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Energy Efficiency in Buildings: The Case of Germany

Jonas M. Nahm
MIT Political Science Department

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292 Main Street, E38-104, Cambridge, MA 02139-4307
617-253-7522
web.mit.edu/www

Energy Efficiency in Residential Buildings – What the United States Can Learn From Germany

Jonas Nahm
Massachusetts Institute of Technology

Department of Political Science
77 Massachusetts Avenue
Room E53-470
Cambridge, MA 02139, USA

jnahm@mit.edu
Phone: +1 617 901 9948

Abstract: Although buildings account for roughly 40 percent of energy consumption in the United States, very few policies to increase the energy efficiency of existing buildings are in effect today. This article looks to the case of Germany as an instructive example of how mandates can be employed to improve the energy efficiency of existing residential buildings. Based on interviews with government officials at federal, state, and municipal levels, as well as building contractors, architects, and energy consultants, I find that – contrary to concerns frequently voiced by American policy-makers – mandates for energy efficiency in existing buildings do not necessarily entail heavy-handed government intervention in the building sector. On the contrary, much of the success in reversing the trend of increasing building energy consumption in Germany can be ascribed to a vibrant private sector response to the new market opportunities created by mandates. The integration of steadily tightened mandates with federal incentive programs has permitted the German building industry to gradually develop the necessary skills to meet such standards before they become compulsory, and has reduced resistance to new standards by subsidizing some of the additional costs.

Keywords: Energy Efficiency, Residential Buildings, Germany.

1. Introduction

Buildings account for 39 percent of all energy use, 38 percent of carbon dioxide emissions and 72 percent of electricity consumption in the United States (Jacobsen and Kotchen 2010). Although advances in energy efficient building technologies and practices over the past three decades have created vast opportunities for reducing energy consumption, extant building stock in the United States continues to suffer from gross inefficiencies due to insufficient insulation and the use of outdated heating and cooling technologies. Recent studies have estimated that cost-effective efficiency retrofits of existing residential buildings could reduce energy consumption and corresponding greenhouse gas emissions by roughly 30 percent in the next 10 years; the White House even considers the reduction of building energy consumption by 80 percent attainable through technological upgrading (Brown et al. 2008; Choi Granade et al. 2009; White House 2009).

Yet a number of barriers currently prevent homeowners from investing in energy efficiency, leaving this enormous energy resource largely untapped. Sunk-cost considerations frequently dissuade people from replacing outdated heating and cooling systems, even if superior technologies have been developed in the meantime. Moreover, because of relatively low energy prices and the high cost of efficiency retrofits, amortization periods for efficiency investments often

exceed the average length of homeownership. In the absence of adequate returns on efficiency investments in the real estate market, efficiency retrofits are thus often uneconomical in the short term. Rental properties suffer from additional split incentive problems: as building owners are burdened with the cost of efficiency improvements but tenants receive the benefit of reduced utility bills, few landlords feel compelled to address energy efficiency shortcomings of their properties. Even if homeowners are interested in retrofitting their buildings with efficient technologies, they often lack clear information about available technologies, struggle to access affordable financing, and have difficulty finding qualified contractors to do the job.

Since the U.S. building sector continues to trail its efficiency potential, the use of energy efficiency mandates for existing buildings has been widely discussed as a path to accelerate the rate of efficiency retrofits. Although many state governments introduced energy requirements for new buildings in the wake of the 1970s oil embargo, few mandates were ever extended to solve the more complex and costly problem of upgrading existing building stock.[1] Concerns about the cost of meeting such mandates has stirred opposition from consumers and the construction industry, while government officials have challenged their enforceability. The controversy around recent attempts to update energy codes for new buildings and to enact such codes at the federal level further highlights the difficulty of enacting comprehensive mandates for existing buildings (Filisko 2010; Seltz 2010). However, given the long life expectancy not just of buildings themselves but also of many of the technologies employed in them, retrofitting existing building stock and replacing inefficient technologies will be critical if ambitious reduction goals set by the Obama administration are to be met.

In light of these challenges, this study looks to Germany, which introduced incentive programs in the mid-1990s and performance requirements in 1978, as an instructive example of how mandates can be employed to improve the energy efficiency of existing buildings. Using a combination of these incentive programs and performance mandates – laws regulating energy efficiency for new construction were introduced in 1978 and efficiency requirements for existing buildings have been in place since 2002 – Germany was able to decrease energy consumption for heat and hot water per square foot by 15 percent between 1990 and 2005, more than offsetting a simultaneous increase in aggregate square footage by 10 percent. By comparison, energy consumption in the U.S. residential sector increased by 22 percent between 1992 and 2003 (BMVBS 2007; U.S. Energy Information Administration 2008).

Existing buildings have been central to this increase in energy efficiency in the German building sector: long building life cycles due to brick construction styles and very low rates of new construction mean that three-quarters of all buildings in Germany were constructed before the first energy building codes were introduced (Statistisches Bundesamt 2006). Meeting efficiency requirements has placed a significant financial burden on the owners of existing buildings, as outdated heating systems, windows, and insulation have had to be upgraded to meet building code. An unusually low rate of home ownership – a mere 43 percent of Germans own their home as compared to 67 percent of Americans – has further complicated this process due to split incentives problems (Voigtländer 2009). Germany's ability to reverse its trend of increasing energy consumption in the building sector under these circumstances offers

important lessons for efforts to improve building efficiency currently underway in the United States.

Based on interviews conducted in Germany during 2009-2010 with government officials at federal, state, and municipal levels, as well as building contractors, architects, energy consultants, and homeowners, this study identifies five features of the German approach that have accelerated the rate of energy efficiency retrofits. *First*, the German government has included stakeholders from the construction industry and consumer associations in the standard-setting process to ensure that mandates can be met with reasonable effort. *Second*, mandates have been tightened gradually and changes are publicized well in advance in order to provide planning security and to ease adjustments to traditional building practices. *Third*, building contractors and architects themselves are made liable for meeting building code in new and existing buildings, mitigating concerns about enforceability of efficiency requirements and alleviating the burden of policing building practices. *Fourth*, mandates are complemented by incentive programs that provide subsidized financing for projects that exceed the legislative minimum. These programs continuously push the technological frontier of building practice and provide data about the feasibility of tighter efficiency requirements. *Fifth*, the German government has complemented mandates with measures to increase returns on investment in energy efficiency in the real estate market, most importantly through the introduction of mandated energy performance certificates.

