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Residential Energy Retrofits: An Untapped Resource Right At Home

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To face the complex and ambitious challenges of climate change, policymakers must use every available tool to mitigate harmful emissions. Homeowners and industry must come together to capitalize on opportunities for increased energy efficiency in existing buildings, which hold enormous potential for reducing energy consumption. However, current and proposed climate change policies focus primarily on setting minimum standards for new homes through building codes. The scope of energy use under consideration by cap-and-trade or carbon taxation schemes complicates inclusion of residential buildings: the emissions from one residence cannot serve as a commodity in the same market as electricity generating facilities. Retrofitting operations supported by utilities and included in emissions reduction mechanisms are a critical solution to the problems of energy consumption, cost, and emissions.

A system of residential energy efficiency improvements, analyzed in this paper, would enable cost-effective improvements financed by homeowners and utilities. Utilities would provide energy auditing services to establish the level of retrofit measures appropriate for homeowner and utility investment. Utilities are ideally situated to play a large role in retrofitting by providing low-cost energy auditing tools, up-to-date energy cost summaries, performance data on retrofit options, and bulk purchase rates for improvements. In addition, utilities have a vested interest in retrofitting residences for energy efficiency because these improvements help utilities cope with rising demand and diminish the need for new plant construction.

In order to improve residential energy efficiency and implement this policy, policymakers should consider the following recommendations:

- **Climate change policy must include provisions to account for the environmental costs of inefficiency in existing residential buildings.**
- **National policymakers should help state public utility commissions decouple sales volume from profits, in turn providing uniform national promotion of energy efficiency.**
- **National policymakers should facilitate the implementation of a system of cooperative investment by homeowners and utilities in household retrofits to improve residential energy efficiency.**

Background

The need for immediate action to mitigate climate change intensifies as scientific research clarifies this reality. Greenhouse gas emissions and public demand for climate change mitigation measures continue to grow, forcing policymakers to face the challenge of reducing the effects of increasing energy consumption while simultaneously maintaining strong economic growth. This paper considers an approach to this problem: a potential policy alternative to create a retrofitting program for single family owner-occupied buildings.

The residential sector accounts for over twenty percent of both CO_2 emissions and energy consumption in the United States (Figure 1). This large percentage continues to increase rapidly. In 2007, residential CO_2 emissions grew more than any other sector, reaching 1,242 megatons of carbon.[1]

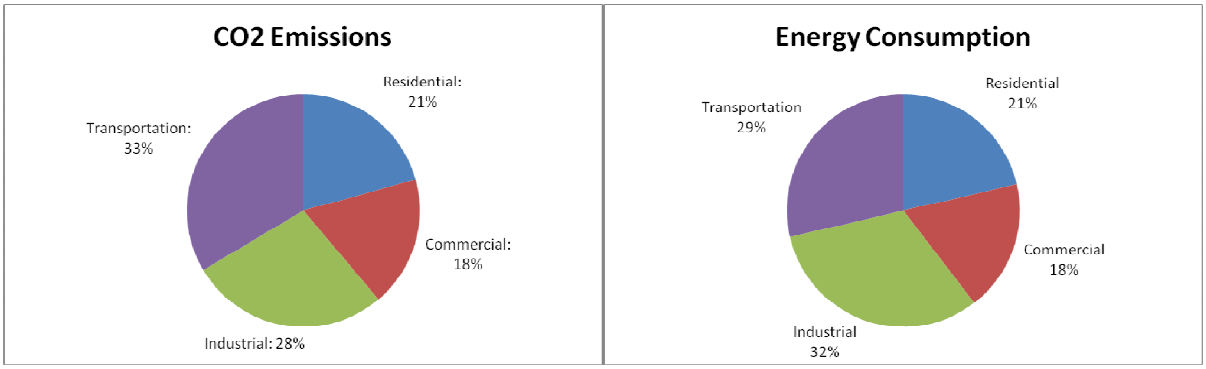

Figure 1: Sector-by-Sector Breakdown of US CO_2 Emissions and Energy Consumption. Residential demand accounts for over twenty percent of CO_2 emissions and energy consumption; the commercial and industrial sectors include significant CO_2 emissions and consumption due to building inefficiency. Created by author.[2]

