**Developing and modeling policies to reduce rebound effects**

Christian Lutz, GWS mbH, 0049 541 40933120, lutz@gws-os.com

Lara Ahmann, GWS mbH, 0049 541 40933288, ahmann@gws-os.com

Maximilian Banning, GWS mbH, 0049 541 40933286, banning@gws-os.com

## Overview

Increases in energy efficiency are not sufficient to contain the consumption of energy and resources. Efficiency gains may be reduced due to rebound effects, i.e. that the theoretically calculated technically possible saving is not realized (Madlener & Turner 2016). These rebound effects can occur at the micro, meso and macro level (Lange et al. 2019). Literature reviews show substantial differences in macroeconomic rebound effects calculated with resepective models (Banning et al. 2019, Colmenares et al. 2020, Brockway).We concentrate on economy-wide rebound effects and present economic instruments and measures that aim to reduce these effects.

Although there is still a need for research to explain the rebound phenomenon, there are already some publications discussing policies to mitigate rebound effects (e.g. Maxwell 2011, van den Bergh 2011, Vivanco et al. 2016). The analyzes conclude that an absolute limit on energy use or greenhouse gas emissions through so-called "caps" would be the most effective measure against rebounds. In addition to caps, there are also other approaches to contain rebound effects, i.a. taxes, various designs of efficiency promotion, standards and information provision, not least to reduce barriers to the implementation of caps.

In the project ReCap "Reconsidering the Role of Energy and Resource Productivity for Economic Growth, and Developing Policy Options for Capping Macro-Level Rebound Effects." together with the Institute for Ecological Economy Research (IÖW) and the University of Göttingen, we first ask to what extent the less reduced energy consumption - is actually due to rebound effects and not caused by other economic effects. The investigations enable a quantified statement of the effects of policy mixes that aim to reduce rebound effects and thus the consumption of energy and resources in Germany.

## Methods

Based on stakeholderworkshops and results from theoretical analyses regarding the occurrence of macroeconomic rebounds (Banning et al. 2019), different sets of policy measures and instruments directed at the containment of rebounds are developped.

In previous simulations with macroeconomic models, autonomous energy efficency increases were assumed to calculate the indirect and induced impacts on energy use. We will build a reference scenario with similar assumptions and compare it to scenarios with a set of policies that aim to limit rebound and reduce energy use in line with the initial energy efficiency improvements.

One set includes established measures of the energy transformation policy (Set 1). An energy efficiency support programm for industry is included to foster energy efficiency improvement. Carbon tax rates – 60 Euro per t of CO2 in 2026 - of the recent German climate package to reach GHG targets in the non-ETS sectors will also be applied.

Due to doubts that these carbon prices will be sufficient enough to reach the German target to reduce national GHG emissions by 55% until 2030 against 1990 levels, the second set (2) will build on set 1 but will apply higher carbon tax rates to reach GHG reduction targets in the industry sector.

Results will also be compared to similar modelling exercices (Böhringer, Rivers 2018).

## Results

The results in this paper will be derived from a quantitative and empirical analysis of the three scenarios. Therefore, the macroeconometric top-down model PANTA RHEI will be applied (Lutz et al. 2015, Lutz et al. 2021). The model links the energy balance to economic sectors and behavioural equations. Macroeconomic, sector specific and environmental effects are calculated including direct effects and different second-round and feedback effects.

The combination of programmes to promote energy efficiency and CO2 taxes will affect industrial sectors differently depending on technologies and energy use. On the one hand, efficiency measures will be implemented, which is likely to entail additional investment and thus capital costs. At the same time, higher CO2 prices mean that measures to reduce emissions will amortize faster. This may involve substitution of energy sources or reduced energy use.

## Conclusions

By using PANTA RHEI, we can not only identify rebound effects in the German economy, but also investigate measures that are designed to reduce macroeconomic rebound effects. Consequently, we are able to analyze the environmental and economic effects of policy measures and economic instruments to counteract rebound effects.

By comparing the scenarios, conclusions are drawn as to which combination of measures is well suited to effectively reduce macroeconomic rebound effects. The investigation enables model-based statements on the macroeconomic and environmental impacts of selected policies that are rebound-proof or contain macroeconomic rebound effects. Conclusions will be related to the literature. The use of tax revenues with regard to rebounds will also be discussed.

## References

Banning, M., Lutz, C. (2019): Rebound effects in macroeconomic models. Approaches to cover and reproduce, Working Report 2 of the research project ReCap.

Böhringer, C, Rivers, N. (2018): The energy efficiency rebound effect in general equilibrium, Oldenburg Discussion Papers in Economics, No. V-410-18, University of Oldenburg, Department of Economics, Oldenburg.

Brockway, P. E., Sorrell, S., Semieniuk, G., Heun, M. K., Court, V. (2021): Energy efficiency and economy-wide rebound effects: A review of the evidence and its implications, in Renewable and Sustainable Energy Reviews 141 110781 10.1016/j.rser.2021.110781.

Colmenares, G., Löschel, A., Madlener, R. (2020): The rebound effect representation in climate and energy models, Environmental Research Letters 15 123010 10.1088/1748-9326/abc214.

Lange, S., Banning, M., Berner, A., Kern, F., Lutz, C., Peuckert, J., Santarius, T., Silbersdorff, A. (2019): Economy-Wide Rebound Effects: Policies based on theoretical and empirical bottom up and top down analyses.

Lutz, C., Banning. M., Ahmann, L., Flaute, M. (2021): Energy efficiency and rebound effects in German industry - evidence from macroeconometric modeling. Economic Systems Research, submitted.

Lutz, C., Zieschank, R., Drosdowski, T. (2015): Green Economy: Nachhaltige Wohlfahrt messbar machen unter Nutzung der umweltökonomischen Gesamtrechnungs-(UGR) Daten. Umweltbundesamt (UBA) Texte 69/2015, Dessau.

Madlener, R., Turner, K. (2016): After 35 Years of Rebound Research in Economics: Where Do We Stand? In: Santarius et al. (Ed.): Rethinking Climate and Energy Policies. New Perspectives on the Rebound Phenomenon. Springer, New York. S. 17–35.

Maxwell, D., Owen, P., McAndrew, L., Muehmel, K., Neubauer, A. (2011): Addressing the rebound effect, a report for the European Commission DG Environment. Europäische Kommission, Brüssel.

Van den Bergh, J. C. (2011): Energy Conservation More Effective With Rebound Policy. Environmental and Resource Economics 48 (1): S. 43-58.

Vivanco, D., Kemp, R., van der Voet, E. (2016): How to deal with the rebound effect? A policy-oriented approach. Energy Policy 94: S. 114–125.