Tackling Information Barriers: Adoption of Energy Efficient Technologies Through the HERS Index

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Abstract

The use of energy efficient technologies in the United States lags behind other developed countries. This problem is not the result of a lack of product development or availability; the problem stems from the information barriers surrounding efficient technologies and the low demand for these technologies on the part of the consumer. This study evaluates a scenario in which the city of Chicago implements mandatory audits are paid for by the city, and conducted for each place of residence. The results of these audits must then be made public to both the current residents as well as any individual looking to buy or rent the home. This policy will improve the information surrounding residential energy use and will increase the use of energy efficient technologies for those consumers who have a desire to save money or energy but do not have the time, funding, or knowledge, to initiate their own audit. Long run implications include: increased understanding of energy efficient technologies and practices, decreased cost of energy on a residential level, improved city-wide respiratory health as a result of a decrease in pollution, and potential spill-over effects to other cities and states in the country.

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Introduction

Demand for energy efficient technologies continues to be low, despite robust evidence that the adoption of such technologies would decrease individual energy costs, health problems, and harmful gases (The National Academies, Summary 2010). This paper seeks to address the lack of demand for energy efficient technologies in Chicago's residential housing sector by mandating that every residential building be rated through the Home Energy Rating System (HERS) index, with the results of each audit made public.

In 2009, the United States had one of the highest ratios of energy consumption to GDP of developed countries in the world (The National Academies, Report in Brief). This is a problem on many fronts, such as dependence on foreign oil, decreased competition in the commodities market due to high prices, global warming, and the health effects of pollution. A recent study, which involved determining the health effects of the emissions of Illinois power plants, concludes that there are "potentially significant public health impacts" of pollution. The authors estimate Chicago's Fisk and Crawford coal-fired power plants contribute to an additional "41 premature deaths, 550 emergency room visits and 2,800 asthma attacks every year" (Levy, 2002).

The production and consumption of energy has significant short and long-term effects. One study estimated that in 2005, the unseen cost of energy use in the U.S. reached the figure of $120 billion (Hidden Costs, 2009). In light of this, the U.S. would benefit greatly from decreased energy consumption and an increase in energy efficient technologies.

The National Academies published a report in 2010 on the future of energy efficiency in the United States. The findings of the report support the adoption of energy efficient technologies as a solution to the negative impacts of energy use. Of the predicted energy consumption in 2030, the report claims that 30% would be saved if the United States adopted the energy efficient technologies that are available today (The National Academies, Summary 2010). This value is supported by similar findings in other studies (The National Academies, Summary 2010, Granade, 2009). The use of energy efficient technologies would not only save what one report predicts to be $130 billion annually, but would also more than cover the increase in energy consumption that is expected to occur by 2030 (National Academies, Summary 2010, Granade, 2009). Of these possible energy savings, buildings account for 53%, which is more than industry and technology combined (National Academies, Summary 2010).

In addition to these benefits, energy efficiency avoids downfalls of other energy-saving methods, such as renewable energy or energy conservation. Energy efficiency can be thought of as using less energy to accomplish a specific task, for instance heating a house, or driving to the store. In comparison to this, energy conservation involves individuals changing behavior in order to conserve energy, such as turning the heat off, or walking to the store. In not requiring individuals to change their habits, energy efficiency could be considered a more appealing and easily adopted solution. Additionally, energy efficiency does not require the environmental and monetary cost that building alternative energy producing facilities can incur. (The National Academies, Summary 2010).

Despite the great potentials of energy efficient technologies that are currently available, they have not been adopted widely in the United States (Granade, 2009). This accounts for roughly 50% of the difference in energy consumption between the United States and other, more energy efficient, developed countries (The National Academies, Brief 2010). Given the energy and monetary savings of energy efficient technologies, the lack of demand in the US suggests the existence of barriers. These barriers should be addressed when suggesting a policy to increase the usage of energy efficient technologies.

In order to make the most impact on long-term energy reduction, it is important to arm the consumer with the most relevant information possible. Thus, energy use in households is an ideal target for policy makers since homeowners and renters make daily decisions about their own energy consumption. The important factors that make places of residence appealing for the improvement of information as a path to adopt energy efficient technologies includes: the lifespan of buildings, split benefits, consumer preferences and externalities.

