

## Reduction of CO<sub>2</sub> Emissions Through End-use Efficiency Improvements

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### Summary

Reducing electricity use in homes, offices, and stores by at least 25 percent has been identified as a promising pathway for achieving significant reductions in carbon dioxide emissions. Successful completion of this objective could prevent the release of 25 billion tons or more of carbon dioxide if phased in over the next 50 years. Achieving this goal is feasible with current energy technologies and can be done through implementation of a two-phase solution. Phase I will consist of three core improvements that are the most cost-effective. These include programmable thermostats, weatherization, and replacement of all incandescent light bulbs. For the duration of Phase I, a combined state and federal incentive of 50% of the installed cost, up to \$1,000 per year, will be offered to consumers. Phase II will expand and extend end-use efficiency measures into the utility market. This will provide for a large array of increased end-use efficiency measures, such as replacement of old appliances or installation of double-paned windows through a community-based design approach.

### Background

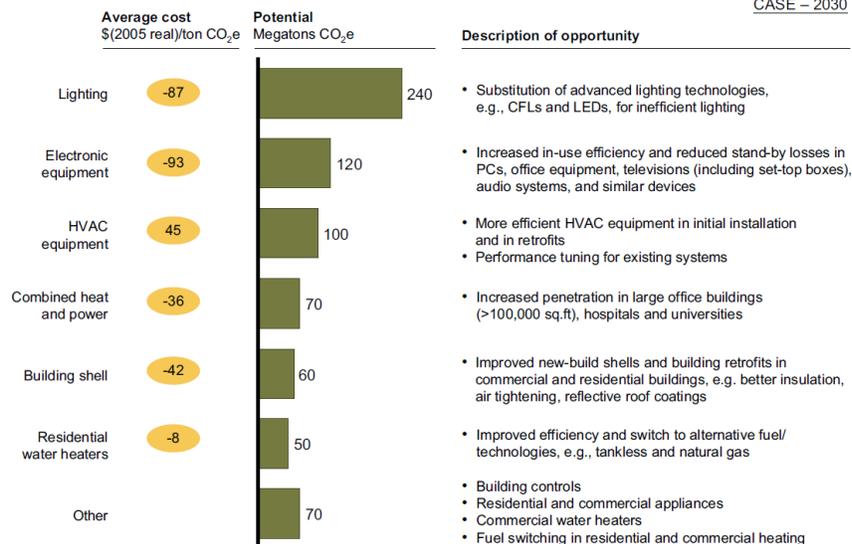
Building systems electricity end-use efficiency has been identified as the most cost-effective pathway to reducing carbon dioxide emissions in the US and worldwide. Among others, the McKinsey Report and statements issued by the Rocky Mountain Institute have made this point clear. The unique advantage that improving end-use efficiency has relative to the multitude of alternative options is its coupling of mature technology, immediate effect on energy use, ease of transition and most importantly, financial charm. Even disregarding the large and immediate effect that end-use efficiency improvements would have on carbon dioxide levels, the financial benefits to the end user alone warrants immediate investment by nearly every home, business and industrial participant on the planet.

Recognizing the financial incentive and the potential for job growth, the latest US economic stimulus plan that should be passed by mid-February this year includes \$26.3 billion allocated for the costs and labor of improving energy efficiency in private and public homes across America [1]. According to the US Department of Energy, weatherization of homes reduces carbon emissions by 35.8 tons per house over the lifetime of the measures taken and returns \$2.72 to the household and society per every \$1 invested into the program [2]. As exemplified with the figure below, the CO<sub>2</sub> reduction potential exceeds 1 billion tons with several home systems impacted resulting in a net profit in savings.

#### ABATEMENT OPTIONS – BUILDINGS-AND-APPLIANCES CLUSTER

Options less than \$50/ton CO<sub>2</sub>e

MID-RANGE  
CASE – 2030



Source: McKinsey analysis

**Figure 1: US Greenhouse Gas Abatement Mapping Initiative Projection of Average Installation Costs Per Ton of CO<sub>2</sub> Emissions Saved [3].**

### Phase I Solution – Individual Rebate Initiative

Phase I empowers individual consumers and businesses to achieve energy efficiency gains voluntarily with encouragement through a rebate program that extends beyond the latest stimulus plan. Within the US, current programs exist that offer weatherization benefits to qualified applicants below low-income thresholds. Creating a national standardized rebate initiative and opening the program to many more electricity consumers through a

graduated scale would encourage many of these consumers to actively seek out weatherization improvements due to greater awareness and shorter pay-back periods.