Economic studies have shown the benefits of residential energy efficiency programs outweigh the costs.[3] The Intergovernmental Panel on Climate Change estimated that cost-effective mitigation strategies in residential and commercial buildings could avoid almost thirty percent of baseline greenhouse gas emissions by 2020.[4] Introducing externality costs through climate change policy would expand the potential for cost-effective emissions reductions by several more percent.[5] According to a report by McKinsey & Company, residential and commercial retrofitting activities constitute the most cost-effective sector of potential emissions abatement. In fact, many of these efficiency gains could be captured at negative cost (Figure 2). Retrofitting building shells could result in sixty megatons of annual carbon emissions abatement.[6] Efficiency improvements in both residential and commercial buildings could lead to 500 megatons of abatement by 2020.[7] However, no widespread capitalization on the enormous potential for improved energy efficiency, reduced demand, and lowered CO_2 emissions in owner-occupied single family buildings has occurred.

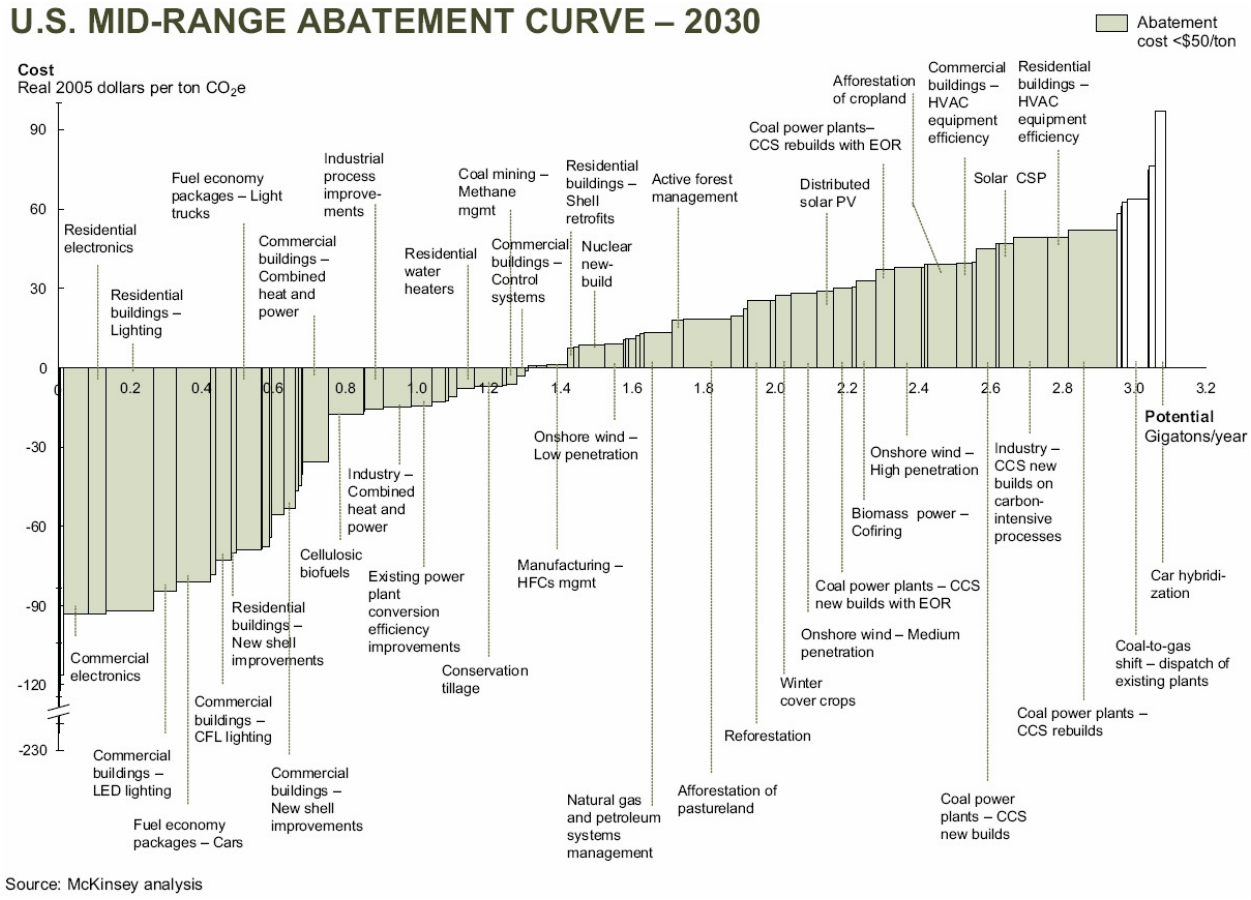

Figure 2: Cost Curve for Greenhouse Gas Abatement. On the left, building retrofit measures constitute a substantial portion of the negative-cost measures for emissions mitigation.[8]

Past, Proposed, and Existing Climate Change Solutions

Current policy approaches to mitigating climate change have included cap-and-trade and carbon taxation schemes.[*] Cap-and-trade involves setting a limit to allowed emissions and makes emissions permits a tradable commodity. This provides an economic incentive for polluters to reduce emissions and lower energy consumption. Carbon taxation is a more direct approach – taxing polluters to encourage lower emissions and using this revenue to resolve the effects of these emissions. Cap-and-trade receives significant attention because its flexibility allows for least-cost emissions reductions, allowing policymakers to introduce environmental costs in an economically feasible manner.

[*] For more information, see:

Congressional Budget Office. (2008). *Policy options for reducing CO_2 emissions*. Washington, DC: U.S. Government Printing Office.

However, significant complications prevent policymakers from including residential buildings in climate change proposals.[†] For instance, natural gas furnaces in individual residences do not emit enough CO_2 to be included in a cap-and-trade system alongside coal-fired power plants. In order to turn residential emissions into a tradable commodity, some system for aggregating houses would be necessary. Although utilities should pass externalities to customers in the form of higher costs, it is unclear whether or not this would give homeowners sufficient incentive to pursue energy efficiency. This market inefficiency demands attention in the design of climate change policy. Policymakers must tie incentives for energy conservation and efficiency, as well as disincentives for wastefulness, to true potential for climate change mitigation.

