Adaptive Climate Protection Policy: Designing a Market-Based Instrument to Promote the Emergence of Carbon-Neutral, Green Buildings

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ABSTRACT

The uncertainty surrounding global warming impacts and solutions requires innovative approaches to creating and implementing new climate protection policies. Since these policies will evolve over time, the most successful climate protection solutions of the future are essentially undetermined. Still, the magnitude of potential climate change impacts on our economies and ecosystems demands that governments begin taking precautionary measures. A policy design that includes periodic opportunities for change offers an alternate path recognizing the need to establish new policies in the near-term that can adapt over time, as uncertainties become certainties. The City of Portland's High Performance Green Building Policy proposes a market-based instrument with the adaptive capacity to maintain environmental effectiveness, economic efficiency and social equity while promoting the rapid emergence of highly energy efficient and carbon-neutral buildings.

Introduction

This paper describes a collaborative project between Portland State University and the City of Portland Office of Sustainable Development (OSD) to abate the future impacts of climate change using a market-based instrument and adaptive management to significantly reduce local carbon dioxide (CO_2) emissions from newly constructed buildings while improving the local economy and community health. Climate change is recognized as a major threat to the survival of species and integrity of ecosystems as CO_2 emissions from human activities increase. Reducing anthropogenic CO_2 emissions by 80% below current levels may be necessary to stabilize the climate, however developing and industrialized nations are challenged to place any limit on CO_2 emissions as fossil fuel consumption increases. Even if incremental implementation of current carbon-neutral energy technologies and carbon sequestration practices could potentially stabilize atmospheric CO_2 concentration in the next 50 years, the long atmospheric residence time of CO_2 would still result in a concentration of approximately 500 parts per million (ppm), nearly double the pre-industrial era. Since humans are not known to have existed within this atmosphere, uncertainty exists regarding the consequences of anthropogenic climate change on civilization and ecosystem resilience. Therefore, the use of adaptive management is proposed as an innovative policy design to accelerate the reduction of local CO_2 emissions from new building construction.

Background

Climate Change Impacts on Local Public Health and Ecosystem Services

There is widespread consensus in the scientific community that human activities are changing the climate through the release of greenhouse gases, particularly CO_2 (Hasselmann, et al., 2003). Based on observed changes in the latter half of the 20th century, the United Nations Intergovernmental Panel on Climate Change projects the following additional global climate changes are likely in the 21st century: warmer and more frequent hot days and nights over most land areas; warm spell and heat wave frequency increases over most land areas; heavy precipitation event frequency increases over most areas; area affect by droughts increases, intense tropical cyclone activity increases, and incidence of extreme high sea level increases. (Intergovernmental Panel on Climate Change, 2007). Moreover, research by the United States National Research Council indicates that the Earth's climate may involve nonlinear, abrupt changes between very different states rather than gradual shifts (National Research Council, 2002).

As ambient air temperatures rise, public health concerns include exacerbated morbidity and mortality incidences due to heat-related illness and respiratory disease. Rising temperatures indirectly impact public health by increasing air pollutant emission rates from anthropogenic and biogenic sources. In addition to increasing incidences of morbidity, higher concentrations of air pollutants can also increase mortality when combined with higher ambient temperatures during heat waves (Bernard, et al., 2001). Combined with the urban heat island effect, global climate change impacts on air pollution may present a significant health risk for citizens in the City of Portland and surrounding region. Rising atmospheric temperatures may also negatively impact local salmon recovery efforts as stream temperatures increase.

In the Pacific Northwest, the University of Washington's Climate Impacts Group has identified climate change impacts on natural resources and ecosystem services that are likely to affect Portland residents. Most PNW watersheds are highly dependent on the accumulation of winter snow pack for meeting water supply needs. Limited reservoir storage reduces the ability of watersheds to capture winter precipitation and snowmelt for use in the summer and fall (Climate Impacts Group, 2004). By mid-21st century, the Climate Impacts Group expects a decrease in water stored as snow and reduced late spring and summer stream flow. Due to projected decreases in annual snow pack and stream flow, declining water resources may reduce the supply of drinking water as well as electricity generated from hydropower for the City of Portland.

