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Energy Efficiency in Buildings: A Global Economic Perspective

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At the 2008 summit in Hokkaido, Japan, G-8 leaders called for a 50 percent global reduction in greenhouse gas (GHG) emissions by 2050 to avoid "the most serious consequences of climate change."[1] Meeting this goal will require transforming the way energy is produced, delivered, and consumed across all sectors of the economy and regions of the world. The International Energy Agency (IEA) estimates that the building sector alone will need to reduce annual emissions by 8.2 gigatons below business-as-usual by 2050, an amount equal to nearly one third of global emissions today (IEA 2008a).

Improving energy efficiency in buildings is often heralded as the cheapest way to cut emissions, with a wealth of individual investment options available at negative cost.[2] Few studies, however, have attempted to estimate the cost of completely overhauling the building sector to meet long-term emission-reduction goals. The World Business Council for Sustainable Development's (WBCSD) Energy Efficiency in Buildings project has developed a model, based on a rich database of building types, designs, and technologies, that makes such analysis possible.[3]

This policy brief highlights preliminary findings from a forthcoming Peterson Institute for International Economics study on the economics of building efficiency. The study draws upon the WBCSD model to assess the cost of transforming the global building stock in line with the G-8's 50 percent emission-reduction target and evaluates policy options for catalyzing such transformation. The study finds that while achieving aggressive, whole-building improvements in energy efficiency is more expensive than studies of individual building components would suggest, average abatement costs in buildings are still cheaper than in other sectors. Barriers to efficiency investment in the building sector, however, make it difficult to take advantage of these low-cost abatement opportunities, even at a relatively high carbon price. New approaches to financing are important in overcoming these investment barriers, but these will need to be coupled with improved standards for building construction, government spending to buy down investment "first costs," and improved awareness of potential energy savings among households and firms.

APPROACH AND METHODOLOGY

The WBCSD model, developed over four years by a consortium of fourteen major global companies, simulates investment decision-making in five submarkets: single-family residential buildings in France and the southeast United States, multifamily residential buildings in China, and office buildings in Japan and the northeast United States. In each submarket, the model simulates investment decision-making based on a database

1. "Environment and Climate Change," July 8, 2008, available at www.g8.utoronto.ca/summit/2008hokkaido/ (accessed on April 24, 2009).

2. The most well-known study of abatement costs for building efficiency is McKinsey & Company (2009).

3. See WBCSD (2008).

of thousands of potential building types and equipment configurations, each with its own cost and energy-demand profile. The WBCSD team assessed what types of policy incentives would be required to achieve per-building emission reductions of 50–75 percent by 2030 and to sustain these levels through 2050.

The model's estimated change in investment costs and energy demand from increased energy savings in buildings at the micro level serve as the basis for the PIIE study's macroeconomic analysis. Per square meter results from the five WBCSD submarkets are converted into global estimates using energy demand and CO_2 emission data from the International Energy Agency (IEA 2008b; IEA 2008c), economic growth projections from the Economist Intelligence Unit (EIU 2009), and population forecasts from the United Nations Population Division (UNPD 2009). In the PIIE study, first costs and energy prices are held constant across regions, and energy savings are discounted at 6 percent annually over the average life of the investment (20 years in most cases in the WBCSD model) to assess the overall economic impact and compare it to abatement opportunities in other sectors.

ECONOMIC COSTS AND ENVIRONMENTAL BENEFITS

Cutting building emissions by 8.2 gigatons annually by 2050 will require an additional $1 trillion per year in investment globally between now and 2050. This accounts for roughly 1.5 percent of global GDP over the same period and would constitute an increase in energy-related investment of 18 percent. Of this, $209 billion per year would take place in the United States, $158 billion in the European Union, $114 billion in China, and $37 billion in Japan (table 1), assuming per-building transformation occurs equally across regions.

