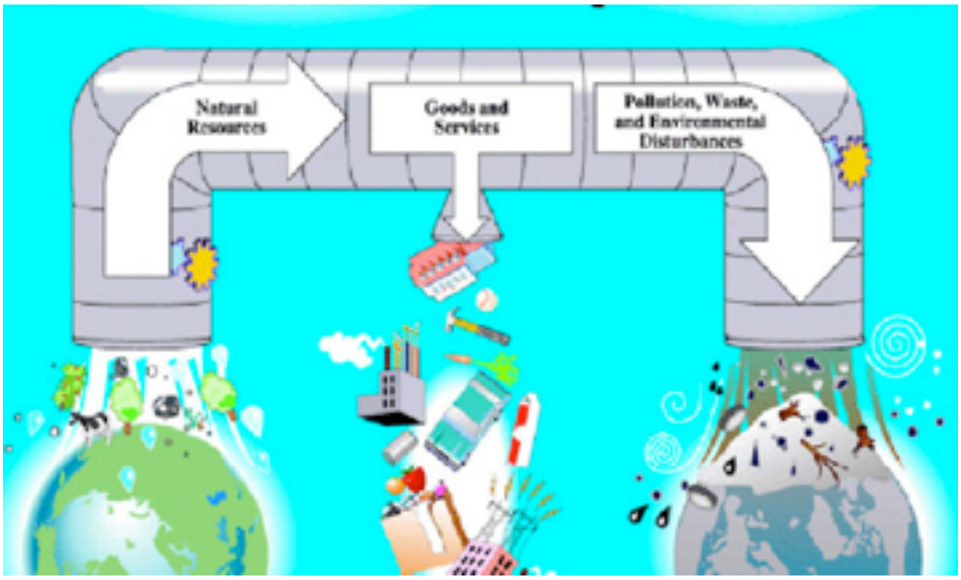
Efficiency Paradox

Paradoxically, all the productivity-enhancing efficiency innovations of the past have resulted in more consumption, pollution, and waste in absolute terms than ever before.

Today, a staggering one-half to three-quarters of the resources consumed annually by industrial economies are returned to the environment as waste within a year.[1]



Related to this massive increase in resource and waste throughput is the so-called "rebound" or "takeback" effect. While efficiency gains are common sense measures, this has not stopped critical commentaries. The prime criticism is that efficiency is not a panacea - a cure-all. The argument has weak and strong versions.

The weak version is more rhetorical than substantive, arguing that efficiency doesn't solve the problem of adequate clean energy supply, let alone total reduction of CO_2 emissions. No efficiency expert has ever made such a moronic claim, and such critics are guilty of foisting a false dilemma fallacy into the debate.

The strong version of the argument goes by various other names, mainly the snap-back effect, the Jevons Paradox, or the Khazzoom–Brookes postulate. The phenomenon is real, whereby a person who buys a more energy efficient product that costs less to use may end up increasing its usage, hence increasing energy consumption.

More broadly, as individuals make microeconomic decisions to purchase energy efficient products, the cost of manufacturing goes down, resulting in macroeconomic expansion of the product as more people can afford to purchase the lower cost goods.

This is seen in national statistics whereby the absolute amount of energy consumption rises as the economy grows bigger and bigger, even as the energy used per unit of economic growth steadily declines.

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[1] Emily Matthews et al, The Weight of Nations, World Resources Institute, 2000, www.wri.org/ .

Again, the criticism seems to imply that efficiency is no panacea, and again, that is a straw man fallacy attacking something efficiency proponents have not claimed.

The rebound effect also occur,s as when someone purchases a more efficient refrigerator, then also decides to get a larger model size, potentially canceling out the energy savings. The same holds true for upsizing to efficient, but larger homes, bigger cars, larger television sets. But this is not always the case.

Take refrigerators as an example. The share of US households with two or more refrigerators increased by 5.2% between 2001-05.

However, during the same period the total electricity consumed by the fleet of growing refrigerators declined by 3.3%.

On a per capita and per household basis the decrease was nearly 7% (see Table-1).