The following is a brief overview of past and current approaches to regulating building energy use. These examples offer instructive experience to policymakers developing new programs that incorporate the current level of concern about climate change.

1. In the early 1980s, the U.S. Residential Conservation Service required utilities to offer low-cost energy audits to and initiate residential retrofitting projects with its customers. Utilities completed two million energy audits through this program during its first two years.[9] Although this policy did not tie into a framework for combating climate change, reviews of its performance lend insight into how better to implement energy efficiency programs involving utility companies. This program encountered barriers including low participation, a lack of cost-benefit ratio information, dependence upon state and utility promotion, and site specific results.[10] Despite these obstacles and significant political opposition, escalating energy costs, concern about both climate change and future availability of fuels, and an ever-changing political climate could now support the creation of a similar system. The policy outlined in this article takes into account the shortcomings of the Residential Conservation Service by allowing greater utility flexibility and requiring more homeowner investment.

2. The European Union implemented the Emissions Trading Scheme, the first cap-and-trade system for carbon emissions, in 2005. This initiative deals with residential buildings through "policies and measures" requiring member states to achieve broad targets.[11] These provisions include standards for new construction and large existing buildings.[12] Although it is too early for a thorough evaluation of its performance, this policy does offer an alternative for buildings outside the cap-and-trade system. While this program allows that regional factors should influence building energy policy, uniform goals and inter-state cooperation are also necessary to combat climate change. Economic incentives (such as those reached through emissions trading) can serve this role by accounting for regional factors while maintaining broad goals.

[†] For more information, see:

National Foreign Trade Council. (2007). *WTO – compatibility of four categories of U.S. climate change policy.* Washington, DC: Syunkova, A.