In combination, these measures have solicited an active and positive response from the construction industry and consumers. To a visitor from the United States, the pervasiveness of the issue of energy efficiency in Germany is

striking: advertisements by contractors and heating installers for efficiency retrofits are ever-present on TV and in newspapers; real estate listings frequently feature the energy performance of buildings; banks advertise government-subsidized loans for efficiency retrofits; and the media abounds with features on energy efficiency. Even popular home renovation shows on cable stations discuss energy performance when assessing amateurs' do-it-yourself projects. As the following discussion will show, however, the case of Germany is not without problems. When the government has failed in its commitment to energy efficiency – by letting programs expire, failing to provide a clear direction for the future of energy mandates, or tightening mandates too quickly – enthusiasm has quickly given way to insecurity and frustration among consumers and industry.

2. Background

Germany's first attempts at regulating energy consumption of buildings through the introduction of energy-related building codes were motivated by concerns about energy security, brought to light by the oil price shocks of the 1970s (IEA 2008). Data on the average energy consumption of buildings shows that significant reductions in energy consumption had already been achieved at that time – buildings constructed in the 1970s used only 70 percent of the energy for space heating and hot water consumed in buildings completed before 1900 – and the introduction of energy related building code in 1978 sought to further reduce energy consumption by enforcing minimum standards for insulation as well as heating systems (BMVBS 2007).

Beginning in the 1980s and 1990s, emerging environmental concerns provided the impetus for additional requirements. While in the United States the

end of the oil crisis and the onset of cheap energy prices during the 1980s forestalled further political activity, environmental protection and energy efficiency became important political factors in Germany, particularly after the Chernobyl reactor accident exposed much of the country to nuclear fallout in 1986. A Ministry of the Environment was established in the wake of that disaster and the Green Party became a significant political force in the years to come. Early recognition of the problems posed by climate change led the German government to present ambitious targets to reduce CO_2 emissions in 1990, which became the basis for Germany's commitment to reduce greenhouse gas (GHG) emissions to 20 percent below 1990 levels by 2012 under the 1997 Kyoto Protocol. The enormous potential of the building sector to contribute to such emission reductions motivated a second revision of energy efficiency requirements for new buildings in 1995, after a first tightening of the 1978 code had occurred in 1984 (IEA 2008).

In recent years, much impetus for further efficiency improvements in new and existing buildings has sprung from European Union legislation. The 2002 *Energy Performance of Buildings Directive* set EU-wide minimum standards for the energy performance of new and existing buildings, standardized procedures for how such performance should be calculated, and required member states to enact legislation mandating the certification of the energy performance of buildings as well as regular inspection of heating and cooling systems (European Council 2002). This directive was implemented in Germany in the *2002 Energy Conservation Ordinance*, which replaced the Thermal Insulation Ordinance from 1978 and, for the first time, also applied to existing buildings (IEA 2008).

In addition to directly influencing building legislation, the European Union has also put pressure on member states to reduce energy consumption through mandatory carbon reduction goals, which are determined in relation to per capita GDP. As one of the richest European economies, Germany is required to reduce emissions by almost 30 percent for industrial sectors not included in the European emissions trading scheme. Germany has voluntarily exceeded these requirements and has committed to reducing emissions by 40 percent over 1990 levels by 2020 (Vogler 2009). The building sector will have to play a central role if this target is going to be met; as a consequence, efficiency requirements for new and existing buildings included in the Energy Conservation Ordinance were tightened by 30 percent in 2009 (BMVBS 2009).

3. Mandates

Energy Building Legislation for New and Existing Buildings

In contrast to the United States, where building codes have thus far been under the jurisdiction of states, Germany has a tradition of federal involvement in legislating the building sector. While in the United States most building codes are developed by independent industry associations – such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the International Code Council (ICC) – and are subsequently adopted by individual states, the German government has been developing its own building legislation. Federal building legislation is prepared by the Ministry of Transport, Buildings and Urban Affairs and is ratified by parliament and the *Bundesrat*, the second legislative chamber that represents states at the federal level. States thus have an influence on determining the requirements of federal mandates through

their representation in the *Bundesrat*, but federal law acts as a minimum standard. States are not permitted to fall short of federal standards, but often exceed federal requirements through state legislation.

Although energy-related regulations have existed since the 1950s, until the 1970s these were largely focused on safety aspects of heating systems. In response to the 1970s oil crises, the German parliament passed the *German Energy Conservation Act*, which forms the legal basis for federal regulation of energy consumption and provides the foundation for subsequent energy-related building codes through the *Insulation Ordinance* and the *Heating Operations Ordinance* (1978). Both ordinances were combined in the *Energy Conservation Ordinance* in 2002.

Initially, the insulation ordinance limited the maximum value for heat transmission either as an average heat transmission coefficient through the entire building shell or as a prescriptive transmission coefficient for each of the building components (IEA 2008). These standards were gradually tightened and the basis for calculating energy performance of buildings became more complex. Starting in 2002, the *Energy Conservation Ordinance* incorporated the ratio of volume to surface – detached single-family homes have to be more efficient than multi-family buildings – as well as a primary energy conversion factor based on the main source of heating energy. This conversion factor is a multiplier that adjusts the efficiency requirements based on the carbon intensity of the main fuel source for heating. As a consequence, buildings primarily using biomass or natural gas have lower efficiency requirements than those heating with oil or other fuels with high carbon emissions. This conversion factor was introduced to encourage the use of energy from sources with lower CO_2 emissions; it is

adjusted annually based on the share of renewable sources in electricity and gas supply.

