Laying the Foundation for a More Energy Efficient Future:
Reducing Climate Change through Green Building

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Global Warming Context

In 2001, the Intergovernmental Panel on Climate Change (IPCC), which subscribes to the most rigorous standards, released its full climate change report and confirmed that the average global temperature is increasing as a result of human activity, with possibly catastrophic consequences for life on earth (Shaw, 2002).[1] The release of high quantities of CO_2 has been shown to be the primary cause of this increasing temperature. Quick reductions are especially important since these emissions remains in the atmosphere for at least a century, meaning that actions taken now will have long term consequences (Shaw, 2002).

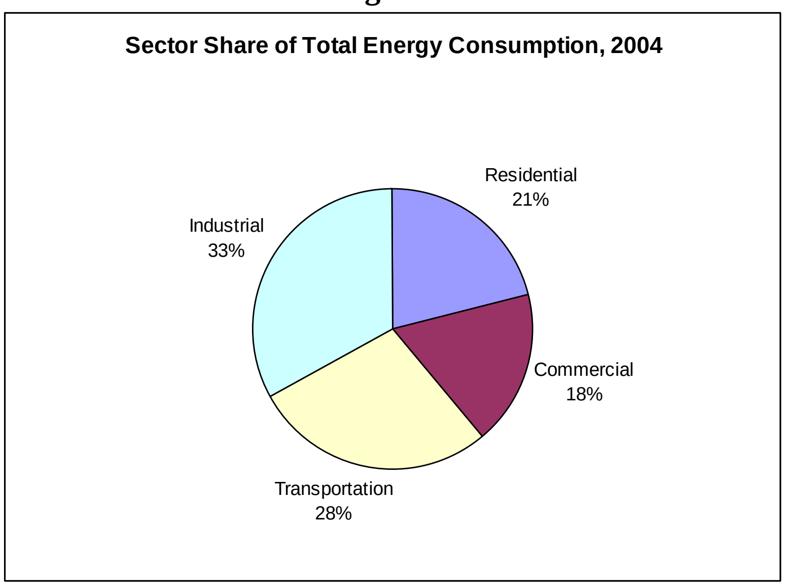
There are essentially two ways to reduce greenhouse gas emissions. One approach focuses on the supply side and attempts to minimize the production of greenhouse gases through cleaner energy production. The other method looks at the demand side and tries to reduce the amount of energy required by the world's population by increasing efficiency and reducing energy demand. Realistically, a combination of both approaches needs to be taken in order to tackle the problem effectively, and Steven Pacala and Robert Socolow have developed a stabilization wedges concept to addresses how global warming can begin to be tackled with a combination of existing technologies. According to the two professors, the basic tools needed to solve the carbon and climate problem for the next fifty years already exist and simply need to be implemented (Pacala and Socolow, 2004). No one technology will solve the problem by itself, but a piecemeal combination can prevent climate change from worsening (Pacala and Socolow, 2004). The wedges model divides the necessary reduction of CO_2 emissions into seven equal parts, with one wedge being "More Efficient Buildings" (Pacala and Socolow, 2004).

[1] The full IPCC report can be seen at www.ipcc.ch

Why Target Buildings

Buildings are huge energy consumers. As is shown in Figure 1, residential and commercial buildings account for 39% of total energy use in the US, (Energy Information Administration, 2004) meaning that reductions in buildings' energy demand could result in a great drop in the need for carbon-emitting power plant production. Additionally, peak electricity loads, which tend to determine the number of power plants needed and which sometimes requiring older, dirtier plants to come back online, are usually determined by the demand for lighting and cooling of buildings (Tester et al, 2005).

Figure 1



(Data Source: Energy Information Administration, 2004)

Residential electricity use per capita has been increasing since the 1980's, and US energy consumption, as a whole, is expected to continue growing due to the creation of more commercial floor space, the continued increase in the use of electric appliances in residential buildings, and expanding industrial output (Energy Information Administration, 2006). Essentially, decrease energy demand from buildings could greatly reduce energy production and its accompanying carbon emissions. As things stand now, however, builders usually care more about cutting their own initial capital costs than about long term efficiency, so inefficient building stock tends to get cemented into the building infrastructure. Even the construction of buildings themselves account for about one-third of total industrial energy use (Tester et al, 2005).

The incorporation of cleaner, more energy efficient buildings is extremely important to address now rather than later because buildings, unlike cars for example, have a very long life time. Building infrastructure that is invested in now is very difficult to change, so, if efficiency isn't incorporated at construction, it will be very difficult to improve in this area in the future. Office space in the US is expected to increase between one and two percent per year in the coming future (Energy Information Administration, 2006), so there is potential to make an impact.

