Hot topic: Does energy efficiency lead to increased energy consumption?

By Making It on 16 June, 2011

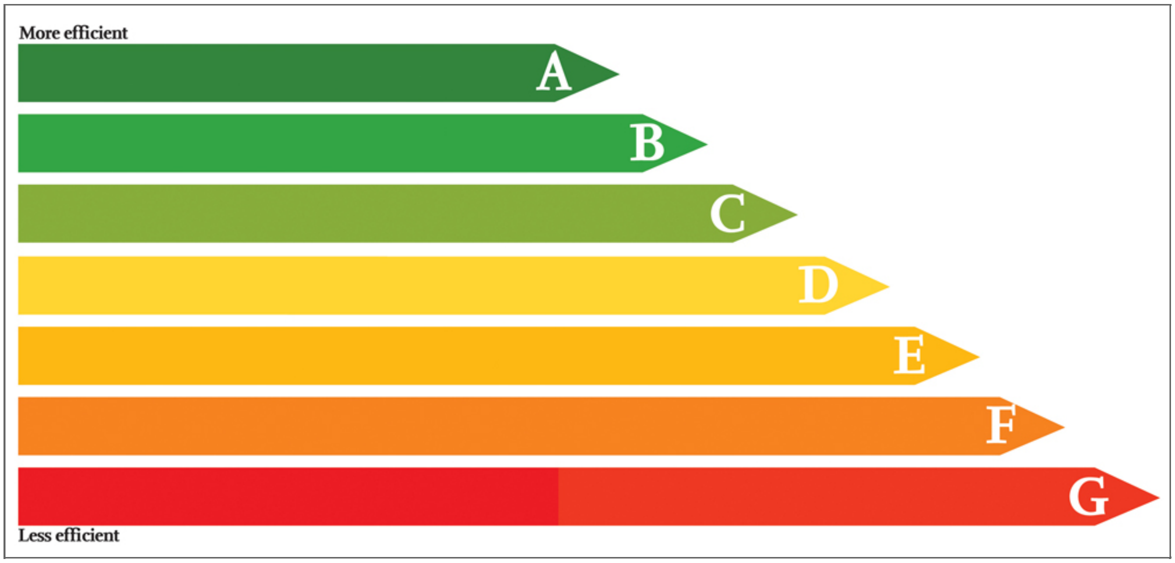
In February 2011, the Breakthrough Institute published a comprehensive review of the literature and evidence for rebound effects which concluded that a large amount of the energy savings from below-cost energy efficiency are eroded by demand rebound effects. In some cases, the rebound exceeds the savings, resulting in increased energy consumption from efficiency, known as backfire.

Jesse Jenkins and Harry Saunders outline the importance of the rebound effect. In response, Marianne Moscoso-Osterkorn, Director General of the Renewable Energy and Energy Efficiency Partnership (REEEP), argues that energy efficiency yields considerable economic and energy security benefits, and that measures to improve it are always justified.

Rethinking rebound and efficiency

Energy efficiency is widely viewed as an inexpensive way to reduce energy consumption and drive reductions in global emissions of greenhouse gases. Efficiency policies feature prominently in the toolkits of many national governments, international development agencies, and NGOs, and both the International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC) estimate that energy efficiency measures will do the heaviest lifting as the world seeks the emissions reductions needed to stabilize the global climate. This focus on efficiency is particularly prominent in the world's emerging economies, where getting more out of less energy is seen as a key path to both sustainable growth and reduced climate risk.

Yet recent research, including new reports authored by each of us, highlights a powerful but largely overlooked economic phenomenon that requires a global rethink of energy efficiency and its role in climate mitigation and sustainable development strategies: the rebound effect.



