# The Missing Piece in Climate Policy:

## Renewable Heating and Cooling in Germany and the U.S.

10th Anniversary
HEINRICH BÖLL FOUNDATION
Washington DC

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April 2008

**The Heinrich Böll Foundation** is a non-profit political foundation affiliated with the German political party of Alliance 90/The Greens. Since 1998, the Heinrich Böll Foundation has an office in Washington, DC. The Heinrich Böll Foundation North America focuses its work on the issues of foreign and security policy and transatlantic relations, global governance, sustainable development, social equity and gender democracy.

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Published by the Heinrich Böll Foundation North America
Cover design and interior layout by Sarah Vickers

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# FOREWORD

The next one and a half years are crucial for global climate diplomacy. The goal is to negotiate a post 2012-agreement during 2008 and 2009 that all countries around the world will agree to at the United Nations Climate Change Conference in Copenhagen (COP15). With a roadmap developed at COP13 in December 2007 in Bali, Indonesia, the groundwork for a new global climate deal following the Kyoto Protocol has been built. However, the challenge is huge and time is short to find a consensus that is both ecologically sufficient in regards to climate change, and that also reflects a fair balance between the differentiated responsibilities of countries in the North and the South.

Previous years have shown the stark differences from the United States and Europe on their respective reactions to the Kyoto Protocol. While the European Union agreed on mandatory emission targets and therefore launched several policy packages to cut back greenhouse gases, the U.S. announced its withdrawal from the Kyoto Protocol. Continuing on this path, aside from select technology programs and support of voluntary approaches, there has been a lack of a federal presence on climate policies. Under the Bush Administration, climate change mitigation has clearly not been a national priority. It is widely anticipated, however, that the next U.S. President will engage more actively in international climate change negotiations, and could push for new domestic policies targeting greenhouse gas reductions. In addition to more energy efficiency programs and the introduction of a U.S. wide cap and trade scheme, a national climate policy could also include measures to promote renewable energies. In preparation for this, groups such as the Presidential Climate Action Project are already drafting formal recommendations for how the future U.S. President should integrate renewable energy into strategies for climate change.

If the United States does begin to address climate change and renewable energy more aggressively on a national level, new opportunities for transatlantic dialogue on best practice policies may be created. Member states of the European Union have adopted national renewable energy targets since 2001, and have experimented with a broad range of different national support mechanisms- all of which could be helpful in informing U.S. policy decisions.

The Heinrich Böll Foundation North America encourages transatlantic policy dialogue, and has sponsored a series of publications focusing on climate and energy policy. Previous publications have focused on strategies for balancing electricity restructuring and environmental protection (Fritsche et al., 2000), opportunities for transatlantic cooperation on climate and renewable energy policy at the subnational level (Berthold, 2004; Kittler, 2003), and the implications of the European renewable electricity policy debate for the U.S. (Rickerson and Grace, 2007).

This report builds on these previous publications, but focuses specifically on the topic of renewable energy for heating and cooling for two reasons. First, the heating and cooling sector contributes largely to energy consumption, and therefore the emission of greenhouse gases. Globally, heating and cooling accounts for an estimated 40-50% of final energy demand. In the United States, heating and cooling is estimated at a lower, but still significant, proportion of 20% of energy demand. Second, the topic of renewable heating and cooling provides a window of opportunity for both Europe and the U.S. to learn from each other on a transatlantic level. Renewable electricity aside, Europe is not that far ahead of the United States in promoting renewable energies for heating and cooling. Some EU member states have only recently began implementing policy measures for the promotion of renewable heating and cooling energies. Therefore, the time is right to draw attention to the missing piece in climate policies.

So far, the debate on renewable energies has had policy makers around the world concentrating mainly on electricity and biofuels. Renewable heating and cooling has unfortunately remained the Cinderella of the renewable energies. If countries like Germany and the United States were to find effective ways to promote renewable heating and cooling energies, this could be a big step forward towards restructuring the world's energy system. This would mean switching to a renewable-based, low carbon infrastructure.

The first chapter in this report, written by Wilson Rickerson, Sander Cohan, Tina Halfpenny, and Katherine Stainken, discusses the current status of U.S. renewable heating markets and identifies barriers that must be overcome for effective policy measures in promoting renewable heating and cooling in the US. The second chapter, written by Uwe Leprich, Veit Bürger, Stefan Klinski, Michael Nast, and Mario Ragwitz, provides insight into European renewable heat policy development by reviewing policy options currently being considered in Germany.

Now is the time for shaping new policies on energy and climate. The Heinrich Böll Foundation North America is delighted to be a part of this process and looks forward to upcoming engaging events, discussions, and publications that all aim to promote these policies.

April 2008

**Arne Jungjohann**
*Program Director*
*Global Dialog and Environment Program*
*Heinrich Boell Foundation North America*

# AN OVERVIEW OF RENEWABLE HEATING IN THE UNITED STATES:

## *Policy and Market Trends*

***By Wilson Rickerson, Sander Cohan,***

***Tina Halfpenny, and Katherine Stainken***

# 1. Renewable Heat as a Policy Priority

In a recent report, the International Energy Agency (IEA) concluded that renewable heating and cooling technologies, based on geothermal, solar thermal, and biomass energy, are "amongst the lowest cost options for both reducing $CO_2$ emissions and fossil fuel dependency" available (Langniss et al., 2007). Despite a vast potential for renewable heating and cooling (REHC) worldwide, the IEA found that REHC market growth has been relatively stagnant, especially when compared to the renewable electricity and transportation markets. The IEA report echoes a number of commentators on both sides of the Atlantic who have recently highlighted the untapped potential of REHC, and puzzled over its absence from climate change and alternative energy policy discussions (Eggertson, 2004b, 2005b; Epp, 2005; Schäfer, 2005; Wolfe, 2005).

The primary reason for REHC's comparative inertia has been the fact that it has not been historically recognized as a distinct policy priority, and therefore has not been supported by targeted incentives. During the past ten years, governments on both sides of the Atlantic have established targets for renewable energy, but most of these policies have focused on electricity and transportation, rather than heating and cooling.

In the United States, both the federal and state governments have developed policies to support renewable transportation and renewable electricity. At the federal level, the Energy Policy Act of 2005 required that refiners, importers and blenders of gasoline supply 4 billion gallons of renewable transportation fuels by 2006, and 7.5 billion gallons by 2012. This amount was later expanded to 36 billion gallons by 2022, with interim targets of 9 billion gallons by 2008[1], and 15 billion gallons by 2012. On the electricity side, the federal government has not established a national renewable energy target, although Congress has debated national renewable electricity legislation since the 105$^{th}$ Congress (1997-1999), and a federal renewable electricity portfolio standard (RPS) has passed the Senate on three occasions (Sissine, 2007). The primary federal incentives for renewable energy include investment tax credits, established under the Energy Policy Act of 2005, and production tax credits, which were established by the Energy Policy Act of 1992.[2] At the state level, twenty-

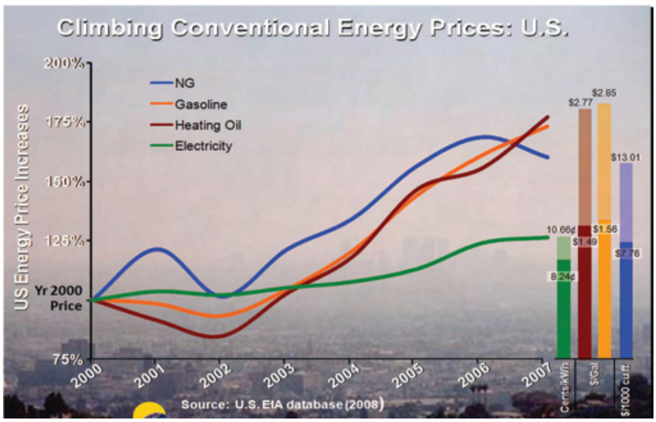
1 The 2008 target equates to 7.76% of national consumption (EPA, 2007)

2 For currently available federal incentives for renewable energy, see the Database of State Incentives for Renewables and Efficiency's federal incentive page at www.dsireusa.org

nine states have established their own renewable electricity targets; seven states, have passed their own renewable fuel standards, and another 14 are considering renewable fuel legislation (Brown et al., 2006). As will be explored in greater detail in Section 4 below, however, there have been almost no policies explicitly targeting renewable energy in the REHC markets at either the state or federal levels, despite the fact that REHC accounts for over 32.4% of US total energy consumption (New England Wood Pellet, 2008).

If the United States begins to plot a more aggressive response to the climate challenge, as discussed in the Introduction, there could be an increasing role for renewable heating and cooling, especially given the recent sharp increases in heating fuel prices (Figure 1).

**Figure 1. US Energy Price Increases 2000-2007**




*Source: Center for Energy and Environmental Policy (2008); based on 2008 EIA data*

A number of recent studies have argued that climate stabilization will require a portfolio of responses that includes both energy efficiency and renewable energy (Prindle et al., 2007; Socolow, 2006). To date, there has been wide recognition of the potential role of thermal energy efficiency (Cowart et al., 2008), but no comprehensive discussion of integrating renewables into the heating and cooling sector. It is true that renewable electricity policies could reduce greenhouse gas emissions associated with electrical heating and cooling technologies, but electricity accounts for only 2.33 quadrillion British thermal units (quads) of commercial and residential heating and cooling end uses (US Energy Information Administration (EIA), 2008). Fossil fuels account for 8.45 quads. As a result, a large majority of the carbon emissions from the heating sector are currently not targeted by US renewable energy policies.

## *1.2 Renewable Heating Policy Development in Europe*

In Europe, renewable energy policy has generally been more centrally coordinated and ambitious than in the United States, but there is still no European Union-wide policy target supporting renewable heating and cooling. In a 1997 White Paper, the European Commission (1997) set a target for the European Union to supply 12% of its total energy consumption from renewable sources by 2010. Although renewable heating was identified as a contributor to the overall goal established by the White Paper, the EU only set specific targets for renewable electricity (22.1%) and for renewable fuel (5.75%) (European Parliament, 2001, 2003). The Commission (2008) has subsequently proposed updated renewable energy targets of 20% by 2020 for final energy, and 10% for transportation specifically.

Although the focus on electricity and transport fuels in the US and Europe will achieve significant renewable energy market transformation if the targets are reached, there is growing concern that the markets for renewable heating technologies will continue to remain comparatively stagnant if specific policy targets are not developed.

During the past several years, a concerted advocacy and policy campaign to secure more formal recognition for renewable heat in Europe has achieved some results. In 2005, there was strong support from both renewable industry associations (AEBIOM, 2007; European Geothermal Energy Council, 2007; European Solar Thermal Industry Federation, 2007) and the European Parliament for the European Commission to establish targets for renewable heating and cooling. A report from the Parliament's Committee on Industry, Research and Energy, for example, found the EU would not reach its 2010 and 2020 overall renewable energy targets without the establishment of formal renewable energy targets for heating and cooling, and called for an increase in renewable energy's contribution to heating and cooling from 10% in 2005 to 25% by 2020 (Rothe, 2005).

In response, the European Commission launched a public consultation on the "Promotion of Heating & Cooling from Renewable Energies" in 2006 (Mercier and Peteves, 2006). Although the European Commission has yet to establish a formal policy for renewable heating and cooling, the need for such a policy has been acknowledged in "road map" documents published by both the European Parliament (Thomsen, 2007) and the Commission (2007).

Although some European nations like Denmark and Sweden have made significant progress in supporting renewable heating and cooling (Ernst & Young, 2007; Langniss et al., 2007), REHC as a sector is still quite new across the EU. Policy best practices are just now being discussed among European Union member nations and a "silver bullet" mechanism for REHC policy has not yet been developed. Given that REHC is still in its formative stages in Europe, there is ample opportunity for transatlantic dialogue on REHC with North America. In the United States, REHC is not explicitly recognized as a sector and there are currently no policies targeting renewable heating as a whole. This policy vacuum could allow for joint learning in Europe and the US as policy makers on both sides experiment with different approaches.