The US and China

As the US is the biggest CO_2 emitter, this paper and its policy recommendations focus mainly on the US; however, since Asia accounts for 50% of the growth in the demand for energy every year (World Summit on Sustainable Development, 2002) and since China is a rising power with increasing wealth, some of the recommendations can be applied to China as well. China is currently experiencing a massive building boom, which will affect the country's building infrastructure for decades to come. The urban housing stock in China is expected to more than double within just the next twenty years, and commercial buildings are going up at a similarly rapid rate (World Bank, 2006). Additionally, heating energy per floor area in China is at least double the energy needed for comparable spaces in Western Europe and North America due to poor insulation, leakage, and thin building materials (World Bank, 2006). This high level of energy consumption means that there is feasible room for improvement. Additionally, since the US joined with China and other Asian nations for the aim of working to reduce global climate change through the "Asia-Pacific Partnership on Clean Development and Climate" and since one of the purposes of this alliance was "Strengthening [the] adoption and use of building and appliance efficiency standards," (US Department of State, 2006) it is rational to explore how improvements in the US's green building practices could be similarly applied to China.

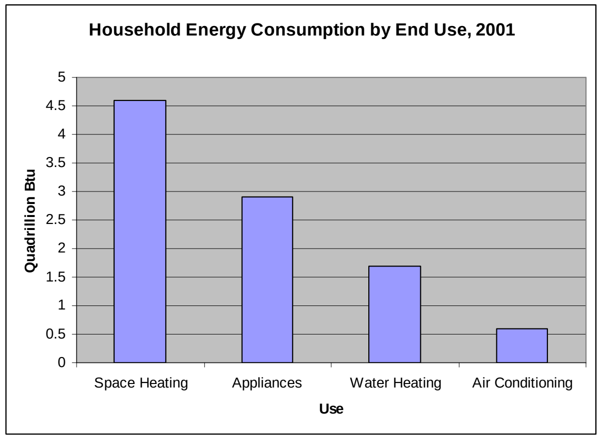
Increased Efficiency through Construction

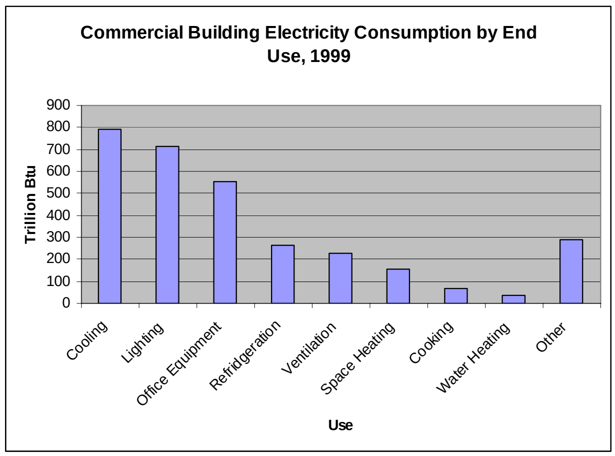
Before operational efficiencies are addressed within the building envelope, inefficiencies during the initial design and construction are important to take into consideration. Different building materials have different levels of embodied energy, due to their production and transportation to site, (Tester et al, 2005) which should be factored into the overall energy use of buildings. Since lots of energy and toxins are used during the production of many building materials, (Williams, 2006) there is a need to reduce energy consumption and toxic content on the production side of building materials, even before their uses within structure is analyzed.

Certain materials take little energy to produce and do not require far, energy-intensive transportation. Concrete made from fly ash, ashes from waste incineration, for example, uses significantly less energy to produce than regular concrete (Williams, 2006). Sustainably grown wood also avoids further deforestation and therefore has a smaller negative effect on CO_2 absorption. In order to encourage the use of these more energy efficient building materials, California's Integrated Waste Management Board has developed a labeling system that takes into account the various environmental effects of the production of building materials (California Integrated Waste Management Board, 2006). This kind of labeling could be prominently implemented throughout the country and could also include scales that show how the material's production energy level compares with other, similar products. Additionally, the ability of consumers to see these labels might encourage more energy efficient choices, and it is possible that material energy consumption could be included in building plans. The most efficient way to reduce energy use during production is to reuse and recycle existing products and to readapt existing structures instead of demolishing them. Government could facilitate the reuse of materials by organizing exchanges and recycled material depots, where builders could discard or pick up previously used materials.

Overall, though, the amount of energy used in construction is much less than the amount consumed over the lifetime of a building's operation (Tester et al, 2005). Heating and cooling systems are the biggest energy consumers in residential and commercial buildings, as is shown in Figure 2. Certain design decisions that are made before and during construction, however, can greatly impact a building's eventual heating, cooling, and general electricity needs.