Local Climate Protection Solutions

In 2001, the City of Portland and Multnomah County prepared a Local Action Plan on Global Warming (Global Warming Plan) that includes a goal to reduce total CO_2 emissions by 10% relative to 1990 levels by 2010 (City of Portland, 2001). A recent progress report on the effectiveness of this plan concludes that the City of Portland has nearly stabilized CO_2 emissions and reduced per capita CO_2 emissions by 12.5 % since 1993 (City of Portland, 2005). In 2007, the Portland City Council and Multnomah County Board of Commissioners voted unanimously to update the Global Warming Plan including a new goal to reduce total CO_2 emissions 80% below 1990 levels by 2050. Climate change mitigation measures implemented by the City of Portland and Multnomah County may also benefit the local economy since consuming less fossil fuel increases energy savings that can be spent on local services and products. However, determining the full economic benefits of mitigation measures is difficult since many of the costs attributed to future climate change impacts are unknown and externally shared by the community. An economic evaluation of mitigation measures may aid the City of Portland in prioritizing implementation of technologies and policies to abate climate change. Policies that demonstrate both significant CO_2 emission reductions and benefits to the local economy are most likely to be successfully implemented by the City of Portland. If ample negative or zero cost options are available, then stabilization of atmospheric CO_2 concentration would entail little if any mitigation costs (Wigley, Richels & Edmonds, 1996).

Besides direct economic benefits from reducing CO_2 emissions, climate change mitigation measures may also have additional local environmental benefits that indirectly affect social costs. For instance, mitigation measures for global climate change tend to overlap with urban heat island effect abatement while also reducing air pollutant emissions. Mitigating urban heat islands reduces cooling demand, and consequently decreases primary air pollutant emissions from power plants and contributions to atmospheric CO_2 concentration. In addition, the reduction of fossil fuel combustion for air conditioning, heating, industrial processes and transportation decreases the release of primary air pollutants, CO_2 and waste heat into the atmosphere. Also, establishing vegetative cover in urban areas increases CO_2 sequestration through photosynthesis and urban cooling through evapotranspiration. Large numbers of trees and expansive green spaces can reduce local air temperatures by 1.8 ^oF to 9 ^oF, and the advection of this cool air can lower demand for air conditioning (McPherson, 1994).

High Performance Green Building Policy

As part of its Global Warming Plan, OSD conducts an annual inventory of CO_2 emissions from buildings, transportation, industry and solid waste disposal. Nearly half of the total CO_2 emissions result from electricity, natural gas and fuel oil consumption in buildings, including 21% from existing residential building stock, and 26% from the existing commercial building stock in 2004. Despite continuous economic growth and building development, CO_2emissions from the building sector have fallen since 2000. From 2000 to 2004, new building construction in the City of Portland increased at an average rate of 9,000,000 square feet per year, while CO_2 emissions from buildings decreased by 3.3%. The 2005 Global Warming Plan progress report notes.

> Energy-efficiency activities have made solid progress since 2000, with per capita building energy use declining 7%...Energy efficiency has also achieved considerable success as a core element of "green building," an emerging field in which Portland has established itself as a national leader. In 2000, OSD launched a program that offers technical assistance, education, and financial incentives for green building to the design, development and building communities and the general public. (City of Portland, 2005, p. 3)

Although much progress has been accomplished to reduce building CO_2 emissions from Portland's buildings, existing incentives are not enough to change the market.

In 2007, Portland's City Council asked OSD to develop policy options to significantly reduce CO_2 emissions created by the construction and operation of buildings. In response, OSD is drafting a High Performance Green Building Policy (HPGBP) to support a market transformation toward green building development while making significant progress on the Global Warming Plan update goal, 80% CO_2 emissions below 1990 levels by 2050, and recommendations from a city-appointed task force to adopt a goal of slashing oil and gas consumption in half by 2030. The HPGBP seeks to (a) cut global warming pollution from new building construction while conserving water, minimizing waste, and improving storm water management, (b) increase the number of living-wage local green building jobs, and (c) improve building occupant health and indoor environmental quality. The Global Warming Plan, Progress

Report, and drafts of the policy for commercial and residential new construction and existing buildings are posted on the OSD website: www.portlandonline.com/osd.