This report reviews the REHC markets and policies in the US, and outlines barriers to REHC growth. A subsequent chapter presents a European perspective on REHC policy. It should be noted that this paper is intended to be an introductory survey of the US REHC market and current policies. There has been little published literature on the topic in the US, and it is clear that many of the topics discussed briefly in this paper deserve further exploration.

# 2. The US Heating and Cooling Market

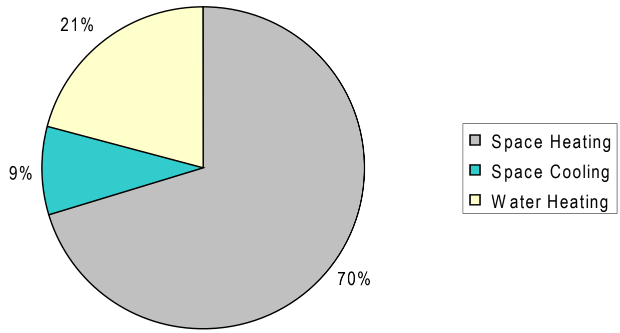
As mentioned above, heating and cooling account for over 30% of US energy use across the commercial, residential, and industrial sectors. This section provides an overview of heating and cooling demand in the residential and commercial sectors. The industrial sector is not discussed in this paper because the scale and end uses of industrial heating and cooling vary dramatically from those of the other two sectors, and because industrial heating and cooling data from the EIA is relatively incomplete.[3]

## *2.1 Residential Heating and Cooling*

According to the EIA, U.S. households will consume a projected 7.84 quadrillion Btus of delivered energy resources for water heating and space conditioning (heating and cooling) in 2008 (Figure 2). Overall, water heating and space conditioning make up approximately 67 percent of residential final energy consumption. The majority of this energy, approximately 70 percent, is consumed in space heating, while the remainder is consumed for water heating and space cooling.

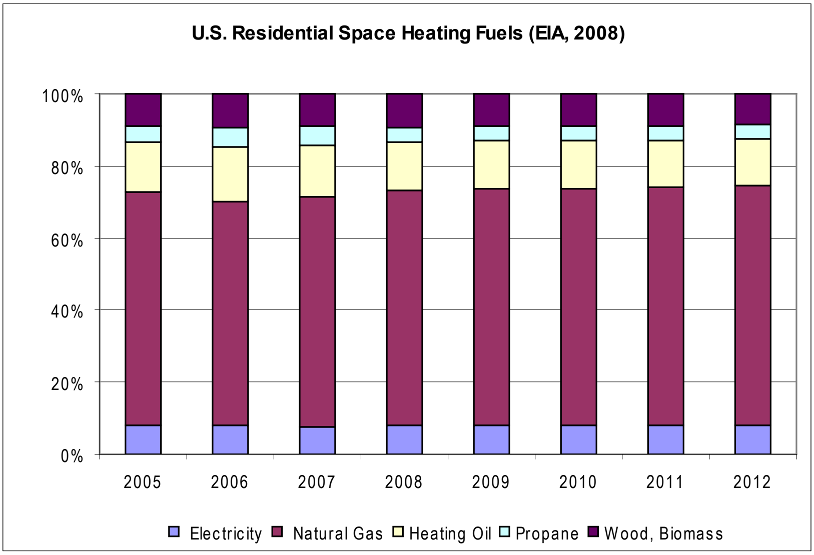
3 The US Energy Information Administration (EIA) currently does not track heating or cooling as distinct sectors, but instead tracks them through surveys of residential, commercial, and industrial sector energy use. Residential and commercial data can be drawn from the EIA Annual Energy Outlook 2007's Table 4. Residential Sector Key Indicators and Consumption and Table 5. Commercial Sector Indicators and Consumption. The EIA does not project energy consumption data by heating and cooling end use for the industrial sector as a whole (personal communication with Robert Adler, 2008). The EIA 2002 Manufacturing Energy Consumption Survey (MECS) does include heating statistics, but does not take into account all industrial sectors (i.e. mining, agriculture, etc.).

**Figure 2. Energy for Residential Heating and Cooling. Source: (EIA, 2008)**




As reported by the EIA (2008), U.S. homes and businesses are heated by three primary energy sources: natural gas, heating oil, and electricity, followed to a lesser extent by propane (i.e. LPG or liquid petroleum gas) and wood (Figure 3).

**Figure 3. US Residential Space Heating Fuels Source: (EIA, 2008)**

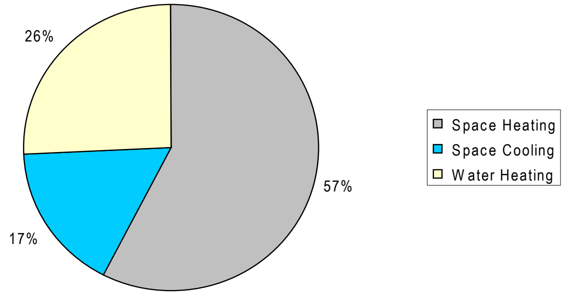


The U.S. heating market is varied and regional. Space heating demand is higher in the northern parts of the country, and the fuels used for space and water heating vary from state to state. Owing to an older housing stock and well-established distribution infrastructure, for example, heating oil is located primarily in the Mid-Atlantic and New England region. In these markets, oil heat serves around one third of households' space heating needs. In the West, oil heat serves only 6 percent of homes. Propane has prominence in rural areas, where lack of access to natural gas infrastructure and high portability of the fuel makes it an ideal energy source (National Oilheat Research Alliance, 2005). Trends do change, however gradually. As heating oil prices have risen in recent periods, there has been an increasing trend to move towards natural gas heat, which burns cleaner and is less sensitive to the price of crude oil. Natural gas, however, is limited by pipeline and distribution infrastructure. LPG is also an option, but prices, tank space, and distribution infrastructure remain barriers.

Recent downturns in the housing market notwithstanding, the energy consumption of homes is expected to continue. A projected increase in housing stock, coupled with an increase in the average size of an American home, will place increased demand on traditional home-heating energy sources. The average home size is expected to increase from 1802 square feet in 2005 to 1882 square feet by 2012. In order for energy consumption to increase sustainably, investments into renewable energy and energy efficiency have to be made.[4]

## *2.2 Commercial Heating and Cooling*

In the commercial sector, space conditioning and water heating are projected to comprise 33 percent of total commercial final energy use in 2008, or approximately 2.8 quadrillion Btus. Of this, space heating is the most significant end use, accounting for 57 percent.




4 The EIA projections assume an eventual reduction in energy consumption: overall energy intensity in homes will remain around 100 Million BTU, peaking at 102 Million BTU in 2008 and declining through 2012 to 100 Million BTU.

Space cooling and water heating play a larger role in the commercial sector than they do in the residential sector. Another important distinction between the commercial and residential sectors is that there is reliance on a narrower range of heating fuels (oil heat, natural gas, and electricity). The technology for large-scale LPG or biomass heat in commercial buildings is generally not available. This is most likely due to the older age of commercial space and associated costs of large scale heating and cooling technologies: businesses generally take the attitude of "if it ain't broke, don't fix it" and are reluctant to replace adequately performing technologies with newer and more expensive infrastructure. Commercial heating fuels and patterns, like those of the residential sector, vary by region. As will be discussed in greater detail below, there is no single REHC technology or alternative fuel that can address the heating and cooling industry nationally. Instead, growth in the REHC market will require an emphasis on a variety of renewable technologies serving different end uses in different regions.

# 3. Renewable Heat Markets in the United States

Unlike in Europe, where the renewable industry associations have issued a joint renewable heating action plan (EREC, 2007), the US REHC industry is not formally organized. As a result, US REHC market data is not as comprehensive or as readily available as it is in Europe. The sections below attempt to characterize the US renewable heating markets by reviewing each of the three REHC fuel-types individually.

## *3.1 An Overview of Biomass Heating in the US*

According to the EIA (2007a), biomass heat accounted for 0.5 quads of residential and commercial energy consumption in 2005.[5] Biomass, as it relates to the concept of "renewable heat" however, is an elusive concept to define in the United States for several reasons. First the term "biomass" itself encompasses a broad array of fuel sources that have drastically different environmental and energy profiles (Sims, 2002). As a result, there has been lively domestic and international debate as to what types of biomass should be considered truly "renewable" or "sustainable" (Greene and Martin, 2002; UN-Energy, 2007). Secondly, biomass conversion technologies range from low-tech residential fireplaces, to

5 As discussed above, industrial heating is not discussed in this paper. According to the EIA Renewable Energy Annual's Table 4. *Renewable Energy Consumption for Nonelectric Use by Energy Use Sector and Energy Source, 2001-2005* the industrial sector consumed 1.55 quadrillion Btus of biomass for heating in 2005. Even when the industrial sector's use of biomass for heating is not taken into account, however, the EIA reports that residential and commercial biomass heating in 2005 is five times larger than the combined total of solar and geothermal energy.

advanced district heating, combined heat-and-power, and gasification technologies, and it is unclear whether the full spectrum of these technologies should be supported as "renewable heat." Finally, current national data on biomass for heating is lacking in detail. According to the EIA, biomass heating in the residential and commercial sectors grew steadily between 2002 and 2005 at an average annual rate of 3%. EIA biomass data, however, is aggregated under the heading "wood," which does not describe what type of wood is being used (e.g. closed loop biomass or black liquor), or what type of conversion technology is being employed. As a result, it is difficult to draw concrete conclusions about how much of the current biomass heating market could be considered sustainable.

A detailed analysis of biomass heating feedstocks in the residential and commercial sectors, and their comparative environmental implications, is beyond the scope of this paper. Rather than discussing current market trends for biomass as a whole (as the next sections do for solar and geothermal), this section discusses trends in emerging biomass heating feedstocks: pellet fuels and biodiesel. Both of these fuels involve the processing of organic material to increase energy density and portability, and appear poised for market growth in response to sharply rising fossil fuel prices.

### *3.1.1 Pellet Fuel*

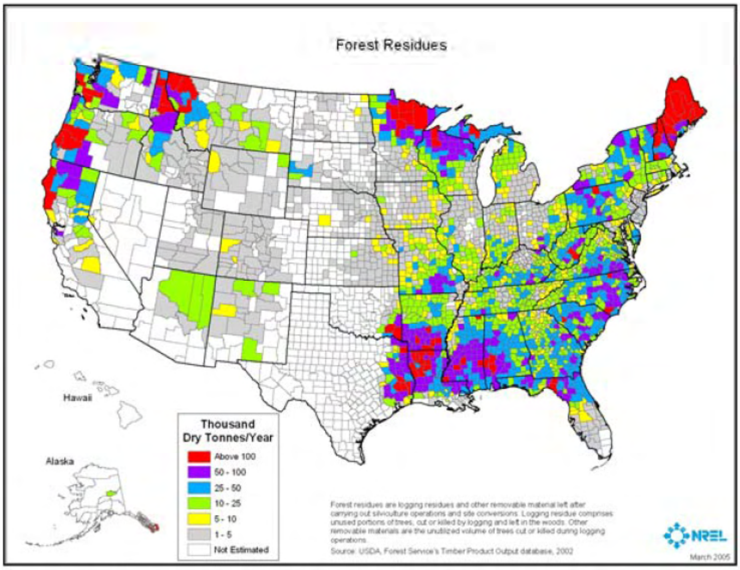
The large majority of biomass consumption in the United States is the direct combustion of wood (Wright et al., 2006). As can be seen in Figure 4. below, resources for US wood biomass are widely distributed across the country. In the industrial sector, biomass heating typically involves the combustion of wood chips from wood-related industry as part of large-scale combined heat-and-power installations. While wood chips are one of the lowest-cost biomass feedstocks, their use in other sectors is limited by transportation concerns and comparatively slow market growth during the past decade.

In contrast to the comparatively stagnant industrial heating market, one of the fastest growing biomass heating markets in the United States is the pellet industry, driven almost exclusively by the residential sector (Peska-Blanchard et al., 2007). Biomass heating in the residential sector has historically been associated with fireplaces and wood stoves. Since the 1970s, however, there has been an increasingly rapid growth in pellet stoves.[6] Pellets are made of compressed wood waste, typically from sawdust or ground wood chips. Pellets have distinct advantages over other types of biomass: they have four times the energy density of standard wood chips, which makes them easier to transport and store, they burn more consistently and completely than wood chips or firewood, and they can be stored more safely than biofuels (Jones, 2006; Kopetz, 2007). Pellet stoves also have higher efficiency and lower emissions than

6 In fact, market growth in the US during the past two years has been so rapid that it has caused pellet shortages (Rakos, 2008).