Figure 2





(Data Source: Energy Information Administration, 2004)

Improved Insulation and Sealing

Insulation and a tight building envelope can greatly reduce the amount of energy needed to cool and heat a structure by minimizing the leakage of conditioned air into the outside environment. Adding wall insulation effectively diminishes heat loss and gain through the outside shell of the house and can be easily installed. The biggest savings and easiest place in a house to insulate insulation is usually in the attic (Energy Star, 2006). Additionally, sunspaces or vestibules in houses or commercial buildings act as thermal buffers, reducing the heat exchange between indoor and outdoor spaces every time someone enters or exists the building (Growther, 1992). If these buffer spaces are lined with windows, they can additionally often reheat themselves during winter months from the sun's heat, eliminating the neat to heat even these smaller areas (Growther, 1992).

Sealing the building envelope, in general, can reduce drafts and the need for more conditioned air production. Air leakage is an important component to address since it accounts for 25-40% of energy used by heating and cooling systems in the average house (Energy Star, 2006). The biggest gaps in residential houses are usually found in attics and basements and can be easily remedied, even retroactively, through wraps, tapes, spray foam, caulk, and weather stripping (Energy Star, 2006). Sealing is cost effective because it minimizes the need for conditioned air (Energy Star, 2006). Another way in which leakage and insulation can be addressed is by creating tight, insulated air ducts. Leaky ducts cause at least 25% of the energy used in conditioned air to be lost before it even reaches its final destination (Energy Star, 2006). As a remedy, ducts should be tightly sealed, insulated, and should not run through areas of the house, such as attics or garages, that are not temperature controlled (Energy Star, 2006).

Windows and Solar Use

Window type and placement during construction can also play a large role in determining the amount of energy that a building will require for heating, cooling, and lighting. Heat gain and loss through windows typically causes 25-50% of a building's heating and cooling needs, (Energy Star, 2006) and window area can determine the amount of artificial light needed. Thermal glass, as well as double glazing, can help keep indoor air at its desired temperature by preventing warming from the sun and by preventing exchange of heat through window surfaces. Additionally, insulating materials and tightly sealed window frames can help reduce heat exchange (Energy Star, 2006). The US Environmental Protection Agency's Energy Star programs labels windows that have these efficiency components.

The sun is the most direct source of energy, and its heat and light can be easily incorporated into the architectural system through the placement and size of windows. Large, vertical banks of windows on the south sides of buildings are the most efficient for taking advantage of the sun's energy because vertical glass walls avoid overheating the interior in the non-winter seasons and eliminate the annoyance of direct radiance, which often results from skylights. Thermal mass, such as dark concrete, brick, stone, marble, and tile can then be placed in the path of the incoming sunlight, and the heat that these materials absorb can be redistributed throughout the house with the use of interior air blowers, preventing the heat from simply reradiating back out through the windows (Growther, 1992). Minimal interior walls, feasible in many office and commercial buildings, in particular, can help reduce the need for artificial light (Pogrebin, 2006), and studies have shown that the use of natural instead of artificial light improves performance by between 20-25% (Pogrebin, 2006). Lastly, sealed windows in tall buildings are not necessarily the most efficient for climate control, as natural ventilation can sometimes provide more comfort with less energy (Tester et al, 2005).

Siting and Landscape

Older ideas about siting and passive climate control have mostly faded in the US, where builders don't always think about the efficiency of their structures (Tester et al, 2005). Incorporating features such as overhangs, canopies, awnings, and recessed windows, however, can minimize unwanted heating in the summer, (Growther, 1992) and trees can be placed strategically for shade in hot climates and for windbreak in colder ones (Growther, 1992). Low, dense evergreens block winter winds, and deciduous trees allow for sun in the winter but shade in the summer (Growther, 1992). Native landscaping also does not require high upkeep and reduces the need for pollution-emitting machines, such as leaf blowers and lawnmowers (Growther, 1992). Roof gardens not only provide for the reclamation of natural space, but they also serve as huge insulators and can produce a fifty percent reduction in air conditioning needs in most buildings (Whiting, 2006). In addition to these siting improvements, counter to the current trend in the US, smaller buildings are inherently more efficient because they have less space to heat, cool, and light.

Though the limited length of this paper does not allow for an in-depth discussion on siting within the urban context, decisions relating to this field are also extremely important. Energy efficiency can be improved through the use of smart growth practices, where buildings are clustered in dense, multi-use, walkable areas with access to public transportation. Not only does proximity to public transportation reduce reliance on carbon-emitting private cars, but density ensures the feasibility of public transportation infrastructure in the first place and walkable, multi-use clustering reduces the need travel far distances in the first place. Changes in land use practices, however, will not happen on their own and require policy intervention, through updated building codes and zoning regulations.