That buildings last for so long is one of the primary reasons for targeting buildings in implementing energy efficient technologies. Constructing a building that is energy efficient will lock in that low energy usage for a lengthy period of time. On the other hand, there is little incentive to renovate older buildings to make them more energy efficient, and so these will most likely remain at their higher level of consumption until they are no longer in use. Given the necessary information, certain consumers will elect to change their own behavior and the energy efficiency of their inefficient homes.

The problem of split benefits occurs when the person constructing or designing a building does not receive the benefits of adopting energy efficient technologies, as in the case of tax breaks, and thus lacks the incentive to make improvements on the energy consumption of a building. An increase in understanding of energy use places an impetus on the resident of the house to ensure that the appropriate technologies are in place; thus removing the cost burden from the builder.

Another barrier to the use of energy efficient technologies is that the price of energy does not reflect the externalities, for instance pollution (Hidden Costs, 2009). In the past, when the price of energy rose, public interest in alternative energy or energy efficiency rose as well (The National Academies, Summary 2010). The low price of energy is a barrier to the adoption of energy efficient technologies; however, there is no political will to increase the cost of energy during difficult economic times and thus it is imperative that the government provide more information for consumers to make their own educated choices.

The proposed policy includes the use of the HERS index, which provides information on the relative energy efficiency of a building based. A HERS audit is comprised of an onsite analysis and a computer simulation that serve to evaluate such factors as "insulation levels, window efficiency, wall-to-window ratios, the heating and cooling system efficiency, and the solar orientation of the home" (RESNET). The index runs from the value of 0%, awarded to net-zero energy homes, to 100%, which is awarded to homes with the energy efficiency of a building built to the 2006 International Energy Conservation Code. Each 1% step down from 100% represents a 1% increase in energy efficiency. Houses with low HERS index ratings are more energy efficient (RESNET).

Existing Literature

Addressing the Information Barrier

In a recent pan-European survey, the Commission of the European Communities asked participants: "How could the community and the Commission in particular, better stimulate European investment in energy efficiency technologies?" Participants overwhelmingly responded that "funds would be better spent on demonstrating and validating the potential of current technology, avoiding the situation in which good solutions stay in closed boxes without delivering results" (Commission 2005; Kounetas et al 2010:1-2). Survey respondents agreed that neither cost nor technology was the problem, but rather a lack of information about the available technologies and their benefits to consumers.

Results from the Commission's survey are by no means atypical. Out of all the market barriers, information is continually cited as most influential to future uptake, or lack thereof, of energy efficiency technologies. Schleich and Gruber (2008:449) empirically tested five barriers to energy efficiency (information and transaction costs, bounded rationality, capital constraints, uncertainty and risk, and split incentives), finding that information and split incentives were by far most significant. Haberl et al (2009) surveyed small business owners in energy decision making positions and found they were ill informed and ill equipped to make energy efficiency decisions. At the heart of the information barrier are transaction costs, or the cost of obtaining information. Energy efficiency is technologically and ideologically complex, and therefore has above average transaction costs. As a result, the information barrier is more significant with energy efficiency than many other technologies. Energy efficiency policies need to first address the information barrier before additional policy interventions can be successful.

In addition, addressing the information barrier simultaneously affects other perceived barriers such as cost, risk, and split-incentives, reducing the need for future policy intervention. Split-incentives are an important market barrier that is often mentioned separately from information. While the two are in fact distinct, decreasing the information barrier has the potential to profoundly affect the problem of split-incentives. Particularly, the proposed policy would mandate energy efficiency labeling for residential buildings. If required to present a HERS energy efficiency score when selling a house or renting a property, the landlord/architect/seller would then have increased incentive to improve the energy efficiency of the building. The mandate would act as a full disclosure rule, insuring that consumers are fully informed and able to make market decisions based on their true preferences.