The key feature of the draft HPGBP is the Carbon Incentive Options, a market-based instrument that encourages the development of green buildings similar to an environmental economics feebate strategy. As shown in Figure 1, developers of building projects would have three options that, combined with additional incentives from the Energy Trust of Oregon (ETO) and the Oregon Department of Energy (ODOE) Business Energy Tax Credit (BETC), would reward buildings that demonstrate exemplary energy performance, and charge a fee for buildings that meet minimum State requirements:

1. Meet a 3rd party-certified green building standard that includes exceeding the Oregon energy code by at least 45%, receive a one-time carbon reward and be eligible for financial incentives from the ETO and ODOE BETC, as well as potential federal tax credits. The reward is based on the following calculation:

   Carbon Reward = (EUI of code building - EUI of building) x square footage x (carbon emissions per unit of energy) x ($ per ton of carbon) x building lifetime

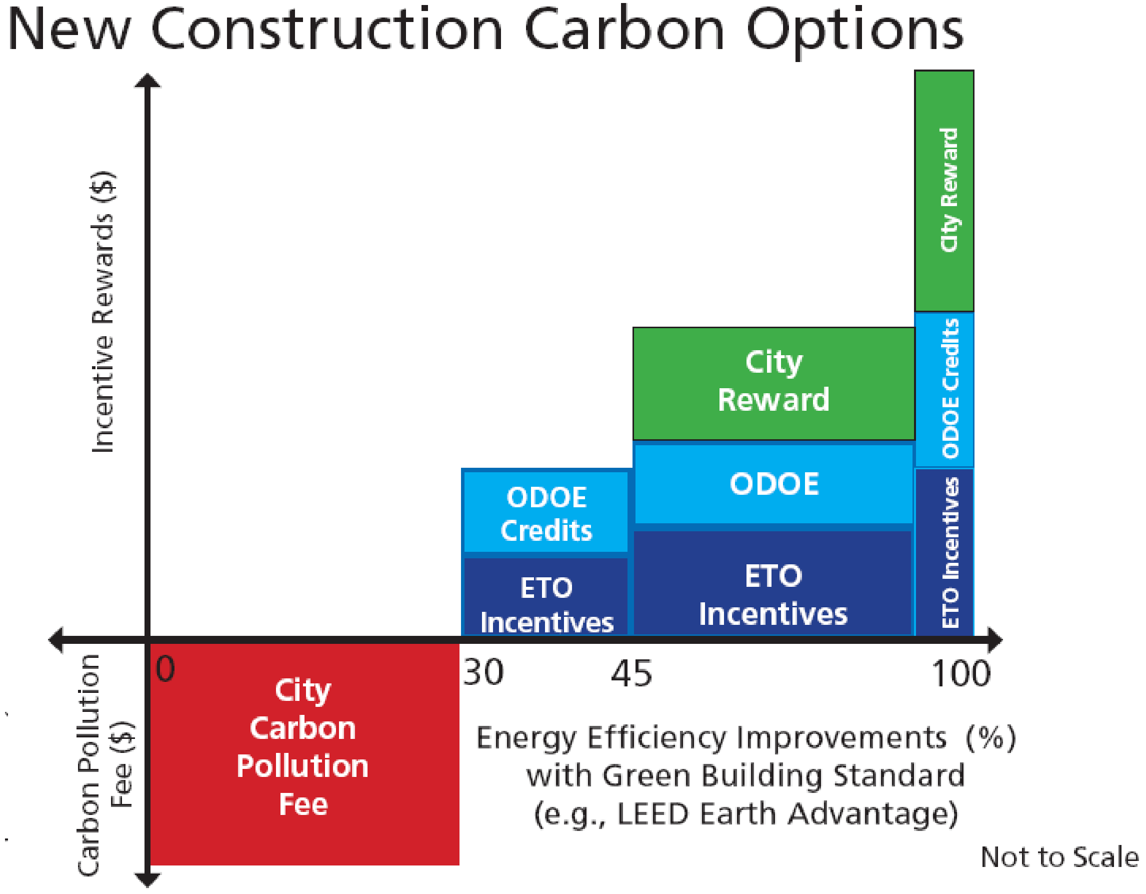
   EUI = energy use intensity, e.g., thousand British thermal units per square foot (kBtu/sf)

2. Meet a 3rd party-certified green building standard that includes exceeding the Oregon energy code by at least 30%, receive a carbon fee waiver and be eligible for financial incentives from ETO, ODOE BETC and applicable Federal tax credits.
3. Elect to not meet the waiver or reward options, and pay a one-time fee based on the following calculation:

   Carbon Fee = (EUI of code building) x square footage x (carbon emissions per unit of energy) x ($ per ton of carbon) x building lifetime

Carbon fees collected by the City of Portland would create a self-sustaining carbon fund to pay for financial reward incentives, technical assistance for policy compliance, project recognition and green building education programs. In the future, the proposed HPGBP carbon fund may also support green building market transformation through affordable housing grants, expedited permitting processes, floor to area ratio bonuses, and financial reward incentives for existing building remodels that significantly increase energy performance.