Energy efficiency rating labels are now found in many new buildings and on household appliances and electronics, allowing consumers to gage their energy usage

Truly cost-effective energy efficiency measures lower the effective price of the services derived from fuel consumption – heating, cooling, transportation, industrial processes, etc. – leading consumers and industry alike to demand more of these services. There are other indirect and economy-wide effects as well, as consumers re-spend money saved through efficiency on other energy-consuming goods and services, industrial sectors adjust to changes in the relative prices of final and intermediate goods, and greater energy productivity causes the economy as a whole to grow. Collectively, these economic mechanisms drive a rebound in demand for energy services that can erode much – and in some cases all – of the expected reductions in total energy use, along with much-hoped-for reductions in greenhouse gas emissions.

Furthermore, rebound effects are often most pronounced in the productive sectors of the economy, including industry and agriculture, as well as throughout the world's emerging economies.

Anything but linear and direct

These rebound effects run counter to a core assumption of conventional energy and climate forecasting and analysis: the idea that efficiency improvements lead to a linear, direct, and one-for-one reduction in overall energy use.

Estimates of the energy use and emissions reductions possible through efficiency are typically derived from 'bottom-up' engineering models and calculations of the cost effective efficiency opportunities available in each economic sector. Analysts then sum up the available efficiency measures in each sector to determine the gains possible for the economy as a whole, and subtract these efficiency gains from business-as-usual forecasts of energy use accordingly. This basic method is at the heart of widely cited climate and efficiency strategies authored by McKinsey and Company, the IEA, and the IPCC.

Crucially, these studies assume no feedbacks between improvements in energy efficiency and either economic activity or demand for energy services. Thus, a given percent gain in efficiency is assumed to lead simply and directly to an equivalent and equal percent reduction in total energy use. In reality, however, the economy is anything but direct, linear, and simple, especially when responding to changes in the relative price of goods and services.

When a good or service, or input, to production gets cheaper, consumers and firms use more of it, find new cost-effective uses for it, and on top of this re-invest any savings in other productive activities. Meanwhile, any net improvement in energy productivity contributes to economic growth.

No paradox

Often labeled "Jevons' Paradox," after the British economist who first noted the mechanism in an 1865 treatise, rebound effects actually operate through well-understood economic principles of demand elasticity, substitution, and the contribution of productivity to economic growth.

Economists would never assume, for example, that a ten percent improvement in labour productivity – also known as a "labour efficiency" improvement – would reduce overall demand for labour in the economy by 10%.

Energy efficiency can reduce the costs of operating container terminals. Siemens Drive Technologies have improved control functions for the operation of rubber-tired gantry cranes, with a resultant 70% reduction in fuel consumption | Image: Siemens

At the scope of the individual factory or assembly line, improving labour productivity may mean the plant can get by with fewer laborers on the shop floor. Yet here again, higher labour productivity lowers product costs, increases demand for those products, and opens up new markets that were not previously profitable. It frees up money to re-invest in other areas of production, and it creates new jobs in other areas of business. All of these dynamics cause a rebound in labour demand.

At the macroeconomic level, it is widely understood that improving labour productivity drives economic growth, creates new profitable ways to utilize labour, and generally increases overall employment, rather than decreases it. And despite the simplified assumptions common to energy forecasting and analysis, the reality is that energy isn't different from labour, or materials, or capital.

Rebound likely to be largest where least studied

Dozens of academic studies have examined the empirical evidence, conducted modeling inquiries, and otherwise tested the scale of rebound effects. Rebound effects differ in scale, depending on the type of energy efficiency improvement and the sector of the economy in question. As it turns out, rebounds are generally smallest in exactly the situations that have received the most research to date: for improvements in the efficiency of end-use consumer energy services in wealthy, developed economies. This includes efficiency improvements in personal transportation, home heating and cooling, and appliances. Here, relatively wealthy consumers already fully enjoy most energy services, or come close to it. A consumer may gain little utility, for example, from heating his or her home above a comfortable room temperature, even if the efficiency of home heating improves.

The direct increase in demand for these end-use energy services due to the decrease in their apparent price is therefore relatively modest, and commonly erodes 10-30% of the initial energy savings or less.

Additional indirect and macroeconomic effects may mean total energy demand rebound can erode roughly one quarter to one third of the expected energy savings arising from end-use efficiency measures in developed economies.

