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Building Energy-Efficiency: Best Practice Policies and Policy Packages

Executive Summary

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Executive Summary

This report addresses the single largest source of greenhouse gas emissions and the greatest opportunity to reduce these emissions. The IPCC 4th Assessment Report estimates that globally 35% to 40% of all energy-related CO2 emissions (relative to a growing baseline) result from energy use in buildings. Emissions reductions from a combination of energy efficiency and conservation (using less energy) in buildings have the potential to cut emissions as much as all other energy-using sectors combined. This is especially the case for China, India and other developing countries that are expected to account for 80% or more of growth in building energy use worldwide over the coming decades. In short, buildings constitute the largest opportunity to mitigate climate change and special attention needs to be devoted to developing countries.

At the same time, the buildings sector has been particularly resistant to achieving this potential. Technology in other sectors has advanced more rapidly than in buildings. In the recent past, automobile companies have made large investments in designing, engineering, and marketing energy efficient and alternative fuel vehicles that reduce greenhouse gas emissions. At the same time, the buildings sector – dependent on millions and millions of decisions by consumers and homeowners – face a large variety of market barriers that cause very substantial underinvestment in energy efficiency.

How can the trajectory of energy use in buildings be changed to reduce the associated CO_2 emissions? Is it possible to greatly accelerate this change? The answer to these questions depends on policy, technology, and behavior. Can policies be crafted and implemented to drive the trajectory down? Can the use of existing energy efficiency technologies be increased greatly and new technologies developed and brought to market? And what is the role of behavior in reducing or increasing energy use in buildings?

These are the three overarching issues. The information assembled in this study and the knowledge derived from it needs to be brought to bear on these three questions. And thus we turn to some of the insights from the study, presented in the form of findings and recommendation. Of the many findings that could be presented we have chosen the few that we consider to be particularly important. Others reading this report would undoubtedly choose a different set. The reader is encouraged to do so.

1. Findings: Policy

1.1. Building Energy Standards

Building energy standards are ubiquitous in the United States, the European Union, and China. They are the most potent of all policies in reducing energy use from heating and cooling of buildings. Almost all of the standards thus far promulgated in three regions have been cost-effective. There is a long (multi-decade) tradition of building standards in all of the regions. This is especially true of the north of Europe with extreme cold weather and countries wealthy enough to invest in energy efficiency.

To date, most standards have been applied only to new buildings. The problem of high-energy use of existing buildings – of great importance in the two regions (the United States and the European Union) in which the building stock is growing slowly – has not been well addressed and standards have played little role. There is increasing interest and activity in applying standards at point of sale.

The most important issues in making standards more effective are (1) increasing training (of code officials, builders, and other building professionals), (2) the rigorous updating of the standards to promote the development and use of new, efficient technology, (3) announcing new codes early on so that the industry can prepare for more stringent codes and, (4) demonstrating the feasibility of constructing progressively more efficient buildings that are cost effective.

1.2. Building Energy Labels

Whole building energy labels have been particularly effective in three ways. They provide the necessary knowledge to the building owner or occupant to motivate decisions to invest in energy efficiency (for buildings receiving low ratings). Some of the labels recommend measures for reducing energy use (e.g., the European Union). The effectiveness of this application of labels is strongly dependent on consumers' view of their trustworthiness.

A second application of labels is to provide information about the building's energy-efficiency or energy use at the point of transaction (e.g., as required for example by France). The premise is that such knowledge is likely to be useful and used when the building is sold or rented.

The third use of labels is in our judgment the most important. The combination of standards (setting a floor on efficiency or energy use), a label (serving as a measuring stick), and financial incentives (to improve building performance beyond existing standards) is an extremely powerful means of increasing energy efficiency. If all three policies are well integrated with each other (e.g., California), they can drive efficiency aggressively and over a long period of time. The incentive and labeling policies will promote state of the art energy efficiency on which updates to standards can be based. This is effective as a policy design for new buildings but also can be applied to retrofits of existing buildings.

1.3. Building Energy Incentives

The fundamental issue of incentive programs is how to maintain funding, particularly if the funds come from governments. There are many innovative approaches to the problem that have potential for success. There are at least two approaches that have been successful on a large scale: utility demand side management (DSM) in the United States (funds from ratepayers who are the beneficiaries of the lowered total cost of supplying energy for the utility system) and in Germany (the KfW program where the increased taxes resulting from the program cover the costs of administering the program plus the cost of the incentives).

1.4. Building Energy Policy Packages

As noted in section 1.2, incentives with labels and standards produces a particularly effective means of reducing energy use in buildings as well as encouraging the development and use of advanced energy-efficiency technologies. Three prime examples of the strong synergy among the three policies are California's utility and standards programs, Germany's KfW loan program, and several innovative municipal programs in China. The approach of packaging policies that can be implemented in many different configurations (e.g., levels of standards and incentives; different rating systems; agents responsible for implementation; form and identity of beneficiary of the incentives, etc.) has the potential for greatly expanding the reach and impact of the individual policies.