Figure 1. Carbon Incentive Options Proposed by the HPGBP



The City of Portland carbon reward could be combined with incentives from the Energy Trust of Oregon (ETO) and Oregon Department of Energy (ODOE) tax credits for highly energy efficient buildings (City of Portland, 2008).

Adaptive Policy Design

Effective policies for limiting anthropogenic climate change may include both near and long term greenhouse gas reductions. Aggressive reduction policies in a near-term, decade-scale period would include energy conservation coupled with switching to alternative fuels (Hammitt, Lempert & Schlesinger, 1992). However, few policy problems are dependent on such significant unknowns as the threat of climate change (Lempert, Schlesinger & Bankes, 2000). The uncertainty of future climate impacts can be attributed to a combination of environmental, economic and social factors:

- Variation in solar gain from the sun,
- Positive and negative climate feedback mechanisms,
- Historical evidence of abrupt climate change scenarios,
- The level of atmospheric CO_2 concentration that will stabilize the climate,
- Fossil fuel consumption rate,
- Endogenous growth and technological innovation,
- Undefined benefits of CO_2 emissions reduction policies, and
- Unknown costs of future climate damages.

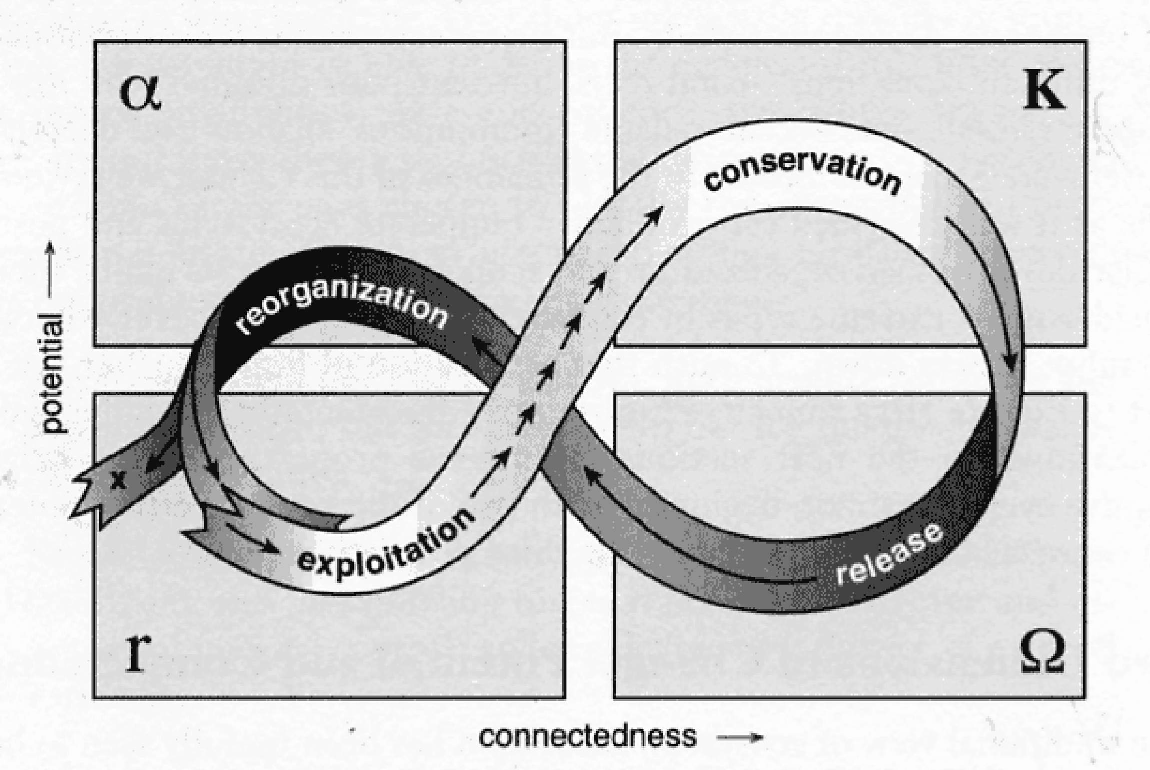
Since much uncertainty exists regarding the economic, social and ecological consequences of anthropogenic climate change on civilization and ecosystem resilience, establishing long-term climate change mitigation policies to implement new technologies may prove difficult as best available options are not clearly defined and potentially undiscovered. Still, near-term implementation of long-term adaptable climate change policies may be necessary to reduce anthropogenic CO_2 emissions 80% below current levels and potentially stabilize the climate at a pre-industrial atmospheric CO_2 concentration. Therefore, adaptive management is proposed as a least-cost abatement policy method to accelerate the reduction of local CO_2 emissions.

