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Rebound Effects in the Context of Developing Country Efficiency



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FINAL REPORT

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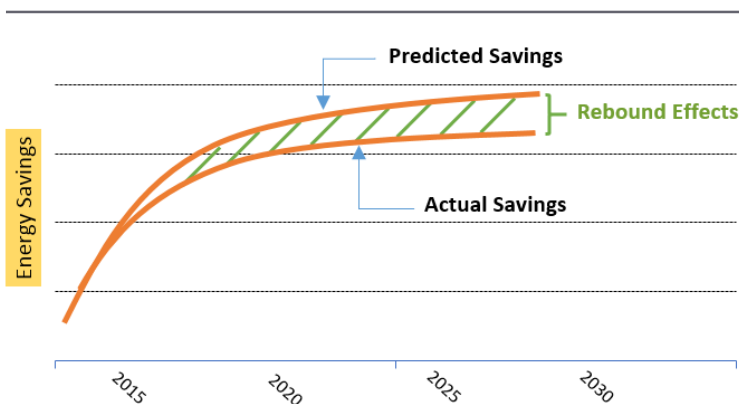
Contents

1. Introduction.....	4
2. What are Rebound Effects?.....	5
3. How Big are Rebound Effects?.....	6
4. Rebound Effects and Multiple Benefits of Energy Efficiency.....	8

1. Introduction

Energy efficiency-related “rebound effects” usually refer to the tendency of most consumers to increase their use of energy services in response to efficiency measures that have reduced their energy costs. This phenomenon is one reason why energy efficiency policies often result in lower energy savings than engineering-based estimates predict. Rebound effects have been the subject of intense debate in the field of energy efficiency policy for many years.¹ In the past, the focus of this debate has been on the perceived loss of the expected energy savings and related benefits resulting from the rebound effects. However, more recently, there has been a growing recognition that policymakers need to consider the health,

FIGURE 1. Rebound Effects



economic and other non-energy benefits that often result from the increase in energy services represented by user “rebound effects”. This is especially true in developing countries where basic energy service demands—such as lighting, heating, cooling, and refrigeration of food—are often not being met. As economic conditions improve and household incomes increase, demand for increased energy services (such as space conditioning and appliances) tends to rise rapidly. Improving energy efficiency

reduces the amount of energy needed to produce one unit of energy service output (for example an hour of cooling at 21°C delivered for X vs Y kWh). Greater efficiency therefore often enables more rapid increased in energy services (and sometimes access), expanding the amount of services that can be provided by a fixed amount (or cost) of energy. Therefore, to assess the costs and benefits of efficiency measures, especially in developing economies, it is important to take into account both the potential impact on energy savings, and the non-energy benefits indicated by rebound effects.² As highlighted in a recent International Energy Agency (IEA) publication, “Where energy savings are ‘taken back’ in the achievement of health benefits, poverty alleviation, or improving productivity, the rebound effect can be viewed as having a net positive outcome, amplifying the benefits of the energy efficiency intervention.”³

¹ Gillingham, K., M. Kotchen, D. Rapson, G. Wagner, 2013. The Rebound Effect is Over-played. *Nature*, 493: 475-476. <http://www.nature.com/nature/journal/v493/n7433/full/493475a.html>