Building Operation: Heating and Cooling

As Figure 2 illustrates, heating and cooling remain the two largest energy consumers in US buildings, followed by lighting and appliances. Energy use can be greatly diminished through operational choices in these three areas. With the US population moving farther South and West, electricity demand for air conditioning in homes and commercial spaces is burdening the electrical grid; (Energy Information Administration, 2006) however, there are many non-energy intensive ways in which a comfortable temperature can be maintained. With the advent of advanced electronics, energy and conditioning use can be controlled more selectively. Thermostats with daytime-nighttime settings and thermostats on timers can increase efficiency for buildings used at selective times (Tester et al, 2005). Humidity control and increased air circulation, with such simple equipment as desiccants and fans, can provide more comfort with less energy, as moving, dry air allows people to comfortably tolerate higher temperatures (Lechner, 1991, as sited in Tester et al, 2005).

In the new Hearst Building in New York, architects have focused on reducing heating and cooling costs by incorporating an indoor waterfall that chills and humidifies the air and by installing a lobby floor of radiant stone, which will generate heat in the winter and absorb heat in the summer through water that flows just below its surface (Pogrebin, 2006). Running this water system has lower cost and is less energy intensive than conditioning the air of the entire lobby, especially since people only come into contact with air several feet above the floor anyway (Pogrebin, 2006). Similar to the overall wedge model, when thinking about improving buildings' energy efficiency, one should not just focus on the primary energy source but also on how complimentary energy sources and reused energy can be harnessed to increase efficiency.

Geothermal Heat Pumps

Location, regional geography, and tectonics all play a role in determining the depth, position, and temperature of geothermal energy sources, but geothermal systems exist worldwide (Tester et al, 2005). Spontaneous geothermal systems have the potential to provide large amounts of energy but are not always located near markets; however, the constant temperature of the earth's subsurface ground can be harnessed everywhere in order to aid in the heating and cooling of individual buildings (Tester et al, 2005). A reliance on the constant temperature of the ground as a heat source or sink would decrease the need for other heating and cooling energy generation, currently the largest aspect of buildings' energy demand.

Essentially, geothermal heating and cooling works by drilling into the ground and installing a closed loop pipe horizontally beneath the frost zone, at depths ranging from 100-400 feet depending on the latitude. Geothermal heat pumps (GHP) then circulate a liquid solution through these pipes, and this solution absorbs or releases heat into the consistently temperature of the ground. The solution is then cycled through the above building, heating or cooling it in the process (Tester et al, 2005).

Geothermal heat systems are actually fairly cost competitive with other energy sources and can reduce energy consumption by 63-72% over electrical heating and standard air conditioning (L'Ecuyer et al., 1993, as cited in Tester et al, 2005). Granted, there is a higher initial investment in than with traditional heating and cooling systems, but the additional initial cost is returned in energy savings within five to ten years (US Department of Energy, 2005). Since the system life is twenty-five years for the outside components and over fifty years for the ground loops (US Department of Energy, 2005), geothermal systems are not only a carbon free way of heating and cooling buildings but are also cost advantageous.

As of 2005, there were 2 million GHPs heating and cooling buildings worldwide (Renewable Energy Policy Network, 2005). Forty thousand are installed in the US every year (US Department of Energy, 2005), and the instillation of GHPs has been growing at a rate of 15% per year in the last decade (Tester et al, 2005); however, with relatively low costs for gas and heating oil, there is an insufficient incentive for consumers to make the initial investment in geothermal heating (Tester et al, 2005). This is the case even though geothermal heating is cost effective and carbon free and though it takes up very little surface area, which is a benefit among renewable energy sources. Barring significant policy or energy price changes, the use of on-site solar electricity and GHPs is expected to more than double between 2006 and 2030; however, these energy sources would still comprise less than one percent of total delivered residential energy use during that period (Energy Information Administration, 2006). For these reasons, the US government should continue to promote and aid in the instillation of GHPs. In addition to benefiting the US by providing reduced reliance on carbon-emitting energy sources, rapidly growing countries like China, which still face occasional energy shortages, would also benefit from increased industrial and economic production if GHPs could provide a base level of uninterrupted heat (Tester et al, 2005).

Other On-Site Clean Energy Sources

Just like GHPs, other onsite renewable energy sources can be helpful in reducing the demand for carbon-emitting energy production. Photovoltaic solar collectors (PVC) can be especially helpful in meeting additional energy demand from air conditioning and hot water heating. Peak loads on the electrical grid in the US can be diminished, for example, with solar powered air conditioners (Tester et al, 2005). The US could also learn from the rest of the world, where rooftop PVC panels provide hot water for 40 million households, the majority of which are in China (Renewable Energy Policy Network, 2005). Instillation of GHPs and PVCs shows that a building does not need to convert completely to renewable energy sources for renewables to effectively reduce carbon-emitting energy production.