Today, software applications are available to calculate the energy performance of new and existing buildings according to federal standards based on a single-value-indicator of building performance similar to mileage standards for cars. For instance, the 2009 version of the *Energy Conservation Ordinance* limits the permissible energy consumption for heat and hot water in newly constructed buildings to 70 kilowatt hours per square meter per year. This reduction of efficiency requirements to a single indicator of energy consumption in kilowatt hours per square meter per year has added much transparency to requirements for energy efficiency and has allowed for easy comparisons of efficiency performance across buildings irrespective of building type or occupants' behavior.

For existing buildings, energy efficiency standards have to be met after larger renovation projects. When existing buildings were first regulated with the creation of the *Energy Conservation Ordinance* in 2002, specific maximum heat transmission coefficients for various building components were prescribed. These had to be met if more than 20 percent of an exterior structural element with the same orientation is renovated. For instance, if more than 20 percent of windows on any given side of the building were replaced, all windows had to abide by the heat transmission values included in the code. In addition to these performance standards, particular technologies, such as all furnaces installed before 1978, had to be replaced by 2008 (IEA 2008). Since its 2009 amendment, the *Energy Conservation Ordinance* integrates existing buildings into the single-value, performance-based approach. According to these new regulations, if more

than 10 percent of any given building element is renovated, the building cannot exceed performance standards for new buildings by more than 40 percent.

To further reduce carbon emissions, all new buildings in Germany have been required to use renewable sources for a share of their energy consumption for heating and domestic hot water since January 1, 2009. The *Renewable Energy Heating Law* specifies different minimum shares of renewable energy depending on the source: buildings utilizing biomass or geothermal heat, for example, are required to cover a minimum of 50 percent of their heating and hot water energy from these sources, while solar thermal systems only have to provide 15 percent of a building's energy used for heating and hot water. The *Renewable Energy Heating Law* aims at increasing the share of renewable energy in space heating and domestic water heating to 14 percent by 2020, from 6 percent today. This law is not only motivated by concerns about carbon emissions and energy imports, but the Federal Ministry of the Environment has explicitly stated the intention to use the law to promote the development of renewable energy technologies, for both domestic use and export (BMU 2008).

These mandates illustrate Germany's approach of achieving energy efficiency in buildings through improving the efficiency of building structures rather than through behavioral changes. In addition to emphasizing that energy efficiency does not sacrifice comfort, this strategy also has the advantage of easing measurement and verification of mandates and policies. In contrast to the approach taken in California, for instance, where utilities need to demonstrate that *actual* energy consumption has been reduced as a result of incentive programs, German mandates and incentive programs focus on the theoretical energy performance of a building. While utilities in California need to employ

expensive surveys to determine the impact of their programs – they spend more than $100 million annually on measurement and verification[2] – in Germany the improvement of energy performance from retrofitting can be calculated cheaply and quickly using software applications prior to construction. Such a system using a "mileage standard approach" also avoids measurement problems resulting from changes in actual consumption due to changes in occupancy – teenagers leaving for college or seniors moving in with their children – and is thus based on a much more objective assessment of building performance.

Gradual Tightening of Energy Efficiency Requirements

Since the initial regulation of the energy performance of new buildings in 1978, energy efficiency requirements for both new and existing buildings have increased substantially. Starting from a maximum permissible energy consumption for space heating and hot water in new buildings of 220 kilowatt hours per square meter per year in 1978, successive rounds of amendments in 1984, 1995, 2002, and 2009 have reduced the legislative maximum to 70 kilowatt hours per square meter per year, reducing energy consumption of new buildings by 70 percent compared to the initial standards prescribed in 1978. Existing buildings, first regulated in 2002, can exceed these standards by 40 percent, with maximum energy consumption declining from 140 kilowatt hours per square meter per year in 2002 to roughly 100 kilowatt hours today.[3]

This process of federally-mandated, progressive tightening of energy building code for new and existing buildings contrasts sharply with the current situation in the United States. Although ASHRAE, ICC and the Department of Energy continuously work to update building codes and energy efficiency

standards prescribed in the International Energy Conservation Code (IECC), states are not required to adopt the latest standards. Instead, U.S. law merely requires each state "to certify that it has reviewed its residential building energy code regarding energy efficiency and made a decision as to whether it is appropriate for that state to revise its residential building code to meet or exceed the revised code" (U.S. Department of Energy 2010a). As a consequence, building energy standards vary widely across states. For instance, Arizona and Wyoming have not implemented any version of the IECC, whereas California and Massachusetts require new buildings to meet the 2009 version (U.S. Department of Energy 2010b).

In Germany, the process of gradually tightening energy performance requirements is conducted by the Federal Ministry of Transport, Buildings and Urban Affairs. Decisions about the tightening of standards are made according to both economic criteria – based on payback periods of 30-40 years – and the technical feasibility of such measures in practice. Detailed studies are conducted both by the federal development bank, *Kreditanstalt für Wiederaufbau* (KfW),[4] as well as independent research institutes and universities to provide information about the technical and economic feasibility of particular standards. Incentive programs, which include loan subsidies for residential building projects surpassing federal minimum standards, generate additional data on the development of building practices.

For particular standards included in the Energy Efficiency Ordinance, such as the standard prescribing how building energy performance is calculated (*DIN 18599*), the federal government establishes a standardization committee (*Normungsausschuss*) with representatives from industry, academia, and

consumer associations. Participation is voluntary and provides stakeholders with an opportunity to critique and comment on drafts prepared by the Ministry of Buildings. Although suggestions from stakeholders are not binding, participants perceive standardization committees both as a successful way to balance the interests of various stakeholders and to stay informed about upcoming changes in legislation.[5]

The Federal Ministry of Transport, Building and Urban Affairs estimates that it takes about five to ten years until methods from scientific studies and model buildings are utilized in conventional building practice. It then takes another 5 to 10 years until the Ministry has gathered enough data and practices have become sufficiently economical for energy performance standards resulting from new building practices to be prescribed in building code (BMVBS 2007). New minimum standards are ratified and set several years in advance in order to provide adequate lead-time for the construction industry to adapt to new requirements. For instance, even though a new, 30 percent stricter version of the *Energy Savings Ordinance* came into effect in October 2009, the federal government already announced plans to further increase efficiency requirements by 30 percent in 2012.[6] Communicating several iterations of building code in advance also emphasizes the government's commitment to a continued tightening of efficiency requirements and encourages homeowners and construction industry to build beyond current minimum requirements. Partly as a result of these expectations of continual ratcheting, studies have found that buildings consistently and significantly exceed minimum legal standards (BMVBS 2007).