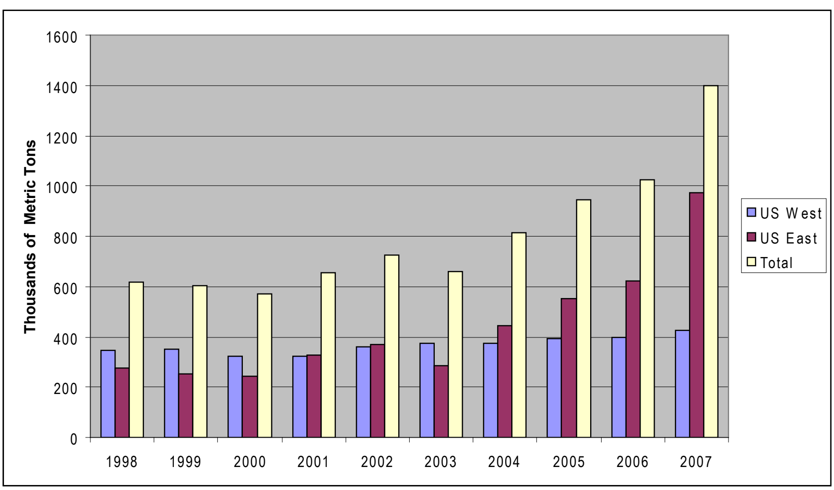
do both fireplaces and traditional wood stoves. As can be seen in Figure 5 below, pellet sales have increased rapidly during the past several years. Since 2003, the market grew by an average of 21% annually, and

**Figure 4: U.S. Forest Residues**




*Source: Milbrandt (2005)*

**Figure 5. Annual US Wood Pellet Sales in Metric Tons (1998-2007)**




*Source: Peska-Blanchard et al. (2007)*

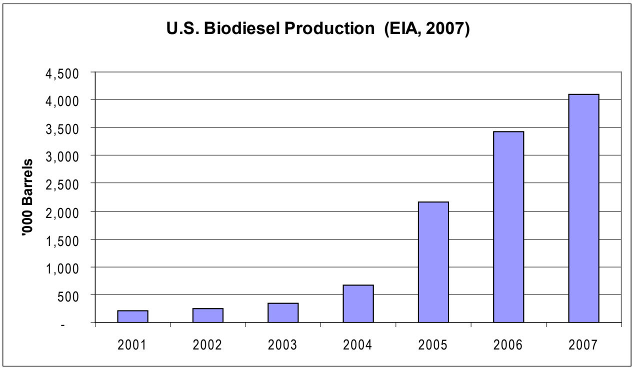
then jumped to 37% between 2006 and 2007. The primary driver for this growth has been a sharp increase in the cost of conventional heating fuels, particularly in the eastern United States (Peska-Blanchard et al., 2007). The market for pellet stoves has also increased dramatically, with the number of stoves shipped annually increasing from 33,978 in 2002 to 133,105 in 2006 (Hearth Patio & Barbeque Association, 2007).

While in Europe there is some use of pellet heat for the production of electricity, pellet fuel is exclusively used as a heating technology in the United States (Jones, 2006). Additionally, while European markets have seen significant penetration of pellet technology into industrial and district heating applications, the United States has seen pellet heat mostly as a residential phenomenon, with commercial and industrial applications seen as a future market.

### *3.1.2 Biofuels for Heating*

Another emerging market for biomass heating in the US is biofuel blends, particularly in heating markets that already have a heavy reliance on fuel oil, such as the Northeast. Much of the focus on biofuels has been for transportation, using ethanol and biodiesel as a way to extend transportation fuel supplies, ensure energy security, and reduce air emissions. The use of biodiesel blends as substitutes for heating oil has received little attention over the past five years, and currently makes up a miniscule portion of overall biofuel consumption. While there has been a broad based policy effort to encourage the development of biodiesel as a transportation fuel, there has been little effort to encourage biodiesel for heating. Instead, biofuels for heating has been relegated to a series of small scale studies and advocacy work by the National Biodiesel Board, a U.S. biofuel industry association.

**Figure 6. US Biodiesel Production (2001-2007)**



Bioheat's low profile might change, however (Kotrba, 2008). As biodiesel capacity grows in the United States - driven by the Renewable Fuels Standard - and starts to outpace domestic demand, the opportunities for the fuel to be used for heating become more apparent. While US biodiesel production has increased markedly (Figure 6), the consumption of biodiesel in the United States has lagged, mostly due to difficulties in producing a marketable product that meets the tight quality specifications of U.S. automakers. The market does, however, continue to adapt. A 2006 survey of biodiesel, quality, for example, found that most marketed types did not meet these specifications (Alleman et al., 2007). Recent retesting, however, found that quality has improved markedly and that more recent biodiesel products adhere more closely to quality specifications (Alleman and McCormick, 2008).

A dilemma rises in that the national Renewable Fuels Standard requires this fuel to be blended with petroleum product to count towards annual quotas. If this fuel cannot be safely used in transport markets, then heating markets would be available as an interim market in the short term, taking advantage of the lower operating parameters and temporarily less stringent fuel quality requirements. While all heating oil will be held to the same standard as transportation diesel in the coming years, the current disconnect in quality standards could provide an opening for biofuels until production and quality control improves.

Over the last five years, a number of states and organizations have experimented with using biofuel heat as a replacement to home heating oil. Although no official guidance or standards for using biodiesel in oil heaters has been published by ASTM International (ASTM), it has been found that biodiesel generally is acceptable for use in heaters, so long as the fuel used meets the ASTM heating oil standard. As with transportation, the biodiesel affords a number of benefits over heating oil, including lower emissions and greater thermal stability. A National Renewable Energy Laboratory study found that biodiesel used as heating oil afforded lower NOx emissions than traditional distillate fuel oil, a phenomenon not witnessed when biodiesel is burned as a transport fuel (Krishna, 2001).

Recently, in response to historic lows in heating oil stocks and threats of a colder than normal winter, policy mandates have begun to gain ground. A recent survey of state officials in the Northeast found that "interviewees from all states and sectors see a generally positive future for bioheat" (David Gardiner & Associates LLC, 2007). The State of Massachusetts was the first in the nation to propose standards for blending biofuels with heating oil, following a recent pilot program (Aceti Associates and Industrial Economics Inc., 2007). The Massachusetts rule would require B2 blends of biodiesel by 2010 and B5 blends by 2013. It also includes tax breaks for the blending of biofuels into petroleum fuels. The state of New Hampshire is also considering similar measures to introduce biofuels into the heating oil stock.

### *3.1.3 Climate and Energy Concerns for Biofuels*

While there has been a global move towards the acceptance of biofuels, especially as a replacement for transportation fuels, there have been significant questions raised as to their ability to limit emissions and greenhouse gas emissions. While biofuels generally emit less than fossil fuels when combusted (VIEWLS, 2005), the degree to which biofuels benefit emissions when their entire energy lifecycle is taken into account is the subject of intense debate (Hammerschlag, 2006; Pimentel and Patzek, 2005; Samson et al., 2008; Wang, 2005). Depending upon the feedstock used and the refining method, overall emissions vary, from negative emissions, to zero emissions, to low-emitting. There is also intense debate on the fuel's overall impact on the environment. In Europe, for example, there has been controversy over the viability of palm-oil derived biodiesel since it can encourage land-clearing and deforestation (Cameron, 2006; German Advisory Council on the Environment, 2007). It remains to be seen whether the market potential for bioheat will be constrained by environmental and energy concerns.

## *3.2 An Overview of Solar Heating in the US*

Although solar heating is typically associated with domestic hot water, solar thermal systems are also being used internationally for space heating (Weiss et al., 2004), industrial process heating (Weiss, 2006), solar air heating, pool heating, and solar cooling (Dienst et al., 2007). To date, the solar heating market in the United States has been dominated by the residential market, with pool heating consuming the largest share of solar heat, followed by domestic water heating.

Water heating is the second largest source of energy consumption in the residential sector and the fourth largest in the commercial sector (US Water Heater Industry, 2005). According to a recent study by the National Renewable Energy Laboratory (NREL), residential water heating consumed about 23% of all residential natural gas use and about 8% of all electric use in 2004. Overall, residential and commercial water heating consumed 3.5% of total, primary U.S. energy demand in 2004 (Denholm, 2007). The same NREL study found that solar water heating alone has the technical potential to supply up to one quad of energy, and achieve an annual reduction of 50-75 million metric tons of carbon dioxide (Denholm, 2007). The market potential of solar water heating in the U.S. depends on system efficiency and performance. Solar water heating performance is estimated as the solar fraction, which is the amount of a building's water heating demand that can be met by the solar system. Figure 7 illustrates the range of anticipated solar fraction from solar water systems throughout the U.S.

Despite this significant technical potential, US solar water heating market growth has been slow during the past several decades. The solar thermal industry boomed in the late 1970's and early 1980s, with 12 million

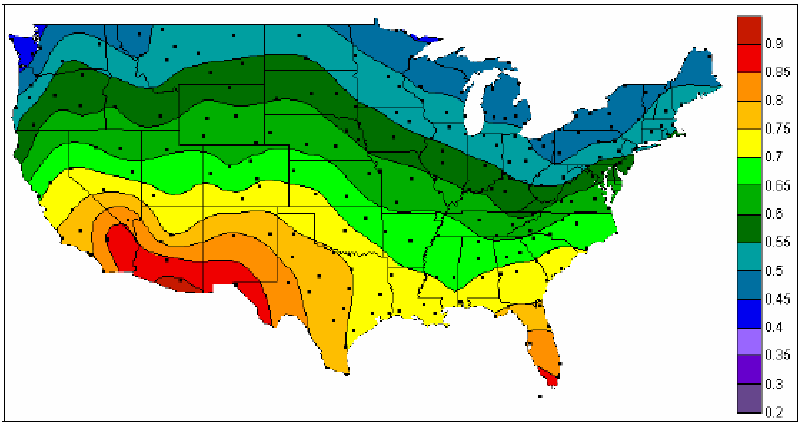



**Figure 7. Simulated Solar Fraction in the United States. Source: Denholm (2007)**

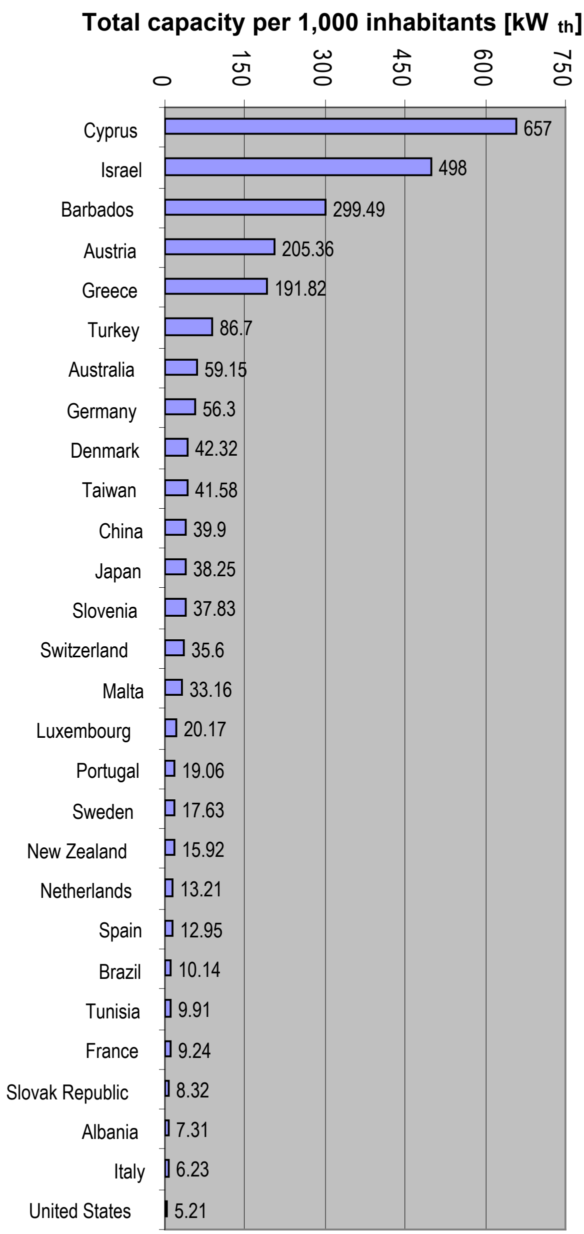
square feet of collectors installed in 1984 alone, and 225 domestic manufacturers in operation (Morrison and Wood, 1999). Generous federal and state tax incentives supported the market through 1985, but the incentives were abruptly removed in 1986, and the market collapsed. By 1994, the industry had contracted to only 800,000 square feet of installations. The industry has since struggled to recover, and has been dogged by a legacy of poor installations and failed systems from the 1980s (Del Chiaro and Telleen-Lawton, 2007).