Operation: Lighting and Appliances

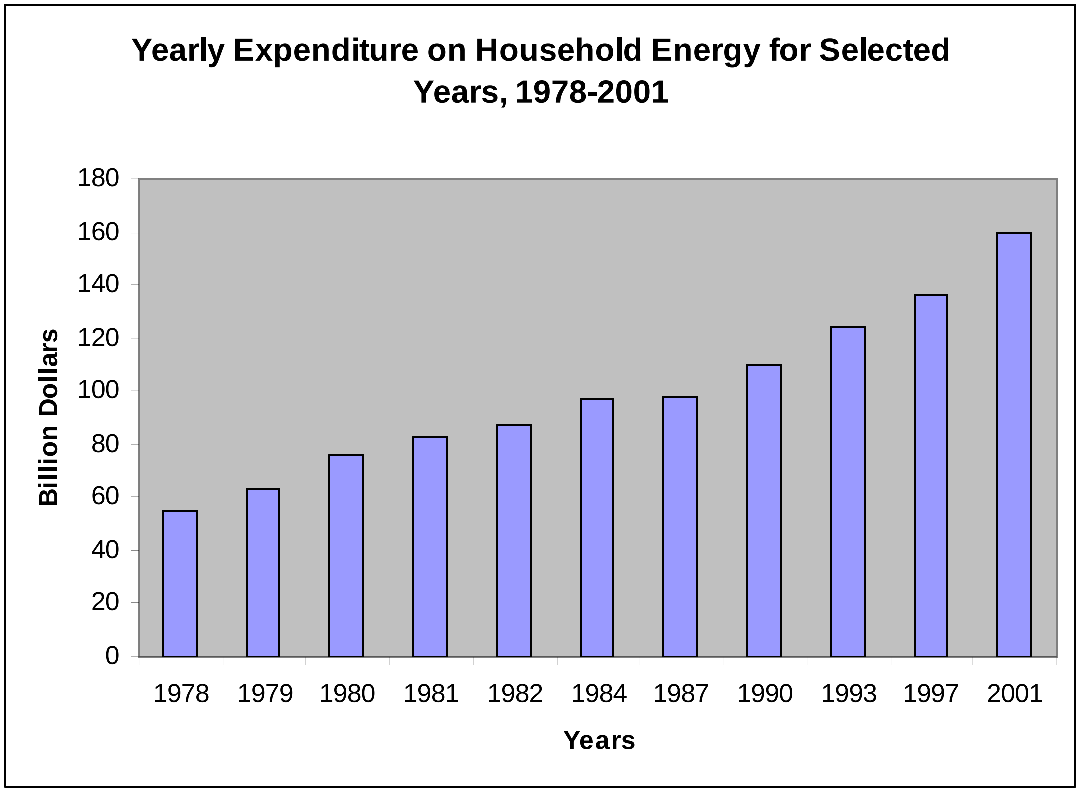
Lighting and appliances play the second largest role in buildings' energy demand (Energy Star, 2006), and consumer choices can greatly affect the energy consumption of these products. In the early 1990's, the US government launched the Energy Star program, which facilitates making environmentally smart choices through a voluntary labeling program that identifies energy efficient products (Energy Star, 2006). Energy Star products meet the strictest energy efficiency guidelines set by the Environmental Protection Agency and the US Department of Energy and are labeled as such as a way of encouraging their purchase (Energy Star, 2006). A typical US household has a yearly energy bill of $1,500; however, by changing over to all Energy Star certified appliances, lighting, and electronics, and by following Energy Star recommendations for insulation and sealing, the typical household would reduce their energy bill by 30% (Energy Star, 2006).

Energy Star certified compact fluorescent lights (CFL) consume 66% less than the typical incandescent bulb and last ten times longer (Energy Star, 2006). If every household in the US replaced one existing incandescent bulb with an Energy Star CFL bulb, the effects on carbon emission resulting from reduced energy consumption would be the equivalent of removing 1 million cars from the road (Energy Star, 2006). If every US family did the same thing with five light bulbs, the US would eliminate 1 trillion pounds of greenhouse production, and it would be the equivalent of taking more than 8 million cars off the road or twenty-one power plants off line (Energy Star, 2006). Not only would the carbon savings be great, but the energy savings would reduce operating costs too. Replacing a 100-watt incandescent bulb with its CFL equivalent would save $30 in energy cost over the lifetime of the bulb, more than added cost of buying a CFL bulb (Energy Star, 2006). Occupancy and brightness-intensity sensors can additionally be used to cut down on excessive lighting in commercial buildings, where lighting consumes 13% of those buildings' energy demand (Energy Star, 2006).