Aspen Insitute. (2004). The hybrid options: what is the role of product efficiency standards under a cap-and-trade program? *A climate policy framework: balancing policy and politics.* Washington, DC: Nordhaus, R. R.

3. The most recent attempt at climate change legislation in the United States, the Lieberman-Warner Climate Security Act of 2008, proposed giving states allowances for industry compliance with certain building codes that promote energy efficiency in new construction.[13] In fact, this bill does not require compliance; it only gives incentives to states to enact these codes. These incentives appear misplaced, as builders and prospective homeowners have little vested interest in pursuing energy efficiency under this bill. Most importantly, this bill does not include provisions to improve energy efficiency in existing buildings.

The second and third policies above illustrate potential frameworks based on building standards for promoting energy efficiency to mitigate climate change. Future policies should focus on yet another approach—market transformation—to augment the current focus on standards.

Incorporating Residential Buildings into Climate Change Policy

Three commonly accepted forms of technology transfer for building efficiency exist: mandatory efficiency standards, market transformation, and research and development. State and local governments adopt building standards, whereas private interests and all levels of government pursue research and development goals. Regulatory standards function as an immediate solution while research and development activities produce results over decades, leaving an opening for intermediate solutions. The federal government could lead an immediate market transformation effort to create widespread technology transfer sustained over time, fulfilling a niche in building retrofit activities.

An article in *Energy and Buildings* reinforced the importance of market transformation, asserting efficiency standards alone cannot achieve sufficient energy savings. Use of market transformation policies would accelerate the successful introduction of technology and reduce energy consumption.[14] Approximately seventy percent of technologies necessary to combat climate change through building efficiency already exist.[15] Market transformation can use these tools to effect change. A harmonious combination of standards, market transformation, and research could drive significant advances in energy efficiency to mitigate climate change.[16]

Policy Alternative Overview

In order to spur the reduction of residential energy use within the current financial market, a program of utility and homeowner cooperation for residential energy audits and retrofits should be implemented. This policy promotes home improvements to owner-occupied single family dwellings with or without direct investment by utilities.[‡]

Utilities would hire energy service companies (ESCOs) to complete building retrofits in order to capture bulk purchase rates. In the past, the energy services industry has focused largely on commercial and industrial buildings.[17] However, advocates believe this industry could penetrate the residential sector

[‡] For purposes of this proposal, the term 'utility' refers to vertically integrated electricity companies and natural gas providers. These companies have the physical connection and regular interaction with homeowners necessary to assess their needs and facilitate retrofit measures.

through aggregation or coordination.[18] This policy would boost activity in the residential sector, creating job opportunities and economic growth. Cooperation between utilities and contractors would improve the effectiveness of retrofits. For instance, information sharing would facilitate expedient identification of appropriate measures. Along these lines, utility bills could become public record. This would open up a market for energy auditors and contractors to complete energy efficiency projects independently.

Many utility companies have conducted energy efficiency programs in the past. Over the past three decades, Pacific Gas & Electric has avoided 125 megatons of CO_2 emissions and the construction twenty-four large power plants through its energy efficiency programs.[19] Such existing programs would provide a foundation for increasing the scope of household retrofit programs.

Utility participation would enable residential retrofit inclusion in climate change policy. Under a cap-and-trade or carbon tax system, utilities could be awarded allowances or tax credits as a result of retrofit investments. This would aggregate the incremental savings from residential retrofits, solving the problem of fairly administering residential energy use within a cap-and-trade program. Utilities could claim credits or allowances for the savings that result from improvements, giving them incentive to invest more heavily in home retrofits.

Metrics

The first metric by which to judge this proposal is avoided energy consumption. This fundamental goal addresses issues of climate change, energy independence, household energy costs, public health, and energy use simultaneously. It is an oversimplification to say that optimizing avoided energy consumption would maximize mitigation of all these problems. For example, fuel source and use define emissions levels while the broad objective of reduced energy use could ignore these. In fact, some of these goals could even conflict: low energy costs and energy independence may not come together naturally. However, energy consumption and greenhouse gas emissions correlate well in the residential sector and energy use data is more reliable (as shown in Figure 1). For these reasons, this analysis uses avoided energy consumption as the primary metric.