Enforcement of Energy Building Legislation

As in the United States, building legislation in Germany is enforced by municipal building authorities, which are responsible for verifying that plans adhere to code when building permits are issued. Municipal authorities are also in charge of carrying out building inspections, though the number of checks is low due to personnel and budget constraints. Environmental groups have criticized the lack of regular building inspections, arguing that regulations for existing buildings are often not enforced.[7] Similar concerns have been raised in the United States, where cash-strapped municipalities have argued that energy efficiency requirements are difficult to implement without significantly increasing the number of building inspectors. Energy-related requirements are particularly difficult to inspect, as they require visits to construction sites within very short time windows: once insulation is wrapped in the building envelope, it is hard to determine whether legislative requirements have been met.

Although critics rightly assert that the number of building inspections should be increased, the German government has avoided some of these shortcomings by relying on liability law in the enforcement of building code. Architects and builders are legally responsible if code violations are discovered and are liable for 30 years for the performance of their buildings according to the theoretical performance metrics included in building code. Particularly in light of the recent introduction of energy performance certificates, which have provided additional transparency by making visible any discrepancy between the theoretical energy performance calculated prior to construction and actual energy consumption after construction or retrofitting, architects, builders and industry

associations have confirmed that liability considerations drive adherence to code even in the absence of building inspections.[8]

Energy Performance Certificates

To complement energy efficiency mandates and to raise the return on efficiency investments in the real estate market, Germany has recently introduced mandatory energy performance certificates for residential and commercial buildings. These performance certificates are intended to address a problem often referred to as the "Prius-effect" among policy-makers in the U.S.: since energy efficiency is not a visible feature of a building, it is much harder to use energy efficiency as a prestigious identifier of a green lifestyle and to demand the appropriate price in the real estate market. The success of the Toyota Prius, which is only manufactured with a hybrid engine, is often ascribed to its value as a green status symbol due to its immediate recognizability as a hybrid car.

The impetus to introduce energy performance certificates to address this problem has come from the 2002 EU *Energy Performance of Buildings Directive*, which requires all member states to introduce legislation mandating such performance certificates for new and existing buildings. In Germany, the EU directive was translated into national law in a stepwise process as part of the *Energy Savings Ordinance* from 2002. For buildings built before 1965, performance certificates have been required since 2008, whereas new and younger existing residential buildings have been required to have an energy performance certificate at time of sale or lease since the beginning of 2009. These requirements were extended to non-residential buildings in July 2009. Energy performance certificates have to be renewed after 10 years and in

buildings larger than 1000 square meters these certificates need to be publicly displayed.

In Germany, performance certificates are tightly integrated with the 'mileage standard' approach of the *Energy Savings Ordinance*. For buildings with fewer than five apartments, the performance certificates are based on the standardized single-value indicator for the energy efficiency of each building also employed in energy building code. This indicator is based on a theoretical calculation of building energy performance that considers heat transmission coefficients for the various building parts, and it reflects the theoretical energy consumption for heating and hot water per square meter per year based on standardized behavior and weather patterns. In addition, energy performance certificates also display the actual energy consumption per square meter per year to better reflect usage patterns of current occupants. For larger apartment buildings and commercial spaces, this consumption indicator is sufficient, since energy usage patterns of several occupants can be averaged to provide a more reliable estimator of the building's energy efficiency. Both the calculated and the actual energy performance of the building are displayed on a scale together with reference values to allow building owners and tenants to better classify their unit's efficiency.[9] Some issuers of performance certificates also provide detailed suggestions for retrofits that would improve the building's rating.[10]

Although, because of their recent introduction, no systematic evidence of the effect of energy performance certificates has yet been generated, anecdotal evidence suggests that particularly in housing markets with sufficient supply, potential buyers and renters have started taking energy efficiency performance into consideration.[11] Since indicators included in performance certificates

employ the same mileage standard approach as building code, the performance certificates also allow home-owners and tenants to see how their building compares to the legal requirements for new buildings. This can provide important information about the feasibility of reaching necessary efficiency standards for eligibility for preferential loan programs, as will be discussed in the following section. Moreover, the certificates have added an important control mechanism to the enforcement of building code, as potential construction mistakes become visible. Since architects and builders are liable for meeting building code standards, performance certificates can provide the basis for legal action if efficiency standards required by code are not met in practice.[12]

To be sure, a number of problems with performance certificates remain to be resolved. Many observers have voiced criticism that the great number of issuers and insufficient standardization of certificates are confusing to customers. Homeowners object to the expense of performance certificates, which cost up to 500 Euros if extensive measurements and calculations are involved. Lastly, the effect of performance certificates in high-demand rental markets remains questionable. If desirable apartments are in short supply, will potential tenants dare to ask for performance certificates or refrain out of fear of not being considered for the apartment?