The average cost of weatherizing a household was found to be \$1,871 in 2007 while the average savings in energy costs going back into the economy from this procedure was \$3,174 [2]. The cost of installing a programmable thermostat starts around \$20 with easy self-installation [4]. Insulating a 1000 ft<sup>2</sup> attic with 15 inch deep recycled cellulose insulation results in around \$350 [5], while the cost of replacing 5 incandescent light bulbs with 5 compact fluorescent light bulbs is around \$20 [6].

Transitioning from incandescent light bulbs to compact fluorescent light bulbs (CFLs) provides an illuminating example to reduce carbon dioxide emissions. Production of incandescent light bulbs should be halted by 2014, followed by a plan to phase in CFL bulbs beginning in 2015, as shown in Chart 1. Over the next 50 years, each decade will see an increase in the number of CFLs installed in each home. Following an exponential increase in world population from 5.1 billion in 2009 to the projected 7.9 billion in 2050 (accounting for only those families with access to electricity), and assuming each household contains 3 people, the potential reduction in emissions for 50 years from 2015 to 2065 is 28 billion tons of carbon dioxide [7]. This is an extraordinary amount of emissions, exceeding the goal of utilizing many end-use efficiency technologies to decrease emissions by 25 billion tons of carbon dioxide in the next half-century.

Effective Year	Number of CFLs Replaced in a Household	Tons CO <sub>2</sub> reduced per lifecycle	# Households (average 3 people per household)	Billion tons CO <sub>2</sub> /decade
2015	3	1.04	1.93	2.75
2025	4	1.39	2.17	4.11
2035	5	1.73	2.33	5.54
2045	6	2.08	2.50	7.12
2055	7	2.43	2.63	8.75
<b>Total CFLs</b>	<b>25</b>		<b>Total reduction, billion tons CO<sub>2</sub></b>	<b>28.27</b>

Chart 1: Projection of tons of CO<sub>2</sub> emissions reduced by replacing incandescent light bulbs with compact fluorescent light bulbs [8].

## Phase II Solution – Advanced Energy Infrastructure Technology

The easy implementation of Phase I within the 50 year time frame allows expanding the scope and scale of efficiency to include whole community systems designed to maximize energy savings. Within an integrated community, it is not reasonable to replace regulated power utilities with another entity due to their embedded infrastructure and prevalent position within the current energy system. Effective new regulations could provide the impetus to stimulate financial and environmental innovations across whole communities. Along these lines, a set of regulatory policies that reward utilities based on the performance of their energy conservation programs would shift the focus in this industry to achieving real gains in energy efficiency. Shifting these regulatory mandates would be used to build a Sustainable Energy Utility as recommended by Byrnes, et al., who found that "an average participating household will be able to reduce annual energy expenditures by more than \$1,000. Reductions of this magnitude have important positive implications for the local economy [9]." Strategy implementation for Phase II can be assessed at each step on the local level using ecological and carbon footprint analysis in order to maximize local sustainable infrastructure. Within the US, Phase II implementation will display the leadership and examples necessary to engage the international community in setting the standards and goals for both 1st and 3rd world countries.

## Concerns and Issues with Implementation

The phenomenon known as Jevon's paradox asserts that many of the gains from improved energy efficiency would be negated by accompanying increases in energy usage. However, this may not be indicative of real behavior. According to RMI co-founder and Chief Scientist Amory Lovins, Vermont has reduced energy use per household in recent years. Similarly, California has held per-capita electricity use flat for 30 years -- saving 65 peak GW and more than \$100 billion of power-system investment -- while per-capita real income rose 79 percent [10].

## Conclusion

We recommend implementing this policy because of its financial, economic, and environmental benefits. Phase I provides for reduction of CO<sub>2</sub> emissions through installation of programmable thermostats, weatherization, and replacement of all incandescent light bulbs. Phase II extends the CO<sub>2</sub> emissions savings through extending regulation to include utilities and other community-based initiatives. Additionally, we recommend that the US takes the lead

internationally through diplomatic initiatives to encourage other countries to follow these initiatives. Only if the entire world adopted these policies could the goal of major reductions in carbon dioxide emissions be achieved.

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