent reduction from 1990 levels by 2030 (Climate Protection Plan, 2050). The country wants to be largely greenhouse gas neutral by 2050. Energy efficiency plays a key role in meeting these goals. The measures contained in the National Action Plan on Energy Efficiency (BMWi, 2014) were intended to reduce overall primary energy consumption in Germany by 20 percent from 2008 levels by the year 2020. Although this goal was nearly achieved a reduction of 18.7 percent (BMWi, 2021), thanks in no small part to the economic downturn and mild weather in 2020 – it is entirely uncertain how further targets, to be met by the year 2030, namely a 30 percent reduction over 2008 in accordance with Germany's Energy Efficiency Strategy 2050, are to be achieved. The expert commission convened by the Federal Ministry for Economic Affairs and Energy (BMWi) to oversee the monitoring process (Energy of the Future, 2021) therefore comes to the conclusion in its latest statement that "the warning signal... in the field of energy efficiency is glowing red" (p. Z-5).

Even though energy efficiency measures frequently represent the most cost-effective means to reduce CO_2 emissions, neither the private sector (homeowners) nor industry are taking full advantage of their potential. Accordingly, there are a number of incentive programs that encourage investment in energy efficiency measures. Such subsidies are reasonable to the extent that they create incentives for investment, but they are also prone to rebound effects. **Rebound effects are the unintended consequences of energy efficiency improvement measures that either reduce the potential for savings or even, in extreme cases, lead to increased energy consumption.** Rebound effects undermine the effectiveness of investments in energy efficiency and thus widen the gap between climate goals and current policies. Additional policy measures are necessary to ensure that investments in energy efficiency in Germany reduce energy consumption in absolute terms and thus result in a relevant contribution to achieving the country's climate goals.

Recommendations for an effective energy efficiency and climate policy

1. **A clear, target group-specific communication strategy on rebound effects** is required, one that takes into account their existence in the private sector, industry, and at the macro-economic level and explains why it is necessary to contain them. A positive narrative should be developed that shows how political measures to counter rebound effects can contribute to socially desirable co-benefits.

2. The subsidy programs for energy efficiency in industry should be supported by a **policy mix** that also – but not only – includes an increase in CO_2 prices in order to effectively reduce rebound effects and thus contribute to the achievement of the climate goals.

3. It is necessary to develop a more extensive **transformation strategy**, as carbon neutrality cannot be achieved through energy efficiency policy measures alone. Instead, a structural change towards CO_2-free goods and industries and an absolute decoupling of growth and environmental impacts is required. Since decoupling is uncertain, the transformation strategy should be based on the **precautionary post-growth position.**

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The problem: Rebound effects diminish energy savings from efficiency investments and jeopardize climate goals

Achievement of Germany's energy reduction objectives requires a concerted effort in all areas of the national economy. The Energy Efficiency Strategy 2050 features a large number of measures addressing industry (BMWi, 2019). These range from EU emissions-trading and national CO_2 pricing, investment and funding programs, regulations and tenders, to informative instruments, audits and the promotion of energy efficiency networks. Subsidy programs play a central role in this, although the payback times for energy efficiency investments are often two to three years or less (Peuckert & von Andrian, 2019), meaning that such investments will likely pay off economically in the short term even without incentives. As a justification for the funding, the Federal Ministry for Economic Affairs and Energy argues "that energy efficiency is not part of the core business of [most] companies" (BMWi 2019, p. 17), therefore additional incentives are necessary.

While investments in energy efficiency in both private households and industry are central to achieving climate goals, the level of technically possible energy savings is in reality rarely achieved. One explanation for this are rebound effects – the unintended consequences of improvements in energy efficiency – meaning that the savings actually achieved are often lower than the theoretical potential (Sorrell, 2007). Rebound effects are triggered by various mechanisms that reduce savings potential or even, in extreme cases, lead to increased consumption ('backfiring') (see Figure 1).