Response of Building Industry and Consumers

Representatives from the building industry and consumers interviewed for this study generally responded positively when asked about the process of introducing and gradually tightening energy efficiency legislation in Germany. Although current legal requirements are stringent when compared to the

standards that were first introduced in the 1970s, the gradual nature of the adjustment process – with requirements increasing every seven to ten years – has provided both industry and consumers with the opportunity to slowly adjust to new building practices. Instead of perceiving energy building codes as a form of government coercion, the owner of a small construction company described energy efficiency legislation as a factor in a learning process that has significantly improved how buildings are built and renovated over the past 30 years. Asked about building practices before the introduction of energy building code in the 1970s, he chuckled as he described the kind and quality of work – absence of airtight membranes in walls to reduce heat loss through drafts and minimal insulation in walls and attics – he discovers when renovating buildings he himself constructed decades ago.[13] In the experience of architects, builders and representatives from government and the building industry, the slow and deliberate introduction of energy efficiency requirements has thus far also prevented investment delays caused by the increased cost of meeting such objectives, a concern often raised in U.S. debates about energy building codes (See, for instance, Swita 2010). Instead, the positive effect of these laws on the building sector was emphasized, particularly at a time when construction rates for new buildings continue to fall and energy efficiency retrofits provide an alternative income stream.

However, the widespread negative reaction to plans of the federal government to shorten the cycle of code revisions from seven to three years in order to meet ever more ambitious carbon reduction goals suggests that the process of increasing energy efficiency in buildings cannot be accelerated indefinitely. Industry and consumer associations have called for a delay of the

planned 2012 revision of the *Energy Conservation Ordinance*, arguing that more time is needed to improve building practices and technologies since the last amendment in 2009.[14] As building standards become ever more complex – DIN 18599, the 2009 standard for calculating energy performance of buildings, comprises roughly 1000 pages – small construction firms and architects need more time to familiarize themselves with new requirements and software applications and are unable to do so every three years. Moreover, industry representatives have expressed concerns about liability, as new technologies necessary to meet such standards – new types of tapes and seals to fix membranes in building envelopes, for instance – have not been sufficiently tested to ensure reliable performance for 30 years.[15] Such critics have suggested that Germany already has some of the strictest energy efficiency legislation in the world, and policy-makers should focus on speeding up the rate of compliance with the current code rather than shorten the cycle of building code amendments. However, despite such points of contention about the appropriate timing of further increases in efficiency requirements, few have challenged the governments' approach to regulating energy consumption of buildings as such or the need to increase requirements in the future.

4. Incentive Programs

In addition to mandating energy efficiency in new and existing buildings through building codes and other legislation, the German government employs a number of incentive programs to encourage homeowners to exceed the legally required energy efficiency requirements for buildings. These programs differ both in scope and implementation from similar efforts in the United States. In the

U.S., much debate in policy circles has focused on whether and how public and investor-owned utilities (IOU) should be included in government efforts to reduce energy consumption in buildings. While some have argued that energy companies have access to customer data and, once their profits are decoupled from the amount of energy sold, are best equipped to target energy efficiency potential through incentive programs, others have reasoned that IOUs have historically developed on the premise of selling as much energy as possible and are unlikely to change their ways as result of decoupling or other measures.

As a consequence, states in the United States have chosen from a wide range of strategies to encourage homeowners to invest in energy efficiency. California, for instance, has picked IOUs as the primary body through which to run incentive programs. Utilities are decoupled and are paid for any kilowatt hour saved as a result of incentive programs they run to encourage their customers to reduce energy consumption. Other states, such as Oregon and Vermont, have created independent non-profit organizations to choose and implement incentive programs financed through surcharges on energy rates while decoupling utilities to mitigate opposition to energy efficiency efforts. Financial rewards tied to energy savings are intended to incentivize these organizations in their energy efficiency efforts. In New York, such programs are run by the New York Energy Research and Development Authority itself. Incentive programs run by these organizations differ widely in scope and scale, from public education campaigns and energy audits to rebates for energy efficient lighting and appliances. However, some states have not implemented any state-wide incentive programs to date, though some local regulations require utilities to

offer rebate programs for the replacement of inefficient heating and cooling technologies and other small-scale incentives for energy efficiency.[16]

In Germany, by contrast, competition between electric utilities has encouraged many of them to voluntarily offer energy efficiency incentive programs. After a series of regulatory reforms in the early 2000s, only grid operators currently enjoy regulated monopolies in Germany, while both electricity generation and retail have been deregulated.[17] As a consequence, hundreds of electricity retailers compete nationwide for customers. Unlike their American peers, which in many regions retain regulated monopolies and therefore a fixed revenue base, German electricity retailers often see the provision of energy efficiency services as a way to attract and retain additional customers. Hence, even in the absence of legislative requirements, many retailers offer energy efficiency services – from public education campaigns to energy efficiency audits of buildings – to set themselves apart from their competitors. In interviews, utilities stated that even though they have not yet found a business model to profit directly from these activities, in offering energy efficiency services they are responding to the expectations of their customers and increased competition in energy retail markets.[18]

Against this background, government incentive programs in Germany have bypassed utility companies and have instead focused on encouraging homeowners to exceed minimum energy efficiency requirements during new construction and when existing buildings are undergoing major renovations. Since buildings are assumed to require significant updates every 20-40 years, the entire building stock could theoretically be retrofitted every 30 years if renovations are used as an opportunity to upgrade energy efficiency performance

of existing buildings (Pöschk 2010). Since 85 percent of energy consumed in residential buildings in Germany is used for heating and hot water, such programs have prioritized the replacement of space and water heating equipment and updates to insulation over energy use in electrical appliances and lighting (BMBVS 2007). Most government incentive programs are tightly integrated with building code requirements and serve as a way to prepare the next round of legislative requirements, both by making the construction industry familiar with future requirements and by providing the government with data on the practical feasibility of particular efficiency mandates. To facilitate the integration of incentive programs and mandates, incentive programs are using the same 'mileage standard' approach that distinguishes federal building codes.