High up-front costs are a barrier that causes many consumers, particularly in the residential sector, to perceive energy efficient technologies as unaffordable. In this instance, however, cost (and risk) barriers are perceptions; the payoff from energy efficiency investments can be justified purely on an economic basis (Miller et al 2008:1). Energy efficiency investments usually provide a return on investment (ROI) in a range of 2-3 years, yet even with longer payback periods: "energy efficiency projects can be financed and structured to insure that the *monthly payment is less than the energy savings realized*. As such, energy efficiency projects do not have to compete with other capital projects for funding," (Lovins 2007; Zobler and Sauchelli 2009).

The Federal government offers tax credits for 30% of the cost of most energy efficiency home improvements, and the Federal Housing Authority (FHA) has an Energy Efficient Mortgage program (EEM) allowing homeowners to finance the cost of energy efficiency technologies as part of a new home purchase or refinancing mortgage (citation). In addition, ComED, the Illinois Municipal Electric Agency, Nicor Gas, North Shore Gas, and Peoples Gas are all utilities servicing the Chicago area that provide rebates on energy efficient technology purchases (DSIRE).

Economically, energy efficiency investments are often in the best interest of a household or business, yet such investments are often forgone because the homeowner or proprietor is unaware of the potential ROI, not to mention the aesthetic improvement in living and working conditions. The consumer is unable to make fully informed decisions, thus market demand does not reflect true consumer preferences. Policy intervention is particularly apt for cases like this, where a market failure prevents the best outcome for both individuals and society as a whole (Schleich and Gruber 2008:450).

Deficiencies of Current Policies: The Need for Mandatory Rating

Current policies addressing the information barrier - generally falling within two categories, marketing campaigns (often as part of utility demand-side management programs) and labeling programs - have to date had only limited effect (Gillingham et al 2009:27-28). Marketing programs attempt to decrease the search cost of acquiring information, but rarely reach a large enough audience, while rating systems do little to affect search cost (Koutenas et al 2010:12).

In addition, current rating systems have a limited affect on information spreading due to their voluntary nature. Those pursuing and paying attention to rating systems are often the most informed and the least affected by the information barrier. (Schleich and Gruber 2008).

Caloric posting provides a fitting example to illustrate the shortcomings of voluntary labeling. Before becoming mandatory, caloric labeling was widely unused and implemented mainly by those with the most nutritious, low-calorie food options (Farley et al 2009). It was used only as a reward for good behavior and did nothing to incentivize the worst offenders to change the caloric content of their menus.

Before implementation of mandatory calorie posting, some argued that market effects and consumer demand encouraged better practices by the worst offenders in food production, yet the fast-food chains' intense opposition to New York City's 2007 mandate for chain restaurant caloric menu labeling suggests there was little market based pressure on chain restaurants to focus on nutrition concerns prior to the mandate (Farley et al 2009).

When calorie information was provided in chain restaurants, Bollinger et al (2010) found calorie intake decreased by 6%. The significant change in behavior suggests that consumers lacked the information to make the correct choices that would influence market demand enough to incentivize suppliers to change behavior.

The mandatory caloric posting decreased an information barrier and allowed consumers to more accurately express their true preferences. Similarly, mandatory HERS rating would give consumers the power to choose between more and less efficient buildings and in this way, express the true market demand for energy efficiency.

Why focus on the residential sector?

Households are the focus of the proposed policy for three reasons: In comparison to firms, 1) households are currently less informed about the benefits of energy efficient technology; 2) households lack the incentives of firms to adopt energy efficient technology; and 3) households have less resources to become informed about energy efficient technology.

1) Lack of information

In a recent survey of 505 U.S. residents, Attari et al (2010) found that public perception of personal energy consumption and the cost saving from increased energy efficiency were widely inaccurate. Another survey, found that more than half of the 10,236 participants were willing to accept energy efficiency improves even at significant cost. Combined, the surveys illustrate a population that values energy efficiency yet does not know much about it (Zhong et al 2009).