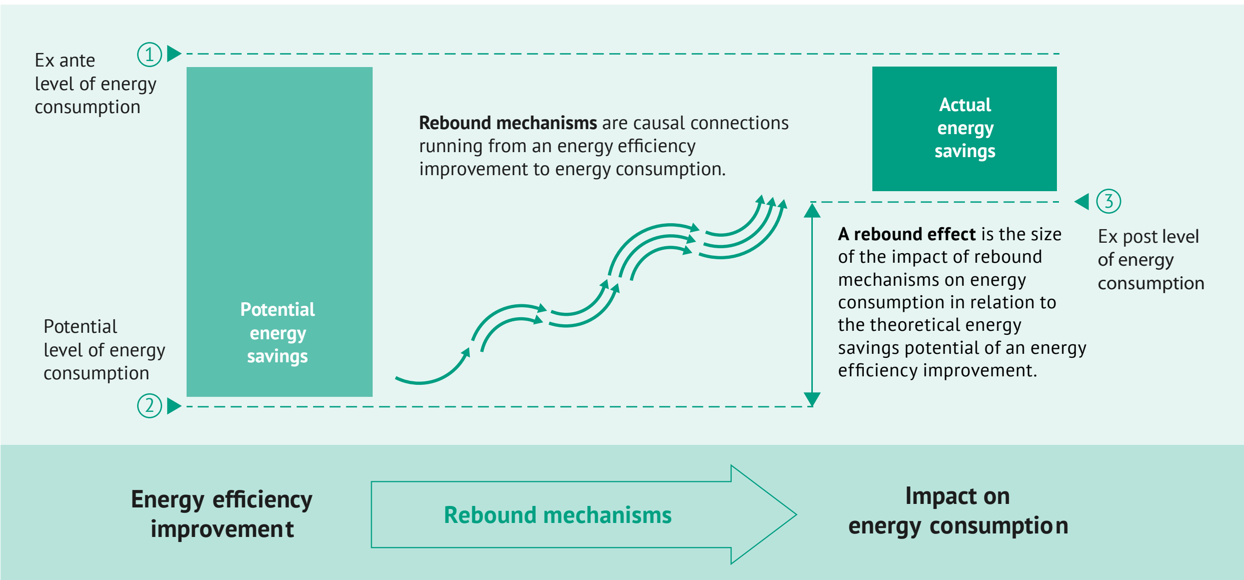

Abbildung 1: *Was sind Reboundeffekte und welche Mechanismen lösen sie aus?* (Lange et al. 2021)

Empirical studies conclude that the rebound effects at both the industrial and the macroeconomic level are significant. With respect to industrial production, estimates for the USA, China, Norway, and Great Britain show substantial rebound effects, ranging from 24 to 75 percent (Bentzen, 2004; Grepperud & Rasmussen, 2004; Orea et al., 2015; Saunders, 2013). At the macroeconomic level, there are by now many studies with differing approaches (Stern, 2020). Their assessment of the magnitude of rebound effects vary significantly – from the low double-digits to more than 100 percent (Adetutu & Weyman-Jones, 2016; Jin & Kim, 2019; Zhang & Lawell, 2017). These estimations suggest that rebound effects are of such magnitude that they should be included in

energy policy considerations, as they otherwise risk jeopardizing the achievement of ambitious climate targets.
Studies show that the various energy efficiency policy instruments differ in terms of their susceptibility to rebound effects (Semmling et al., 2016). The faster the amortization of an energy efficiency investment, the greater the likelihood and extent of rebound effects. Financial subsidies for such investments shorten the amortization period and thus contribute to rebound effects, since the costs saved are available to be spend in other ways, thus increasing consumption. From a business point of view, this is entirely desirable. This is one of the reasons why the funding of energy efficiency investments in industry is one preferred instrument of the Federal Ministry of Economics and Technology (BMWi). In BMWI publications, the existence of rebound effects is either not mentioned at all or only in passing, and their impact on the effectiveness of the policy measures in use is not critically addressed. This is problematic in view of policy goals of absolute energy savings.
Unfortunately, to date there is little research that we can draw on as to how rebound effects can best be countered. Beyond the general demand that such rebound effects be adequately taken into account in policy-making, the economic research literature has provided few if any concrete suggestions. Absolute quantity restrictions (caps) and increasing energy and CO_2 prices are seen as effective instruments, but so far there have been no detailed recommendations for their specific design or an assessment of their actual impact on rebound effects. Since a possible increase in the price of energy or CO_2 emissions introduces questions of social justice, international competitiveness, and political acceptance, it is important to take these aspects into account when designing policy.