Essentially the energy efficiency gains, which averaged 3.6% per year since 1990, were sufficient to reduce total electricity consumed by refrigerators in US households.

Table-1 Refrigerators--Household Energy Consumption (US)	2001	2005	% change (2001-05)
1. Share of households with ≥ 2 refrigerators	16.9%	22.1%	5.2% ▲
2. Total electricity consumed by refrigerators (billion kwh)	156.1	151	-3.3% ▼
3. Refrigerator electricity per household (kwh)	1,462	1,359	-7.0% ▼
4. Refrigerator electricity per capita (kwh)	547.6	510.8	-6.7% ▼

Source: Residential Energy Consumption Survey (RECS), EIA

The same trend is true for Canada, also where the total energy needed for household refrigerators declined by 42% since 1990.

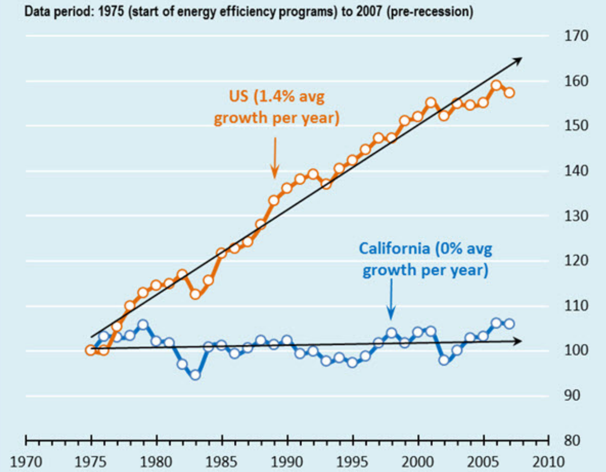
Or take the case of building efficiency improvements, as shown in Exhibit 7.

California, which is among the most energy efficient economies in the world, has pursued efficiency policies since 1974.

They have achieved dramatic improvements in the average per capita electricity consumption for over three decades.

In comparison if the rest of the U.S. had followed California's efficiency leadership, they could have avoided constructing 160,000 MW of unnecessary fossil fuel power plants.

Exhibit-7
Electricity use per capita trend—California & Rest of the US
Data period: 1975 (start of energy efficiency programs) to 2007 (pre-recession)



Source: EIA * Base year 1975=100

So, when efficiency critics argue its not a panacea, point out it's a "meso-acea" (not a cure-all, but half the cure) and never claimed to be a panacea.

Yet, the snapback effect remains one of the most persistent common criticisms of energy efficiency policies and programs, with critics arguing that efficiency proponents overstate energy savings by ignoring the direct rebound effect.[2,3]

Some critics have gone so far as to suggest that improvements in energy efficiency could result in an increase, rather than a decrease, in energy use

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2 Inhaber, H. 1997. Why Energy Conservation Fails. Westport, CT: Quorum Books.

3 Brookes, L. 2000. "Energy Efficiency Fallacies Revisited." Energy Policy 28: 355-366.

due to the rebound effect.[4]

The key issue is the magnitude of the rebound effect. Does empirical evidence suggest it is large or small?
This question has been addressed in in-depth literature reviews.[5],[6]

After examining econometric studies and direct measurements of the rebound effect for different sectors and major end-uses in the United States, research findings indicate the effect is very small.

It is less than 10% for residential appliances, residential lighting and commercial lighting, and less than 20% for industrial process uses.

For residential space heating, water heating and automotive transport, the rebound effect is small to moderate (from less than 10% to 40%). And for residential space cooling, the rebound effect is in the range of 0-50% (see Table above).

Summary of Empirical Evidence of the Rebound Effect in the United States

Sector	End Use	Size of rebound effect
Residential	Space heating	10-30%
Residential	Space cooling	0-50%
Residential	Water heating	<10-40%
Residential	Lighting	5-12%
Residential	Appliances	0%
Residential	Automobiles	10-30%
Business	Lighting	0-2%
Business	Process uses	0-20%

Sources: IEA 1998; Greening, Greene and Difiglio 2000.