One reason why residents have little knowledge of energy efficiency/consumption is the current lack of energy auditing in the residential sector. When deciding to buy or rent a new home, an individual has no way of knowing whether one building is more or less efficient than another. One might ask for the average cost of utility bills, but as energy consumption is much more subjective than energy efficiency, such information is of little use. As a result, an individual may prefer a more energy efficient building, but have no way of acting on those preferences. The market is unable to faithfully reflect consumer demand in the residential sector.

2) Incentives

Individuals can be viewed separately from firms because each entity has fundamentally distinct goals and incentives. While firms generally follow a profit maximization strategy toward utility maximization, individuals, and thus households, view utility in a much more complex and nuanced way. Individuals often value personal time, family interaction, and relaxation. Their incentives tend to weigh more heavily on values, aesthetics, and happiness than the typical business. Thus the households actively seeking information about energy efficiency tend to have environmentally oriented value systems. In the absence of consumer demand, the households without such values are less likely to surpass the transaction costs needed to invest in energy efficiency. In essence, market incentives are lacking making policy intervention particularly apt. Economists generally argue market failure is necessary before market intervention should be considered. Here, market barriers are preventing the uptake of a technology that will benefit not just the individual but society as a whole.

3) Least amount of resources

As mentioned previously, transaction cost, or the cost of finding information about energy efficiency, is often cited by businesses as a primary reason for being under-informed. Kounetas at al (2010:12) added to the Commission's finding by collecting additional data that showed companies with larger resources were more likely to be informed, and uptake increased significantly when technological information was provided freely. Likewise, small firms were at a disadvantage because human capital was often scarce, and time was not available to acquire technological information about energy efficiency. The results led Kounetas et al (2010:12) to suggest policies focus on alleviating "search costs" for the most constrained firms.

Residential households are most like small firms with limited resources: human capital is limited, time is valuable, and attention is often focused away from information gathering. Households have the same amount to gain from energy efficiency, yet are less likely to spend the capital necessary to pursue such an investment. In this way, households have the greatest need for policy assistance, yet are currently the most under served.

Policy Recommendation

Choosing an Ideal Location

This new, information based, energy efficiency policy, is ideally placed to maximize "spillover effects" (Kounetas et al 2010:12). Chicago is the third largest U.S. city located in the center of the country. It has come into the spotlight recently for its pledge to take action against climate change with its Climate Action Plan. The plan calls for a 25% reduction from 1990 emissions levels by the year 2020 and an 80% reduction by 2050. These lofty goals will require decisive action in order to fulfill the promise of emissions reduction (Clinton Foundation, 2010). The proposed policy would make significant strides in achieving the energy efficiency goals of the "Buildings" section of the declared plan, allowing Chicago to improve it's national image and serve an example to other cities both nationally and internationally.

Particle pollution in the city of Chicago has directly resulted in the increase of death from respiratory infections and diseases (K.M. Mortimer et al., 2002). This fact alone creates an incentive for policy makers to improve Chicago's air quality and reduce the amount of energy consumed by the city, however there are already numerous technologies available for individuals to degrease their energy consumption. Nevertheless, these technologies are neither widely available nor understood by the public and demand for such technologies remains low. Areas of improvement that have the most impact but the least demand include: improved insulation, heat and air-conditioning technologies, and economical electric appliances.

The government has the unique position of being able to implement policies that may not be cost effective in the short run, however serve the best interests of the public in the long run. Such policies are necessary, however there is little political will to impose limitations or minimum pollution requirements as this would impose excess costs on individual homeowners. In an economic climate that is hostile to excess costs, the government is most helpful when it provides information to consumers about what they consume and how to make changes in their own lives that can improve future environmental conditions.

In order to increase the demand for currently available energy efficient technologies in the city of Chicago, it is important to reduce the information barriers surrounding residential energy use. The HERS was developed by the Residential Energy Services Network (RESNET) as a way to determine the energy efficiency of a house. The scale is based on the 2006 International Energy Conservation Code and ranges from 0 to 150 will 100 representing a standard new home's energy use; the lower the scale the more energy efficient a home (RESNET). It is important that this scale be made available for each place of residence.

Policy Details

The necessary HERS audits will be conducted every five years for 15 years on every home in Chicago, to be paid for by the city government. However should an individual decide to pay for their house to be audited more often, the individual would pay the excess cost.

