FRAUNHOFER INSTITUTE FOR SYSTEMS AND INNOVATION RESEARCH ISI

HOW ENERGY EFFICIENCY CUTS COSTS FOR A 2-DEGREE FUTURE

Executive Summary

About 40% of global greenhouse gas (GHG) emissions originate from energy use in industry, transport, and buildings, and another 25% from power generation (IPCC 2014). A highly efficient use of energy is thus fundamental to limit GHG emissions. Yet, energy efficiency receives much less attention than the decarbonization of the energy supply. A recent report by the International Energy Agency states that **global energy efficiency (EE) investments since 1990 have avoided more than 870 $MtCO_2e$ (megatons of CO_2-equivalent emissions) in 2014, while reducing fuel costs by 550 billion US Dollar (IEA 2015)**. For this reason, the IEA calls EE the "first fuel" in the context of decarbonization.

This study indicates that scenarios with higher EE mostly show lower abatement costs. This was the result of evaluating the large number of existing scenarios that comply with the internationally agreed 2°C target until 2050. The societal costs of decarbonization in these scenarios vary strongly and a detailed assessment of the potential cost reductions due to EE is lacking. In order to close this gap, **this study estimates the global cost savings up to 2030 associated with a decarbonization pathway with a strong focus on EE measures.** Based on an unpublished update of McKinsey's bottom-up estimates of the potentials and costs of EE options and alternative decarbonization measures (McKinsey & Company forthcoming), this study compares the costs of an *energy-efficient pathway* with an *energy-intensive pathway* that focuses on decarbonizing the energy supply and only uses EE to the extent additionally required to keep emissions in line with the 2°C target.

In accordance with the scenario from the World Energy Outlook considered to be in line with the 2°C target (IEA 2012), **both pathways reduce the global level of annual energy-related GHG emissions in 2030 by 15.4 GtCO2e** compared to a business-as-usual (BAU) scenario, implying an emission mitigation of about 115 GtCO2e between 2015 and 2030. In-depth meta-analyses of McKinsey's estimates yield the following **central findings**:

- Both the energy-intensive pathway and the energy-efficient pathway require significant shares of EE measures and decarbonization of the energy supply. When compared to the BAU scenario, **EE options mainly have negative net societal costs, while most alternatives like renewable energies (RE) show decreasing but still positive net societal costs.**
- In the BAU scenario, the global primary energy consumption in buildings (including appliances), industry and transport is about 450 exajoules in 2030. **Even the energy-intensive pathway requires reducing the primary energy consumption of these sectors by 7%.** The energy-efficient pathway more than doubles the energy savings to 17% of global consumption.
- The **total societal costs in the energy-efficient pathway are 2.5 – 2.8 trillion USD (constant 2005) lower than in the energy-intensive pathway in the period 2015 – 2030 (excluding transaction costs)**. The energy savings of the energy-intensive pathway still result in net cost savings of 1.2 – 1.6 trillion USD compared to the BAU scenario for the same period, with annual savings of approximately 0.2% of the global GDP in 2030. Both pathways are thus more than able to cover any transaction costs associated with EE.
- The costs of a pathway in line with the 2°C target in the period 2015 – 2030 have been **reduced by more than 750 billion US Dollar by historical EE policies in China, the EU and the US** since 1990.

Significant saving potentials exist in all end-use sectors. Their exploitation results in a much greater flexibility when choosing options for decarbonizing the energy supply. The cost estimates assume a strong focus on the cheapest abatement options until 2030. To avoid possible lock-in costs after 2030, it may be important to address more costly abatement options before 2030 as well, depending on the region. The ranges in all the estimates reflect the uncertain impact of direct rebound effects, which increase the demand for energy services due to the lower cost per unit of energy services.

It is of the utmost importance to address why many of the cost savings due to EE are not yet being realized by markets, private investors and households. It is well-known that financial barriers are partly to blame, but there are also **several important non-financial barriers** including lack of information, bounded rationality, uncertainty about revenues and the involvement of numerous end-users and actors (Sorrell et al. 2004).

To overcome these barriers, it is important to choose the right mix of policy instruments that specifically addresses the potentials and barriers (Allcott and Greenstone 2012). Standard economic measures such as **removing subsidies for fossil fuels and pricing carbon** are important pillars for the realization of EE measures, but are not sufficient. Non-financial instruments include **lowering transaction costs and supporting the diffusion of EE measures** via capacity building, networks and energy service companies, but also promoting measures for the cost efficiency of EE measures other than payback periods such as the internal rate of return. Incentives that lower up-front investments may be required, especially where large up-front investments are concerned such as for the retrofit of existing buildings.

The study also provides **region-specific pathways and estimates for** six focus regions, which accounted for more than 60% of global GHG emissions in 2010, namely **the US, the EU, China, India, Brazil, and Mexico:**

- For each region, the **additional cost savings of the energy-efficient pathway are significant with respect to domestic GDP**. The shares vary between 0.1% and 0.4% (see Table 1) and are roughly equivalent to the current annual investments in renewable energies in those regions (Frankfurt School-UNEP Centre/BNEF 2014).
- **On average, the specific cost savings are 20 – 23 US Dollar per tCO_2e.** The specific cost savings are slightly lower in China and India, because the gap between EE and the decarbonization of the energy supply is smaller here, i.e. the energy-intensive and the energy-efficient pathways overlap strongly.
- Sensitivity to **rebound effects** is relatively high in India and China due to rising levels of living standards and mobility here. This underlines that most of the reduced savings are not lost, but **result in a higher level of service to end-users**.