2. Findings: Technology

2.1. Opportunities with Existing Technologies and Systems

The biggest opportunity for saving energy in buildings in the coming decade(s) in all four regions (even those with the highest rate of construction) is adopting already available energy efficiency technology. The existence of many underutilized energy efficiency technologies and the associated market barriers strongly justify government policies.

Systems rather than technologies offer the greatest promise of energy savings. They typically underperform and in the process use excessive amounts of energy. This is particularly the case for space conditioning systems in large buildings. Improving system performance has large potential for energy saving in the near time.

For those developing countries with large numbers of poor people in cold regions, the single most important means for reducing greenhouse emissions for heating (cooking and water heating in all climates) is the replacement of inefficient biomass and/or coal burning stoves with modern fuels and equipment.

2.2. Creating Future Technologies

In spite of the plethora of underutilized high-efficiency technology today, research and development (R&D) is needed to achieve technologies and systems with lower costs or better performance. There are numerous R&D opportunities to achieve these goals.

Current R&D programs unfortunately give very little emphasis to systems as distinct from technologies. Passive solar houses, with a combination of many technologies[1], illustrate the importance of systems in reducing energy use. Integrated design is arguably the most important system (in reality, a "system of systems") for designing large buildings with very low energy use. An especially good example of the results of an integrated design process is the seven-story building housing the Institute for Building Research (IBR) in Shenzhen China. The building delivers substantial energy savings (greater than 50%) at construction cost lower than that of comparable buildings.[2] We believe that the integrated design process, with one knowledgeable person or organization having control over all aspects of the design process (architectural and engineering), construction, commissioning, and use of the building played an important role in the success of this building.

Thus R&D needs to focus much more strongly than it does today on designing, creating, testing, and producing techniques to assure effective performance of systems.

3. Findings: Behavior, Comfort Preferences, and the Operation of Buildings

Research going back to the 1970s has shown the variation of energy use as a function of occupant behavior. Studies of identical houses in close proximity to each other showed a factor of two difference in heating energy use between houses with the lowest and highest energy.[3] Numerous measurements and simulations have confirmed this variation or greater in commercial and residential buildings in the United States, China, Europe, and elsewhere throughout the world.[4] The body of this work shows that the effect of behavior and operational practices on energy use in buildings can be and often is greater than that of technology. Unfortunately, policies and programs have not demonstrated an ability to capture a significant portion of this occupant-related variation in energy. A miniscule portion of research on energy efficiency addresses how behavioral issues can best be addressed to achieve long-term energy savings.

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[1] Importantly, the passive house as any complex system needs to be operated properly to be successful.

[2] Current estimates are that the construction cost may have been 1/3 less per square meter less than that of a comparable building.

[3] Stated more precisely, the factor of two is the ratio of the highest decile of heating energy use to the lowest decile.

[4] Annex 53 International Energy Agency (IEA), with participants from Asia, Europe, and the United States, has been studying this phenomenon for the past several years with a report scheduled for 2013.

4. Policy Research Needs

There is a need for experimentation, demonstrations, policy research, data and/or analysis on:

- Impacts of policies on heating and cooling energy use and costs (treated broadly[5]) based on quantitative and reproducible research.
- The effects of behavior on energy use in buildings and policies that encourage energy-conserving behavior.
- Well-documented costs and energy savings of buildings with very low heating and cooling energy.
- Quantitative effects of employing multiple policies (policy packages) to reduce building energy use.
- Sharing policy experience on building energy efficiency policies in actionable forms to developing countries.
- Effective methods to communicate information not widely known or understood to policy makers and the public.

5. Recommendations

Earlier[6] we identified the high-level issues that are the intellectual challenge underlying the research on which this report is based. It is our intent that the recommendations collectively provide insight into the issues. They are repeated below.

> *How can the trajectory of energy use in buildings be changed to reduce the associated CO2 emissions? Is it possible to greatly accelerate this change? The answer to these questions depends on policy, technology, and behavior. Can policies be crafted and implemented to drive the trajectory down? Can the use of existing energy efficiency technologies be increased greatly and new technologies developed and brought to market? And what is the role of behavior in reducing or increasing energy use in buildings?*

To increase the effectiveness and energy savings of building energy standards, we recommend that governmental organizations with authority over energy use in buildings should:

- As a matter of highest priority create (if they do not already exist) or strengthen building energy standards and their enforcement in measureable ways.
- Regularly update the standards as new technology or practices are demonstrated to cost-effectively save energy for space conditioning in buildings.
- Provide sufficient advance notice of the specifics and timing of the updates so that industry can prepare for the updates.

[5] Including costs to consumers, energy suppliers, builders, the environment, etc.
[6] Third paragraph of this Executive Summary.

- Assure that demonstrations of improved practices and advanced systems and technology take place frequently and of sufficient quality to support standards updates.

To increase effectiveness of labels, organizations responsible for them should:

- Assure that they are designed and promulgated to be easy to use.
- Are as consistent with actual energy use or efficiency of the building to which it is applied.
- Are communicated to consumers, builders, and other building professionals in a manner to assure their trustworthiness.

For financial incentives programs to have large and sustaining impacts, they need to be long-lived and at assured minimal levels.