**Energy, expenditure, and consumption aspects of rebound, Part I: Foundations of a rigorous analytical framework**

*Matthew Kuperus Heun*[[1]](#footnote-1)*, Gregor Semieniuk*[[2]](#footnote-2)*, and Paul E. Brockway*[[3]](#footnote-3)

**Executive summary**

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. A new clarity is needed, one that is built upon solid analytical frameworks involving both economics and energy analysis.

In this paper (Part I of two), we advance foundations of a rigorous analytical framework that starts at the microeconomic level and is approachable for both energy analysts and economists. We develop foundations of a consumer-sided rebound analysis framework that clarifies the energy, expenditure, and consumption aspects of rebound, combines embodied energy effects with operations, maintenance, and disposal effects (under a new “emplacement effect” term), and provides the first operationalized link between rebound effects on microeconomic and macroeconomic levels. Furthermore, our framework enables exact analytical determination of the effect of non-marginal energy service price decrease, the effect of satiation of energy service demand for the energy service, and the effect of reduced energy demand on energy price.

This paper helps advance the analytical foundations for empirical analyses and 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.

**Keywords** Energy efficiency, Energy rebound, Energy services, Microeconomic rebound, Substitution and income effects, Macroeconomic rebound

1. Corresponding author. Engineering Department, Calvin University, 3201 Burton St. SE, Grand Rapids, MI, 49546; Sustainability Research Institute, School of Earth and Environment, University of Leeds, Woodhouse, Leeds, LS2 9JT, UK; School for Public Leadership, Faculty of Economic and Management Science, Stellenbosch University, Private Bag X1, Matieland, 7602, Stellenbosch, South Africa [↑](#footnote-ref-1)
2. Political Economy Research Institute and Department of Economics, University of Massachusetts Amherst, Amherst, MA, 01003 [↑](#footnote-ref-2)
3. Sustainability Research Institute, School of Earth and Environment, University of Leeds, Woodhouse, Leeds, LS2 9JT, UK. [↑](#footnote-ref-3)