In addition to these savings, EE measures bring additional substantial societal benefits by reducing the cost of bringing power to the under-served, and fostering the domestic economy (IEA 2014).

Table 1: Annual savings of the energy-efficient pathway in comparison to the energy-intensive pathway by region in 2030 (based on McKinsey & Company, see Section 4)

	Additional annual energy savings	Additional annual net cost savings Total	/ per GDP	/ per abatement
	Exajoule/year	bUSD05/ year	% of GDP	$USD05/tCO_2$
US	5.7 – 6.2	63 – 70	0.31 – 0.34	28 – 30
EU	4.1 – 4.5	79 – 82	0.34 – 0.36	72 – 75
China	4.7 – 6.0	54 – 69	0.24 – 0.31	10 – 12
India	1.1 – 1.3	10 – 15	0.17 – 0.25	6 – 9
Brazil	0.7 – 0.8	12 – 13	0.31 – 0.32	53 – 55
Mexico	0.1 – 0.2	2 – 3	0.11 – 0.15	13 – 17

These findings have **important consequences for the current EE policy debates in the studied regions** (see also Figure 1):

- **In the US**, tightening and expanding fuel economy standards and crediting of EE in the Clean Power Plan represent major steps forward to realizing the cost savings from EE. Nevertheless, incentives are still lacking for significant retrofits of existing buildings, and the reduction of fuel consumption in energy-intensive industries.
- **The EU** is on the right path with the revision of its Energy Efficiency Directive and implementation of the 3rd National EE Action Plans. However, standards for the retrofit of existing buildings are insufficient to exploit the existing potentials, which can be seen as a major shortcoming. Other options for improvement lie in stricter fuel economy standards for cars and stronger policies for freight transport.
- Over the last decade, **China** has embarked on fostering EE polices and measures in all the relevant sectors. The growth of energy-intensive industries and the rising demand for mobility will require even greater efforts, in particular in supporting changes to industrial processes and modal shifts in transport. These issues are planned to be addressed in the upcoming Five-Year Plan.
- In **India, Brazil, and Mexico**, power production, industry and the transport sector hold vast potentials for cost savings via numerous EE measures. This is partially indicated by these countries' Intended Nationally Determined Contributions to the UNFCCC. However, only a limited number of measures are being implemented or considered for these sectors. The potentials in buildings are already targeted by many on-going and planned activities, but are not fully addressed.

In summary, the findings of this study suggest that it is **highly beneficial to society to implement EE policies that boost EE in each of the six regions reviewed and beyond,** because a decarbonization pathway with a strong focus on energy efficiency offers much greater flexibility in decarbonizing the energy supply as well as significant societal cost savings up to 2030.

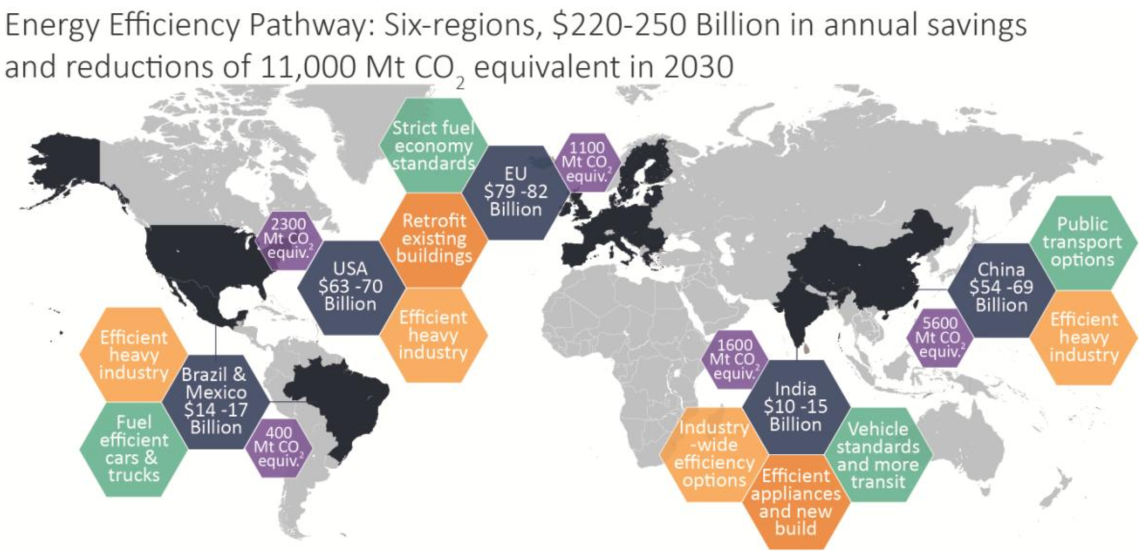

Figure 1: Overview of annual emissions reductions, cost savings and most important additional EE measures of the energy efficiency pathway by region