Adaptive management serves as a compass for developing sustainable natural resource policies and embodies a simple imperative: policies are experiments; *learn from them* (Lee, 1993). An adaptive policy is designed to have explicit, quantifiable goals that can be measured to compare the policy targets with actual results. If the policy fails to achieve these targets, or the goals themselves change, specified elements of the policy can be modified to correct errors or experiment with alternative parameters. Adaptive management plans for unanticipated outcomes by collecting information, and usually the greater the surprise, the more valuable information gained (Lee, 1993). Unlike trial and error, an adaptive approach designs and collects measurements so that action yields knowledge regardless of the policy outcome. The policy can then be adjusted based on environmental, economic and social responses with a better base of understanding for future decisions. Adaptive management is highly advantageous when policymakers face uncertainty, but the adaptive approach is not free: the cost of information gathering and political risks of having clearly identified failures are two barriers to its use (Lee, 1993).

An emphasis on adaptive management is appropriate for climate protection public policy because it recognizes the large uncertainty regarding the possibility of abrupt climate change scenarios and technological breakthroughs that radically reduce projected abatement costs (Lempert, Schlesinger & Bankes, 1996) and avoids actions with high social costs and expensive irreversibilities (Castle, Berrens & Polasky, 1996). This approach should assist in choosing realistic targets and in determining how best to implement greenhouse gas emissions reductions in the short and long term (Hammitt, et al., 1992). An adaptive climate protection policy enables early adoption of energy-efficient practices and technologies based on current knowledge while allowing for the capacity to change as future solutions emerge. Undoubtedly, the solutions to climate change envisioned today will appear different decades from now.

As drawn in Figure 2, the adaptive cycle is an approach for addressing complex and dynamic environmental problems based on the flow of events through four phases observed in ecosystem dynamics: a period of rapid growth and exploitation (r), leading into a long phase of accumulation and resource conservation (K), followed by a rapid creative destruction or release phase (Ω), and, finally, a relatively short phase of renewal and reorganization (α).

Figure 2. A Representation of the Four Ecosystem Functions (r, K, Ω, α) and the Flow of Events among Them



The cycle reflects changes in two properties: the potential that is inherent in accumulated resources, and the degree of connectedness among controlling variables. The exit from the cycle indicated at the left of the figure suggests the stage where the potential can leak away and where a flip into a less productive and organized systems is most likely (Gunderson & Holling, 2002).

In the α-phase, potential novelty can enter, such as new species, institutions, ideas, policies, and technologies, and the system can reorganize while sustaining its previous structure. Hence, sustainability can be defined as the ability to maintain continuous adaptive capacity.

On a global scale, anthropogenic climate change has resulted from an r-phase rapid exploitation of fossil fuel and forest resources during the era of Industrialization. Climate change mitigation measures include the initiation of the resource conservation K-phase. However, an Ω-phase release of existing industrial energy technologies followed by α-phase innovations may be necessary to avert significant anthropogenic interference of the climate system and subsequent collapse of ecosystem services. Reorganization of resource management strategies provides potential innovations in new energy policies and technologies as well as economically viable solutions to mitigate climate change. Climate protection policies to manage these new opportunities could then be implemented in an α-phase exploitation of carbon-neutral technologies and practices.