Analysis: Rebound effects also occur in industry and broaden the knowledge-action gap in climate policy

Rebound effects are found not only in the private sector, but also in companies and at the macroeconomic level. In the project ReCap: Investigation of the Role of Energy and Resource Productivity for Economic Growth and Development of Political Instruments to Curb Macroeconomic Rebound Effects, the Institute for Ecological Economic Research, the Society for Economic Structural Research and the Chair of Statistics of the University of Göttingen estimated the magnitude of these effects using various methods.
For a start, the rebound effect at the company level in various manufacturing sectors was estimated on the basis of company data. For this purpose, a benchmarking approach was chosen that assumes that the competitive position of the companies, and thus relative improvements in energy efficiency, are decisive for energy consumption. This approach analyzes the relationship between two mechanisms: As a result of a relative improvement in efficiency, energy consumption of the company decreases, as a more efficient company requires less energy per unit of production. But as the company improves its competitive position and thus increases sales, this in turn leads to greater energy consumption and thus to a rebound effect. The analysis of industrial sector data indicates, on average, a significant rebound effect in all sectors. The extent in each case depends on the level of increase in output and various company characteristics. For example, an increase in the share of expenditures for research and development, as well as in wages vs. gross output, or in the share of renewable energy generation vs. energy consumption will lead to a lower rebound effect. A proportional expansion of foreign sales and investments in relation to gross output, increases the rebound effect.
Secondly, the rebound effects associated with an increase in energy efficiency in German industry were modelled and quantified using the PANTA RHEI macroeconomic model. The magnitude of the effects varies depending on the specific industrial sector. On average, these were estimated to be 13 percent in 2030 (Berner et al., manuscript in preparation). The macroeconomic rebound effect is higher at 19 percent. This is due to the fact that increased efficiency initially leads to a reduction in energy consumption and thus energy prices. Other

economic actors such as private households also benefit from this and increase their energy consumption. Compared to similar international studies, the estimated rebound effect is rather at the lower end of the spectrum.

Thirdly, the project dealt with the relationship of rebound effects and economic growth. The analysis of various economic theories as well as our own econometric estimates suggest that improvements in energy efficiency contribute to economic growth, which in turn leads to greater energy consumption. According to our estimates which are based on the Odyssey database, this growth rebound is between 20 and 47 percent, which also makes it more difficult to achieve absolute reduction targets (Lange et al., manuscript in preparation). This growth rebound indicates that there is a trade-off between the reduction of rebound effects and the pursuit of economic growth, as reducing rebound effects also dampens growth. This requires a policy approach that goes beyond green growth in order to achieve the necessary reductions in energy consumption.

Overall, our analyses show: Rebound effects arise not only in private households, but also in companies and at the macroeconomic level and should therefore be taken into account when formulating energy and climate policy. In a situation in which current policy measures are insufficient to achieve the 55 percent reduction in greenhouse gases the government is aiming for (Prognos 2020), a rebound effect of say "only" 20 percent increases the disparity between the goals and current policies. Given that climate goals at the European level have already been strengthened and will foreseeably be strengthened in Germany as well, additional measures will be necessary to close the gap.

In the course of the project ReCap, stakeholder workshops and expert interviews were used to discuss and analyse the feasibility of a range of policy measures to counter rebound effects. Our modelling shows that rebound effects can in fact be counteracted by various policy measures. The following complimentary measures to increasing energy efficiency were modelled: CO_2 pricing with income reimbursement, a tax reform, an energy efficiency savings reinvestment requirement for subsidy recipients, and a reduction in working hours. All of these measures (or combinations of measures) were able to counter rebound effects to some degree; however, their macroeconomic effects on employment and GDP vary. CO_2 pricing of up to 180 euros per tonne CO_2 equivalent in combination with a reduction in the German Renewable Energy Sources Act (EEG) surcharge and a tax reform that favors labor costs at the expense of energy show a slightly negative effect on gross domestic product. The negative effect becomes somewhat greater for a reduction of working hours with partial wage compensation. In contrast, the effect on employment of a reduction in working hours is positive, while the other sets of measures that were modelled show hardly any effects here. All sets of measures lead to a reduction in final energy consumption; this is most clearly the case with CO_2 pricing with reimbursement.