The city government will provide a stipend for each residence, based on the size of the home, to be audited by the company of the resident's choice. Information on city auditors will be provided to the homeowner along with the allotted funds for his audit. The information provided will include ratings on each company as well as the price they charge for a HERS audit. Should a homeowner chose a company that is more than the stipend the extra cost will come out of pocket. The audit information will then be made public through the city of Chicago, although it must be provided to any individual looking to buy or rent a new home.

In order to decrease the lack of information surrounding energy efficiency and those daily activities consume the most energy, the precise rating of each home must be made available to both the current resident as well as an individual looking to purchase or rent a new home. This policy aims, not to force individuals to change their behavior, but to bring energy efficiency and pollution to the forefront of their minds when they approach energy-consuming activities within their homes.

Cost Benefit Analysis

Overview

The costs and benefits of this proposal are assessed for the City of Chicago, across a wide range of considerations. All estimates of the costs and benefits are reported as real dollars, having used the real discount rates recommended by the Office of Management and Budget, which take both discounting and inflation rates into consideration. Due to uncertainty surrounding the number of residents who will undertake efficiency related home improvements as a result of the new information gained from the home rating provided by this policy, we have conducted sensitivity analysis of these values. Due to the increase in information alone generated by the new calorie reporting requirements in restaurants in New York restaurants, Starbucks observed a change in 6% of consumers (11% for food choices, less for drink). As a consumer's choice in ordering a meal is a more immediately alterable decision than improvements in the home, 6% was used as the high estimate, with 4% and 2% representing more conservative estimates.

The costs and benefits were analyzed using a fifteen-year time frame, based on the expectation that participation and consumer behavior will change over time. Although audits would likely be staggered as a result of how the policy is executed, for the purposes of this analysis, we have assumed that audits will be conducted now, at a point five years in the future, and at a point ten years in the future. Calculations of auditing costs and energy-savings are based on the 2000 Census, which reported 1,061,928 households in the City of Chicago.

Discounting

Assuming that the first audits would occur when the policy is instituted, their net present value would thus be equivalent to the cost. As audits would be required every five years, future audits were discounted at a rate of 7%, the value used and recommended by the U.S. Office of Management and Budget (OMB 2003). All other costs and benefits were assessed using this discount rate, with the exception of the social costs of carbon, SO_2, and NOx, which were discounted at a rate of 2%. It has been suggested that such high discount rates as are in use for monetary assets are not appropriate when applied to environmental or health concerns. The OMB supports the use of a discount rate of "3% or less" and the U.S. Environmental Protection Agency frequently uses a 2% or lower discount rate.

Cost of Time

The cost to the city's time was based upon City of Chicago's current pay scales for a clerical worker, who can be employed as a B-04, B-06, or B-08. B-06 was chosen to represent a median value. The B-06 pay scale classification corresponds to annual salaries, which can range from $25,932 to $43,656 depending on the number of years of service. Our estimates were based on an employee who has worked with the city for ten continuous years, whose annual salary would be $33,024.

In order to accommodate the adoption of the proposed policy, the City of Chicago will have to consider the establishment of a new division in the Department of Buildings. The role of this division will be to specialize in managing all matters regarding the rating of residential buildings. To this end, the city will need to increase personnel by an estimated 46 employees, based on a representative division within the City's current Department of Buildings. The division will be charged with the logistics of rendering all necessary information on energy efficiency ratings available to Chicago residents while enforcing the Chicago Building Code as it relates to the City's existing housing stock.

In addition to personnel cost, the operational cost of this undertaking is estimated by the department's budget proposal for FY2010 to be $902,069. Postage cost for mailing information to home-owners, advertising, equipment rentals and maintenance and software maintenance and licensing are the main components of this figure. An allocated $2 million in DOB's budget for 'Professional and Technical Services and Other Third Party Benefit Agreements' was eliminated in our calculation of operational cost, because of its lack of relevance to this proposal.