However, the consumption of end-use services in the world's wealthy nations is far from indicative of broader trends across the global economy. In fact, the largest rebound effects are typically found elsewhere: in the productive sectors of the economy that consume the bulk of energy in any nation, and in the world's emerging economies, home to the vast majority of future energy demand growth.

Emerging economies

In contrast to conditions in wealthy nations, demand for energy services is far from saturated throughout the developing world. After all, roughly one-third of the global population still lacks sufficient access to even basic modern energy services.

In the world's emerging economies, the cost and availability of energy services is often a key constraint on their enjoyment. Demand is thus far more elastic (responsive to changes in price), and rebound effects much larger than in the developed economies. That in turn means rebound effects are much larger.

Very few studies have carefully examined rebound dynamics in developing economies, but those that have find direct rebound effects alone to be on the order of 40-80% for end-use consumer energy services, such as lighting and cooking fuel – more than twice as large as the equivalent rebounds found in wealthier nations.

As a wide body of development literature recognizes, expanding access to modern energy services is also a principal driver of development outcomes. Whether such services are provided by burning more fuels, burning them more efficiently, or both (the most likely scenario), the outcome is the same: greater economic activity and expanding welfare, which in turn demands more energy.

Energy analysts must therefore be very careful in generalizing experiences or intuitions about rebound effects in rich, developed nations to the larger bulk of the global population living in developing economies. The shadow of Jevons' Paradox still looms large over much of the developing world.

Productive sectors

Far more study of rebound effects for efficiency improvements in producing sectors (e.g. industry, commerce, and agriculture) is also warranted, given the fact that roughly two-thirds of global energy is consumed in the production and transportation of goods and services, and the refining, processing, and delivery of energy to end-uses.

However, the literature to date indicates that direct rebound effects are much larger in the productive sectors than in end-uses – on the order of 20-70% for these sectors, at least within a United States context – with additional rebound due to indirect and macroeconomic effects.

Rebound effects in productive sectors depend principally on the ability of firms to rearrange their factors of production (labour, capital and equipment, and various materials) to better take advantage of now-cheaper energy services (a process known in economics as input or factor substitution). If, over the long-term, it is relatively easy for firms to substitute increasingly efficient energy services for other production factors, direct rebound effects can be substantial. This is especially true for decisions related to the construction of new productive capacity – and so we should again expect more pronounced rebound in the fast-growing productive sectors of emerging economies.

Additional mechanisms add to the scale of rebound, as consumers demand more of now-cheaper products and economic productivity overall improves.

Where does this leave us?

Conventional climate mitigation strategies count on energy efficiency to do a great deal of work. For example, the IEA in a global climate stabilization scenario published by the agency in December 2009, estimates that efficiency measures could account for roughly half of the emissions reductions needed. Yet, from a climate or global resource conservation perspective, rebound effects mean that for every two steps forward taken through greater efficiency, rebounds take us one (or more) steps backwards. This is particularly true throughout the developing world, and in the productive sectors of the global economy.

A clear understanding of rebound effects therefore demands a fundamental re-assessment of energy efficiency's role in global climate mitigation efforts.

A continued failure to accurately and rigorously account for rebound effects risks an over-reliance on the ability of efficiency to deliver lasting reductions in energy use and greenhouse gas emissions. Without a greater emphasis on the other key climate mitigation lever at our disposal – the de-carbonization of global energy supplies through the deployment and improvement of low-carbon energy sources – the global community will fall dangerously short of climate mitigation goals.

At the same time, however, we can re-affirm the role of energy efficiency efforts in expanding human welfare and fueling global economic development. Unlocking the full potential of efficiency may very well mean the difference between a richer, more efficient world, and a poorer, less efficient world. The former is clearly the desirable case – even if the world uses more or less the same amount of energy in either scenario.

The pursuit of any and all cost-effective efficiency opportunities should thus continue as a key component of an efficient course for global development, even as we reconsider the degree to which these measures can contribute to climate mitigation efforts.

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● *Read part two in this series:* Hot topic: The many benefits of energy efficiency ←

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