Partially as a result of the boom-bust cycle of the previous decades, the US solar water heating market lags far behind that of other nations. According to the IEA (Weiss et al., 2007), the U.S. ranked 28$^{th}$ of 45 countries for total installed capacity of glazed flat-plate, and evacuated tube collectors per 1,000 inhabitants. In 2005, the global solar water and space heating market[7] is led by China, with 52,500 megawatts of thermal equivalent ($MW_{th}$) installed, followed by Turkey, Germany, Japan, and Israel. By comparison, the US had 1,554 $MW_{th}$ installed, far below the market leaders in terms of total capacity and capacity per capita (see Figure 8) (Weiss et al., 2007).

The US solar water heating market has shown recent signs of growth and diversification. In 2005, for example, close to 50% of the US market is concentrated in the state of Hawaii (Sherwood, 2007). In 2006, the combination of rising energy prices and a 30% federal tax credit for commercial and residential systems caused the market to grow by 30%, and the number of annual installations outside Hawaii to quadruple. As of 2007, the top 5 US markets are now Hawaii, Florida, California, New York, and Puerto Rico (Sherwood, 2008). Both residential and commercial markets have seen growth during the past several years, but the residential market received 92% more square footage in collectors than the commercial markets, according to the most recent EIA (2007c) data. The recent market growth has been supported by quality

7 For glazed collectors and evacuated tube collectors

**Figure 8. Solar Water Heating Capacity per Capita, by Country**




*Source: Weiss (2007)*

assurance infrastructure that was not in place during the 1980s, such as the Solar Rating and Certification Corporation, which certifies solar water heating collectors, and the North American Board of Certified Energy Practitioners, which offers credentialing for solar thermal installers.[8] Although these recent growth and infrastructure trends are encouraging for industry participants, current market momentum does not measure up to the growth rates seen in the early 1980s, and solar water heating remains a largely unexplored resource in comparison to its development in Europe and Asia.

In contrast to the market for solar water heating, the US dominates the global market for unglazed solar collectors with 78% market share. Unglazed collectors are primarily used for swimming pool heating, and total unglazed collector capacity was 18,844 $MW_{th}$ at the end of 2005 (Weiss et al., 2007). The unglazed market grew at an average annual rate of 10% between 1998 and 2006, but then declined sharply in 2007 as the downturn in the housing market slowed the installation of new pools (Sherwood, 2007, 2008).

The solar air heating market also enjoyed a boom in the 1980s, albeit smaller than that of solar water heating, and a 1980 survey found that there were 85 US companies manufacturing solar air heating systems at that time (Hastings and Mørck, 2000). The solar air heating market collapsed alongside the solar water heating market in 1986, and domestic solar air heating manufacturing effectively ceased. The market for solar air heating has recently begun to revive, however, and the US currently leads the comparatively small market for glazed solar air collectors with 159.7 $MW_{th}$, or 91% of global capacity installed (Weiss et al., 2007).

## *3.3 An Overview of Geothermal Heating in the US*

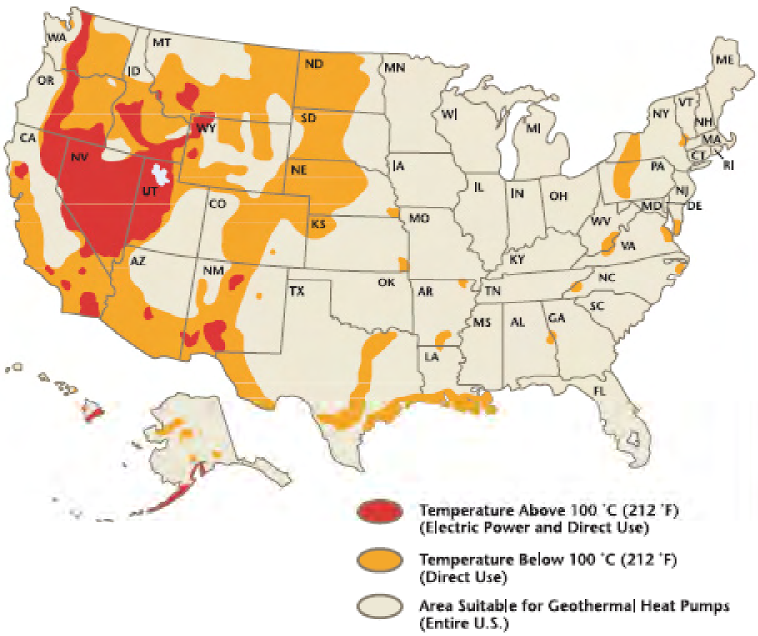
Geothermal energy refers to heat contained below the Earth's surface. Geothermal energy can be harnessed to create both electricity and heat, depending on the temperature of the resource and the technology employed.  In 2006, there were approximately 2,800 MW of geothermal electric capacity installed across the United States (Green and Nix, 2006). As can be seen in Figure 9 below, the higher-temperature, deep geothermal resource required to support electricity generation is concentrated primarily in the western United States, Alaska, and Hawaii.

Unlike geothermal electricity, geothermal heating technologies can extract useful energy from shallower, lower-temperature geothermal resources. The US geothermal heating market is the world's largest, and eclipses geothermal electricity in terms of installed capacity. The geothermal heating market can be subdivided into two subsectors: the direct use of geothermal energy (e.g. water from hot springs and wells), and geothermal heat pumps. In the United States, there were an

8 See www.solar-rating.org and www.nabcep.org

estimated 650 MW of direct geothermal energy applications installed at the end of 2007, which supplied the equivalent of 2,640 gigawatt-hours of electricity (Lund, 2008).[9] Applications of direct geothermal energy vary widely in the US, and include pool heating, space heating, district heating, greenhouses, aquaculture facilities, snow melting, agricultural drying, and industrial applications. Market growth for direct use between 2000 and 2005 was an average of 2.6% per year, although space heating and agricultural drying grew by 9.3% and 10.4%, respectively, during that time period (Lund et al., 2005).

**Figure 9. US Geothermal Energy Resource**




*Source: Green & Nix (2006)*

In contrast to direct use, geothermal heat pumps typically use a circulating water loop to exchange heat between conditioned space and the Earth. The temperature of the Earth near the surface is relatively constant all year, and can be used as a heat source during colder seasons, and a heat sink during warmer seasons. Geothermal heat pumps can therefore provide both heating and cooling. As can be seen in Figure 9 above, the US geothermal heat resource is sufficient to support geothermal heat pumps across the country.

9 Or approximately 9,000 billion Btus

The United States has the world's largest geothermal heat pump market. Between 50,000 and 60,000 systems are installed each year (Lund, 2007), with the majority of the systems being supplied to the Midwest and the South (EIA, 2007b). By 2007, there were an estimated 8,000 MW of heat pumps installed across all 50 states, supplying the equivalent of 6,500 GWh annually (Lund, 2008).[10] The US geothermal heat pump market has had the fastest consistent growth of the renewable heating markets, with annual growth averaging 11% between 2000 and 2005 (Lund et al., 2005; EIA, 2007a).

# 4. Policy Support for Renewable Heating in the US

Based on the comparative sizes of the US heating and cooling market, the US renewable energy resource, and the current contribution of REHC to residential and commercial energy use, there is significant opportunity for future growth in the REHC market. REHC technologies currently face numerous barriers to near-term market growth, however. Many of these barriers are the same faced by all renewable energies, such as high initial costs, long paybacks, cumbersome or uncertain permitting processes, the need for workforce training, the absence of a national marketing infrastructure, and a lack of research and development funds (Ernst & Young, 2007; European Renewable Energy Council, 2007; MVV Consulting, 2007; Sinclair, 2007). Rather than reviewing the full range of market barriers, this section discusses several near term challenges, and reviews the current policy landscape for REHC in the US.

One of the most significant barriers to REHC market growth is a general lack of awareness about REHC technologies. Among the general public, there is a lack of awareness that renewable heating technologies exist, confusion about the difference between renewable heating and renewable electricity technologies, and a lack of public information resources about REHC (Eggertson, 2004a; MVV Consulting, 2007; San Diego Regional Energy Office, 2007). For solar water heating, this lack of awareness has been compounded by lingering skepticism about the technology's performance, thanks to its legacy from the 1980s (Del Chiaro and Telleen-Lawton, 2007). This lack of awareness has complicated efforts to create the kind of grassroots support that has sustained more "sexy" technologies like photovoltaics (Eggertson, 2004a).

At the policy maker level, there is a lack of recognition of heating and cooling's impact on the environment, a lack of recognition of REHC as a distinct sector requiring policy support, and a lack of consistency in how renewable heating technologies are classified. Some US renewable energy stakeholders define solar heat systems as green power generating

10 Or 23,420 billion Btu

technologies (Reedy, 2006, 2007), for example, while others insist that they are not generators, but instead energy efficiency technologies (Burton, 2006). Still others argue that renewable heat technologies should "qualify to be eligible under [policy] directives to encourage both demand efficiency and supply diversification (Eggertson, 2004c)." These definitions would each dictate different policy approaches, but no conclusions have been reached on how to reconcile these viewpoints.

A related issue is that there is little evidence that the individual REHC industries in the US have identified or sought opportunities for collaboration. Solar and geothermal technologies are nominally represented by the same trade organizations that represent their electricity-generating counterparts, while biomass technologies are represented by a range of different associations depending on the conversion technology and feedstock.[11] To date, there have not been concerted attempts by REHC industries to undertake joint planning or policy development as there have been in Europe (European Renewable Energy Council, 2007).

A second major barrier to REHC technology market growth is that the technologies are relatively difficult to craft unified polices for. Generally speaking, it is more straightforward to formulate policy governing renewable electricity, because electricity relies on centralized infrastructure. Moreover, electricity can generally be used interchangeably to serve different end-uses. In contrast, there is no analogous "grid" for renewable heating in the US, outside of the district heating systems in certain parts of the country.[12] Also, different renewable heating technologies serve a heterogeneous mix of end-uses (e.g. geothermal for heating and cooling, solar for air heating, water heating, and/or space heating, etc.), and displace different fuel and technology types. It can therefore be complicated to design a policy that encourages all renewable fuels simultaneously, especially since there is no central heating utility or grid operator to obligate with targets or quotas.

A related challenge to the promotion of renewable heat is the fact that heat output is harder to measure and verify than renewable electricity is, particularly since so much of the US heating market consists of distributed, behind-the-meter resources. In order to encourage a renewable heating sector in the US, there will have to be a more straightforward method of measuring progress and assessing renewable heat value (Eggertson, 2005a).

The general lack of recognition for REHC as a distinct sector, the lack of industry coordination, and the diversity of REHC end-uses have resulted in an uneven policy landscape for REHC in the US. As discussed in the next section, the incentives for renewable heating and cooling that are in place tend to target individual technologies, rather than the entire

11 For example, pellet stove manufacturers are affiliated with the Hearth, Patio & Barbeque Association

12 According to the International District Energy Association , there are currently 122 cities in 37 US states that currently have district heating networks, see http://www.districtenergy.org/city_system_list.htm

sector, and are typically part of a larger policy designed to encourage renewable electricity, or energy efficiency, rather than heating.