Most of this investment would be offset by energy cost savings, though this effect would be less than previous studies focusing on specific building-efficiency technologies have suggested.[4] Many individual building improvements, like insulation and heat pumps, easily pay for themselves over the life of the product but are overlooked because of a range of barriers to action identified in WBCSD (2008). Investments necessary to achieve whole-building emission reductions of 50–75 percent, however, will not be paid back in energy savings at current energy prices,[5] even over relatively long time horizons.[6] At the global level, 83 percent of the investment required for transformation is recovered over a 20 year period, resulting in a net cost of $180 billion per year.

Efficiency measures in residential buildings offer better cost recovery than in commercial buildings, and within the residential sector investments in multifamily homes score better than in single-family homes. Variation in building stock between regions creates differences in the net-present value (NPV) of efficiency investments. In the United States, $209 billion in annual investment to improve the efficiency of the building sector as a whole has a negative NPV of $40 billion per year. In Europe, the NPV is negative $25 billion per year, and in Japan it is negative $9 billion (table 1). This is the "social cost" of transforming the building sector at current energy prices.

While significant in absolute terms, the social cost of a 50–75 percent improvement in building efficiency is still cheap relative to other abatement opportunities. Based on initial results from the forthcoming PIIE study, cutting building emissions by 8.2 gigatons globally by 2050 has an average abatement cost of $25 per ton of CO_2. Lower carbon-intensity of energy supply makes abatement costs slightly higher in Europe ($30 per ton), while China's coal-dominated energy mix yields an average abatement cost of $14 per ton. With a higher share of investment costs recovered through energy price savings, reducing emissions in residential structures is cheaper than in other parts of the building sector. In the United States, the average abatement cost for households is $9 per ton, compared to a building sector–wide average of $28 per ton.

The range of building-sector abatement costs found in this study are lower than estimates from the IEA of the cost of achieving comparable emission reductions from power generation, industry, or transportation (IEA 2008a). This makes it critical, from an economic standpoint, to remove barriers to improved building efficiency. Failure to catalyze building-sector transformation will force other sectors to make deeper, more expensive cuts, raising the cost of meeting long-term climate goals by at least $400 billion per year globally.

FINANCING BUILDING TRANSFORMATION

While meeting building-sector emission-reduction targets comes at an average abatement cost of $25 per ton of CO_2, imposing a market price for carbon alone will not catalyze

4. See, for example, McKinsey & Company (2009).

5. The WBCSD model uses 2005 energy prices (electricity and natural gas primarily) as its core assumption. In the forthcoming PIIE study, higher energy price scenarios are evaluated.

6. This is largely due to the cost of installing solar panels to enable individual structures to reach target reductions in net emissions; see, for example, NAIOP (2008). Forecasting technology prices over multiple decades is obviously a challenge. If the price of solar falls more rapidly than expected, building-sector transformation could very well become profitable at current prices.

Table 1 The economics of global building transformation

Country/Region	Additional investment Billion USD per year 2005–2050	Net-present value* Billion USD per year 2005–2050	Emission reduction Million tons in 2050 relative to BAU	Average abatement cost USD per metric ton, 2005–2050
OECD North America	244	–46	1,699	30
United States	209	–40	1,555	28
OECD Europe	170	–26	915	30
EU 27	158	–25	861	30
OECD Pacific	67	–17	353	48
Japan	37	–9	168	52
Transition Economies	78	–12	548	24
Russia	51	–10	345	33
Developing Asia	188	–26	2,343	14
China	114	–15	1,427	14
India	19	–2	221	12
Latin America	31	–5	148	39
Brazil	10	–2	28	61
Middle East	80	–17	663	32
Africa	29	–3	298	10
World	1,042	–180	8,200	25

BAU = Business as usual

* Net-Present Value is calculated over 20 years using constant energy prices and a 6 percent discount rate.

Source: WBCSD Energy Efficiency in Buildings Model, International Energy Agency, United Nations Development Program, Economist Intelligence Unit.

the necessary transformation on an economy-wide scale. The WBCSD project has identified several barriers that prevent households and companies from investing in efficiency even when it makes economic sense from a societal standpoint to do so (WBCSD 2008). Perhaps most important is the short timeframe decision-makers in the building sector use when considering efficiency improvements. Most firms and households are only willing to invest in energy-saving technology and design if it pays for itself in five years or less. This means that even a relatively high carbon price will not change consumer behavior.