Preferential Loan Programs

The main mechanism for incentivizing energy efficient construction and renovation beyond code requirements is through preferential loans from the main German economic development bank, *Kreditanstalt für Wiederaufbau* (KfW). KfW is jointly owned by the German states and the federal government, and first began offering preferential loans for energy efficiency and CO2 emission reduction in 1996. However, a housing modernization program for Eastern Germany, starting in 1990, also included some energy efficiency requirements to qualify for preferential interest rates. Loan programs offered by the KfW are developed by the Federal Ministry for Transport, Buildings and Urban Affairs, though the bank itself employs an engineering department to supervise implementation and evaluate the programs.[19]

As a triple A institution due to government guarantees, KfW raises capital at competitive rates in regular capital markets. Moreover, as a non-profit bank, it does not make profit nor is it required to pay taxes, so lending costs remain low. Depending on the loan program, interest rates are additionally subsidized through tax funds from the federal government of 1.5 billion Euros per year, so that the interest rate is generally about two percent below commercial rates. Loans to individual applicants are processed by regular commercial banks, which advertise, perform credit checks and collect payments in return for a fee. Banks are also required to verify documentation that the loans are used for the intended purposes and that required efficiency levels have been reached. This business model is attractive for commercial banks particularly in the case of large projects: since loan sums of preferential programs are capped, customers often additionally rely on commercial loans to finance the remaining cost of their construction or renovation project. Banks thus usually offer customers a mix of commercial and public preferential loans, relying on preferential loans to reduce the average interest rate.

Over the years, eligibility criteria were adjusted several times to reflect technological developments and changes in building codes, but the underlying principle of KfW loan programs has remained unchanged. Two main loan programs for residential buildings are in effect today, one for new buildings and one for existing ones.

For new buildings, KfW's *Energieeffizient Bauen* (energy-efficient construction) program offers preferential loans for the purchase or construction of buildings which use no more than 70 percent of the maximum energy consumption mandated by current building code. Interest rates are determined by

the efficiency level reached, with buildings consuming less than 55 percent of the permissible energy consumption qualifying for additional interest reductions. Loans of up to 50 000 Euros per accommodation unit are granted under this program.

KfW's *Energieeffizient Sanieren* (energy-efficient renovation) program offers preferential loans for the purchase of an existing building that has been retrofitted to meet current building code requirements for new buildings, as well as loans for the energy-efficient renovation of existing buildings. Only buildings whose building permit was applied for before January 1, 1995 are eligible for loans under this program. As in the program for new buildings, energy performance standards have to be reached to qualify for a loan. Owing to the difficulty of retrofitting existing buildings, eligibility criteria are more lenient than in the case of new buildings. At the minimum, existing buildings qualifying for a loan under this program have to reach the standard for new buildings (100 percent of code), and additional subsidies are available for projects which reach 70 percent of the maximum permitted energy consumption of new buildings. Up to 75,000 Euros per accommodation unit are granted under this program. A third component of *Energieeffizient Sanieren* provides smaller loans of up to 50,000 Euros for a wide variety of projects that increase energy efficiency of buildings but may not be sufficient to reach the performance levels of new buildings. To make energy efficient retrofits more attractive, interest rates in the existing buildings program are subsidized to a greater extent than those for new buildings. At the time of writing, interest rates for loans for existing started at 1.41 percent, as compared to 2.42 percent for new buildings.

In addition to subsidized interest rates, *Energieffizient Sanieren* supports projects through non-repayable grants that are funded through the federal government. The size of these grants is determined by the efficiency level reached: for projects surpassing the requirements for new buildings by 30 percent, 17.5 percent of the total investment up to 13,125 Euros is paid out as a grant. For projects reaching efficiency levels required for new buildings, 10 percent of the project cost up to 7,500 Euros are paid out as a grant. Smaller efficiency retrofits not reaching particular efficiency levels qualify for a grant worth five percent of the total investment, up to 2,500 Euros.

Other Incentive Programs

In addition to loan programs, the *Federal Office of Economics and Export Control* (Bafa) offers a number of grants for the use of renewable energy for space and water heating, similar to the tax rebates offered in the United States under the 2009 stimulus bill (EPA 2010). These grants are intended to offset some of the additional cost caused by requirements in the *Renewable Energy Heating Law* in new buildings, and to prepare for a future extension of such requirements to existing buildings. At the time of writing, installations of solar thermal systems were subsidized with up to 105 Euros per square meter of collector area, biomass heating systems received subsidies of up to 2500 Euros, and geothermal heat pumps were subsidized with up to 3000 Euros per accommodation unit. These subsidies can be applied for up to 3 years after completion of the project. In addition to subsidies for renewable energy heating and hot water systems, Bafa also provides a 300 Euros grant for residential energy consulting by certified energy consultants, with additional funds available

for blower door tests and thermographic imaging. Bafa also administers a 2000 Euros subsidy for quality management during energy efficiency retrofits to ensure that measures are correctly implemented.

At the state and municipal level, a variety of additional incentive programs are available, especially in regions where local building code requirements significantly exceed the federal minimum. Most states have also made subsidies for affordable housing dependent on surpassing the minimum building code requirements by at least 30 percent, effectively instituting loan programs similar to those run by KfW. These state loan programs are generally administered by local government-owned development banks, which have long provided subsidized loans to low-income families and investors in affordable rental apartments. Many of these sub-national loan programs can be combined with federal loans so that a larger part of the project can be funded at preferential interest rates.[20]

Building Sector and Consumer Response to Incentive Programs

According to the German Federal Government, between January 2006, when the latest generation of loan programs was introduced, and Decemer 2010, more than 35 billion Euros were paid out through KfW federal loan programs, causing more than 70 billion Euros of investment in energy efficiency in more than 2 million new and existing buildings. The German Federal Government estimates that as a result of these programs, consumers have already saved more than 2 billion Euros in expenses for heating energy, and GHG emissions were mitigated by 15 million tons since January 2006, not including the effect of stricter building codes themselves. In 2010 alone, loans amounting to 8.7 billion

Euros led to 21 billion Euros of investment in energy efficiency in buildings, reducing carbon dioxide emissions by 4.7 billion tons.[21] The size of this investment in energy efficiency is remarkable, particularly given the relatively modest size of taxpayer subsidies of roughly 1.5 billion Euros annually. The KfW banking group estimates that every Euro in tax subsidies to buy down interest rates for efficiency loans generates 9 Euros of investment in energy efficient buildings.[22] Although still shy of the government target of 3 percent, the annual rate of energy efficiency retrofits as a percentage of total building stock has steadily increased from 1.6 percent of building in 1994 to 2.2 percent in 2006 as a result of incentive programs (BMVBS 2007). Building activity as a result of incentive programs sustains an estimated 340,000 jobs in construction.[23]

For comparison, California is spending roughly 1 billion dollars annually on efficiency programs run by IOUs, which are estimated to reduce GHG emissions by 1 million metric tons per year (California Energy Commission 2008b). Although numbers are difficult to compare, this suggests that German incentive programs are achieving roughly 60 percent larger reductions in GHG emissions per dollar spent.[24] Since much of California's incentive programs target lighting and appliances with relatively short life cycles rather than building parts, it is also questionable whether program results in California are as lasting as Germany's investments in insulation and building parts with much longer life spans.