### *4.1 Renewable Heating and Cooling in State Renewable Portfolio Standards*

During the past ten years, the states have led renewable energy development and climate change mitigation efforts in the US (Peterson, 2004; Rabe, 2004). As a result, the US renewable energy policy framework is a patchwork of direct incentives (e.g. rebates and grants), tax benefits (e.g. credits and exemptions), net metering, and green power marketing that varies widely from state to state (Byrne et al., 2007).

The umbrella policy in most of the primary state renewable energy markets is known as a renewable portfolio standard (RPS), which requires a certain amount of renewable energy to be supplied by a certain date (e.g. 20% by 2020). The exact number of renewable portfolio standards in the United Stats is subject to debate, depending on how the policy is defined. Some analysts count only mandatory targets as RPS (Wiser et al., 2007), while others count both mandatory and voluntary targets as RPS (DSIRE, 2008). It is safe to say that twenty-nine states and the District of Columbia currently have established renewable energy targets (see Appendix I). Of these policies, eleven allow the output of certain types of renewable heating and cooling technologies to satisfy the target. It is important to note, however, that renewable portfolio standards were originally enacted in response to the electricity restructuring movement of the late 1990s. As a result, the focus of almost all of the renewable energy goals is exclusively on electricity generation. Generally speaking, renewable heating and cooling technologies can only contribute to renewable standards if they directly displace electricity generation (Table 1). The one exception is the state of Arizona.

In 2006, the Arizona Corporation Commission (ACC) adopted rules expanding the states Renewable Energy Standard from 1.1% by 2012, to 15% by 2025. The regulations require that 30% of the standard, or 4.5% of the equivalent of state electricity demand, be met by distributed renewable energy resources. The ACC is explicit that commercial solar pool heating, solar heating, ventilation and air-conditioning (HVAC) systems, solar industrial process heating and cooling, solar space cooling, solar space heating, solar water heating, and geothermal heating (but not cooling) systems qualify as eligible resources for the distributed generation requirement. Moreover, the ACC explicitly includes biomass thermal systems,[13] and the heat and electrical output of renewably-fueled combined heat-and-power systems in its target. Perhaps most significantly for renewable heating and cooling, the ACC regulations state that distributed energy resources can displace conventional energy resources, which includes fossil fuels in addition to electricity.

13 Excluding wood stoves, furnaces, and fireplaces

**Table 1. Renewable Heating and Cooling Technology Eligibility to Satisfy State Renewable Energy Goals**

| State | Target (RE Heat Tier) | Technologies | Displaces |
|---|---|---|---|
| Arizona | 15% by 2025<br>(4.5% from distributed resources) | • Solar water heating<br>• Solar pool heating (commercial)<br>• Solar air heating<br>• Solar space and process heating and cooling<br>• Geothermal heating<br>• Biomass and biogas heating<br>• Renewable combined heat and power | Electricity or any fossil fuel |
| Connecticut | 27% by 2020<br>(4% from CHP and energy savings) | • Solar water and pool heating<br>• Solar space and process heating and cooling<br>• Solar air heating<br>• Geothermal heating and cooling<br>• Combined heat and power | Electricity only |
| Delaware | 20% by 2019 | • Solar water and pool heating<br>• Solar space and process heating and cooling<br>• Solar air heating | Electricity only |
| Hawaii | 20% by 2020 | • Solar water and pool heating<br>• Solar cooling<br>• Combined heat and power<br>• Seawater district cooling systems | Electricity only |
| Illinois | 25% by 2025 | • Solar water and pool heating<br>• Solar space and process heating and cooling | Electricity only |
| Missouri | 11% by 2020 | • Solar water heating | Electricity only |
| Nevada | 20% by 2015<br>(1% from solar) | • Solar water and pool heating<br>• Solar space and process heating<br>• Geothermal hot water district heating | Electricity only |
| New Hampshire | 23.8% by 2025 | • Solar water heating | Electricity only |
| North Carolina | 12.5% by 2021<br>(0.2% from solar) | • Solar water and pool heating<br>• Solar cooling<br>• Solar process heating<br>• Solar dehumidification<br>• Solar thermally driven refrigeration | Electricity only |
| Pennsylvania | 18% by 2020<br>(10% from energy efficiency) | • Solar water heating | Electricity only |
| Texas | 5,880 MW by 2015 | • Solar water heating<br>• Geothermal heat pumps | Electricity only |

Arizona's renewable energy target is the most advanced in the US in terms of both explicitly defining renewable heating and cooling technologies, and in rewarding those technologies for their ability to offset fuels beyond electricity. To date, the only other state considering a renewable heating policy is New Hampshire, whose 2007 renewable portfolio standard legislation requires the state Public Utilities Commission to consider "the potential for addition of a thermal energy component to the electric renewable portfolio standard.[14]" Arizona's new RPS policy has yet to take effect, and the fate of New Hampshire's thermal RPS has yet to be decided. Successful experiences in either Arizona or New Hampshire, however, could open the door to interstate REHC policy diffusion in the future.

Beyond RPS, the patchwork of federal and state policies is harder to characterize succinctly. At the federal level, the Energy Policy Act of 2005 (EPAct of 2005) established federal income tax credits for solar water heating and for geothermal heat pumps, but both of these credits are set to expire at the end of 2008, and the most recent versions of the federal energy bill did not renew them.15 At the state level, renewable heating resources are supported through a wide range of tax incentives (deductions, credits, exemptions, etc.), loan programs, and rebates that vary widely by magnitude, by structure, and by state. A state-by-state economic analysis of how these different policies cumulatively impact REHC system economics is beyond the scope of this paper. What is clear from surveys of state policy clearinghouses such as DSIRE, however, is that no states are currently opting to support the full range of REHC technologies in a coordinated and targeted manner.

## *4.2 Opportunities for Transatlantic Dialogue*

The leaders in renewable heat in Europe are dealing with many of the market, barrier, and policy questions currently confronting renewable heat technologies in the United States, and there is fertile ground for transatlantic dialogue on this issue. Just as several US states are currently considering feed-in tariffs, and several European countries have adopted climate and renewable energy systems supported by tradable credits, there is an opportunity for the US and Europe to share best practices with regard to renewable heat market development and policies.

In Europe, the need for REHC policy has emerged from broader discussions on climate change mitigation, and the need to establish energy targets in order to meet climate goals. In the US, renewable energy policy making has taken place without federal climate targets as a unifying framework. Nevertheless, US stakeholders can learn from European experience with recognizing REHC as a distinct sector in need of a unified policy approach, creating a cross-technology industry

14 New Hampshire Revised Statutes, Title 34, Chapter 362-F:5
15 The EPAct of 2005 also authorized a rebate program for high efficiency biomass heating appliances, but this program has not yet been funded and has not gone into effect.

coalition to support renewable heating and cooling, crafting a joint action plan for renewable heating and cooling technologies, identifying barriers to renewable heating and cooling market growth, and defining policy options to support the REHC sector.

Specifically with regard to policy, there have been several recent studies on the comparative incentives and regulations to support renewable heating and cooling technologies (Bisson and Miller, 2003; Ernst & Young, 2007; Kopetz, 2007; MVV Consulting, 2007; Nast et al., 2007; The Scottish Government, 2008). The next chapter of this report reviews the broad categories of renewable energy policies and discusses their applicability to the heating sector in Europe.

## ACKNOWLEDGMENTS

The authors would like to thank Bob Adler, Calvin Birge, John Crouch, Brian Gallagher, Sue Gouchoe, Ed Holt, Louise Guey-Lee, Joanne Morin, Ted Peck, Larry Sherwood, and Ray Williamson, for their insights and expertise. The authors would also like to thank Jack DiEnna, Executive Director, Geothermal Heat Pump National & International Initiative, David Dungate, President and CEO of Advanced Climate Technologies, LLC, Sarah Emerson, Managing Director of Energy Security Analysis, Inc., John Lund, Director of the Geo-Heat Center, Les Nelson, Executive Director of the Solar Rating & Certification Corporation, and Charlie Niebling, General Manager of New England Wood Pellet, LLC, for their review and comments. The authors would also like to thank Arne Jungjohann, Program Director of the Heinrich Böll Foundation's Environment and Global Dialogue Program for guiding and refining this research effort.

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# APPENDIX I.

## *Inclusion of Renewable Heat in State Renewable Energy Targets*

| State | RPS | Renewable Heat? |
|---|---|---|
| Arizona | 15% by 2025 | Yes |
| California | 20% by 2010 | No |
| Colorado | 20% by 2020 | No |
| Connecticut | 27% by 2020 | Yes |
| Delaware | 20% by 2019 | Yes |
| Hawaii | 20% by 2020 | Yes |
| Illinois | 25% by 2025 | Yes |
| Iowa | 105 MW by 1999 | No |
| Maine | 40% by 2017 | No |
| Maryland | 9.5% by 2022 | No |
| Massachusetts | 4% by 2009 | No |
| Minnesota | 25% by 2025 | No |
| Missouri | 11% by 2020 | Yes |
| Montana | 15% by 2015 | No |
| Nevada | 20% by 2015 | Yes |
| New Hampshire | 23.8% by 2025 | Yes |
| New Jersey | 22.5% by 2021 | No |
| New Mexico | 20% by 2020 | No |
| New York | 25% by 2013 | No |
| North Carolina | 12.5% by 2021 | Yes |
| North Dakota | 10% by 2015 | No |
| Oregon | 25% by 2025 | No |
| Pennsylvania | 18% by 2020 | Yes |
| Rhode Island | 16% by 2020 | No |
| Texas | 5880 MW by 2015 | Yes |
| Vermont | Incremental growth between 2005-2012 | Yes |
| Virginia | 12% by 2022 | No |
| Washington | 15% by 2020 | No |
| Washington, DC | 11% by 2022 | No |
| Wisconsin | 10% by 2015 | No |

# SUPPORT SCHEMES TO PROMOTE RENEWABLE ENERGIES IN THE HEAT MARKET:

## *The German Case*

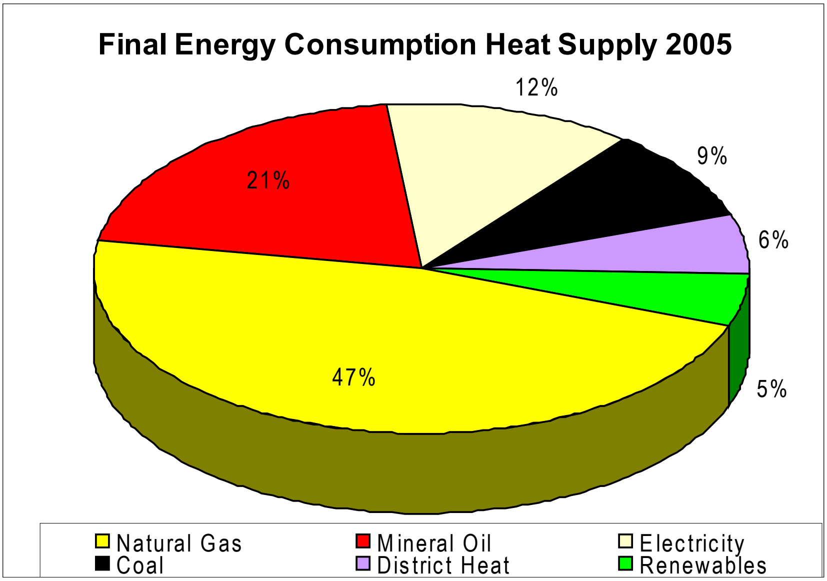
***By Uwe Leprich, Veit Bürger, Stefan Klinski, Michael Nast, and Mario Ragwitz***

# 1. The German Heat Market

In Germany, the total use of high- and low-temperature heat amounts to about 57% of the total final energy demand. About a third of it is consumed by industry (mainly high temperature heat), nearly half by private households (mainly space heating and warm water), and the rest by small businesses and the public sector (mainly space heating).

The following figure (Fig. 1) breaks down the final energy demand into the individual energy carriers. On the one hand, the dominant role of natural gas is apparent. On the other hand, we also see that renewable energy sources play a relatively small role with a share of just 5%.

