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A VISION FOR PERFORMANCE BASED BUILDING DESIGN AND OPERATIONS

A position paper on merging public policy with building energy performance monitoring to significantly reduce greenhouse gas emissions from the building sector

By
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The views expressed in this position paper are those of its author. However, the author would like to acknowledge the contribution of many others as a result of direct and indirect conversations over the months preceding writing this paper. In that time the author has participated in many formal and informal discussions at conferences, meetings and informal gatherings. The major points and conclusions stated in this paper are those of the author, but this does not in any way diminish the important contributions of others from the many discussions in which the author has been involved. The assistance and candor of others in developing the ideas contained in this paper are greatly appreciated.

INTRODUCTION

A worldwide scientific consensus has established that potentially catastrophic changes in climate as a result of human contributions to greenhouse-gas (GHG) emissions are likely within the next century if the current growth in emissions is not reversed. To help meet this challenge, a growing number of cities, states, corporations and organizations have pledged large reductions in their greenhouse-gas emissions. However, many of the initiatives undertaken with respect to buildings are almost certain to fall far short of meeting their ambitious objectives because they are based on flawed or unrealistic assumptions about the building industry's processes and technologies. These shortcomings are the result of a gap between the unique technical and economic characteristics of the building industry, and the development of policy that currently seeks to drive these energy efficiency initiatives forward.

The purpose of this position paper is to try to bridge that gap by outlining new approaches that better merge industry efforts with policy initiatives that are directed toward resolving the technical and economic barriers hindering large scale improvements in the energy efficiency of buildings. By making public policy advocates more aware of industry developments and initiatives as well as the current barriers, I believe we can develop a comprehensive public policy roadmap to a more sustainable future for the building industry and the utilities that serve it.

THE BUILDING INDUSTRY

Presently, buildings of all types consume about 40% of all primary energy in the United States. This level of energy use is much higher than what modern technologies require to provide comfort and support occupant activities. But the decentralized nature of the

building industry makes it difficult to introduce new technologies that could vastly improve the energy performance of buildings. However, a more fundamental reason new and more energy efficient technologies continue to be ignored and the technologies that are applied rarely perform as they should is because of a lack of accountability for building energy performance in current building design and operation practices.

The result is that buildings of all types today typically consume more than twice the energy really required to provide comfort and a quality environmental for building occupants. I estimate that the realistically achievable energy savings from well designed energy efficiency improvements in the existing building stock are sufficient to serve the energy requirements for all new buildings through the next thirty to fifty years. And by upgrading current building design and construction processes, these energy improvements would cost less and be more reliable sources of energy for that expected load growth than constructing and operating new power plants or bringing in new sources of fuels.

Therefore, energy efficient improvements in existing buildings could, at a minimum, free sufficient energy to serve all new building energy requirements without the need for any added sources of power generation or fuels through much of this century. It is therefore clear that changes in industry practices and technologies along with encouraging a compatible public policy, can reverse the current upward trend in building related greenhouse gas emissions in this decisive near term. It's also clear that efficiency is the lowest cost path to obtaining the energy needed for growth in our building stock over that time.

THE UTILITY INDUSTRY

On the energy supply side, the scientific community estimates that by the middle to the end of the century, low carbon and environmentally compatible forms of energy for buildings that are safe, reliable and plentiful can be developed from a variety of options currently being researched, developed and tested. Then, the human contribution to greenhouse-gas emissions from utilities that serve the building sector can be significantly reduced. However, these new low carbon electric and fuel sources will be more costly than electric and thermal energy sources now used in building operations. Without improvements in building efficiency, the large costs associated with switching to these newer sources of energy could be a significant burden and dampen overall economic activity.

In the meantime, utilities as a whole continue to rely on energy sales as their primary source of revenue. This business model conflicts with the need for a near term reduction in energy use and explains why as a whole the current focus of utilities is on winning approval for new plants and sources of energy rather than placing their primary emphasis on improvements in energy efficiency to provide for load growth.