The second metric is the cost-effectiveness of this policy. In this assessment, policymakers should consider the 'net cost' of building energy consumption. This takes into account market costs of constructing and operating residential buildings in addition to the environmental costs associated with energy consumption. Cap-and-trade or carbon taxation policies would introduce these environmental costs, altering the results of cost analyses by energy auditors and utilities. A thorough study would be necessary to understand the full distribution of costs and benefits resulting from this program. Instead, this analysis discusses the flexibility offered to utilities, allowing them to distribute their funds as efficiently as possible.

The third metric is the time frame for completely retrofitting the national housing stock. As innovative technologies develop, retrofitting alternatives must be continually reevaluated. Only through continual upgrading of residential buildings can society achieve greenhouse gas mitigation and, in turn, sustainability.[20] If national retrofitting activities proceed too quickly or slowly, they would offset the

potential to integrate new technologies gradually into existing buildings. Therefore, policymakers should continuously evaluate the optimal time frame of this retrofitting cycle.

The fourth metric is appropriateness of utility participation. In order to quickly implement a successful residential energy efficiency program, policymakers must use current infrastructure and businesses. This proposal capitalizes on the historic role of utilities in providing energy services and communicating regularly with homeowners.

The fifth metric is state acceptance. Although the federal government regulates interstate transport of natural gas and electricity, state public utility commissions regulate utilities within their borders. Inconsistent regulatory policies would complicate the implementation of a national plan for residential retrofitting. However, recent trends in state policy, such as decoupling sales from profits, give hope for the future of utility-sponsored energy efficiency programs.[21]

The sixth and final metric is political feasibility. Although this approach envisions elimination of bureaucratic inefficiency or wasteful government spending, this policy would still encounter political and market-based opposition. This program should bring together the all industry members' interests and balance them to pursue complex efficiency goals for the collective good. Assessing the opposition of each affected group and dealing with these concerns appropriately would ensure program success. This may include establishing incentives, setting requirements, or simply removing barriers to market acceptance. Lessons learned from past programs such as the Residential Conservation Service, Energy Efficient Mortgages, and the Weatherization Program could provide solutions to alleviate political opposition.

Analysis

Avoided Energy Consumption

Through this broad program, avoided energy consumption would vary as a function of government involvement. With little or no government interference, economic factors alone would determine the total avoided energy consumption. On the other hand, regulatory stiffness would result in a fixed level of energy savings while allowing flexibility in the pursuit of that goal. Eric Hirst estimated the Residential Conservation Service avoided, on average, between four and five MBtu's of energy consumption per year per residence in the year following program establishment.[22] With average household consumption of 103 MBtu's during the same period, these retrofits translated to almost five percent annual savings on utility bills.[23] Estimates assert that residential retrofits can reduce energy consumption by twenty to twenty-five percent.[24] This potential matches the twenty-seven percent increase in residential electricity demand estimated by 2030.[25] This policy would remove market barriers to capture maximum energy efficiency and partially offset the need for new generating facilities.

Cost-effectiveness

This policy would provide the maximum volume of cost-effective improvements sought by the participant and utility. Each retrofit measure recommended by energy auditors would be cost-effective on a local, or microeconomic, scale. The flexibility of this system allows for greater economic efficiency and incorporation of environmental costs of power generation. While homeowners generally have only one property to invest in, utilities and other industry members have control over the distribution of their funds. Therefore, utilities would be able to find the most cost-effective combination of retrofitting measures on the macroeconomic scale, giving it similar advantages to a broader cap-and-trade system for emissions.

Retrofitting Time Frame and Payback Periods

Policymakers must consider the payback periods of different retrofit measures in conjunction with the time frame for retrofitting our nation's housing stock: although auditors primarily use cost-effectiveness to determine the appropriateness of efficiency measures, homeowners and utilities cannot benefit from measures with payback periods that exceed the lifetime or retrofitting cycle of a home. A study of Minnesota's Residential Conservation Service reported the median payback period of wall insulation improvements just exceeded ten years while that of high-efficiency boilers and furnaces exceeded twenty years.[26] A 2005 study comparing residential retrofitting and rebuilding in Toronto, Canada concluded broadly that retrofit options had lower economic costs over a forty-year (or shorter) life cycle.[27] This wide variation in payback periods should affect the measures chosen under this program: if the payback period of a retrofit project exceeds the time frame for national housing stock retrofits or the useful life of the home, the appropriateness of retrofitting options should be reevaluated.