**Fig. 1: Final energy consumption for heat supply in Germany 2005**




If the share of renewable energy is referred only to the low-temperature applications space heating und warm water, it currently amounts to about 9%.

The following figure (Fig. 2) illustrates that the share of renewable energy in the heat market has approximately doubled in the last 10 years. The goal of the German Federal Government is to increase this share to 14% by 2020, already taking into consideration that the heat demand will decrease due to improved heat insulation and more efficient use of energy. This goal can be derived from the objective set by the European Commission to achieve a 20% share of renewables in the energy consumption in the EU by 2020 (EC 2007).

**Fig. 2: Development of renewable energy sources in Germany 2006**

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

## Development of renewable energy sources in Germany in 2006

### Contribution of renewable energy sources to heat supply in Germany 1990 - 2006

| | Biomass * | Biomass share of waste ** | Solar thermal energy | Geothermal energy | Total heat generation | Share of total heat supply |
|---|---|---|---|---|---|---|
| | [GWh] | | | | | [%] |
| 1990 | k.A. | k.A. | 130 | k.A. | k.A. | k.A. |
| 1991 | k.A. | k.A. | 166 | k.A. | k.A. | k.A. |
| 1992 | k.A. | k.A. | 218 | k.A. | k.A. | k.A. |
| 1993 | k.A. | k.A. | 279 | k.A. | k.A. | k.A. |
| 1994 | k.A. | k.A. | 351 | k.A. | k.A. | k.A. |
| 1995 | k.A. | k.A. | 440 | 1,425 | k.A. | k.A. |
| 1996 | k.A. | k.A. | 550 | 1,383 | k.A. | k.A. |
| 1997 | 45,646 | 2,900 | 695 | 1,335 | 50,576 | 3.2 |
| 1998 | 48,625 | 2,988 | 857 | 1,384 | 53,854 | 3.5 |
| 1999 | 47,811 | 3,140 | 1,037 | 1,429 | 53,417 | 3.5 |
| 2000 | 51,036 | 3,278 | 1,279 | 1,433 | 57,026 | 3.9 |
| 2001 | 52,043 | 3,283 | 1,612 | 1,447 | 58,385 | 3.8 |
| 2002 | 51,302 | 3,324 | 1,919 | 1,483 | 58,028 | 3.9 |
| 2003 | 62,555 | 3,806 | 2,183 | 1,532 | 70,076 | 4.6 |
| 2004 | 66,251 | 3,694 | 2,487 | 1,558 | 73,990 | 4.9 |
| 2005 | 72,190 | 4,692 | 2,828 | 1,601 | 81,311 | 5.4 |
| 2006 | 79,700 | 4,379 | 3,273 | 1,907 | 89,259 | 6.0 |

* In contrast to previous years, from 2003 anwards figures acc. To §§ 3, 5 (congeneration and heating plant) of the Energy Statistica Act of 2003 and direct use of sewage gas

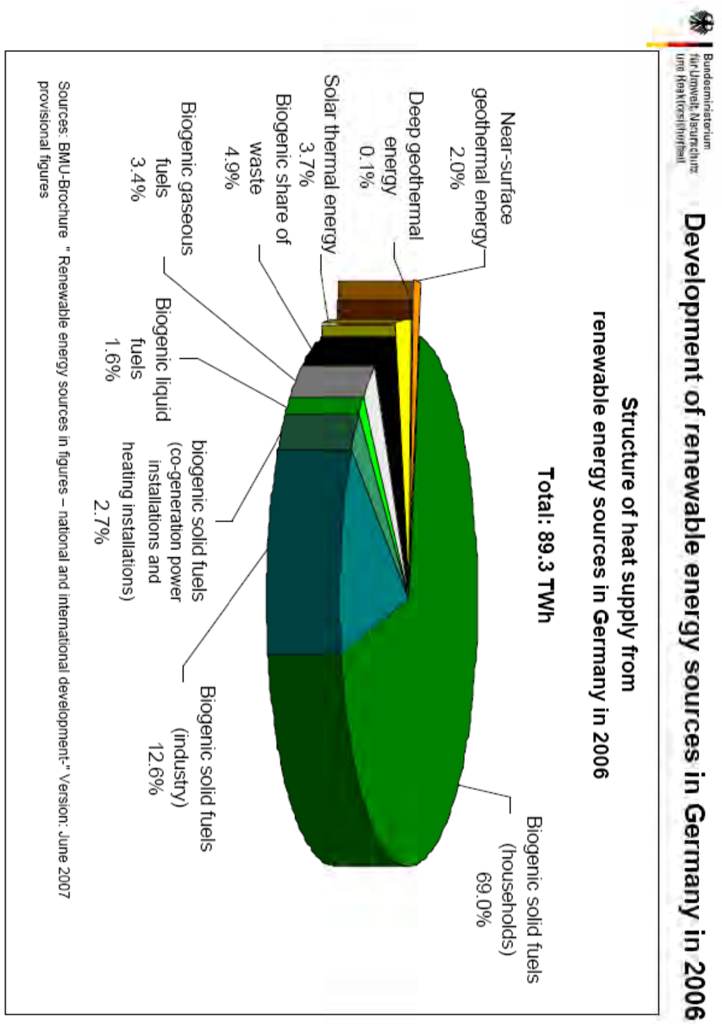
** Biogenic waste share in waste incineration plants estimated at 50 %

Sources: BMU-Brochure " Renewable energy sources in figures – national and international development-" Version: June 2007

*Source: BMU 2007*

Biomass has by far the largest share of renewable energy in the heat market, as illustrated by the following figure (Fig. 3).

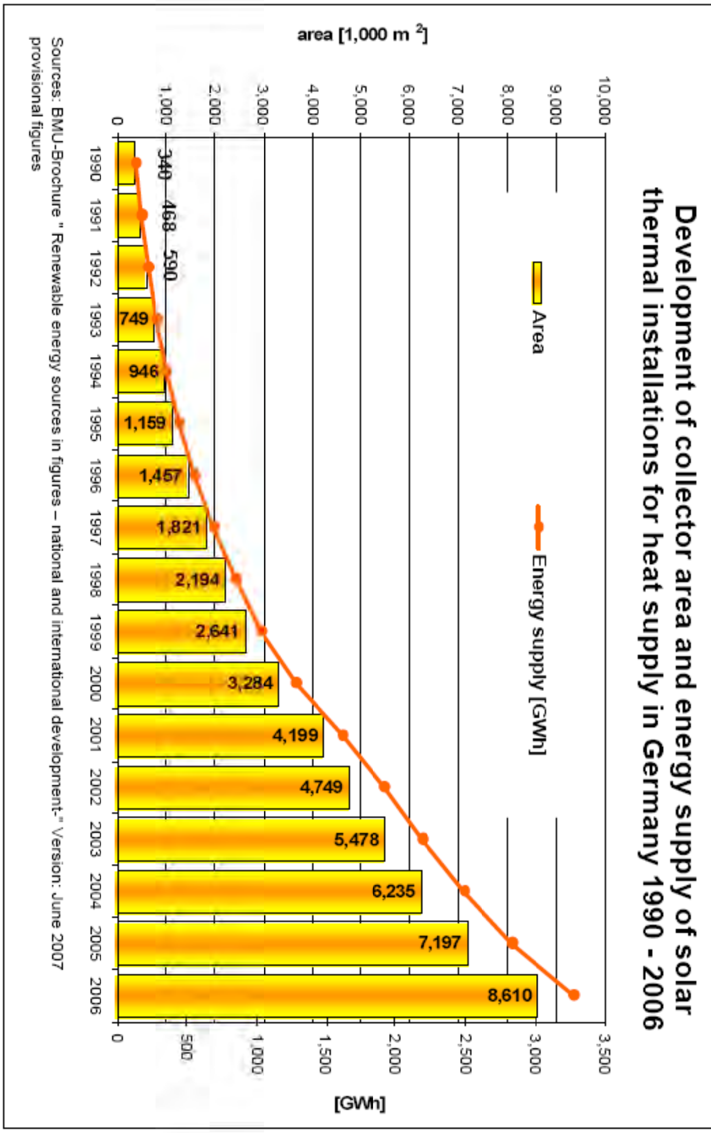
**Fig. 3: Structure of heat supply from renewable energy sources in Germany 2006**




*Source: BMU 2007*

Even though the 3.7% share of solar thermal energy is still relatively small, the development in this area has nevertheless been very dynamic over the last few years, as demonstrated in Fig. 4.

**Fig. 4: Development of collector area and solar energy supply in Germany 1990-2006**




*Source: BMU 2007*

A significant reason for the doubling of the share of renewable energy in the heat market, besides the price increases for the fossil energy carriers natural gas and mineral oil, was the German Federal Government's market incentive programme which has been supporting the market introduction of renewable energies since 2000.

### *The Market Incentive Programme (MAP)*

The Market Incentive Programme (BMU 2007) was created to promote measures for the utilisation of renewable energies and is financed by revenues from the ecological tax reform.[16] It supports the construction of systems for generating heat from renewable energy sources. From the beginning of the programme in 2000 up to the end of 2006, over 523,600 solar thermal collectors with an area of around 4.6 million square metres and over 95,300 small biomass boilers were installed using financial grants from this programme. Within the framework of the Market Incentive Programme, the German Reconstruction Loan Corporation (Kreditanstalt fuer Wiederaufbau, Programme Renewable Energies) has agreed to provide over 3,095 loans, totalling more than 887 million Euros for large installations for the combustion of solid biomass, installations for the utilisation of deep geothermal energy, and biogas plants over the period 2000 to 2006. Since the launch of this programme, a total of more than 623,900 investment projects for the use of renewable heat had been funded by the end of 2006 with the available funds of over 827 million Euros, triggering an investment volume of more than 6.5 billion Euros. The current overall budget of the programme amounts to 300 million Euros per year, and a further increase up to 500 million Euros is planned for next year.

A serious disadvantage of the market incentive programme is its dependence on available budgetary funds. The following figure (Fig. 5) illustrates the large fluctuations in the number of applications for solar thermal collector systems in the years 2000 to 2004, which caused a great deal of uncertainty for the respective manufacturers.

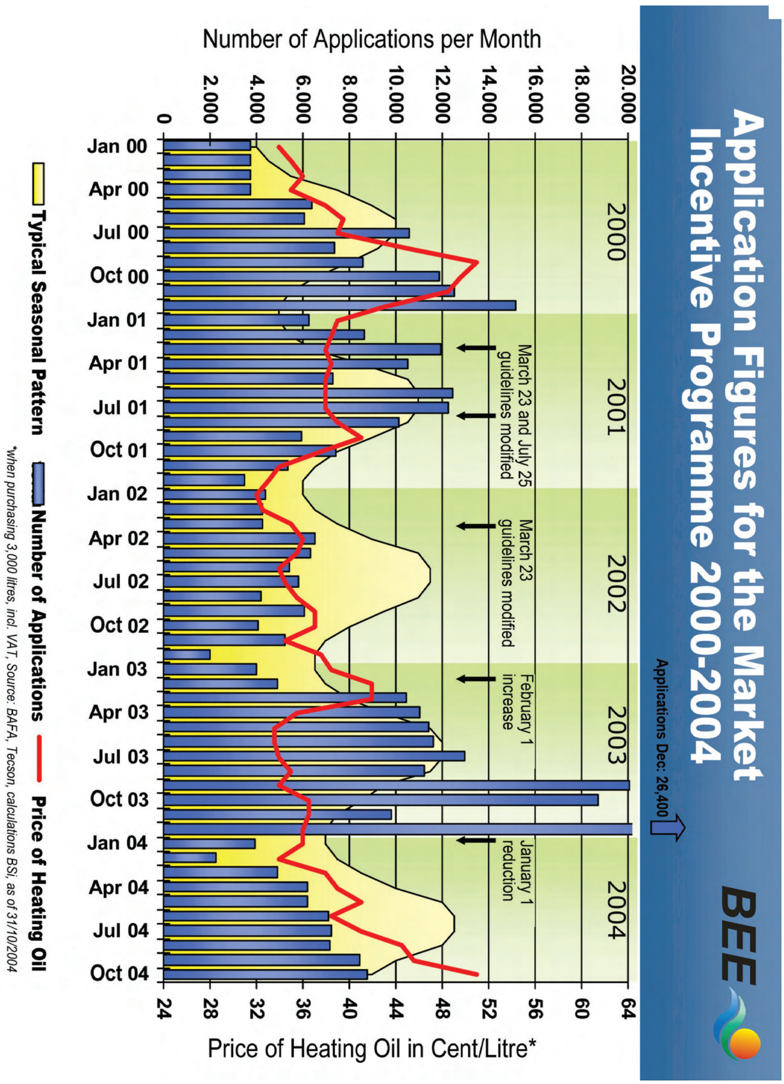
# 2. Need and requirements for a targeted support scheme