According to the assessments of fifteen experts from politics and administration, science, civil society, and industry and trade unions, acceptance problems must be anticipated with the implementation of such flanking measures to counter rebound effects. The experts were of the opinion that the willingness of business, politicians, and citizens to accept putative losses in competitiveness and consumer power for the sake of combating rebound effects was not very pronounced. The political feasibility of price instruments was therefore assessed as problematic, although their effectiveness and practicality were rated positively. In contrast, policy options that limit the use of efficiency gains were seen as less practicable. Overall, our assessment of the interviews is that the acceptance of anti-rebound measures is negatively affected by an unfamiliarity with the problem, especially in the fields of politics, administration, and industry, and a lack of understanding of the complex relationships. Rebound effects are viewed as relatively unimportant and not easily comprehended. According to our analysis, the reasons for this are discussions heavily laden with technical terms, the complexity of the phenomenon itself, but also an inadequate problematization in the political discourse, which can be blamed on a desire to avoid unpleasant truths and incorrect conclusions with respect to the supposed ineffectiveness of energy efficiency policy.

Recommendations for an effective energy and climate policy

1. Develop a clear and target group-specific communication strategy for addressing rebound effects

In order to increase the acceptance of measures addressing rebound effects, communication strategies appropriate for each target audience need to be developed jointly by science, civil society, business, politics, and administration. The nature of the problem should be elucidated in a generally understandable way, the various mechanisms for action differentiated, and conflicts and trade-offs clearly identified. A ReCap video animation offers an initial attempt to bring the topic out of the specialist discourse and make it accessible to a wider audience. It is also necessary to initiate a broad societal debate on how to deal with rebound effects. The generally high level of acceptance for climate protection goals offers a number of starting points for this. Addressing rebound effects should be clearly associated with a positive narrative. It could be helpful to emphasize that the "skimming off" of efficiency gains can be combined with social co-benefits, such as a more equitable distribution of income, stronger social security, or a better work-life balance.

2. Expansion of the policy mix to stem rebound effects in industry

Macro-economic modeling shows that funding measures to increase energy efficiency in Germany will lead to rebound effects of roughly 20 percent by 2030. Because energy efficiency measures are particularly susceptible to rebound effects, they need to be accompanied by supplemental, so-called flanking, measures. In particular, pricing instruments or caps such as nation-wide CO_2 pricing and EU emissions trading can significantly reduce rebound effects. Revenue reimbursement from national pricing via a reduction in the renewables (EEG) surcharge can lead to increases in electricity demand. Another instrument could be a reinvestment requirement linked to the subsidy, requiring companies to reinvest saved energy costs in further energy efficiency measures. An increase in energy tax rates with the inflation rate while at the same time lowering wage costs could also reduce rebound effects. The tightening of the EU climate targets also opens up a window of opportunity at present to implement further measures. It is important, in every case, that the measures are appropriately combined and well-coordinated with a view to rebound effects. Furthermore, they should neither restrict the international competitiveness of companies nor lead to regressive distributional effects. With this in mind, a per capita reimbursement of CO_2 revenues from CO_2 pricing would be preferable to a reduction of the EEG surcharge.

3. Develop a transformation strategy for climate neutrality based on the precautionary post-growth position

Long-term absolute energy reduction goals, let alone GHG emissions neutrality, cannot be achieved through increases in energy efficiency alone. It is therefore essential that we develop a transformation strategy for the German economy that supports a structural change in the direction of CO_2-free goods and industries. The use of CO_2-free technologies such as renewable energies must not be allowed to become a free pass to increased energy consumption and the renunciation of efficiency measures as these are also associated with negative impacts in other environmental media, for example raw materials and land consumption. In addition, the nationwide expansion of renewable energies often faces acceptance problems. Therefore, "efficiency first" should remain the core principle of German energy policy.

The noted close relationship between macroeconomic rebound effects and growth in the context of absolute reduction targets illustrates the dilemma of a green growth strategy, the success of which depends on the absolute decoupling of environmental consumption and growth. Since it is uncertain whether energy, resource consumption, and growth can be absolutely decoupled, the transformation strategy should be based on a precautionary post-growth position (Petschow et al., 2020), which argues that vital areas of society must become less dependent on economic growth.

ReCap research results in detail (selection)

Jan Peuckert, Nick von Andrian (2020):
Akzeptanzanalyse Rebound-begrenzender Politikmaßnahmen, ReCap Arbeitsbericht 4
https://www.macro-rebounds.org/publikationen/.

Lara Ahmann, Maximilian Banning, Christian Lutz (2021):
Zusammenstellung der Modellierungsergebnisse der Politikmaßnahmensets zur Vermeidung makroökonomischer Rebounds, ReCap Arbeitsbericht 5
https://www.macro-rebounds.org/publikationen/.

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Bibliography

Adetutu, A., & Weyman-Jones, T. (2016).
Economy-wide Estimates of Rebound Effects: Evidence from Panel Data.
The Energy Journal, Volume 37(Number 3).