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THE ENVIRONMENTALLY RESPONSIBLE OBJECTIVE

To meet the challenge for an immediate reduction in greenhouse-gas emissions while ensuring long term economic well-being and stability, I recommend that a moratorium on the development and construction of all new greenhouse-gas emitting power and fuel sources for buildings be initiated. Concurrently, the building industry, utilities, regulators and policy advocates must agree to work together to transition to a significantly more efficient and sustainable building stock on an unprecedented scale while cleaner sources of energy for building systems are developed.

Beyond helping to reverse the present trend in greenhouse-gas emissions and deferring excessive short term capital investments, focusing on an energy efficient and sustainable building stock will help reduce the costs associated with more expensive low-emission sources as they become available and ensure this transition does not diminish our competitive advantage or our standard of living.

ENERGY PERFORMANCE PROBLEMS

Because the energy cost for building operations is a relatively small factor in the economics of virtually all building types, there is little emphasis today on energy performance. Building owners, designers, contractors, or operators seldom have a good understanding of energy performance aspects of buildings. This lack of understanding by key decision makers leads to a lack of energy performance focus in the design, construction, and the day to day operations of today's buildings.

This lack of understanding and focus on energy performance issues explains why actual energy performance of buildings varies widely when compared to projected performance. It also explains why so many energy performance projects and upgrades fail to meet expectations and why, as a result, building owners are reluctant to make investments in energy performance improvements at all.

ENERGY PERFORMANCE THROUGH ACCOUNTABILITY

I believe accountability is essential for any strategy aimed at a large scale improvement in building energy performance to succeed. A properly developed industry wide emphasis on energy performance accountability will pull new, more efficient energy technologies into the industry and ensure they are applied and supported effectively. Because of the decentralized and fragmented nature of the various entities that make up the building industry, developing energy accountability is not a simple matter. To accept accountability, one generally requires some authority or control over the technologies and processes involved throughout design, implementation and operation of a building.

However, designers and contractors have only limited control over issues outside their immediate scope during the design and construction process, and usually no control over buildings once they are occupied and operating. Instead, it is the building owner

that wields ultimate control over the design and construction of energy systems in new buildings or acceptance of those systems in a purchased building. Furthermore, it is the building owner who has primary access to the ongoing metered building energy use information and control of operations. It is therefore reasonable to conclude that the fundamental accountability for the energy performance of each building should reside with its owner.

Studies have found that providing building owners with relevant and useful energy performance and utility pricing information alone leads to energy performance improvement. So, if the responsibility for building performance responsibility is defined properly, targets are set, and useful information made available, building owners are well positioned to dictate energy performance as a criterion in the purchase or design of buildings, as well as effectively manage their buildings' energy performance once occupied.

However, if public policy places building owners on the front lines of greater building energy efficiency to reduce greenhouse gasses, it must also provide some compensation or reward for making this important contribution. Benefits such as preferred energy rates or tax incentives need to be a component of the policy for building owners who succeed in capturing targeted energy reductions. Options for incorporating such incentives are discussed later in this paper.

MEASURING ENERGY PERFORMANCE

If it is agreed that building owners are the correct points of accountability for building energy performance, three key issues need to be resolved to give owners the tools to manage their building energy performance more effectively. First, various building types should be held accountable to energy performance standards. Second, simple energy performance metrics should be used to judge whether the appropriate performance standards are being met. Finally, tools that allow building owners to verify performance of individual components upon purchase or construction of a building must be readily available. Such tools must also be useful when rated performance is not achieved to aid in determining what is required to bring energy use back into alignment with the applicable standard. To be effective, each of these tools must be clear and simple to apply.

Because total building energy use is the fundamental parameter of concern, basic energy performance standards should be developed around the actual metered energy use of each building. However, when building energy use exceeds the standard, additional performance monitoring metrics are needed to help with more information. To provide this additional information, public policy should require that specific performance monitoring be integrated into all building systems.

Designers, contractors and equipment manufacturers need to incorporate adequate measurement metrics into each new building or building upgrade so it can be clearly determined during commissioning and startup that all the energy consuming systems perform as expected when turned over to the owner. Building owners then need specific performance information to help keep each piece of equipment and system operating efficiently throughout each building's life and to meet the overall building performance standard each month.