From the viewpoint of ecological effectiveness and economic efficiency, while choosing and designing the policy instruments for achieving defined goals, it is important to decide whether the legislator should

16 The German ecological tax reform was introduced in 1999. Over several years, federal taxes on mineral oil, electricity and natural gas have been raised. In return, most of the annual revenues of around 17 Billion Euros are spent on lowering pension contributions of employers and employees. http://www.foes.de/en/GermanEcotax.html

concentrate on conceiving a specific instrument exclusively for the renewable energy heat sector, or whether comprehensive, global instruments that do not focus on a specific sector or technology (like emissions trade or the ecological tax) are sufficient to achieve the goals in sight. In our opinion, there are several substantial reasons supporting the introduction of a promotion instrument specifically tailored to the renewable energy heat market:

**Fig.5: Number of applications in the market incentive programme 2000-2004**




*Source: BEE 2007*

### *Long-term perspectives*

Global steering instruments like emissions trading effect rather short-term adjustment reactions due to their intended changes. For areas like the renewable energy heat market, however, such instruments often fail to provide sufficiently effective price signals and therefore finally lead to suboptimal results. A suitable promotion instrument must be designed for a long-term horizon in order to effect the required adjustments in the heat market infrastructure.

### *Technology portfolio*

The transformation of markets in terms of a sustainable, fit for the future development requires a large measure of "learning investments", i.e. new options must be developed, and existing but not yet economic options must be retained, in order to be able to access a sufficiently large technology portfolio in the long term. Global steering instruments which lead to a market behaviour that tends to align with short-term demands on investment returns are to a large extent blind to such long-term requirements.

### *Special market obstacles*

Beyond the existence of external effects, the renewable energy heat market exhibits several particular market obstacles and imperfections which cannot be precisely addressed by global steering instruments. These include, for example, information deficits, insufficient know how for implementation, as well as opaque structures which are not open to competition and powerful markets for the grid-bound energies.

### *Multidimensionality*

The spectrum of goals for a sustainable development in the heat sector is not as one-dimensional as the steering impact of global instruments, which generally aim exclusively to internalise external effects. A bundle of sector-specific instruments, however, is appropriate to achieve a multitude of specific steering impacts (like climate protection, resource conservation, supply security, regional economic promotion, etc.).

In the long run and with the growing significance of renewable energies in the heat market, the promotion of heat production with renewables using tax revenues should be shifted to other, budget-independent forms of financing.

A new support scheme must ensure that the goals defined for expanding renewable energy use in the heat market are achieved in practise. The goals should be achieved at minimum costs, so that not only the direct financial expenditures, but also the administration and inspection efforts must be minimised. Windfall profits should be avoided as far as possible: Someone who would be building with renewables anyway - whether the reasons are environmental consciousness, ownership pride, or personal hedging against negative developments in the fuel market - does not require additional financial support.

It is easy to overlook the fact that a support scheme should set the course today for structural changes effective in the long term. Such changes include especially:

- the increased use of biomass in cogeneration plants,
- the development of the so far little-used potential for solar heat in multi-family and industrial buildings, as well as the development of cost-efficient seasonal heat stores,
- and the cost-efficient construction of local heat distribution grids which is indispensable for the use of (deep) geothermal energy and also vitally important for the efficient use of solar heat or biomass.

In particular, the task of fulfilling these long-term requirements cannot be left to the market forces which are blind in this regard. Therefore, we discuss in the next chapters selected support schemes which we consider capable to at least partially fulfil these requirements.

# 3. Categories of typical economic support instruments

In all we studied around 20 proposed models to promote heat production from renewable energies, some with various sub-variants. A preliminary assessment was made in order to identify several particularly promising models and thus limit the amount of work involved in the subsequent, more detailed studies and selection process. The preliminary assessment focussed on legal aspects.

Around half of the models studied can be classified as fiscal instruments whose key feature is that the state itself manages the funding flows below the legislative level (i.e. is responsible for execution) or commissions and other agencies do so on its behalf.

In many cases, renewable energy utilisation is still more expensive at present than the alternative option, namely fossil fuel use. In general, this situation can be tackled effectively using fiscal instruments, either by making fossil fuels more expensive for the consumer or by reducing the price of renewable energies through the adoption of appropriate measures. The following four options are available:

1. creating new and/or increasing existing taxes on fossil fuels,
2. subsidising renewable energies from current tax revenue,
3. providing various types of tax breaks for renewable energies systems (exemption from Value Added Tax,[17] improved depreciation opportunities, tax subsidies analogous to the old owner-occupied homes premium),
4. and raising new revenue, to be deployed under the state's supervision to promote renewable energies (many different options exist here).

Each of the fiscal models studied falls within one of these four categories. Our findings showed that none of these models appears to be suitable as a key steering instrument to promote renewable energies in the heat market. The main reasons for this are as follows:

1. To have any significant impact in terms of promoting renewables, a new or increased tax on fossil fuels would have to be very substantial, thus giving rise to major problems with public acceptance.
2. Subsidies for renewable energies from current tax revenue are budget-dependent. The rate of subsidy always depends on the tax revenue raised by the state and on policy-makers' willingness to maintain these subsidies. They therefore do not offer a reliable basis on which to launch more ambitious investment projects, especially the development of additional production capacities. Subsidies can provide important impetus but cannot be the main steering instrument in the longer term.
3. Tax breaks for renewable energy systems limit the budgetary resources available.
4. If the funding flows are managed by the state, or agencies commissioned by it, outside the general public budgets, then the instrument concerned might get some legal problems.

As a result, none of the examined fiscal models was selected for further consideration (see e.g. Ernst&Young 2007 for a discussion of fiscal models).

17 The Value added tax (VAT) is a general **tax** on exchanges. It is levied on the added value that results from each exchange and is a major source of state and federal tax revenue in Germany and other European countries. As in 2008, the German VAT is 19%.

In light of the problems arising in relation to special levies, it was concluded that instruments based on a remuneration entitlement for parties who produce heat with renewable energies would have to be structured in such a way that financial flows are organised through exchange relationships between private persons, i.e. without the involvement of a public-sector distribution agency.

# 4. Description and assessment of selected support schemes in detail[18]

## *4.1 Use obligation models mainly for house-owners*

The term "use obligation" means that an obligation is imposed on specific parties to utilise renewables to a defined extent. This category was sometimes described in very simplified terms as "regulatory law". Spain was the first EU country to introduce a variant of a use obligation at the national level.

The obligation to utilise renewable energy arises in connection with the new installation or replacement of heating systems and therefore addresses mainly the house-owners. Proposals which merely imposed an obligation to install a renewable energy system in new buildings would generally have minimal impact on the heat markets due to the decline in construction activity in Europe. So this obligation has to address the building stock in the first place if it really aims at realizing the existing large potentials. The German state of Baden-Württemberg passed this kind of comprehensive obligation in the last year, and it has to be seen whether it will be adapted at the federal level where a first draft of a renewable heat law addressing only new buildings was passed by the German Government in December.

The advantage of the use obligation model is that its method of operation and impacts are very easy to communicate. However, it has significant weaknesses in terms of its technology-specific effects and the structural change in the heat sector (towards more network-based supply systems) that are required in the longer term.

Three variants of the use obligation model were considered. In the basic variant, the authorities must be able to provide exemptions from the use obligation in hardship cases. The two modified variants allow compensation without an exemption decision by the authorities, either through an obligation to pay a substitute levy or by offering the option to acquire / trade certificates for surpluses produced. The two latter alternatives are preferable to the basic model: deficits in execution are

18 For more details see DLR et al. 2007

less likely, they offer greater flexibility in implementation, and entail lower administrative overheads (as no costly individual exemption decisions are required). The use obligation model with substitute levy was selected for more detailed study because it allows for targeted expenditures for a broader range of technologies which might not be chosen in the basic model for different reasons.

### *Focus on the use obligation model with substitute levy*

The crucial point of this model is the introduction of a proportional use obligation for renewable heat for the areas of building and water heating. In order to avoid laborious exception allowances in cases with unfavourable structural or economic conditions, it will be possible to pay a fee as a substitute for the use obligation. Basic characteristics:

- The regulation obligates every building owner who installs a new heating system or who replaces an existing system to meet a minimum proportion (e.g. an average of 10%) of the annual space heating and water heating requirements for the building in question by using renewable energy. In order to ensure commensurability, a higher minimum proportion should be required for new buildings (e.g. 12%) than for existing buildings (e.g. 8%). A reduced minimum proportion for older buildings is justifiable since the respective owner would have to install a larger renewable energy system for the same living space due to the generally lower thermal standards for the older structure. Furthermore, for some types of buildings, the obligation only arises with a time delay of some years (a distinction should be made between single-family houses, apartment blocks, non-residential buildings, and new buildings, for example). Without this progressive system, the demand for renewable energy systems could increase so dramatically that the market would no longer be able to cope. At the same time, in the interest of a longer-term sustainable energy policy, the legislator should not stop at a milestone set at one point in time. Instead, it should dynamically define the minimal obligation proportions, i.e. successively increase them over time.

- Buildings which are connected to local / long-distance district heating networks are exempt from the use obligation because usually the heat stems from CHP plants which have already low specific $CO_2$ emissions. The obligation does apply, however, to the network operators and heat suppliers.

- Another significant feature of the model is that the obligated parties are allowed the possibility to pay a substitute levy instead of directly fulfilling their obligation. This substitute levy could, for example, amount to 1,500 € for a single-family house with an annual heating requirement of 20 MWh. The affected building owners should be able to choose whether they will meet their proportional use obligation directly by installing a renewable energy system, or contribute indirectly to achieving the target goals. The latter is achieved when the revenue from the substitute levy is used to promote cost-efficient structural measures and large systems with heat grids, which are not sufficiently included in the underlying use obligation. This possibility to make the use obligation more flexible has not yet been implemented anywhere. It is also not included in the federal use obligation legislation which is anticipated to become effective in 2009.

- The use obligation may lead some building owners to postpone exchanging their heating systems in order to avoid having to install a renewable energy heating system. For this reason it should be considered to determine a space of time after which every building must meet the use obligation (e.g. in 2025), regardless of whether or not the heating system has been replaced by then.

## *4.2 Purchase, sale, and remuneration obligations for market participants*

The "purchase, sale, and remuneration obligations approach" encompasses all the models that aim to achieve economic leverage effects without channelling the financial flows through a public-sector agency. It includes, in particular, models which in terms of environmental economics can be classified as quota/price regulations.[19] In practical terms, these could include obligations for traders to purchase or sell specific amounts from renewable energy systems, quota-based obligations for the fuel trade to purchase or sell heat products produced from renewable energy (Quota Model), or entitlements for the producers of heat from renewable energy to receive additional remuneration for renewables-generated heat used by other market participants (Bonus Model).

In this category, the obligated parties should be selected primarily in accordance with the "polluter pays" principle. Practicality criteria also come into play, which in turn have a strong impact on the level of transaction costs. Alongside the consumers of fossil fuels, the various levels of the fuel trade and the manufacturers of heating systems that run on fossil fuels can be considered in this context.

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19 A "quota" in Europe is similar to the so called "Renewable Portfolio Standard" (RPS) in the U.S.: A renewable energy target is set and the mechanism for achieving the target is a market of tradable green certificates (TGCs), or what is known in the U.S. as Renewable Energy Credits (RECs) or "green tags". Tradable credits for energy efficiency and non-electrical renewable generation are known as "white tags" in the U.S.