Additional Advantages to Green Building

In addition to the environmental benefits of green building, becoming more energy efficient, in the long run, brings down costs and reduces waste. The geothermal payback period and the savings resulting from the use of CFL bulbs are two examples of how energy efficiency is cost effective. This reduced cost is significant in the face of consistent increases in household energy expenditures, as shown in Figure 3. Sustainable architecture once added up to 20% to the cost of a project, but, now, because of the availability of new materials, it adds only between 1 and 5% (Pogrebin, 2006).

Figure 3



Data Source: (Energy Information Administration, 2004)

Many office developers are also finding that building green is cheaper than expected, increases a property's value, and attracts tenants (Roeder, 2006). There is simply a greater upfront cost, since the majority of green technology requires higher than normal initial investment. Over time, however, returns more than make up for the added cost. Some builders believe that it is very worthwhile to get the US Green Building Certification because it produces savings for tenants and therefore justifies higher rents, especially in an atmosphere where many corporations are beginning to include environmental consciousness in their company values (Roeder, 2006). This increasing efficiency of office buildings is encouraging since these buildings are the largest commercial building energy consumers, at 767 trillion Btu, in comparison to the next highest 521 trillion (Energy Information Administration, 2004).

Another added benefit to increased energy efficiency is the reduced need for power plant construction. Especially in the US, where finding sites to build power plants can be extremely controversial, there would seem to be broad support for policies that reduce the need for new power generators. In countries like China, where there is such rapidly rising energy demand, there is an increasing awareness that energy efficiency and better construction is cheaper than building new power plants (Tester et al, 2005), illustrating that more energy efficient buildings can benefit developing countries too and showing to the US that energy efficiency is a logical goal, irrelevant of its environmental consequences.

Obstacles towards Green Buildings

Unfortunately, many US citizens do not realize the benefits of increased building efficiency. In Europe and Japan, where energy costs are much higher than in the US, operating costs play a bigger role in buyers' decisions (Tester et al, 2005), showing that higher energy costs make people realize the consequences of inefficient energy use. Because of the present price structure for energy and materials, people and companies are constructing ever larger buildings because they can easily afford the needed energy (Tester et al, 2005). People do not factor in energy conservation into their decisions; they simply buy as much as they can (Tester et al, 2005). US policy should harness this information and make it less cost effective for consumers to be inefficient. In the early 1980's, energy demand dropped due to recession and high energy prices, but, by the mid-

1980’s, energy consumption had increased again due to declining prices and an economic upturn (Energy Information Administration, 2006). This historical fact shows that the ease with which people can buy energy and the price of energy greatly affects consumption. The US, therefore, must devise a policy that valuates the cost of inefficiencies through taxes, that makes excessive energy consumption expensive, and that creates other disincentives for inefficient energy use. Building codes in Japan and Europe also usually emphasize higher levels of efficiency than US codes do (Tester et al, 2005). Zoning efficiency requirements in the US could mandate a certain level of energy efficiency but leave the means with which the goals are met up to the builder or owner.

In addition to energy costs, environmental costs are also not always given much attention in the US because there are few visible or immediate consequences. Because of this ignorance, the externality of environmental damage is not usually factored into design, construction, or purchasing decisions. US policy would therefore benefit by internalizing the cost of carbon emissions for consumers and producers.

Lastly, an obstacle towards green building is that energy efficient equipment and infrastructure usually requires higher capital investment than traditional energy infrastructure. Government policy, therefore, needs to find a way to bring down the initial cost by either subsidizing green investment or by increasing demand enough to make energy efficient materials, equipment, and generators common and cheap. Currently, technology that has the ability to reduce commercial energy consumption by up to 50% through more efficient air conditioning compressors is available, but, when businesses consider equipment purchases, they often place more weight on additional capital investment required for the most efficient technologies than they do on future energy savings (Energy Information Administration, 2006). This kind of thinking limits the adoption of efficient technologies (Energy Information Administration, 2006). The US government should therefore try to take actions that would cause people to internalize the life-cycle cost of their buildings and products rather than just the upfront investment.

Though some players in the building industry will create sustainability standards in the current climate, the entire industry will not incorporate green building practices on its own; it will only happen through regulation or market pressure (Tester et al, 2005). Governmental organizations should therefore facilitate alliance based around green building practices and should implement requirements through building codes and zoning that require increased efficiency and reduced carbon footprints.