Social Cost of CO2, NOx, and SO2

The price of NOx and SO_2 are based on the emissions trading scheme currently established in the European Union. Converting from euros to dollars, the cost per ton of SO_2 in March, was $6.28, and the cost per ton of NOx was trading at $2.27. Although these are obviously monetized values of the cost of these gases, it is likely that they inadequately capture the entire social cost. As the same report points out, "Despite these reductions, excess nitrogen deposition on nature remains a widespread EU problem in 2020. The problems of ozone exposure, acidification and health-fine particles persist, but are increasingly of a regional or even local nature," indicating that the negative externalities resulting from emission of these gases is reduced but not eliminated, and that this value may be low. It would be politically unfeasible and perhaps even unreasonable to force industry to bear the entire social cost of these pollutants. Although, if this is indeed an underestimate, it will lower the estimated benefits of this policy, which would be higher if the full social cost of these gases could be taken into consideration.

The cost per pound of CO_2 is based on a report from the E3 Network, Economics for Equity and Environment, concerning the social cost of carbon (SCC). However, this study has been widely criticized as using faulty assumptions, which as a result, has lead to an inaccurately low SCC value. One such potential problem with the study was the use of discount rates that are inappropriately high. According to environmental economist Frank Ackerman, "[The study] relies on an overly narrow review of climate economics, relying on a handpicked set of models -- FUND, PAGE, and DICE -- that happen to produce very low SCC estimates. All three models have serious problems: FUND mistakenly predicts a huge reduction in mortality due to the early stages of climate change, then values the lives allegedly saved on the basis of their per capita incomes. PAGE, in its default mode, assumes that developed nations will adapt to climate change at near-zero cost... DICE assumes on very thin evidence that most people in the world would prefer, and would be willing to pay for, a warmer climate." If his, and others' criticisms are correct, this underestimate will lead to an underestimation of the benefits of this policy. The results of the cost-benefit analysis should be evaluated with these and other uncertainties in mind.

Average Cost and Cost-Savings of Efficiency Based Home Improvements

Energy savings can be significant even at a relatively low cost. According to architect Lindsey Roberts, the average household can save $1,100 annually by following recommendations given by an energy audit. In order to do so most cost-effectively, the main targets are duct sealing, compact fluorescent light bulbs, water-saving toilets, energy-saving refrigerators, and caulking cracks, gaps, and joints. The average resident investing in such improvements will make an estimated investment of $2,714, which will return an average annual savings of $830, with an average payback period of 3.7 years. Some of these improvements, such as caulking gaps and the use of compact fluorescent light bulbs, have a payback time of less than one year.

Amount Reduction of CO2, NOx, and SO_2

Chicago's energy profile is heavily nuclear, with approximately 92% of electricity generation coming from nuclear power, 4% from coal, 3% from purchases, and 1% other. As such, the benefits from a reduction in these pollutants would be substantially lower than the potential in other parts of the United States which rely much more heavily on coal. This is one main area in which the costs and benefits of this policy would vary greatly by geographic location. As a result of this energy profile, which is heavily nuclear, in 2005 ComEd generated 72.2 pounds of CO2, 0.14 pounds of SO_2, and 0.14 pounds of NOx waste per 1,000 kilowatt hours. Based on this ratio of waste, the estimated amount of reduced energy use was then used to estimate the reduction in these pollutants.

Other Benefits

The negative effects of the pollutants generated by electricity production are not only related to global warming, acid rain, and other environmental damages, but also to health harms to people in the form of asthma and other respiratory diseases as the result of decreased air quality. It has been estimated that Chicago's Fisk and Crawford coal-fired power plants alone contribute to an additional 41 premature deaths, 550 emergency room visits and 2,800 asthma attacks each year. These health damages are not only unfortunate, but also costly. The Center for Disease Control and Prevention estimates that asthma costs the United States $30 billion annually, including the cost of treatment. A study by the Michigan Network for Children's Environmental Health indicates that the average asthma related hospitalization costs $7,732 - not all of which is paid for by the patient or patient's family. Due to the wide assortment of air pollutants in the city of Chicago, many of which are incredibly difficult to trace back to the specific source, it is not possible to quantify the improvement in air quality in Chicago as a result of this policy, and the resulting benefits to health. However, it is nevertheless an important benefit, which should be considered when thinking about the effects of a policy aimed at energy consumption.