To assemble useful information that goes beyond utility metered data, two categories of building system performance metrics need to be developed. The first category is "efficiency" based information. This includes heating and cooling operating efficiency, and in some cases air delivery operating efficiency expressed as an overall system coefficient of performance (C.O.P.), watts per unit output, energy efficiency ratio or other widely used term.

To ensure the owner or operator has the ability to diagnose and correct building operation problems when energy use begins climb, a second "use" category of energy performance monitoring may be needed that includes heating, cooling, air delivery, lighting and plug load energy use expressed in energy use per unit building area such as kilowatts or thermal units per square foot over a variety of accounting periods, primarily monthly and annually. Also, an instantaneous peak rate of energy use for each of these categories expressed in kilowatts per square foot may be helpful. In the event that energy use increases slowly, periodic information for each of these categories can be compared with historical use or with published norms to determine which building operation areas need attention. Ongoing building commissioning procedures that operate with such comparisons have already shown to be effective when supported properly over the long term.

The exact "efficiency" and "use" energy monitoring parameters required depends on the complexity of the building and the nature of the systems incorporated. Residential buildings may require only heating and cooling system efficiency information that can be incorporated into each home heating/air conditioning unit without any additional monitoring equipment. Large commercial or industrial buildings are likely to require a full set of efficiency and use metrics that are monitored by the building control system and compared daily or weekly with historical values to ensure ongoing building performance compliance. Basic performance monitoring parameters are selected to ensure owners can confirm upon completion or purchase that the promised level of energy performance has been achieved. As the owner assumes responsibility for operating the building, performance information must be adequate to ensure that the owner can manage and meet the energy performance goal each month.

ESTABLISHING ENERGY PERFORMANCE STANDARDS

In developing the most straightforward path to a more energy efficient building stock based on an energy performance standard that building owners are responsible to maintain, the first step is to determine the standard that each building must meet. Here, the EPA Energy Star Building Label program represents a successful existing building rating process that provides an excellent basis for such building performance standards. In the Energy Star program buildings are categorized by building type and the building's rating is based on a climate compensated standard of energy use per unit area of the building. This is a relatively simple and straightforward method that is already widely and successfully employed.

While the types of buildings in the existing Energy Star rating program need to be expanded for this standard to be universally applied, such an expansion combined with a change from annual to monthly accounting periods to coincide with utility billing cycles would not be difficult to develop. An updated standard based on Energy Star could be readily applied as a mandatory city, state or national requirement for all buildings based on actual utility metered energy use.

In a widely applied building performance standard, separate categories should be developed for existing and new buildings, with new buildings having more stringent energy performance standards, and existing buildings adhering to lower minimum ratings that become more stringent over time. It is also recommended that single family residences employ a standard in which larger buildings have a more stringent per square foot energy allowance. This would make it incumbent upon those building large homes to make them much more efficient.

INCORPORATING ENERGY PERFORMANCE STANDARDS INTO UTILITY RATES

A renewed dialog with utilities and their regulating agencies is essential to move a large scale energy efficiency initiative forward that is building owner focused. Utilities' fundamental sources of revenue are their energy sales but they have also been inserted into energy efficiency activities through a concept called "decoupling." Moving forward, it is crucial that the utility industry and regulators be engaged as a part of developing this new approach. This engagement is necessary to make the transition in responsibility for energy reduction targets move smoothly from utilities to building owners, and to be certain its goals are not undermined as utilities work to maintain their revenue stream. This potential loss of near term revenue must be addressed but there are policy approaches that provide new opportunities for utilities as their business model changes to mitigate this loss of energy sales revenue.

Key utility regulatory and public policy steps are also needed to support a performance based sustainable building program. These additional steps include developing a plan for formatting utility billing information so building owners can quickly assess with each utility bill whether or not the building is meeting its standard for energy use. Advances in metering and data management technologies make this a practical part of utility

connection and billing procedures. Some utilities already offer limited analysis services, and several states have passed or are considering laws that will standardize reporting formats.