Useful Policy Models

Existing and proposed policies can serve as effective models in formulating policies that can promote green building. Over the years, there has been discussion about increasing the gasoline tax as a way of increasing the number of fuel efficient vehicles, reducing unnecessary and inefficient driving, and making public transportation more attractive. Since there is a similar lack of awareness about inefficiencies and the environmental costs associated with excessive energy use in the building sector, a similar carbon tax could be applied to energy consumption coming from carbon-emitting sources in order to discourage inefficiency.

Additionally, current policies that aid home buying could incorporate green building requirements or could be applied in different ways so as to encourage the purchase of green homes. Fannie Mae and Freddie Mac offer government-sponsored mortgages to lower income citizens and first time home-buyers in order to help them purchase houses. If these or additional mortgage aid could be applied to the purchase of green houses, the demand for and, therefore, the supply of energy efficient, green buildings would increase, and lower income residents would have the added benefit of lower operation costs.

Models in the private sector also exist and can be built upon. The creation of the international, private partnership Sustainable Building and Construction Initiative (SBCI), which aims to promote environmentally friendly building practices in the building industry (National Environmental Education and Training Foundation, 2006), shows that there is demand for increased green building even among builders. This alliance has the objective of adopting sustainable building practices, encouraging legislation and building standards that include sustainability impacts, and encouraging a "life-cycle approach," an approach that takes into consideration the cost, environmental impact, and energy consumption of a building over its entire lifetime (National Environmental Education and Training Foundation, 2006). These types of organizations should be further promoted by the UN and the US.

In general, there is a need to expand US policy in the area of green building and renewable energy. Regulations should move beyond simply requiring industrial energy efficiency and should begin to target the biggest segment of the energy consumption pie: buildings. By requiring higher standards for heating, appliances, weatherization, and building codes and by targeting consumers, policies can help drive producers to respond with more appropriate equipment. The US's hesitation to clamp down seriously on global warming and energy use could eventually put the country at an economic disadvantage if other countries, spurred by requirements for greater efficiency, develop technologies that the US ends up having to import.

Currently, the US federal government offers tax credits and subsidies for energy efficient appliances (Tester et al, 2005). Capital grants, rebates, and investment tax credits for solar hot water heating usually cover about 20-40% of the system cost (Renewable Energy Policy Network, 2005), and federal and state governments began giving tax credits and incentives for the use of geothermal heat in the 1970's (Tester et al, 2005). Additionally, states offer a variety of their own incentives, such as Maine's $7,000 rebate for the cost of solar panels (Williams, 2006). Further reducing the investment needing to be made by individuals or companies in green building equipment and materials will serve to increase the adoption of green building practices. Federal buildings are some of the biggest users of energy-efficient technologies due to congressional and executive mandates (Palmer, 2006). The prevalence green components in these buildings shows that the technology is available but just needs to be fostered, that increased demand reduces prices and makes energy efficient equipment more accessible to everyone, and that incentives and requirements can effectively cause people to adopt better practices.

Providing more information to consumers about the true costs of their investments will also help consumers make more rational choices that factor in life-cycle energy costs. This knowledge would rationally cause them to gravitate towards energy efficient offerings. Energy Star certifies a range of building materials and equipment based on their efficiency and long-term cost savings already. Its certification is also available for homes that incorporate a certain number of energy efficient components. The fact that, in

2004, 8% of new single-family homes were Energy Star certified (Energy Information Administration, 2006) shows that these more stringent efficiency guidelines are feasible. In 2005, more than 2500 buildings in the US earned the Energy Star, and, combined, these certified buildings save an estimated $349 million annually in lower energy bills and save 1.8 billion pounds of greenhouse gas emissions (Energy Star, 2006).

The US Green Building Council (USGBC) also has a certification program designed to promote environmentally responsible, profitable, healthy buildings. It uses the Leadership in Energy and Environmental Design (LEED) certification system that awards different levels of certificates to buildings based on how green and efficient the building is, using a point system to determine qualification (US Green Building Council, 2005). Part of the attractiveness of the LEED program is that it includes different levels of certification, which pushes builders to seek out continual increases in efficiency even after they have reached the baseline requirement. A similar approach could be applied to Energy Star's energy efficiency labeling and would serve to encourage further efficiency improvement even after the initial goals have been met.

The incentive to get LEED certified is the positive visibility that results from certification. The USGBC provides recognition and allows companies to promote their certification status (Roeder, 2006). This visibility is what pushed both the new 7 World Trade Center and Hearst Building in New York to get LEED certified. John Buck Company, a green office building firm in Chicago, says that following LEED guidelines adds about 1-2% to the cost of a building's construction but add considerable resale value, (Roeder, 2006) implying that going green is cost effective and showing that there is demand for green building but not enough supply.

