Executive summary for Energy, expenditure, and consumption aspects of rebound, Part I: A rigorous analytical framework

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Motivations underlying the research

Widespread implementation of energy efficiency is a key greenhouse gas emissions mitigation measure, but rebound can "take back" energy savings. However, the absence of solid analytical foundations hinders empirical determination of the size of rebound. Until now, the microeconomic categories of substitution and income effects provided analytical clarity about how behavior changes affect energy service consumption, but it was unclear how they could be used for precise numerical rebound calculations. Where previous numerical calculations were made, they tended approximate the substitution effect from other goods to the cheaper energy service, without maintaining constant utility for the device user. They also used constant price elasticities for non-marginal efficiency improvements, even though constant price elasticities provide only approximations of substitution and income effects for small efficiency changes. Further, previous analytical studies have stressed the importance of the cost of buying the new device as well as energy embodied in the device. Yet, there is no clearly formulated approach for how to incorporate these cost and energy components into rebound calculations. While recent general equilibrium rebound modeling has led to important insights about the effects of changing prices, dynamic aspects of a macroeconomic rebound have been neglected by these approaches. Finally, rebound involves simultaneous changes in energy, expenditure, and consumption aspects, and keeping an overview of all aspects is hard, with no approach to our knowledge documenting all changes in a straightforward manner. A new clarity is needed, one that is built upon solid analytical frameworks involving both economics and energy analysis.

Short account of the research performed

In this paper (Part I of a two-part paper), we help advance a rigorous analytical framework that starts at the microeconomic level and is approachable for both energy analysts and economists. We develop the first (to our knowledge) rebound analysis framework that (i) clarifies the energy, expenditure, and consumption aspects of rebound, (ii) combines embodied energy effects with maintenance and disposal effects (under a new "emplacement effect" term), and (iii) encompasses non-marginal energy efficiency increases and non-marginal energy service price decreases. Furthermore, we develop the first operationalized link between rebound effects on microeconomic and macroeconomic levels.

The key contributions of this paper are (i) a novel and clear explication of interrelated energy, expenditure, and consumption aspects of energy rebound, (ii) development of the first (to our knowledge) rebound analysis framework that combines embodied energy effects, maintenance and disposal effects, non-marginal energy efficiency increases, and non-marginal energy service price decreases, and (iii) the first operationalized link between rebound effects on microeconomic and macroeconomic levels.

Main conclusions

Development of the rigorous analytical rebound framework shows that it is possible to quantify rebound magnitudes simultaneously at microeconomic and macroeconomic levels, including direct and indirect rebound and emplacement, substitution, income, and macro effects.

Potential benefits, applications, and policy implications

With careful explication of rebound effects and clear derivation of rebound expressions, we facilitate interdisciplinary understanding of rebound phenomena toward the goal of enhancing clarity in the field of energy rebound and enabling more robust rebound calculations for sound energy and climate policy.