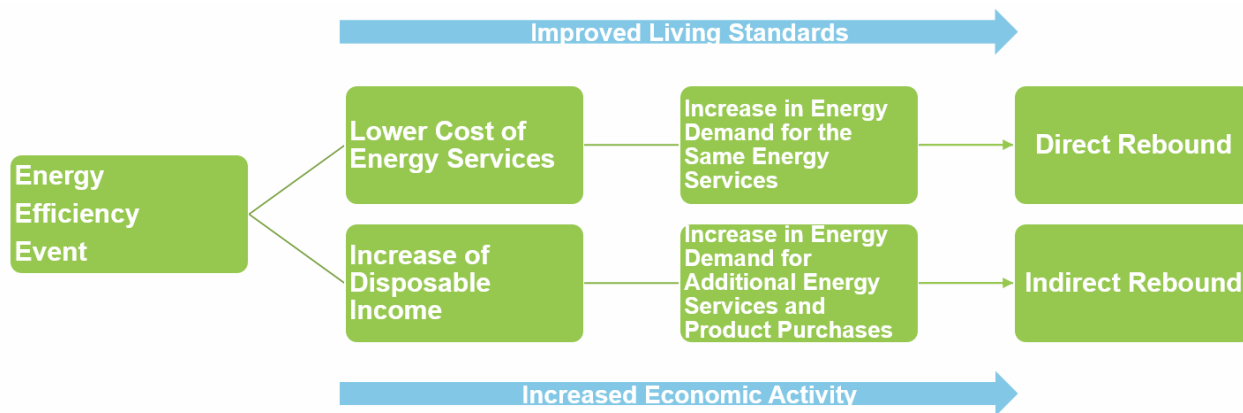
² Non-energy benefits are the valuable outcomes of efficiency improvements that are not directly energy-related, for example the creation of jobs, improved health, etc.

³ IEA, 2014. “Capturing the Multiple Benefits of Energy Efficiency”. [https://www.iea.org/bookshop/475-Capturing the Multiple Benefits of Energy Efficiency](https://www.iea.org/bookshop/475-Capturing%20the%20Multiple%20Benefits%20of%20Energy%20Efficiency)

2. What are Rebound Effects?

As described above, rebound effects are behavioral reactions to the lower cost of energy services resulting from energy efficiency improvements and, for this reason, they are often treated the same as demand elasticities for modeling purposes. Rebound effects may cause a portion of anticipated reductions in energy consumption to be offset by increased demand for the same or other energy services. In other words, the financial savings accrued from increased efficiency are spent on a larger amount of energy services. [In economies where energy supply is restricted, energy efficiency measures may simply permit the available supply to provide more energy services.] Rebound effects can be categorized as *direct rebound*—the increase in consumption of the targeted energy service due to its lower cost—and *indirect rebound*—the increased consumption of non-targeted energy services due to a rise in disposable income.

FIGURE 2. Simplified representation of direct and indirect rebounds



Efficiency improvements generally decrease energy consumption, i.e., require less energy to provide a given level of energy service. This decrease can be accurately measured in engineering terms. However, the effects of subsequent consumer behavior on actual energy savings is more difficult to predict. Rebound effects usually offset a small portion of expected energy-use reductions (0-30%), either directly or indirectly. In rare cases, the responses of certain consumers to efficiency improvements may entirely offset the expected energy savings, a phenomenon sometimes referred to as “backfire”. While experts agree on the existence of rebound effects, there is much debate on their magnitude.⁴

⁴ Sorrell, S., 2007. “The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency”. A report produced by the Sussex Energy Group for the Technology and Policy Assessment function of the UK Energy Research Centre.

3. How big are Rebound Effects?

Rebound effects are generally expressed as the percentage of lost benefit compared to the estimated energy savings based on the tested performance of the relevant efficiency measure(s). Determining this ratio, however, is a very difficult analytical task because of the many different factors that affect energy use before and after the adoption of energy efficiency measures, and the general tendency of energy use (and related services) to increase over time, along with household income and general economic growth. Based on a range of studies, this ratio appears to vary widely depending on the type of equipment or energy use targeted, the magnitude of the efficiency improvements considered, and the class of consumers affected. Since rebound effects cannot be quantified with great confidence or precision, they are often indicated as broad ranges. A 2014 literature review⁵ by Economic Consulting Associates (ECA)—accounting for over 163 published studies containing a total of 241 estimates—provides a range of rebound effect estimates for different sectors and country income level groups (see Table 1). Although there is a considerable literature on rebound in developed countries, there are few studies of rebound in developing economies. Only 34 estimates of rebound effects were found for the middle- and low-income country group in the ECA literature review.