Rather than setting linear goals to attain incremental CO_2 emissions reduction, an adaptive policy allows for a cyclical evolution of economically efficient energy conservation policies and endogenous growth of innovative energy technologies. For example, the adaptive cycle could be applied periodically to incorporate changes in economic impact assessment methodology, valuation of external costs including community and environmental health, benefits to ecosystem services, and technological advances in carbon-neutral energy technologies that are currently under research. Implementation of an adaptive climate protection policy requires political inertia and is implemented in two phases: first, the challenging task of institutionalizing a framework for implementing intentional and varied policies, and second, the easier task of learning over time by monitoring the responses of varied experimental policies (Arvai, et al., 2006).

On a local scale, an adaptive climate protection policy evaluates a variety of direct and indirect policy outcomes, and then reorganizes aspects of the policy design to assure that policy goals are achieved. Since the proposed solution may not work in practice, or the problem may be much more difficult than originally envisioned (Van Horn, Baumer & Gormley, 2001), assessing policy performance requires effective monitoring of policy performance and evaluation of progress toward policy goals. There are many inherent difficulties in assessing a public policy including (a) making decisions regarding what questions to ask, (b) availability of enough reliable, objective evidence to make sound decisions, (c) establishing cause-and-effect relationships between a government action and a societal consequence, (d) applying standards, including public perception, to judge success or failure, and (e) anticipating and addressing problems before they become unmanageable crises or potential catastrophes (Van Horn, et al., 2001). Designing adaptive management at the beginning of a policy's development involves planning periodic evaluation of successes and failures with opportunities for reorganization of policy details while retaining the basic policy structure.

Much like how the resilience of a migrating species to climate change depends on the species' adaptive capacity, a resilient policy would be designed to increase future success through flexible opportunities for change. Early in the policy development, identification and monitoring of parameters is necessary to evaluate the effectiveness of a policy in achieving climate change goals. Just as integrated building design includes a commissioning agent at the beginning of a design process, including adaptive management in the early stages of a policy design process assures effective monitoring and evaluation of policy performance on a continuous basis to verify success in the future.

HPGBP Monitoring, Assessment, and Adaptive Management

To achieve the long-term Global Warming Plan goals for CO_2 emissions from new commercial and residential buildings, OSD could identify a regular, predictable schedule for raising building performance and monitor the progress of modeled and actual energy use within buildings. For instance, OSD could adopt The 2030 Challenge proposed by the American Institute of Architects and continuously update the HPGBP to assess whether the policy is successful in meeting this challenge. The 2030 Challenge proposes incremental fossil fuel reduction targets for the design of all new buildings, developments and major renovations as compared to the average energy use of the existing building stock:

- 60% reduction in 2010
- 70% reduction in 2015
- 80% reduction in 2020
- 90% reduction in 2025
- Carbon-neutral in 2030.

These targets may be accomplished by implementing innovative sustainable design strategies, generating on-site renewable power or purchasing (20% maximum) renewable energy offsets. The United States Green Building Council has set similar targets for reduction in site energy consumption with building certification through its Leadership in Energy and Environmental Design (LEED) rating system at 50%, Silver at 65%, Gold at 80% and platinum at 100% (Holness, 2008). As a baseline for measuring energy performance, LEED for New Construction, version 2.2, references the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings. In alignment with The 2030 Challenge, ASHRAE has developed a schedule for regularly increasing building energy performance for the 90.1 standard as well as a new green building standard, ASHRAE 189.1, Design of High-Performance Green Buildings Except Low-Rise Residential Buildings. The ASHRAE 189.1 standard includes prescriptive designs to improve energy performance by 30% greater than the equivalent ASHRAE 90.1 standard. The 2030 Challenge, ASHRAE 90.1 and ASHRAE 189.1 targets are shown in Table 1 relative to an ASHRAE 90.1-2004 baseline.