Results

Costs		
Auditing Costs (Costs ultimately billed to the government)		
	Auditing Cost per Household	$400.00
	Total Auditing Costs	**$943,559,333.88**
Administration and Operational Costs (Costs to Government)		
	Annual Salary	$33,024.00
	Extra Employees	46
	Operational Costs	$902,069.00
	Total Annual Admin. Costs	$2,421,173.00
	Total Admin. Costs	**$22,051,835.48**
Home-improvement Costs (Cost to Residents who Make Improvements)		$2,714.00
	If 2%	$57,641,451.84
	If 4%	$115,282,903.68
	If 6%	$172,924,355.52
Total Costs	**2%**	**$1,023,252,621**
	4%	**$1,080,894,073**
	6%	**$1,138,535,525**

Benefits	Sensitivity Analysis: 2%	4%	6%
Cost Savings (Benefits to Residents)			
Avg. Annual Household Cost Savings	$830.00	$830.00	$830.00
Avg. Annual Household Energy Savings (kWh)	5253.16	5253.16	5253.16
Total Energy Savings (kWh)	111,569,650.63	223,139,301.27	334,708,951.90
Total Cost Savings	**$160,554,351.80**	**$321,108,703.60**	**$481,663,055.40**
Reduction in Pollution			
Reduction in CO2 pollution	$103,505,042.02	$207,010,084.05	$310,515,126.07
Reduction in SO2 pollution	$200,702.30	$401,404.60	$602,106.89
Reduction in NOx pollution	$200,702.30	$401,404.60	$602,106.89
Total Reduction in Pollution	**$103,906,446.62**	**$207,812,893.24**	**$311,719,339.85**
Total Benefits	**$264,460,798.42**	**$528,921,596.84**	**$793,382,395.25**

As can be seen from the cost-benefit analysis, based on these assumptions, the costs range from about $1.02 billion to $1.14 billion over the entire span of 15 years. Similarly, based on these assumptions, the benefits range from $264 million to $793 million, varying depending on the number of residents who make efficiency home improvements. The benefits are almost entirely dependent upon the number of households making such changes, whereas the costs are less dependent on such rates, and in fact these rates have little relevance in terms of costs to the City.

Potential Problems

Due to the lack of information surrounding the cost of pollution in the long run, it is very difficult to calculate the benefit from abatement. As a result, the cost to the city will remain high in the short-term because of the direct costs of providing stipends and providing information on the auditing companies. This problem is unavoidable and any policy in which the government steps in to fill an information void or provide a service will be costly. Nonetheless, given that we can safely conclude that the long-term social cost of pollution is significantly high, any policy that reduces pollution will ultimately have positive payouts. This policy is more politically feasible than a mandatory level of efficiency or a subsidy for research and development because it allows the market to find its own equilibrium based on consumers' preferences.

The reason this policy is politically feasible during economic times is also one of the potential problems. Since there is no mandate for consumers' to change their behavior, there is the potential for no decrease in pollution. This potential problem could render the policy ineffective. Nevertheless, similar policies have shown that the consumers who are provided with more information tend to make more educated choices. This policy will serve to both bring energy efficiency more to the forefront of people's minds, as well as provide more information for those consumers whose preferences align with more energy efficient behavior.

Finally, a common problem with policies that seek to provide information to consumers happens when the public becomes desensitized to the information and no longer makes the necessary behavioral changes. This occurred with the Surgeon General's Warning on cigarettes and, as a result, the warning had to be changed to accommodate the actions of the consumers. For this reason, we suggest that the policy only stay in effect for 15 years, at which point it will come up for review. This timeframe will not only prevent consumer fatigue but will also allow for new policies or technologies to take hold of the market.

Policy Alternative

Given that the cost of the policy is high and the city of Chicago is currently in a severe budget crisis, an alternative to the proposed policy is a scaled back version in which only those individuals who are selling their homes are required to provide an energy audit at the point of sale. Similar policies include the certifications required regarding mold in the home. This alternative would be significantly less expensive to the city government because there would be no upfront cost and the individual selling the house would pay for the audit; presumably, the cost of the audit would be included in the cost of the house.