TABLE 1. Ranges (25th to 75th percentile) of estimates for rebound effects for different sectors

			Residential (Non-Heating)	Industrial and Commercial
Country Group	High Income	Direct effect	0-20%	0-20%
		Total/economy-wide effect	10-30%	20-40%
	Middle + Low Income	Direct effect	10-30%	0-20%
		Total/economy-wide effect	30-50%	20-40%

Source: ECA, 2014

Table 1 provides ranges for estimates of direct rebound effects and economy-wide rebound effects. No estimates are given specifically for indirect rebound effects due to the lack of studies found. Indirect rebound effects are rarely estimated due to the difficulties of determining the type of goods bought with the financial savings and estimating their energy intensity (per \$) compared to the energy intensity of the equipment targeted and the difficulty of distinguishing these types of impacts from changes caused by other factors.

⁵ Economic Consulting Associates, 2014. “The Rebound Effect for Developing Countries”, Phase 1 Final Report, Evidence on Demand with the assistance of the UK Department for International Development (DFID).



While direct and indirect effects are assessed using a micro-economic approach, which looks at individual consumption behavior, economy-wide effects are based on a macro-economic approach that looks at total energy consumption. Care should be taken in adopting the estimates shown in Table 1 for economy-wide rebound effects, as the evidence base is both small and subject to theory-driven models with limited empirical evidence.⁶ Moreover, other literature review studies have found different estimates; see Nadel (2012)⁷ for example.

From this review, it is interesting to note (1) that direct rebound effects in developing countries are not dramatically higher than in developed countries, and (2) that too much uncertainty on indirect rebound exists to estimate its impact in a systematic way.

⁶Economy-wide rebound effects are generally calculated using economic models such as Computable General Equilibrium (CGE) or macroeconomic models where end-use energy efficiency is difficult to integrate. (see Sorrell, 2007)

⁷ Nadel, Steve, 2012. "The Rebound effect: Large and Small?" White Paper, American Council for an Energy-Efficient Economy (ACEEE). <http://aceee.org/sites/default/files/pdf/white-paper/rebound-large-and-small.pdf>

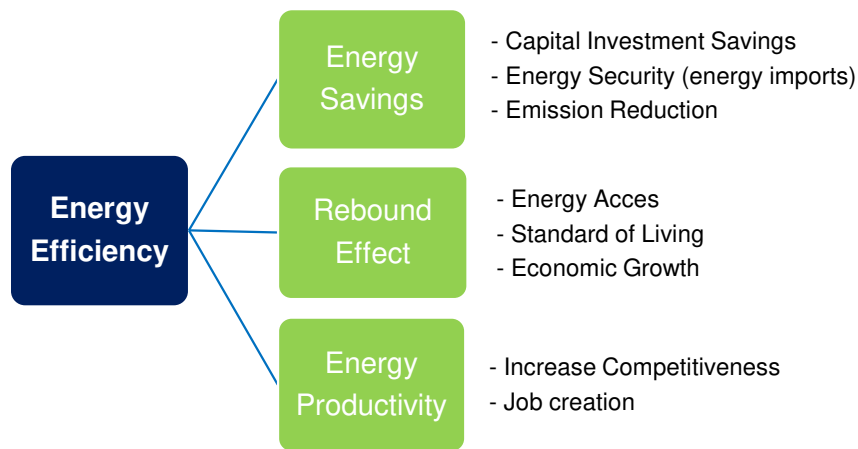


4. Rebound Effects and Multiple Benefits of Energy Efficiency

While rebound effects may offset some of the energy-use reductions achieved by energy efficiency policies, they also indicate that energy efficiency is facilitating greater service value for consumers. This added value could lead to healthier and more comfortable indoor environments, improved lighting and increased access to refrigerated food, all of which lead to an improved standard of living.

The value of energy efficiency policies should be measured not just by their efficacy in lowering energy consumption, but by their overall social, economic, and environmental benefits. Figure 1 outlines a variety of social, economic, and environmental benefits that different aspects of energy efficiency create—including rebound effects.

FIGURE 3. The multiple benefits of energy efficiency



In communities where energy access is strictly limited, the largest benefit of energy efficiency policies may be an increase in access to energy services, and this benefit could potentially lead to no decrease in overall energy consumption. Taking into account different stakeholder perspectives and the perspective of society as a whole, policymakers should analyze these trade-offs in order to choose energy efficiency measures and programs that will increase the country's overall welfare.