In the case of purchase, sale, and remuneration obligations, the state must adopt the necessary regulations but does not play a role in the processing and especially the administration of the financial flows. Instead, it becomes the subject of exchange relationships between private persons, thereby removing the risk that the models could evolve in the direction of special levies.

Typically, the obligated parties in the models falling within this category do not necessarily produce or use heat from renewable energy themselves. Instead, one option is for others to do this for them, with a certificate then being issued (for details see below).

Of the three most debated models falling into the "purchase, sale, and remuneration obligations" category, i.e.

- the combined purchase/remuneration model ("Bonus Model")
- the quota or renewable portfolio standard model
- the obligation model for the heating system manufacturers

especially the Bonus Model appears to be particularly promising and was therefore selected for more detailed study. Significant elements of the Bonus Model are based on the German feed-in tariff law Renewable Energy Sources Act (EEG) from 2000/2004. The quota model has shortfalls in transaction procedures and, additionally, the present European experiences in the electricity market with this instrument are not very promising. The third model, which obliges the heating systems manufacturers to construct a minimum number of renewable energy systems that is fixed by a quota, is an interesting option. However, it has shortcomings related to transaction costs and aspects of environmental economics, and was therefore not pursued further.

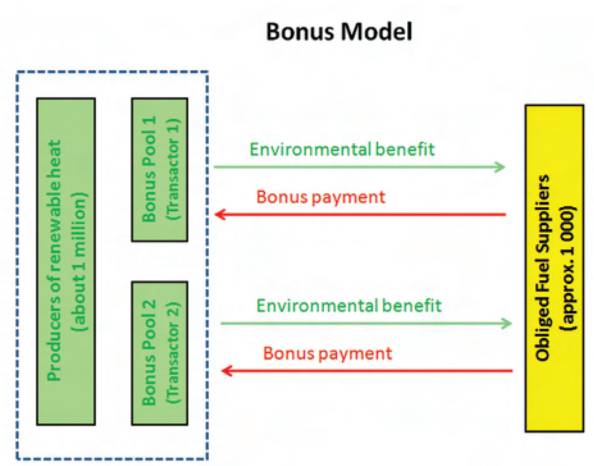
The Bonus Model was selected for more detailed study.

### *Focus on the Bonus Model as a combined purchase/ remuneration model*

The Bonus Model is a rather new concept in the discussion about suitable support options for renewable energies in the heat market. The Bonus Model can be characterised as a purchase/remuneration obligation with fixed reimbursement rates. The model involves major mechanisms of a classic feed-in scheme which is well known from the RES-E sector. Operators of renewable heat systems are entitled to receive a fixed bonus payment per kilowatt hour of heat produced. The bonus level is set by the government and established by law. The bonus level can be easily adapted and periodically adjusted to the specific needs of the various technologies and the instrument can provide good incentives for the implementation of grid-based heating systems. The bonus is paid by those companies which fall under the German Energy Tax Act and handle fuels for heating purposes (Fig. 6).

The interaction between those who operate renewable installations eligible to receive a bonus (beneficiaries) and those which are obliged to pay the bonuses (obliged parties) requires special attention. The relationship between the two parties in the heating sector differs significantly from the corresponding relationship in the electricity sector under the scope of the Renewable Energy Sources Act (EEG), a feed-in tariff system for renewable electricity. Under the EEG, electricity is physically fed into a network which allows for the distribution of a physical good. The situation is different in the heating sector. Heat is mainly produced in individual house systems and a homogeneous and country-wide transmission and distribution network is missing. So what is the equivalent which obliged companies receive in return for their bonus payments? One option is to introduce a surrogate in the form of certificates of value for renewable energy, representing the environmental benefit associated with the production of renewable heat. In this case, the beneficiaries may provide certificates of value, not (heat) energy itself, to the obliged parties. Another option is to dispense entirely with any sort of tangible service in return: the remuneration is then the direct equivalent, in legal terms, of the environmental recovery brought about by the third parties (i.e. the producers of renewable heat).

**Fig. 6: Overview of the principle architecture of the Bonus Model**




*Source: DLR et al. 2007*

One of the key design elements is the organisation of the relationship between the beneficiaries and the obliged parties. Here legal aspects have to be carefully taken into account. An instrument design needs to be chosen which especially removes the risk that the model is legally classified as a special levy which could result in some institutional restrictions and even in some legal problems. Therefore, in order to avoid legal problems, the state must not take a role in the processing and especially the administration of the financial flows.

Under the Bonus Model, each household or third party operating a renewable heat system would in principle be entitled to apply for funding. This situation would involve millions of beneficiaries leading to millions of transactions. Therefore, we have introduced a key position in our proposed instrument design which is taken by pooling organisations (called "aggregators"). The role of the aggregators is to aggregate the interests and bonus claims of the beneficiaries, thus acting on their behalf. All beneficiaries are obliged to join at least one aggregator in order to be entitled to receive the bonus.

In order to minimise the administrative burden especially for small beneficiaries (households) which constitute the majority of all eligible renewable heat operators, the routines applied within the Bonus Model should be simplified wherever possible. Preferably, small beneficiaries will scarcely notice that there has been a change in the funding framework (by replacing the market incentive programme (see above) by a Bonus Model). The introduction of the aggregators will be advantageous in this regard. From the perspective of the beneficiaries, the aggregators replace the authority to which applications are made for eligible renewable heat devices under the current MAP. Furthermore, small beneficiaries should submit more or less the same documents to the aggregators as to the authorities under current conditions in order to be supported through the MAP. Bonus payments could also be aggregated over several years so that operators of a small renewable heat installation would receive funding for all their eligible renewable heat generation by only a few (e.g. two) payments. The determination of the eligible renewable heat volume (which is the basis for the payments) should be based on few standard plant parameters and simple calculation models (and not necessarily on measurements). Larger systems should, however, underlie more stringent monitoring and documentation requirements, e.g. evidence of the quantity of renewable heat produced should be provided every year on the basis of measurements.

The aggregators claim the bonus payments from the obliged parties (see below). As a manageable number of companies will be concerned (approx. 1,000), each aggregator can claim the bonus that is due from each of these companies according to their individual obligations. Each obliged company is required to pay the bonus based on its market share. In each case, the basis for determining bonus volumes and pertinent obligations consists of the last reference year, and in the interest of simplicity, the amounts and obligations are set by a federal authority based on data gathered in the scope of the energy tax (see below).

The aggregators' role entails substantial responsibility. In order to keep the system manageable, the number of aggregators should be limited (e.g. to around 12 organisations) whereas it must be ensured that aggregator services are offered throughout the whole country. The aggregators process the applications submitted by beneficiaries for bonus payments, check them and then enforce them (in private law) vis-à-vis the individual obliged companies. The aggregators must ensure a high level of transparency in their dealings with these companies and are monitored by a federal authority. Finally, the aggregators pass the bonuses on to the beneficiaries on whose behalf they are acting. Expenses for aggregator services are paid by the beneficiaries through respective service fees.

### *Who should be obliged?*

Obliged parties (who pay the bonus) should be selected primarily in accordance with the "polluter pays" principle. This principle is linked to the question to which extent different parties can be made responsible for the environmental impact and damage originating from activities in the heating sector in general. The answer to this question is manifold. Alongside the consumers of fossil fuels, the various levels of the fuel chain - but also the manufacturers of heating systems that run on fossil fuels - could be considered in this context. In addition to the "polluter pays" principle, practicality criteria should be applied in order to minimise the transactions costs of the system.

In our recommended system, the obligation is put on those companies which initially place environment-damaging fuels for heating purposes on the market or which supply them to consumers and thus fall under the German Energy Tax Act (EnergieStG). In the case of oil, the obligation will affect those companies which exploit oil in Germany or import it. In the case of gas, those companies will be obliged that supply gas to final consumers. The obligation does not apply to fuels going to power plants for electricity generation (e.g. gas) or fuel which is used in the chemical industry for non-energetic processes (e.g. oil). In addition, the bonus obligation applies only to the proportion of fuels that should be replaced by renewables.

Allocating the obligation to this specific group can apparently be well justified by the "polluter pays" principle, but also has another important advantage. Most of the data required for determining the specific bonus volumes which must be paid by each obliged company within a settlement period is readily available as it is already collected by the financial authorities within the energy tax system. This fact simplifies procedures to a considerable extent. In addition, the German Energy Tax Act already applies similar exemptions as those foreseen within the Bonus Model (e.g. for heat generation from fossil CHP systems). However, the timeframes and organisational procedures stipulated in the Energy Tax Act must be taken into account and might cause some delays in processing the Bonus System.

Although the obligation is put on specific companies, the costs of the promotion scheme will finally be carried by the consumer. The obliged companies will most likely pass the additional costs due to the bonus payments on to their consumers, leading to slightly higher fuel prices. However, compared to the present funding framework, this scenario constitutes a shift in the funding philosophy as it will now be the consumer who is bearing the costs for renewable heat support and not the tax-payer anymore.

The following table gives a rough qualitative assessment of both models according to selected criteria.

**Table 1: Rough assessment of the two most promising support schemes**

| | Use obligation model | Bonus model |
|---|---|---|
| Establishment of stable and dependable investment conditions | + | + |
| Long-term efficiency | o | ++ |
| Total transaction costs | o | + |
| Acceptance | + | - |
| Promotion of technological development | - | + |
| Compliance with “polluter pays” principle | + | ++ |

Legend
++ - very good result
+ - good result
o - medium result
- - bad result

From an industry perspective, both models offer the advantage of providing more reliable bases for investment and personnel planning compared to the current situation. Qualitative differences between the two models exist in the following areas:

- The bonus model offers advantages in terms of technological development. This model offers scope for the targeted promotion of the exploration of deep geothermal sites, heat and power cogeneration from biomass facilities, and technologies for more intensive utilisation of solar collectors, including seasonal storage systems. The expansion of local district heating, which is essential for the use of these technologies, will also benefit from the bonus model.
- Both models offer good, long-term compliance with the "polluter pays" principle. In the short term, however, the use

obligation model has disadvantages as it will only apply to a relatively small number of people at first. It will take around 25 years for all heating systems to be replaced, with every building owner then having made a contribution to the expansion of renewable energy.

- The disadvantages of the bonus model arise primarily in relation to acceptance. As a new model which has no precedent anywhere in the heat market, it will be unfamiliar to the players. It is also more complex in its structure than the use obligation model. It will thus require more explanation as a part of the political debate about the introduction of a new instrument. It will also require substantial initial regulation; although this factor will no longer be relevant when the scheme is implemented in practise, it does contribute to the current acceptance problems.

As a result, we prefer the Bonus Model as the best model to support renewable energy heating systems in order to fulfil the political targets.

# 5. Outlook

Within its integrated climate protection and energy programmes, the German Federal Government has recently (December 2007) presented a draft for a Renewable Heat Law, which is constructed as a use-obligation model, but which applies only to new buildings and does not provide for substitute levies. Compared to the considerably more efficient bonus model, which however is more complex and requires more conviction, the current draft represents a very tentative and defensive entry into the budget-independent promotion of renewable energy sources in Germany. In order to maintain the prospect of still achieving the self-set goals, an increase in the budget-dependent promotion is planned. With regard to the law, we would recommend at the very least to:

- extend the use obligation to existing buildings and to define the replacement of the heating system as the only element which triggers the obligation,
- treat possible substitute measures as alternatives to fulfilling the obligation very restrictively and to prioritise them according to ecological criteria,
- and to provide for a substitute levy for the case that the obligation is not fulfilled. This substitute levy should be used to promote larger renewable heating systems in connection with heat networks.

## ACKNOWLEDGEMENT

The authors would like to thank the German Ministry of Environment, Nature Conservation and Nuclear Safety for funding this investigation.

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  Editor: Arne Jungjohann. (2008)

- **The Right to Development in a Climate Constrained World: The Greenhouse Development Rights Framework.**

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- **The Debate over Fixed Price Incentives for Renewable Electricity in Europe and the United States: Fallout and Future Directions**.

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