Table 1. A Comparison of Building Energy Efficiency Targets (Holness, 2008)

CO_2 Reduction Program	Target Date	Energy Efficiency Improvement (relative to ASHRAE 90.1-2004)	Aggregate Building Site Energy (kBtu/sf)
ASHRAE 90.1	2004	0 %	47.0
	2007	6.4 %	44.0
	2010	23.4 %	36.0
	2013	36.2 %	30.0
	2020	61.7 %	18.0
	2025	78.7 %	10.0
ASHRAE 189.1	2007	27.0 %	34.3
	2010	46.4 %	25.2
	2013	55.3 %	21.0
	2020	73.2 %	12.6
	2025	86.6 %	6.3
	2030	100 %	0
2030 Challenge	2010	23.4 %	36.0
	2015	42.6 %	27.0
	2020	61.7 %	18.0
	2025	80.1 %	9.0
	2030	100 %	0

The ASHRAE 90.1-2004 standard is roughly equivalent to the current energy code for new buildings in Oregon, and ODOE is considering a 2010 code update that would establish prescriptive measures to increase commercial building energy performance by 30% based on the future ASHRAE 90.1-2010 standard. Similarly, ODOE is in the process of promulgating a voluntary financial incentive, the Oregon High Performance Homes BETC, that establishes prescriptive measures to increase residential energy performance by 30% beyond the current Oregon energy code.

The 2030 Challenge and ASHRAE schedules for the reduction of building CO_2 emissions assume an incremental, linear relationship between building energy-efficiency and time. However, achieving these targets may not be feasible depending on technological advancements and improvements in economic saliency. Current LEED-certified projects have implemented building envelope and mechanical features that reach improvements in energy efficiency up to 60% greater than ASHRAE 90.1 – 2004 with a short-term payback period based on design modeling. However, actual energy use within a building can vary significantly because of occupant behavior, declining performance as a building ages, and plug loads that are generally increasing in contrast to improvements to building design. These operational unknowns, combined with the scientific uncertainties inherent to climate change, demonstrate the need for climate protection policies that have the capacity to adapt to the uncertain pace of technological, environmental, economic, political and social transformation within the building market.

In the case of the HPGBP, adaptive management would allow for building improvements and policy requirements to change over time, either increasing or decreasing, in concert with the capabilities of building designers that are leading technological innovation, and developers that are transforming the broader building market. Assessing the HPGBP success may include monitoring of the following metrics to determine the effectiveness of short-term and long-term policy outcomes:

- CO_2 emissions from new building construction as well as existing building stock,
- Local indoor and outdoor air pollutants,
- Electricity and fossil fuel consumption,
- Fiscal solvency of the carbon fund,
- Energy cost savings,
- Impacts on the local economy,
- Equitable distribution of social costs and benefits, and
- Participation and compliance with policy requirements.

An initial direct goal of the HPGBP is to reduce new building CO_2 emissions by providing financial incentives for buildings receiving 3rd party-certified green building standards that improve building energy performance. Achievement of this goal may be complicated by an increase in building plug loads despite significant energy efficiency improvements in building lighting, envelope, and heating, ventilation and air condition mechanical systems. If the goal is not achieved or indirect outcomes indicate the need for policy refinement, an adaptive HPGBP could periodically adjust specific policy elements including the following:

- energy efficiency thresholds for the fee, waiver and reward carbon incentive options,
- acceptable green building standards to demonstrate compliance, such as the ASHRAE 189.1 standard, or LEED Silver, Gold or Platinum certifications,
- carbon fee and reward calculations,
- exemptions for building types or sizes, and
- the funding of other green building programs.

Given the capacity to adapt, these policy elements could be adjusted every 3 years (i.e., in accordance with updates to the relevant codes and ASHRAE standards) to assure optimal progress toward the long-term OSD Global Warming Plan goals.

Conclusion

The future effects of global climate change may be uncertain, however the range of potential impacts on local, regional and global communities support the need for climate protection, energy efficiency and green building policies that significantly reduce anthropogenic emissions of greenhouse gases and mitigate the accumulation of heat in the troposphere. The proposed HPGBP is based on the premise that it is possible to achieve “a climatically brighter path with actions that make economic sense independent of global warming” (Hansen, 2002). The goal of the HPGBP is to develop an environmentally effective, economically efficient and socially equitable market-based strategy to significantly reduce local greenhouse gas emissions. The HPGBP also has the potential to establish an adaptive climate protection policy model that can diffuse throughout the United States despite the lack of a federal climate change abatement policy. The recent rise in public awareness around the science of global warming and the benefits of climate protection actions present policy windows for the rapid development of new, innovative climate change mitigation solutions. Implementation of successful climate change policies will benefit from additional research in the field of adaptive management applications to policy design characteristics as well as collaborative policy processes. The HPGBP presents an early opportunity to test these theories in practice.

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