A second crucial utility regulatory and policy step to support a building energy performance standard is the need to institutionalize performance standards by adjusting utility rate structures such that marginal cost of energy for each building served increases if that building consumes energy above the standard's limit for the building's size, type and local climate during any utility billing cycle. Such a rate, which has already been test implemented in a limited fashion in some areas is called an "excess use rate." This rate structure provides a strong financial incentive for building owners to maintain their energy use within the standard's limits over time, and it also provides a much improved incentive for investments by the building owner in measures that will reduce energy use to within the building's energy performance limit if it does exceed that boundary.

MOVING FORWARD

The window of opportunity for making a significant change in the environmental consequences of fossil-fuel based energy use over the last several hundred years is now considered by scientists and energy experts to be relatively narrow. While significant progress in building energy efficiency improvements has been made since the original energy crisis era thirty years ago, it will be necessary to advance energy efficiency far more substantially in the next thirty years. Getting started now by reorganizing the industry toward a more effective path to that end is essential to becoming successful in changing the trends in climate change.

The next logical steps once a shared principle for applying energy performance standards to reduce building energy use is developed can be broken down into two categories – **Industry** steps and **Public Policy** steps. The Industry category includes initiatives that are recommended to be undertaken primarily within the building design, construction and equipment manufacturing communities. The Public Policy category steps are those recommended for the public agencies responsible for governmental or institutional energy policy, and especially groups and agencies influencing utility and building regulatory policy. To be successful, a shared vision for moving forward must be developed and the industry and public policy steps must be coordinated to succeed. The industry steps I envision that are needed to move the industry toward a sustainable energy future include:

1. Work to reorganize building design, construction, turnover and operation processes to incorporate "performance based" building design and operation concepts wherein each new or retrofitted building project establishes specific energy performance goals and these goals are complimented with clear paths of authority and accountability to ensure they are established, achieved and maintained over time in concert with the supporting steps listed below.

2. Using the Energy Star model, develop a rating system of effective climate compensated performance standards that can be applied to all the building types that constitute the current building stock, and in place of the CBECS database provide benchmarks based on projected energy performance using currently available technologies to determine compliance. It is recommended that the basic Energy Star program with this new data base, separate categories for existing and new buildings, and a monthly assessment period be used as the basis for this expanded set of standards.
3. Develop equipment and control system standards for automatically monitoring and reporting performance information such that real time and historical performance data is available to the owners of residential, commercial, and industrial buildings, at all times and in a form that is useful in assuring their ability to manage and meet an overall monthly building energy performance standard, and identify and correct any developing problem that may affect building energy performance.

The recommended public policy steps include

1. Work with responsible government agencies to implement performance standards into enforceable codes and regulations for buildings based on an Energy Star Building rating system format. Monthly certification of minimum building performance may be tied to tax rates (incentives) or other surcharge. Or performance can be tied directly to an excess use energy rate. There are a variety of methods that have been considered and discussions with involved agencies should be initiated to find the most straightforward path. It is not difficult to imagine laws or ordinances requiring existing buildings to meet an accepted performance rating program on a specific timetable, and new buildings to meet somewhat more stringent energy performance requirements based on the same metric as soon as they become occupied.
2. Work with utility regulators to begin implementing individualized “excess use” energy rates and reporting formats wherein the non-process energy unit cost for each building escalates if the usage rises above the performance standard’s monthly energy use limit developed for that building based on building type and size. Such a path could mitigate or even replace the need for the codes or laws outlined above. Utilities served by forward thinking regulators may also provide energy performance certification for new buildings and energy performance monitoring/improvement services.
3. Develop performance based assistance programs that are funded with a portion of the excess use revenue to help owners improve the operating efficiency of their buildings. For residential building owners, availability to these funds could be based on need. For commercial and industrial owners, the funds could provide low cost loans. Unbiased technical assistance would also be provided as part of these programs to any building owner whose use exceeds the standard for their building.

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The positions and next steps recommended in this paper are the result of a thorough publicly vetted effort to determine the most effective path for incorporating significant improvement in building energy performance quickly and should be considered a starting point for further discussion. The author requests readers to provide comments, criticisms and alternative thoughts so that those can be incorporated into discussions with technical and public policy experts in order to reach a level of consensus as to how best to move forward and meet the challenge our society faces over the next several decades. Please address any comments or criticisms to: Tom Hartman at: (http://www.hartmanco.com/contact.htm)