In combination with minimum efficiency requirements prescribed in building energy codes, Germany's energy efficiency incentive programs have created a large and thriving market for the private sector. The building industry has actively embraced preferential loan programs as a way to attract additional

business, and all of the builders and architects interviewed for this study had knowledge of the loan programs and mentioned the frequent use of these programs for marketing purposes.[25] Semi-governmental organizations, such as the German Energy Agency (DENA), support these efforts by providing marketing materials to firms, and by running regional workshops to help the building sector provide accurate and up-to-date information to their customers. Since federal preferential loan programs are processed through commercial banks, they, too, have used these programs as an opportunity to expand their customer base. Large advertisements of energy efficiency loans displayed in many branch windows suggest that preferential loan programs are not only of commercial interest to the financial sector, but that banks have taken on an important role in advising customers on energy efficiency financing.

The trend of private companies taking advantage of the framework of mandates and federal incentive programs to advance their commercial interests in the field of energy efficiency is also present in workforce education. Many workforce education centers are operated on a for-profit basis by regional chambers of trade, and contractors, architects and heating installers pay significant fees for courses on energy efficient building techniques. While in areas such as heating installations such courses are required to be certified for the installation of geothermal heat pumps and solar thermal systems, in other areas, such as insulation, no formal certifications or legal requirements exist. However, building sector professionals are willing to pay fees of up to 10,000 Euros for continuing education courses on advanced insulation materials and other efficiency topics in order to stay competitive in the market. Many workforce

education centers also offer marketing training to building contractors to help them advertise their new skills.

Not all building sector professionals have been equally welcoming of the opportunities provided by federal incentive programs, and representatives of the chambers of trade reported on the existence of resistance to new building techniques. However, due to legal liabilities and the increasing complexity of construction practices, most builders, craftsmen and architects appreciate the need for additional training. For instance, meeting current building codes for new buildings often involves the use of air-tight membranes in exterior walls to prevent heat loss. Ensuring an accurate seal is important to pass blower door tests and reach the required efficiency standards. This also involves new practices on the part of other professionals who were previously uninvolved in insulation. Electricians, for example, need to ensure that power sockets are installed without piercing the membranes, or they could be responsible for expensive repair work. This mix of new market opportunities and liability concerns has created widespread demand for workforce education and private actors have responded rapidly in meeting this demand.[26]

The largely positive response of the private sector has dwindled, however, at times when incentive programs have come under threat or have been temporarily suspended. While federal loan programs have provided consistent financing over time, federal tax funds available for energy efficiency grants provided by the *Federal Office of Economics and Export Control*, for instance, have not always been renewed in time and have led to temporary suspension of grants. Appliance manufacturers and contractors reported very immediate effects of such suspensions for their businesses, as customers responded by postponing

energy efficiency retrofits or by abandoning plans altogether.[27] This suggests that long-term planning security is critical for an active private sector response to the market opportunities provided by energy efficiency incentive programs.

Despite such shortcomings, the system of incentive programs in Germany has solicited a very active response from the private sector that has resolved some of the problems similar programs have faced in the United States. The relatively simple administration of loan programs, for instance, has removed the need for complicated measurement and verification systems that are required to reward organizations for their energy efficiency services in many parts of the United States. In California, where utilities are paid for avoided energy consumption as a result of their efficiency programs, disputes over the measurement of so-called "negawatts" have led to costly legal battles between utilities and the public utility commission.[28] Since any qualified contractor is eligible to perform energy efficiency retrofits under the German preferential loan programs, the government has created a market in which the building sector can freely compete. Many incentive programs in the United States, by contrast, have entrusted particular businesses and organizations with running efficiency programs, crowding out private businesses unable to compete against those organizations that have been awarded public subsidies.[29]

The scale and consistency of the German federal loan programs has also provided sufficient incentives for the private sector to establish adequate workforce training opportunities without the need for additional government funds, avoiding the problem of bottlenecks that is frequently raised in debates on scaling-up energy efficiency in the United States. In an interview, an instructor for the California community college system reported that, due to funding issues,

courses for energy efficiency HVAC technicians have space for only a fraction of applicants and students are often recruited after completing only part of their training since demand for trained technicians is so high in the private sector.[30] Even though innovative local loan programs, such as loans repayable through property taxes and utility bills, are being established in municipalities across the U.S. to address financing problems in energy efficiency retrofits, the small scale of such programs is unlikely to solicit private sector marketing and training efforts comparable to those in Germany.

5. Conclusions

The German approach to increasing energy efficiency, comprising of a tightly integrated combination of mandates, incentive programs and measures for market transparency and public education, has caused a declining trend in energy consumption for space and water heating in buildings. Despite an increase of square footage in buildings by more than 10 percent since 1997, aggregate energy consumption for water and space heating has decreased over the same period. After increasing gradually until 2000, annual energy consumption of new and existing residential buildings for heat and hot water has decreased by 10 percent between 2001 and 2008. Over the same period, carbon emissions from heating and hot water in residential buildings decreased by 11 percent or 16 million metric tons (BMVBS 2007; Statistisches Bundesamt 2010).