Bentzen, J. (2004).
Estimating the rebound effect in US manufacturing energy consumption.
Energy Economics, 26(1), 123–134.

Berner, A., Lange, S., & Silbersdorff, A.
(unveröffentlichtes Manuskript).
Relative Energy Efficiency, Competition and Rebound Effects in the Manufacturing Sector.

Bundesministerium für Wirtschaft und Energie (2021).
Stellungnahme zum achten Monitoring-Bericht der Bundesregierung für die Berichtsjahre 2018 und 2019.
URL: https://www.bmwi.de/Redaktion/DE/Downloads/S-T/stellungnahme-der-expertenkommission-zum-achten-monitoring-bericht.pdf

Bundesministerium für Wirtschaft und Energie (2019).
Energieeffizienzstrategie 2050.
URL: https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/energieeffiezienzstrategie-2050.pdf

Bundesministerium für Wirtschaft und Energie (2014).
Nationaler Aktionsplan Energieeffizienz.
URL: https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/nationaler-aktionsplan-energieeffizienz-nape.pdf?__blob=publicationFile&v=6

Experten-Kommission zum Monitoring-Prozess »Energie der Zukunft« (2021):
Stellungnahme zum achten Monitoring-Bericht der Bundesregierung für die Berichtsjahre 2018 und 2019, Berlin, Münster, Nürnberg, Stuttgart
URL: https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/energieeffiezienzstrategie-2050.html

Grepperud, S., & Rasmussen, I. (2004).
A general equilibrium assessment of rebound effects.
Energy Economics, 26(2), 261–282.

Jin, T., & Kim, J. (2019).
A new approach for assessing the macroeconomic growth energy rebound effect.
Applied Energy, 239, 192–200.

Orea, L., Llorca, M., & Filippini, M. (2015).
A new approach to measuring the rebound effect associated to energy efficiency improvements: An application to the US residential energy demand.
Energy Economics, 49, 599–609.

Lange, S. und Berner, A. (unveröffentlichtes Manuskript),
The Growth Rebound Effect: A Theoretical-Empirical Investigation into the Relation Between Rebound Effects and Economic Growth.

Lange, S., Kern, F., Peuckert, J. & Santarius, T. (2021).
The Jevons paradox unravelled: A multi-level typology of rebound effects and mechanisms.
Energy Research & Social Science, 74, 1-15.
URL: https://www.sciencedirect.com/science/article/pii/S221462962100075X?via%3Dihub

Peuckert, J., & von Andrian, N. (2019). *Dokumentation des zweiten Stakeholder-Workshops des Projekts ReCap: »Politische Maßnahmen zur Eindämmung von Rebound-Effekten«*, Berlin, 21. November 2019.
URL: https://www.macro-rebounds.org/app/dowload/8123877463/ReCap+SW2+Workshop+-+Dokumentation_offiziell.pdf

Petschow, U., Lange, S., Hofmann, D., Pissarskoi, E., aus dem Moore, N., Korfhage, T., Schoofs, A., & Ott, H. (2018):
Gesellschaftliches Wohlergehen innerhalb planetarer Grenzen: Der Ansatz einer vorsorgeorientierten Postwachstumsposition
(No. 89/2018; Texte, p. 194).
URL: https://www.umweltbundesamt.de/publikationen/vorsorge-orientierte-postwachstumsposition

Prognos (2020). *Energiewirtschaftliche Projektionen und Folgenabschätzungen 2030/2050*
URL: https://www.bmwi.de/Redaktion/DE/Publikationen/Wirtschaft/klimagutachten.html

Saunders, H. D. (2013).
Historical evidence for energy efficiency rebound in 30 US sectors and a toolkit for rebound analysts.
Technological Forecasting and Social Change, 80(7), 1317–1330.

Semmling, E., Peters, A., Marth, H., Kahlenborn, W., & de Haan, P. (2016).
Rebound-Effekte: Wie können sie effektiv begrenzt werden?
Umweltbundesamt.

Sorrell, S. (2007).
The Rebound Effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency.
UK Energy Research Centre London.

Stern, D. I. (2020). *How Large is the Economy-Wide Rebound Effect?*
SSRN Electronic Journal.

Zhang, J., & Lawell, C.-Y. C. L. (2017).
The macroeconomic rebound effect in China.
Energy Economics, 67, 202–212.

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