One of the draw backs to this alternative is that the policy would have a significantly slower affect on energy consumption in the city since the only time an audit would be conducted would be when the ownership of a house changed hands. Nevertheless, the problems of an information barrier would still be mitigated because those individuals who have preferences for more energy efficient homes will be able to make an educated decision based on the information provided.

Conclusion

In order to increase the demand for energy efficient technologies and thus decrease both energy cost and negative externalities, it is imperative that the government improves the flow of information to the consumers. The city of Chicago can achieve this by mandating an energy audit for each residence, to subsequently be made public, every five years. Likewise, the information from the audit must be provided to those individuals who plan to buy or rent a new home.

There is not a shortage of new technologies, but rather, there is a lack of demand for these technologies and a lack of understanding of the best ways to decrease energy consumption. According to the U.S. Department of Energy, the most expensive part of an American home's energy bill comes from heating and air-conditioning. While these expenses are sometimes unavoidable due to weather extremes, much of the cost can be reduced through improved insulation. According to an architect who specializes in green buildings, an individual can cut his energy costs in half by simply improving the insulation and replacing inefficient appliances, in his home. The most effective way to get consumers to change their behavior is to provide them with information that will help them make decisions that are more in line with their preferences.

High levels of energy consumption are both costly to the consumer who must pay monthly bills to the utility companies, and to the environment in the form of particulate pollution and air quality degradation. It is crucial that the city of Chicago begin to inform its citizens of the efficiency of their homes and thus, create a market for energy efficient technologies.

Appendix

Values used in calculations		Costs		Benefits	Sensitivity Analysis: 2%	4%	6%
Total number of Chicago households	1,061,928	**Auditing Costs (Costs ultimately billed to the government)**		**Cost Savings (Benefits to Residents)**			
Discount rate	7.00%	Auditing Cost per Household	$400.00	Avg. Annual Household Cost Savings	$830.00	$830.00	$830.00
Environment and health discount rate	2.00%	Total Auditing Costs	**$943,559,333.88**	Avg. Annual Household Energy Savings (kWh)	5253.16	5253.16	5253.16
Average cost of home improvements	$2,714.00	**Administration and Operational Costs (Costs to Government)**		Total Energy Savings (kWh)	111,569,650.63	223,139,301.27	334,708,951.90
Average annual savings	$ 830.00	Annual Salary	$33,024.00	Total Cost Savings	**$160,554,351.80**	**$321,108,703.60**	**$481,663,055.40**
CO_2 emitted / 1000 kWh	72.2	Extra Employees	46	**Reduction in Pollution**			
SO_2 emitted / 1000 kWh	0.14	Operational Costs	$902,069.00	Reduction in CO_2 pollution	$103,505,042.02	$207,010,084.05	$310,515,126.07
NO_x emitted / 1000 kWh	0.14	Total Annual Admin. Costs	$2,421,173.00	Reduction in SO_2 pollution	$200,702.30	$401,404.60	$602,106.89
$ / ton CO_2	$21.00	Total Admin. Costs	**$22,051,835.48**	Reduction in NO_x pollution	$200,702.30	$401,404.60	$602,106.89
$ / ton SO_2	$6.28	**Home-improvement Costs (Cost to Residents who Make Improvements)**	$2,714.00	Total Reduction in Pollution	**$103,906,446.62**	**$207,812,893.24**	**$311,719,339.85**
$ / ton NO_x	$2.27	If 2%	$57,641,451.84	**Total Benefits**	**$264,460,798.42**	**$528,921,596.84**	**$793,382,395.25**
Cost per kWh electricty	$0.158	If 4%	$115,282,903.68				
NPV of $1 annually for 15 years, discounted 7%	9.1079	If 6%	$172,924,355.52				
NPV of $1 annually for 15 years, discounted 2%	12.8493	**Total Costs 2%**	**$1,023,252,621**				
		4%	**$1,080,894,073**				
		6%	**$1,138,535,525**				

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