The case of Germany illustrates that mandates for energy efficiency do not necessarily entail heavy-handed government intervention in the building sector. On the contrary, much of the success in reversing the trend of increasing energy consumption for space and water heating can be ascribed to a vibrant

private sector response to the new market opportunities created by mandates. Many commercial banks, construction firms, developers, educational institutes and power utilities have used energy efficiency mandates to advance their own commercial interest, and in the process have contributed to increasing the energy efficiency performance of the German building stock. Instead of harming the building sector and the construction industry, as often feared in the United States, the drive to increase energy efficiency has created new markets, added local jobs, and provided new commercial opportunities for domestic firms. The intention to provide a domestic market for technological developments that can later be exported is frequently mentioned in government documents.

Together, the private and public response to mandates, incentive programs and marketing and education programs have prominently established the topic of energy efficiency in German public discourse. In this regard, the common use of a simple 'mileage standard' approach has been beneficial, making it simple to communicate efficiency standards that otherwise are difficult to describe. Using the indicators for standardized energy consumption per square meter per year, homeowners and tenants can compare the efficiency of their units to others, find out whether they comply with building code, and can estimate whether they are eligible for preferential loans and other incentive programs. As with mileage standards for cars, few laypersons are aware of how these indicators are calculated, but they nevertheless provide a meaningful reference for communicating efficiency standards.

The integration of mandates, incentive programs and educational activities has also been helpful for the tightening of mandates. Incentive programs have provided government officials with data about the cost and

feasibility of reaching new energy performance standards, have permitted the building industry to gradually develop the necessary skills to meet such standards before they become compulsory, and have reduced resistance to new standards particularly in the case of existing buildings by subsidizing some of the additional costs.

Despite these successes, Germany needs to significantly step up its efforts if it is to meet its target of reducing CO_2 emissions by 40 percent by 2020. Studies have estimated that the current approach will lead to a reduction of total German GHG emissions of 22 percent in 2020, suggesting that existing efforts are insufficient to achieving a 40 percent reduction of GHG emissions unless other sectors contribute disproportionally (Hansen 2009). The mounting resistance to a further acceleration of energy code amendments on the part of industry and consumers raises doubts about whether the rate of energy efficiency retrofits can be increased much further. Moreover, while the focus on space and water heating – currently accounting for roughly 85 percent of energy use -- has led to declining energy consumption in these areas, electricity usage by appliances is becoming a proportionally larger share of aggregate energy consumption and will need to be addressed in the near future (Statistisches Bundesamt 2010).

Nevertheless, Germany's use of mandates and its long-term approach to increasing the energy efficiency of its building stock provide valuable lessons for countries like the United States, which have only recently begun to look for policy solutions for energy efficiency in the building sector. Most importantly, the case of Germany demonstrates that mandates can create abundant

opportunities for private market responses to solving the efficiency problem, from innovative marketing campaigns to technological innovation.

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Footnotes

[1] A notable exception to this trend are California's Title 24 Building Energy Efficiency Standards, which now include efficiency requirements for building additions as well as new windows and HVAC systems if these are installed in existing buildings (California Energy Commission 2008a).

[2] Author interview, San Francisco CA, 2008.

[3] Author interviews, Berlin, 2009.

[4] KfW banking group was founded in 1948 with the aim of promoting reconstruction and economic recovery after World War II. Initially funded through financing provided by the Marshall plan, the government-owned bank today raises most of its funds in capital markets. Guarantees provided by the German federal government allow it to do so at very attractive rates. KfW is not allowed to compete with private banks, but cooperates with the banking sector in providing affordable financing for a wide range of purposes, including housing construction, energy efficiency retrofits, investment loans for small and medium enterprises, student loans, investments in a low-carbon energy infrastructure by municipalities, export financing for medium and large companies, and a wide range of economic development programs abroad. See www.kfw.de.

[5] Author Interviews: Berlin and Frankfurt, 2010.

[6] Author interview, Berlin, 2009.

[7] Author interviews: Berlin, Frankfurt, Kiel, 2010; Berlin, 2009.

[8] Author interviews: Berlin and Kiel, 2010; Kiel, 2009.

[9] Energy performance certificates avoid a letter classification as is common in appliance standards: since both the technological limits and legal requirements for energy efficiency in buildings change rapidly, a letter grade would quickly be outdated.

[10] Author interview, Berlin, 2009.

[11] Author interviews: Kiel, 2010; Hamburg, 2009.

[12] Author interviews: Berlin, 2010; Hamburg, 2009.

[13] Author interview, Kiel, 2010.

[14]Author interviews: Berlin and Kiel, 2010; Hamburg and Kiel 2009.

[15] Author interviews: Berlin and Frankfurt, 2010.

[16] Author interviews: Portland OR and San Francisco CA, 2009; Sacramento CA and San Francisco CA, 2008.

[17] Electricity retailers purchase power from generating companies and pay a regulated transmission fee to the grid operators.

[18] Author interviews: Berlin, 2010; Berlin and Hamburg, 2009.

[19] Author interview, Berlin, 2009.

[20] Author interview, Kiel, 2009.

[21] Email correspondence, KfW, 2011.

[22] Author interview, Berlin, 2009.

[23] Email correspondence, KfW, 2011.

[24] Calculation as follows: in California, 1 billion dollars reduce GHG emissions by 1 million tons annually, while in Germany, 1.5 billion euros (roughly 2 billion dollars) reduce GHG emissions by 3.2 million tons annually (12 million tons reduction between 01/2006 and 08/2010). For double the investment, Germany thus receives three times the amount of GHG emission reductions.

[25] Author interviews: Berlin and Kiel, 2010; Hamburg and Kiel, 2009.

[26] Author interviews, Hamburg, 2009.

[27] Author interviews: Berlin, Frankfurt, Kiel, 2010; Berlin and Kiel, 2009.

[28] Author interviews: Sacramento CA and San Francisco CA, 2008.

[29] Author interviews: Portland OR, 2009; San Diego CA, 2008.

[30] Author interview, San Diego CA, 2008.