Some municipalities have decided to actually mandate certain green building requirements through building codes. Israel requires solar hot water heaters in all new construction, and many cities, such as Barcelona, have requirements mandating a certain amount of solar use (Renewable Energy Policy Network, 2005). In Barcelona, buildings over a certain size must heat 60% of their hot water with solar thermal collectors (Renewable Energy Policy Network, 2005). Even within the US, New York City mandated in October of 2005 that non-residential public buildings costing $2 million or more and any private projects receiving $10 million or more than half of its budget from public funds must be built to LEED standards (Pogrebin, 2006). These policies show that energy efficiency requirements are feasible and are probably more realistic when applied to larger projects, where the initial cost of green infrastructure will not overwhelm the budget.

Building codes in China that require certain energy efficient components continue to show that mandated efficiency is a feasible and effective way to ensure the construction of greener buildings. After the 1996 Energy Conservation Design Standard went into effect in Beijing, which mandated improved insulation, better windows, and lower air filtration, there has been a 59% drop in the annual heat load between 1996 and 2001 (Glicksman et al., 2001, as cited in Tester et al, 2005).

In addition to mandates, which have shown significant results, making consumers pay for their specific heat consumption is also believed to be responsible for greatly reducing wasteful heat consumption. Throughout most of China, there are no incentives to conserve heat or use it efficiently because the country do not meter heat use; consumers simply pay on a per square foot basis, irrelevant of their level of consumption

(World Bank, 2006). Developers have no incentives to construct energy efficient buildings since consumers do not care (World Bank, 2006). The World Bank is currently engaged in a project with the Ministry of Construction of China that aims to increase energy efficiency in urban residential buildings partly by reforming heat pricing and billing through metering and consumption-based billing (World Bank, 2006). If these efforts succeed, the World Bank estimates that energy use in new residential buildings will be halved and that the savings would be 13 million tons of coal and the avoidance of 10 million metric tons of carbon emissions from the six target cities over twenty years (World Bank, 2006). The program was decided on because officials have discovered that an integrated approach is needed to address building efficiency, meaning that consumers need to have incentives to be energy efficient or disincentives to be inefficient at the same time that codes must mandate more energy efficient components to create supply for any new demand (World Bank, 2006). These lessons from China can be applied to the US and justify a multi-pronged attack in increasing building efficiency.

Policy Recommendations:

1) Impose a carbon tax on consumers for the consumption of electricity originating from carbon-emitting sources.

Since the externality of climate change is not strongly factored into people's electricity consumption habits and since higher prices have been shown to reduce consumption, this tax could effectively discourage consumers from inefficiency and would spur electric companies to respond with renewable power generation, which they would be able to sell to end consumers for less money. Additionally, the revenue gained from this “dirty electricity tax” should be used to subsidize renewable energy infrastructure.

2) Increase subsidies for the initial cost of geothermal heating and cooling systems, using funds obtained from the “dirty electricity tax.”

The instillation of GHPs has been shown to be an effective and efficient way of reducing the need for carbon-emitting heating and cooling, the largest energy consumers in buildings. Additionally, GHPs are feasible country-wide. The main obstacle in the way of their widespread use is the high initial investment, which increased subsidies would help ease.

3) Create a mortgage program through Fannie Mae and Freddie Mac that offers concessionary rates for mortgages on energy efficient buildings.

Making green buildings financially more attractive would increase demand and would also eventually increase supply.

4) Mandate LEED certification or a certain renewable energy component for buildings over a certain size.

Although the capital investment in efficient equipment and renewable energy sources can be expensive, these costs are less of a burden for larger and already more expensive projects. The Barcelona and New York models have shown the feasibility of such requirement policies. Additionally, this requirement would both serve to increase efficiency in these buildings and expand the market for green equipment and materials, eventually serving to bring down prices and make them more feasible for others.

5) Incorporate estimated life-cycle and yearly energy operating costs on the labels of all appliances, lighting, and other energy consuming equipment.

Since consumers are resistant to spend the premiums that accompany greener, more efficient materials and equipment, labeling the estimated energy cost for operation would help consumers evaluate the true cost of equipment ownership. Additionally, unlike the current Energy Star program and more similar to the LEED program, including levels instead of just an efficiency baseline would further encourage manufactures to increase the efficiency of their products.

6) Use Type II partnerships to provide resources and an organizing framework for those in the building industry to come together in the creation of green building alliances.

Due to SBCI and the advantages that many builders are beginning to see in green building, it seems as though there is a growing movement within parts of the building industry to advance energy efficient and environmentally related goals, which governmental organizations should foster and help succeed.

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