Other assessments looked in more detail at studies of the rebound effect associated with vehicle efficiency improvements in the United States, i.e. the change in vehicle use as the fuel cost per mile declines.

The findings showed the overall experience with fuel price and fuel economy changes over 25 years lead to a short run rebound effect on the order of 10% and a long run effect of about 20%. The author notes, "the implication is that 80-90% of the maximum potential reduction in fuel consumption and greenhouse gas emissions due to a technical change in vehicle efficiency will be realized, even after the increase in vehicle miles due to lower per mile costs has had its full effect."[7]

In essence, the rebound effect is a dynamic phenomenon. It tends to decline over time as the saturation and quality of energy services increase.

In a 2005 review for the International Energy Agency, leading efficiency expert Howard Geller and co-author Sophie Attali emphasized,

> "It is important to note that the direct rebound effect, to the extent that it occurs, is not evidence that energy efficiency is a failure. It simply means that some consumers choose to respond to reduced energy costs in part by increasing their level of energy service, for example by increasing their level of space heating or cooling, rather than minimizing energy consumption and energy costs. Energy efficiency improvements still contribute to an

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[4] Khazzoom, J.D. 1980. "Economic Implications of Mandated Efficiency in Standards for Household Appliances." The Energy Journal 1(4): 21-40.

[5] IEA [International Energy Agency]. 1998. The Rebound Effect: A Review of U.S. Literature. Draft Report. IEA/SLT/EC(98)1. Paris, France: OECD/IEA.

[6] Greening, L.A., D.L. Greene and C. Difiglio. 2000. "Energy efficiency and consumption – the rebound effect – a survey." Energy Policy 28(6-7): 389-401.

[7] Greene, D.L. 1998. "Why CAFE worked." Energy Policy 26(8): 595-614.

improvement in 'general welfare' whether by enabling a higher level of comfort, increased activity, or lower energy cost, or some combination of these responses."[8]

Efficiency backbone of economic growth

There is another dimension to the rebound issue, however, that seems totally lost on efficiency critics.

It has been the ongoing efficiency revolution that has enabled manufacturing and vast expansion of lower cost goods and services, making them accessible to an increasing fraction of humanity; goods that were previously limited to kings and queens and the wealthiest individuals.

Efficiency gains are instrumental in lifting all of humanity out of grinding poverty.

This is a critically important function of efficiency, above and beyond, but also integral to, the myriad of sustainability challenges efficiency also addresses.

Myriad barriers thwarting efficiency gains

Efficiency gains are universally accepted in spirit and rhetoric, but far less so in actual practice.

The traditional economist's view is that the market will provide the correct level of efficiency, and the only thing of concern is to get the prices right.

However, the empirical evidence is emphatically clear on this point: market prices, alone, are not adequate.

This is evident in utility districts with electricity prices ten times higher than another utility district.

For example, high-electricity cost Chicago is achieving many-fold less efficiency improvements than low-electricity-cost Seattle.

And high-cost Singapore has achieved much less efficiency than San Francisco with half the cost levels.

There is also the egregious situation where poor households and cash-strapped businesses, particularly throughout the developing world, or during economic downturns, are simply unable to respond to high cost energy.

They are forced to go without, or accelerate damage to the environment (deforesting surrounding areas while scavenging for fuelwood), or simply steal from the power system.

The reality is, there is a thicket of market barriers thwarting most of these savings.

This is not surprising, given several centuries of public policies promoting supply expansion via R&D, standards and codes, financing, educating skilled professionals, subsidies, etc., while ignoring the customer-side opportunities at the end-use.

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[8] op cit., Geller and Attali.

It is clear from the accumulated experience and evidence from the leading cities, states and nations vigorously pursuing efficiency, that with equivalent commitment of time and resources end-use efficiency emerges as a robust competitor to any supply option.