Appropriateness of Utility Participation

Utility companies stand poised to facilitate the success of this policy for several reasons. Utilities have a vested interest in retrofitting residential buildings for energy efficiency. The Energy Information Administration forecasts a growth of twenty-seven percent in residential electricity demand by 2030.[28] In order to face increasing demand from customers, utilities can use efficiency programs to complement construction of new power plants. Significant efficiency gains have the potential to reduce the need for increased generating capacity.[29] As fuel prices rise, these conservation measures will become more economically desirable and utilities will be more likely to voluntarily adopt residential retrofitting programs (Figure 3).

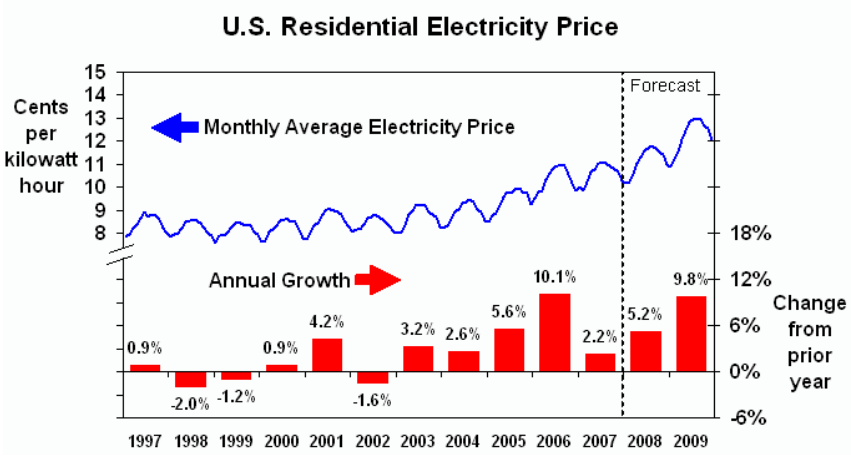

Figure 3: Residential Electricity Price Forecast. High fuel prices will drive residential rates up considerably in the coming years. Energy Information Administration, 2008b

Although energy efficiency improvements lower utility bills for homeowners, the benefits reaped from such improvements also extend to regional ratepayers. For instance, decreased loads during typically high-demand (peak load) periods would result in lower electricity pricing for all customers. Utilities should administer energy efficiency programs to achieve these improvements due to the communal nature of savings. Also, energy providers generally consider long-term costs whereas homeowners focus on upfront expenses.[30] Utilities would play a key role in this approach by providing low-cost energy auditing tools, technical capabilities, up-to-date energy cost summaries, performance data on retrofit options, and bulk purchase rates for energy improvements.[31]

State Acceptance

Regulation of public utilities has traditionally associated sales volume with profits, giving these companies little incentive to pursue energy efficiency programs. In 1978 and 1982, California became the first state to decouple sales from profits for its natural gas and electric utilities, respectively.[32] Under decoupling schemes, states adjust rates according to energy consumption in order to cover only the fixed costs of utility companies. As a result of its regulatory measures, California now uses the least electricity per capita in the country.[33] To date, over half of states have either decoupled sales from profits or are considering decoupling (Figure 4).[34] In the coming years, this decoupling trend would facilitate the adoption of the proposed policy. However, current regulatory practices stand as a barrier to successful implementation of this retrofitting program. It is imperative that federal policymakers work closely with states to encourage national uniformity in decoupling practices so as to make this policy feasible.