Providing households and businesses with access to longer-term and lower-cost sources of capital will be critical in overcoming this barrier. Promising models for financing efficiency investments are being developed, but they remain untested at the scale necessary to achieve transformation. In the United States, meeting emission-reduction goals in the residential sector will require an additional $139 billion in annual investment on average between now and 2050. This increase in real estate investment is large but not unprecedented. Based on the technology cost estimates in the WBCSD model, reducing emissions from the US housing stock by 65 percent by 2050 will require a 15 percent increase in the amount of money spent on residential building construction and renovation each year.[7] This is roughly on par, in terms of scale, with the increase that occurred between 2002 and 2007 as a result of low-cost capital and lax mortgage lending criteria, most prominently in the United States but also in parts of Europe and the developing world. Yet while residential investments over the past decade grew less sustainable overtime as income lagged and mortgage payments soared, investments in efficiency get cheaper overtime as lower energy bills offset up-front costs and home-resale values increase.

For the residential sector, electrical utilities can provide an important source of financing for energy-saving investments. Utilities have lower capital costs and longer time-horizons than households. Regulations will need to change to give utilities a financial incentive to deliver efficiency rather than energy

7. US residential construction data are from US Census Bureau (2009).

(Cappers et al. 2009; Brennan 2009), particularly given the 50–75 percent decline in per-building electricity purchases necessary to achieve transformation. For commercial buildings or multifamily residential properties, a broad range of financial tools exist through capital markets, but harnessing these will require a policy framework that addresses some of the risks inherent in efficiency investment.[8]

That policy framework will need to extend beyond support for private-sector financing. To take full advantage of lower cost-abatement opportunities in the building sector, governments will need to develop standards that consider the energy footprint of the building as a whole rather than its individual components. They also must help to buy-down the cost of meeting those standards through targeted fiscal spending. Climate policy can provide governments with the resources they need to overcome barriers to energy savings in buildings, which will be critical in offsetting the cost to households of capping GHG emissions.

THE POLITICAL BENEFITS OF BUILDING EFFICIENCY

Market-based climate policy, like a carbon tax or a cap-and-trade system, will raise energy prices for consumers, which can be quite regressive in its impact depending on how revenue generated from the policy is used (Burtraw, Sweeney, and Walls 2009). Building efficiency can ensure that this does not result in an increase in total energy costs that households bear. In the United States, for example, the EIA estimates that the Lieberman-Warner Climate Security Act of 2007 would have raised residential energy prices by 11 percent by 2030 (EIA 2008). While the modest improvements in building efficiency projected by the EIA mitigates some of these increases, overall household expenditures in 2030 are $10 billion higher than in the absence of climate policy.

Transformation of the building sector along the lines outlined above would more than offset these cost increases, cutting overall household energy expenses from $285 billion per year in 2030 to $163 billion. A relatively small share of the government revenue raised through a carbon tax or a cap-and-trade program could help catalyze the private investment in building efficiency that will be required for households to take advantage of these savings.

This is particularly important in Europe, where the comparatively low carbon-intensity of energy supply means that meeting aggressive emission-reduction targets will require more-ambitious improvements in energy efficiency. The German Federal Environment Agency estimates that reducing GHG emissions by 40 percent below 1990 levels by 2020 will cost $31 billion annually, one third of which will come from spending on building and infrastructure modernization; but improving end-use energy efficiency will yield savings of $38 billion per year (Bundesumweltamt 2008).

CONCLUSION

Achieving the degree of emission reductions in buildings necessary to achieve global emission reductions of 50 percent by 2050 is possible with existing technology and without compromising living standards. The cost of such transformation, while more expensive than past studies of individual efficiency improvements have suggested, is manageable and cheaper than achieving comparable emission reductions in other sectors. Imposing a price for carbon alone will be insufficient to achieve the necessary emission reductions from buildings, and barriers to adoption must be addressed through building standards, fiscal spending, and new approaches for financing energy-saving design and technology at scale. Removing these barriers will reduce the cost of climate policy overall and will be particularly important in alleviating the impact on consumers.

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