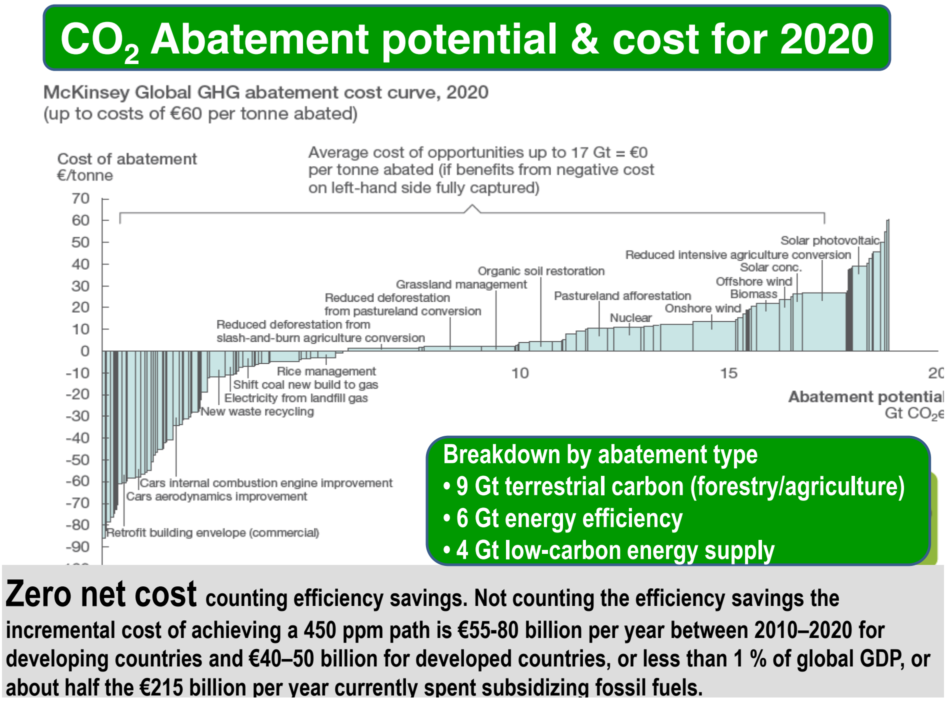
The economic benefits are obvious, detailed in scores of economic-engineering assessments over the past four decades.

The 2007 assessment by the McKinsey Global Institute (chart on right) concluded that energy efficiency improvements worldwide through 2030 could provide an estimated 75% of projected new energy service demand with a 10% or better return on investment.[9]

Technology can deliver, but the financial wherewithal is absolutely essential to take advantage.

Efficiency improvements, like solar and wind power, require more upfront capital, unlike coal and natural gas power plants, where fuel costs constitute a significant percentage of lifecycle costs.

Efficiency improvements constitute the largest pool of potential lost opportunities in the energy sector, given that a significant percentage of efficiency gains take place at the manufacturing and construction phases. Far fewer efficiency savings are available after these phases, and at much higher cost.



One immense source of finance capital resides in the utilities throughout the world.

Tens of trillions of dollars will be invested in the coming decades, virtually all for supply expansion.

Most of the funds will go to expanding fossil fuel power plants, typically at a regulated rate of earnings of about 10 to 12 percent.

Utilities (electric, natural gas, water, sewage) are long overdue for a makeover, transitioning them from antiquated regulatory practices designed for last century's industrial smokestack era to state-of-play methodologies designed for 21st century technology and delivered service opportunities.

Without significant changes in utility regulatory planning and incentive rate methodologies, as well as government policies spurring stronger efficiency performance standards and codes for buildings, vehicles, appliances, motors, lights and other energy and water consuming devices, it is highly unlikely that more than 10 to 20 percent of the efficiency gains will be achieved.

For three decades pioneering states like California have been incentivizing utilities with innovative regulatory procedures that encourage them to invest their long-term, relatively lower-interest capital in the large pool of customer-site LCR efficiency improvements.

9 McKinsey Global Institute, 2007, Curbing global energy demand growth: The energy productivity opportunity, www.mckinsey.com/mgi/publications/Curbing_Global_Energy/index.asp

It is proving beyond a shadow of a doubt to be a win-win-win outcome for ratepayers, shareholders, and taxpayers. (See chapters on social/public capital assets, pp. XX, and the chapter on financial capital assets, pp. XX, for more thorough discussions).