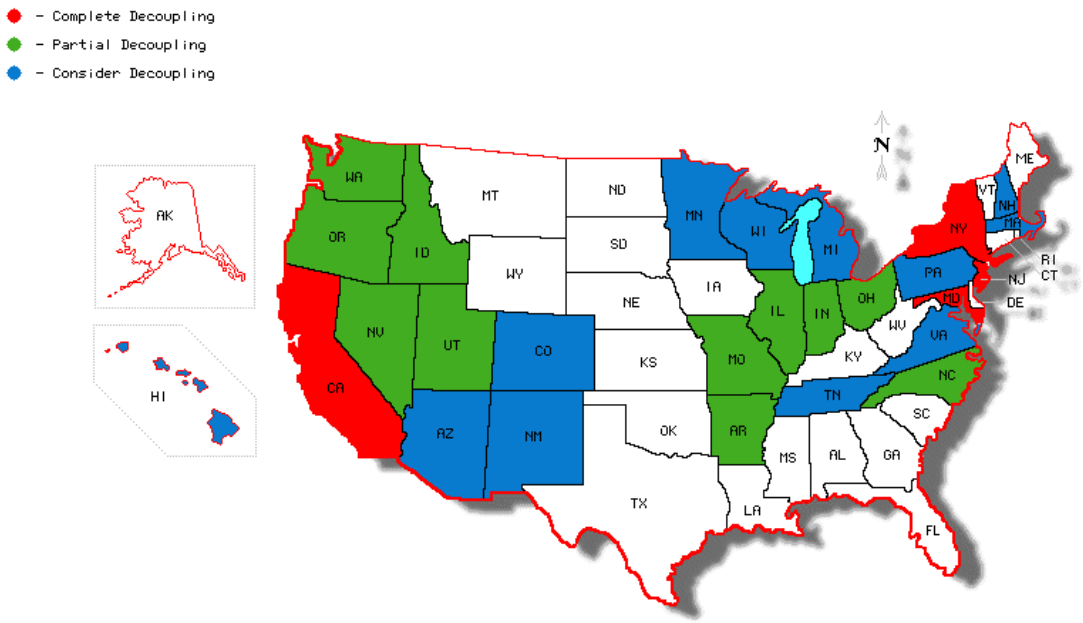

Figure 4: Map of State Decoupling Policies. 28 states either have or are considering decoupling for electric and natural gas utilities. Created by author.[35]

Political Feasibility

Economic feasibility would affect the political acceptance of this proposal by utility companies around the country. Many utility companies have avoided comprehensive programs of this nature because of high levels of investment: each kilowatt-hour saved through energy efficiency improvements in residential buildings costs approximately four to ten cents.[36] At this time (1996), the national average residential electricity rate was 8.36 cents per kilowatt-hour.[37] While these statistics do not reflect current values due to inflation, average electricity rates have simultaneously risen almost twenty-five percent.[38] Other programs to reduce residential energy demand such as loans and rebates require less utility investment, ranging from one to three cents per kilowatt-hour saved.[39] However, the higher figures reflect programs such as weatherization that require little or no investment on the part of the homeowner. The homeowner's investment under this policy proposal would reduce demand growth thereby reducing or potentially eliminating the utility's need to build costly new plants. Other programs to reduce customer demand do not satisfy short-term energy efficiency needs as effectively as comprehensive retrofitting.[40]

Mandatory participation requirements and ratepayer subsidized energy audits explain some of the utility opposition to the Residential Conservation Service program.[41] Although it would be difficult to remove these barriers, tying this program into climate change policy while allowing utilities to manage retrofitting services would result in least-cost alternatives to maximize climate change mitigation.[42] This increased disincentive to release emissions from energy production could resolve utility opposition.

Conclusion

Policymakers must act quickly to lessen the release of harmful emissions leading to climate change. In accordance with principles of capitalism, policymakers and utility administrators should focus on profitable, sustainable retrofitting measures requiring minimal public funding. This proposed system of energy efficiency improvements would allow homeowners and utility companies to reach ideal levels of investment in retrofitting measures. Incorporating utility-sponsored efficiency improvements into climate change policy would remove market barriers, enabling homeowners to obtain a higher standard of living at negative cost while safeguarding the future of our manmade and natural environments.

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